THE NATURE OF HEALTH

INTEGRATING HEALTH CONSIDERATIONS IN URBAN NATURE-BASED SOLUTIONS

OCTOBER 2021

Smart Prosperity Institute

The author would like to thank Health Canada for their funding and support for this project. Thanks to Shirra Freeman, Kathleen Wolf, Jacob Cramer, Melissa Lem, and Thomas Bowers for providing helpful comments on earlier drafts of this report, and to Brian Buchardt and Adrina Bardekjian for providing key insights during many stimulating conversations. Thanks also to Smart Prosperity Institute's Alice Irene Whittaker, Mathias Schoemer, and Mac Radburn for their editing and production support, to Jared Bell and Diane Torlone for additional editing and design support, and to the entire SPI nature team for their ongoing effort in furthering the message around the importance of improving environmental health in Canada.

About Smart Prosperity Institute

Smart Prosperity Institute is a national research network and policy think tank based at the University of Ottawa. We deliver world-class research and work with public and private partners – all to advance practical policies and market solutions for a stronger, cleaner economy.
institute.smartprosperity.ca

Recommended citation: Twigg, M. 2021. The Nature of Health: Accelerating the integration of health considerations in urban nature-based solutions. Smart Prosperity Institute.

October 2021

With support

The views expressed herein do not necessarily represent the views of Health Canada.

KEY MESSAGES

Nature has direct and indirect impacts on health outcomes, including physical and mental health, social determinants of health, and health impacts associated with environmental exposures and climate change.

Health outcomes rely on the accessibility of nature. Factors that limit exposure to urban nature and greenspaces also limit the impact of associated health benefits. These factors include perceptions of safety, sense of community, feelings of belonging and attachment, and cultural dignity.

Health benefits from urban nature are not distributed equally. Vulnerable populations are disproportionately affected by poor environmental health. Community engagement and health equity must be top of mind for planners and public health advocates when considering the merits of nature-based solutions, as equity and inclusion issues strongly influence who benefits.

Investments in nature-based solutions can generate substantial health cost savings. However, connecting natural features to specific health outcomes and these outcomes to cost savings is complex, and studies are limited. This can make it difficult to justify additional projects costs based on positive health outcomes.

Limited availability of ecosystem and health data is a significant challenge. A lack of local data limits the ability to identify environmental health baselines and potential health cost savings from NBS.

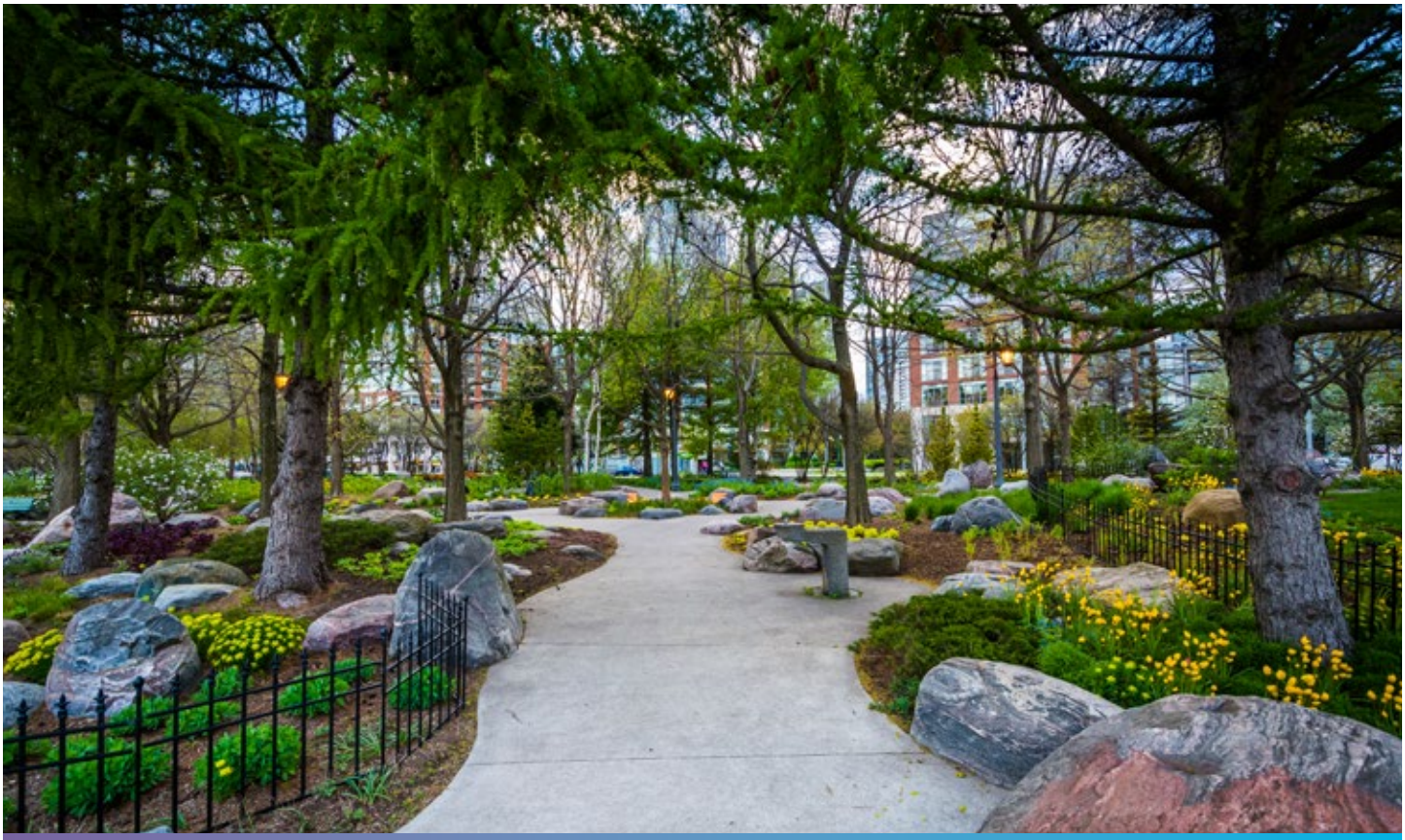
Existing funding streams are not sufficient for cross-jurisdictional collaboration. At the local level, health and environment are connected through climate resilience and healthy city strategies. Yet funding streams are often fragmented across the local, provincial, and federal jurisdictions responsible for different aspects of nature-based solutions and health.

Integrated management of urban nature is key to building healthier communities. Adopting an ecosystem-based approach to manage urban nature would facilitate the integration of activities across local departments to better track project performance, while broadening the knowledge base currently used to advance discussions.

Best practice guidelines are needed. Standardizing measurements and processes, as we have seen with Natural Asset Management, and developing best practice guidelines could help reduce transaction costs for integrating health considerations, making these types of projects more accessible across various settings.

Interdisciplinary partnerships are necessary. Coalitions of specialized stakeholders are often responsible for advancing dialogue and action. While these networks are useful for advancing discussions, strengthening collaboration between local government departments is critical to support greater action and investment on the ground.

Regional partnerships and multidisciplinary coalitions drive innovation and collaboration. Collaboration between multiple levels of government and across stakeholder groups will continue to be the key for successful implementation. Developing effective strategies to mainstream NBS as a method to build both health and climate resilience will require existing coalitions to be strengthened and the development of new, long-term, and inclusive partnerships.



EXECUTIVE SUMMARY

Access to nature is crucial for maintaining the health of Canadians – more greenspace means a lower risk of cardiovascular diseases and respiratory illnesses, and integrated urban ecosystems improve air quality and reduce the urban heat island effect. Urban parks and greenspaces are also increasingly understood as vital to support mental health and community cohesion. This reality is further emphasized by the growing number of health impacts exacerbated by increasing urbanization and climate change.

Canada's 2021-2022 federal budget, A Recovery Plan for Jobs, Growth, and Resilience, charts a course for a green economic recovery from COVID-19 that underlines the importance of nature for building healthier Canadian communities. The budget includes more than $3 billion in investments to support the protection, conservation, and restoration of greenspaces and natural infrastructure across Canada. The proposed investments acknowledge the underlying health impacts of urban living and the crucial importance of investing in the conservation and restoration of natural assets for building more resilient communities that are accessible to everyone. As a result, local and regional governments are presented with an unprecedented opportunity to invest in nature-based solutions (NBS) that enhance the functioning of vital ecosystem services and improve health outcomes in their communities, while also building long-term resilience to climate change.

Including health considerations in NBS projects and Natural Asset Management makes economic sense as it can generate significant health care cost savings – up to $4.2 million annually for local governments and estimated at $100 billion nationally by 2050[7 155 156].

While the positive relationship between nature and health is well-established across Canada, the **measurable impacts of specific NBS on human health are less clear**. We identify three main challenges that continue to drive this lack of clarity:

1. **Quantifying health co-benefits of NBS in meaningful economic terms.** At the project level, capturing the value of different health benefits from NBS requires the use of complex accounting methods. For example, measuring how much cleaner air can reduce the incidence of respiratory illnesses is relatively simple, but capturing how much of an increase in the urban tree canopy is needed to reduce hospital costs to treat respiratory illnesses caused by poor air quality requires the consideration of multiple additional variables;

2. **Ensuring health co-benefits are equitably distributed** and meet the needs of the community to build health resilience, maintain well-being, and ensure the ability of these communities to thrive;

3. **Identifying the right metrics and collecting the right local data** to track the impact of different projects and potential health co-benefits to determine how NBS contribute to positive health outcomes.

The purpose of this report is to provide a better understanding of the underexplored nature-health-climate nexus in Canadian strategic planning. It also highlights the necessary tools, data, assessment methodologies, and evaluation techniques to assess specific health outcomes from using different types of NBS. We achieve this by:

1. Reinforcing the explicit connection between urban nature and human health by examining the pathways that link various types of NBS with different health outcomes;

2. Identifying the current approaches, challenges, and opportunities that local governments in Canada face when designing NBS that integrate human health and climate resilience;

3. Assessing the suitability of various project-level accounting methods, valuation instruments, and evaluation tools for capturing the value of both health and nature impacts;

4. Identifying the key challenges and potential solutions to better integrate health considerations when designing NBS projects;

5. Highlighting innovations, opportunities, and potential solutions to promote cohesion and strategic alignment among existing stakeholders and those seeking entry points for designing NBS projects that account for health benefits.

Our findings are intended to support local and regional governments, community-based organizations, and environmental stakeholders that are interested in advancing projects that capture the value streams of different health co-benefits generated from NBS. They may also be useful for health-based organizations seeking to better integrate the environmental determinants in project level decision-making.

Overall, our report evaluates how persistent challenges have influenced the integration of health considerations in NBS projects; and how these considerations are being evaluated by different local and regional governments across Canada. The following details our main findings, including ongoing challenges and key opportunities to better integrate health considerations in local and regional planning:

Main Findings

The connection between human health and urban nature is highlighted in the strategic planning of local and regional governments across Canada. Our report identifies this connection has become as a central facet of Canadian urban planning for at least the past 15 years and, in most cases, accelerated by the growing impacts of climate change;

Equity, diversity, and inclusion are widely identified by local and regional governments as significant considerations when evaluating the benefits of urban nature; however, strategies to integrate these considerations are highly variable and are indicative of various levels of success for integrating these considerations across different jurisdictions;

Intersectoral and community engagement are widely acknowledged as being integral for the sustainability of NBS projects by fostering a greater sense of community ownership; engagement tools and evaluation methods are highly variable across different jurisdictions;

Local governments are using similar project tools to design and evaluate NBS projects, but **National standards and project guidelines are needed** to support decision-makers with integrating the right metrics and approaches to capture the value of related health co-benefits.

Challenges and Gaps

Environmental health issues are fragmented across local departments and regional public health authorities. Health benefits are multi-dimensional and accounting for those generated by NBS requires an integrated approach that facilitates collaboration across different departments and sectors;

Engagement needs to be ongoing and responsive to changes in local demographics and challenges from climate change. Integrating socio-economic and demographic considerations is crucial to ensure health benefits are equitably distributed among different population groups and will require substantial investment and innovative strategies to ensure equitable participation;

The availability of local and longitudinal environmental health data is limited and remains a significant barrier for better integration of health considerations when using NBS;

Local and regional governments have a limited mandate to act on environmental health. In the absence of a clear and binding mandate to include health criteria in project planning and program design, the integration of these considerations in local planning is often ad-hoc, limited by competing priorities and funding streams, and encourages the fragmentation of strategies across different sectors.

Innovations and Opportunities

Including health considerations in NBS projects and Natural Asset Management makes economic sense as it can generate significant health care cost savings – up to $4.2 million annually for local governments and estimated at $100 billion nationally by 2050[7,155,156];

Examples in Quebec and British Columbia illustrate that **local governments can be empowered to act on environmental health when provided with a (in)direct mandate**;

Improved tracking and diagnostic reporting of environmental health factors is needed during patient intake – like reporting changes as a result of COVID-19 – and can help isolate the specific health impacts generated by different features of the built environment;

Supported by improved institutional capacity at the local level, **existing knowledge networks are well placed to (a) support the vertical and horizontal exchange of information across jurisdictions, and (b) reduce the fragmentation of public policy** around human health, urban nature, and climate resilience.

To accelerate the integration of these considerations in local and regional planning across Canada we emphasize three priority areas for action:

1. **Empowering local governments to act on health with a clear and expanded mandate**
   Quebec and British Columbia have provided an explicit health mandate for local governments, raising the profile of community health considerations, and enabling action at the local level. Better understanding the experiences in these jurisdictions and drawing on the lessons learned could enable a greater scaling out of nature-health-climate considerations to local governments in other jurisdictions.

2. **Harmonize strategies and develop best practices**
   In the absence of national standards, the diversity of approaches creates challenges for decision-makers when considering the best option for designing processes that integrate health considerations in local decision-making. Developing comprehensive national standards and best practices will be integral for initiating a widespread integration of health considerations at the project level.

3. **Align institutions and funding streams to target the health-nature-climate nexus**
   Understanding the role of provincial and territorial health authorities and how these networks connect local communities to national funding streams is the key to fostering more integrated management strategies. Investing in the creation, expansion, and formalization of vertical knowledge networks will be necessary to support the creation and distribution of effective tools and resources to move projects forward. The success of these networks will hinge on the development of sufficient institutional mechanisms to support ongoing collaboration between stakeholders.

Equipped with the right tools, further research in a few key areas, and comprehensive guidelines to support the design, development, and monitoring of NBS projects, local and regional governments will be well placed to accelerate investment in nature-based projects to build healthier and more resilient communities.

TABLE OF CONTENTS

Acknowledgements **II**
Key Messages **III**
Executive Summary **IV**
Glossary **1**
Introduction **2**
1. What are the health benefits of nature? **6**
A review of evidence linking nature to positive health outcomes
1.1 Physical Health 7
1.2 Mental Health 8
1.3 Social Health 8
1.4 Climate and Environmental Health 9
1.5 Benefit pathways linking health impacts to nature-based solutions 11
2. Understanding The Canadian context: **12**
How health considerations are being integrated in local and regional planning
2.1 Urban Forestry 14
2.2 Parks and Greenspace Master Plans 15
2.3 Climate Resilience 17
2.4 Healthy Cities 18
2.5 Key Takeaways 22
3. What is the value of 'Good Health'? **24**
Strategies for quantifying the health benefits of nature-based projects
3.1 Establishing economic value of urban greenspace and natural infrastructure 25
3.2 Establishing economic value of health outcomes 25
3.3 Instruments and Tools 29
3.3.1 Project evaluation instruments 29
3.3.2 Project design and evaluation tools 32
3.3.3 Subjective well-being assessments and health surveys 44
3.4 Building the business case 52
4. Key challenges **58**
for integrating health considerations when using NBS
4.1 Ongoing challenges to integrating health considerations 59
4.2 Gaps in project design 60
5. Nature and health:
innovations and opportunities **62**
5.1 Policy Innovations and Opportunities 63
5.2 Capacity Building 65
5.3 Research Pathways 66
6. Conclusion **68**
Appendix 1: Literature Review Background **70**
Appendix 2: Additional details on benefit pathways linking nature and health **71**
Appendix 3: Additional project instruments & tools **73**
Appendix 4: City Plans Reviewed **78**
Appendix 5: SPI Workshop on NBS - Agenda **90**
References **98**

GLOSSARY

Asset Inventories: catalogue of tangible and intangible assets that are owned and managed under specific jurisdictional powers. For natural asset management, these inventories typically include natural resources, ecosystem services, and other aspects of urban nature that are central to the provision of one or more community services.

Accessibility of Nature: factors that limit exposure to urban nature and greenspaces can also limit the accessibility of associated health benefits. These factors include perceptions of safety, sense of community, feelings of belonging and attachment, and cultural dignity.

Cardiometabolic: spectrum of conditions that include cardiovascular conditions – heart disease, stroke, hypertension – as well as type II diabetes and kidney failure.

Ecosystem Services: benefits that communities receive from the natural environment. These benefits can be direct or indirect and are typically divided between provision (direct product), regulating ecological functions (e.g., water filtration), cultural (impact of human lifestyles) and supporting (habitat health) ecosystem services.

Environmental Health: encompasses all aspects of the living and constructed environment that can have an impact on human health outcomes. These impacts can result from direct, pathological effects – e.g., health impacts from air pollution or extreme heat – as well as salutogenic effects of the surrounding environment on overall well-being – e.g., visual enjoyment of urban trees.

(Urban) Greenspaces: identified as a wide array of urban features that incorporate various green features, including parks, street trees, private gardens and urban woodlands. Specifically, urban greenspaces are designated for recreation, relaxation or aesthetic enjoyment, and can include both natural spaces and green infrastructure.

Green Infrastructure: constructed features of the urban environment that draw inspiration from or supports the functioning of various natural systems – e.g., bioswales that promote water infiltration and hydrological functioning.

Health Impact Assessment (HIA): project evaluation tool designed to simplify the integration of health considerations in project-level decision-making. HIAs use scientific information to estimate the overall impacts on human health, as well as any potential changes to environmental, economic, and social determinants that influence the wider public health landscape.

Heart Rate Variability (HRV): measure of the variation between heartbeats. This function is controlled by the autonomic nervous system to regulate blood pressure, heart rate, breathing and digestion. HRV has emerged as a robust method for measuring the short- and long-term impact of environmental pollutants on health and well-being.

Morbidity: overall condition of individuals suffering from specific health conditions (e.g., antibiotics can reduce the morbidity of bacterial infections), or the rate of disease in the wider population (e.g., extreme temperatures are linked to increased morbidity from cardiovascular disease).

Mortality: overall risk or actual rate of death in each population attributed to a specific disease, condition of driving cause. Measured as the total number of deaths for this condition over a set period and scaled to a rate for the target population group.

(Urban) Nature: refers to the wide collection of natural features – including plants, animals, and landscapes - that comprise diverse, species-rich ecosystems. Specifically, urban nature exists on a spectrum of wilderness that can include, parks and gardens, as well as forests and wetlands.

Nature-based solutions (NBS): actions inspired and supported by nature to protect, sustainably manage and restore ecosystems to enhance community resilience, address societal challenges, conserve biodiversity and improve human well-being. Broadly, NBS can include different aspects of both green infrastructure and urban nature that seek to enhance urban vegetation, improve ecological and ecosystem service functions, and develop greenspaces that encourage positive human-nature interactions.

Natural Asset Management (NAM): effective management by local and regional governments of stocks of natural resources or ecosystems that contribute to the provision of one or more services required for the health, well-being, and long-term sustainability of a community and its residents.

Non-communicable diseases (NCD): chronic diseases that are not communicated between people are usually long-lasting – e.g., heart disease, stroke, diabetes, etc.

Normalized Vegetation Difference Index (NDVI): industry standard tool that uses satellite imaging to measure changes in surface vegetation over time

Small for Gestational Age: babies that are born below the 10th percentile in weight compared to those with similar gestational ages

Low Birth Weight: babies that are born less than 5 pounds, 8 ounces regardless of gestational age.

Urban Vegetation: refers to surface cover vegetation that can include both natural (e.g., urban forest) and green infrastructure features (e.g., green roofs)

Vascular Inflammation: inflammation of blood vessels that restricts blood flow and can lead to severe organ and tissue damage

INTRODUCTION

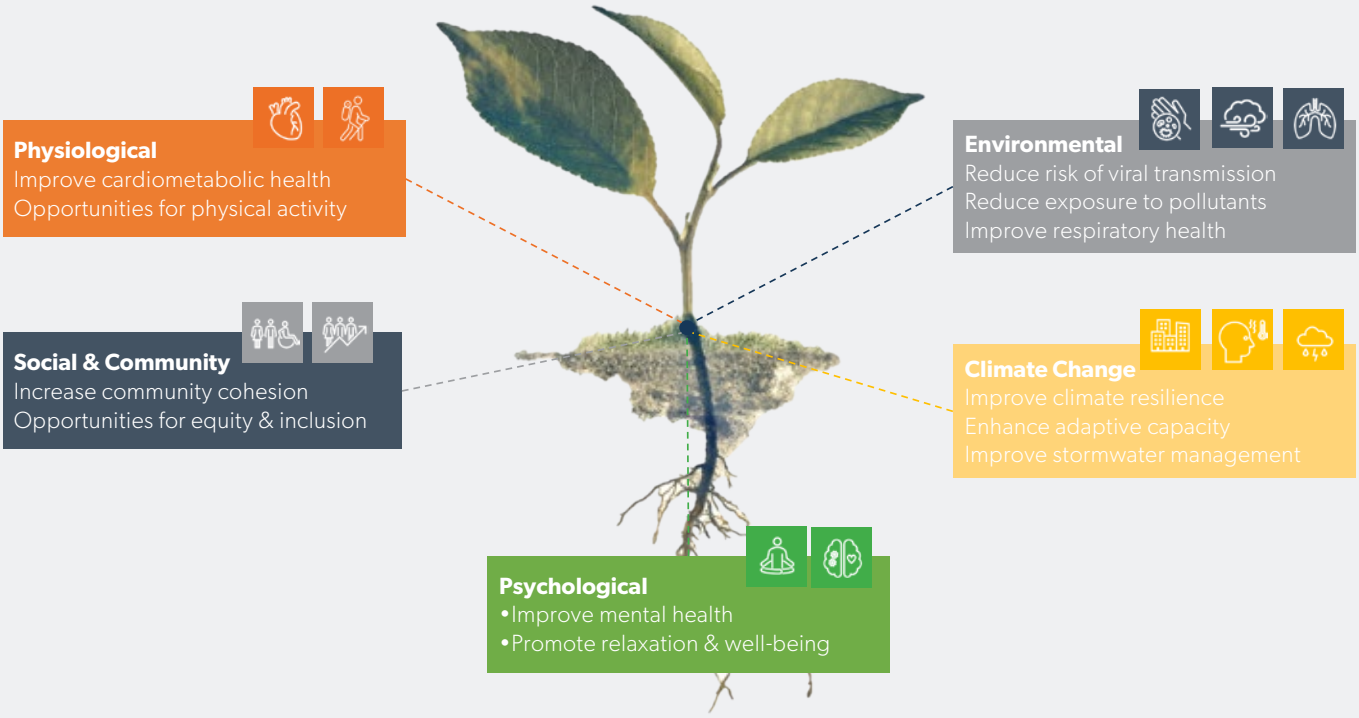
Over the next 15 years, Canadian communities will become older, warmer, and sicker. By 2036, 10 million Canadians will be over the age of 65, which significantly increases the risk of suffering from chronic illness or disability[1]. As a result, health care expenditures are forecasted to increase by 33%, with both individuals and the public health system anticipated to be paying more to maintain current levels of health and well-being[2]. At the same time – and under the most conservative estimates – close to 85% of Canadians will be living in cities, placing the way we design and interact with our urban environment at the forefront of conversations about environmental health and city living.

In tackling the health risks associated with city living, it is crucial to reinforce that these risks are not inherent to urbanization. They are created by undervaluing the benefits of urban nature. This approach to modernization – ingrained in urban planning since the mid-1920s – tends to ignore the vital role of ecosystem services in building local health resilience and reducing rates of mortality and morbidity. Across the country, urban greenspace deprivation drives poorer health outcomes and results in an increased risk of mortality that disproportionately impacts low-income households, young adults, and people belonging to groups designated as visible minorities[3].

Investing in Nature Can Help Build Healthier Canadian Communities

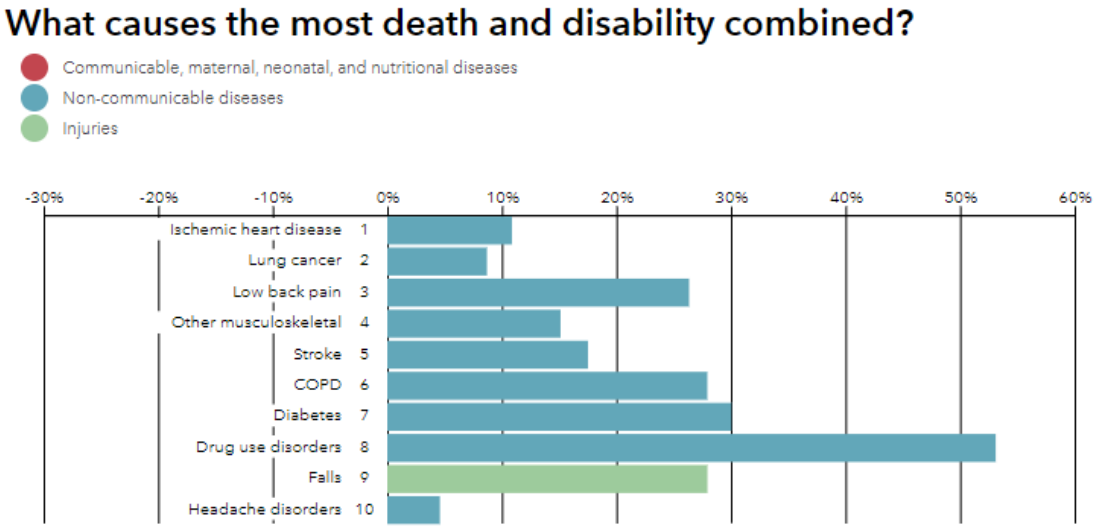
Healthy city initiatives are highlighting the growing connection between urban nature and human health. The nexus of human health, urban nature, and climate resilience in Canadian urban planning illustrates the health benefits of nature, and that nature-based solutions (NBS) are being increasingly recognized as a cost-effective strategy for many local communities to enhance the health and well-being of their residents. Broadly speaking, more urban greenspace means a lower risk of cardiovascular diseases and respiratory illnesses; and increasing the integration of natural features in urban design can help improve air quality, reduce the urban heat island effect, limit flooding damage, and reduce the spread of communicable diseases (**Box 1**). When accounting for the full scope of potential health co-benefits, investing in NBS could result in lower government health expenditures and fewer out-of-pocket expenditures for individuals, while simultaneously improving public health and building the long-term health resilience of local communities.

Box 1: Health benefits of urban nature



Designing healthier cities that invest in urban nature presents an unparalleled opportunity to better understand the impact of the urban environment on health outcomes. There is a strong evidence base connecting NBS to a reduced risk of several non-communicable diseases (NCD) that drive rates of mortality and morbidity across Canada (**Figure 1**). Integrating parks, trees, and greenspaces in dense and compact urban areas, while also being able to account for their positive impact on public health, will be crucial for reducing the severity of environmental health risks and building more inclusive local communities that promote health and well-being for all Canadians.

Figure 1: Main causes of death and disability in Canada (IHME 2020)



Top 10 causes of death and disability (DALYs) in 2019 and percent change 2009-2019, all ages combined

How Can Urban Nature Contribute to Building Health Resilience in Canada?

Natural systems produce a range of **ecosystem services**[4] that can benefit people and the environment. Health impacts derived from ecosystem services **can be direct** – improved air quality from the presence of trees having a positive effect on cardiovascular health; **or indirect** – studies show that people will spend more time outside on treed streets, which can produce a measurable impact on both physical and mental health due to increases in physical activity, as well as feelings of inclusion and social cohesion[5 6.]

Three pathways at the nexus of health, nature, and climate are attracting the attention of decision-makers:

1. **Urban greenspaces limit the prevalence and incidence of NCDs.** Access to urban greenspace for outdoor recreation and increasing the density of urban vegetation is a cost-effective solution for improving health and well-being by encouraging more active lifestyles and reducing the risk of increased mortality and morbidity from several cardiometabolic diseases, respiratory illnesses, and poor mental health.

2. **Urban greenspaces and green infrastructure limit the exposure of communities to negative environmental health impacts**, such as air and noise pollution, extreme temperatures, and the encroachment of chemical pollutants from gray infrastructure and industrial processes.

3. **Nature provides a buffer against the impact of climate change** and its associated health effects. Many effects of climate change disproportionately affect the most vulnerable communities, e.g., high heat days are especially problematic for seniors, children, and individuals with pre-existing health conditions. Urban vegetation plays a significant role in reducing the urban heat island effect; wetlands and greenspaces can improve water infiltration, reducing the risk of floods and water contamination; and conserved natural spaces reduce the risk of zoonotic disease spread and reduce the likelihood of future pandemics.

In the context of this report, we collectively refer to the range of possible ecosystems, parks, urban greenspaces, and natural environments that deliver health benefits as nature-based solutions (NBS, **Box 2**).

Box 2: Nature-based solutions

Nature-based solutions (NBS) are actions inspired and supported by nature to protect, sustainably manage and restore ecosystems to enhance community resilience, address societal challenges, conserve biodiversity, and improve human well-being.

NBS are divided into five main categories:

Restoration: Ecological restoration/engineering, e.g., afforestation

Issue-specific: e.g., Climate change adaptation/ mitigation, disaster risk reduction

Infrastructure: Natural/Green infrastructure, e.g., rain gardens, green roofs

Ecosystem-based management: integrated approaches that account for nature and people e.g. Great Lakes

Ecosystem protection: maintaining greenspaces, e.g., urban and Provincial parks

IUCN (2020). Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS. First edition. Gland, Switzerland: IUCN.

How Are Health Considerations Being Integrated Into Resilient Recovery Efforts?

Substantial investments in natural infrastructure were announced as part of the economic recovery efforts in response to COVID-19 in the 2021-2022 Federal Budget. For cities and local governments across Canada, this marks an opportunity to further invest in NBS to enhance climate resilience while also contributing meaningfully to positive health outcomes. For example, investing in urban parks can improve air quality, sequester carbon, and support stormwater management, while also encouraging residents to adopt healthy active lifestyles. While there is growing interest and attention on the connections between greenspace and healthy environments, health outcomes have not been central to NBS policy conversations, despite established impact pathways. New impact pathways and health co-benefits of NBS are also being discovered -- recent evidence points to the importance of urban nature for mitigating the negative health impacts from social isolation and anxiety linked to COVID-19 physical distancing guidelines.[6]

The lack of health-nature integration at the policy level can be partially explained by the **complexity of existing evidence and the diversity of tools to assess the benefits derived from specific interventions**. As highlighted above, a park may produce multiple benefits, but measuring the possibility of multiple concurrent sources of value is a challenge when tying these findings to decisions that influence investments in local projects:

- Quantifying health impacts with a **level of precision** that can be tied to specific NBS interventions – e.g., the relationship between tree cover and air quality is well established, but how does 10% tree canopy cover compare to 25% in affecting the incidence of respiratory problems for a specific population subgroup?

- Attaching a specific **economic value to health-related cost savings** – e.g., if rates of respiratory disease are reduced in a neighbourhood, how can the economic cost savings be captured, and what are appropriate measurements to account for changes in health outcomes?

The business case for investment at the project scale is complex but modelling collective action suggests the impact of investing in NBS has tremendous health and economic potential. Recent analysis from the Canadian Association of Physicians for the Environment points to the significant health benefits presented by achieving net-zero climate targets by 2050. They estimate the resulting change to CO_2 concentrations and associated improved environmental conditions would lead to over 100,000 avoided deaths, a significant reduction in hospital stays and hospital visits for thousands of Canadians, and an estimated $30-100B in health care cost savings[7]. Applying a health lens to NBS recovery activities can further communicate the potential return on investments to enhance urban nature.

An Opportunity for Collaboration and Innovation

Nature-based approaches are being integrated into local and regional climate strategies, and greenspaces and parks have become a vital aspect of urban planning and "healthy city" strategies to promote mental and physical health. A range of approaches are being developed across Canada to integrate nature and health, but they lack consistency. These approaches are tracking different data and due to differences in public health reporting, how hospitals evaluate patients, and the difficulty in removing non-health costs savings from the equation, they are rarely connected to the real health cost savings of NBS.

There is a need to better understand how the integrated relationships between health, nature, and climate are being addressed across Canada. By examining existing initiatives, we gained insight on how to improve coordination and build local capacity. Through a review of available scientific evidence, an evaluation of data from expert interviews and stakeholder workshops, an analysis of municipal plans, and tools being applied to assess health benefits and outcomes from urban greenspaces, this report seeks to:

- Summarize the evidence linking NBS and health outcomes [Section 1.0]

- Review municipal plans to examine how NBS and health are being assessed in Canada [Section 2.0]
  - examine which metrics are being used
  - highlight data gaps

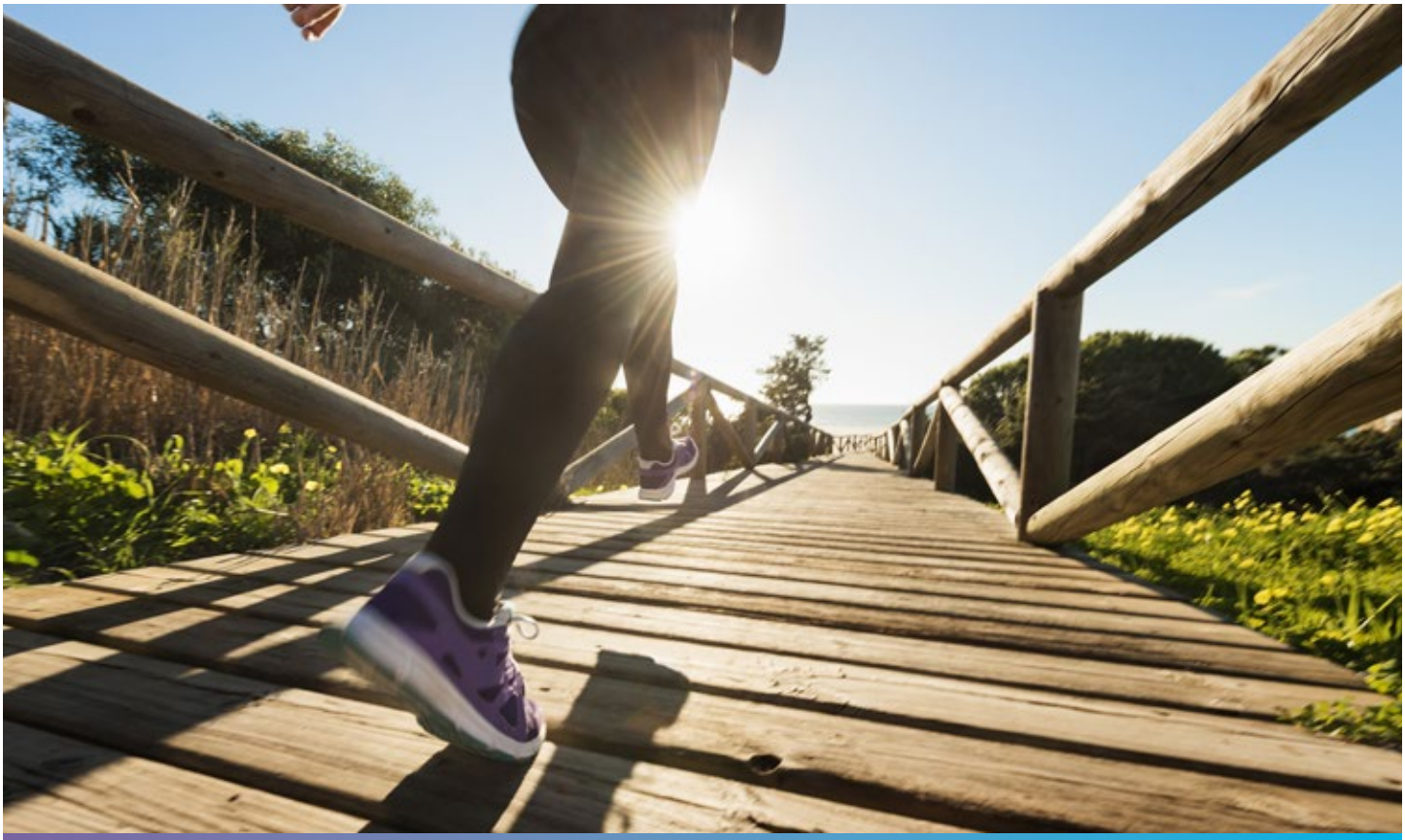
- Identify tools to assess ecosystems and health and how they can support governments and organizations to derive impact data [Section 3.3]

- Examine how health benefits are translated to cost savings and present economic evidence where available, with an emphasis on each being replicable [3.1, 3.2, 3.4]

- Highlight challenges and gaps emerging from the analysis in Sections 1, 2, 3 and SPI's workshop series on NBS and Health [Section 4.0]

- Present policy opportunities and suggest further resources to advance the integration of health data into NBS investments. [Section 5.0]

Canada's urban ecosystems can provide communities with a range of benefits that can be measured in terms of both their monetary value and impact on human health. The purpose of this report is to provide local and regional governments, community-based organizations, and environmental stakeholders with consistent and clear information on how to enhance these benefits using NBS and equip decision-makers with approaches and tools to integrate health considerations when investing nature-based projects and programming.



1. WHAT ARE THE HEALTH BENEFITS OF NATURE?

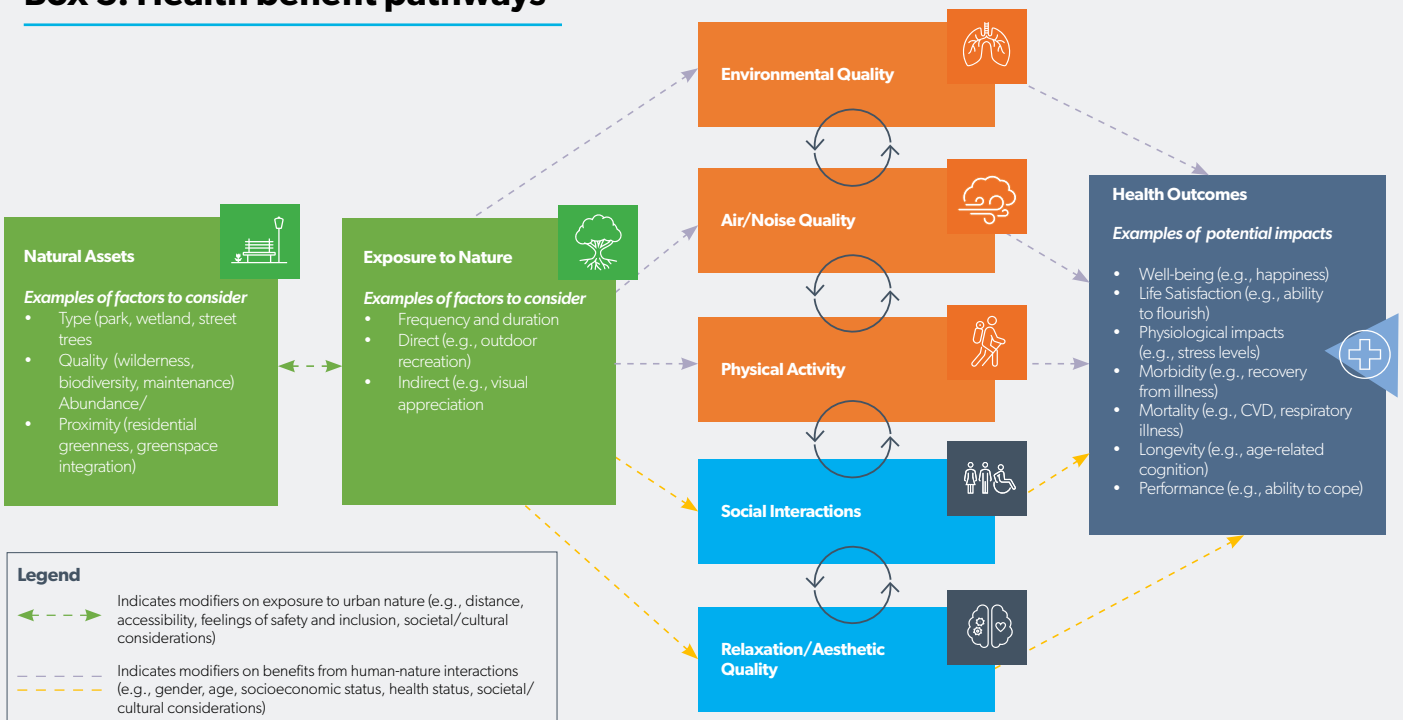
A REVIEW OF EVIDENCE LINKING NATURE TO POSITIVE HEALTH OUTCOMES

This review examines both direct and indirect benefits of natural systems on four health categories: physical health, mental health, social health, and climate and environmental health. It is followed by an examination of the benefit pathways (physical activity, community, environmental exposure and climate change, and relaxation and well-being) linking NBS to measurable health benefits. See **Table 1** for a summary of relationships between urban nature and different health outcomes.

There is a strong correlation between the natural urban environment and positive health outcomes in academic literature; however, determining the causality of different benefit pathways for measuring different health outcomes is less clear. Causal relationships within benefit pathways can operate independently or collectively, and concurrently or in opposition – see **Box 3** for examples.

From the results of our literature review and examination of existing guidelines, the potential health benefits from using NBS have been drawn into four broad categories: **physical health, social health, mental health, and climate and environmental health**. For the purposes of this report, these four categories frame the benefit pathways, which will then guide our discussion around the current municipal policy landscape in Canada, outlined in Section 2. See **Appendix 1** for the guiding principles and methods used for this review.

Box 3: Health benefit pathways



Adapted from Hartig et al., 2014

1.1 Physical Health

The effects of NBS on physical health is one of the most studied co-benefits of enhanced urban greenspaces[8]. With an increase in the number and quality of urban greenspaces, outdoor recreation areas and active transportation routes are widely shown to improve health outcomes by encouraging physical activity and the adoption of healthy active lifestyles[7 9-12]. In Ontario, a study by Paul et al. (2020) estimates that greater exposure to residential greenspace can have a significant protective effect on physical health, reducing the incidence of stroke (4%) and dementia (3%). A further study by Crouse et al. (2017) in several large Canadian cities identified a greater exposure to urban nature as having a similar protective effect on physical health outcomes. This study estimates that greater residential greenness can decrease the mortality risk from both cardiometabolic diseases and respiratory illnesses by between 8-12%, with the strongest protective effect found among adults aged 35-74[13].

Overall, more urban greenspace is shown to reduce the risk of several negative physical health outcomes, including diabetes[14], respiratory illnesses[15], and cardiovascular diseases – including many of the underlying risk factors, such as hypertension, high blood pressure and vascular inflammation[16 17]. Most literature also points to more urban greenspaces reducing the risk of obesity and being overweight[18-20]. However, a study by Prince et al. (2011) in 85 Ottawa neighbourhoods shows the opposite relationship whereby more urban greenspace is linked to greater odds of obesity and lower levels of physical activity. This points to lifestyle choices (e.g., active versus sedentary) as being an important factor – independent from greenspace proximity – when determining the potential health benefits of urban greenspaces from changes in patterns of outdoor physical activity[21 55 59].

Greater exposure to urban greenspace is also shown to reduce the risk of certain negative pregnancy outcomes, including low birth weight[22 23] and being small for gestational age[24 25]. A study in Connecticut by Ebisu et al. (2016) identified an association between a greater density of residential urban vegetation with a 3.2g protective effect on weight by gestational age and a 7% reduced risk of low birth weight. A further study by Jimenez et al. (2020) across the Northeastern U.S. identifies proximity to high density urban vegetation during the perinatal period as having long-term positive impacts on physical health – lowering the risk of developing hypertension and high blood pressure as adults. A study in the Netherlands by Bijnens et al. (2015), similarly suggests that greater exposure to urban greenspace during pregnancy can have a protective effect on placental telomere length, which can slow the progression of many long-term physical health complications, including heart disease, diabetes, osteoporosis, and the risk of developing several types of cancer. Increased exposure to greenspace during pregnancy has also been suggested to reduce the risk of infant mortality[21] and pre-term birth[22]. However, reviews by Twohig-Bennett and Jones (2018) and Akaraci et al. (2020) provide mixed results on the strength of these associations.

1.2 Mental Health

The proximity and abundance of urban greenspaces are also shown to be associated with improvements in mental health outcomes that can result from both active and passive (or existence) use[26-29]. Studies show that greater exposure to urban nature can reduce stress and anxiety[30-32], lower the risk of chronic mood disorders and impulsivity[26 33 34], and provide a significant protective effect on long-term the mental health[35-39].

Several studies from across North America and Europe also show that greater exposure and residential proximity to urban greenspaces can result in fewer psychosocial disorders in children[30 37 40-42] and promotes adopting a more active lifestyle, thereby reducing the long-term risk of poor mental health in both adolescents and adults[27 32 43 44]. These studies also show that increased passive exposure in early childhood can lead to higher levels of self-reported happiness[38], improved emotional coping skills[41], and a greater attachment and use of specific urban greenspaces for both children and their parents[40]. Evidence from across these studies identify urban greenspace features that are important for mental health outcomes across all age groups. Specifically, mental health outcomes are shown to be linked to the density and wilderness of vegetation[24 39 45], the presence of greenspaces to buffer exposures to city pollutants (noise, poor air, and excessive light)[37 46 47], and the presence of amenities to support outdoor recreation and social relaxation, including water features, park benches, and shaded areas[27 29 48 49].

Even though **proximity and abundance** are important metrics when evaluating the potential mental health benefits of urban greenspaces, they are also partial mediators that **provide mixed results when used as standalone measures**[25 27 50]. A study by Astell-Burt et al. (2013) identifies the link between greenspace abundance and proximity with improved mental health as the result of changes in physical activity patterns that help improve overall feelings of well-being. Chang et al. (2020) identify accessibility features and spatial complexity of greenspaces as additional mediating measures that can predict the mental health benefits of specific urban greenspaces via increased physical activity. **In addition to proximity and abundance, alternative measures, such as the frequency and duration of exposure[25 39 51], the spatial orientation and complexity of greenspaces[25 26], and the presence of accessibility features[30 36 48] are identified as important co-mediators when evaluating the potential health benefits of urban nature.**

Alternatively, several studies identify greenspace quality[28 52], vegetation type and density[35 39], feelings of ownership and attachment[53 54], and feelings of security and inclusion[28 55] as crucial mediators when determining potential improvements to mental health outcomes from greater exposure to urban greenspaces. The concept of **subjective greenspace proximity** – defined by self-reported feelings of inclusion, belonging and social support – is widely identified as a strong mediator for evaluating mental health benefits from the direct use of urban greenspaces[36 43 48 56 57]. Collectively, these measures are representative of the restorative aspects of urban greenspaces, and the mental health benefits are shown to better reflect the distribution of these benefits for specific population groups - including women[48], children[58], and seniors [36 59].

1.3 Social Health

Residential proximity to urban greenspace is unequally distributed among Canadians. A recent study by Pinault et al. (2021) identifies low-income households, recent immigrants, people belonging to visible minorities, and individuals in rental accommodations as experiencing significant barriers in accessing urban greenspaces and benefiting from any potential health co-benefits. A similar study by Jennings et al. (2019) corroborates that existing socio-economic and demographic inequalities in North America often overlap with greater deprivation of urban greenspaces. While urban nature and greenspaces in Canada are shown to have a significant positive effect on health and well-being – including a lower incidence of overall mortality – several studies also show that the relationship between urban nature and health outcomes are influenced by persistent socio-economic inequalities[3 60 61]. For example, the ability to access urban greenspaces – in addition to greater residential proximity to these spaces – was found to impact pregnancy outcomes, with access barriers shown to be concentrated among women in low socio-economic neighbourhoods[62-64] and those with lower levels of education[20]. In Canada, household income is positively associated with greater access to urban greenspaces across all ethnocultural groups[3].

Enabling better access to urban greenspaces is important for improving community cohesion and reducing social inequities in public health. Greenspace access is shown to create more inclusive communities by encouraging greater self-esteem, improving psychosocial behaviours and offering therapeutic benefits, promoting cultural dignity, and encouraging active healthy lifestyles[36 47 65-67]. A study by Van Der Jagt et al. (2017) identifies community gardens as an NBS that can improve social health by increasing the availability of outdoor greenspaces for socialization and establishing an emotional connection with natural surroundings. For seniors, Artmann et al. (2017) identify urban greenspaces in several European cities[68] as having a significant positive health impact for residents as well as visitors and staff in senior care facilities. A study in Michigan by Gronlund et al. (2015) illustrates the protective effect of urban greenspaces for reducing the vulnerability of seniors to cardiovascular complications induced by extreme heat – protective effects were shown to be greatest for those living alone. While greenspaces promote social health and well-being, studies in the United States[69] and Australia[16] show that seniors with active lifestyles benefit more from urban greenspaces than their counterparts with sedentary lifestyles.

Among children, urban areas with a low concentration of greenspaces have been associated with poor motor development and obesity[70]. A study by Richardson et al. (2017) in Scotland shows that access to private gardens has a positive impact on child psychosocial development, especially among families with lower levels of education. Schoolyard greening can also have a positive effect on the social health of children by encouraging outdoor play[71]. While availability of urban greenspaces is important, two Canadian studies identified distances from home, the perceived safety of access routes, and perceived park safety as the most significant factors influencing the accessibility and usage of urban greenspaces[40 72]. Greenspaces that promote community cohesion with lower levels of social disorder – feelings of safety and security by both parents and children – are widely shown to positively impact children's physical activity, screen time, and general health[22 38 40 49].

Gender considerations are also important when planning urban greenspaces[50 58 65]. Several studies point to individual feelings of security, attachment and belonging among women as being more important determinants of visitation patterns to outdoor greenspaces than any other geo-physical measurement[48 50 55]. Overall, security and social cohesion are shown to be crucial determinants on the visitation patterns of women, with self-reported feelings of fear, insecurity, and exclusion identified as the most significant barriers to address for encouraging equitable access to urban greenspaces[27 47 73]. Several studies identify gender-based designs, increased safety features and maintenance in urban parks as potential strategies to address the disproportionate barriers experienced by women[17 43 70 74].

1.4 Climate and Environmental Health

Climate change poses a serious threat to cities and towns and increases vulnerability to floods, storm surges and urban heat islands, all of which can directly impact health. Studies have shown a higher probability of injury[75], overall morbidity from both communicable and NCDs[76] and a greater risk of mortality from worsening environmental exposures related to climate change[77-79]. Extreme temperatures significantly increase the risk of developing respiratory illnesses, kidney diseases, and several cardiometabolic diseases[80-81]. The benefits of greenspaces for mitigating these adverse health impacts range from reduced exposure to harmful pollutants[4 82], reducing the severity of temperature extremes[56 67], improving stormwater management[83 84], and reducing the vulnerability of communities to natural disasters[50 73]. A study of urban parks in Milan, Italy by Panno et al. (2017) identified greater tree canopy cover as having a significant protective effect on the adaptive capacity of local communities to cope with extreme temperatures during summer heat waves. A similar study by Graham et al. (2016) in 544 neighbourhoods across Toronto estimates that a marginal increase in tree canopy cover by 1-2% could reduce heat-related ambulance calls by up to 80%. Nowak et al. (2018) estimate that tree canopies in Canadian cities provide up to $227M in annual health care cost savings by reducing exposure to environmental pollutants.

In addition to proximity and abundance, alternative measures, such as the frequency and duration of exposure, the spatial orientation and complexity of greenspaces, and the presence of accessibility features are identified as important co-mediators when evaluating the potential health benefits of urban nature.

Noise pollution and air pollution both pose a serious threat to environmental health. The negative impacts of air pollution are well-documented, with strong associations shown to include an increased risk of respiratory illnesses[56 85-87], cardiovascular diseases[84 88], and higher mortality rates[89-91]. Additional health impacts with moderate associations with air pollution include negative perinatal outcomes[22 92 93], as well as psychosocial disorders and cognitive impairment[37 64 94]. Emerging studies have also identified that greater exposure to noise pollution – independently from other environmental factors – can produce similar health impacts, including an increased risk of cardiovascular disease, hypertension, high blood pressure[95]; impulsive decision-making and cognitive impairment[96]; stress, anxiety, and sleep deprivation[97-99], and negative pregnancy outcomes, including low birth weight and small for gestational age[100]. Poor environmental health resulting from increased exposure to air and noise pollution has been shown to negate most of the positive health benefits of outdoor recreation in nature[22 85 101].

Emerging evidence also suggests that urban greenspaces and NBS can reduce the epidemiological burden of disease in urban environments by improving overall well-being to enhance health resilience[50] and reduce transmission vectors of communicable diseases[102-104]. A recent study by Zhang et al. (2020) points to urban temperatures, humidity, and air pollution as directly impacting the dilution rate of viral aerosols. The study shows that air pollution ($PM_{2.5}$), reduced natural air circulation, and warmer temperatures are strongly correlated with an increased life span of infectious viral aerosols. A further study by Kaufmann (2016), also indicates that the primary vectors of transmission during the emergence of West Nile Virus (WNV) in North America in the early 2000s were influenced by the urban environment - most cases of WNV were found in disturbed wetlands and urban areas with minimal greenspace. Together, these factors suggest that NBS can reduce the spread of communicable diseases under specific circumstances and, according to Johnson et al. (2020), may be able to limit the growing risk of increasing viral richness emerging in high density urban areas.

Table 1: Summary of relationships between urban nature and different health outcomes

Health category	Health outcomes	Strength of relationship
Physiological	Cardiovascular disease	Strong
	Obesity/Overweight	Moderate (Mixed)
	Type II Diabetes	Moderate
	Hypertension, High blood pressure, Vascular Inflammation	Strong
	Respiratory Illnesses (non-infectious)	Strong
Pregnancy Outcomes	Small for gestational age	Moderate
	Low birth weight	Moderate
	Telomere Shortening/ Placental Ageing	Emerging
	Infant mortality, Pre-term birth	Mixed
Psychological	Stress and anxiety	Strong
	Mood disorders	Strong
	Impulsivity, attention disorders, emotional coping skills	Moderate
	Life satisfaction/Self-reported happiness	Strong
Social & Community	Community cohesion, feelings of inclusion & belonging	Strong
	Cultural dignity	Emerging
	Improved socialization	Strong
	Health equity	Emerging
	Gender equity	Mixed
	Feelings of safety/security	Moderate
Climate & Environmental	Disaster-related injury/stress	Strong
	Heat stress/Urban Heat Island	Strong
	Communicable diseases/viral transmission	Emerging
	Sleep deprivation	Moderate

Note: the summary of relationships represented in this table does not represent a systematic review of available literature and therefore does not represent an exhaustive and comprehensive overview of pathways and potential pathways. The strength of the relationships identified in this table is based on a combination of the total number of studies and available systematic reviews for each relationship. These indications should not be taken to represent statistical significance, strength of correlation between specific variables, or to imply causation.

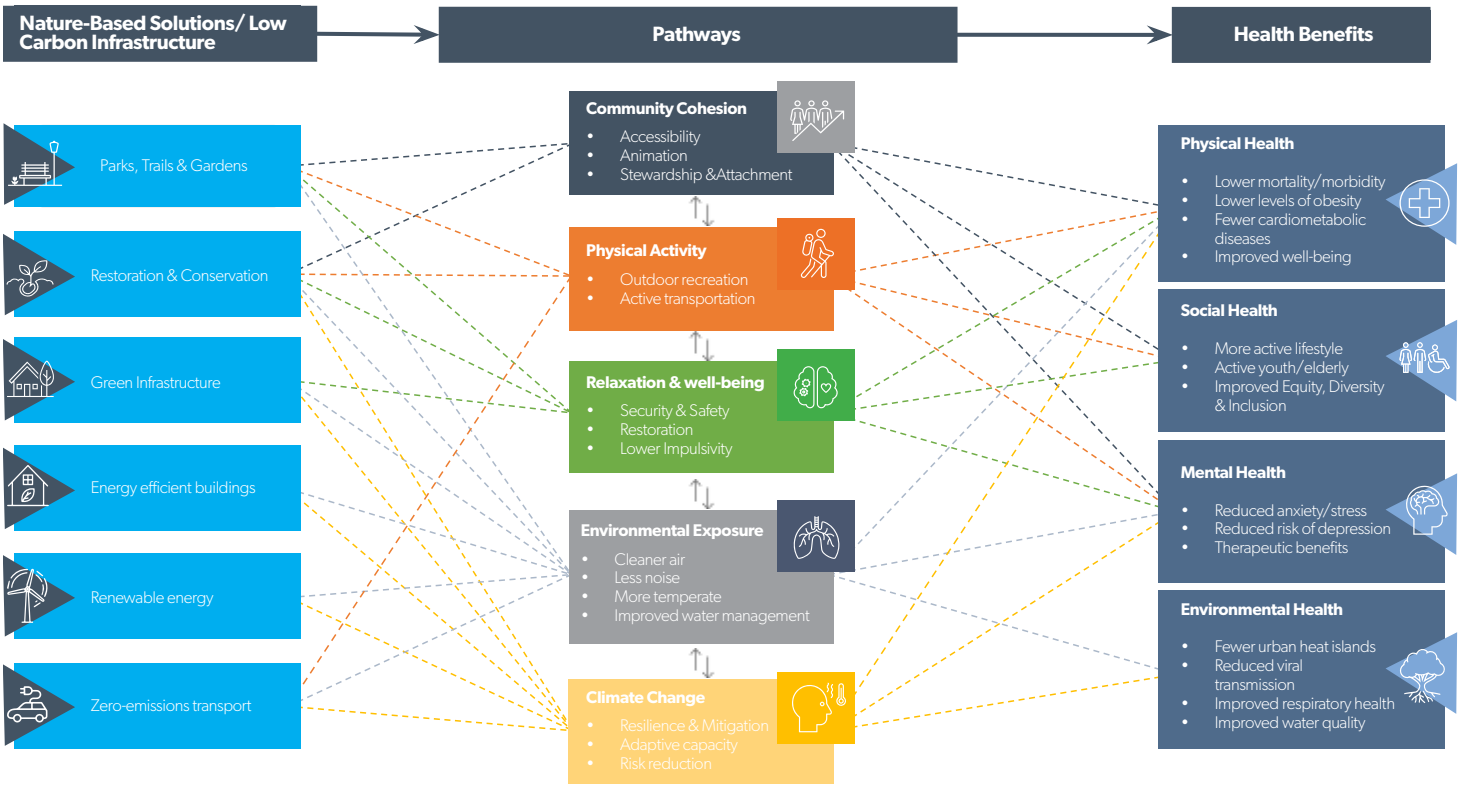
1.5 Benefit Pathways Linking Health Impacts to Nature-based Solutions

Benefit pathways connect NBS projects to specific health benefits. At the project level, the key to capturing health co-benefits from NBS is understanding that multiple benefit pathways are typically responsible for determining different health outcomes. Each pathway can have multiple health outcomes that can be mutually reinforcing, mutually limiting or inversely related. For example, when referring to **Figure 2**, a city park presents a physical space that directly contributes to health outcomes by providing opportunities for **physical activity.** It can also promote **relaxation and improved mental well-being** with time spent there reducing the stress of everyday life, and it can generate greater **community cohesion** and associated social health benefits. A city park can also reduce **exposure to environmental contaminants** and **limit the impacts of climate change,** which can influence health outcomes over both the short- and long-term. **Appendix 2** contains further details on each of the identified benefit pathways and elaborates on the available evidence supporting the connection between urban nature and human health.

The abundance of available evidence demonstrates that there are various ways urban greenspaces can contribute to positive health outcomes in Canada. The identification of multiple pathways, which are often mutually reinforcing when producing health co-benefits, illustrates the myriad of potential positive health impacts from investing in NBS to encourage healthier lifestyles in Canadian cities.

In the following section, we explore how the implications of these studies are translating into investment and practice on the ground, in the context of practical strategies being developed by local governments and municipalities across Canada.

Figure 2: Overview of pathways connecting nature-based solutions to health benefits



Note: the arrows between benefit pathways represent the potential for their mutual interaction in framing the possible health co-benefits from NBS. These interactions can be positive, negative, reinforcing, conflicting, and are important areas of consideration that should be highlighted in any future framework to support project level decision-making. Socio-demographic factors, such as age, gender, and culture, as well as self-reported influences of security, inclusion, community belonging and attachment to natural assets, are not directly represented in this figure. Their influence is instead represented by the dotted lines to indicate both 1) their power in influencing the links between NBS, benefit pathways and health co-benefits at every project stage and 2) the need to better map these influences in developing a comprehensive decision-making framework.

2. UNDERSTANDING THE CANADIAN CONTEXT:

HOW HEALTH CONSIDERATIONS ARE BEING INTEGRATED IN LOCAL AND REGIONAL PLANNING

Despite the strong evidence outlined in Section 1, demonstrating the health benefits of using NBS to enhance urban ecosystems, integrating health considerations at the project level continues to be a challenge in Canada. The limited capacity of public agencies and local governments to quantify health benefits when evaluating the merits and impact of using NBS remains a key issue – a sentiment that was echoed in the preamble to the Public Health Agency of Canada's Designing Healthy Living Report (2017, p 8.): **"we do not yet know how to quantify the extent to which the built environment affects healthy living[105]".**

Most municipalities continue to consider health co-benefits as a "bonus" to primary project objectives.

Figure 3: Municipal plans reviewed

To better understand how health impacts of NBS are being tracked in different jurisdictions across Canada, SPI reviewed the strategic plans of 26 Canadian municipalities (See **Figure 3** – For a detailed list see **Appendix 4**). The purpose of our national scan was to determine whether the health impacts of NBS are being evaluated at the project level, and if so, what types of strategies local governments are using to integrate these considerations in project-level decision-making. Plans were selected based on:

1. Whether they explicitly mention a **link between the natural environment and human health**;
2. If they use **specific health indicators**, and;
3. Ensuring a relatively **equitable geographic distribution** to capture local and regional differences.

Our review provides insights into:

- **How local governments are using NBS to improve community health outcomes**;
- **The diversity of structures and strategies being used** to promote collaboration across departments and reinforce local capacity to build healthier communities using NBS and;
- **What types of stakeholders are responsible for driving the NBS-health conversations** in different jurisdictions?

Plans are classified into four overarching categories: Urban Forestry, Parks and Greenspace Master Plans, Climate Resilience, and Healthy Cities. Each of these categories highlights different dimensions of health and may contain multiple plan sub-types that were aggregated into one of the four overarching categories to facilitate comparison and analysis. For example, municipal master plans are placed under the Parks and Greenspace Master Plans category based on similarities in structure, types of NBS being implemented, and their existing integration with secondary plans focusing on parks and green infrastructure. Similarly, community sustainability plans are aggregated under the Healthy Cities category. See **Appendix 4** for a full list of plan subtype placements.

The following section outlines key attributes for each of the four overarching categories, the different tools used during project planning and evaluation, which types of tools are most applicable for specific types of NBS, and how community engagement and consultation are being integrated. **Table 2** provides a breakdown of findings by plan type, including the types of economic valuation methods and instruments used to quantify the benefits of urban nature.

2.1 Urban Forestry

Urban forestry plans are designed to facilitate the sustainable management of city forests, street trees and other tree-based natural infrastructure, including trees located in parks, riparian zones and on public and private land. These plans typically involve the development of natural asset inventories to catalogue forestry resources based on different species, foliage types, maintenance costs, and the specific location and life cycle of individual trees. They use diverse technical strategies to evaluate the percent of canopy coverage, overall tree health, the local use of forest resources, and the impact of these parameters on community well-being.

Tools

Among the plans reviewed, urban forestry plans used the most technologically sophisticated tools for projects measuring NBS. All urban forestry plans included natural asset inventories, ranging from lists of urban tree species to comprehensive maps using geospatial imagery to detail the location and type of individual trees. Planning and evaluation tools using satellite imagery to track total canopy cover were also ubiquitous among urban forestry plans, although capacity and cost barriers limited smaller municipalities' ability to access and use current datasets.

Sustainable forest management models and existing best practices are widely used – e.g., the FORMOD[106] framework, ANSI[107] Standard A300, ISA TRAQ[108] methodology, and tree inventories that include species, age, and health. The models and practices were observed to be well integrated into the design and evaluation of the plans we reviewed, which suggests a high level of horizontal knowledge transfer among municipal decision-makers. In addition, many of these strategies indicated support from inter-municipal working groups and urban forest management committees, including the Waterloo Region Shade Working Group, the Peel Region Urban Forest Working Group, and the *Société de verdissement du Montreal métropolitain* (Soverdi).

Urban forest plans were also accompanied by local bylaws and regulatory instruments to enforce the long-term protection of urban trees as natural assets – including protection from construction activities and urban development. Each of the reviewed plans also included detailed strategies for replacing urban trees – either those damaged or those at the end of their lifecycles – with many local governments encouraging citizen participation in this process. Despite the commonality of strategies for the protection and replacement of urban trees, the details of local bylaws and regulatory instruments varied across different jurisdictions – e.g., physical barriers required to protect trees during construction can differ based on a combination of the type of encroachment activity (adjacent construction, site access pathway, etc.), trunk diameter, canopy size, and an assessment of overall tree health. The development of local bylaws and regulations were largely drawn from a combination of the ANSI guidelines for arboriculture and the ISA standards for best practices, with practical experience shared between different local governments. A compendium of Canadian best practices for urban forest management drawn from the experience of different local governments is available from Tree Canada to support local decision-makers – see Section 3.3.2 for more details.

Health Impacts and Metrics

Urban forestry plans focused on the following health impacts, listed in order of their frequency of appearance:

- Improving social and community health by fostering greater feelings of inclusion and belonging reducing mental stress and anxiety;
- Mitigating poor air quality and the associated adverse impacts;
- Reducing the urban heat island effect.

Despite their focus on certain health impacts, urban forestry plans did not include direct evaluation metrics related to health. Instead, they used indirect measurements - including the abundance and proximity of greenspace, fixed targets of overall tree canopy cover and the dollar value of air pollutants removed. The plans referred to academic literature to link each of these measurements to additional health co-benefits, including improved well-being from greater feelings of inclusion and security, a lower risk of stress and anxiety, and a reduced risk of cardiovascular disease and respiratory illnesses.

The direct measurement of benefits was limited to the timescale comparisons of changes in the urban tree canopy, linked to additional measurements that include:

1. Changes in adjacent property values (hedonic pricing, see **Table 3**);
2. The total number of trees planted in conservation areas;
3. The total per-tree return on investment through a combination of market-based methods for valuing natural infrastructure, such as the value of carbon sequestered, the value of air pollutants removed and cost savings from increased energy efficiency.

The City of Edmonton used a combination of the Street Tree Resource Assessment Tool for Urban forest Managers (STRATUM) and the Urban Forests Effect Model (UFORE) – now collectively known as the i-Tree suite – to calculate the total dollar value of individual trees based on the maintenance costs and pollution sequestration capabilities of different species. The results of the evaluation are published in the OpenTreeMap platform (See Section 3.3.2), along with a complete city-wide asset inventory, showing an approximate benefit of $66.44 per tree. The City

of Edmonton then indirectly linked the market value of these trees to implied health benefits including reduced mental stress, improved quality of life and a lower risk of morbidity from chronic illness, however, the value of these benefits were not directly quantified under this evaluation.

The Village of Cumberland, in British Columbia, adopted a similar strategy, although cost and capacity limitations were noted as significant barriers to implementation. In general, we found that the use of sophisticated evaluation tools to link urban tree health benefits to market valuations is mostly limited to larger municipalities.

Community Engagement

Urban forest plans used different methods for community engagement and implemented them at different phases of the project.

- **Most have limited community engagement during planning and development phases.** For example, the Soverdi urban forestry plan for the Greater Montreal Area did not include community engagement in its initial design phase but identified it as a priority for implementation.

- **A few integrate community engagement throughout the project.** For example, both the City of Kitchener and the Village of Cumberland actively encourage citizen participation during design and implementation phases using surveys, towns halls and workshops, consultations with NGOs and private stakeholders, and community tree walks.

Overall, we found an inverse relationship between the sophistication of tools used for project planning and the integration of community engagement over the course of the project lifecycle. Smaller municipalities with limited staff and access to current data tended to rely on long-term community engagement and participation in project implementation, while larger municipalities tended to rely on complex project design and implementation tools.

Despite these noted variations, urban forestry plans were found overall to be more technically sophisticated and tended to rely more on technical tools, rather than community engagement, when determining the impact of specific projects on community well-being.

2.2 Parks and Greenspace Master Plans

Parks and greenspace master plans focus on a wider range of urban natural infrastructure, including curated parks, wildlife conservation areas, trail networks and other integrated urban vegetation features. These plans are primarily developed to assess the existing needs of communities for greenspaces and outdoor recreation areas and to predict future needs. These plans focus on developing physical natural infrastructure to address the social needs of different socio-economic and demographic groups, including ensuring accessibility for underserved neighbourhoods and people living with disabilities.

Tools

Parks and greenspace master plans also use relatively sophisticated tools for project planning and development, including asset inventories, spatial analysis tools (both GIS and land-use databases) and guidelines based on equity, diversity, and inclusion.

However, in contrast to urban forestry plans, capacity limitations were shown to cause a much greater disparity in the sophistication of project tools – this disparity was observed to be broadly correlated with variations in municipal size. Overall, smaller municipalities tended to use less technologically sophisticated tools to connect health benefits to greenspace planning, including literature reviews and basic asset inventories that rely on manual accounting. In contrast, larger municipalities tended to use more complex tools, combining socio-demographic data and digital mapping of the geo-physical characteristics of urban greenspaces.

Common project implementation and evaluation metrics included:

- Total per capita number of parks and outdoor recreation spaces;

- Residential proximity of greenspaces (or "walkability");

- Total abundance of greenspace;

- Type of vegetation cover (urban forests, wildlife conservation areas, recreational parks, etc.);

- The level of community engagement with local greenspace, tracked by the total number of visitors, participation rates in park programs, and the number of community groups actively engaged in park stewardship initiatives.

In most cases, use of these metrics did not vary based on municipality size or region, aside from the definition of walkability, which was more stringent in larger municipalities. In these plans the definition of a walkable urban greenspace ranged from 400m to more than 2.5km.

Health Metrics and Impacts

Parks and greenspace master plans focused on the following health impacts, listed in order of their frequency of appearance:

- Reducing the risk and morbidity of NCDs by providing more opportunities for physical activity and promoting active lifestyles;
- Improving social and community health by fostering greater feelings of inclusion and belonging;
- Improving mental health through a combination of physical activity and socialization.

Again, **plans do not use direct evaluation metrics** related to health. Instead, they use **indirect measurements** such as:

- The percentage of total park space coverage (abundance) and the number of walkable parks (proximity), linking these to health co-benefits identified in academic literature (i.e., lower risks of cardiometabolic diseases, obesity, and respiratory illnesses;
- Lower levels of stress and anxiety in those exposed;
- Improved community belonging through healthy habits and overall well-being.

All plans evaluated **greenspace quality**, treating it as an important metric to measure the impact of municipal park spaces on community well-being. Methods to measure greenspace quality included:

- Establishing guidelines for park reinvestment based on growing community needs;
- Establishing schedules and minimum maintenance standards for specific greenspace features and amenities;
- Evaluating development priorities based on the equitable access of high-quality greenspaces.

A Note on Equity and Inclusion

Each plan emphasized accessibility and equity of access, but only two included methods to evaluate the equity of greenspace access:

- The City of Whitehorse used continuous community engagement to promote the access of marginal populations to outdoor recreation spaces, tracking equity of access through program participation and encouraging community stewardship of outdoor leisure and physical activity programs.
- The City of Toronto developed a heat map of underserved neighbourhoods to guide future park development. The heat map was developed with extensive community engagement and the use of socio-economic, demographic, and geo-physical data. Equity of access to high quality greenspaces was based on a combination of the percent change in greenspace coverage, the number of people served by a particular greenspace (<500m catchment range), and the total amount of greenspace investment in underserved areas. The City also identified community groups, participation in park stewardship programs and individual feedback to ensure continued equitable access but did not include implementation provisions for these elements.

Smaller municipalities appear to lack the capacity to use sophisticated tools to design park based NBS projects. Yet small municipalities also exhibited more horizontal knowledge transfer and integration of best practice guidelines. In contrast, larger municipalities developed and used more sophisticated project planning tools, but also relied more on external experts and consulting firms when measuring the proximity, quality, and equity of access to urban parks and greenspaces.

Municipalities are conducting extensive community engagement in the planning and development phases, but they are struggling to maintain community engagement during project implementation.

2.3 Climate Resilience

We included climate resilience plans for the Cities of Montreal and Calgary in our national scan since both plans draw an explicit link between human health and the urban natural environment. Although these plans focused on specific regional interests – urban heat island effect in Montreal and stormwater management in Calgary – both share an understanding that climate change, natural infrastructure, and human health is related to regulating services provided by urban ecosystems. These services included cleaner air, better stormwater management, improved carbon sequestration, and temperature regulation, in addition to conserving biodiversity and promoting overall ecological functioning.

Tools

The plans often use the following project planning tools:

- Integration of best practices and lessons learned from other cities across North American and Europe;
- Development of Natural Asset Inventories;
- Enhancing the capacity of municipal staff to lead the ecological-health transition, including the creation the Chief Resilience Officer position in the City of Calgary and the *Bureau de la transition écologique et de la résilience* in the City of Montreal (Montreal is further along in integrating environmental impacts on human health into project planning and design).

Health Impacts and Metrics

The main health impacts targeted in the plans were:

- Reducing exposure to environmental pollutants (air pollution, noise pollution, flood waters);
- Reducing the impacts of climate change (health impacts related to heat/cold stress and natural disasters).

Although the plans mentioned support for physical health and mental well-being, neither mentioned direct health outcomes such as a reduction in cardiovascular disease, obesity, stress, or anxiety. This may suggest that municipalities continue to see health outcomes as secondary objectives when using NBS to tackle climate change. For example, the City of Montreal measured the health benefits of using NBS through their progress toward achieving a target for protected areas (10%), the number of trees planted (500,000), and CO_2 emission reductions (55% below levels in 1990). The City also suggested that changes in surface albedo and the number of zones affected by the urban heat island effect could measure the vulnerability of various sub-populations to the impacts of climate change. Both metrics are indirect measures of the health impacts of using NBS, although there may be an opportunity to tie these metrics to local environmental health data that is currently being collected across Quebec – details of these connections may become available in future annual reports.

Community Engagement

Both the City of Montreal and the City of Calgary included provisions for community engagement in their respective climate resilience strategies. Since each strategy is at a different stage of development, the timing and methods for community engagement between the two plans varied.

With Montreal's plan entering the implementation phase, community engagement is focused on improving local participation of community groups and various population subgroups, including:

- Improving the participation of seniors/youth in community greening programs;
- Improving access to nutritious foods with the development of community gardens;
- Providing outdoor spaces to promote socialization and community cohesion;
- Implementing a unique pilot project to develop community resilience hubs that encourage local communities to develop their own strategies to improve the resilience of urban greenspaces. Building a network of local resilience hubs is meant to facilitate cross-community collaboration and identify best practices.

In contrast, the climate resilience strategy in the City of Calgary is in the planning and design phase. As a result, community engagement is geared more toward expert consultation and the integration of local priorities for the final strategy. The strategies used include:

- Identifying priorities and challenges using community workshops;
- Soliciting community feedback and expert input on a draft strategy ;
- Running focus groups to pilot certain aspects of the strategy.

2.4 Healthy Cities

Healthy city plans were found to take a more holistic approach to promoting community health and well-being. These types of plans included programs specifically designed to support marginal population groups and address the underlying social determinants of health. Programs to promote health using NBS in these plans included increasing the accessibility and availability of greenspaces for outdoor recreation and socialization and making these spaces more inclusive through social programming and animation.

Tools

Of all the types of plans, healthy city plans varied the most in terms of the types of tools used to monitor and evaluate how NBS can improve community health. The tools included natural asset inventories, healthy living data points drawn from extensive public consultations, and integrating guidelines based on equity, diversity, and inclusion in urban planning.

Tool selection depended on municipal size:

- Larger communities, such as Vancouver, used complex tools to integrate health considerations.
  - They have more staff capacity, allowing them to convene coalitions of specialized stakeholders for project steering committees and collect local socio-economic, demographic and health data

- Smaller communities, such as Charlottetown, face barriers integrating health considerations.
  - They tend to use literature reviews, basic asset inventories, and rely heavily on input from regional health authorities
  - While they lack capacity to collect local data, some compensate by engaging local community groups in monitoring and evaluation

Health Impact and Metrics

Healthy city plans focused on the following health impacts, listed in order of their frequency of appearance:

- Reducing the risk and morbidity of NCDs by providing more opportunities for physical activity and promoting active lifestyles;

- Improving social and community health by fostering greater feelings of inclusion and belonging among seniors and youth;

- Improving the mental and physical health of marginal population groups by mainstreaming the principles of equity, diversity, and inclusion in the design and management of urban greenspaces to promote the equitable use of these spaces for outdoor physical activity and socialization. Healthy city plans identified a strong social link between urban greenspaces and cultural dignity for many population subgroups, including those rooted in the principles of reconciliation for Indigenous peoples.

Only one plan used direct evaluation metrics to measure the health impact of using NBS: Vancouver's Healthy City Strategy 2015-2018. The plan sets a strategic goal of promoting active living and healthy lifestyles through access to urban nature and greenspaces. It measures success based on tree canopy cover, Park Board OneCard usage, the number of residents meeting the Canadian Physical Activity Guidelines, and the total percentage of the city population living less than 400 meters from urban greenspaces suitable for outdoor recreation. Combining greenspace proximity and specific usage patterns allows decision-makers to quantify the health benefits of investing in urban greenspaces for outdoor recreation, which include:

- Improvements to physical health from a lower risk of death, cardiometabolic diseases, obesity, and a reduction in the long-term incidence of functional decline from poor physical fitness;

- Improvements to mental health resulting from the preventative effect of physical activity in lowering the risk of stress, anxiety, depression, and long-term cognitive decline;

- Improvements to social health by promoting active healthy lifestyles that improve the overall quality of life and reconnect individuals to the natural environment.

Vancouver's plan also includes indirect evaluation metrics for equity, diversity, and inclusion, informed by extensive community engagement and local data collection. It sets two strategic goals – Being and Feeling Safe and Included, and Environments to Thrive In – and tracks progress based on metrics for individual belonging (pop%), sense of safety (pop%) and neighbourhood walk scores. These metrics capture the distribution of the health benefits of NBS projects among different population subgroups.

None of the other healthy city plans used direct evaluation metrics to measure the health impacts of using NBS. In fact, healthy city plans were the most heterogeneous in terms of the level of integration of health co-benefits into decision-making on NBS projects. Larger municipalities primarily use indirect metrics – including the abundance and proximity of greenspace, fixed targets of overall tree canopy cover and air pollutants removed. Meanwhile, smaller municipalities acknowledge the importance of measuring health benefits but also acknowledge capacity limitations in taking these measurements. Instead, they adopted two broad strategies:

1. Many small municipalities evaluate health benefits based on the conceptual links of specific types of NBS to health impacts identified in academic literature – e.g., a higher abundance of greenspaces equates to lower community risks of obesity.

2. Two small municipalities evaluated health benefits through engagement with community groups and service delivery partnerships with local health-based NGOs.

Community Engagement

Healthy city plans tend to integrate community engagement and public consultation into project planning and design. In developing these plans municipalities use diverse public consultation strategies, including:

- Hosting town halls;
- Local workshops;
- Online surveys to collect local data;
- Soliciting input from expert stakeholder groups, including health-based NGOs, public health authorities and local community development organizations.

Community engagement strategies are dependent on municipal size:

- Larger municipalities gathered more community engagement data. For example, the City of Vancouver collected over 1,200 local data points from community engagement and used them to design and evaluate projects.
- Smaller municipalities used community engagement to directly guide program implementation rather than develop extensive local datasets.
  - The City of Charlottetown noted a limited capacity to monitor and evaluate implementation, and instead used micro-grants distributed through community engagement to replace traditional monitoring and evaluation. This increased local participation and engagement and encouraged the development of micro-level programs.
  - The City of Kelowna gave funding to community organizations to help design municipal programs to support the health of marginal populations.

Healthy city plans identified a strong social link between urban greenspaces and cultural dignity for many population subgroups, including those rooted in the principles of reconciliation for Indigenous peoples.

Table 2: Summary of findings from our national scan of city plans

Plan type	Urban forestry	Parks and GS master plans	Climate resilience	Healthy city
Benefit pathway	**Environmental exposure & climate change**	**Physical activity; relaxation & well-being**	**Environmental exposure & climate change**	**Physical activity; community cohesion**
Strengths	**High visibility; politically popular** • Project tools and modeling instruments are sophisticated and widely available; • Sustainable urban forest management and best practices are established and accessible • Valuation metrics are well-established – i.e., cost of trees; value of GHG removed	• Design guidelines and best practices are well-established and widely available • Support is available from national and international stakeholder networks • Principles around EDI are becoming more common in local project planning • Community consultation is well-integrated in planning	**High visibility; politically popular** • Inherent understanding of the nature-climate-health nexus • Support is readily available for building climate resilience. Funding and institutional mechanisms are clear and well-established. Extensive stakeholder networks are available for support	• Holistic approach to environmental health well-integrated across each strategy. • Strong focus on equity and inclusion for outdoor recreation and social/ cultural activities in greenspaces • Good integration of different determinants of public health, including social, economic and environmental
Limitations	• Highly technical modeling; limited chance for community engagement in the planning/design phase • Project tools may be cost prohibitive	**Less politically visible** • Local capacity can limit the design and evaluation of NBS-health projects; • Overemphasis on physical activity	• Emphasis on climate resilience can cause health to become a secondary objective • Evaluation metrics are more focused on GHG emissions, temperatures and avoided costs	**Less politically visible** • Funding and institutional mechanisms are less clear. • Stakeholder networks are relatively new and involve actors not typically present at the local level
Project planning tools	• Asset inventories; satellite imaging; FORMOD; i-Tree; Open Tree Map	• Asset inventories; satellite imaging; land use databases; EDI guidelines; Greenspace catchment model; Demographic/ usage studies;	• Asset inventories; best practices; benchmarking studies; building staff capacity	• Asset inventories; Local datasets; Land use database; Canopy studies
Health Impacts	• Greater inclusion & belonging • Reduced mental stress • Improved air quality • Reduced UHI effect	• Promote active lifestyles • Greater inclusion &belonging • Promote mental health	• Reducing exposure to pollutants • Mitigating and adapting to climate change • Disaster risk reduction	• Promoting physical activity • Active and healthy lifestyles • Greater inclusion & belonging • Greater equity & diversity
Health Metrics	• Abundance of greenspaces • Proximity to greenspaces • Tree/canopy targets	• Abundance of greenspace • Proximity to greenspace • Visitation patterns • Tree/Canopy/GHG targets • Youth/Senior participation • Maintenance targets (quality)	• Abundance of greenspace • Trees planted (#) • Fewer UHI zones (#) • Protected areas (%) • GHG emissions (%) • EV ownership (%)	**150min of PA (#)** • Canopy cover (%) • AT Trips (#) • Belonging and Safety (%) • Protected areas (#) • GHG emissions (%) • Walkability (20 min)
Valuation Metrics	**Hedonic pricing –** change in property values **Market pricing –** pollutants removed; energy efficiency	**Human capital costs –** costs of inactivity **Eudaemonic well-being –** promotion of outdoor space for cultural dignity **Life Satisfaction –** active lifestyle **Market pricing –** investment per resident; access revenues generation; land value; **Avoided Costs –** avoided health care costs **Hedonic pricing –** change in property values **Contingent valuation –** willingness to pay (access; community gardens	**Market pricing –** Energy cost savings (Montreal); Flood damage mitigation (Calgary) **Life satisfaction –** quality of life improvements (Montreal)	**Market pricing –** Carbon tax revenues **Hedonic pricing** – change in property value **Eudaemonic well-being –** cultural dignity; ability to flourish **Avoided Costs –** avoided health care costs **Life Satisfaction –** feelings of safety, inclusion; quality of life
Community Engagement	**Mixed;** community engagement was mostly linked to project planning and implementation. The majority used community engagement as part of their implementation strategy	**High;** strategies are diverse and applied throughout project life cycle; Limited variation with community size **Unique strategies of noted:** • Children's voice drawings • Live dashboard reporting • Adopt-a-park programs • Pop-up collaboration with local businesses •Guided tours	**Mixed; phase dependent strategies** Montreal – Community Resilience Hub to support implementation and cross- community collaboration Calgary – Workshop, stakeholder input and expert focus groups to support strategy design	**High;** but strategies and scope dependent on municipal size. Large cities can mobilize local data collection; small cities leverage their community relationships to support implementation

2.5 Key Takeaways

Integration of Health Considerations

Municipalities across the country understand the link between human health and the natural environment.

- They largely recognize the benefits of nature-based solutions for urban ecosystems and community health.
- There was some regional variation in targets and priorities, and several smaller municipalities noted that capacity constraints limited their ability to implement NBS and realize the benefits.

Municipalities have **relatively low capacity** to integrate health considerations into NBS projects.

- Smaller municipalities directly note this lack of capacity as a significant limitation in local planning.
- Larger municipalities rely on external consultants and NGOs during project planning and evaluation. Despite the cities of Montreal, Toronto, Calgary, and Vancouver indicating active efforts to develop local capacity, these initiatives are still in the early stages and face questions around the sustainability of funding.
- **Most municipalities continue to consider health co-benefits as a "bonus" to primary project objectives.** Typically, this removes the incentive for local governments to quantify and measure health co-benefits as they are considered peripheral to primary project objectives, existing outside the scope of evaluating successful project implementation.

Engagement

Municipalities are **focusing on community engagement** during project planning and development.

- Municipalities are conducting extensive community engagement in the planning and development phases, but they are **struggling to maintain community engagement during project implementation**: only five out of twenty-six plans did so. Interestingly, those five were able to do so at low cost, suggesting cost is not a limiting factor.

Equity

Municipalities are considering **inclusion and the equitable distribution of benefits** in their plans.

- The sophistication of the tools and strategies used to mainstream these considerations varied significantly based on region and municipal size.
- Consideration of **cultural dignity and psychosocial belonging** in municipal plans connecting urban greenspaces and social health is largely **limited to Western and Northern Canada**. These considerations could be particularly important for Indigenous Reconciliation and social health of marginalized populations across the country.

Metrics

Municipalities **are using tools like community "walkability" assessments, geospatial imaging and measuring the proximity of residential greenspaces** to integrate health considerations in NBS planning.

- Some smaller municipalities lack the capacity to implement these kinds of tools and assessments.

- There is a **lack of common standards** for use of these tools (for example, definitions of walkability range from 5 to 30 minutes of proximity from 400m to 2.5km). This makes comparisons across jurisdictions more difficult.

Municipalities are **most commonly measuring residential proximity and the total abundance of greenspace** in municipal planning to l**ink the natural urban environment to positive health impacts**.

- These impacts range from improvements in cardiovascular health and climate resilience, to lower levels of mental stress and exposure to harmful environmental pollutants.

- Greenspaces also support greater community cohesion, fostering more inclusive outdoor spaces and stimulating a sense of belonging, which many Canadian municipalities have routinely identified as fundamental for improving the long-term health and well-being of their local communities.

Apart from the City of Vancouver's healthy action plan, most municipalities are **not measuring the direct impacts of NBS on human health.**

- The City of Vancouver uses greenspace abundance and park visitation frequency to assess a change in the percentage of the population meeting the Canadian physical activity guidelines to indicate changes in physical health.

- Other municipalities could adopt this metric when using NBS to support physical health by encouraging recreation and active healthy lifestyles.

3. WHAT IS THE VALUE OF 'GOOD HEALTH'?

STRATEGIES FOR QUANTIFYING THE HEALTH BENEFITS OF NATURE-BASED PROJECTS

Decision-makers face many challenges when selecting economic valuation methodologies that can capture the value of changes in both health outcomes and urban nature. Differences in the project lead (e.g., Parks and Recreation vs. Transportation), goals and objectives, and the metrics established during the design phase can influence the selection of different economic valuation methodologies, producing a diversity of approaches for making a business case for using NBS. Choosing the correct valuation methodology is particularly difficult in the Canadian context due to the low number of case studies available to support decision-makers in connecting different value streams at the project level. **This challenge is further exacerbated by a lack of guidelines and standards to support decision-makers in selecting the appropriate valuation methods when designing different types of NBS projects.**

Health and environmental goods are similar in that they are generally understood to have intrinsic non-market value, however, the value end points for health benefits are more subjective and highly variable.

To better support local decision-makers, this section provides an overview of the most common economic valuation mechanisms and how they are being used to assess the physical, mental, social and climate and environmental health benefits of NBS, as outlined in Section 1.0. Section 3.1 and 3.2 includes methods from environmental and health economics to identify the similarities and differences in determining value end points for changes in health and nature outcomes, and Section 3.4 includes relevant case studies on how the preceding methodologies – and the valuation instruments and project tools in Section 3.3 – are being integrated at the project level to quantify health co-benefits of NBS.

3.1 Establishing Economic Value of Urban Greenspace and Natural Infrastructure

The value of urban greenspace and natural infrastructure can be quantified using a variety of methodologies from environmental economics including:

- **Market-based –** market price, avoided costs, and human capital costs;
- **Revealed preference –** examines both direct and indirect use, including hedonic pricing, travel-cost, and preventative expenditures;
- **Stated preference –** contingent valuation and contingent behaviour used to assign value to non-market goods based on preferences solicited from the target beneficiaries;
- **Subjective well-being –** self-reporting on changes in well-being and life satisfaction, the ability to flourish in the environment (eudaimonia) and intervention-based changes in momentary well-being (OECD, 2018). Value is expressed as a dollar equivalent to a quantified change in the environment – e.g., 10% increase in tree canopy cover is the equivalent of $20,000 of additional annual income.

In selecting a methodology, decision-makers need to balance the ease of use, the applicability for different types of NBS, and the resources required for implementation. For example, market valuation methods facilitate comparison between project alternatives and are well suited to capturing the tangible benefits from direct use and the direct cost savings provided by using NBS (e.g., outdoor recreation in urban greenspace). However, these methods are less able to capture the full value of more intangible benefits (e.g., indirect use or existence benefits)[110]. Consequently, market methods typically undervalue more intangible health co-benefits from investing in NBS, such as feelings of restoration and relaxation.

In contrast, stated preference methods are better suited for valuing intangible benefits from indirect use of urban greenspaces, such as the aesthetic value of high-quality greenspaces[111]. These methodologies rely on subjective data, which is a strength when considering less tangible value streams (e.g., perceptions of quality), but this also makes it more difficult to compare these values across different projects. As a general guide, using a stated preference method can be an advantage for decision-makers when valuing health co-benefits related to relaxation, well-being, and community cohesion that are framed by changes in feelings of restoration, inclusivity, belonging, and security.

Table 3 outlines the strengths, limitations and proposed project-level application for the methodologies and economic valuation methods available for decision-makers to consider when designing NBS projects.

3.2 Establishing Economic Value of Health Outcomes

Health and environmental goods are similar in that they are generally understood to have intrinsic non-market value, however, the value end points for health benefits are more subjective and highly variable[114]. For example, reductions in mortality have a clear value *end point,* while those associated with reduced pain and suffering are less clear. The latter can be measured in several ways based on individual perceptions of what constitutes improved health – e.g., days of hospitalization versus days without chronic pain. As a result, decision-makers will need to balance the ease and comparability allowed by market-based methods with the relative thoroughness allowed by non-market methods to ensure two primary challenges in valuing health cost savings are adequately addressed. Scoping considerations include:

1. **Assigning a dollar value to health is controversial and can overshadow the lived experience of vulnerable population groups.** Good health is subjective and improving health can take numerous forms and have different values for different people.
2. **Health sector markets provide an incomplete economic measure of good health**, despite having well-established prices and multiple health-adjacent goods being exchanged across Canada – e.g., cost of diagnostic instruments, pharmaceutical expenditures, cost of mental health treatment. Even though these markets may represent an easy entry point for costing health impacts at the project-level, there is a risk in assuming health outcomes can be valued using simple market-based valuation techniques. Good health is inherently a non-market good, meaning market valuations are unable to capture cost savings from improved health in areas such as dignity and happiness. In this case, non-market methods are needed to capture the intangible cost savings resulting from improved health – e.g., health cost savings generated by reduced pain and suffering.

Table 3: Economic methodologies and valuation methods

Methodology	Method	Strength	Limitation	Proposed application
Market-based approach (Direct Use)	Market Price	• Prices are established and objective. Easy to integrate this type of valuation into existing project-decision making structures	• Partial valuation of health benefits (Costs only) • Limited scope for application - Requires an existing market where nature-based health goods are being actively being priced and traded (ex/ paid park fitness program)	• Pay for access outdoor recreation sites and programs • Carbon sequestration and pollution removal potential
	Avoided Costs	• Prices are established and objective. Inherently values the conservation of natural infrastructure	• Partial valuation of health benefits (Costs only) • Avoided costs are indirect estimates of changes in health outcomes – limited by the direct value of natural infrastructure	• Comparing the effectiveness of NBS to gray infrastructure projects to achieve set project objectives
	Human Capital Cost	• Estimates the opportunity cost of avoiding illness based on lost income/ productivity due to poor health.	• Assumes health status is reflected by income. • Value of life based on present and future earnings - questionable ethics • Undervalues women, people of colour and people living with disabilities	• Evaluate the global potential of different interventions to limit disease burdens related to specific environmental conditions, climate impacts at the population level
Revealed Preferences (Direct and Indirect Use)	Travel-cost	• Semi-objective assumed WTP based travel-costs to access greenspace • Uses established market prices to infer benefits from access • Evaluates user preferences	• Limited by data sampling design • Quality often outside of scope • Limited examples of application in environmental-health projects	• Estimating the value of greenspaces from direct use • Evaluating usage patterns and behaviours that determine accessibility
	Hedonic Price Model	• Potential to capture the full value of health co-benefits - Based on price variations in market traded goods • Health seeking choices/ behaviours are integrated in valuation estimates	• Unable to account for externalities affecting changes in market value - health benefits to be under or overestimated • Limited ability to address specific health outcomes	• Estimating the total value of enviro-health benefits in urban areas • Evaluating differences in health benefits between neighbourhoods
	Preventative Expenditure	• Directly targets specific health outcomes • Projects costs are considered a proxy for the value of observed benefits – fits with cost-utility analyses	• Partial valuation of health benefits (Costs only) • High potential for an inequitable distribution - costs required to prevent adverse health outcomes may not be congruent with existing benefits for certain population groups	• Evaluating costs to improve an existing negative health impact- e.g., costs to planting trees to reduce UHI • Projects that aim to reduce the prevalence of specific negative health outcomes
Stated Preferences (Indirect Use)	Contingent Valuation	• Ability to measure hypothetical scenarios and existence values	• Sensitive to survey design and respondent affirmation bias	• Estimating the existence value of greenspaces
	Discrete Choice Experiment	• Can separate the value of choices from health outcomes • Reduces affirmation bias by offering multiple responses • Can identify marginal values with proper design	• Value of health is wholly ascribed to stated price • Survey design may influence value choices – i.e., inflated values may make certain choices more attractive to respondents	• Understanding preferences and motivations the underlie value choices
Mixed (Direct and Indirect – depends initial case)	Benefits Transfer	• Methods are established and can be quickly applied • Good option with limited local resources and data	• Limited by the availability of case studies • Assumes equal socio-economic and welfare conditions across cases	• Rapid assessments for health benefits of NBS in low resource settings
Subjective Well-being (Mostly Direct Use)	Life Satisfaction	• Self-reported feelings of well-being based on multiple criteria • Includes social determinants of health and is measured over the long term	• Challenging to measure existence values (less so than other SWB) • Limited by self-reporting bias and requires data to be rigorously verified • Typically used in cross-sectional studies; can be challenging to establish causality	• Can be used in conjunction with stated preference methods to value NBS changes to well-being • Easy integration with projects using CEAs
	Eudemonic well-being	• Self-reported feelings of well-being based on multiple criteria • Focuses on the concepts of flourishing in the environment (belonging, inclusion)	• Challenging to measure existence values • Least used of the three methods in policy making, can be challenging to find comparative cases	• Valuing the subjective feelings based on environmental health conditions associated with flourishing (belonging, inclusion) • Can be appropriate for understanding equity issues
	Momentary well-being	• Captures acute and situational mental health impacts • Established sampling methods - Positive and Negative Affect Schedule (PANAS) • Less resource intensive for experience sampling method (ESM) - becoming more integrated in mobile platforms	• Challenging to measure existence values • Challenge to evaluate long-term health benefits • Limited application to value benefits from natural infrastructure	• Eliciting direct feedback from users of urban greenspaces; understanding behaviours/preferences • Sampling method is well-suited for gauging feedback during project life cycle

Table 4: Overview of suggested economic valuation methods based on different environmental health factors[110,112]

Benefit pathway	Environmental health factor	Changes in health outcomes	Economic valuation methods
Community Cohesion	Community gardens & public greenspaces	• Improved nutrition • Increase socialization	• Market price (garden outputs) • Hedonic pricing
	Street trees & urban greenness	• Improved HRV • Improved self-reported health	• Market price (retail sales, tourism revenues) • Hedonic pricing • Contingent valuation • Discrete choice experiments
Physical Activity	Outdoor recreation in urban greenspaces	• Lower blood pressure • Reduced risk of CVD • Reduced risk of obesity	• Market price (access fees) • Avoided costs • Human capital Cost • Discrete choice experiments
Relaxation & Well-being	Greater active and passive exposure to greenspaces	• Reduced stress & anxiety • Reduced risk of CVD • Improved immune function • Improved self-reported health	• Avoided costs • Human capital costs • Preventative expenditures • Life satisfaction
	Greater human-nature interaction	• Improved mental health • Reduced risk of depression • Lower risk of cognitive decline	• Avoided costs • Preventative expenditures • Discrete choice experiments • Life satisfaction
	Therapeutic nature exposure	• Reduced pain & suffering • Reduced stress & anxiety • Reduced mental distress	• Avoided costs • Preventative expenditures • Contingent valuation • Life satisfaction
Environmental exposure and climate change	Air pollution	• Improved respiratory health • Lower risk of asthma	• Market price ($ value of pollution) • Avoided costs • Preventative expenditures
	Noise pollution	• Improved HRV • Lower risk of CVD	• Hedonic pricing • Contingent valuation • Discrete choice experiments • Life satisfaction
	Stormwater management	• Disaster risk reduction • Reduced stress & anxiety	• Avoided costs • Preventative expenditures
	Extreme weather/heat	• Lower risk of mortality • Reduced morbidity from NCDs	• Avoided costs • Preventative expenditures

Note: multiple valuation methods are required to capture the full scope of potential health benefits and the value of diverse end points from changes in health outcomes from using NBS.

Based on these considerations, decision-makers will often find that health cost savings need to be considered as a separate, equal part in the valuation of benefits at the project level.

During these considerations, health cost savings from using NBS should be considered as being broadly drawn from the following three areas that frame different potential economic value *end points* of good health[114]:

1. **Resource cost savings:** lower costs from the treatment or prevention of illness. Typically valued using **market-valuation or revealed preference** methods.

2. **Opportunity cost savings:** fewer lost wages due to morbidity/mortality from poor health. Typically valued using **market-valuation methods.**

3. **Dis-utility cost savings:** less stress, anxiety and suffering from illness or poor health. Typically valued using **non-market valuation methods.**

Understanding health cost savings in terms of tangible (resource and opportunity costs) and intangible (dis-utility) costs of illness can equip decision-makers to select the methods best suited to their needs. **Table 4** provides a snapshot of emerging best practices for selecting different economic valuation methods based on specific environmental health factors and changes in health outcomes. Project evaluation instruments that correspond to these methods are discussed in section 3.3.1.

3.3 Instruments and Tools

A variety of instruments and tools are available to help decision-makers integrate health considerations into the planning, design and implementation of projects using NBS. This section identifies these instruments and tools and discusses their compatibility with various types of NBS projects, scales, and valuation methods.

3.3.1 Project Evaluation Instruments

Instruments are broadly characterized as the methods used to monitor and evaluate changes in greenspace features, to collect local data and evaluate changes resulting from the implementation of NBS projects. Decision-makers should select instruments based on their compatibility with their intended scale of application and ability to accurately measure impacts over the longer term, within dynamic systems.

For decision-makers, selecting the ideal combination of instruments means balancing several considerations:

- Cost and effectiveness;
- Ability to collect relevant local data and involve community stakeholders in the design of NBS projects;
- Feasibility within the local context;
- Ease of use across multiple projects, to reduce the overall cost barriers for implementation;
- Standardization of measurement approaches and metrics, which can facilitate project scaling and collaboration across jurisdictions to support the development of best practices.

The following economic analysis instruments have emerged as the most effective for valuing the health impacts of NBS projects. **Table 5** contains an overview of emerging best practices when applying different instruments at the project level.

Cost Benefits Analysis (CBA)

Cost-benefit analyses are standard evaluation methods for gray infrastructure projects and are also used to measure the monetary value of health outcomes for different types of interventions. Recently, CBAs have been adapted to evaluate natural infrastructure and NBS projects supporting community health. For example, the Hamilton parks and recreation master plan identifies a 3:1 ratio in terms of health cost savings generated by investing in city parks (i.e., each $1 of investment provides $3 in returns for community health).

Benefits

- Uses standard units of evaluation.
- Are easily understood by both decision-makers and project stakeholders.
- Facilitates the comparison of projects benefits across jurisdictions.

Limitations

- Does not consider the full range of socio-economic, environmental, and demographic impacts.
- Does not account for consider costs and benefits over the entire life cycle of the project, as some of the benefits of NBS are realized only over the longer term.
- Discount rates from gray infrastructure projects may skew results as they do not reflect the exponential increase of health co-benefits over time. Compared to traditional infrastructure projects and regulatory interventions that use a discount rate between 7-10%[113], the scope of benefits from using NBS projects expressed in monetary value has been shown to be more accurate when using a discount rate of between 3-5%[114].

Cost Effectiveness Analysis (CEA) and Cost Utility Analysis (CUA)

Compared to traditional CBAs that measure project outcomes using monetary value, cost effectiveness analyses measure project benefits using 'natural units' – e.g., the efficiency of specific interventions in reducing community cases of heart disease by 10%. CEAs are more widely used for health interventions and use fewer cost assumptions to determine overall project benefits, leading to more accurate analyses[115]. CEAs are necessarily comparative instruments that help identify which among several intervention options is the most effective strategy to achieve the desired outcome. Depending on whether the use of NBS to achieve a desired health outcome is more, or less, cost-effective than the status quo, CEA benefits would be expressed in one of the following three ways.

1. **For NBS projects that are <u>less cost-effective than the status quo,</u>** which is often the case for projects with *preventative health co-benefits,* the net benefits are expressed as total project costs minus total costs averted for anticipated negative health impacts. These costs are then divided by the total number of 'natural' units from an NBS intervention to calculate the cost-effectiveness ratio that provides a dollar value per incremental health benefit.

Example:
Cost of Planting 300 000 trees: $158M
Avoided costs from improved mental health: $100M
Net costs: $58M
Number of improved mental health cases: 36 000
Cost effectiveness ratio [Net costs/# improved health] = $1 611 per case

2. **For NBS projects that are <u>more cost-effective than the status quo,</u>** which is often the case for projects with *treatment-based health co-benefits,* the net benefits are also initially expressed as the total project costs minus those averted from a reduction in necessary treatment. However, in this case, the cost-effectiveness of using NBS to achieve a desired health co-benefit would be the result of total cost savings resulting from the need to access medical treatment interventions due to a global reduction in morbidity and mortality from the proposed NBS intervention.

Example:
Park development: $6M
Fewer medical visits + reduced BP medications: $14 M
NBS cost savings: $8M

3. **A cost utility analysis (CUA)** is a specialized form of CEA that streamlines the consideration of multiple health benefits. CUAs consider the total project costs against a more holistic view of health outcomes based on health changes in the wider community. These changes are expressed using either Quality Adjusted Life Years (QALY) or Disability Adjusted Life Years (DALY)116, which can facilitate comparison across a diversity of sectors and local contexts. CUAs are best able to consider the wider community impact of NBS projects, as well as the interaction of multiple health benefit pathways and their effect on community health over the longer term. However, one of the main criticisms of this approach is that the semi-standardized nature of QALY and DALY measurements results in variation between population subgroups in how the value of added life quality (for QALY) and the value of avoided disability (for DALY) are determined[114].

Benefits

- CEAs are more effective than CBAs or CUAs when comparing the cost of achieving different health co-benefits using NBS. CEAs let decision-makers identify the overall effectiveness, rather than absolute costs, of different alternatives to achieve a set health outcome – e.g., analyzing the cost effectiveness of an investment in an urban park to reduce the risk of cardiovascular disease by 10% compared to the effectiveness of other traditional intervention measures. In this case, the reduction of cardiovascular disease by 10% is the primary measure of evaluation, rather than maximizing project benefits expressed as a dollar value.

- The natural units used by standard CEAs are less subjective than health adjusted life years (QALY and DALY), allowing for a less subjective comparison across population groups – e.g., reduction in cardiovascular diseases versus improvements to life quality.

Limitations

- It is not possible to compare the cost effectiveness of different health co-benefits, because cost effectiveness measures refer to natural units (such as the risk of cardiovascular disease).

- Since health co-benefits of using NBS depend on local contexts, this limits the comparison of strategies across jurisdictions and disciplines and may require the development of multiple strategies to evaluate different health co-benefits. This can be costly and slow projects down.

- CEAs typically require expert input to determine whether a given NBS would be capable of achieving the desired health impact. Collaboration between the right stakeholders and the coordination of their various interpretations of the benefits of using NBS are key to the success of using CEAs – a factor that has been widely identified as one of the most persistent challenges by Canadian decision makers.

- CEAs make it difficult to capture mediators in the relationship between NBS interventions and their health impacts. The accessibility of benefits, the inclusion of different members of the community, and the equity of distribution are considered as external factors by CEAs. This is a serious concern and care should be taken to consider equity, diversity and inclusion when using CEAs.

- CEAs do not account for depreciation of natural infrastructure and the resulting changes in health co-benefits, although this can be addressed in post-intervention monitoring and evaluation.

Life Cycle Costing (LCC)

Life cycle costing and CEAs both evaluate the NBS projects based on total project costs to achieve a specified health co-benefit outcome. LCC considers the total project costs of using NBS, including upfront investment costs and future costs associated with ensuring the long-term use and enjoyment of the new greenspace (e.g., annual park maintenance costs)[117]. LCCs should use a similar discount rate of between 3-5%, which is emerging as a standard in natural asset accounting, to better reflect the increasing returns of health co-benefits during the mid- to late-stages of the project life cycle[117].

Benefits

- Compared to standard CBAs, LCCs avoid the financial competitiveness issue when NBS are compared to gray infrastructure alternatives, due to the single focus on total project costs.

- Where resource constraints affect project-level decision-making, LCC may be the most effective economic valuation instrument to ensure alternatives are selected based on increasing returns with minimal costs over time.

Limitations

- Accurately estimating long-term project costs up front is challenging. There is little information on the applicability of the 3-5% discount rate being used specifically to capture health co-benefits and how it applies in different local contexts.

- Focusing on project costs reduces some of the vulnerability to climate change, although the impact could result in higher than anticipated maintenance and remediation cots leading to greater uncertainty in LCC assessments.

- Evaluating projects based on total costs underestimates the multitude of potential health co-benefits and their long-term impact on health outcomes.

- LCC analyses are sensitive to variations in scoping potential project costs. A partial or inadequate evaluation of these costs can increase the level of uncertainty around project benefits. Selecting which factors are included in LCC should be considered against existing examples to reduce these uncertainties. This may be made more difficult by a low number of available examples in the Canadian context.

Multi-criteria Assessment (MCA)

Multi-criteria assessment (MCA) uses a semi-quantitative approach to rank project alternatives based on their performance according to multiple, pre-set project criteria that aims to achieve a balanced assessment of project alternatives[119].

Benefits

- Criteria can be readily adapted to various local contexts and incorporate considerations around environmental, socio-economic, demographic and health. MCA allows the incorporation of distinct or even competing criteria.

- MCAs use a relatively transparent decision-making framework and engage diverse stakeholders to identify project criteria, with this engagement being key for shaping the evaluation process and starting conversations that can also inform later stages of the project.

Limitations

- MCAs are typically more time consuming than CBAs, CEAs or LCCs as establishing criteria often requires multiple rounds of vetting by stakeholder groups.

- Engaging stakeholders in identifying criteria can be tricky
  - It may shift potential conflicts between stakeholder groups to the initial project design phase, which can often limit the benefits of further community engagement during project planning.
  - There is a lack of resources advising on how to choose stakeholders, how much to involve them, and when. With community engagement already shown to be a challenge for many local governments across Canada, the absence of sufficient guidelines may limit the benefits of this type of economic valuation instrument in the Canadian context.

- MCAs rely on project-specific criteria, often tailored to local conditions. This makes it hard to compare MCAs across case studies. Even if criteria are based on standard metrics, they may be weighted differently based on local priorities. This customizability should be considered a strength of MCAs for individual project designs, but also as a limitation for decision-makers when comparing project outcomes across jurisdictions.

- MCAs have been criticized by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) as lacking in objectivity when evaluating the health benefits of using NBS. In the absence of established best practices and guidelines, there is a risk that MCAs simply perpetuate the interests and values of dominant stakeholder groups.

Social Return on Investment (SROI)

Social Return on Investment (SROI) is often used by non-profit organizations to estimate the social, environmental, and economic return on investment in a project - also known as the *triple bottom line*[118]. Like CBAs, SROI compares the net present value of project benefits with the net present value of costs. Also, like CBA, it calculates the value of benefits by assigning economic value to intangible environmental and social benefits using financial proxies and combining these values with those of economic benefits. But unlike CBA, it actively involves stakeholders in identifying important benefits and estimating their value. These stakeholders may include beneficiaries, implementing organizations, and project funders.

Benefits

- By prioritizing stakeholder engagement, SROI allows for a more comprehensive and realistic estimation of project benefits.

Limitations

- SROI estimates are not easily compared between projects.

- Stakeholder engagement requires time and money. Better-resourced stakeholder engagement processes may identify more benefits when using SROI. This means capacity differences can limit the usefulness of SROI for certain organizations.

- In addition, stakeholder engagements typically involve a small number of people, meaning contextual factors and individual differences can shape estimates.

3.3.2 Project Design and Evaluation Tools

We define project design and evaluation tools as procedures to support decision-makers in selecting the right instruments, identifying the correct benefit pathways, and establishing indicators that can measure the health impacts of NBS. Different tools are available for different types of NBS and different elements of project planning and design, including community engagement, health-based assessments, and natural infrastructure audits. Here we highlight a few of the most prevalent and pertinent tools that can support the design and evaluation of projects that aim to capture the value of potential health co-benefits of using NBS. Further tools are elaborated upon in **Appendix 3** and **Table 7** provides an overall summary.

Table 5: Overview of project evaluation instruments

Instrument	Benefits	Limitations	Proposed applications
Cost Benefit Analysis	• Most common economic valuation instrument. Provides an easy, ready to use option for decision-makers to consider the merits of different types of projects. • Standard units of measure facilitate the comparison of interdisciplinary projects and encourages the collaboration of multi-sectoral stakeholders	• Discount rates applied to project benefits are subjective. These rates vary across different sectors and have only recently emerged as a 3% standard for using NBS. Standard CBAs do	• Effective instrument for evaluating project benefits when submitting applications to external organizations to receive project funding. • Can also be useful to consider the natural asset portion of using NBS in conjunction with additional evaluation instruments to be applied to the corresponding health co-benefits.
Cost Effectiveness Analysis	• Able to avoid the pitfalls of placing a cost on health outcomes	• Analyses are limited to the single natural unit of evaluation. Using CEAs to evaluate all health co-benefits associated with using NBS would result in multiple analyses for each anticipated project outcome	• CEAs are an effective valuation instrument for projects that aim to integrate health considerations as a primary objectives/ outcome • Projects evaluating health impacts at mid- to small-scale – e.g., neighbourhoods, small cities, towns
Cost Utility Analysis	• Ability to capture aggregate health impacts for entire communities/ populations • Standard measurements of health using Quality of Life Adjusted Years / Disability Adjusted Life Years	• Utility lens can disadvantage minority populations, people living with disabilities, children, and women • Ongoing debate around use of QALY and DALY for accurately measuring health outcomes	• Projects evaluating health impacts at larger scales – e.g., large cities, region, provinces/territories
Life Cycle Costing	• Simple; less resource intensive than other options • Reduces inherent cost-benefit advantage of gray infrastructure projects by focusing on long-term project costs • Easy to compare across cases	• Can only capture partial valuations (costs only) • Long-term project costs are required to be estimated up front. Can lead to discrepancies over the appropriate discount rate • Scoping challenges in determining project costs - limited examples for comparison	• Useful for the direct comparison of NBS projects with gray infrastructure alternatives. Each project being considered must have well-established benefit outcomes and relatively accurate costing schedules to ensure comparative accuracy. e.g., comparing a tree planting project around a playground to increase shade cover to the installation of shading screen
Multi-criteria Assessment	• Integrates stakeholder engagement in project planning and design • Includes diverse values to develop appropriate evaluation metrics • Provides a framework to include a diversity of considerations in project planning - environmental, health, social, economic, etc.	• More time consuming; collaborative ranking of project priorities can lead to stakeholder conflicts during project design • Can be a challenged to scale. Locally specific evaluation metrics – may limit cross-jurisdictional comparison above the micro-meso level • Can produce highly subjective project level decision-making structures	• With sufficient guidelines, this type of project assessment instrument would be viable for local governments with few resource limitations when designing projects using NBS to enhance community health. • Good option for second generation project planning and design.
Social Return on Investment	Uses triple bottom line (environmental, social, economic) to evaluate project alternatives Procedurally like CBAs making these types of assessments easy to integrate with existing project planning strategies	• Lack of clarity around values and metrics for measuring environmental and social outcomes • Can be resources too resources intensive in certain cases. Success hinges on substantial resources being devoted to stakeholder consultation and engagement	• Minimum alternative to CBAs for evaluating the health co-benefits of projects using NBS.

Vegetation Indices

Vegetation indices evaluate the proximity and abundance of urban greenspaces at a variety of spatial resolutions and temporal scales. These instruments are typically calibrated at resolutions ranging from 30m to 8km and use satellite imagery to determine vegetation density[22]. The **Normalized Difference Vegetation Index** (NDVI) is considered the industry standard and has been independently validated as an effective tool for measuring the residential proximity and abundance of urban greenspaces across wider geographic areas and within more immediate timescales (remote sensing results of NDVI can be generated in as little as seven-day intervals)[22,119]. NDVI values range from -1 to 1 and are further divided into four sub-quartile ranges for the purpose of analyzing changes in vegetation cover, including differences between gray infrastructure and natural vegetation cover, vegetation density, and vegetation health.

The values in **Box 4** should be used as a general guide when analyzing NDVI outputs due to the possibility of variations in vegetation health and seasonal/regional differences interfering with the overall accuracy of the observations. For example, snow, cloud cover, and water surfaces register in the negative range, which could be problematic depending on the application[121]. The following are alternative forms of spatial imaging that can handle cloud and snow cover, soil, and water, which may make them more suitable for certain types of NBS, such as improvements to stormwater management systems[120].

Soil Adjusted Vegetation Index (SAVI) – this index is designed to minimize the influence of uncovered soil as a possible confounding variable, which can result from differences soil colour, moisture, and variability within the area of observation. This type of index is well suited to evaluate young vegetation cover and for use in arid climates – e.g., Penticton, British Columbia.

Atmospherically Resistant Vegetation Index (ARVI) – this index is designed to minimize the influence of atmospheric aerosols as a possible confounding variable, which can result from higher levels of rain, fog, smoke or air pollution. This type of index is well suited to evaluate areas that are susceptible to higher levels of atmospheric effects – e.g., coastal regions, high density urban areas.

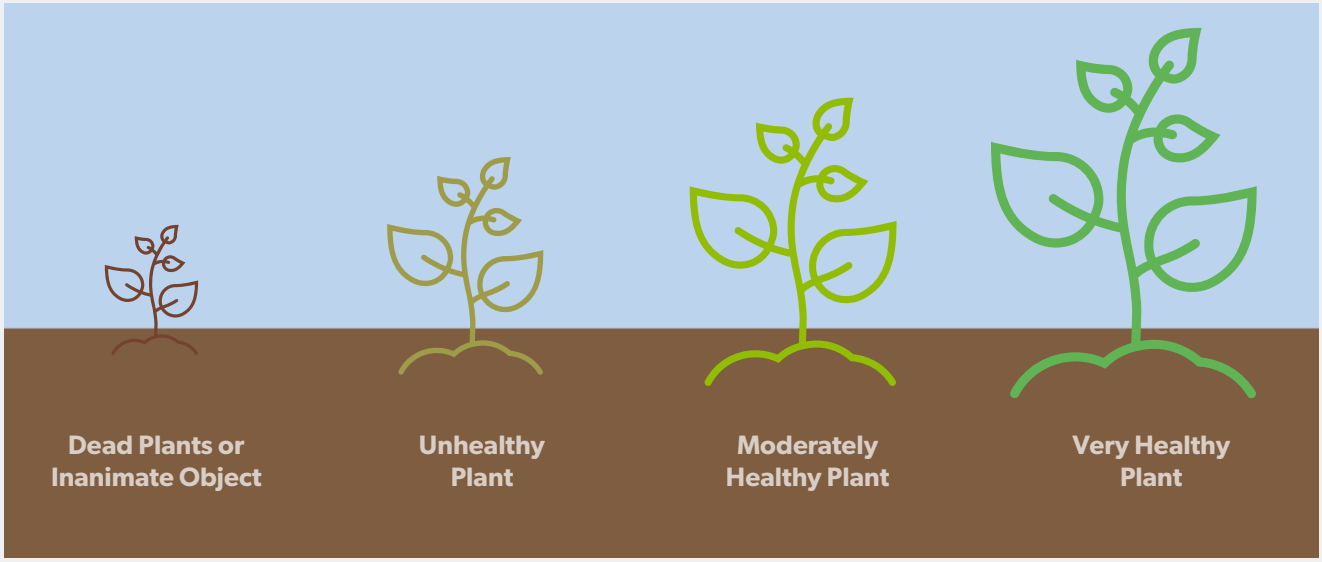
Box 4: Interpretation of NDVI value ranges

-1 to 0
Gray infrastructure, rocks, and snow cover. May also include confounding elements, such as cloud cover and water surfaces.

0 to 0.33
Most vegetated surfaces in urban areas would be found within this range, which includes sparse to moderate vegetation density.

0.33 to 0.66
Bare soil moving toward sparse vegetation cover in the upper bounds of the range.

0.66 to 1
High density vegetation



Enhanced Vegetation Index (EVI) and Structure Insensitive Pigment Index (SIPI) – these indices are designed for use in areas with higher vegetation density and more complex canopy structures – e.g., Prince Rupert, British Columbia. They are optimized for reading differences in vegetation canopies, including type and overall composition, and are calibrated to capture changes in canopy composition that result from different types of stress on vegetation, including drought stress (EVI) and plant diseases (SIPI).

Green Chlorophyll Index (GCI) – this index is designed to track changes in vegetation health. Whereas output from NDVI provides a general guide on the status of vegetation cover, GCI can accurately monitor the impacts of seasonal change, environmental stressors (e.g., human encroachment), and exposure to environmental pollutants on the overall health of vegetation cover.

Normalized Burn Ratio (NBR) – this index is specifically designed to detect and assess the impact of wildfires (both active and inactive). The main purpose of this index is to provide a more accurate assessment of damage to natural infrastructure caused wildfires by analyzing the severity of the fire, the overall footprint of the burn radius and identifying any surviving vegetation.

Benefits

- They use globally standardized methods, allowing results to be replicated across geographic locations. This facilitates both the scaling up and scaling out of strategies using NBS to promote health.
- Measurements are available on a short timescale and can use a wide range of resolutions.
- Vegetation indices are appropriate for both project planning and ongoing evaluation at various scales including for single streets, neighbourhoods, cities, and regions.

Limitations

- Technical knowledge is required to generate and interpret geo-spatial images. The cost of using vegetation indices may therefore be prohibitive for some users.
- Greenspace quality is not accounted for, which has been identified as equally important when determining the access and usage patterns of greenspace users.
- Distribution of benefits from greenspace exposure among population subgroups is not included.

Proposed Application

Vegetation indices are a relatively low-cost and effective tool to map the overall proximity and abundance of urban vegetation. They are useful for integrated spatial planning and evaluation of urban greenspaces and are a valuable tool to support the geo-physical design of NBS projects to enhance community health. Coupled with additional tools to evaluate greenspace quality, socio-economic status, and issues of security, inclusion and cultural belonging, vegetation indices are part of a toolkit for maximizing exposure, reducing distance barriers to access, and promoting the equitable distribution of health benefits by prioritizing greenspace development in underserved neighbourhoods.

The types of NBS projects that benefit from the use of vegetation indices include:

- Expanding the canopy cover of street trees;
- Prioritizing adjacent open spaces for parkland expansion;
- Monitoring the progress of nature restoration projects;
- Prioritizing the greening of high-density gray infrastructure areas.

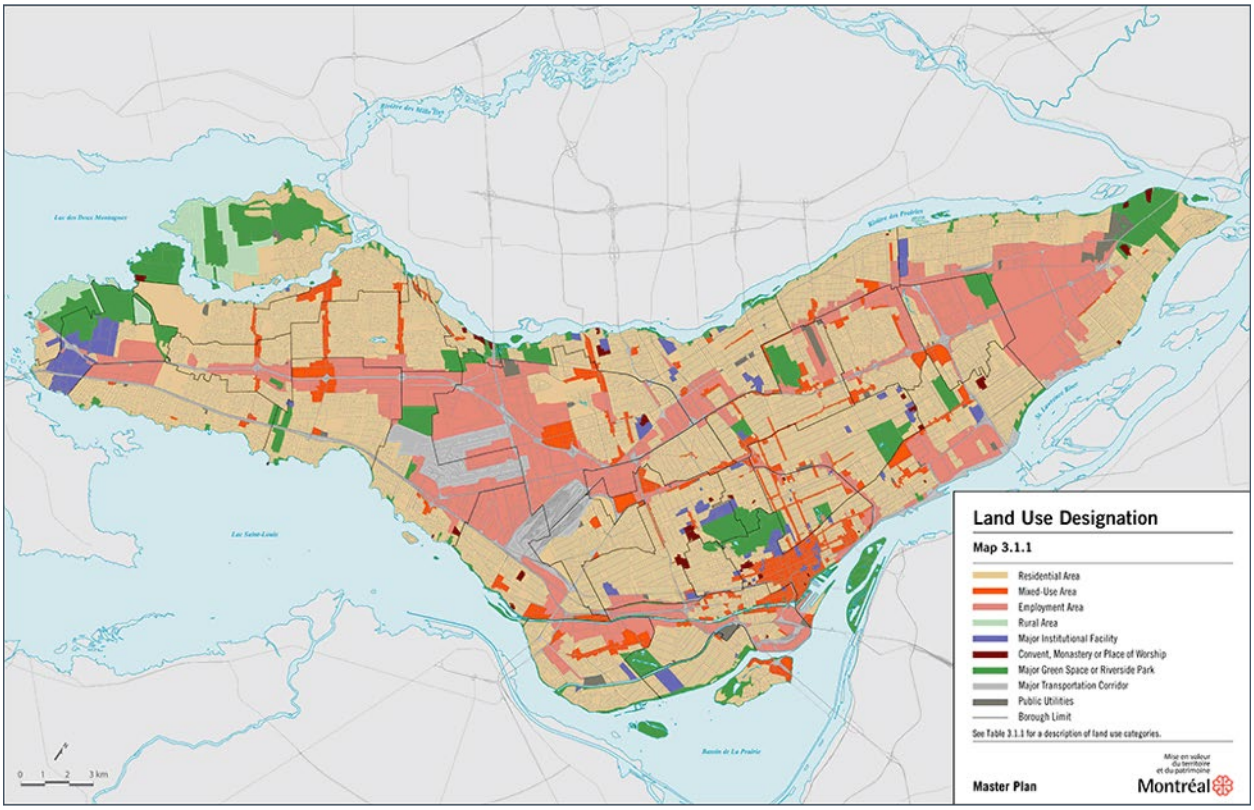
Land Use Databases

Land use databases classify land by the predominant use type and can be useful for distinguishing between different types of urban greenspaces when designing NBS projects. Compared to vegetation indices, which provide data on vegetation density, land use databases are a more effective tool for identifying specific types of urban natural infrastructure including parks, private gardens, sports fields, and forests. They can also identify urban blue spaces[121], coastal areas and variations in municipal zoning – residential, commercial, and industrial (**Figure 4**). As a tool supporting NBS projects, land-use databases can be more effective than vegetation indices to identify the distribution of quality greenspaces, as well as for predicting usage patterns and types of exposure (social, physical, environmental) based on the type of greenspaces identified[22].

Benefits

- Land use classifications allow identification of important variables that influence the distribution of health benefits, such as greenspace quality, type, and the overall integration of natural urban features with the wider city landscape.
- They facilitate identification of underserved neighbourhoods. They allow more accurate estimation of overall public access to urban greenspaces by removing private lands and gardens from a dataset.

Figure 4: Land use classification map for the 2002 City of Montreal Master Plan



Limitations

- Comparable to vegetation indices, they are incapable of determining the distribution of health benefits among population subgroups and identifying barriers to access and geophysical features that influence usage patterns – e.g., limited public transportation access, higher levels of roadway integration, inaccessible or unsafe access points, etc.

- Depending on their resolution, they can be less effective in mapping the overall abundance of urban vegetation. As shown in **Figure 4**, coarser resolutions limit the identification of street trees and other smaller scale vegetation cover.

- Land use databases are less effective for mapping the health benefits of more integrated urban vegetation, such as street trees, green boulevards, and micro-parks (pocket parks), that can reduce exposure to environmental pollutants and climate change and improve mental restoration and well-being. The Government of Canada's Land Cover of Canada database (2015) uses a finer 30m resolution, which makes it a more effective and accessible tool for decision-makers. However, even at this resolution, this tool has difficulty identifying integrated urban vegetation types and has a limited accuracy of 76.60%[122].

- They provide static, infrequently updated snapshots. Updates are provided on an annual basis, with the industry standard being five-year intervals (e.g., 2015 Land Cover of Canada)[22].
  - This increases the error risk when evaluating health impact and outcome data, as the timescales of datasets may not match
  - There is the risk that land use will have changed in the interim
  - This limits the ability of land use databases to support ongoing project evaluation to adapt strategies for success over time. Since NBS are typically focused on enhancing dynamic ecosystem processes in urban areas where there are often competing land use interests, this is an important limitation

Proposed Application

- Land use databases are better suited for determining the overall distribution, type, and quality of public greenspaces when seeking to evaluate the potential impact of a project on social health (including community cohesion, equity, diversity, inclusion and belonging), and mental health (including relaxation, mental restoration, and lower incidences of stress and anxiety).

- Land use databases can also be used to determine the distribution of different types of greenspaces known to promote health, such as high-quality parks, sports fields, nature trails, woodlands, and conservation areas, but care should be taken to also survey the local community to understand any potential barriers or facilitators that influence access patterns and feelings of overall accessibility of different greenspaces that may not otherwise be represented.

USDA Forest Service i-Tree Tools

i-Tree Tools is a free software suite developed by the USDA Forest Service to quantify the benefits of urban trees based on species type and other physical characteristics (e.g., canopy cover, shading by leaf area, tree placement, and total number of trees). I-Tree uses local asset inventories or remote sensing to generate baseline data for several health benefits from urban trees – including improvements to air quality, carbon sequestration and avoided emissions, improvements to stormwater management, and habitat conservation[123]. The tool tracks changes in these metrics over time and calculates resulting cost savings. i-Tree has four (4) core tools that can support decision-making during the design of NBS projects in Canada (See **Table 6**).

Benefits

- Step-by-step guidance are available for each of the i-Tree tools that walk users through initial access, data collection, analysis, interpretation, and evaluation.
- i-Tree is maintained by the USDA Forest Services with project application dating back to 2006.
- Numerous Canadian case studies are available to support the deployment of i-Tree in urban forestry planning.

Limitations

- Except for i-Tree Canopy, these tools are dependent on the availability of local air pollution, meteorological and environmental data to perform the functional analysis of urban forests and individual trees.
- Only i-Tree Eco is adapted for 'out-of-the-box' use for larger NBS projects in Canada, although other versions of the i-Tree suite may be customizable for use in Canada (at additional cost).

Proposed Application

- i-Tree MyTree and Design rely on local data collection that can be generated by both local governments staff and members of the community to evaluate micro-scale NBS projects.
- For larger NBS projects, i-Tree Eco is readily adapted for use in Canada and populated with basic versions of the necessary datasets. However, it is strongly recommended that users gather local data that is best adapted to the context of their NBS projects.
- The instrument is most useful for quantifying the benefits of NBS projects using urban tree cover – e.g., increasing canopy cover, reducing air pollution, and parkland development. It can also track changes in stormwater management and habitat conservation related to the urban tree canopy.

Table 6: Summary of available i-Tree tools available for use in Canada

Name	Description
i-Tree MyTree	Digital asset inventory of individual trees based on the species, age, and placement relative to urban gray infrastructure. MyTree maps annual CO_2 sequestration, avoiding stormwater runoff and energy savings. MyTree is better adapted to small NBS projects, or as a community engagement tool that would allow users to identify the benefits of trees in their areas.
i-Tree Design	Project planning tool that can estimate the cost and long-term benefits provided by individual trees. Benefits from multiple trees can be aggregated into larger datasets to provide an estimate of the overall benefits at the parcel level.
i-Tree Canopy	Estimates total vegetation and non-vegetation cover in urban areas. Users must classify imported data points (e.g., tree, building, grass, road, etc.) which are laid over satellite imagery and interpreted by the tool to provide an overall vegetation cover estimate for a set urban area.
i-Tree Eco	Provides a functional analysis of both forests and individual trees. Analysis includes health impacts from pollution removal, carbon sequestration, hydrology effects, building energy impacts, habitat evaluation (avian species) and UV radiation mitigation from tree shading. Well-suited for larger NBS projects and is designed for use in Canada.

Figure 5: Example of OpenTreeMap in Kawartha Lakes, Ontario

Open Tree Map

Open Tree Map is a pay-to-use platform that aims to enhance the i-Tree platform by allowing local governments to crowdsource local data on changes to the urban tree canopy[124]. This data can be used to estimate cost savings from improvements to local ecosystem service functions. Data includes tree species, location and projected planting sites and can be populated with pre-existing datasets. Updates are managed as a collaboration between the local community and the department responsible for managing urban greenspaces (See **Figure 5**).

Benefits

- Crowdsourced data is a low-cost alternative to contracting the collection of local data.
- Optional features are available at an additional cost ($4,000/year) that enables expanded inventory management of green infrastructure - including rain gardens and bioswales.

Limitations

- The full suite of options provided by Open Tree Map costs around CAD $8,000 /year to inventory and analyze the benefits of 25,000 trees. For local governments looking to inventory and analyze the benefits of more than 300,000 trees, costs quickly run up to more than $40,000[125]. These costs may be prohibitive for certain local governments.
- Crowdsourced data must be continuously verified to ensure accuracy.

Proposed Application

- Useful to develop small-medium sized natural asset inventories at a relatively low cost.
- For larger asset inventories, the costs of using the platform would need to be weighed versus the ease of collecting data through community involvement.
- OpenTreeMap can serve as an innovative approach to encourage better community engagement in tree planting projects and the stewardship of urban greenspaces.

Health (Equity) Impact Assessment

Health Impact Assessments (HIA) can be used at the project level to evaluate how policies and programs may affect human health[126]. HIAs are meant simplify the integration of health considerations in project-level decision-making by using available scientific information to estimate both long- and short-term project impacts on human health, as well as any potential changes to environmental, economic, and social determinants that influence the wider public health landscape[127 128]. Properly executed, HIAs can help decision-makers avoid projects that cause disease and injury; and select those that promote health and well-being in Canadian communities.

In 2019, the Impact Assessment Act passed by the Government of Canada provided more clarity for how human health considerations should be integrated into project-level impact assessments. As a result – and following the example of the 2002

Loi sur la santé publique in Quebec – health considerations are now mandatory within impact assessments regulations in each province and territory. A Practitioner's Guide is available to support decision-makers when implementing project-level HIAs, although each province and territory is ultimately responsible for administering impact assessments and may have different local processes and requirements. Different types of health impact assessments can be used to support project-level decision-making:

- **Standard Health Impact Assessments (HIA)** are comprehensive assessments that require establishing local baselines, collecting relevant health data and engaging with the local community. They typically follow a 6-step process (**Box 5**) for evaluating the human health impact of project proposals, although best practices in different industries and across different jurisdictions may recommend anywhere from 4 to 7 procedural steps.

- **Rapid Health Impact Assessments (rHIA)** are typically selected when time or resource constraints create barriers for engaging a standard HIA. Although no standard framework exists for rapid HIAs, some common strategies include prioritizing the most important health determinants for evaluation, using focus groups and community panels to speed-up local engagement, and using existing datasets[129].

- **Health Equity Impact Assessments (HEIA)** are specialized HIAs with a focus on supporting equity driven decision-making. HEIAs aim to support decision-makers in selecting projects that reduce health disparity between population groups and to ensure benefits are equitably distributed across beneficiaries. The Ontario Ministry of Health has developed a toolkit to support decision-makers in using HEIAs to evaluate potential projects, policies and programs.

- **Environmental Health Impact Assessment (EHIA)** are standard EIAs that include an additional, specific health component – e.g., pollution exposure or cancer risk from different projects. These types of assessments can be readily adapted to existing EIA frameworks but are mostly incompatible with qualitative health data and have limited capacity to evaluate the underlying drivers behind changes in public health.

- **Integrated Environmental Health Impact Assessment (IEHIA)** combine features of standard risk assessments, environmental impact assessments and standard HIAs to assess the health impacts of different environmental features, as well as impacts from related policies and interventions. According to a profile of IEHIAs by Diallo (2021), these types of assessments are more inclusive and consider a wider range of impacts and risks relating to environmental health. Compared to other types of HIAs, IEHIAs use a four-step process:

  - **Issue framing** – construct a conceptual model that includes the scope of the assessment and a framework that will be used to compare different scenarios
  - **Design** – transition conceptual model into comparative protocol, complete with term definitions, scenario parameters, datasets, and evaluation tools
  - **Execution** – develop different scenarios based on identifying different hazards, potential levels of exposure, and the characterization of various health risks
  - **Appraisal** – interpret results and rank policy/project options based on their effectiveness

Box 5: Comparison of health impact assessment procedures

Step 1: Screening. The HIA team and stakeholders determine whether an HIA is needed, can be accomplished in a timely manner, and would add value to the decision-making process.

Step 2: Scoping. The HIA team and stakeholders identify the potential health effects that will be considered and develop a plan for completing the assessment, including specifying their respective roles and responsibilities.

Step 3: Assessment. The HIA team evaluates the proposed project, program, policy, or plan and identifies its most likely health effects using a range of data sources, analytic methods, and stakeholder input to answer the research questions developed during scoping.

Step 4: Recommendations. The team and stakeholders develop practical solutions that can be implemented within the political, economic, or technical limitations of the project or policy to minimize identified health risks and to maximize potential health benefits.

Step 5: Reporting. The team disseminates information including the HIA's purpose, process, findings, and recommendations to a wide range of stakeholders.

Step 6: Monitoring and evaluation. The team and stakeholders evaluate the HIA according to accepted standards of practice. They also propose a plan for monitoring and measuring the HIA's impact on decision making and the effects of the implemented decision on health.

Adapted from the WHO (2021) and McCallum et al., (2018)

Other than IEHIAs, each type of HIA can be conducted as a separate part of project planning or can be embedded within other types of impact assessment frameworks, including environmental impact assessments (EIA), strategic environmental assessments (SEA), or risk assessments (RA). In the case of IEHIAs, the integrated approach is meant to capture the features from various types of impact assessments to provide a comprehensive overview of the impact of different projects on environmental health. With these types of assessments designed to evaluate proposals developed outside of the health sector (e.g., natural resource projects, transportation, and urban planning), collaboration with health sector stakeholders is essential to ensure accuracy.

Benefits

- **HIAs are readily adaptable to other types of project-level assessment frameworks.** The Federal Government and each Canadian province and territory provide guidelines for procedures and local requirements.

- **HIAs are flexible and readily adapted to suit the needs of specific project proposals.** A decision-making matrix developed by McCallum et al., (2018) is available to support decision-makers in navigating the different steps of HIAs.

- **HIAs apply a holistic view of health** that includes the intersection of social, economic, and environmental determinants of health.

- **HIAs can evaluate both positive and negative health outcomes.** In contrast to other types of project assessment tools - e.g., risk assessments, environmental impact assessments – HIAs enable projects to be selected based on their potential positive health impacts.

- Equity and community participation are central components when conducting HIAs. When done correctly, they can:
  - Build trust and strengthen relationships with the local community
  - Improve equity in the local health landscape by identifying projects that focus on health-promoting resources such as healthy foods, safe places for physical activity, transit, and health care
  - Reduce vulnerability by identifying disproportionate exposures to environmental hazards

Limitations

- **HIAs do not provide guidelines for navigating the trade-offs between health and non-health project objectives.** This may create conflict between different project objectives, influencing what is being measured and how.

- Although Federally mandated under the 2019 Impact Assessment Act, each province and territory have different standards, procedures, and requirements for conducting HIAs. This can act as a barrier for cross-jurisdictional collaboration and establishing Canada-wide best practices.

- **Economic valuation of health outcomes only provides one dimension of potential benefits** – i.e. HIAs do not provide a value for happiness, dignity or life satisfaction. Accurately valuing project-level health co-benefits will often require an additional and separate valuation instrument to capture non-market aspects of what constitute good health (See **Table 2** for an overview of suitable non-market valuation instruments).

- Since HIAs are typically conducted on projects outside of the health sector, **human health may not be a primary project objective.** A high degree of coordination between health and non-health stakeholders is necessary to ensure accurate representation of potential health outcomes; however, local stakeholders often lack the experience and capacity for effective collaboration.

Proposed Application

- HIAs are used to evaluate human health and the underlying social, economic and environmental determinants of public health of different project proposals, as mandated under Canada's Impact Assessment Act[130].

- The practitioner's guide can provide decision-makers with the Public Health Agency of Canada's recommendations for considering the social determinants of health and best practices for ensuring equity when using HIAs to support project-level decision-making[130].

- While Quebec is currently the only jurisdiction with legislation requiring HIAs, other provinces, territories, and authorities are now required to integrate health considerations in local impact assessments. The legislative experience in Quebec may be able to serve as a benchmark for other jurisdictions working to better integrate health considerations in local project planning[128].

Health Economic Assessment Tool (HEAT)

HEAT is a practical tool developed by the European Commission in collaboration with the World Health Organization's European office[131]. HEAT is a user-friendly project planning tool that evaluates the impact of projects that support cycling and walking. The tool uses minimal data inputs to calculate changes in physical activity, risks of exposure to air pollution, as well as the risk of personal injury and long-term carbon emissions. The impact of these changes on overall levels of mortality are then monetized and can be integrated into existing project planning structures.

Benefits

- Minimal data inputs are required, and the tool can be adapted to different local contexts.
- Assumptions and methodological approaches are transparent and updated when new information becomes available – methodology includes study data from Canada.
- Can analyze both current and prospective patterns of physical activity that can include variables associated with changes in infrastructure, user habits and weather.
- The tool combines health impact assessments and comparative risk assessments for investments in cycling and walking infrastructure.

Limitations

- Not designed to capture potential health benefits for anyone under 20, and has a higher level of uncertainty for people 64 and older.
- Designed for population-level assessments; limited for individual and targeted assessments.
- Not designed for application in areas with existing high levels of air pollution (above 50ug/m^3).
- Limited to assessing changes in physical activity/ transportation from walking and cycling.
- Accuracy is dependent on the availability of local data sets (default calibration for Western Europe).

Proposed Application

- Monetizing the direct health impacts from more active transportation and reductions in CO^2.
- Local jurisdictions with readily available local datasets would be the most likely to benefit from applying the HEAT tool for project planning and design.
- The methodology used to create HEAT is readily available and may be useful for creating local, regional, or national tools that can be applied to calculate the health impacts from investments in active transportation networks and associated air quality improvements.

HealthyDesign.City

The Canadian Urban Environmental Health Research Consortium (CANUE), in partnership with the Dalla Lana School of Public Health, has developed HealthyDesign.City (formerly GoodScore.City), a digital evaluation tool to communicate data on characteristics of Canadian urban neighbourhoods that affect human health, including air pollution, greenness, weather and climate, transportation, and urban design and land use. The tool uses geo-spatial data from OpenStreetMap and NDVI data from the Google Earth Engine with a 30m resolution to evaluate the physical characteristics of both the constructed and natural environment across different Canadian postal code neighbourhoods. The tool produces environmental health scores generated by differences in land use, recreation opportunities, transit options, urban greenery, and air quality. For each factor, the tool calculates percentiles across Canada and assigns points to each neighbourhood based on the average of the observed values. The tool allows for each factor to be evaluated individually or collectively and is intended for use by public and environmental health professionals, urban planners, and the public.

Benefits

- HealthyDesign.City offers intuitive, simple comparisons of urban neighbourhoods across Canada on a variety of factors affecting public health. It also provides a visual interface that allows users to explore the spatial variation in these factors.
- An associated learning hub provides additional information on the benefits of city designs that address physical activity, green infrastructure, community amenities and the environment.
- Two additional tools – **HealthyPlace.City** and **HealthyPlan.City** are currently in development to better understand the role of the built environment in supporting public health and building resilience to climate change.

- CANUE also maintains a portal for environmental health data and can act as a "data broker," compiling metrics from disparate and sometimes proprietary data sources, producing standardized metadata, and negotiating data sharing agreements. This can significantly reduce the administrative burden on researchers and practitioner organizations.

- CANUE is also contributing to greater standardization efforts to enable consistent cross-jurisdictional research in the field of environmental health. For example, a recent paper by Doiron et al., (2020) uses nationally indexed scores of walkability, the level of NO_2 air pollution and neighbourhood greenness using NDVI to identify environmental health deprived neighbourhoods in Canada's three largest cities.

Limitations

- HealthyDesign.City does not yet provide access to underlying datasets, meaning users only interact with standardized data values.

- HealthyDesign.City is currently in the development phase. User feedback is currently being collected on which features, factors, and functions can be added to enhance the instrument.

- Portal data can only be downloaded by members of academic institutions participating in the DMTI Spatial SMART Consortium Agreement – a data and mapping sharing agreement between various Canadian academic institutions.

Proposed Application

- Data can be used for research, program evaluation, or to set policy agendas; the protocol can be used to inform further data-gathering.

- This tool is useful for comparing urban neighbourhoods across Canada and for visually identifying areas which perform well or poorly.

- It may also be useful to identify urban areas in need of improvement as well as areas that can be emulated.

Tree Canada – Compendium of Best Urban Forest Management Practices

The compendium of online resources created by Tree Canada provides local practitioners with examples of best practices drawn from local contexts across Canada. The compiled resources are intended to support local decision-makers by showcasing technical standards for urban forest management, specifically those applicable to the Canadian context, as well as additional information on resources, initiatives, and programs. These resources include best practices for developing urban tree inventories and carrying out tree inspections, species selection and tree planting methods, economic value and appraisal of urban trees, and the social considerations attached to urban forests.

Benefits

- Facilitates the sharing of information, best practices and lessons learned between different local communities across Canada.

- Provides accessible information for local governments and stakeholders to compare their plans and designs with other similar sized jurisdictions, providing soft guidelines for benchmarking sustainable urban forestry plans at different scales.

- Includes technical guidelines aggregated from a variety of sources for the planning, design, maintenance and implementation of sustainable urban forestry plans – including the identification of enabling legislation, recommended tree inspection cycles, and potential abiotic stress of forest ecosystems.

- The compendium includes a novel carbon impact calculator to evaluate emissions from electricity and transportation. The calculator estimates the number of trees required to offset carbon emissions from both individuals and businesses.

Limitations

- Practical guidelines and industry-wide standards are currently unavailable to support decision-makers.

Proposed Application

- The Compendium portal provides decision-makers with a starting point, as well as detailed information on specific topics, when designing urban forestry projects ranging from urban woodlands to planting individual street trees.

- The associated carbon calculator could be a novel tool to stimulate citizen engagement around the importance of trees for mitigating the impacts of climate change.

Cities 4 Forests - Social Equity Guide for Urban Forestry Development

The Cities4Forests social equity guide for decision-makers aims to achieve the "absence of avoidable or remediable differences among groups of people *in their experience of the benefits of urban forests*"[132]. The guide outlines processes to enhance the equity of projects and policies through intentional community involvement throughout the project lifecycle. The guide advocates for designing NBS projects that hold space for the opinions, needs and knowledge of vulnerable populations. It suggests approaches that provide greater assurance that these populations will share in the direct and indirect health benefits of NBS.

Benefits

- The Guide advocates for addressing **equity issues at the outset of project design,** which can provide greater ownership among the local community, often leading to more efficient project implementation.
- It advocates for **combining engagement and urban forestry planning with disaggregated socio-economic and demographic data**, which can help decision-makers to better understand equity considerations around existing urban greenspaces and ensure funding for NBS projects is also being designated for underserved communities. This also helps to reduce the incidence of "green gentrification" where changes in urban land-use have an overall negative impact on the health of low-income residents by pricing them out of their own neighbourhoods.
- It recommends **a platform for individuals to rate their personal feelings towards greenspace features.** This can help planners to identify barriers to equitable access. For example, some groups, like women, persons living with disabilities, and children, may feel less safe in areas with dense vegetation.
- Montreal, Toronto and Vancouver are signatories to the Cities4Forests declaration.

Limitations

- Less technical than other urban forestry design tools.
- There may be some conflict between community engagement and collaboration, which are emphasized in these guidelines, and the use of some of the more technically sophisticated tools.

Proposed Application

- These are most useful as a set of guidelines for community engagement for existing local governments project structures. Care needs to be taken to identify points of intersection, feasibility, and barriers to mainstream these considerations at the project level.

EcoHealth Ontario Conceptual Framework

The EcoHealth Ontario Alliance created a conceptual framework to support establishing a business case for greenspace investments in Ontario (See **Figure 6**)[133]. It articulates the connections between greenspace investments, health returns, and associated cost savings. Decision-makers can use the conceptual framework as a guide to understand the business case of specific investments and to inform policies, programs, and planning decisions to enhance greenspaces.

Benefits

- By highlighting economic benefits of improved health outcomes, the conceptual framework can help build a strong business case for more greenspace investment.
- The framework provides flexibility for users to integrate indirect health considerations using local health and social datasets, when available.

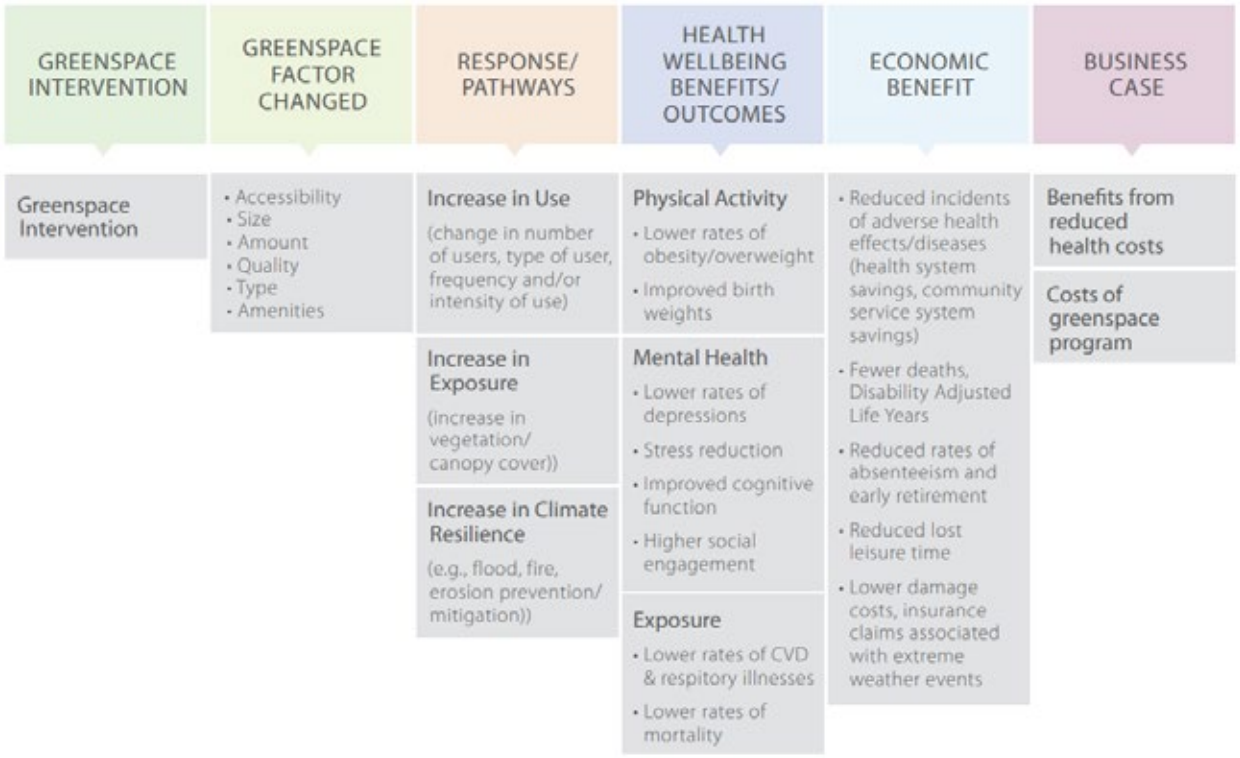
Limitations

- The conceptual framework currently focuses on health benefits associated with greenspace investments only. It does not reflect potential negative effects of these investments.
- The framework relies on user initiative and the availability of local datasets to integrate considerations around indirect health impacts, such as the equitable distribution of project health benefits. This type of local data is often unavailable and proper execution depends on the experience of the end-user.

Proposed Application

- The conceptual framework could be used to engage in a dialogue on changes to Ontario's Provincial Policy Statements (PPS) that have implications for incorporating environmental health into official plans, secondary plans, and design standards.
- It could also be applied to the Growth Plan for the Greater Golden Horseshoe to communicate the potential environmental health implications of development and greenspace loss.
- At the local government level, it could help staff to earn the support of council and community groups, create a business case to present to developers, understand which municipal recreation facilities provide the most cost-effective services to the widest range of users, support local planners to defend or justify changes to planning policies or by-laws, educate the public and help build support for an urban forest policy.

Figure 6: EcoHealth Ontario Conceptual Framework



3.3.3 Subjective Well-being Assessments and Health Surveys

Subjective well-being assessments and health surveys are critical tools for evaluating changes in health outcomes. They also support ongoing community engagement with urban greenspaces and help evaluate the distribution of health co-benefits among population groups. Given the variability of what constitutes "good health", these assessments are pivotal for understanding a diversity of potential value *end points* and how these values may apply to different populations. Furthermore, these assessments are key to better understanding the various socio-economic, demographic, and ethnocultural variables that affect the overall accessibility of urban nature. Subjective well-being assessments and health surveys are valuable project tools for decision-makers when establishing both health status baselines and by how much different population groups may be able to benefit from different types of NBS.

Community Well-being Index

The Community Well-being Index (CWI) assesses socio-economic well-being of communities across Canada in four components over time: (i) education, (ii) labour force activity, (iii) income, and (iv) housing. The CWB score is calculated on a scale of 0 to 100, which allows comparison among Inuit, First Nations, and non-Indigenous communities. Quinquennial data from 1981 to 2016 (except 1986) is publicly available, and the next dataset will be published in 2021, based on Statistics Canada Census. In 2016, the scores for 623 First Nations, 50 Inuit and 3 781 non-Indigenous communities were available.

Canadian Health Measure Survey (CHMS)

The CHMS is a cross-sectional survey that collects relevant data on the overall health of Canadians aged 3-79 that reside in a Canadian province[134]. The survey collects detailed health information regarding blood pressure, height, weight and physical fitness, in addition to collecting biological samples of blood and urine to test for chronic and infectious diseases and identify relevant nutrition and environmental markers. The purpose of the survey is to develop a national baseline for major health issues in Canada, including obesity, hypertension, cardiovascular diseases, exposure to infectious diseases and

exposure to environmental contaminants. Additional information collected from survey participants includes, socio-economic status, demographic data, current health status, nutrition levels, lifestyle choices, physical activity patterns and characteristics of the surrounding environment. Participation in the survey is voluntary and data is collected every two years, with the availability of survey dating starting in 2007.

Canadian Community Health Survey (CCHS)

The CCHS is a cross-sectional survey aggregating data on health status, usage of health care, and the determinants of health for different population groups[135]. The survey collects information from large sample groups every two years to generate an estimate of the health landscape in different Canadian regions. The survey generates more than 60 thousand datapoints, and historical data is available from November 2000 to July 2021 for population groups aged 12 and over from each Province and Territory. Data is collected on a voluntary basis and covers the following subject areas:

- Diseases and health conditions;
- Health;
- Health care services;
- Lifestyle and social conditions;
- Mental health and well-being.

Health-related Quality of Life Assessment

The Health-related Quality of Life (HRQOL) assessment was designed by the *Centers for Disease Control and Prevention* to identify trends, disparities and determinants of health needs in different populations. HRQOL consists of three modules – (i) core healthy days, (ii) activity limitations, and (iii) healthy days symptoms – to estimate the total number of unhealthy days during the previous 30 days due to poor mental and physical health. These types of assessments have been widely used since 1993 and provide several advantages for evaluating the health status of local populations, including insight into health behaviours and lifestyles, the ability to predict changes in short-term trends in mortality, hospitalizations and physician visits, and the ability to integrate existing socio-economic, demographic, and ethnocultural determinants of public health.

World Health Organization – Quality of Life Assessment

The WHO-Quality of Life (WHOQOL) assessment was developed by the *World Health Organization* to assess changes in overall health, including quality of life, well-being and life satisfaction. The original version WHOQOL-100 consists of 100 questions and an abbreviated version consisting of 26 questions, WHOQOL-BREF, has been developed for use to address potential timescale limitations. Both assessments are self-administered and consists of questions across four domains: (i) physical health, (ii) psychological, (iii) social relationships, and (iv) the environment. The WHOQOL assessment has been widely used since 1995 and has been repeatedly tested and updated to ensure the continued reliability and validity of potential results.

Personal Well-being Index

The Personal Well-being Index (PWI) was developed by *The Australian Centre on Quality of Life, Deakin University.* The PWI is self-administered to assess personal well-being across seven domains: (i) standard of living, (ii) health, (iii) life achievement, (iv) personal relationships, (v) personal safety, (vi) community connectedness, and (vii) future security. Each item is rated on a scale of 0 to 10, and the average the total score is used to calculate the PWI. Like the WHOQOL, the PWI is considered a reliable cross-cultural measure of quality of life, in addition to specifically being adapted and validated for use with adults, children, and people living with disabilities.

Table 7: Summary of project planning and design tools

Natural asset evaluation tools			
Tool	**Benefits**	**Limitations**	**Proposed application**
Vegetation Indices	• Standard measurements; easy to replicate • Short-time scale and wide range of resolutions • Suitable for planning and monitoring from micro- to meta-scale	• High technical and financial costs • Unable to assess greenspace quality • Unable to assess usage types; frequency • Unable to remove private land/gardens from data • Does not directly measure community health benefits	• General spatial planning and evaluation of greenspaces • Residential proximity and abundance • Use with local socio-economic and demographic data in NBS project design
Land use database	• Measure greenspace quality, type and landscape level integration • Measure public/private distribution of greenspace • Better accuracy for measuring community greenspace access	• Does not directly measure community health benefits • Does not account for socio-economic and physical access barriers • Limited ability to account for gray infrastructure intrusion and integrated green infrastructure – i.e., street trees • Accuracy of abundance measurements are resolution dependent • Long-time scales can cause greater inaccuracy	• Measuring the distribution, type, and quality of public greenspaces • Evaluating potential social and mental health impacts • Evaluating potential access patterns based on greenspace type • Government of Canada (2015) Land Cover Canada uses a 30m resolution, which addresses most accuracy concerns
USDA i-Tree	• Free software suite with step-by-step guidelines • Developed by USDA and in use since 2006 • Many examples of usage in Canadian urban forestry plans	• Dependent on the availability of local data sets • i-Tree eco is adapted for use in Canada. Other tools in the suite can be adapted for use in Canada at an additional cost	• i-Tree My Tree and Design can collect crowdsourced local data. Good for micro-scale projects • i-Tree Eco is useful for quantifying benefits from urban tree cover • i-Tree Eco is population with default datasets, but local data is strongly recommended
Open Tree Map	• Ability to crowdsource local tree data at a relatively low-cost • Can also be used to management other types of green infrastructure	• Use is based on a price-per-tree model. Can cost more than $40,000/year to analyze the benefits of urban woodlands	• Useful to develop natural asset inventories at a relatively low-cost • Crowdsourcing data can be used as an innovative community engagement strategy
Sustainable Asset Valuation (SAVi)	• Can be run during different project phases • Values co-benefits outside traditional project valuation methods • Already applied in Canadian context (Pelly's Lake, MB) • Support available from IISD	• Highly technical; requires extensive local datasets • Required data collection may be cost-prohibitive	• SAVi can be useful for directly valuing health co-benefits of existing natural infrastructure • Help integrate health consideration when considering green v. gray alternatives
Protected Areas Benefits Assessment Tool+ (PA-BAT+)	• Designed for universal application • Works well under specific local conditions; ecological contexts • Provides an assessment of benefits for different stakeholder groups • Low-cost, rapid assessments	• Results are based on local knowledge > biophysical data • Benefits are not quantified; can cause over/underestimation • Intended for single-site use	• Useful for evaluating policies and procedures in established protected areas; and key ecological areas with unofficial status
Toolkit for Ecosystem Service Site-Based Assessment (TESSA)	• Comprehensive framework and step-by-step guidelines • Can provide both qualitative and quantitative value of ecosystems • Value of ecosystem services are low-cost and robust enough to use in decision-making • No specialist knowledge required	• Assessment scope is limited • Assessment results are static representations of benefits (current or proposed) • Long-term sustainability, natural asset discount rates and future resilience are not included in outputs • No spatial output	• Rapid, low-cost assessments to determine significant site-level ecosystem services • Can be used to identify key stakeholders, beneficiaries • Can determine maximal value and net consequences for site-level planning • Can evaluate trade-offs and synergies between different ecosystem services to inform more detailed assessments and local mapping
Ecosystem Services Toolkit (EST)	• Provides step-by-step guidelines • Integrates diverse valuation methods and software-based modelling tools • Informs on strategies to incorporate ecosystem service assessments into land use planning, impact assessments and conservation incentives	• Highly technical and comprehensive guidelines • Selection of tools and valuation methods are user dependent - requires specialization	• Can support general ecosystem service assessments • Priority ES Screening Tool is an effective rapid assessment tool • Can be used at larger scales • Can be used to inform decision-making processes

Table 7: Summary of project planning and design tools (continued)

Project design and evaluation tools			
Tool	**Benefits**	**Limitations**	**Proposed application**
Health Impact Assessments (HIA)	• Flexible and easily adaptable to different project contexts • Includes social-economic and environmental determinants of health • Can evaluate both positive and negative health outcomes • Equity and community participation are well-integrated	• No guidelines on how to navigate health and non-health objectives • Diverse procedures and regulations for HIAs in Canada • Does not provide a value for less tangible health benefits – e.g., life satisfaction • Require a high level of coordination and collaboration with health officials	• Can be used to evaluate human health and the underlying social, economic and environmental determinants of public health of different project proposals • Legislative experience of HIAs in Quebec may provide guidance elsewhere
Health Economic Assessment Tool (HEAT)	• Minimal data inputs are required • Can be adapted to different local contexts • Can analyze current and prospective scenarios • Combines HIAs and RAs in a single assessment	• Not designed to capture benefits for <20 and >64 years old • Limited application for individual and sub-population levels • Limited to changes in physical activity/transportation from walking and cycling • Greater inaccuracy in areas with high levels of air pollution • Accuracy depends on availability of local data	• Can be used to monetize health impacts from active transportation and air quality improvements • Methodology is available to be adapted for use in Canadian context
Healthy Design.City	• Simple, intuitive comparisons of urban features that impact health • Learning hub and CANUE data portal provide a wealth of informational support • Efforts for standardization of measurements and tool improvements are ongoing	• Does not provide access to underlying datasets • Currently under development, certain features may not be available • Data portal is only available for academic institutions participating in the DMTI Spatial SMART Consortium Agreement	• Data can be used for research, program evaluation, or to set policy agendas • Can help compare urban neighbourhoods across Canada and identify areas with good/poor environmental health • Can help identify urban areas in need of improvement as well as areas that can be emulated.
Compendium of Best Urban Forest Management Practices (Tree Canada)	• Facilitates the sharing of urban forestry best practices between local governments • Acts as a soft guideline for benchmarking forestry plans at different scales • Includes technical guidelines for urban forestry design • Includes as novel carbon impact calculator	• Practical guidelines and industry-wide standards are currently under development	• Vital resource to support urban forestry planning, maintenance and design • Carbon calculator could be useful citizen engagement tool
Social Equity Guide for Urban Forestry Development (Cities4Forests)	• Equity issues are central to the guidelines • Provides guidance on the collection and use of local datasets • Recommends community engagement platforms to ensure inclusive participation • Examples of use in Canada – e.g., Montreal, Toronto, Vancouver	• Guidelines are less technical than other forest management tools • Conflict between engagement and the use of other more technically sophisticated tools may arise	• Essential guidelines for ensuring equity in design and that the feelings and opinions of the local community are expressed in urban forestry planning
EcoHealth Ontario Framework	• Provides step-by-step guidelines for building a business case that accounts for the health benefits of urban nature • Provides flexibility for use to integrate indirect health considerations when using local health and social datasets, when available	• Currently focuses on health benefits associated with greenspace investments only. It does not reflect potential negative effects of these investments. • Relies on user initiative and the availability of local datasets to integrate indirect health impacts, such as the equitable distribution of project health benefits. Data availability and proper execution depends on the experience of the end-user.	• Useful for engaging in discussion around changes to urban planning policies to incorporate environmental health • Can be applied to regional development plans to communicate issues of environmental health – e.g., Growth Plan for the Greater Golden Horseshoe • Can help local staff and community groups in local project development
Health and Climate Adaptation Tool (WHO-ROE)	• Precision can be adapted to different local conditions, capacity limitations and data availabilities • Recommends 3% discount rate in line with emerging best practices • Guidelines can be adapted to different contexts and jurisdictions	• Designed initially for use in Europe, may carry default assumptions, parameters that are not applicable in Canada • Uses excel sheet for data outputs; can be time consuming and prone to input errors • Focus on health outcomes and climate change; no specific focus on urban nature and NBS	• Can be adapted to the Canadian context. The tool may be useful as a starting point for developing a similar set of Canadian guidelines
Climate Change, Health and Equity Framework (CHEVA)	• Comprehensive guidelines complete with informational tools • Provides communication support to enhance local messaging around climate-health • Health equity and social determinants of health are well-integrated	• Designed for the U.S. health policy landscape • Less well-adapted to public health issues not caused by climate change	• Can provide Canadian decision-makers with certain foundational guidelines and information to support the integration of climate change and health equity in local planning
Horizon 2020 Framework (European Commission)	• Provides suggestions and guidelines for metric and tool selection when designing NBS projects at scale • Integrated 7-step co-benefit assessment is available to support development • Easy to use, low cost for application and support by a knowledge hub	• Far from comprehensive • Benefit pathways are identified, but not addressed in the framework • Integration of long-term monitoring and evaluation is limited • Designed for use in European cities; although global guidelines are available	• Useful entry point for connecting the health impacts of NBS with relevant evaluation metrics at the appropriate scale. • Can be adapted to the Canadian context and foster greater cross-jurisdictional collaboration

Table 7: Summary of project planning and design tools (continued)

Subjective well-being assessments and health surveys			
Tool	**Benefits**	**Limitations**	**Proposed application**
Community Well-being Index	• Flexible and easily adaptable to different project contexts • Includes social-economic and environmental determinants of health • Can evaluate both positive and negative health outcomes • Equity and community participation are well-integrated	• No guidelines on how to navigate health and non-health objectives • Diverse procedures and regulations for HIAs in Canada • Does not provide a value for less tangible health benefits – e.g., life satisfaction • Require a high level of coordination and collaboration with health officials	• Can be used to evaluate human health and the underlying social, economic and environmental determinants of public health of different project proposals • Legislative experience of HIAs in Quebec may provide guidance elsewhere
Canadian Health Measure Survey	• Minimal data inputs are required • Can be adapted to different local contexts • Can analyze current and prospective scenarios • Combines HIAs and RAs in a single assessment	• Not designed to capture benefits for <20 and >64 years old • Limited application for individual and sub-population levels • Limited to changes in physical activity/transportation from walking and cycling • Greater inaccuracy in areas with high levels of air pollution • Accuracy depends on availability of local data	• Can be used to monetize health impacts from active transportation and air quality improvements • Methodology is available to be adapted for use in Canadian context
Canadian Community Health Survey	• Simple, intuitive comparisons of urban features that impact health • Learning hub and CANUE data portal provide a wealth of informational support • Efforts for standardization of measurements and tool improvements are ongoing	• Does not provide access to underlying datasets • Currently under development, certain features may not be available • Data portal is only available for academic institutions participating in the DMTI Spatial SMART Consortium Agreement	• Data can be used for research, program evaluation, or to set policy agendas • Can help compare urban neighbourhoods across Canada and identify areas with good/poor environmental health • Can help identify urban areas in need of improvement as well as areas that can be emulated.
Health-related Quality of Life Survey	• Facilitates the sharing of urban forestry best practices between local governments • Acts as a soft guideline for benchmarking forestry plans at different scales • Includes technical guidelines for urban forestry design • Includes as novel carbon impact calculator	• Practical guidelines and industry-wide standards are currently under development	• Vital resource to support urban forestry planning, maintenance and design • Carbon calculator could be useful citizen engagement tool
WHO-Quality of Life Survey	• Equity issues are central to the guidelines • Provides guidance on the collection and use of local datasets • Recommends community engagement platforms to ensure inclusive participation • Examples of use in Canada – e.g., Montreal, Toronto, Vancouver	• Guidelines are less technical than other forest management tools • Conflict between engagement and the use of other more technically sophisticated tools may arise	• Essential guidelines for ensuring equity in design and that the feelings and opinions of the local community are expressed in urban forestry planning
Personal Well-being Index	• Provides step-by-step guidelines for building a business case that accounts for the health benefits of urban nature • Provides flexibility for use to integrate indirect health considerations when using local health and social datasets, when available	• Currently focuses on health benefits associated with greenspace investments only. It does not reflect potential negative effects of these investments. • Relies on user initiative and the availability of local datasets to integrate indirect health impacts, such as the equitable distribution of project health benefits. Data availability and proper execution depends on the experience of the end-user.	• Useful for engaging in discussion around changes to urban planning policies to incorporate environmental health • Can be applied to regional development plans to communicate issues of environmental health – e.g., Growth Plan for the Greater Golden Horseshoe • Can help local staff and community groups in local project development

Environmental health databases	
Database	**Description**
Canadian Chronic Disease Surveillance System	Harmonizes provincial and territorial data on chronic diseases, health services and outcomes. The system provides gender, age and disease segregated trend data that is available to the public.
CanPath	CanPath is the largest population cohort study in Canada, examining how the intersection between genetics, the environment, and human lifestyles and behaviours contribute to the development of several NCDs.
Canadian Longitudinal Study on Aging	Longitudinal study based on data collected from 51,000 participants between 45 and 85 years old. The data will be collected from these participants until 2033 to uncover ways of promoting longevity.
Ontario Child Health SUPPORT Unit	Collects and aggregates health data for children in Ontario
Population Data BC	Provides population health data for British Columbia residents since 1985, which includes environmental data, to further research around the causes of human health, well-being,. and development.

3.4 Building the Business Case

The economic valuation methods, instruments and project design tools identified in the previous section show us that there is a sufficient toolkit to support local decision-makers in building a business case for NBS as the cornerstone of healthier Canadian communities. The cases outlined in **Table 8** below are examples of local projects and academic studies that have successfully integrated environmental and health economic valuation methods to build a business case for using NBS to improve overall health and well-being. These cases represent a diversity of local contexts with various socio-economic, socio-demographic, cultural, and resource conditions, including two that are specific to the Canadian context.

The above is not meant to represent an exhaustive list of successful case studies but is instead intended to provide an overview of the diverse approaches available when valuing the health benefits of NBS. The cross-section of cases illustrates the diversity of economic valuation methods being applied to different types of nature-based solutions, the different ways that cost savings are being reported, and the applicability/scalability of various project designs and costing methods – all of which encompass the challenges when developing local businesses cases around the health benefits of using NBS.

Accounting for Health Cost Savings

The cases in **Table 8** illustrate that calculating the cost savings resulting from different types of NBS is possible, including the economic costs associated with expanding the urban tree canopy, promoting greenspace conservation, developing nature-based therapeutic treatment programs, and promoting outdoor recreation.

These cases also show us that it is possible to calculate cost savings arising from changes in each of the main health benefit areas outlined in Section 1.0: physical health, mental health, social health, climate, and environmental health. The health cost savings in these cases were primarily avoided costs, specifically avoided opportunity and resource costs associated with illness, although a few cases also illustrate the possibility to account for dis-utility cost savings of NBS in improving overall life satisfaction. For example, a study by Methorst et al. (2020) combined subjective well-being and contingent valuation methods to value the health benefits of urban biodiversity conservation, illustrating that a 10% increase in the species richness of urban birds is around 1.53 times more effective for improving life satisfaction when compared to a 10% increase in annual family income.

Accuracy

Three main factors affect the accuracy of the estimations of health costs savings among the reviewed business case studies:

- Most generate a single estimate of health cost savings, despite the impact variance among population subgroups. See **Table 3** for a list of methods for estimating health cost savings that are more sensitive to socio-demographic factors.

- Most case studies use market valuation methods. As indicated in **Table 3** and mentioned in the discussion of valuation methods in Section 3.3, market valuation methods are limited to partial valuations based on direct, tangible uses of benefits derived from NBS projects. In addition, the market-value of health cost savings of NBS is not yet well established, which leads to greater uncertainty when accounting for the potential health co-benefits of urban nature.

- The accuracy of health cost savings estimates depends on the resources devoted to project planning, evaluating existing strategies and developing local cost saving models. Despite a growing number of cases examining the health cost savings from NBS, finding existing strategies to evaluate can be challenging and may cause many local governments to build their business cases from the ground up. In these cases, even though market valuations only produce partial health cost savings estimates, the relative low-cost and ease of integration of these methods with other project evaluation techniques would likely make them the preferred option.

A promising sign in the Canadian context is that multiple dimensions of health were recognized in each of the business cases reviewed. Our review suggested a growing ability to make a strong business case, even though the methods used only capture a part of the value of improved health resulting from NBS. For example, studies estimated the potential for $4.2M in annual health cost savings from a downtown park development in Peterborough[136], Ontario and up to $3.2M in annual health cost savings from expanding the tree canopy to 80% coverage in Brampton[137], Ontario.

The following are the key takeaways from the business case studies outlined in **Table 8**:

1. There is a **high level of variation** in methods used to value health benefits from using NBS.

2. Studies **typically focus on a single type of health outcome,** such as reduced morbidity, reduced risks of mental illness or improvements in outdoor physical activity.

3. **Certain valuation methods are better suited to evaluate health cost savings** derived from specific types of NBS. Although further research is needed to determine the best practices for selecting valuation methods, patterns that emerged from our analysis included:

    a. **Market-based methods are most common.** The main benefit for decision-makers in using this type of valuation method is that values are drawn from established markets -- either commodity or labour – which facilitates comparison between projects and reduces the methodological distance between environmental and health sector economics. They are equally effective when valuing the health benefits of using different types of NBS, including coastal restoration[138], residential greening[139], and expanding the urban tree canopy[140]. Using this approach, health benefits are typically valued through either the total *avoided costs* or the total value of *lost wages* that are avoided resulting from improvements to health and well-being (human capital). Specific health impacts that are measured using this approach typically include those associated with physical health – e.g., cardiometabolic diseases, respiratory illnesses, inactivity, etc. – as well as cost savings associated with the treatment of mental illnesses or mitigating the impacts of climate change.
    b. **Revealed preference methods** such as the travel-cost and hedonic pricing approaches are better suited for valuing the health benefits of greenspaces for outdoor recreation, and the overall health of different neighbourhoods.
    c. **Subjective well-being methods are the most challenging, as well as the most comprehensive.** Project design is more challenging, but these methods are the most effective for capturing the social determinants of health, including the equitable distribution of health benefits and the inclusion of marginal population groups.

4. Most of the business **case studies address opportunity and resource cost savings from health benefits.** Dis-utility (wellbeing and life satisfaction) cost savings are more problematic when determining health cost savings for marginal population groups. Valuation methods that focus on dis-utility cost savings typically use DALY and QALY measurements, which disadvantage certain population groups. Discount rates are a particularly sensitive modifier in determining the health cost savings among children.

5. **Comprehensive business case analyses are not often undertaken at the local level due to high technical and administrative costs.** With few Canadian models and data sources readily available, most local governments need to develop their own project designs to accompany valuation methods. This is challenging, time consuming and resource intensive, and creates a significant disincentive for local governments decisions makers to consider health benefits as anything other than a bonus to primary project objectives. The methods used in the few comprehensive business cases available would be out of reach for all but Canada's largest cities due to high costs associated with implementation. Valuing intangible health benefits would be even more costly.

Even though market valuations only produce partial health cost savings estimates, the relative low-cost and ease of integration of these methods with other project evaluation techniques would likely make them the preferred option.

Table 8: Measuring health costs savings from nature-based solutions

Project title, authors & location	NBS of interest	Health target	Health outcome	Health cost savings	Methods	Scalability
Physical Activity in Parks: A Randomized Controlled Trial Using Community Engagement Cohen et al., 2013, Los Angeles, U.S	• Parks and Recreation	• Meet physical activity guidelines	• Reduced health risks from inactivity	• Resource cost savings • $0.22 - $0.72 per MET hour gained when compared to traditional health interventions	• Subjective well-being valuation	**Moderate** • Small sample size; site specific • Other variables can mediate PA
Mapping distance-decay of cardiorespiratory disease risk related to neighborhood environments Requia et al., 2016, Brasilia, Brasil	• Residential Greenness	• Reduced cardiorespiratory diseases	• Reduced hospital admissions	• 1km2 increase in GS abundance, 2 less hospital admissions • Every 46,000 light vehicles on roads <500m GS buffer, 6 additional hospital admissions	• Revealed preference • Avoided costs	**Moderate** • Air quality/climate considerations are less applicable in Canada • Requires extensive local datasets
Comprehending the multiple 'values' of green infrastructure – Valuing nature-based solutions for urban water management from multiple perspectives Wild et al., 2017 Sheffield. UK	• Residential Greening	• Improved well-being	• Greater life satisfaction	• 5% above market price for new housing development • Requires extensive greenspaces, shown to reduce developer profit by 15%	• Benefits Transfer • Contingent Valuation • Comparative WTP schemes	**Low** • Data uses studies from Sheffield, UK • Methods need to be adapted to Canadian context • Developer loss outweighs WTP for greenspaces in new developments
The importance of species diversity for human well-being in Europe Methorst et al., 2020 , Europe, 26 countries	• Biodiversity Conservation	• Life satisfaction • Quality of life • Well-being	• Improved well-being • Stress Reduction • Attention restoration	• 10% bird species increase provides 1.53 times more return on life satisfaction than a 10% increase in income	• Subjective well-being; Quality of life survey • Stated preferences Contingent Valuation	**Low-moderate** • Highly technical • Requires multiple data sources to establish covariates • Additional parameters needed to avoid multicollinearity between variables
Biodiversity and ecosystem services in urban green infrastructure planning Caportorti et al., 2019, Rome, Italy	• Conservation and Restoration	• Reduced air pollution and improved health	• Reduced morbidity/ mortality	• 40,700 to 130200 EUR/year	• Market valuation • Human Capital Cost • Avoided Costs	**Moderate-high** • Methods are established and relatively simple.
More greenspace is related to less antidepressant prescription rates in the Netherlands Helbich et al., 2018, National, Netherlands	• Urban vegetation and greenspace cover	• Improve mental health	• Lower rates of depression	• Reduction in antidepressant prescription rates	• Market Valuation • Human Capital Cost • Avoided Costs	**Low-moderate** • Partial measure of health impact • Statistical approach is complex
A Long-Term Follow-Up of the Efficacy of Nature-Based Therapy for Adults Suffering from Stress-Related Illnesses on Levels of Healthcare Consumption and Sick-Leave Absence Corazon et al., 2018, National, Denmark	• Urban Forest	• Increased exposure to restorative space	• Improved mental health,	• Avoided sick leave (17% increase above CBT)	• Market valuation • Human Capital Cost	**Low** • Small sample size • High variability of exposure methods
Valuing London's urban forest: results of the London i-Tree Eco Project Rogers et al., 2015, London, UK	• Tree Canopy	• Climate Health	• Air Quality • Carbon Sequestration • Stormwater management • Amenity value	• Avoided Costs (UK Social Damage Costs framework) • NO = $54M • CO = $29K • PM10 = $63M • PM2.5 = $1.1M • 03 = $6.5M • SO2 = 102K	• Revealed preference • Pollutant-based Market valuation (avoided costs)	**Moderate-high** • Valuation metrics need translation to Canadian context • Persistent barriers around mapping air pollution

Table 8: Measuring health costs savings from nature-based solutions (continued)

Project title, authors & location	NBS of interest	Health target	Health outcome	Health cost savings	Methods	Scalability
Woodland improvements in deprived urban communities: What impact do they have on people's activities and quality of life? Ward Thompson et al., 2013, Glasgow, Scotland	• Nature Stewardship	• Quality of life • Well-being • Security	• 25% increased recreation in greenspace	• WIAT Cost $15/person • Mental health treatment cost $2,000/person	• Subjective well-being assessment; Quality of life survey before and after intervention	**Moderate** • Simple methodology; Health cost savings are less direct
Comparing the cost effectiveness of nature-based and coastal adaptation: A case study from the Gulf Coast of the United States Reguero et al., 2018 , Gulf Coast, U.S.	• Wetland and oyster reef restoration	• Disaster Risk Reduction	• Mitigation of the impact of coastal flooding	• Avoided costs of $57.4 billion in damages to 2030; • Estimate of 85% to 65% from NBS ($49B to $24B)	• CEAs; increasingly being used for NBS to reduce impact of climate change on human health • Revealed preference & market valuation (avoided costs)	**Moderate-high** • Partial measure of the impact on human health; linked to reduction in infrastructure damage
Economic Values of Metro nature health benefits: a life course approach Wolf et al., 2015, National, U.S.	• Urban vegetation and greenspace cover	• Increased exposure to restorative space and healthier urban environments	• Birth weight • ADHD • School perf. • Crime rates • CVD • Alzheimer's	• Avoided costs, cost savings and increases in income between $2.7 and $6.8 billion a year	• CEAs; avoided costs; human capital costs;	**Moderate-high** • Extensive consideration of direct and indirect valuations of human-nature interactions; uses the Life Course Framework for valuation • Limited data availability necessitated certain approximations, carries similar limitations to benefits transfer methods
Case Study: Downtown Urban Park, Peterborough, Ontario Wilson, 2020, Peterborough Ontario	• Park Development • Land Restoration	• Improve health and well-being	• Reduced mortality • Lower number of productivity days lost to illness	• $4.24M in annual benefits	• Market-valuation • Avoided costs • Human capital costs	**Moderate-high** • Partial valuation of potential health impacts • Canadian study; support available for replication
Case Study: Increasing Tree Canopy, Brampton, Ontario Wilson 2020b, Brampton, Ontario	• Canopy Cover	• Fewer very hot days	• Lower number of hospital visits • Fewer ambulance calls	• $2.5M to $3.2M of health system savings	• Revealed Preference • Market valuation	**Moderate-high** • Complex methodology; require large amounts of data • Does not take into consideration non-market value of health • Canadian study; support available for replication

4. KEY CHALLENGES

FOR INTEGRATING HEALTH CONSIDERATIONS WHEN USING NBS

There is strong evidence that the urban natural environment impacts health, and it is common for local government decision-makers to refer to this evidence in their planning. While a range of tools and instruments are available to measure ecological, health, and economic impacts of interventions involving NBS, they are infrequently applied and are being used in different ways at the project level, as highlighted in section 3. Analysis of the evidence base, municipal plans, and available guidelines and tools, reveals several key challenges to the integration of health considerations in NBS.

Details supporting and elaborating these challenges emerged from Smart Prosperity's workshop on NBS and health. Experts and practitioners from public and environmental health, as well as academia, local governments, provinces, and environmental NGOs, and some of the messages included below were discussed and informed by the experts participating in this event (Agenda in ***Appendix 5****).*

Overcoming these challenges will hinge on a multitude of stakeholders – public health practitioners, urban planners, parks and recreation staff, and others – adopting a more integrated approach to track performance, communicate across silos, and broaden the overall knowledge base.

4.1 Ongoing Challenges to Integrating Health Considerations

Health impacts are multi-dimensional. Decision-makers experience capacity limitations when evaluating the merits of NBS using a health lens for two main reasons:

- **Complexity in cause-effect relationships.** Health benefits from NBS are the result of multiple concurrent and intersecting pathways, which can be difficult to isolate.
- **Integrating equity considerations.** Integrating socio-economic and demographic considerations is crucial to ensure health benefits are equitably distributed among population subgroups. Continuous engagement is needed to support marginalized populations and promote feelings of security, inclusion, and belonging.
- **Local participation and fostering feelings of ownership are keys to success.**

Long term health benefits from NBS can make them less attractive than conventional approaches.

- Developing **natural infrastructure projects takes longer than traditional gray infrastructure,** which can cause challenges for decision-makers seeking quick delivery of benefits or projects that fit neatly in existing decision-making frameworks.
- In risk-averse decision-making environments the **limited visibility of short-term project benefits** may present political challenges. Furthermore, given the longer wait before benefits appear, evaluating NBS using a health lens represents an additional upfront risk for decision-makers in the absence of clear evaluation milestones.

Limited data availability, data gaps, and inconsistent application of metrics can significantly increase the transactions costs when identifying specific health impacts of NBS

- **Data collection and treatment.** Smaller municipalities face capacity limitations with data collection, whereas larger municipalities are often faced with more complex datasets and shifting socio-demographic profiles. In each case, external consulting firms often end up being responsible for the collection and management of local datasets, which do not end up in public databases, and favours the resource advantage enjoyed by larger municipalities.
- **Tool Selection.** Evaluation tools can be highly technical and improper selection may limit the scope of project planning without comprehensive guidelines to support decision-makers.
- **Choosing the Right Metrics.** There is no universal set of metrics for evaluating features of NBS, including size, density, quality, and type. Metric selection depends on the specific benefit pathways and type of natural infrastructure being examined, as well as local socio-demographic and geographic features.

Higher relative costs

- **Transaction costs of one-off projects.** Integrated management of the urban environment has been slow to develop at the local level. Adding a health lens beyond the usual mandate of local governments requires collaboration between urban planners, public health agencies and recreation departments, and continues to be primarily ad-hoc and focused on single projects.
- **Project development and monitoring costs**. NBS projects require multi-stakeholder collaboration, which takes time and money. The long investment horizon of these projects makes these costs particularly risky for decision-makers.
- **Lack of Guidance.** Multiple methods and instruments are available to evaluate the health benefits of NBS projects. However, in the absence of established guidelines that determine the appropriate discount rates and economic valuation instruments (discussed in Section 3.3.1), project costs may appear prohibitive, when the value of the project benefits (economic and otherwise) are not captured.

Collectively these factors make evaluating the full range of health benefits from NBS projects difficult. This may steer decision-makers towards more conventional projects (notably gray infrastructure) with lower up-front costs and more readily measurable and quantifiable impacts. It may also lead to health impacts being sidelined as secondary considerations when considering NBS, which could result in a *net negative impact* on community health. These challenges are reinforced when simplistic assumptions about greenspace and nature (e.g., more greenspace means better health outcomes) do not consider additional factors that lead to positive health outcomes (e.g., accessibility or usage patterns), as well as how benefits are distributed and how NBS projects may influence other social determinants of health.

4.2 Gaps in Project Design

There are persistent gaps that limit the integration of health considerations in NBS project design. They range from data gaps (e.g., insufficient ecological or health data to draw from), policy gaps (e.g., lack of institutional structure to connect benefits to those bearing the cost) procedural gaps (e.g., the improper selection of evaluation tools) to knowledge gaps (e.g., a lack of Canadian case studies to share learned experiences and establish best practices). In this section we will discuss how these gaps influence quantification of health benefits.

Quantifying Health Benefits and Health-related Cost Savings

The most common project evaluation methods do not capture costs savings generated by environmental, social, economic, and health benefits.

Traditional accounting methods do not capture the full scope of benefits

Gray infrastructure project accounting methods like CBAs have become the most common for evaluating the health lens of NBS. Since health considerations are not part of standard CBA, NBS are at a disadvantage when decision-makers are considering viable interventions to build healthier communities.

Cost effectiveness (CEA) or Cost utility (CUA) analyses better account for the full scope of NBS benefits.

CEAs and CUAs can evaluate benefits based on a desired health-based unit of improvement – e.g., the cost of street trees compared to other interventions with the aim of reducing the incidence of skin cancer. An overview of the available project accounting techniques is available in **Table 5**, section 3.3.1.

Availability and Accessibility of Relevant Data

Limited access to local and longitudinal data limits the ability to integrate health considerations when designing, planning, implementing, and evaluating NBS projects in Canada.

Cross-sectional approaches limit accounting for long-term impact when most health benefits accrue.

Most studies that examine the health impacts of NBS are cross-sectional. These methods are more effective for mapping an overall reduction in health risks in a fixed moment of time, but they pose a challenge when evaluating long-term health impacts. Cross-sectional studies are also less capable of capturing changes in socio-economic and demographic factors that mediate the potential health outcomes of NBS. The limited number of longitudinal studies prevents a deeper understanding of the complex relationships between the natural urban environment and community health in Canada.

Limited Local Data

A lack of local data makes it hard to credibly identify both baseline health impacts and potential project benefits. The consequential lack of additionality in terms of health impacts makes it difficult to justify devoting project resources to track these outcomes.

Few Canadian Studies

A lack of Canadian examples, and the low visibility of NBS as a solution to support healthier communities, continues to limit consideration of NBS in many jurisdictions across the country. With most studies drawing on the experience of Western European and Southern U.S. cities, questions remain concerning the applicability of methods and findings in Canada.

Jurisdictional Challenges – Capacity and Mandate

While many investments in NBS are part of local government planning or take place in partnership with cities, health is primarily within provincial jurisdiction. Mainstreaming NBS beyond parks and recreation to include infrastructure, procurement and other departments is already a challenge. When health is not part of the local mandate, and the cost savings accrue at the provincial level, one can see why health can become a secondary or tertiary consideration.

"Health" is a limited mandate for the majority of local and regional decision-makers

Local public health authorities and local government departments that focus on infrastructure, including transportation and urban planning, are limited in their capacity to address environmental health concerns in their communities. Even though many of these public health authorities and governments are directly responsible for addressing the environmental health needs of their communities, they are faced with a narrow mandate for delivering local health services which precludes their effective participation in directing environmental health policy that takes place at the provincial/territorial level. This limits the capacity of local stakeholder to engage in collaboration across jurisdictions and effectively funnels resources towards local projects that are only nominally able to address environmental health objectives, even if there is a shared agreement about the need to consider health outcomes.

Institutional support is required to facilitate cross-departmental and multi-scalar coalition building

There are persistent issues with coordination and integrated management for projects that involve NBS. From the outset, these projects typically require substantial coordination across multiple departments and various levels of government. In the absence of established institutional structures and mechanisms to foster coordination, gathering the right stakeholders to design and implement NBS projects using a health lens will continue to have a greater cost than most local and regional governments can afford.

Greater cross-jurisdictional collaboration is needed to foster collective action

Coalitions of specialized stakeholders are often responsible for advancing conversations that connect health, climate, and nature. While these advocates can drive discussions forward, collaboration across departments and disciplines is critical to support greater action and investment. Overcoming these challenges will hinge on a multitude of stakeholders – public health practitioners, urban planners, parks and recreation staff, and others – adopting a more integrated approach to track performance, communicate across silos, and broaden the overall knowledge base.

5. NATURE AND HEALTH:

INNOVATIONS AND OPPORTUNITIES

Exploration of the Canadian context has shown an emphasis in the role of NBS in health and healthy cities, a range of strategies, plans, and tools to integrate and consider health outcomes from NBS, but also significant heterogeneity. A workshop series hosted by the Smart Prosperity Institute further highlighted the range of stakeholders from public health, local governments departments, ENGOs, and academia that are confronting these issues in various ways (See **Appendix E** for SPI workshop agenda). This work emerged from the acknowledged need to collate and consolidate evidence, strategies, and tools, to identify leading examples as well as highlight opportunities and innovations that may scale the integration of health considerations into NBS. The need is more pressing particularly considering investments in NBS being anticipated as pillar of national economic recovery plans, where improving capacity to consider the health lens could optimize investment outcomes in NBS.

Despite the challenge of pinning down the exact contribution of NBS to individual health outcomes, it is possible, and must start with the identification of environmental health factors during patient intake and throughout service delivery across the Canadian health system.

Emerging from this synthesis we point to several areas of opportunity. They are far from exhaustive but serve as a starting point to promote more cohesion and strategic alignment among the already engaged stakeholders in the space, as well as those seeking appropriate tools and entry points relevant to their context. In this section we:

- Highlight existing policies/strategies that have shown promise/results, or are worth exploring further;
- Point to capacity building programs or strategies that can support advancement, based on the analysis of gaps and challenges;
- Outline several research pathways/opportunities surfaced by this work.

5.1 Policy Innovations and Opportunities

Empowering Local and Regional Governments to Act With a Clear and Expanded Mandate

In the absence of established legislative structures and institutions that encourage local and regional governments to engage in what can be a costly and time-consuming process, health considerations are not integrated early or often in nature-based project development. Two provinces have an explicit health mandate for local and regional governments, raising the profile of community health considerations, and enabling action at the local level.

In **British Columbia** health considerations at the local level are embodied in a partnership between the Ministry of Health and BC Healthy Communities, which supports the creation of healthy communities under the PlanH program. The program emphasizes the impact of local and Indigenous government decision-making on health and well-being and aims to provide these governments with funding, planning support, and other tools and resources to promote equitable built and social environments.

In **Quebec**, health and well-being is embedded in local community development, which provides local and regional governments with a mandate for health considerations in developing their urban planning strategies. The environmental health agenda is set by the provincial health authority (INSPQ) under the *Loi sur l'aménagement et l'urbanisme,* which mandates the integration of creating a healthy environment in community planning.

Hospitals and Health Care Providers: Tracking Health Data to Environmental Influences

Many factors influence individual health outcomes. For example, mortality from cardiovascular disease can be influenced by genetics, obesity, lifestyle choices and habits, in addition to environmental factors including air quality, soundscape quality, and extreme temperatures. Evidence shows that the negative impact of each of these factors can be mediated by greater access to greenspace, with positive affects drawn largely from increased rates of physical activity and greater exposure to restorative natural spaces from engaging in outdoor recreation. Since most studies examine how NBS influence the overall incidence of disease – in this case, mortality from cardiovascular disease – it can be difficult to attribute the extent NBS can enhance individual health outcomes.

Despite the challenge of pinning down the exact contribution of NBS to individual health outcomes, it is possible, and must start with the identification of environmental health factors during patient intake and throughout service delivery across the Canadian health system. This means providing an option for physicians and nurses on the front line to track and report environmental health factors that contribute to rates of mortality and morbidity – which is crucial for understanding the trajectory around environmental health issues – and actively working to mainstream the social determinants of health for developing effective health policies that actively integrate the geo-physical features of different local communities.

Taking an example from the recent COVID-19 pandemic, a similar reporting challenge arose with tracking mortality and morbidity rates attributed to the virus. Initially, increases in mortality and morbidity were attributed to the exacerbation of existing cases of pneumonia, COPD, or other respiratory illnesses, even though COVID-19 was primarily responsible for the acceleration of negative health outcomes. In these cases, the presence of confounding co-morbidities limited the capacity for local health authorities to accurately track and report on the evolving health impact from COVID-19, which led to a delayed public health response. This phenomenon highlights the potential for declines in environmental health resulting from climate change to be similarly under reported in the absence of established local data collection frameworks.

In the wake of COVID-19, many hospitals changed their reporting metrics to account for the virus playing a role in increasing rates of morbidity or mortality, despite the potentially confounding presence of existing and worsening co-morbidities[141]. The change in diagnostic reporting underlined how deeply COVID-19 was affecting rates of morbidity and mortality, which provided crucial insight into the wider impact of the virus on overall community health. A similar approach for environmental factors would provide valuable data to improve reporting on the positive and negative influence of the urban environment on health – both individually and collectively – and limit the potential for an increase in health inequity due to the impact of climate change.

Environmental health tracking of this nature has been piloted in Quebec under the *Policy on Health and Well-being*, which includes reporting on environmental health, infectious diseases and factors that determine social inequities in health during patient intake[142]. Relevant environmental health indicators are selected by a panel of experts in accordance with the objectives established by INSPQ regarding environmental health in the province. Of the 26 environmental health indicators reported, 17 are related to environmental exposure and 9 are linked to health status data[143]. Given the similarity of regional public health structures, this approach is relatively easy to scale across other jurisdictions in Canada. Success would hinge on the participation of expert stakeholders to identify regionally relevant environmental health indicators, the buy-in from front line health workers to report on these indicators and increasing local awareness to ensure accurate self-reporting of environmental health issues among community members.

Investing in Multi-stakeholder Programs and Partnerships

Public policy relevant to health, climate, and environmental conditions is fragmented. By creating and leveraging well-integrated vertical knowledge networks that include regional public health authorities (e.g. local governments in Quebec supported by INSPQ and frontline health works), health-based and environmental NGOs, and small coalitions of expert stakeholders, several regional partnerships and thematic associations have demonstrated how working together on NBS and health can lead to new programs and projects that are reflective of local needs, as well as supporting the creation of tools and resources to move these projects forward.

EcoHealth Ontario (EHO)

EHO is a collaborative network made up of regional health units, public health associations, academic partners, conservation authorities, and environmental NGOs. By building professional knowledge, developing resources, and piloting NBS projects with health outcomes, they seek to build public awareness around eco-health, increase the number of local greenspaces, expand usage and access to high quality greenspaces, build climate resilient communities, and increase the overall health and well-being of Ontarians. Their framework tool highlighted in section 3.3.2 illustrates the type of resources created by their network in support of making the business case for NBS investments with health outcomes in mind.

BC Healthy Communities

BC Healthy Communities is a non-profit organization with support from multiple government agencies. They provide resources, programs, funding, and services to improve impact assessment and support provision of healthy built, natural, and social environments. Their interdisciplinary team also works directly with local governments to support equity and engagement planning and program design. Their freely accessible resource catalogue includes guidance and frameworks with a specific emphasis on equity.

Health institutions and medical associations are also well-equipped to call for support, promote standards, and develop guidance to support the health care community in considering the role of NBS in health outcomes, and supporting the NBS community to consider a health lens in their work.

Canadian Association of Physicians for the Environment (CAPE)

CAPE released a research report to support the case for investment in a healthy recovery, addressing specific issues associated with climate change[6]. Of the 25 recommendations three focused specifically on NBS, and are aligned with the evidence base established in part 1 of this report:

- Work with provincial and local governments to invest in urban tree cover, new urban greenspaces, improvement and expansion of existing urban greenspaces, park trail upgrades, and green corridors;
- Invest in initiatives that enhance the accessibility and quality of our national and provincial parks systems;
- Invest in a broad range of measures that preserve, manage, and restore our natural ecosystems.

Research developed specifically for the CAPE report estimates that 112,081 lives could be saved in Canada between 2030 and 2050 from improved air quality, if Canada is able to meet its climate targets[7]. Like many studies highlighted in **Table 8**, this is only a single dimension (improved air quality) when considering the potential pathways for enhancing human health by improving the urban environment. Consequently, this research – as acknowledged in the report – is only a partial estimate of the potential benefits from building healthier urban environments. CAPE's recommendations can serve as a focal point for future collaboration since further research and investment is required to better understand how different benefit pathways intersect with human health in Canadian communities.

National Collaborating Centre for Public Health (NCCPH)

Six National Collaborating Centres (NCCs) funded by the Public Health Agency of Canada (PHAC) provide evidence-based resources to support public health in Canada.

- National Collaborating Centre for Healthy Public Policy (NCCHPP)
- National Collaborating Centre for Methods and Tools (NCCMT)
- National Collaborating Centre for Infectious Disease (NCCID)
- National Collaborating Centre for the Determinants of Health (NCCDH)
- National Collaborating Centre for Indigenous Health (NCCIH)
- National Collaborating Center for Environmental Health (NCCEH)

NCCEH focuses specifically on health risks associated with the physical environment to support the work of environmental health practitioners and policy makers. The NCCEH translates and mobilizes knowledge across four thematic areas: climate, food, water, and the built environment.

In contrast to the traditional risk mitigation focus of environmental health – e.g., reducing air pollution, exposure to pollutants, and risks associated with climate change – the proactive *public health perspective* used by NCCs is better able to integrate human health factors when considering NBS. This type of perspective captures both positive and negative health impacts of a project proposal, focuses on community health promotion and evaluates the determinants of health using standardized HIAs (Section 3.3.2). The network of interdisciplinary NCCs may also provide a roadmap for initiating and encouraging the collaboration of required stakeholders from different professions, levels of government, and areas of expertise to facilitate the integration of health considerations in projects using NBS.

Advancing Asset Management to Incorporate Health Dimensions in NBS Planning

Municipal Natural Assets Initiative (MNAI)

The Municipal Natural Assets Initiative's framework and tools support local governments in conducting Natural Asset Management to analyze and catalogue the contributions of ecosystems to core municipal service delivery. The framework follows a similar process for analyzing engineered assets that cities and towns account for as part of their financial planning and asset management programs. This allows these communities to understand the contributions and economic values provided by a range of ecosystem services, such as water retention and stormwater management, carbon sequestration, and other dimensions of climate resilience. The MNAI model brings together all municipal departments affected by ecosystem service delivery, provides appropriate metrics, and presents resulting data in ways that are meaningful to practitioners making natural asset investment and planning decisions.

MNAI has not yet integrated dimensions of health associated with natural assets, although moving forward with this type of initiative would create a standardized model that could be readily integrated, applied, and scaled to measure the influence of natural assets on health across Canada. More research is needed to determine exactly which metrics would be the most important to capture in such a process, but Natural Asset Management is a viable method through which health considerations can be integrated alongside other benefits associated with natural systems.

5.2 Capacity Building

Cross-jurisdictional Collaboration

Addressing gaps highlighted in Section 4 will require a considerable effort to establish best practices for local and regional decision-makers and reduce risk and transaction costs of integrating and accounting for health when executing NBS projects. Integrated management structures that can coordinate value assessments of natural infrastructure, health outcomes, and urban planning at various scales will be an integral development for many local governments across Canada that are currently considering the benefits of NBS without the support of expert stakeholder steering committees.

Practical Guidelines to Support the Integration of Academic Evidence at the Project-level

Developing a step-by-step guide to walk project planners through the available evidence, and link specific health impacts to different types of natural infrastructure, could help bridge the gap between a focus on the accuracy of measurements in the literature, and how these assessments can be successfully applied at the project level to establish a business case and more projects forward.

Tool Selection and Standards

A variety of measurement tools, ranging from vegetation indices to self-reported health data, have proven to be effective in measuring a particular dimension of NBS and associated health benefits. However, matching the correct tools or processes to measure specific health benefits continues to present challenges. Standardizing measurements and processes, and developing best practice guidelines for tool selection, can help reduce transaction costs for integrating health considerations, making these types of projects more accessible across a variety of resource settings.

Harmonize Strategies and Develop Best Practices

Multiple integration strategies are being used across the country to mainstream health considerations when using NBS. Vulnerability assessments, climate resilience strategies, and health impact assessments are all being applied with varying levels of success, creating challenges for decision-makers when considering the best option for creating a process that can integrate health considerations into decision-making.

Alignment of Appropriate Funding Streams

Benefits of NBS are diffuse and not easily accounted for in traditional economic structures. Even when dollar values can be placed on benefits to ecosystems and the corresponding health impacts, there remains the challenge of who pays. Health cost savings primarily benefit provincial budgets, though how much can be attributed to NBS is rarely tracked. Ideally project developers at the local level could incorporate anticipated health cost savings associated with natural infrastructure, parks, or other greenspace to attract funding from federal or provincial budgets. Currently, no discrete funding mechanisms exist to address this jurisdictional incentive gap, though there is opportunity for innovative policy or program design.

Leadership

Associated with the funding challenge is acknowledgement that addressing multi-sectoral and multi-jurisdictional impacts requires leadership. Both Environmental and Public Health issues are relevant to NBS, though are handled through distinct agencies and institutional arrangements. Many challenges and proposed solutions involve integration and systemic changes. No single institution has a mandate to set an agenda of research priorities, capacity building support, and other guidance and resources to address challenges and gaps highlighted in this report.

5.3 Research Pathways

Several interesting questions beyond the scope of this report emerged through this work that we highlight as relevant paths forward to advance research and implementation at the nexus of health, nature, and climate.

Canada-Specific Needs

Assessing existing data. Case studies using Canadian datasets present an opportunity to replicate studies from other jurisdictions to better understand the relevance of international findings to the Canadian context, while also assessing existing data access, gaps, and pressing needs.

Increasing the number of Canadian studies. More local case studies are needed to raise the overall profile of NBS as cost-effective and advance these types of interventions as efficient methods to improve human health that are well adapted to the Canadian context.

Tracking the Right Data. Much of advancing the case of NBS in Canadian communities involves developing appropriate systems to define and track specific impacts on health and urban ecosystems at different scales and for different population groups. For this the following questions need to be answered:

- How are health impacts from NBS being measured at the provincial and national level? What are the main challenges for measuring these impacts at each level?
- How should data be managed for provincial health authorities to inform local planning decisions? Who should create and oversee the system?
- How can hospitals and health care providers be motivated to track environmental data? What are the best methods and practices to do so? How can the Quebec environmental health model be applied to other Canadian provinces and territories?

Examining the Right to Nature in Canada. The idea of a fundamental Right to nature and living in a healthy environment is gaining traction in some Canadian policy circles.

- Further research is necessary to understand how these Rights would translate into best practices and environmental policies for urban design – e.g., minimum standards for Canadian per capita greenspace.
- Environmental rights are central to the concept of cultural dignity for many population groups and would require more research to understand how socio-cultural issues are affected by varying levels of access to nature.

- An emphasis should be placed on examining this line of research within the principles of Reconciliation to highlight the emerging evidence of the psychosocial impact on Indigenous people living in high density urban areas.

Examining how NBS and health interact at different levels: local, regional, and national

- What are examples of programs/resources/strategies that have facilitated inter-jurisdictional action? Are there examples from outside Canada that may apply here? Are there examples within Canada that can be expanded across the country?

- Is there a role for private sector actors? If so, what? e.g. Can the environmental health business case attract financing for natural infrastructure projects?

Engagement and Collaboration

- What strategies are being used to engage local communities and encourage their participation and stewardship of NBS? Does a health lens increase or otherwise change engagement patterns?

- What types of coordination challenges exist for integrating health considerations in NBS decision-making? What types of strategies have been used to ease these challenges?

- What lessons can we learn from existing NBS initiatives to better promote interdisciplinary collaboration and improve on existing decision-making frameworks?

- How can public health and environmental health research efforts work together?

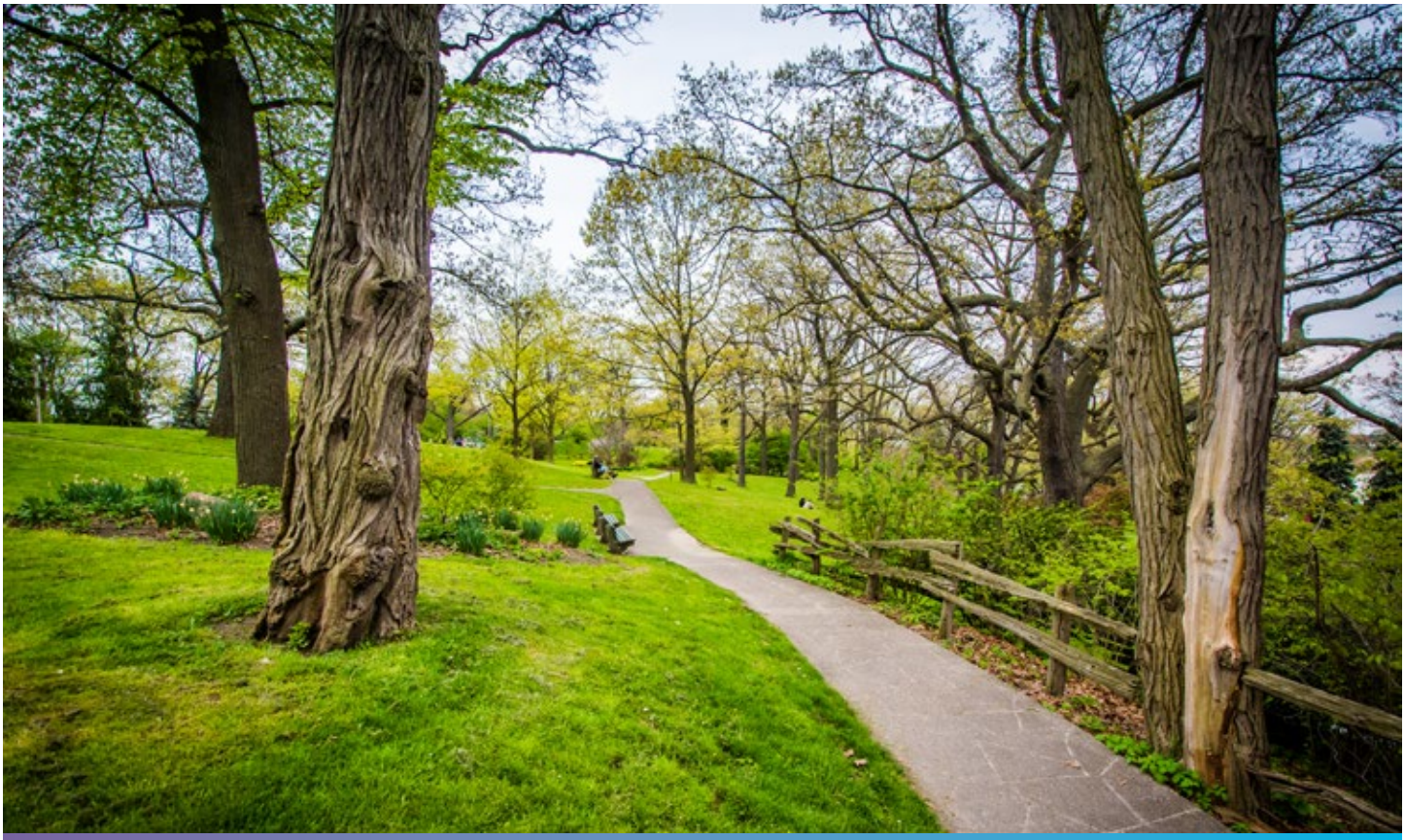
Dimensions of Health Equity

Assessing the distribution of health benefits. Broader social, environmental, and economic determinants of health need to be considered within project and local impact assessments and adopting a health equity lens is essential to understanding how benefits are distributed throughout the project life cycle and to ensure a fair distribution of co-benefits. For this the following needs to be taken into consideration:

- How can we ensure health benefits are accessible and equitably distributed within communities?

- How can we ensure marginal populations and disadvantaged communities experience feelings of belonging, attachment, and inclusion in urban greenspaces? What drives changes in these feelings for different communities? How can data collection be designed to accurately report on these variables for project planning?

- The high level of variation of health benefits from NBS based on gender differences necessitates GBA+ analyses being mainstreamed in local project planning. Integrating GBA+ considerations simultaneously with health impacts is crucial to ensure that gender dynamics of different outdoor spaces are considered when evaluating the distribution of community health benefits.



6. CONCLUSION

Natural systems in Canada produce a range of benefits that can build community resilience – including limiting the prevalence of non-communicable diseases, limiting exposures to harmful pollutants, and mitigating the impacts of climate change. However, quantifying these benefits and attaching an economic value at the project-level are difficult and continue to limit the use of nature-based solutions as resilience-building tools that generate positive health outcomes. The result among Canadian policymakers is a recognition of the importance of urban nature for building community resilience, while simultaneously acknowledging the limitations on the ground for integrating health consideration in investments in nature. This is due to 1) a lack of clarity around the causality of health benefit pathways, the availability of Canadian studies, and the structure of local datasets; 2) inconsistent accounting methods for the economic value of health and other co-benefits of urban nature; and 3) a heavy reliance on ad-hoc working groups that are institutionally fragmented by sector-focused ministries and government departments.

This report has demonstrated many tools that support the business case for using NBS and represents an opportunity for significant health costs savings – identified in the case studies we examined to be between $3-4 million annually at the local level and estimated elsewhere to be up to $100 billion nationally.

Over the next 15 years, Canadian communities will become increasingly dependent on the benefits that natural urban ecosystems can provide to improve physical and mental health outcomes. With substantial investments in natural infrastructure anticipated as part of the economic recovery efforts in response to COVID-19, local communities across Canada are facing an unprecedented opportunity to enhance climate resilience and overall well-being in their communities. A growing importance of environmental health, as well as the public health benefits of a healthy environment, have led to many local and regional governments in Canada consider the role of NBS to address health, nature, and climate challenges.

Despite growing interest in the connection between urban greenspaces and health outcomes, a few critical knowledge gaps remain. Quantifying health benefits derived from specific aspects of urban nature remains a challenge for securing adequate funding to advance projects that account for these benefits at the local level. Health equity and the social determinants of health add further complexity when evaluating how NBS co-benefits are distributed among different population groups.

Although challenges persist, strides are being made to reinforce the case for NBS to produce measurable improvements to health outcomes across Canada. This report has demonstrated many tools that support the business case for using NBS and represents an opportunity for significant health costs savings – identified in the case studies we examined to be between $3-4 million annually at the local level and estimated elsewhere to be up to $100 billion nationally by 2050[7,155,156]. By providing a better understanding of existing environmental health initiatives, we have identified several opportunities to improve coordination and build local capacity for integrating health considerations in NBS project planning. Of these opportunities, we identify three key priorities for accelerating the integration of environmental health considerations in local and regional planning:

1. Empowering local governments to act on health with a clear and expanded mandate

Quebec and British Columbia have provided an explicit health mandate for local governments, raising the profile of community health considerations, and enabling action at the local level. Better understanding the experiences in these jurisdictions and drawing on the lessons learned could enable a greater scaling out of nature-health-climate considerations to local governments in other jurisdictions.

2. Harmonizing strategies and develop best practices

Vulnerability assessments, climate resilience strategies, and health impact assessments are all being used with varying levels of success. In the absence of national standards, the diversity of approaches creates challenges for decision-makers when considering the best option for designing processes that integrate health considerations in local decision-making. Developing comprehensive national standards and best practices will be integral for taking the next step toward the widespread integration of health considerations at the project level.

3. Aligning institutions and funding streams to target the health-nature-climate nexus

Public policy institutions and funding mechanisms addressing the nature-health-climate nexus are fragmented. Understanding the role of provincial and territorial health authorities and how these networks connect local communities to national funding streams will be key to fostering more integrated management strategies. Investing in the creation, expansion and formalization of vertical knowledge networks will be necessary to support the creation and distribution of effective tools and resources to move projects forward. The success of these networks will hinge on the development of sufficient institutional mechanisms to support ongoing collaboration between regional public health authorities, health-based and environmental NGOs, and small coalitions of expert stakeholders.

Equipped with the right tools, further research in a few priority areas, and comprehensive guidelines to support the design, development and monitoring of local NBS projects, local and regional governments will be well placed to conserve and restore their natural assets to build healthier communities that are accessible to everyone for years to come.

APPENDIX 1: LITERATURE REVIEW BACKGROUND

To guide our initial scan of the literature, physical activity, relaxation and well-being, and climate change were initially identified as the major benefit pathways acting between NBS and their corresponding health co-benefits. Additional pathways of community cohesion and environmental exposure emerged as themes and were added in the review process. Although the full range of health impacts from urban nature and greenspaces is beyond the scope of this review, an effort was made to include a mixture of resources from the fields of environmental and social sciences, medical and public health, and urban planning, in addition to drawing resources from widely used, multidisciplinary databases to ensure a diversity of potential benefits, perspectives, and proposed pathways. **Table 9** details the databases included as part of this review.

In addition to these databases, existing health guidelines, reports and other gray literature were examined to evaluate the general knowledge and understanding among decision-makers regarding the potential health benefits of using NBS. This included, but was not limited to, reports prepared by the World Health Organization, the European Environment Agency, the Public Health Agency of Canada, the Canadian Public Health Association, and other public health agencies and environmental advocacy organizations at various levels across Canada.

Table 9: Databases included as part of the literature review for this report

Database name	Field	Relevance
CAB Reviews	Environmental Sciences	Animal and veterinary science, agriculture, applied plant sciences, environmental sciences, and nutrition & food science.
CINAHL	Medical/Public Health	Authoritative resource for nursing and allied health professionals, students, educators and researchers
Cochrane Library	Medical/Public Health	The Cochrane Library consists of a regularly updated collection of evidence-based medicine databases, including The Cochrane Database of Systematic Reviews, which provide high quality information to people providing and receiving care.
GreenFILE	Environmental Sciences	Multidisciplinary in coverage of environmental sciences, focusing on topics such as agriculture, education, law, health, and technology
EMBASE	Medical/Public Health	Major biomedical and pharmaceutical database
Environmental Impact	Environmental Sciences	climate change on the terrestrial and freshwater biosphere, mitigation strategies and adverse influences of humans on the environment.
Environmental Studies & Policy Collection	Environmental Sciences	Covers environmental issues and policies, including diverse perspectives from the scientific community and governmental policy makers, as well as corporate interests.
ProQuest - Databases	General/Interdisciplinary	Includes APA PsychInfo; PAIS Index and others
PubMed	Medical/Public Health	National Library of Medicine collective database - MEDLINE
ScienceDirect	Scientific	More than 11 million full-text peer-reviewed journal articles and book chapters from the core scientific literature
SCOPUS	General/Interdisciplinary	Covers science, technology, medicine, social sciences, arts and humanities
Web of Science	General/Interdisciplinary	Key research journals in Science, Engineering, Medicine, Social Sciences, and Humanities

APPENDIX 2: BENEFIT PATHWAYS LINKING URBAN NATURE AND HUMAN HEALTH

Community Cohesion

Social activities in greenspaces can improve both physical and mental health outcomes. Several studies identify feelings of individual attachment[28 1], security,[2] and inclusion[43 58] as the primary factors that encourage the use of greenspaces for recreation and socialization, and encourage community members to adopt healthier lifestyles. For example, European studies by Van Der Jagt et al. (2017) and Vujcic et al. (2017) identify community gardens as being important for the physical and mental health of women under 65. In both cases, these benefits were shown to be dependent on greater community cohesion through established governance structures that encouraged equitable participation in stewardship of these spaces. Orstad et al. (2020) identifies that greenspaces in New York City that elicit greater feelings of community cohesion, security, and belonging are equally as important as those designed for physical activity in terms of their potential health benefits.

Physical, mental, and social health outcomes that result from greater community cohesion are disproportionately beneficial for marginal populations including women, children, seniors, people of colour, and people living with disabilities[51 58 70]. Lee and Maheswaran (2011) and a Danish study by Thomas (2015) identify feelings of exclusion from existing health issues, such as chronic illness, obesity, and disability – as well as feelings of insecurity due to potential conflicts around gender and culture – as being significant determinants when evaluating potential health benefits from exposure to urban greenspaces. Studies by Sander et al. (2017) and Tsai et al. (2020) in the U.S. similarly identify feelings of inclusion and security as predictors of greenspace visitation among women. In both cases, these patterns were triangulated with the presence of specific park amenities that promote both physical and social activities – e.g., trails, water fountains and accessible areas for socialization (benches, picnic tables, etc.).

Social activities in greenspace significantly reduce the severity of age-related morbidity. Greater exposure to urban greenspaces for social activities is widely identified as having a protective effect against age-related health decline[48,66,88]. Greenspaces that promote community cohesion can lead to increased use of these outdoor spaces for physical activity, relaxation, and socialization – all of which can provide numerous health benefits for middle-age to older adults by contributing to building a local community that encourages a healthier and more active lifestyle[67]. A study by Brown et al. (2016) in the Southern U.S. suggests that socializing in greenspaces can be correlated to a reduction of 49 chronic illnesses per 1,000 individuals aged 65 and over – including a reduced risk of diabetes, hypertension and hyperlipidemia (high cholesterol). Further studies by Van Der Jagt et al. (2017) in Europe and Becker et al. (2019) in the U.S. identify greenspaces that stimulate greater feelings of inclusion and belonging as sources of good health for seniors.

Urban greenspaces that accommodate cultural activities can have a significant positive impact on feelings of dignity and inclusion, while also furthering Reconciliation. Studies by Books-Cleator et al. (2016) and Senese and Wilson (2013) identify the importance of fostering community cohesion in urban greenspaces to establish these areas as safe environments for cultural activities and socialization. The study by Sense and Wilson (2013) ties Indigenous land rights to health by examining feelings of exclusion among Indigenous people living in Canadian cities, and how being disconnected from culturally safe outdoor spaces can negatively impact psychosocial health.

Physical Activity

Greenspaces provide opportunities for physical activity, which has a direct positive effect on physical health. Several studies have shown that greenspaces have significant impacts on physical health by increasing levels of physical activity[9 2], reducing inactivity in children[49] and promoting active lifestyles for seniors[34 66]. The health benefits associated with physical activity in urban greenspaces include a reduced risk of cardiometabolic diseases[12 13 57] and a reduction in many underlying risk factors including, high blood pressure[78], airway and vascular inflammation[85 98] and lower rates of obesity and malnutrition[18].

Physical activity in greenspaces has additional benefits for mental health. Exercise in greenspaces has been shown to provide additional mental health benefits, such as reduced stress and anxiety, compared to similar physical activity in non-green environments[24,98]. Several studies link the physical activity pathway to additional mental health benefits, including a reduced risk of mood disorders[45], a lower risk of impulsive decision-making and poor eating habits[5 6], and less risky behaviours that impact well-being[46]. A review of Canadian studies by Zanchetta et al. (2017) identify the importance of physical activity in nature as a vital pathway to improve mental health for men at an increased risk of social isolation. A study by Thomas (2015) in Denmark identifies similar impacts for women, highlighting that physical activity in urban greenspaces improves mental health due to opportunities for increased self-reflection, restoration and socializing.

Physical activity in urban greenspaces is also an important contributor to social health. Tsai et al. (2020) identify a 10% increase in a neighbourhood in the U.S. as increasing the odds of women self-reporting better overall health that can be explained by increased levels of physical activity stimulating

greater social cohesion among residents. A longitudinal study in Australia by Putra et al. (2020) identifies a similar importance of physical activity in nature for the psychosocial development of children. The study identifies different types of greenspaces as are more beneficial for young boys (sports fields) and young girls (private yards and parks with water features), but also points to physical activity in shared greenspaces as having a long-term effect of reducing egocentrism and increasing the willingness to collaborate.

Subjective features influence how often greenspaces are used and by whom. Features such as the extent of the urban tree canopy, green buffers along roadways, the patch size of grassy areas and the proximity of parks and recreational trails to busy roadways have all been shown to be important factors for influencing patterns of physical activity[55 69 78 102]. These features can also be highly predictive of both the user and usage type of different greenspaces. A study in Leipzig, Germany identifies established parks with mature vegetation to be preferred by people over 65, whereas new parks and sports fields are visited more by youth, children, and young adults[150].

Physical activity has additional positive health effects when performed in nature. Natural experiments by Olafsdottir et al. (2017) and De Brito et al. (2020) identify physical activity in nature as having additional health benefits that arise independently from those that simply come with being more physically active. These studies identify that physical activity in nature carries additional benefits for heart rate variability (HRV) that can improve long-term health.

Relaxation & Well-being

Spending time in nature improves feelings of well-being and elevates reported levels of life satisfaction. Health benefits attributed to the relaxation and well-being characteristics of urban greenspaces include, improved HRV and vascular functioning[98 105]; lower risks of cardiovascular diseases and the underlying risk factors of hypertension and high blood pressure[92 94]; and a lower incidence of risky behaviours and impulsive decision-making[38 40 47 105]. Perceptions of greenspace quality[28, 08]; the integration of surrounding roadways and gray infrastructure[36 37 151]; walkability and ease of access[40 69]; and feelings of security and value attachment rooted in the principles of equity, diversity and inclusion are key determinants on the relaxation potential of different urban greenspaces. Feelings of security and value attachments are shown to be particularly important for vulnerable population groups, including women, children, seniors, people of colour and people living with disabilities[33 41 57].

Quiet, calm, and safe surroundings influence the frequency and impact of physical, social, and mental health benefits derived from urban greenspaces. Goon et al. (2020) identify the presence of 'social disorder' in and around urban greenspaces (e.g., loud traffic, perceptions of threats, feelings of security etc.) as limiting the frequency and vigor of outdoor recreation patterns among children in Saskatoon, Saskatchewan. Several additional studies similarly point to higher levels of social disorder as having a significant mitigating factor on the physical health benefits of urban greenspaces by limiting the frequency and duration of visitation[27 52 70 108]. These studies identify that assessing social disorder in urban greenspaces can be either objective (i.e., crime rates) or subjective (i.e. feelings of inclusion). Studies from Canada, Europe and Australia identify subjective evaluations of social disorder as being more effective for evaluating health benefits from urban greenspaces by capturing the equity of distribution for different population groups[17 43 65].

Environmental Exposure and Climate Change

Trees, parks, and natural areas reduce exposures to harmful pollutants and mitigate negative impacts of climate change. Greater abundance and proximity to urban greenspaces is widely identified as being correlated with positive health impacts caused by reducing human exposure to harmful environmental pollutants[64 84 86 152] and reducing the severity of impacts from climate change[46 72 153]. More urban greenspaces and vegetation cover are shown to reduce negative health impacts from air pollution[4 48 84 109], noise pollution[44 92 94], and physical stress related to temperature extremes cause by climate change[46 75 154]. A systematic review by Rugel and Brauer (2020) identifies that sufficient evidence exists linking traffic related air pollution, urban noise pollution, and low greenspace cover to higher rates of morbidity from cardiovascular diseases, and increased mortality from traffic related air pollution. Studies by Paul et al. (2020), Nowak et al. (2018), Crouse et al. (2017), and Villeneuve et al. (2012) illustrate that these correlations persist in the Canadian context. The former links more greenspace to lower risks of dementia and ischemic strokes, and the latter a reduced risk for all the major underlying drivers of mortality and morbidity from NCDs, including cardiovascular diseases and respiratory illnesses.

Vegetation type and density, and the frequency of exposure influence the potential physical and mental health effects of NBS.[7 10 16 77 78] A review by Hartig et al. (2014) and a Canadian study by Nowak et al. (2018) identify urban trees as having a significant impact on reducing the health impacts of air pollution. However, Hartig et al. (2014) and an English study by Alcock et al. (2017) also point to the potential for higher density in the urban canopy to create an 'urban canyon effect' that reduces the dispersion pollutants, which can increase negative health impacts from greater exposure. These studies point to tree species, leaf shapes and the integration of street trees within the broader urban landscape as crucial factors that determine impacts on human health. Canadian studies by Pinault et al. (2021) and Crouse et al. (2017) identify exposure patterns to urban greenspaces as being strongly linked to underlying socio-economic and demographic factors.

APPENDIX 3: ADDITIONAL PROJECT INSTRUMENTS & TOOLS

Project Design and Evaluation Tools

Climate Change, Health, and Equity Framework (CHEVA)

Developed by the American Public Health Association the CHEVA framework is intended to serve as a guide for local decision-makers seeking to better integrate issues of climate change and health equity in local planning. The guide provides a summary overview of the impact of climate change on health and health equity, connecting the impacts of climate change with the need to develop integrated strategies at the local level to improve environmental health.

Benefits

- The guidelines are comprehensive and offer decision-makers with a complete set of informational tools to support decision-making.
- The framework maps out the role of various public health actors and provides communication tools to support local messaging around the importance of health and climate change.
- Health equity and the social determinants of health are well-integrated.

Limitations

- The framework is designed for public health and health policy landscape in the United States.
- Specific focus on the intersection of climate change and public health; less well-adapted to address other issues of the built environment affecting health outcomes.

Proposed Application

- Although adapted for use in the United States, the CHEVA framework can provide Canadian decision-makers with certain foundational guidelines and information to support the integration of climate change and health equity in local planning.

WHO Regional Office for Europe (WHO-ROE) Health and Climate Adaptation Tool

In response to the growing costs from the negative health impacts of climate change, the WHO Regional Office for Europe developed a comprehensive tool to support members states in the integrated economic analysis of health benefits and from climate adaptation measures. The tool provides a step-by-step guide to estimate the health costs of climate change and determine the cost effectiveness of various sector-based adaptation strategies for improving health outcomes and providing health cost savings.

Benefits

- Precise and can be adapted to different local conditions, capacity limitations and data availabilities.
- A 3% discount rate is recommended to compare different adaptation strategies, which is aligns with the emerging best practices for considering NBS.
- The tool consists of written guidelines that can be adapted to different contexts and jurisdictions.

Limitations

- Originally designed for European Member states, the tool may carry default assumptions, figures and regulatory parameters that are not applicable to the Canadian context.
- The tool uses a comparative Excel spreadsheet as the primary output to compare the costs of different strategies. Using the guidelines to populate the spreadsheet should be acknowledged as time consuming with a high possibility for input errors.
- The tool is limited to the intersection of health outcomes with adaptation strategies to climate change; nature and nature-based solutions are not the primary focus.

Proposed Application

- These guidelines represent a valuable starting point for any government or stakeholder organization seeking to engage in an integrated analysis on environmental health impacts. Although designed for use in Europe, the parameters, guidelines and processes can be adapted to the Canadian context. The tool may be useful as a starting point for developing a similar set of Canadian guidelines.

Sustainable Asset Valuation (SAVi)

The Sustainable Asset Valuation (SAVi) instrument is an assessment methodology developed by the International Institute for Sustainable Development (IISD) that provides policymakers with the appropriate steps to develop a comprehensive valuation of NBS projects that includes environmental, social and economic costs, as well as any associated governance risks. Using a combination of system dynamics – tracking changes in complex systems over time – and project finance modeling, the SAVi instrument simulates changes in project costs based on perceived risks and externalities that may emerge over the project lifecycle, ultimately providing a dollar value based on the sustainability of the project being evaluated, in addition to perceived project co-benefits – e.g., dollar value of health benefits from improved air quality. The instrument is populated primarily with data drawn from the EU's Copernicus Climate Change Service initiative; however, the tool may be customized with datasets for specific projects. In evaluating the benefits of NBS, SAVi uses an eight-step process and is supported by IISD's technical guidelines developed to help policymakers select the proper data sources from across various disciplines in populating the simulation tool.

1. Project descriptions and business plans
2. Externalities and environmental, social and governance impact already identified and/or measured
3. Carbon footprints and greenhouse gas reduction plans.
4. Characteristics of the asset and material composition
5. Financial feasibility studies, including capital expenditure, fixed and variable operational expenditures, funding split (debt versus equity percentage), debt tenor, debt interest rate, project discount rate.
6. Technical feasibility studies including output/generating capacity, levelized costs, load factor and generating/operating efficiency. SAVi directly calculates these costs, but requires estimates for validation
7. Environmental and Social Impact Assessment
8. Pricing Strategy

Benefits

- SAVi simulations can be run at different stages in project planning – e.g., design, implementation and evaluation - and can provide effective support for decision-makers to track project co-benefits that might otherwise be outside the scope of more traditional valuation methods.
- Can be useful in the absence of better integrating health considerations as primary project objectives when using NBS – a major challenge noted in various local governments across Canada – SAVi represents a viable alternative to measuring the additionality of health impacts as specific co-benefits when using NBS.
- A recent example of a SAVi simulation in Pelly's Lake, Manitoba, aimed to value the co-benefits of using the natural infrastructure to promote recreation, improve carbon sequestration and reduce damage from flooding, compared to a nearby engineered reservoir. This example provides solid evidence that the tool is readily adaptable to measuring and evaluating the health co-benefits of using NBS in the Canadian context.

Limitations

- The simulations are highly technical and require an extensive amount of local data to ensure accuracy. IISD can provide decision-makers with support in developing the simulation, although in the absence of readily available datasets, the collection of necessary may be cost prohibitive in certain jurisdictions.

Proposed Application

- SAVi is useful for evaluating the health co-benefits of existing natural infrastructure and comparing value benefits with gray infrastructure alternatives.

Protected Areas Benefits Assessment Tool (PA-BAT)

The Protected Area Benefits Assessment Tool (PA-BAT) is a PDF/PowerPoint format tool for identifying the range of ecosystem services and other benefits (such as employment) supplied by a protected area. The PA-BAT uses a questionnaire approach in a workshop with a range of local stakeholders, representing different interest groups, to identify PA benefits. The tool includes a list of 24 benefits; the analysis of which are dependent on the type of PA being evaluated. PA-BAT includes nine different types of stakeholder groups integrated in the assessment framework, including Indigenous stakeholders, the local community and the wider global community. These groups can be selected based on different local conditions. Each benefit is classified as a minor, major and/or a potential benefit, and either as an economic or non-economic/subsistence benefit. The PA-BAT includes a range of potential add-ons, including the use of artists to illustrate results in a workshop setting, participatory mapping, and others, which could be useful for ongoing community engagement, and engagement with various social-demographics and different age groups.

Benefits

- The tool is designed for use anywhere in the world, and can be adapted for specific regions, sites, biomes, or PA networks.
- The PA-BAT is one of the few tools reviewed that allows for rapid assessment of key benefits to different stakeholder groups.
- The process to apply the PA-BAT is quick and relatively inexpensive, requiring only resources for a stakeholder workshop.

Limitations

- Results are generally based on local knowledge rather than biophysical data and therefore are subject to the limitations and/or biases of local stakeholders.
- Results are not generally quantified and may under-represent or underestimate the importance of certain ES if stakeholders are absent.
- The PA-BAT can only be applied to one site at a time; it is not feasible to apply it to multiple sites simultaneously.

Proposed Application

- The PA-BAT was developed for PAs and has already been widely used in a range of sites, including some natural World Heritage sites and Key Biodiversity Areas with protected status.
- This tool is useful for evaluating the policies and procedures associated with protected area designations and, theoretically, it could also be useful for examining Key Biodiversity Areas without official protected status.

Toolkit for Ecosystem Service Site-Based Assessment v2.0 (TESSA)

TESSA is an interactive PDF that provides practical guidance on how to identify which ES to assess at a site, what data are needed to measure them, what methods or sources can be used to obtain the data, the steps required for each method, and how to communicate the results to inform decision making.

There are two key steps: the Preliminary Scoping Appraisal (conducted through a stakeholder workshop) which produces qualitative information about all the ecosystem services provided by a site, followed by a full assessment whereby methods for quantifying a set of ecosystem services are provided. Multiple methods have been included for individual services so that they are applicable across all terrestrial habitat types and under different resource constraints. TESSA is not a software-based tool. It focuses on collecting local data wherever possible and on engaging with stakeholders at the site throughout the assessment and interpretation process.

Benefits

- TESSA is both a framework and a methods manual for practitioners wanting to understand the ecosystem services provided by a site compared to an alternative state. The two stages mean that it can be used for qualitative assessment or for quantifying the value of selected ecosystem services in biophysical and monetary units.
- The toolkit can provide approximate service estimates that are robust enough for informing decision-making, without necessitating investment of considerable resources (i.e., time and funding) or requiring specialist technical knowledge.

Limitations

- The tools in TESSA do not aim to help with assessment of all services, as many are extremely hard to quantify or to assess in a robust and rapid way. TESSA provides full assessment methods for coastal protection, cultivated goods, cultural services, global climate regulation, hydrological services, harvested wild goods, nature-based recreation, and pollination.
- Results derived from TESSA represent snapshots of each of the two states (i.e., current and alternative) of the focal site.
- The toolkit does not yet address complexities such as long-term sustainability, non-linearities, tipping points, discount rates and resilience.
- TESSA does not produce spatial outputs.

Proposed Application

- TESSA is a rapid and relatively low-cost tool for determining the significant ecosystem services in a specific geographic area and can identify important stakeholders and beneficiaries.
- The TESSA tool can be used to determine the maximal impact of a specific site and the net consequences in terms of value from ecosystem services to inform local decision making and site-level planning.
- It can also be used to evaluate synergies and trade-offs among different ES within a given study area and by providing locally relevant information for more detailed assessments and mapping.

Figure 7: EKLIPSE Evaluation Framework for NBS

Indicators	Measurement scale				
	Mesoscale			Microscale	
	Regional	Metropolitan	Urban	Street	Building/Park
Health indicators related to physical activity (Sports and leisure activities including e.g. walking, cycling).					
• Number and share of people being physically active (min. 30 min 3 times per week).			✔		
• Reduced percentage of obese people and children; reduced overall mortality and increased lifespan.			✔		
• Reduced number of cardiovascular morbidity and mortality events (Tamosiunas et al., 2014).			✔		
Health indicators related to ecosystem service provision (Buffering of noise and air pollution, reduced heat, exposure to microflora).					
• Reduced autoimmune diseases and allergies (potentially) (Kuo, 2015).			✔		
• Reduced cardiovascular morbidity and mortality (Tamosiunas et al., 2014).			✔		
• GIS related indicators: NDVI, proximity measures (greenspace of min. 2 ha within 300m, (Maas et al., 2006; Vries et al., 2003)), percentage of greenspace (Kabisch and Haase, 2014; van den Berg et al., 2010).	✔	✔	✔	✔	✔

European Commission Horizon 2020 – Impact Evaluation framework to support planning and evaluation of nature-based solutions projects

The framework developed by the EKLIPSE working group aims to guide the design, development, implementation, and assessment of NBS projects based on a range of environmental, economic and societal benefits. The framework provides a multi-directional approach to evaluating the benefits of using NBS to enhance urban climate resilience with quantifiable indicators covering a variety of climate challenges, including climate change adaptation and mitigation – water management, coastal resilience, air quality; environmental - urban regeneration, biodiversity, greenspace management; and societal health – participatory planning, social cohesion, health and well-being. Indicators for each of these challenge areas are outlined in terms of their scale applicability – macro, meso and micro (**Figure 7**).

Benefits

- The framework provides suggested methods for evaluating the associated indicators linked to the anticipated health benefits outlined in the tables – in this case those related to physical activity and reduced exposure to environmental pollutants. These suggestions include guidance around the appropriate methodological format (self-assessment, remote sensing, spatial analysis) and potential limitations when designing NBS projects.
- The framework also includes an integrated seven step co-benefit assessment to support project design and implementation that involves a simple, seven step process.
- The framework is easy to understand, requires minimal cost for application and is supported by the thinknature knowledge hub and extended project guidelines.

Limitations

- Suggested indicators/methods, socio-economic and socio-cultural considerations are not comprehensive.
- Interactions between benefit pathways are identified, but not addressed in the indicators or methods for evaluation.
- Integration of long-term monitoring and evaluation is limited.
- The knowledge hub focuses on European case studies, although a more global focus in the extended project guidelines that have recently been made available address some of these euro-centric components.

Proposed Application

- Entry point for decision-makers from local and regional governments in connecting the health impacts of NBS with relevant evaluation metrics at the appropriate scale.

- Potential for adaptation to Canadian context, as well as serving as a toolkit for cross-jurisdictional collaboration.

Ecosystem Services Toolkit (EST)

The Ecosystem Services Toolkit is a guideline document that consists of a set of steps for conducting ecosystem services assessment, as well as an extensive compendium of available analytic tools and methods and data sources that might be applied.[157] Each step includes guidance as well as templates such as worksheets that can assist with the completion of the step. In addition to the step-by-step guidance, the EST includes a typology of ecosystem services with descriptions of each one; discussion of cross-cutting issues (such as scale and uncertainty); guidance on conducting ES assessment with Indigenous communities (it is the only such toolkit reviewed with specific guidance on this issue); discussion of approaches to both economic valuation and socio-cultural valuation, and resources such as tables of possible ES indicators to support analysis, guidance on approaches to valuation, and a compendium of factsheets describing data sources, and analytic methods and tools relevant to ES assessment. The EST advises users to start by defining the question that is driving their need for an assessment and to choose indicators, data and analysis methods to answer that question in a relevant and credible way (a problem-oriented approach). In addition, the EST contains advice about how to integrate ecosystem services assessment results and other ecosystem services considerations into the established practices associated with a wide range of policy and decision contexts.

Benefits

- EST walks a team step-by-step through an ecosystem services assessment and includes a significant amount of background material and worksheets to support each step.

- It is also extremely comprehensive, covering everything from diverse valuation methods to software-based modelling tools (ARIES, InVEST, etc.).

- It can advise on strategies to incorporate results of ecosystem services assessment and other ecosystem services -focused information into eleven common policy activities such as land use planning, impact assessment, and conservation incentives.

Limitations

- The sheer length of the EST document (284 pages) could seem daunting to a project team with limited time. While it is comprehensive, this might also pose a challenge, as a user must navigate a multitude of options when it comes to the assessment of methods and tools, select the most appropriate one, and then spend time learning and applying the selected methodology.

Proposed Application

- EST can support general ecosystem services assessments, including those that involve Indigenous peoples, which can often be relevant for site-level assessments.

- The EST's Priority ecosystem services Screening Tool can be used to determine whether an ecosystem services assessment is necessary or useful, and it can be the basis for a "rapid assessment" when time and resources are severely constrained.

- EST can also be used for moderate and more comprehensive assessments if needed. It also provides guidance on how to make sure results will feed into a specific decision-making process.

Environmental Health Databases

CIHR has launched several national platforms to provide macro-level data for research and public information that are useful for informing policy and project planning to improve environmental health. Below are a few examples of population health databases that are available to support environmental health initiatives:

Canadian Chronic Disease Surveillance System harmonizes provincial and territorial data on chronic diseases, health services and outcomes. The system provides gender, age and disease segregated trend data that is available to the public.

Canadian Partnership for Tomorrow's Health (CanPath) project is hosted by University of Toronto's *Dalla Lana School of Public Health*. CanPath portal provides access to identify epidemiological and biological data for research purpose. CanPath is the largest population cohort study in Canada, examining how the intersection between genetics, the environment, and human lifestyles and behaviours contribute to the development of several NCDs.

Canadian Longitudinal Study on Aging (CLSA) is a longitudinal study based on data collected from 51,000 participants between 45 and 85 years old. The data will be collected from these participants until 2033 to uncover ways of promoting longevity.

Ontario Child Health SUPPORT Unit (OCHSU) collects and aggregates health data of children in Ontario.

Population Data BC (PopData) provides population health data for British Columbia residents since 1985, which includes environmental data, to further research around the causes of human health, well-being and development.

APPENDIX 4: CITY PLANS REVIEWED

Type	Municipality Prov./Terr.	Plan name	Date (timeline)	Plan history/planning tools	Advisory/steering committee	Community engagement tools	Health metrics
Urban Forestry Plans	Edmonton AB	Urban Forest Management Plan	2012 (10 years)	**Plan History** • 2009 electronic tree inventory • 2010 Corporate Tree Policy **Planning Tools** • UFORE (i-Tree) • STRATUM • Asset inventory • Banister Research & Consulting Inc. public opinion research	• City Staff • External expert consultations • Advisory consultants	• Focus groups • Online Questionnaire • Informal consultations	**Market valuation** **Indirect health metrics** • $3M value of reduced air pollution
	Cumberland BC	Urban Forest Management Plan	2019 (20 years)	**Plan History** • 2010 Maintenance and Removal of Trees of Public Land **Planning Tools** • Orthoimagery – Comox Valley RD • University of Maryland tree canopy data • Asset inventory • ISS TRAQ	• Tili Aboriculture Consulting Inc. • Mumbyès Aboriculture Consulting Ltd. • Foul Bay Ecological Research Ltd. • Diamond Head Consulting	• Online survey • Cumberland Community Forest Society	**Market valuation** • $1.88-$12.70/tree **Indirect health metrics** • Canopy cover >56% • Change in pervious cover (%) • Species diversity
	Cambridge ON	Urban Forest Plan 2015-2034	2015 (20 years)	**Plan History** • 2012 Official City Plan • 2013 Cambridge Urban Forest Canopy Assessment • 2013 GHG Reduction (Energy Management) **Planning Tools** • Waterloo Region Shade Work Group	• City Staff • Grand River Conservation Authority • Cambridge Hydro, Energy+ • Region of Waterloo • Cambridge Environmental Advisory Committee • Cambridge City Green • Shade Work Group • Urban Forests Innovations • Beacon Environnemental	• Focus on Trees in Cambridge (Community Canopy Assessment) • Digital Outreach • Natural Heritage Tour • Creating Shady Outdoor Space Contest • Workshops, community displays, participatory inventory assessments	**Non-market valuation** • Hedonic pricing (house value/sale price) • Consumer WTP on well-treed streets **Health co-benefits are recognized, but unmeasured under plan CBA (pg. 5)**
	Kitchener ON	Sustainable Urban Forest Strategy	2019 (10 year)	**Plan History** • 2015 Strategic Plan • 2017 Sustainable Urban Forest Report Card	• City staff	• Public Tree Walks • Displays at special events • Public workshops • Online surveys • Stakeholder interviews • Community tree-planting program • Love My Hood Strategy	**Indirect health metrics** • Canopy cover >26% • Track customer service requests for NI.
	Greater Montreal Area QC	Plan d'action canopée	2012 (10 years)	**Plan History** • 2011 Plan métropolitain d'aménagement et de développement (PMAD)	• City Staff from Greater Montreal municipalities • Soverdi	• Community tree-planting program • Business/Industry participation	**Indirect health metrics** • 300,000 trees planted • 5% canopy increase (2,333ha) • Invest in îlots de fraîcheur (metric TBD)

APPENDIX 4: CITY PLANS REVIEWED

Type	Municipality Prov./Terr.	Plan name	Date (timeline)	Plan history/planning tools	Advisory/steering committee	Community engagement tools	Health metrics
Parks, Greenspace and Master Plans	Toronto ON	Parkland Strategy	2019 (20 years)	**Plan History** • 2017 Parks and Recreation Master Plan **Planning Tools** • Park Catchment Tool	• City Staff • O2 Planning + Design • Gladki Planning Associates • Hemson Consulting • N Barry Lyon Consultants	• Community consultation • Online surveys • Open houses • Pop-up events • TOParks talks	**Market-valuation** • CAD$ per resident • CAD$ NI investment in low-income areas • Weekly hours of park programming **Indirect health metrics** • Park area per person • New park space • #park visits • Park space <500m from transit, active transportation • #residents <500m to nature • %park land cover
	Whitehorse YT	Parks and Recreation Strategy	2018 (10 years)	**Plan History** • 2007-2017 Parks & Recreation Master Plan • 2014-2019 Department of Health and Social Services Strategic Plan • 2015 Truth and Reconciliation Commission, Calls to Action • 2015 A Framework for Recreation in Canada: Pathway to Wellbeing • 2015-2050 Sustainability Plan • 2018 Parks for All: An Action Plan for Canada's Parks Community **Planning Tools** • Demographic study • Benchmarking • Trends, best practices, EDI principles • Infrastructure assessment and inventory • Usage analysis	• City Staff • Jane of all Trades Consulting • RC Strategies + PERC • BINNIE	• Public Survey • Stakeholder Survey • Focus Groups	**Market valuation** • CBA analysis of park investments • Annual cost recovery % • Total recreation spending **Indirect health metrics** • Recreation patterns by age group/cultural background • Community group participation rates • Maintenance reinvestments
	St. John's NL	Parks and Open Spaces Master Plan	2014 (long-term)	**Plan History** • City Master Plan **Planning Tools** • National Recreation and Parks Association baseline data • Design and Maintenance guidelines (best practices	• City Staff • Trace Planning & Design • Greener Prospects • MQO Research	• Focus groups • Small meetings • Workshops	**Both market & non-market valuation** • Change in property value • Change in well-being, life satisfaction **Indirect health metrics** • Meeting established maintenance and design guidelines • Tot lot – park space by-law; 1 park per 70 single family homes
	Halifax NS	Green Network Plan	2018 (2-7 years)	**Plan History** • 2015 State of the Landscape Report • Cultural Landscape Framework Study	• City Staff • O2 Planning & Design	Phase 1 – values of open spaces; community vision Phase 2 – feedback on plan Phase 3 – input on objectives	**Undetermined valuation** **Indirect health metrics** • #residents <800m to nature • # of trees planted • # of beach closure days • Status of proposed park developments
	Fredericton NB	Imagine Fredericton: The Municipal Plan	2020 (25 years)	**Plan History** • 2017 City Growth Strategy • NB Community Planning Ac	• City Council	• Open houses • Three-day City Summit • Stakeholder conversations • First Nations engagement • Online surveys	**Valuation - TBD** **Indirect health metrics (Undefined)** • tree canopy target, limit water pollution, increase 4-season outdoor recreation

APPENDIX 4: CITY PLANS REVIEWED

Type	Municipality Prov./Terr.	Plan name	Date (timeline)	Plan history/planning tools	Advisory/steering committee	Community engagement tools	Health metrics
Parks, Greenspace and Master Plans	Hamilton ON	Recreation Trails Master Plan	2016 (long-term)	**Plan History** • 2005 Ontario ACTIVE2010 • 2005 Ontario Trails Strategy • 2007 Recreational Trails Master Plan **Planning Tools** • 2005 Statistics Canada – physical activity data • 2014 Active Transportation Benchmarking • Literature review – Trails and health • GIS trail maps, active transportation routes • Asset inventory • Design best practices (AODA, CPTED, surfacing, lighting, etc.)	• City Staff • Seferian Design Group	• Public information sessions • Stakeholder consultation • Let's Talk Trails questionnaire/expo tables • Online survey	**Market valuation** • National Medical Expenditure Survey ($1 investment = $3 in medical cost savings) **Indirect health metrics** • Maintenance investments • Trail usage inventories • Needs assessments
	Winnipeg MB	Ecologically Significant Natural Lands Strategy and Policy	2007 (Ongoing policy)	**Plan History** • Annual assessments and inventory collected since 2000 **Planning Tools** • Preliminary Habitat Assessment/Evaluation of Natural Areas	• City Staff • Capital Region Habitat Steering Committee	• 2002 Public Opinion Research Survey • Interpretive signage • Educational information • Guided tours	**Market & non-market valuation** • 2% to 10% of development paid for natural heritage conservation • Passive recreation value (POR survey) • Estimated community group/volunteer contribution to environmental stewardship **Indirect health metrics** • Number of active community stewardship groups • 8% of proposed development dedicated for public parks
	Brandon MB	Greenspace Master Plan	2015 (10 years)	**Plan History** • 2002 Master Plan • 2009 Community Health Assessment • 2010 Canadian Heritage, Sports Participation • 2013 Brandon and Area Planning District Development Plan **Planning Tools** • Greenspaces classification and inventory • Land use data base • Best practices and benchmarking • Community data	• City staff • Brandon Riverbank Inc. • Keystone Centre • Brandon School Division • Peter J. Smith and Company	• Vision session • Focus groups • Public meeting • Open house • Community survey	**Market & non-market valuation** • Change in property value • Avoided costs (repair) • Land value of greenspaces • Greenspace/recreation revenues • Improvements in well-being • Healthy habits/lifestyle **Indirect health metrics** • Greenspace per 55,000 • Greenspace abundance by type • Walkability - 30mins
	Regina SK	Recreation Master Plan	2019 (10-25 years)	**Plan History** • 2010-2020 Recreation facility master plan • 2015-2016 The Government of Saskatchewan Ministry of Parks, Culture, and Sport Plan • 2018 State of Recreation • Pathways to Wellbeing: A Framework for Recreation in Canada **Planning Tools** • Community data • Trends and best practices • Asset inventory and classification • Lifecyle budgeting	• City Staff • Economic Development Regina • Homebuilders Association Provincial Capital Commission • Regina Board of Education • Regina Catholic School Board • Regina Exhibition Associated Limited • Regina Police Service • Regina Public Library • Saskatchewan Health Authority Health Region • Saskatchewan Polytechnic University of Regina • White Butte Regional Recreation Group • YMCA • Strategic Prairie Region Alliance • RC Strategies + PERC	• Household survey • Youth survey • Stakeholder interviews	**Market & non-market valuation** • Infrastructure costs; new, repairs, operation • WTP (access fees) • SWB – value of recreation for quality of life **Indirect health metrics** • Park site visitations • Greenspace/outdoor recreation areas per # of residents

APPENDIX 4: CITY PLANS REVIEWED

Type	Municipality Prov./Terr.	Plan name	Date (timeline)	Plan history/planning tools	Advisory/steering committee	Community engagement tools	Health metrics
Parks, Greenspace and Master Plans	Saint John NB	Parks and Recreation Strategic Plan	2012 (15 years)	**Plan History** • 2010 PlanSJ project **Planning Tools** • Intergovernmental Affairs Plan • 2011 Citizen survey • 2011 Statistics Canada Census • Recreation best practices • Demographic study	• City Staff	• Citizen-led advisory committee • Project Storefront – pop-up discussion forums • Youth engagement • Vlogs • Roundtables • Community partnerships • Public/council workshops • Open houses • Regular communications • Adopt-a-park program	**Market & non-market valuation** • Cost of physical inactivity • Adopt-a-park community stewardship materials • WTP for community gardens • Improvements in Quality of life **Indirect health metrics** • Proximity to greenspaces by park type – Regional <5km – District <2.5km – School <1.5km – Neighbourhood <500m • Abundance of greenspace • Youth/Senior involvement
	Saskatoon SK	Strategic Plan	2018 (4 years)	**Plan History** • 2012 Strategic plan **Planning Tools** • 2010 Saskatoon Speaks Community Visioning • Local demographic data	• City Staff • City Council • Meewasin Valley Authority	• Saskatoon Speaks community engagement program	**Undetermined Valuation** **Indirect health metrics** • # trees planted • Walkability – 5min • Abundance of greenspace by type (formal/informal)
	London ON	Parks and Recreation Master Plan	2019 (10 years)	**Plan History** • 2009-17 Parks and Recreation Master Plan • 2011 Thames Valley Corridor Plan • 2012Canadian Sports Policy • 2012 Active Canada 20/20 • 2012 Ontario Healthy Kids Strategy • 2013-18 CycleON Ontario • AODA • 2015 Game ON Ontario • 2015 A Framework for Recreation in Canada: Pathways to Wellbeing • 2017 Parks for All (2017) • 2017 Ontario Trails Strategy • 2018 Let's Get Moving **Planning Tools** • Recreation and outdoor space inventory • Socio-demographic profile • Best practices • Land use mapping • Literature review	• City staff • Moneith Brown planning consultants • Swerhun Inc. • Tucker-Reid & Associates	• Live dashboard Reporting • Visioning Workshops • Stakeholder input sessions • Online Surveys • Focus groups • Partner Interviews • Child's voice drawings • Inter-departmental city staff meetings	**Market & non-market valuation** • Adopt-a-park, $1 city investment yielded $10 in community stewardship • Health costs of inactivity $6.8B • Life satisfaction **Indirect health metrics** • 1 park <800m of residences • Increase natural areas 15% • 40% tree canopy cover in parks
	Windsor ON	Environmental Master Plan	2017 (20 years)	**Plan History** • 2006 Environmental Master Plan • Climate change Adaptation Plan • 2014 Community Energy Plan **Planning Tools** • Environmental health literature review • Best practices	• City Staff – Environmental Sustainability Coordinator	• Community Survey • Annual Reports on the Sate of the Environment (ROSE)	**Market & non-market valuation** • Costs of air pollution • Health care cost savings from park investments (36%) • Energy cost savings $1B/yr • Quality of life • Improved well-being **Indirect health metrics** • % Parkland, tree canopy cover • # trees planted • GHG targets • # AT trips • % water pollutants • % conservation lands

APPENDIX 4: CITY PLANS REVIEWED

Type	Municipality Prov./Terr.	Plan name	Date (timeline)	Plan history/planning tools	Advisory/steering committee	Community engagement tools	Health metrics
Climate Resilience Plans	Montreal QC	Plan Climat 2020-2030	2020 (10 years)	**Plan History** • 2018 One Planet Charter • 2019 Climate Action Summit **Planning Tools** • GHG modeling • Land use database • Natural asset inventory	• City Staff – Bureau de la transition écologique et de la résilience • C40 • Trottier Foundation • David Suzuki Foundation • Caisse de depot et placement du Quebec • CIUSS Centre-Sud • Bronfman Foundation • McConnell Foundation • Echo Foundation • Espace pour la vie foundation	• Community Resilience Hubs (Implementation)	**Market & non-market valuation** • Energy cost savings ~$6B • mprove quality of life **Indirect health metrics** • Increase park coverage • 500K trees planted • 10% protected areas • GHG 55% below 1999 levels • 25% less solo car trips • 47% EV ownership
	Calgary AB	Resilient Calgary	2019 (ongoing)	• 2016 100 Resilient Cities Network • 2018 Resilience Assessment – City Resilience Index (CRI) baselines • 2019-2022 One Calgary	• City Staff • Bow River Basin Council • Canadian Poverty Institute • Blackfoot Confederacy Tribal Council • Alberta Family Wellness Initiative • Age Friendly Steering Committee • Youth Central • Global Shapers • University of Calgary • Alberta Health Services • United Way of Calgary	**Design Phase Consultation:** • Workshops • Draft strategy input • Research focus groups	**Market Valuation** Avoided costs – 2013 flood damage of $400M **Plan Targets** (Metrics in Development) • Revitalization of Indigenous culture • Greater participation of Indigenous communities • Greater awareness of natural infrastructure benefits • Integrated natural infrastructure as a new asset class in corporate asset management • Develop valuation toolkit for natural infrastructure investment • Adopt guidelines to inform natural infrastructure projects
Healthy Cities Plans	Vancouver BC	Healthy City Strategy	2015 (4 years)	**Plan History** • 2014 Healthy City Strategy • Partnerships for Healthy Cities • Vancouver Park Board Strategic Framework • Transportation 2040 • Housing and Homelessness Strategy 2012-2021 • Task force on mental health and additions • Social Amenities Priorities Plan • Vancouver Food Strategy & Park Board Local Food Action Plan **Planning Tools** • Stakeholder engagement • Local baseline data • Natural Asset inventory • Land use database	• City Staff • Vancouver Coastal Health • CMHA, YWCA, SUCCESS, BCIT, MOSAIC, PHAC • Metro Vancouver Aboriginal Executive Council • Greenest City Action Team • Vancouver Board of Education • BC Healthy Living Alliance • Vancouver Foundation • BC Partners for Social Impact • BC Ministry of Health • Reconciliation Canada • Centre for Hip Health and Mobility • Arts Umbrella • BC Ministry of Children and Family Development • Langara College • The Learning City • Vancity Credit Union • Ending Violence Association of BC • Rennie Marketing Systems • Greater Vancouver Food Bank Society • Street to Home Foundation • BC Healthy Communities	• Extensive community consultation and engagement resulting in more than 1200 data points	**Market & non-market valuation** • Avoided costs of ill-health • Improved feelings of safety, inclusion and well-being **Direct & Indirect health metrics** • Canopy cover (%) • Conserved areas (ha) • AT trips (#) • 150min of PA (%) • Feeling of belonging (%) • Feeling of safety (%) • Neighbourhood walk scores
	Kelowna BC	Healthy City Strategy – Community for All	2016 (2 years)	**Plan History** • Official Community Plan • Community Climate Action Plan • Pedestrian and Bicycle Master Plan • Urban Centres Roadmap • Strong Neighbourhood Program **Planning Tool – undetermined**	• City Staff • Interior Health • Central Okanagan Division of Family Practice • Pathways Abilities Society • School District #23 • Seniors Outreach Services Society	• Public input on best practices • Surveys • Workshops • Community conversation events	**Health Metrics - undefined**

APPENDIX 4: CITY PLANS REVIEWED

Type	Municipality Prov./Terr.	Plan name	Date (timeline)	Plan history/planning tools	Advisory/steering committee	Community engagement tools	Health metrics
Healthy Cities Plans	Prince George BC	Healthy City Framework	2018 (4 years)	**Plan History** • 2010 myPG Integrated Community Sustainability Plan • 2018 Social Development Strategy **Planning Tools - undetermined**	• City Council • Community Partners Addressing Homelessness • Community Arts Council • YMCA, RCMP, UNBC • Child, Youth and Family Network • Northern Health • Community Associations • Volunteer PG • Community Member	• myPG Community Council • Neighbourhood grants • Training and resources for Community Associations • Partner with Volunteer PG	**Non-market valuation** • Dis-utility cost savings – city grants to improve quality of life **Indirect health metrics** • Equity, inclusion grants -$350K
	Charlottetown PE	Integrated Community Sustainability Plan	2017 (5 years)	**Plan History** • 2010 ICSP **Planning Tools** • Street tree/ woodland inventory • Tree canopy study	• City Council • The Natural Step 101	• Public Engagement Survey • Community Expo • Public visioning session • Stakeholder meetings • Community Sustainability Micro-grant program	**Non-market valuation** • Improve life satisfaction and well-being **Health metrics undefined**
	Ottawa ON	Ottawa Next: Beyond 2036	2019 (15 years)	**Plan History** **Planning Tools** • Extensive local data set • Ottawa Next: Beyond 2036 • Literature review	• City Staff • The Planning Partnership • Urban Strategies Inc.	• Community Sounding Board • Online questionnaire • Youth questionnaire • Ottawa Youth Engagement Committee	**Market & non-market valuation** • Avoided costs of illness – up to $7.1B/year • Change in property values • Dis-utility cost savings – better quality of life, less suffering • Carbon tax **Indirect health metrics** • Walkability – 20 minutes • GHG emissions 80% below 2012 levels • Improve stormwater management
	Yellowknife NT	Community Plan	2019 (20 years)	**Plan History** • 2010 Natural Area Preservation Strategy • 2010 Smart Growth Development Plan • 2017 Citizen Survey • 2019-2022 Strategic Plan • 2019 Grow: Yellowknife Food and Ag strategy **Planning Tools** • Land use designation • NWT demographic statistics • 2016 Federal census	• City Staff • Dillon Consulting	• PlaceSpeak online public engagement • Focus groups • Open houses • Phone/email interviews	**Market & non-market valuation** • Avoided health care costs • Quality of life from ecosystem services **Indirect health metrics** • Natural vegetation as a noise barrier • Tree planting/ re-vegetation • 100' protected area right of way for riparian zones

APPENDIX 5: SPI WORKSHOP ON NBS – AGENDA

Wednesday, January 27 (Day 3): Digging into nature-based solutions	
1:00pm	Welcoming remarks, review of workshop objectives, overview of today's session and agenda Breakout groups for networking/introductions
1:15pm	Presentation: A Natural path to healthier Canadian Communities: Preliminary Findings on strategies that integrate health considerations in nature-based solutions Speaker: Michael Twigg, Smart Prosperity Institute
1:30pm	Presentations: Regional experiences in building coalitions for climate, nature, and health Speakers: Kiran Ghai, Peel Region Public Health; Jacob Cramer, BC Healthy Communities Reactions and further experiences
2:00pm	Facilitated breakout sessions: Identifying the limitations on local and regional decision-making • What type of coordination issues present significant transactional barriers when considering health co-benefits from NBS? i.e., between departments, levels of government, etc. How can they be overcome? • How has regional/municipal policy addressed NBS and health given the existing barriers/challenges – what are they measuring and how? How accurate are these measurements? Where are the areas of improvements?
2:20 pm	Share discussion highlights
2:30pm	Health break
2:40pm	Presentations: Tools and Methods for Integrating Health and NBS Speakers: Michelle Molnar, Municipal Natural Assets Initiative; Thomas Bowers, Greenbelt Foundation Reactions and further experiences
3:10pm	Breakout discussion: Applying tools and frameworks – what's needed? • What types of lessons can be learned from the MNAI experience and translated into the NBS-health discussion? • Where should the focus be at the project level to ensure health considerations are better integrated into NBS?
3:30pm	Report back discussion highlights
3:45pm	Closing remarks, identify key takeaways, and priority issues to address in ongoing research effort.

ENDNOTE CITATIONS

1 Statistics Canada. 2019. "Population Projections for Canada (2018 to 2068), Provinces and Territories (2018 to 2043)." Government of Canada. Accessed February 3, 2021 https://www150.statcan.gc.ca/n1/pub/91-520-x/91-520-x2019001-eng.htm

2 Institute for Health Metrics and Evaluation (IHME).2020. Financing Global Health Visualization. University of Washington. Accessed February 3, 202 http://vizhub.healthdata.org/fgh/

3 Pinault, Lauren. 2021. "Ethnocultural and Socioeconomic Disparities in Exposure to Residential Greenness within Urban Canada." Health Reports 32 (82): 14. https://www.doi.org/10.25318/82-003-x202100500001-eng

4 Ecosystem services are broadly defined as the benefits that communities receive from the natural environment. These benefits can be direct or indirect and are typically divided between provision (direct product), regulating ecological functions - e.g. water filtration), cultural (impact of human lifestyles) and supporting (habitat health) ecosystem services.

5 Nowak, David J., Satoshi Hirabayashi, Marlene Doyle, Mark McGovern, and Jon Pasher. 2018. "Air Pollution Removal by Urban Forests in Canada and Its Effect on Air Quality and Human Health." Urban Forestry & Urban Greening 29 (January): 40–48. https://doi.org/10.1016/j.ufug.2017.10.019.

6 Howarth, Michelle, Alistair Griffiths, Anna da Silva, and Richard Green. 2020. "Social Prescribing: A 'natural' Community-Based Solution." British Journal of Community Nursing 25 (6): 294–98. https://doi.org/10.12968/bjcn.2020.25.6.294.

7 Edger, R., Howard, C., Lem, M., Zigby, J., Pétrin-Desrosiers, C., Doyle H.M., Kitching, G.T., Luo, O.D., Cohen, A.,Wu, K., Kirsh Carson, J.J., Létourneau S.G., & Kuhl, J. 2020. "Healthy Recovery Plan: For a Safe and Sustainable Future." Canadian Association of Physicians for the Environment. https://cape.ca/wp-content/uploads/2020/07/CAPE_Report2020_EN_HealthyRecoveryPlan-1.pd

8 Van den Bosch, M., and Å. Ode Sang. 2017. "Urban Natural Environments as Nature-Based Solutions for Improved Public Health – A Systematic Review of Reviews." Environmental Research 158 (October): 373–84. https://doi.org/10.1016/j.envres.2017.05.040.

9 Maas, J., R. A. Verheij, S. de Vries, P. Spreeuwen berg, F. G. Schellevis, and P. P. Groenewegen. 2009. "Morbidity Is Related to a Green Living Environment." Journal of Epidemiology & Community Health 63 (12): 967–73. https://doi.org/10.1136/jech.2008.079038.

10 McMorris, Owen, Paul J. Villeneuve, Jason Su, and Michael Jerrett. 2015. "Urban Greenness and Physical Activity in a National Survey of Canadians." Environmental Research 137 (February): 94–100. https://doi.org/10.1016/j.envres.2014.11.010.

11 Shen, Yu-Sheng, and Shih-Chun Candice Lung. 2016. "Can Green Structure Reduce the Mortality of Cardiovascular Diseases?" Science of The Total Environment 566–567 (October): 1159–67. https://doi.org/10.1016/j.scitotenv.2016.05.159.

12 Paul, Lauren A., Perry Hystad, Richard T. Burnett, Jeffrey C. Kwong, Dan L. Crouse, Aaron van Donkelaar, Karen Tu, et al. 2020. "Urban Green Space and the Risks of Dementia and Stroke." Environmental Research 186 (July): 109520. https://doi.org/10.1016/j.envres.2020.109520.

13 Crouse, Dan L, Lauren Pinault, Adele Balram, Perry Hystad, Paul A Peters, Hong Chen, Aaron van Donkelaar, et al. 2017. "Urban Greenness and Mortality in Canada's Largest Cities: A National Cohort Study." The Lancet Planetary Health 1 (7): e289–97. https://doi.org/10.1016/S2542-5196(17)30118-3.

14 Ngom, Roland, Pierre Gosselin, Claudia Blais, and Louis Rochette. 2016. "Type and Proximity of Green Spaces Are Important for Preventing Cardiovascular Morbidity and Diabetes—A Cross-Sectional Study for Quebec, Canada." International Journal of Environmental Research and Public Health 13 (4): 423. https://doi.org/10.3390/ijerph13040423.

15 Vienneau, Danielle, Kees de Hoogh, David Faeh, Marco Kaufmann, Jean Marc Wunderli, and Martin Röösli. 2017. "More than Clean Air and Tranquillity: Residential Green Is Independently Associated with Decreasing Mortality." Environment International 108 (November): 176–84. https://doi.org/10.1016/j.envint.2017.08.012.

16 Gascon, Mireia, Margarita Triguero-Mas, David Martínez, Payam Dadvand, David Rojas-Rueda, Antoni Plasència, and Mark J. Nieuwenhuijsen. 2016. "Residential Green Spaces and Mortality: A Systematic Review." Environment International 86 (January): 60–67. https://doi.org/10.1016/j.envint.2015.10.013.

17 Astell-Burt, Thomas, and Xiaoqi Feng. 2020. "Urban Green Space, Tree Canopy and Prevention of Cardiometabolic Diseases: A Multilevel Longitudinal Study of 46 786 Australians." International Journal of Epidemiology 49 (3): 926–33. https://doi.org/10.1093/ije/dyz239.

18 Sander, Heather A., Debarchana Ghosh, and Cody B. Hodson. 2017. "Varying Age-Gender Associations between Body Mass Index and Urban Greenspace." Urban Forestry & Urban Greening, Special feature: TURFGRASS, 26 (August): 1–10. https://doi.org/10.1016/j.ufug.2017.05.016.

19 Sarkar, Chinmoy. 2017. "Residential Greenness and Adiposity: Findings from the UK Biobank." Environment International 106 (September): 1–10. https://doi.org/10.1016/j.envint.2017.05.016.

20 Kolokotsa, D., Aikaterini A. Lilli, Maria A. Lilli, and Nikolaos P. Nikolaidis. 2020. "On the Impact of Nature-Based Solutions on Citizens' Health & Well Being." Energy and Buildings 229 (December): 110527. https://doi.org/10.1016/j.enbuild.2020.110527.

21 Prince, Stephanie A., Elizabeth A. Kristjansson, Katherine Russell, Jean-Michel Billette, Michael Sawada, Amira Ali, Mark S. Tremblay, and Denis Prud'homme. 2011. "A Multilevel Analysis of Neighbourhood Built and Social Environments and Adult Self-Reported Physical Activity and Body Mass Index in Ottawa, Canada." International Journal of Environmental Research and Public Health 8 (10): 3953–78. https://doi.org/10.3390/ijerph8103953.

22 Dzhambov, Angel M., Donka D. Dimitrova, and Elena D. Dimitrakova. 2014. "Association between Residential Greenness and Birth Weight: Systematic Review and Meta-Analysis." Urban Forestry & Urban Greening 13 (4): 621–29. https://doi.org/10.1016/j.ufug.2014.09.004.

23 Banay, Rachel F., Carla P. Bezold, Peter James, Jaime E. Hart, and Francine Laden. 2017. "Residential Greenness: Current Perspectives on Its Impact on Maternal Health and Pregnancy Outcomes." International Journal of Women's Health 9: 133–44. https://doi.org/10.2147/IJWH.S125358.

24 James, Peter, Rachel F. Banay, Jaime E. Hart, and Francine Laden. 2015. "A Review of the Health Benefits of Greenness." Current Epidemiology Reports 2 (2): 131–42. https://doi.org/10.1007/s40471-015-0043-7.

25 Twohig-Bennett, Caoimhe, and Andy Jones. 2018. "The Health Benefits of the Great Outdoors: A Systematic Review and Meta-Analysis of Greenspace Exposure and Health Outcomes." Environmental Research 166 (October): 628–37. https://doi.org/10.1016/j.envres.2018.06.030.

26 Olafsdottir, Gunnthora, Paul Cloke, and Claus Vögele. 2017. "Place, Green Exercise and Stress: An Exploration of Lived Experience and Restorative Effects." Health & Place 46 (July): 358–65. https://doi.org/10.1016/j.healthplace.2017.02.006.

27 Bratman, Gregory N., Christopher B. Anderson, Marc G. Berman, Bobby Cochran, Sjerp de Vries, Jon Flanders, Carl Folke, et al. 2019. "Nature and Mental Health: An Ecosystem Service Perspective." Science Advances 5 (7): eaax0903. https://doi.org/10.1126/sciadv.aax0903.

28 Chang, Hao-Ting, Chih-Da Wu, Jung-Der Wang, Po-See Chen, and Huey-Jen Su. 2020. "Residential Green Space Structures Are Associated with a Lower Risk of Bipolar Disorder: A Nationwide Population-Based Study in Taiwan." Environmental Pollution, October, 115864. https://doi.org/10.1016/j.envpol.2020.115864.

29 Orstad, Stephanie L., Kristin Szuhany, Kosuke Tamura, Lorna E. Thorpe, and Melanie Jay. 2020. "Park Proximity and Use for Physical Activity among Urban Residents: Associations with Mental Health." International Journal of Environmental Research and Public Health 17 (13): 4885. https://doi.org/10.3390/ijerph17134885.

30 De Vries, Sjerp de, Sonja M. E. van Dillen, Peter P. Groenewegen, and Peter Spreeuwenberg. 2013. "Streetscape Greenery and Health: Stress, Social Cohesion and Physical Activity as Mediators." Social Science & Medicine 94 (October): 26–33. https://doi.org/10.1016/j.socscimed.2013.06.030.

31 Vujcic, Maja, Jelena Tomicevic-Dubljevic, Mihailo Grbic, Dusica Lecic-Tosevski, Olivera Vukovic, and Oliver Toskovic. 2017. "Nature Based Solution for Improving Mental Health and Well-Being in Urban Areas." Environmental Research 158 (October): 385–92. https://doi.org/10.1016/j.envres.2017.06.030.

32 Repke, Meredith A., Meredith S. Berry, Lucian G. Conway Iii, Alexander Metcalf, Reid M. Hensen, and Conor Phelan. 2018. "How Does Nature Exposure Make People Healthier?: Evidence for the Role of Impulsivity and Expanded Space Perception." PLOS ONE 13 (8): e0202246. https://doi.org/10.1371/journal.pone.0202246.

33 Van den Bosch, Matilda Annerstedt, and Michael H. Depledge. 2015. "Healthy People with Nature in Mind." BMC Public Health 15 (1): 1–7. https://doi.org/10.1186/s12889-015-2574-8.

34 Min, Kyoung-bok, Hyun-Jin Kim, Hye-Jin Kim, and Jin-young Min. 2017. "Parks and Green Areas and the Risk for Depression and Suicidal Indicators." International Journal of Public Health 62 (6): 647–56. https://doi.org/10.1007/s00038-017-0958-5.

35 Lachowycz, Kate, Andy P. Jones, Angie S. Page, Benedict W. Wheeler, and Ashley R. Cooper. 2012. "What Can Global Positioning Systems Tell Us about the Contribution of Different Types of Urban Greenspace to Children's Physical Activity?" Health & Place, Using scale to think about HIV/AIDS interventions: local and global dimensions, 18 (3): 586–94. https://doi.org/10.1016/j.healthplace.2012.01.006.

36 Astell-Burt, Thomas, Xiaoqi Feng, and Gregory S. Kolt. 2013. "Mental Health Benefits of Neighbourhood Green Space Are Stronger among Physically Active Adults in Middle-to-Older Age: Evidence from 260,061 Australians." Preventive Medicine 57 (5): 601–6. https://doi.org/10.1016/j.ypmed.2013.08.017.

37 Corazon, Sus Sola, Patrik Karlsson Nyed, Ulrik Sidenius, Dorthe Varning Poulsen, and Ulrika Karlsson Stigsdotter. 2018. "A Long-Term Follow-Up of the Efficacy of Nature-Based Therapy for Adults Suffering from Stress-Related Illnesses on Levels of Healthcare Consumption and Sick-Leave Absence: A Randomized Controlled Trial." International Journal of Environmental Research and Public Health 15 (1). https://doi.org/10.3390/ijerph15010137.

38 Andreucci, Maria Beatrice, Alessio Russo, and Agnieszka Olszewska-Guizzo. 2019. "Designing Urban Green Blue Infrastructure for Mental Health and Elderly Wellbeing." Sustainability 11 (22): 6425. https://doi.org/10.3390/su11226425.

39 Franklin, Meredith, Xiaozhe Yin, Rob McConnell, and Scott Fruin. 2020. "Association of the Built Environment With Childhood Psychosocial Stress." JAMA Network Open 3 (10): e2017634. https://doi.org/10.1001/jamanetworkopen.2020.17634.

40 Van Aart, Carola J.C., Nathalie Michels, Isabelle Sioen, Annelies De Decker, Esmee M. Bijnens, Bram G. Janssen, Stefaan De Henauw, and Tim S. Nawrot. 2018. "Residential Landscape as a Predictor of Psychosocial Stress in the Life Course from Childhood to Adolescence." Environment International 120 (November): 456–63. https://doi.org/10.1016/j.envint.2018.08.028.

41 Engemann, Kristine, Jens-Christian Svenning, Lars Arge, Jørgen Brandt, Christian Erikstrup, Camilla Geels, Ole Hertel, et al. 2020. "Associations between Growing up in Natural Environments and Subsequent Psychiatric Disorders in Denmark." Environmental Research 188 (September): 109788. https://doi.org/10.1016/j.envres.2020.109788.

42 Goon, Shatabdi, Saija Kontulainen, and Nazeem Muhajarine. 2020. "Neighborhood Built Environment Measures and Association with Physical Activity and Sedentary Time in 9–14-Year-Old Children in Saskatoon, Canada." International Journal of Environmental Research and Public Health 17 (11): 3837. https://doi.org/10.3390/ijerph17113837.

43 Richardson, Elizabeth A., Jamie Pearce, Niamh K. Shortt, and Richard Mitchell. 2017. "The Role of Public and Private Natural Space in Children's Social, Emotional and Behavioural Development in Scotland: A Longitudinal Study." Environmental Research 158 (October): 729–36. https://doi.org/10.1016/j.envres.2017.07.038.

44 Helbich, Marco, Nadja Klein, Hannah Roberts, Paulien Hagedoorn, and Peter P. Groenewegen. 2018. "More Green Space Is Related to Less Antidepressant Prescription Rates in the Netherlands: A Bayesian Geoadditive Quantile Regression Approach." Environmental Research 166 (October): 290–97. https://doi.org/10.1016/j.envres.2018.06.010.

45 Thomas, Felicity. 2015. "The Role of Natural Environments within Women's Everyday Health and Wellbeing in Copenhagen, Denmark." Health & Place 35 (September): 187–95. https://doi.org/10.1016/j.healthplace.2014.11.005

46 Van Renterghem, Timothy, Jens Forssén, Keith Attenborough, Philippe Jean, Jérôme Defrance, Maarten Hornikx, and Jian Kang. 2015. "Using Natural Means to Reduce Surface Transport Noise during Propagation Outdoors." Applied Acoustics 92 (May): 86–101. https://doi.org/10.1016/j.apacoust.2015.01.004

47 Egorov, Andrey I., Shannon M. Griffin, Reagan R. Converse, Jennifer N. Styles, Elizabeth A. Sams, Anthony Wilson, Laura E. Jackson, and Timothy J. Wade. 2017. "Vegetated Land Cover near Residence Is Associated with Reduced Allostatic Load and Improved Biomarkers of Neuroendocrine, Metabolic and Immune Functions." Environmental Research 158 (October): 508–21. https://doi.org/10.1016/j.envres.2017.07.009.

48 Panno, Angelo, Giuseppe Carrus, Raffaele Lafortezza, Luigi Mariani, and Giovanni Sanesi. 2017. "Nature-Based Solutions to Promote Human Resilience and Wellbeing in Cities during Increasingly Hot Summers." Environmental Research 159 (November): 249–56. https://doi.org/10.1016/j.envres.2017.08.016.

49 Putra, I Gusti Ngurah Edi, Thomas Astell-Burt, Dylan P. Cliff, Stewart A. Vella, and Xiaoqi Feng. 2020. "Association between Green Space Quality and Prosocial Behaviour: A 10-Year Multilevel Longitudinal Analysis of Australian Children." Environmental Research, October, 110334. https://doi.org/10.1016/j.envres.2020.110334.

50 Dadvand, Payam, Xavier Bartoll, Xavier Basagaña, Albert Dalmau-Bueno, David Martinez, Albert Ambros, Marta Cirach, et al. 2016. "Green Spaces and General Health: Roles of Mental Health Status, Social Support, and Physical Activity." Environment International 91 (May): 161–67.

51 Akpinar, Abdullah. 2017. "Urban Green Spaces for Children: A Cross-Sectional Study of Associations with Distance, Physical Activity, Screen Time, General Health, and Overweight." Urban Forestry & Urban Greening 25 (July): 66–73. https://doi.org/10.1016/j.ufug.2017.05.006.

52 Van Den Berg, Magdalena, Wanda Wendel-Vos, Mireille van Poppel, Han Kemper, Willem van Mechelen, and Jolanda Maas. 2015. "Health Benefits of Green Spaces in the Living Environment: A Systematic Review of Epidemiological Studies." Urban Forestry & Urban Greening 14 (4): 806–16. https://doi.org/10.1016/j.ufug.2015.07.008.

53 Van Der Jagt, Alexander P. N. van der, Luca R. Szaraz, Tim Delshammar, Rozalija Cvejić, Artur Santos, Julie Goodness, and Arjen Buijs. 2017. "Cultivating Nature-Based Solutions: The Governance of Communal Urban Gardens in the European Union." Environmental Research 159 (November): 264–75. https://doi.org/10.1016/j.envres.2017.08.013.

54 Bloemsma Lizan D., Gehring Ulrike, Klompmaker Jochem O., Hoek Gerard, Janssen Nicole A.H., Smit Henriëtte A., Vonk Judith M., Brunekreef Bert, Lebret Erik, and Wijga Alet H. n.d. "Green Space Visits among Adolescents: Frequency and Predictors in the PIAMA Birth Cohort Study." Environmental Health Perspectives 126 (4): 047016. https://doi.org/10.1289/EHP2429.

55 McEachan, Rosemary R C, Tiffany C Yang, Hannah Roberts, Kate E Pickett, Diana Arseneau-Powell, Christopher J Gidlow, John Wright, and Mark Nieuwenhuijsen. 2018. "Availability, Use of, and Satisfaction with Green Space, and Children's Mental Wellbeing at Age 4 Years in a Multicultural, Deprived, Urban Area: Results from the Born in Bradford Cohort Study." The Lancet Planetary Health 2 (6): e244–54. https://doi.org/10.1016/S2542-5196(18)30119-0.

56 Persson, Åsa, Jette Möller, Karin Engström, Mare Lõhmus Sundström, and Carla F. J. Nooijen. 2019. "Is Moving to a Greener or Less Green Area Followed by Changes in Physical Activity?" Health & Place 57 (May): 165–70. https://doi.org/10.1016/j.healthplace.2019.04.006.

57 Tsai, Wei-Lun, Raquel A. Silva, Maliha S. Nash, Ferdouz V. Cochran, Steven E. Prince, Daniel J. Rosenbaum, Aimee A. D'Aloisio, et al. 2020. "How Do Natural Features in the Residential Environment Influence Women's Self-Reported General Health? Results from Cross-Sectional Analyses of a U.S. National Cohort." Environmental Research 183 (April): 109176. https://doi.org/10.1016/j.envres.2020.109176.

58 Kabisch, Nadja, Matilda van den Bosch, and Raffaele Lafortezza. 2017. "The Health Benefits of Nature-Based Solutions to Urbanization Challenges for Children and the Elderly – A Systematic Review." Environmental Research 159 (November): 362–73. https://doi.org/10.1016/j.envres.2017.08.004.

59 Jia, Xianjie, Ying Yu, Wanning Xia, Shahir Masri, Mojgan Sami, Zhixiong Hu, Zhaoxia Yu, and Jun Wu. 2018. "Cardiovascular Diseases in Middle Aged and Older Adults in China: The Joint Effects and Mediation of Different Types of Physical Exercise and Neighborhood Greenness and Walkability." Environmental Research 167 (November): 175–83. https://doi.org/10.1016/j.envres.2018.07.003.

60 Lee, A. C. K., and R. Maheswaran. 2011. "The Health Benefits of Urban Green Spaces: A Review of the Evidence." Journal of Public Health 33 (2): 212–22. https://doi.org/10.1093/pubmed/fdq068.

61 Jennings, Viniece, Matthew H. E. M. Browning, and Alessandro Rigolon. 2019. Urban Green Spaces: Public Health and Sustainability in the United States. SpringerBriefs in Geography. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-10469-6.

62 Kihal-Talantikite, Wahida, Cindy M. Padilla, Benoît Lalloué, Marcello Gelormini, Denis Zmirou-Navier, and Severine Deguen. 2013. "Green Space, Social Inequalities and Neonatal Mortality in France." BMC Pregnancy and Childbirth 13 (1): 191. https://doi.org/10.1186/1471-2393-13-191.

63 Ebisu, Keita, Theodore R. Holford, and Michelle L. Bell. 2016. "Association between Greenness, Urbanicity, and Birth Weight." Science of The Total Environment 542 (January): 750–56. https://doi.org/10.1016/j.scitotenv.2015.10.111.

64 Cusack, Leanne, Andrew Larkin, Sue Carozza, and Perry Hystad. 2017. "Associations between Residential Greenness and Birth Outcomes across Texas." Environmental Research 152 (January): 88–95. https://doi.org/10.1016/j.envres.2016.10.003.

65 Senese, Laura, and Kathi Wilson. 2013. "Aboriginal Urbanization and Rights in Canada: Examining Implications for Health." Social Science & Medicine (1982) 91 (February). https://doi.org/10.1016/j.socscimed.2013.02.016.

66 Hartig, Terry, Richard Mitchell, Sjerp de Vries, and Howard Frumkin. 2014. "Nature and Health." Annual Review of Public Health 35 (1): 207–28. https://doi.org/10.1146/annurev-publhealth-032013-182443.

67 Jarvis, Ingrid, Mieke Koehoorn, Sarah E. Gergel, and Matilda van den Bosch. 2020. "Different Types of Urban Natural Environments Influence Various Dimensions of Self-Reported Health." Environmental Research 186 (July): 109614. https://doi.org/10.1016/j.envres.2020.109614.

68 The study included an examining of greenspaces from 126 long-term care facilities in 17 cities across Austria, Germany, Norway, Poland, Romania and Slovenia.

69 Brown, Scott C., Joanna Lombard, Kefeng Wang, Margaret M. Byrne, Matthew Toro, Elizabeth Plater-Zyberk, Daniel J. Feaster, et al. 2016. "Neighborhood Greenness and Chronic Health Conditions in Medicare Beneficiaries." American Journal of Preventive Medicine 51 (1): 78–89. https://doi.org/10.1016/j.amepre.2016.02.008.

70 Kabisch, Nadja, Niki Frantzeskaki, Stephan Pauleit, Sandra Naumann, McKenna Davis, Martina Artmann, Dagmar Haase, et al. 2016. "Nature-Based Solutions to Climate Change Mitigation and Adaptation in Urban Areas: Perspectives on Indicators, Knowledge Gaps, Barriers, and Opportunities for Action." Ecology and Society 21 (2). https://www.jstor.org/stable/26270403.

71 Bikomeye, Jean C., Joanna Balza, and Kirsten M. Beyer. 2021. "The Impact of Schoolyard Greening on Children's Physical Activity and Socioemotional Health: A Systematic Review of Experimental Studies." International Journal of Environmental Research and Public Health 18 (2): 535. https://doi.org/10.3390/ijerph18020535

72 Loptson, Kristjana, Nazeem Muhajarine, Tracy Ridalls, Nazeem Muhajarine, Karen Chad, Cory Neudorf, Adam Baxter-Jones, et al. 2012. "Walkable for Whom? Examining the Role of the Built Environment on the Neighbourhood-Based Physical Activity of Children." Canadian Journal of Public Health 103 (3): S29–34. https://doi.org/10.1007/BF03403832

73 Weimann, Hanna, Lars Rylander, Matilda Annerstedt van den Bosch, Maria Albin, Erik Skärbäck, Patrik Grahn, and Jonas Björk. 2017. "Perception of Safety Is a Prerequisite for the Association between Neighbourhood Green Qualities and Physical Activity: Results from a Cross-Sectional Study in Sweden." Health & Place 45 (May): 124–30. https://doi.org/10.1016/j.healthplace.2017.03.011.

74 Richardson, Elizabeth A., and Richard Mitchell. 2010. "Gender Differences in Relationships between Urban Green Space and Health in the United Kingdom." Social Science & Medicine 71 (3): 568–75. https://doi.org/10.1016/j.socscimed.2010.04.015

75 Hobbie, Sarah E., and Nancy B. Grimm. 2020. "Nature-Based Approaches to Managing Climate Change Impacts in Cities." Philosophical Transactions of the Royal Society B: Biological Sciences 375 (1794): 20190124. https://doi.org/10.1098/rstb.2019.0124.

76 MacKinnon, Kathy, Chantal van Ham, Kate Reilly, and Jo Hopkins. 2019. "Nature-Based Solutions and Protected Areas to Improve Urban Biodiversity and Health." In Biodiversity and Health in the Face of Climate Change, edited by Melissa R. Marselle, Jutta Stadler, Horst Korn, Katherine N. Irvine, and Aletta Bonn, 363–80. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-02318-8_16.

77 Pachauri, R. K., Leo Mayer, and Intergovernmental Panel on Climate Change, eds. 2015. Climate Change 2014: Synthesis Report. Geneva, Switzerland: Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_Front_matters.pdf

78 Lee, Whanhee, Hayon Michelle Choi, Jae Young Lee, Da Hye Kim, Yasushi Honda, and Ho Kim. 2018. "Temporal Changes in Mortality Impacts of Heat Wave and Cold Spell in Korea and Japan." Environment International 116 (July): 136–46. https://doi.org/10.1016/j.envint.2018.04.017.

79 Schweitzer, Michael D., Andrew S. Calzadilla, Oriana Salamo, Arash Sharifi, Naresh Kumar, Gregory Holt, Michael Campos, and Mehdi Mirsaeidi. 2018. "Lung Health in Era of Climate Change and Dust Storms." Environmental Research 163 (May): 36–42. https://doi.org/10.1016/j.envres.2018.02.001.

80 Rugel, Emily Jessica, and Michael Brauer. 2020. "Quiet, Clean, Green, and Active: A Navigation Guide Systematic Review of the Impacts of Spatially Correlated Urban Exposures on a Range of Physical Health Outcomes." Environmental Research 185 (June): 109388. https://doi.org/10.1016/j.envres.2020.109388.

81 Yang, Bo-Yi, Li-Wen Hu, Bin Jalaludin, Luke D. Knibbs, Iana Markevych, Joachim Heinrich, Michael S. Bloom, et al. 2020. "Association Between Residential Greenness, Cardiometabolic Disorders, and Cardiovascular Disease Among Adults in China." JAMA Network Open 3 (9): e2017507. https://doi.org/10.1001/jamanetworkopen.2020.17507.

82 Kumar, Prashant, Angela Druckman, John Gallagher, Birgitta Gatersleben, Sarah Allison, Theodore S. Eisenman, Uy Hoang, et al. 2019. "The Nexus between Air Pollution, Green Infrastructure and Human Health." Environment International 133 (December): 105181. https://doi.org/10.1016/j.envint.2019.105181.

83 Zölch, Teresa, Lisa Henze, Patrick Keilholz, and Stephan Pauleit. 2017. "Regulating Urban Surface Runoff through Nature-Based Solutions – An Assessment at the Micro-Scale." Environmental Research 157 (August): 135–44. https://doi.org/10.1016/j.envres.2017.05.023

84 Lafortezza, Raffaele, Jiquan Chen, Cecil Konijnendijk van den Bosch, and Thomas B. Randrup. 2018. "Nature-Based Solutions for Resilient Landscapes and Cities." Environmental Research 165 (August): 431–41. https://doi.org/10.1016/j.envres.2017.11.038.

85 Rao, Meenakshi, Linda A. George, Todd N. Rosenstiel, Vivek Shandas, and Alexis Dinno. 2014. "Assessing the Relationship among Urban Trees, Nitrogen Dioxide, and Respiratory Health." Environmental Pollution 194 (November): 96–104. https://doi.org/10.1016/j.envpol.2014.07.011

86 Alcock, Ian, Mathew White, Mark Cherrie, Benedict Wheeler, Jonathon Taylor, Rachel McInnes, Eveline Otte im Kampe, et al. 2017. "Land Cover and Air Pollution Are Associated with Asthma Hospitalisations: A Cross-Sectional Study." Environment International 109 (December): 29–41. https://doi.org/10.1016/j.envint.2017.08.009.

87 Manisalidis, Ioannis, Elisavet Stavropoulou, Agathangelos Stavropoulos, and Eugenia Bezirtzoglou. 2020. "Environmental and Health Impacts of Air Pollution: A Review." Frontiers in Public Health 8: 14. https://doi.org/10.3389/fpubh.2020.00014

88 Lovinsky-Desir, Stephanie., Kyung Hwa Jung, Andrew G. Rundle, Lori A. Hoepner, Joshua B. Bautista, Frederica P. Perera, Steven N. Chillrud, Matthew S. Perzanowski, and Rachel L. Miller. 2016. "Physical Activity, Black Carbon Exposure and Airway Inflammation in an Urban Adolescent Cohort." Environmental Research 151 (November): 756–62. https://doi.org/10.1016/j.envres.2016.09.005

89 Villeneuve, Paul J., Michael Jerrett, Jason G. Su, Richard T. Burnett, Hong Chen, Amanda J. Wheeler, and Mark S. Goldberg. 2012. "A Cohort Study Relating Urban Green Space with Mortality in Ontario, Canada." Environmental Research 115 (May): 51–58. https://doi.org/10.1016/j.envres.2012.03.003

90 Dabass, Arvind, Evelyn O. Talbott, Richard A. Bilonick, Judith R. Rager, Arvind Venkat, Gary M. Marsh, Chunzhe Duan, and Tao Xue. 2016. "Using Spatio-Temporal Modeling for Exposure Assessment in an Investigation of Fine Particulate Air Pollution and Cardiovascular Mortality." Environmental Research 151 (November): 564–72. https://doi.org/10.1016/j.envres.2016.08.024

91 Keijzer, Carmen de, David Agis, Albert Ambrós, Gustavo Arévalo, Jose M Baldasano, Stefano Bande, Jose Barrera-Gómez, et al. 2017. "The Association of Air Pollution and Greenness with Mortality and Life Expectancy in Spain: A Small-Area Study." Environment International 99 (February): 170–76. https://doi.org/10.1016/j.envint.2016.11.009

92 Bijnens, Esmée, Maurice P. Zeegers, Marij Gielen, Michal Kicinski, Geja J. Hageman, Daniëlle Pachen, Catherine Derom, Robert Vlietinck, and Tim S. Nawrot. 2015. "Lower Placental Telomere Length May Be Attributed to Maternal Residential Traffic Exposure; a Twin Study." Environment International 79 (June): 1–7. https://doi.org/10.1016/j.envint.2015.02.008

93 Nielsen, Charlene C., Carl G. Amrhein, Prakesh S. Shah, David M. Stieb, and Alvaro R. Osornio-Vargas. 2020. "Space-Time Hot Spots of Critically Ill Small for Gestational Age Newborns and Industrial Air Pollutants in Major Metropolitan Areas of Canada." Environmental Research 186 (July): 109472. https://doi.org/10.1016/j.envres.2020.109472

94 Braithwaite Isobel, Zhang Shuo, Kirkbride James B., Osborn David P. J., and Hayes Joseph F. n.d. "Air Pollution (Particulate Matter) Exposure and Associations with Depression, Anxiety, Bipolar, Psychosis and Suicide Risk: A Systematic Review and Meta-Analysis." Environmental Health Perspectives 127 (12): 126002. https://doi.org/10.1289/EHP4595

95 Stansfeld, Stephen A. 2015. "Noise Effects on Health in the Context of Air Pollution Exposure." International Journal of Environmental Research and Public Health 12 (10): 12735–60. https://doi.org/10.3390/ijerph121012735

96 Gille, Laure-Anne, Catherine Marquis-Favre, and Julien Morel. 2016. "Testing of the European Union Exposure-Response Relationships and Annoyance Equivalents Model for Annoyance Due to Transportation Noises: The Need of Revised Exposure-Response Relationships and Annoyance Equivalents Model." Environment International 94 (September): 83–94. https://doi.org/10.1016/j.envint.2016.04.027

97 Daiber, Andreas, Swenja Kröller-Schön, Matthias Oelze, Omar Hahad, Huige Li, Rainer Schulz, Sebastian Steven, and Thomas Münzel. 2020. "Oxidative Stress and Inflammation Contribute to Traffic Noise-Induced Vascular and Cerebral Dysfunction via Uncoupling of Nitric Oxide Synthases." Redox Biology 34 (July): 101506. https://doi.org/10.1016/j.redox.2020.101506

98 Hahad, Omar, Jürgen H. Prochaska, Andreas Daiber, and Thomas Muenzel. 2019. "Environmental Noise-Induced Effects on Stress Hormones, Oxidative Stress, and Vascular Dysfunction: Key Factors in the Relationship between Cerebrocardiovascular and Psychological Disorders." Oxidative Medicine and Cellular Longevity 2019 (November). https://doi.org/10.1155/2019/4623109.

99 Fujii, Hisako, Sanae Fukuda, Daisuke Narumi, Tomohiko Ihara, and Yasuyoshi Watanabe. 2015. "Fatigue and Sleep under Large Summer Temperature Differences." Environmental Research 138 (April): 17–21. https://doi.org/10.1016/j.envres.2015.02.006

100 Kingsley, Samantha L., Melissa N. Eliot, Eric A. Whitsel, Yen-Tsung Huang, Karl T. Kelsey, Carmen J. Marsit, and Gregory A. Wellenius. 2016. "Maternal Residential Proximity to Major Roadways, Birth Weight, and Placental DNA Methylation." Environment International 92–93 (July): 43–49. https://doi.org/10.1016/j.envint.2016.03.020

101 De Brito, Junia N. de, Zachary C. Pope, Nathan R. Mitchell, Ingrid E. Schneider, Jean M. Larson, Teresa H. Horton, and Mark A. Pereira. 2020. "The Effect of Green Walking on Heart Rate Variability: A Pilot Crossover Study." Environmental Research 185 (June): 109408. https://doi.org/10.1016/j.envres.2020.109408.

102 Kauffman, E. 2016. "WNV: Emerging Threat to the Americas and Opportunities for Control." CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 11 (011). https://doi.org/10.1079/PAVSNNR201611011

103 Zhang, Renyi, Yixin Li, Annie L. Zhang, Yuan Wang, and Mario J. Molina. 2020. "Identifying Airborne Transmission as the Dominant Route for the Spread of COVID-19." Proceedings of the National Academy of Sciences 117 (26): 14857–63. https://doi.org/10.1073/pnas.2009637117

104 ohnson, Christine K., Peta L. Hitchens, Pranav S. Pandit, Julie Rushmore, Tierra Smiley Evans, Cristin C. W. Young, and Megan M. Doyle. 2020. "Global Shifts in Mammalian Population Trends Reveal Key Predictors of Virus Spillover Risk." Proceedings of the Royal Society B: Biological Sciences 287 (1924): 20192736. https://doi.org/10.1098/rspb.2019.2736

105 The built environment includes both the natural environment and constructed environment in the quoted report

106 The Sustainable Forest Management Framework (FORMOD) is a series of best practices for the collective and sustainable management of shared forest resources in Eastern Europe and Russia. The framework has been applied in Western Canada in sustainable forest management programs to quantify the benefits of specific tree species and model changes to these benefits over time (Jeakins et al., 2014).

107 The American National Standards Institute - https://www.ansi.org/

108 International Standard Associations Tree Risk Assessment Qualification (TRAQ) https://www.isa-arbor.com/Portals/0/Assets/PDF/Certification-Applications/TRAQ-App-Guide.pdf

109 Kardan, Omid, Peter Gozdyra, Bratislav Misic, Faisal Moola, Lyle J. Palmer, Tomáš Paus, and Marc G. Berman. 2015. "Neighborhood Greenspace and Health in a Large Urban Center." Scientific Reports 5 (1): 11610. https://doi.org/10.1038/srep11610.

110 Markandya, Anil, Ramon A. Ortiz, and Aline Chiabai. 2019. "Estimating Environmental Health Costs: General Introduction to Valuation of Human Health Risks." In Encyclopedia of Environmental Health, 719–27. Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.10657-8.

111 OECD (2018), Cost-Benefit Analysis and the Environment: Further Developments and Policy Use, OECD Publishing, Paris, https://doi.org/10.1787/9789264085169-en

112 Wolf, Kathleen L., and Alicia S.T. Robbins. 2015. "Metro Nature, Environmental Health, and Economic Value." Environmental Health Perspectives 123 (5): 390–98. https://doi.org/10.1289/ehp.1408216

113 Treasury Board of Canada Secretariat (TBS). 2007. "Canadian Cost-Benefit Analysis Guide". Government of Canada. Accessed March 9, 2021. https://www.tbs-sct.gc.ca/rtrap-parfa/analys/analys-eng.pdf

114 Gray, Erin, Suzanne Ozment, Juan-Carlos Altamirano-Cabrera, Rafael Feltran-Barbieri, and Gabriela Morales. 2019. GREEN-GRAY ASSESSMENT: HOW TO ASSESS THE COSTS AND BENEFITS OF GREEN INFRASTRUCTURE FOR WATER SUPPLY SYSTEMS. https://doi.org/10.13140/RG.2.2.26788.01923

115 Jamison, Dean T., Joel G. Breman, Anthony R. Measham, George Alleyne, Mariam Claeson, David B. Evans, Prabhat Jha, Anne Mills, and Philip Musgrove. 2006. Cost-Effectiveness Analysis. Priorities in Health. The International Bank for Reconstruction and Development / The World Bank. https://www.ncbi.nlm.nih.gov/books/NBK10253/

116 Quality-adjusted life years (QALY) and disability-adjusted life years (DALY) are units used to assign economic value to the impacts of medical interventions on population health. One QALY is one year of life in perfect health; years of life with illness are assigned a value between 0 and 1, depending on the severity of the illness. One DALY is the sum of years lost due to premature death and years lived with either disability or disease.

117 Somarakis, G., Stagakis, S., & Chrysoulakis, N. (Eds.). 2019. ThinkNature Nature-Based Solutions Handbook. ThinkNature project funded by the EU Horizon 2020 research and innovation programme under grant agreement No. 730338. doi:10.26225/jerv-w202

118 Fowler, Heather Smith, Paul Lalonde, Geneviève Mák, and David Gyarmati. 2016. "Considerations for Assessing the Economic Value of Population Health Interventions." Social Research and Demonstration Corporation https://www.srdc.org/media/200027/phac-report-en.pdf

119 Rhew, Isaac C., Ann Vander Stoep, Anne Kearney, Nicholas L. Smith, and Matthew D. Dunbar. 2011. "Validation of the Normalized Difference Vegetation Index as a Measure of Neighborhood Greenness." Annals of Epidemiology 21 (12): 946–52. https://doi.org/10.1016/j.annepidem.2011.09.001

120 Somvanshi, Shivangi S., and Maya Kumari. 2020. "Comparative Analysis of Different Vegetation Indices with Respect to Atmospheric Particulate Pollution Using Sentinel Data." Applied Computing and Geosciences 7 (September): 100032. https://doi.org/10.1016/j.acags.2020.100032

121 Urban blue spaces can include natural water features such as rivers, lakes, and oceans, as well as constructed water features such as, fountains, reservoirs, constructed ponds and lakes.

122 Natural Resources Canada (NRCAN). 2019. "2015 Land Cover of Canada - Open Government Portal." Government of Canada. Accessed March 10, 2021. https://open.canada.ca/data/en/dataset/4e615eae-b90c-420b-adee-2ca35896caf6

123 Nowak, David. 2013. "A Guide to Assessing Urban Forests." NRS-INF-24-13 Revised. Newtown Square, PA: U.S.Department of Agriculture, Forest Service, Northern Research Station. 4 p. 24–13: 1–4. https://www.fs.fed.us/nrs/pubs/inf/nrs_inf_24_13.pdf

124 Stein, Hadley. 2017. "Launching a successful open data and citizen science initiative." Opentreemap blog. Accessed March 3, 2021. https://blog.opentreemap.org/2017/06/22/launching-successful-open-data-citizen-science-initiative/

125 All prices are converted to CAD and taken from www.opentreemap.org

126 European Center for Health Policy. 1999. "Health Impact Assessment: Main concepts and suggested approach". ECHP, WHO-ROE, Gothenburg consensus paper. Accessed March 16, 2021. http://www.healthedpartners.org/ceu/hia/hia01/01_02_gothenburg_paper_on_hia_1999.pdf

127 Freeman, S. Health impact assessment (HIA) knowledge and needs scan: Findings, gaps and recommendations. National Collaborating Centre for Environmental Health. November, 2019. https://ncceh.ca/documents/guide/health-impact-assessment-hia-knowledge-and-needs-scan-findings-gaps-and

128 Diallo, Thierno, and Shirra Freeman. 2020. Health Impact Assessment—Insights from the Experience of Québec. Environmental Health Review, 63(1). https://doi.org/10.5864/d2020-002

129 American Planning Association. 2016. "Health Impact Assessment Toolkit for Planners". American Planning Association. Accessed March 13, 2021. https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Health-Impact-Assessment-Toolkit.pdf

130 Impact Assessments Act of Canada (IAAC). 2020. "Practitioner's Guide to Federal Impact Assessments under the Impact Assessment Act. Government of Canada." Accessed March 8, 2021. https://www.canada.ca/en/impact-assessment-agency/services/policy-guidance/practitioners-guide-impact-assessment-act.html

131 Kahlmeier, Sonja, Thomas Götschi, Nick Cavill, Alberto Castro Fernandez, Christian Brand, David Rojas Rueda, James Woodcock, Paul Kelly, Christoph Lieb, Pekka Oja, Charlie Foster, Harry Rutter and Francesca Racioppi. 2017. "Health economic assessment tool (HEAT) for walking and for cycling". WHO Regional Office for Europe. Accessed July 23, 2021. https://www.who.int/publications/i/item/health-economic-assessment-tool-(heat)-for-walking-and-for-cycling

132 Cities4Forests. 2020. Social Equity Considerations for Cities' Decision Making Related to Inner, Nearby, and Faraway Forests". Cities4Forests. Accessed January 2, 2021. https://cities4forests.com/wp-content/uploads/2020/07/C4F-SocialEquity_LearningGuide.pdf (pg. 6)

133 Green Analytics. 2020. "A conceptual framework to understand the business case for EcoHealth in Ontario." EcoHealth Alliance. Accessed November 30, 2020. https://static1.squarespace.com/static/5c3cebfd45776eee4408f72d/t/5ecb445972e6a72aac117171/1590379619631/FO_8.5x11_EH_REPORT_FA_4WEB+%281%29.pdf

134 Government of Canada, Statistics Canada. 2018. "Canadian Health Measures Survey (CHMS)." September 10, 2018. https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5071

135 Government of Canada, Statistics Canada. 2021. "Canadian Community Health Survey - Annual Component (CCHS)." June 10, 2021. https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226

136 Wilson, Jeffrey. 2020. "Case Study: Downtown Urban Park, Peterborough, Ontario." Ecohealth Ontario Alliance. Accessed March 15, 2021. https://static1.squarespace.com/static/5c3cebfd45776eee4408f72d/t/603b1bd568222453l3f10573/1614486488711/GB_Ecohealth_PETERBOROUGH_case-study_E-ver.pdf

137 Wilson, Jeffrey[b]. 2020. Case Study: Increasing Tree Canopy, Brampton, Ontario." Ecohealth Ontario Alliance. Accessed March 15, 2021. https://static1.squarespace.com/static/5c3cebfd45776eee4408f72d/t/603b1d6a73d375051e0b4d6f/1614486893019/GB_Ecohealth_BRAMPTON_casestudy_E-ver.pdf

138 Reguero, Borja G., Michael W. Beck, David N. Bresch, Juliano Calil, and Imen Meliane. 2018. "Comparing the Cost Effectiveness of Nature-Based and Coastal Adaptation: A Case Study from the Gulf Coast of the United States." PLoS ONE 13 (4). https://doi.org/10.1371/journal.pone.0192132

139 Requia, Weeberb J., Henrique L. Roig, Matthew D. Adams, Antonella Zanobetti, and Petros Koutrakis. 2016. "Mapping Distance-Decay of Cardiorespiratory Disease Risk Related to Neighborhood Environments." Environmental Research 151 (November): 203–15. https://doi.org/10.1016/j.envres.2016.07.038

140 Rogers, Kenton, Keith Sacre, Jessica Goodenough, Kieron Jochem Doick, and Treeconomics (Business enterprise). 2015. Valuing London's Urban Forest: Results of the London i-Tree Eco Project. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/723230/LONDONI-TREEECOREPORT151202.pdf

141 Maxmen, Amy. 2020. "Why the United States Is Having a Coronavirus Data Crisis." Nature 585 (7823): 13–14. https://doi.org/10.1038/d41586-020-02478-z

142 Pampalon, Robert, Denis Hamel, Carolyne Alix and Maude Landry. 2013. A Strategy and Indicators for Monitoring Social Inequalities in Health in Québec." INSPQ. Accessed March 14, 2021. https://www.inspq.qc.ca/pdf/publications/1929_Strategy_Indicators_Monitoring_Inequalities.pdf

143 Abelsohn, Alan, and John Frank and John Eyles. 2009. "Environmental Public Health Tracking/Surveillance in Canada: A Commentary." Healthcare Policy 4 (3). https://www.longwoods.com/content/20534/healthcare-policy/environmental-public-health-tracking-surveillance-in-canada-a-commentary

144 Cohen, Deborah A., Bing Han, Kathryn Pitkin Derose, Stephanie Williamson, Terry Marsh, and Thomas L. McKenzie. 2013. "Physical Activity in Parks: A Randomized Controlled Trial Using Community Engagement." American Journal of Preventive Medicine 45 (5): 590–97. https://doi.org/10.1016/j.amepre.2013.06.015

145 Shackleton, Charlie M., and Andrew Blair. 2013. "Perceptions and Use of Public Green Space Is Influenced by Its Relative Abundance in Two Small Towns in South Africa." Landscape and Urban Planning 113 (May): 104–12. https://doi.org/10.1016/j.landurbplan.2013.01.011

146 Wolch, Jennifer, Michael Jerrett, Kim Reynolds, Rob McConnell, Roger Chang, Nicholas Dahmann, Kirby Brady, Frank Gilliland, Jason G. Su, and Kiros Berhane. 2011. "Childhood Obesity and Proximity to Urban Parks and Recreational Resources: A Longitudinal Cohort Study." Health & Place, Health Geographies of Voluntarism, 17 (1): 207–14. https://doi.org/10.1016/j.healthplace.2010.10.001

147 Ohri-Vachaspati, Punam, Kristen Lloyd, Derek DeLia, David Tulloch, and Michael J. Yedidia. 2013. "A Closer Examination of the Relationship between Children's Weight Status and the Food and Physical Activity Environment." Preventive Medicine 57 (3): 162–67. https://doi.org/10.1016/j.ypmed.2013.05.009

148 Tryon, M. 2011. "Stress and Food Intake: What's the Deal with Your Meal." CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 6 (034). https://doi.org/10.1079/PAVSNNR20116034

149 Sobko, Tanja, Gavin T. L. Brown, and Will H. G. Cheng. 2020. "Does Connectedness to Nature Improve the Eating Behaviours of Pre-Schoolers? Emerging Evidence from the Play&Grow Randomised Controlled Trial in Hong Kong." Appetite 154 (November): 104781. https://doi.org/10.1016/j.appet.2020.104781

150 Kabisch, Nadja, and Roland Kraemer. 2020. "Physical Activity Patterns in Two Differently Characterised Urban Parks under Conditions of Summer Heat." Environmental Science & Policy 107 (May): 56–65. https://doi.org/10.1016/j.envsci.2020.02.008

151 Koohsari, Mohammad Javad, Andrew T. Kaczynski, Billie Giles-Corti, and Justyna Anna Karakiewicz. 2013. "Effects of Access to Public Open Spaces on Walking: Is Proximity Enough?" Landscape and Urban Planning 117 (September): 92–99. https://doi.org/10.1016/j.landurbplan.2013.04.020

152 Hu, Zhiyong, Johan Liebens, and K. Ranga Rao. 2008. "Linking Stroke Mortality with Air Pollution, Income, and Greenness in Northwest Florida: An Ecological Geographical Study." International Journal of Health Geographics 7 (1): 1–22. https://doi.org/10.1186/1476-072X-7-20

153 Frantzeskaki, Niki, Timon McPhearson, Marcus J Collier, Dave Kendal, Harriet Bulkeley, Adina Dumitru, Claire Walsh, et al. 2019. "Nature-Based Solutions for Urban Climate Change Adaptation: Linking Science, Policy, and Practice Communities for Evidence-Based Decision-Making." BioScience 69 (6): 455–66. https://doi.org/10.1093/biosci/biz042

154 Gronlund, Carina J., Veronica J. Berrocal, Jalonne L. White-Newsome, Kathryn C. Conlon, and Marie S. O'Neill. 2015. "Vulnerability to Extreme Heat by Socio-Demographic Characteristics and Area Green Space among the Elderly in Michigan, 1990–2007." Environmental Research 136 (January): 449–61. https://doi.org/10.1016/j.envres.2014.08.042

155 Clark, D. G., R. Ness, D. Coffman, D. Beugin. 2021. "The Health Costs of Climate Change: How Canada Can Adapt, Prepare, and Save Lives." Canadian Institute for Climate Choices. https://climatechoices.ca/reports/the-health-costs-of-climate-change/

156 Cirillo, Colleen and Liat Podolsky. 2014. "Health, Prosperity and Sustainability: The Case For Green Infrastructure in Ontario." Green Infrastructure Ontario Coalition. https://ecojustice.ca/wp-content/uploads/2014/08/Health-Prosperity-and-Sustainability_The-Case-for-Green-Infrastructure-in-Ontario.pdf

157 Neugarten, R.A., Langhammer, P.F., Osipova, E., Bagstad, K.J., Bhagabati, N., Butchart, S.H.M., Dudley, N., Elliott, V., Gerber, L.R., Gutierrez Arrellano, C., Ivanić, K.-Z., Kettunen, M., Mandle, L., Merriman, J.C., Mulligan, M., Peh, K.S.-H., Raudsepp-Hearne, C., Semmens, D.J., Stolton, S., Willcock, S.. 2018. "Tools for measuring, modelling, and valuing ecosystem services: Guidance for Key Biodiversity Areas, natural World Heritage Sites, and protected areas." Gland, Switzerland: IUCN. x + 70pp. https://portals.iucn.org/library/sites/library/files/documents/PAG-028-En.pdf

REFERENCES

Abelsohn, Alan, and John Frank and John Eyles. 2009. "Environmental Public Health Tracking/Surveillance in Canada: A Commentary." Healthcare Policy 4 (3). https://www.longwoods.com/content/20534/healthcare-policy/environmental-public-health-tracking-surveillance-in-canada-a-commentary

Akaraci, Selin, Xiaoqi Feng, Thomas Suesse, Bin Jalaludin, and Thomas Astell-Burt. 2020. "A Systematic Review and Meta-Analysis of Associations between Green and Blue Spaces and Birth Outcomes." International Journal of Environmental Research and Public Health 17 (April): 2949. https://doi.org/10.3390/ijerph17082949

Akpinar, Abdullah. 2017. "Urban Green Spaces for Children: A Cross-Sectional Study of Associations with Distance, Physical Activity, Screen Time, General Health, and Overweight." Urban Forestry & Urban Greening 25 (July): 66–73. https://doi.org/10.1016/j.ufug.2017.05.006

Alcock, Ian, Mathew White, Mark Cherrie, Benedict Wheeler, Jonathon Taylor, Rachel McInnes, Eveline Otte im Kampe, et al. 2017. "Land Cover and Air Pollution Are Associated with Asthma Hospitalisations: A Cross-Sectional Study." Environment International 109 (December): 29–41. https://doi.org/10.1016/j.envint.2017.08.009

American Planning Association. 2016. "Health Impact Assessment Toolkit for Planners". American Planning Association. Accessed March 13, 2021. https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Health-Impact-Assessment-Toolkit.pdf

Andreucci, Maria Beatrice, Alessio Russo, and Agnieszka Olszewska-Guizzo. 2019. "Designing Urban Green Blue Infrastructure for Mental Health and Elderly Wellbeing." Sustainability 11 (22): 6425. https://doi.org/10.3390/su11226425

Artmann, Martina, and Katharina Sartison. 2018. "The Role of Urban Agriculture as a Nature-Based Solution: A Review for Developing a Systemic Assessment Framework." Sustainability 10 (6): 1937. https://doi.org/10.3390/su10061937

Astell-Burt, Thomas, and Xiaoqi Feng. 2020. "Urban Green Space, Tree Canopy and Prevention of Cardiometabolic Diseases: A Multilevel Longitudinal Study of 46 786 Australians." International Journal of Epidemiology 49 (3): 926–33. https://doi.org/10.1093/ije/dyz239

Astell-Burt, Thomas, Xiaoqi Feng, and Gregory S. Kolt. 2013. "Mental Health Benefits of Neighbourhood Green Space Are Stronger among Physically Active Adults in Middle-to-Older Age: Evidence from 260,061 Australians." Preventive Medicine 57 (5): 601–6. https://doi.org/10.1016/j.ypmed.2013.08.017

Banay, Rachel F., Carla P. Bezold, Peter James, Jaime E. Hart, and Francine Laden. 2017. "Residential Greenness: Current Perspectives on Its Impact on Maternal Health and Pregnancy Outcomes." International Journal of Women's Health 9: 133–44. https://doi.org/10.2147/IJWH.S125358

Becker, Douglas A., Matthew H. E. M. Browning, Ming Kuo, and Stephen K. Van Den Eeden. 2019. "Is Green Land Cover Associated with Less Health Care Spending? Promising Findings from County-Level Medicare Spending in the Continental United States." Urban Forestry & Urban Greening 41 (May): 39–47. https://doi.org/10.1016/j.ufug.2019.02.012

Bijnens, Esmée, Maurice P. Zeegers, Marij Gielen, Michal Kicinski, Geja J. Hageman, Daniëlle Pachen, Catherine Derom, Robert Vlietinck, and Tim S. Nawrot. 2015. "Lower Placental Telomere Length May Be Attributed to Maternal Residential Traffic Exposure; a Twin Study." Environment International 79 (June): 1–7. https://doi.org/10.1016/j.envint.2015.02.008

Bikomeye, Jean C., Joanna Balza, and Kirsten M. Beyer. 2021. "The Impact of Schoolyard Greening on Children's Physical Activity and Socioemotional Health: A Systematic Review of Experimental Studies." International Journal of Environmental Research and Public Health 18 (2): 535. https://doi.org/10.3390/ijerph18020535

Bloemsma Lizan D., Gehring Ulrike, Klompmaker Jochem O., Hoek Gerard, Janssen Nicole A.H., Smit Henriëtte A., Vonk Judith M., Brunekreef Bert, Lebret Erik, and Wijga Alet H. n.d. "Green Space Visits among Adolescents: Frequency and Predictors in the PIAMA Birth Cohort Study." Environmental Health Perspectives 126 (4): 047016. https://doi.org/10.1289/EHP2429

Braithwaite Isobel, Zhang Shuo, Kirkbride James B., Osborn David P. J., and Hayes Joseph F. n.d. "Air Pollution (Particulate Matter) Exposure and Associations with Depression, Anxiety, Bipolar, Psychosis and Suicide Risk: A Systematic Review and Meta-Analysis." Environmental Health Perspectives 127 (12): 126002. https://doi.org/10.1289/EHP4595

Bratman, Gregory N., Christopher B. Anderson, Marc G. Berman, Bobby Cochran, Sjerp de Vries, Jon Flanders, Carl Folke, et al. 2019. "Nature and Mental Health: An Ecosystem Service Perspective." Science Advances 5 (7): eaax0903. https://doi.org/10.1126/sciadv.aax0903

Brook, Jeffrey R., Eleanor M. Setton, Evan Seed, Mahdi Shooshtari, Dany Doiron, Philip Awadalla, Michael Brauer, et al. 2018. "The Canadian Urban Environmental Health Research Consortium – a Protocol for Building a National Environmental Exposure Data Platform for Integrated Analyses of Urban Form and Health." BMC Public Health 18 (1): 114. https://doi.org/10.1186/s12889-017-5001-5

Brooks-Cleator, Lauren A., and Audrey R. Giles. 2016. "Physical Activity Policy for Older Adults in the Northwest Territories, Canada: Gaps and Opportunities for Gains." ARCTIC 69 (2): 169-176-169–76. https://doi.org/10.14430/arctic4564

Brown, Scott C., Joanna Lombard, Kefeng Wang, Margaret M. Byrne, Matthew Toro, Elizabeth Plater-Zyberk, Daniel J. Feaster, et al. 2016. "Neighborhood Greenness and Chronic Health Conditions in Medicare Beneficiaries." American Journal of Preventive Medicine 51 (1): 78–89. https://doi.org/10.1016/j.amepre.2016.02.008

Capotorti, Giulia, Marta María Alós Ortí, Riccardo Copiz, Lina Fusaro, Barbara Mollo, Elisabetta Salvatori, and Laura Zavattero. 2019. "Biodiversity and Ecosystem Services in Urban Green Infrastructure Planning: A Case Study from the Metropolitan Area of Rome (Italy)." Urban Forestry & Urban Greening, Green Infrastructures: Nature Based Solutions for sustainable and resilient cities, 37 (January): 87–96. https://doi.org/10.1016/j.ufug.2017.12.014

Carvalho-Oliveira, Regiani, Luís F. Amato-Lourenço, Tiana C. L. Moreira, Douglas R. Rocha Silva, Bruna D. Vieira, Thais Mauad, Mitiko Saiki, and Paulo H. Nascimento Saldiva. 2017. "Effectiveness of Traffic-Related Elements in Tree Bark and Pollen Abortion Rates for Assessing Air Pollution Exposure on Respiratory Mortality Rates." Environment International 99 (February): 161–69. https://doi.org/10.1016/j.envint.2016.09.008

Chang, Hao-Ting, Chih-Da Wu, Jung-Der Wang, Po-See Chen, and Huey-Jen Su. 2020. "Residential Green Space Structures Are Associated with a Lower Risk of Bipolar Disorder: A Nationwide Population-Based Study in Taiwan." Environmental Pollution, October, 115864. https://doi.org/10.1016/j.envpol.2020.115864

Cirillo, Colleen and Liat Podolsky. 2014. "Health, Prosperity and Sustainability: The Case For Green Infrastructure in Ontario." Green Infrastructure Ontario Coalition. https://ecojustice.ca/wp-content/uploads/2014/08/Health-Prosperity-and-Sustainability_The-Case-for-Green-Infrastructure-in-Ontario.pdf

Cities4Forests. 2020. Social Equity Considerations for Cities' Decision Making Related to Inner, Nearby, and Faraway Forests". Cities4Forests. Accessed January 2, 2021. https://cities4forests.com/wp-content/uploads/2020/07/C4F-SocialEquity_LearningGuide.pdf

Clark, D. G., R. Ness, D. Coffman, D. Beugin. 2021. "The Health Costs of Climate Change: How Canada Can Adapt, Prepare, and Save Lives." Canadian Institute for Climate Choices. https://climatechoices.ca/reports/the-health-costs-of-climate-change/

Cohen, Deborah A., Bing Han, Kathryn Pitkin Derose, Stephanie Williamson, Terry Marsh, and Thomas L. McKenzie. 2013. "Physical Activity in Parks: A Randomized Controlled Trial Using Community Engagement." American Journal of Preventive Medicine 45 (5): 590–97. https://doi.org/10.1016/j.amepre.2013.06.015

Corazon, Sus Sola, Patrik Karlsson Nyed, Ulrik Sidenius, Dorthe Varning Poulsen, and Ulrika Karlsson Stigsdotter. 2018. "A Long-Term Follow-Up of the Efficacy of Nature-Based Therapy for Adults Suffering from Stress-Related Illnesses on Levels of Healthcare Consumption and Sick-Leave Absence: A Randomized Controlled Trial." International Journal of Environmental Research and Public Health 15 (1). https://doi.org/10.3390/ijerph15010137

Crouse, Dan L, Lauren Pinault, Adele Balram, Perry Hystad, Paul A Peters, Hong Chen, Aaron van Donkelaar, et al. 2017. "Urban Greenness and Mortality in Canada's Largest Cities: A National Cohort Study." The Lancet Planetary Health 1 (7): e289–97. https://doi.org/10.1016/S2542-5196(17)30118-3

Cusack, Leanne, Andrew Larkin, Sue Carozza, and Perry Hystad. 2017. "Associations between Residential Greenness and Birth Outcomes across Texas." Environmental Research 152 (January): 88–95. https://doi.org/10.1016/j.envres.2016.10.003

Dabass, Arvind, Evelyn O. Talbott, Richard A. Bilonick, Judith R. Rager, Arvind Venkat, Gary M. Marsh, Chunzhe Duan, and Tao Xue. 2016. "Using Spatio-Temporal Modeling for Exposure Assessment in an Investigation of Fine Particulate Air Pollution and Cardiovascular Mortality." Environmental Research 151 (November): 564–72. https://doi.org/10.1016/j.envres.2016.08.024

Dadvand, Payam, Xavier Bartoll, Xavier Basagaña, Albert Dalmau-Bueno, David Martinez, Albert Ambros, Marta Cirach, et al. 2016. "Green Spaces and General Health: Roles of Mental Health Status, Social Support, and Physical Activity." Environment International 91 (May): 161–67. https://doi.org/10.1016/j.envint.2016.02.029

Dadvand, Payam, Bart Ostro, Francesc Figueras, Maria Foraster, Xavier Basagaña, Antònia Valentín, David Martinez, et al. 2014. "Residential Proximity to Major Roads and Term Low Birth Weight: The Roles of Air Pollution, Heat, Noise, and Road-Adjacent Trees." Epidemiology (Cambridge, Mass.) 25 (4): 518–25. https://doi.org/10.1097/EDE.0000000000000107

Daiber, Andreas, Swenja Kröller-Schön, Matthias Oelze, Omar Hahad, Huige Li, Rainer Schulz, Sebastian Steven, and Thomas Münzel. 2020. "Oxidative Stress and Inflammation Contribute to Traffic Noise-Induced Vascular and Cerebral Dysfunction via Uncoupling of Nitric Oxide Synthases." Redox Biology 34 (July): 101506. https://doi.org/10.1016/j.redox.2020.101506

De Brito, Junia N. de, Zachary C. Pope, Nathan R. Mitchell, Ingrid E. Schneider, Jean M. Larson, Teresa H. Horton, and Mark A. Pereira. 2020. "The Effect of Green Walking on Heart Rate Variability: A Pilot Crossover Study." Environmental Research 185 (June): 109408. https://doi.org/10.1016/j.envres.2020.109408

De Vries, Sjerp de, Sonja M. E. van Dillen, Peter P. Groenewegen, and Peter Spreeuwenberg. 2013. "Streetscape Greenery and Health: Stress, Social Cohesion and Physical Activity as Mediators." Social Science & Medicine 94 (October): 26–33. https://doi.org/10.1016/j.socscimed.2013.06.030

Diallo, T. 2021. "Tools and Methods for Integrating Health into Climate Change Adaptation and Mitigation Policies and Strategies". National Collaborating Centre for Healthy Public Policy. Accessed July 15, 2021. https://www.inspq.qc.ca/sites/default/files/publications/2725-tools-methods-health-climate-change-adaptation-policies_and_strategies.pdf

Dzhambov, Angel M., Donka D. Dimitrova, and Elena D. Dimitrakova. 2014. "Association between Residential Greenness and Birth Weight: Systematic Review and Meta-Analysis." Urban Forestry & Urban Greening 13 (4): 621–29. https://doi.org/10.1016/j.ufug.2014.09.004

Ebisu, Keita, Theodore R. Holford, and Michelle L. Bell. 2016. "Association between Greenness, Urbanicity, and Birth Weight." Science of The Total Environment 542 (January): 750–56. https://doi.org/10.1016/j.scitotenv.2015.10.111

Edger, R., Howard, C., Lem, M., Zigby, J., Pétrin-Desrosiers, C., Doyle H.M., Kitching, G.T., Luo, O.D., Cohen, A.,Wu, K., Kirsh Carson, J.J., Létourneau S.G., & Kuhl, J. 2020. "Healthy Recovery Plan: For a Safe and Sustainable Future." Canadian Association of Physicians for the Environment. https://cape.ca/wp-content/uploads/2020/07/CAPE_Report2020_EN_HealthyRecoveryPlan-1.pdf

Egorov, Andrey I., Shannon M. Griffin, Reagan R. Converse, Jennifer N. Styles, Elizabeth A. Sams, Anthony Wilson, Laura E. Jackson, and Timothy J. Wade. 2017. "Vegetated Land Cover near Residence Is Associated with Reduced Allostatic Load and Improved Biomarkers of Neuroendocrine, Metabolic and Immune Functions." Environmental Research 158 (October): 508–21. https://doi.org/10.1016/j.envres.2017.07.009

Engemann, Kristine, Jens-Christian Svenning, Lars Arge, Jørgen Brandt, Christian Erikstrup, Camilla Geels, Ole Hertel, et al. 2020. "Associations between Growing up in Natural Environments and Subsequent Psychiatric Disorders in Denmark." Environmental Research 188 (September): 109788. https://doi.org/10.1016/j.envres.2020.109788

European Center for Health Policy. 1999. "Health Impact Assessment: Main concepts and suggested approach". ECHP, WHO-ROE, Gothenburg consensus paper. Accessed March 16, 2021. http://www.healthedpartners.org/ceu/hia/hia01/01_02_gothenburg_paper_on_hia_1999.pdf

Fowler, Heather Smith, Paul Lalonde, Geneviève Mák, and David Gyarmati. 2016. "Considerations for Assessing the Economic Value of Population Health Interventions." Social Research and Demonstration Corporation https://www.srdc.org/media/200027/phac-report-en.pdf

Franklin, Meredith, Xiaozhe Yin, Rob McConnell, and Scott Fruin. 2020. "Association of the Built Environment With Childhood Psychosocial Stress." JAMA Network Open 3 (10): e2017634. https://doi.org/10.1001/jamanetworkopen.2020.17634

Frantzeskaki, Niki, Timon McPhearson, Marcus J Collier, Dave Kendal, Harriet Bulkeley, Adina Dumitru, Claire Walsh, et al. 2019. "Nature-Based Solutions for Urban Climate Change Adaptation: Linking Science, Policy, and Practice Communities for Evidence-Based Decision-Making." BioScience 69 (6): 455–66. https://doi.org/10.1093/biosci/biz042

Freeman, S. Health impact assessment (HIA) knowledge and needs scan: Findings, gaps and recommendations. National Collaborating Centre for Environmental Health. November, 2019. https://ncceh.ca/documents/guide/health-impact-assessment-hia-knowledge-and-needs-scan-findings-gaps-and

Diallo, Thierno, and Shirra Freeman. 2020. Health Impact Assessment—Insights from the Experience of Québec. Environmental Health Review, 63(1). https://doi.org/10.5864/d2020-002

Fujii, Hisako, Sanae Fukuda, Daisuke Narumi, Tomohiko Ihara, and Yasuyoshi Watanabe. 2015. "Fatigue and Sleep under Large Summer Temperature Differences." Environmental Research 138 (April): 17–21. https://doi.org/10.1016/j.envres.2015.02.006

Gascon, Mireia, Margarita Triguero-Mas, David Martínez, Payam Dadvand, David Rojas-Rueda, Antoni Plasència, and Mark J. Nieuwenhuijsen. 2016. "Residential Green Spaces and Mortality: A Systematic Review." Environment International 86 (January): 60–67. https://doi.org/10.1016/j.envint.2015.10.013

Gille, Laure-Anne, Catherine Marquis-Favre, and Julien Morel. 2016. "Testing of the European Union Exposure-Response Relationships and Annoyance Equivalents Model for Annoyance Due to Transportation Noises: The Need of Revised Exposure-Response Relationships and Annoyance Equivalents Model." Environment International 94 (September): 83–94. https://doi.org/10.1016/j.envint.2016.04.027

Goon, Shatabdi, Saija Kontulainen, and Nazeem Muhajarine. 2020. "Neighborhood Built Environment Measures and Association with Physical Activity and Sedentary Time in 9–14-Year-Old Children in Saskatoon, Canada." International Journal of Environmental Research and Public Health 17 (11): 3837. https://doi.org/10.3390/ijerph17113837

Government of Canada, Statistics Canada. 2018. "Canadian Health Measures Survey (CHMS)." September 10, 2018. https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5071

Government of Canada, Statistics Canada. 2021. "Canadian Community Health Survey - Annual Component (CCHS)." June 10, 2021. https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226

Graham, Drew, Jennifer Vanos, Natasha Kenny, and Robert Brown. 2016. "The Relationship between Neighbourhood Tree Canopy Cover and Heat-Related Ambulance Calls during Extreme Heat Events in Toronto, Canada." Urban Forestry & Urban Greening 20 (August). https://doi.org/10.1016/j.ufug.2016.08.005

Gray, Erin, Suzanne Ozment, Juan-Carlos Altamirano-Cabrera, Rafael Feltran-Barbieri, and Gabriela Morales. 2019. GREEN-GRAY ASSESSMENT: HOW TO ASSESS THE COSTS AND BENEFITS OF GREEN INFRASTRUCTURE FOR WATER SUPPLY SYSTEMS. https://doi.org/10.13140/RG.2.2.26788.01923

Grazuleviciene, Regina, Asta Danileviciute, Audrius Dedele, Jone Vencloviene, Sandra Andrusaityte, Inga Uždanaviciute, and Mark J. Nieuwenhuijsen. 2015. "Surrounding Greenness, Proximity to City Parks and Pregnancy Outcomes in Kaunas Cohort Study." International Journal of Hygiene and Environmental Health 218 (3): 358–65. https://doi.org/10.1016/j.ijheh.2015.02.004

Green Analytics. 2020. "A conceptual framework to understand the business case for EcoHealth in Ontario." EcoHealth Alliance. Accessed November 30, 2020. https://static1.squarespace.com/static/5c3cebfd45776eee4408f72d/t/5ecb445972e6a72aac117171/1590379619631/FO_8.5x11_EH_REPORT_FA_4WEB+%281%29.pdf

Gronlund, Carina J., Veronica J. Berrocal, Jalonne L. White-Newsome, Kathryn C. Conlon, and Marie S. O'Neill. 2015. "Vulnerability to Extreme Heat by Socio-Demographic Characteristics and Area Green Space among the Elderly in Michigan, 1990–2007." Environmental Research 136 (January): 449–61. https://doi.org/10.1016/j.envres.2014.08.042

Hahad, Omar, Jürgen H. Prochaska, Andreas Daiber, and Thomas Muenzel. 2019. "Environmental Noise-Induced Effects on Stress Hormones, Oxidative Stress, and Vascular Dysfunction: Key Factors in the Relationship between Cerebrocardiovascular and Psychological Disorders." Oxidative Medicine and Cellular Longevity 2019 (November). https://doi.org/10.1155/2019/4623109

Hartig, Terry, Richard Mitchell, Sjerp de Vries, and Howard Frumkin. 2014. "Nature and Health." Annual Review of Public Health 35 (1): 207–28. https://doi.org/10.1146/annurev-publhealth-032013-182443

Helbich, Marco, Nadja Klein, Hannah Roberts, Paulien Hagedoorn, and Peter P. Groenewegen. 2018. "More Green Space Is Related to Less Antidepressant Prescription Rates in the Netherlands: A Bayesian Geoadditive Quantile Regression Approach." Environmental Research 166 (October): 290–97. https://doi.org/10.1016/j.envres.2018.06.010

Hobbie, Sarah E., and Nancy B. Grimm. 2020. "Nature-Based Approaches to Managing Climate Change Impacts in Cities." Philosophical Transactions of the Royal Society B: Biological Sciences 375 (1794): 20190124. https://doi.org/10.1098/rstb.2019.0124

Howarth, Michelle, Alistair Griffiths, Anna da Silva, and Richard Green. 2020. "Social Prescribing: A 'natural' Community-Based Solution." British Journal of Community Nursing 25 (6): 294–98. https://doi.org/10.12968/bjcn.2020.25.6.294

Hu, Zhiyong, Johan Liebens, and K. Ranga Rao. 2008. "Linking Stroke Mortality with Air Pollution, Income, and Greenness in Northwest Florida: An Ecological Geographical Study." International Journal of Health Geographics 7 (1): 1–22. https://doi.org/10.1186/1476-072X-7-20

Institute for Health Metrics and Evaluation (IHME).2020. Financing Global Health Visualization. University of Washington. Accessed February 3, 202 http://vizhub.healthdata.org/fgh/

Impact Assessments Act of Canada (IAAC). 2020. "Practitioner's Guide to Federal Impact Assessments under the Impact Assessment Act. Government of Canada." Accessed March 8, 2021. https://www.canada.ca/en/impact-assessment-agency/services/policy-guidance/practitioners-guide-impact-assessment-act.html

Irvine, Katherine N., Patrick Devine-Wright, Sarah R. Payne, Richard A. Fuller, Birgit Painter, and Kevin J. Gaston. 2009. "Green Space, Soundscape and Urban Sustainability: An Interdisciplinary, Empirical Study." Local Environment 14 (2): 155–72. https://doi.org/10.1080/13549830802522061

James, Peter, Rachel F. Banay, Jaime E. Hart, and Francine Laden. 2015. "A Review of the Health Benefits of Greenness." Current Epidemiology Reports 2 (2): 131–42. https://doi.org/10.1007/s40471-015-0043-7

Jamison, Dean T., Joel G. Breman, Anthony R. Measham, George Alleyne, Mariam Claeson, David B. Evans, Prabhat Jha, Anne Mills, and Philip Musgrove. 2006. Cost-Effectiveness Analysis. Priorities in Health. The International Bank for Reconstruction and Development / The World Bank. https://www.ncbi.nlm.nih.gov/books/NBK10253/

Jarvis, Ingrid, Mieke Koehoorn, Sarah E. Gergel, and Matilda van den Bosch. 2020. "Different Types of Urban Natural Environments Influence Various Dimensions of Self-Reported Health." Environmental Research 186 (July): 109614. https://doi.org/10.1016/j.envres.2020.109614

Jeakins, Paul, Stephen Sheppard, Fred Bunnell, and Ralph Wells. 2014. "FRAMEWORK FOR SUSTAINABLE FOREST MANAGEMENT A Framework for Sustainable Forest Management Introduction." BC Journal of Ecosystems and Management 7 (February): 37–49.

Jennings, Viniece, Matthew H. E. M. Browning, and Alessandro Rigolon. 2019. Urban Green Spaces: Public Health and Sustainability in the United States. SpringerBriefs in Geography. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-10469-6

Jia, Xianjie, Ying Yu, Wanning Xia, Shahir Masri, Mojgan Sami, Zhixiong Hu, Zhaoxia Yu, and Jun Wu. 2018. "Cardiovascular Diseases in Middle Aged and Older Adults in China: The Joint Effects and Mediation of Different Types of Physical Exercise and Neighborhood Greenness and Walkability." Environmental Research 167 (November): 175–83. https://doi.org/10.1016/j.envres.2018.07.003

Jimenez, Marcia P., Gregory A. Wellenius, Peter James, S. V. Subramanian, Stephen Buka, Charles Eaton, Stephen E. Gilman, and Eric B. Loucks. 2020. "Associations of Types of Green Space across the Life-Course with Blood Pressure and Body Mass Index." Environmental Research 185 (June): 109411. https://doi.org/10.1016/j.envres.2020.109411

Johnson, Christine K., Peta L. Hitchens, Pranav S. Pandit, Julie Rushmore, Tierra Smiley Evans, Cristin C. W. Young, and Megan M. Doyle. 2020. "Global Shifts in Mammalian Population Trends Reveal Key Predictors of Virus Spillover Risk." Proceedings of the Royal Society B: Biological Sciences 287 (1924): 20192736. https://doi.org/10.1098/rspb.2019.2736

Kabisch, Nadja, and Roland Kraemer. 2020. "Physical Activity Patterns in Two Differently Characterised Urban Parks under Conditions of Summer Heat." Environmental Science & Policy 107 (May): 56–65. https://doi.org/10.1016/j.envsci.2020.02.008

Kabisch, Nadja, Matilda van den Bosch, and Raffaele Lafortezza. 2017. "The Health Benefits of Nature-Based Solutions to Urbanization Challenges for Children and the Elderly – A Systematic Review." Environmental Research 159 (November): 362–73. https://doi.org/10.1016/j.envres.2017.08.004

Kabisch, Nadja, Niki Frantzeskaki, Stephan Pauleit, Sandra Naumann, McKenna Davis, Martina Artmann, Dagmar Haase, et al. 2016. "Nature-Based Solutions to Climate Change Mitigation and Adaptation in Urban Areas: Perspectives on Indicators, Knowledge Gaps, Barriers, and Opportunities for Action." Ecology and Society 21 (2). https://www.jstor.org/stable/26270403

Kahlmeier, Sonja, Thomas Götschi, Nick Cavill, Alberto Castro Fernandez, Christian Brand, David Rojas Rueda, James Woodcock, Paul Kelly, Christoph Lieb, Pekka Oja, Charlie Foster, Harry Rutter and Francesca Racioppi. 2017. "Health economic assessment tool (HEAT) for walking and for cycling". WHO Regional Office for Europe. Accessed July 23, 2021. https://www.who.int/publications/i/item/health-economic-assessment-tool-(heat)-for-walking-and-for-cycling

Kardan, Omid, Peter Gozdyra, Bratislav Misic, Faisal Moola, Lyle J. Palmer, Tomáš Paus, and Marc G. Berman. 2015. "Neighborhood Greenspace and Health in a Large Urban Center." Scientific Reports 5 (1): 11610. https://doi.org/10.1038/srep11610

Kauffman, E. 2016. "WNV: Emerging Threat to the Americas and Opportunities for Control." CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 11 (011). https://doi.org/10.1079/PAVSNNR201611011

Keijzer, Carmen de, David Agis, Albert Ambrós, Gustavo Arévalo, Jose M Baldasano, Stefano Bande, Jose Barrera-Gómez, et al. 2017. "The Association of Air Pollution and Greenness with Mortality and Life Expectancy in Spain: A Small-Area Study." Environment International 99 (February): 170–76. https://doi.org/10.1016/j.envint.2016.11.009

Kihal-Talantikite, Wahida, Cindy M. Padilla, Benoît Lalloué, Marcello Gelormini, Denis Zmirou-Navier, and Severine Deguen. 2013. "Green Space, Social Inequalities and Neonatal Mortality in France." BMC Pregnancy and Childbirth 13 (1): 191. https://doi.org/10.1186/1471-2393-13-191

Kingsley, Samantha L., Melissa N. Eliot, Eric A. Whitsel, Yen-Tsung Huang, Karl T. Kelsey, Carmen J. Marsit, and Gregory A. Wellenius. 2016. "Maternal Residential Proximity to Major Roadways, Birth Weight, and Placental DNA Methylation." Environment International 92–93 (July): 43–49. https://doi.org/10.1016/j.envint.2016.03.020

Kolokotsa, D., Aikaterini A. Lilli, Maria A. Lilli, and Nikolaos P. Nikolaidis. 2020. "On the Impact of Nature-Based Solutions on Citizens' Health & Well Being." Energy and Buildings 229 (December): 110527. https://doi.org/10.1016/j.enbuild.2020.110527

Koohsari, Mohammad Javad, Andrew T. Kaczynski, Billie Giles-Corti, and Justyna Anna Karakiewicz. 2013. "Effects of Access to Public Open Spaces on Walking: Is Proximity Enough?" Landscape and Urban Planning 117 (September): 92–99. https://doi.org/10.1016/j.landurbplan.2013.04.020

Kumar, Prashant, Angela Druckman, John Gallagher, Birgitta Gatersleben, Sarah Allison, Theodore S. Eisenman, Uy Hoang, et al. 2019. "The Nexus between Air Pollution, Green Infrastructure and Human Health." Environment International 133 (December): 105181. https://doi.org/10.1016/j.envint.2019.105181

Lachowycz, Kate, Andy P. Jones, Angie S. Page, Benedict W. Wheeler, and Ashley R. Cooper. 2012. "What Can Global Positioning Systems Tell Us about the Contribution of Different Types of Urban Greenspace to Children's Physical Activity?" Health & Place, Using scale to think about HIV/AIDS interventions: local and global dimensions, 18 (3): 586–94. https://doi.org/10.1016/j.healthplace.2012.01.006

Lafortezza, Raffaele, Jiquan Chen, Cecil Konijnendijk van den Bosch, and Thomas B. Randrup. 2018. "Nature-Based Solutions for Resilient Landscapes and Cities." Environmental Research 165 (August): 431–41. https://doi.org/10.1016/j.envres.2017.11.038

Lee, A. C. K., and R. Maheswaran. 2011. "The Health Benefits of Urban Green Spaces: A Review of the Evidence." Journal of Public Health 33 (2): 212–22. https://doi.org/10.1093/pubmed/fdq068

Lee, Whanhee, Hayon Michelle Choi, Jae Young Lee, Da Hye Kim, Yasushi Honda, and Ho Kim. 2018. "Temporal Changes in Mortality Impacts of Heat Wave and Cold Spell in Korea and Japan." Environment International 116 (July): 136–46. https://doi.org/10.1016/j.envint.2018.04.017

Loptson, Kristjana, Nazeem Muhajarine, Tracy Ridalls, Nazeem Muhajarine, Karen Chad, Cory Neudorf, Adam Baxter-Jones, et al. 2012. "Walkable for Whom? Examining the Role of the Built Environment on the Neighbourhood-Based Physical Activity of Children." Canadian Journal of Public Health 103 (3): S29–34. https://doi.org/10.1007/BF03403832

Lovinsky-Desir, Stephanie., Kyung Hwa Jung, Andrew G. Rundle, Lori A. Hoepner, Joshua B. Bautista, Frederica P. Perera, Steven N. Chillrud, Matthew S. Perzanowski, and Rachel L. Miller. 2016. "Physical Activity, Black Carbon Exposure and Airway Inflammation in an Urban Adolescent Cohort." Environmental Research 151 (November): 756–62. https://doi.org/10.1016/j.envres.2016.09.005

Maas, J., R. A. Verheij, S. de Vries, P. Spreeuwenberg, F. G. Schellevis, and P. P. Groenewegen. 2009. "Morbidity Is Related to a Green Living Environment." Journal of Epidemiology & Community Health 63 (12): 967–73. https://doi.org/10.1136/jech.2008.079038

MacKinnon, Kathy, Chantal van Ham, Kate Reilly, and Jo Hopkins. 2019. "Nature-Based Solutions and Protected Areas to Improve Urban Biodiversity and Health." In Biodiversity and Health in the Face of Climate Change, edited by Melissa R. Marselle, Jutta Stadler, Horst Korn, Katherine N. Irvine, and Aletta Bonn, 363–80. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-02318-8_16

Manisalidis, Ioannis, Elisavet Stavropoulou, Agathangelos Stavropoulos, and Eugenia Bezirtzoglou. 2020. "Environmental and Health Impacts of Air Pollution: A Review." Frontiers in Public Health 8: 14. https://doi.org/10.3389/fpubh.2020.00014

Markandya, Anil, Ramon A. Ortiz, and Aline Chiabai. 2019. "Estimating Environmental Health Costs: General Introduction to Valuation of Human Health Risks." In Encyclopedia of Environmental Health, 719–27. Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.10657-8

Maxmen, Amy. 2020. "Why the United States Is Having a Coronavirus Data Crisis." Nature 585 (7823): 13–14. https://doi.org/10.1038/d41586-020-02478-z

McEachan, Rosemary R C, Tiffany C Yang, Hannah Roberts, Kate E Pickett, Diana Arseneau-Powell, Christopher J Gidlow, John Wright, and Mark Nieuwenhuijsen. 2018. "Availability, Use of, and Satisfaction with Green Space, and Children's Mental Wellbeing at Age 4 Years in a Multicultural, Deprived, Urban Area: Results from the Born in Bradford Cohort Study." The Lancet Planetary Health 2 (6): e244–54. https://doi.org/10.1016/S2542-5196(18)30119-0

McMorris, Owen, Paul J. Villeneuve, Jason Su, and Michael Jerrett. 2015. "Urban Greenness and Physical Activity in a National Survey of Canadians." Environmental Research 137 (February): 94–100. https://doi.org/10.1016/j.envres.2014.11.010

Methorst, Joel, Katrin Rehdanz, Thomas Mueller, Bernd Hansjürgens, Aletta Bonn, and Katrin Böhning-Gaese. 2020. "The Importance of Species Diversity for Human Well-Being in Europe." Ecological Economics, November, 106917. https://doi.org/10.1016/j.ecolecon.2020.106917

Min, Kyoung-bok, Hyun-Jin Kim, Hye-Jin Kim, and Jin-young Min. 2017. "Parks and Green Areas and the Risk for Depression and Suicidal Indicators." International Journal of Public Health 62 (6): 647–56. https://doi.org/10.1007/s00038-017-0958-5

Natural Resources Canada (NRCAN). 2019. "2015 Land Cover of Canada - Open Government Portal." Government of Canada. Accessed March 10, 2021. https://open.canada.ca/data/en/dataset/4e615eae-b90c-420b-adee-2ca35896caf6

Ngom, Roland, Pierre Gosselin, Claudia Blais, and Louis Rochette. 2016. "Type and Proximity of Green Spaces Are Important for Preventing Cardiovascular Morbidity and Diabetes—A Cross-Sectional Study for Quebec, Canada." International Journal of Environmental Research and Public Health 13 (4): 423. https://doi.org/10.3390/ijerph13040423

Nielsen, Charlene C., Carl G. Amrhein, Prakesh S. Shah, David M. Stieb, and Alvaro R. Osornio-Vargas. 2020. "Space-Time Hot Spots of Critically Ill Small for Gestational Age Newborns and Industrial Air Pollutants in Major Metropolitan Areas of Canada." Environmental Research 186 (July): 109472. https://doi.org/10.1016/j.envres.2020.109472

Nowak, David J., Satoshi Hirabayashi, Marlene Doyle, Mark McGovern, and Jon Pasher. 2018. "Air Pollution Removal by Urban Forests in Canada and Its Effect on Air Quality and Human Health." Urban Forestry & Urban Greening 29 (January): 40–48. https://doi.org/10.1016/j.ufug.2017.10.019

Nowak, David. 2013. "A Guide to Assessing Urban Forests." NRS-INF-24-13 Revised. Newtown Square, PA: U.S.Department of Agriculture, Forest Service, Northern Research Station. 4 p. 24–13: 1–4. https://www.fs.fed.us/nrs/pubs/inf/nrs_inf_24_13.pdf

OECD (2018), Cost-Benefit Analysis and the Environment: Further Developments and Policy Use, OECD Publishing, Paris, https://doi.org/10.1787/9789264085169-en

Olafsdottir, Gunnthora, Paul Cloke, and Claus Vögele. 2017. "Place, Green Exercise and Stress: An Exploration of Lived Experience and Restorative Effects." Health & Place 46 (July): 358–65. https://doi.org/10.1016/j.healthplace.2017.02.006

Ohri-Vachaspati, Punam, Kristen Lloyd, Derek DeLia, David Tulloch, and Michael J. Yedidia. 2013. "A Closer Examination of the Relationship between Children's Weight Status and the Food and Physical Activity Environment." Preventive Medicine 57 (3): 162–67. https://doi.org/10.1016/j.ypmed.2013.05.009

Orstad, Stephanie L., Kristin Szuhany, Kosuke Tamura, Lorna E. Thorpe, and Melanie Jay. 2020. "Park Proximity and Use for Physical Activity among Urban Residents: Associations with Mental Health." International Journal of Environmental Research and Public Health 17 (13): 4885. https://doi.org/10.3390/ijerph17134885

Pachauri, R. K., Leo Mayer, and Intergovernmental Panel on Climate Change, eds. 2015. Climate Change 2014: Synthesis Report. Geneva, Switzerland: Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_Front_matters.pdf

Pampalon, Robert, Denis Hamel, Carolyne Alix and Maude Landry. 2013. A Strategy and Indicators for Monitoring Social Inequalities in Health in Québec." INSPQ. Accessed March 14, 2021. https://www.inspq.qc.ca/pdf/publications/1929_Strategy_Indicators_Monitoring_Inequalities.pdf

Panno, Angelo, Giuseppe Carrus, Raffaele Lafortezza, Luigi Mariani, and Giovanni Sanesi. 2017. "Nature-Based Solutions to Promote Human Resilience and Wellbeing in Cities during Increasingly Hot Summers." Environmental Research 159 (November): 249–56. https://doi.org/10.1016/j.envres.2017.08.016

Paul, Lauren A., Perry Hystad, Richard T. Burnett, Jeffrey C. Kwong, Dan L. Crouse, Aaron van Donkelaar, Karen Tu, et al. 2020. "Urban Green Space and the Risks of Dementia and Stroke." Environmental Research 186 (July): 109520. https://doi.org/10.1016/j.envres.2020.109520

Persson, Åsa, Jette Möller, Karin Engström, Mare Lõhmus Sundström, and Carla F. J. Nooijen. 2019. "Is Moving to a Greener or Less Green Area Followed by Changes in Physical Activity?" Health & Place 57 (May): 165–70. https://doi.org/10.1016/j.healthplace.2019.04.006

Pinault, Lauren. 2021. "Ethnocultural and Socioeconomic Disparities in Exposure to Residential Greenness within Urban Canada." Health Reports 32 (82): 14. https://www.doi.org/10.25318/82-003-x202100500001-eng

Prince, Stephanie A., Elizabeth A. Kristjansson, Katherine Russell, Jean-Michel Billette, Michael Sawada, Amira Ali, Mark S. Tremblay, and Denis Prud'homme. 2011. "A Multilevel Analysis of Neighbourhood Built and Social Environments and Adult Self-Reported Physical Activity and Body Mass Index in Ottawa, Canada." International Journal of Environmental Research and Public Health 8 (10): 3953–78. https://doi.org/10.3390/ijerph8103953

Public Health Agency of Canada (PHAC). 2017. "The Chief Public Health Officer's Report on the State of Public Health in Canada 2017 – Designing Healthy Living." Government of Canada. Accessed January 9, 2021 https://www.canada.ca/en/public-health/services/publications/chief-public-health-officer-reports-state-public-health-canada/2017-designing-healthy-living.html

Putra, I Gusti Ngurah Edi, Thomas Astell-Burt, Dylan P. Cliff, Stewart A. Vella, and Xiaoqi Feng. 2020. "Association between Green Space Quality and Prosocial Behaviour: A 10-Year Multilevel Longitudinal Analysis of Australian Children." Environmental Research, October, 110334. https://doi.org/10.1016/j.envres.2020.110334

Qiu, Yang, Tingting Yang, Barnabas C. Seyler, Xiuli Wang, Yuan Wang, Min Jiang, Bo Liu, and Fuping Li. 2020. "Ambient Air Pollution and Male Fecundity: A Retrospective Analysis of Longitudinal Data from a Chinese Human Sperm Bank (2013–2018)." Environmental Research 186 (July): 109528. https://doi.org/10.1016/j.envres.2020.109528

Rao, Meenakshi, Linda A. George, Todd N. Rosenstiel, Vivek Shandas, and Alexis Dinno. 2014. "Assessing the Relationship among Urban Trees, Nitrogen Dioxide, and Respiratory Health." Environmental Pollution 194 (November): 96–104. https://doi.org/10.1016/j.envpol.2014.07.011

Repke, Meredith A., Meredith S. Berry, Lucian G. Conway Iii, Alexander Metcalf, Reid M. Hensen, and Conor Phelan. 2018. "How Does Nature Exposure Make People Healthier?: Evidence for the Role of Impulsivity and Expanded Space Perception." PLOS ONE 13 (8): e0202246. https://doi.org/10.1371/journal.pone.0202246

Requia, Weeberb J., Henrique L. Roig, Matthew D. Adams, Antonella Zanobetti, and Petros Koutrakis. 2016. "Mapping Distance-Decay of Cardiorespiratory Disease Risk Related to Neighborhood Environments." Environmental Research 151 (November): 203–15. https://doi.org/10.1016/j.envres.2016.07.038

Rhew, Isaac C., Ann Vander Stoep, Anne Kearney, Nicholas L. Smith, and Matthew D. Dunbar. 2011. "Validation of the Normalized Difference Vegetation Index as a Measure of Neighborhood Greenness." Annals of Epidemiology 21 (12): 946–52. https://doi.org/10.1016/j.annepidem.2011.09.001

Richardson, Elizabeth A., and Richard Mitchell. 2010. "Gender Differences in Relationships between Urban Green Space and Health in the United Kingdom." Social Science & Medicine 71 (3): 568–75. https://doi.org/10.1016/j.socscimed.2010.04.015

Richardson, Elizabeth A., Jamie Pearce, Niamh K. Shortt, and Richard Mitchell. 2017. "The Role of Public and Private Natural Space in Children's Social, Emotional and Behavioural Development in Scotland: A Longitudinal Study." Environmental Research 158 (October): 729–36. https://doi.org/10.1016/j.envres.2017.07.038

Rogers, Kenton, Keith Sacre, Jessica Goodenough, Kieron Jochem Doick, and Treeconomics (Business enterprise). 2015. Valuing London's Urban Forest: Results of the London i-Tree Eco Project. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/723230/LONDONI-TREEECOREPORT151202.pdf

Rugel, Emily Jessica, and Michael Brauer. 2020. "Quiet, Clean, Green, and Active: A Navigation Guide Systematic Review of the Impacts of Spatially Correlated Urban Exposures on a Range of Physical Health Outcomes." Environmental Research 185 (June): 109388. https://doi.org/10.1016/j.envres.2020.109388

Reguero, Borja G., Michael W. Beck, David N. Bresch, Juliano Calil, and Imen Meliane. 2018. "Comparing the Cost Effectiveness of Nature-Based and Coastal Adaptation: A Case Study from the Gulf Coast of the United States." PLoS ONE 13 (4). https://doi.org/10.1371/journal.pone.0192132

Saadi, Diana, Izhak Schnell, Emanuel Tirosh, Xavier Basagaña, and Keren Agay-Shay. 2020. "There's No Place like Home? The Psychological, Physiological, and Cognitive Effects of Short Visits to Outdoor Urban Environments Compared to Staying in the Indoor Home Environment, a Field Experiment on Women from Two Ethnic Groups." Environmental Research 187 (August): 109687. https://doi.org/10.1016/j.envres.2020.109687

Sander, Heather A., Debarchana Ghosh, and Cody B. Hodson. 2017. "Varying Age-Gender Associations between Body Mass Index and Urban Greenspace." Urban Forestry & Urban Greening, Special feature: TURFGRASS, 26 (August): 1–10. https://doi.org/10.1016/j.ufug.2017.05.016

Sarkar, Chinmoy. 2017. "Residential Greenness and Adiposity: Findings from the UK Biobank." Environment International 106 (September): 1–10. https://doi.org/10.1016/j.envint.2017.05.016

Schweitzer, Michael D., Andrew S. Calzadilla, Oriana Salamo, Arash Sharifi, Naresh Kumar, Gregory Holt, Michael Campos, and Mehdi Mirsaeidi. 2018. "Lung Health in Era of Climate Change and Dust Storms." Environmental Research 163 (May): 36–42. https://doi.org/10.1016/j.envres.2018.02.001

Senese, Laura, and Kathi Wilson. 2013. "Aboriginal Urbanization and Rights in Canada: Examining Implications for Health." Social Science & Medicine (1982) 91 (February). https://doi.org/10.1016/j.socscimed.2013.02.016

Shackleton, Charlie M., and Andrew Blair. 2013. "Perceptions and Use of Public Green Space Is Influenced by Its Relative Abundance in Two Small Towns in South Africa." Landscape and Urban Planning 113 (May): 104–12. https://doi.org/10.1016/j.landurbplan.2013.01.011

Shen, Yu-Sheng, and Shih-Chun Candice Lung. 2016. "Can Green Structure Reduce the Mortality of Cardiovascular Diseases?" Science of The Total Environment 566–567 (October): 1159–67. https://doi.org/10.1016/j.scitotenv.2016.05.159

Sobko, Tanja, Gavin T. L. Brown, and Will H. G. Cheng. 2020. "Does Connectedness to Nature Improve the Eating Behaviours of Pre-Schoolers? Emerging Evidence from the Play&Grow Randomised Controlled Trial in Hong Kong." Appetite 154 (November): 104781. https://doi.org/10.1016/j.appet.2020.104781

Somarakis, G., Stagakis, S., & Chrysoulakis, N. (Eds.). 2019. ThinkNature Nature-Based Solutions Handbook. ThinkNature project funded by the EU Horizon 2020 research and innovation programme under grant agreement No. 730338. doi:10.26225/jerv-w202

Somvanshi, Shivangi S., and Maya Kumari. 2020. "Comparative Analysis of Different Vegetation Indices with Respect to Atmospheric Particulate Pollution Using Sentinel Data." Applied Computing and Geosciences 7 (September): 100032. https://doi.org/10.1016/j.acags.2020.100032

Stansfeld, Stephen A. 2015. "Noise Effects on Health in the Context of Air Pollution Exposure." International Journal of Environmental Research and Public Health 12 (10): 12735–60. https://doi.org/10.3390/ijerph121012735

Statistics Canada. 2019. "Population Projections for Canada (2018 to 2068), Provinces and Territories (2018 to 2043)." Government of Canada. Accessed February 3, 2021 https://www150.statcan.gc.ca/n1/pub/91-520-x/91-520-x2019001-eng.htm

Stein, Hadley. 2017. "Launching a successful open data and citizen science initiative." Opentreemap blog. Accessed March 3, 2021. https://blog.opentreemap.org/2017/06/22/launching-successful-open-data-citizen-science-initiative/

Thomas, Felicity. 2015. "The Role of Natural Environments within Women's Everyday Health and Wellbeing in Copenhagen, Denmark." Health & Place 35 (September): 187–95. https://doi.org/10.1016/j.healthplace.2014.11.005

Treasury Board of Canada Secretariat (TBS). 2007. "Canadian Cost-Benefit Analysis Guide". Government of Canada. Accessed March 9, 2021. https://www.tbs-sct.gc.ca/rtrap-parfa/analys/analys-eng.pdf

Tryon, M. 2011. "Stress and Food Intake: What's the Deal with Your Meal." CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 6 (034). https://doi.org/10.1079/PAVSNNR20116034

Tsai, Wei-Lun, Raquel A. Silva, Maliha S. Nash, Ferdouz V. Cochran, Steven E. Prince, Daniel J. Rosenbaum, Aimee A. D'Aloisio, et al. 2020. "How Do Natural Features in the Residential Environment Influence Women's Self-Reported General Health? Results from Cross-Sectional Analyses of a U.S. National Cohort." Environmental Research 183 (April): 109176. https://doi.org/10.1016/j.envres.2020.109176

Twohig-Bennett, Caoimhe, and Andy Jones. 2018. "The Health Benefits of the Great Outdoors: A Systematic Review and Meta-Analysis of Greenspace Exposure and Health Outcomes." Environmental Research 166 (October): 628–37. https://doi.org/10.1016/j.envres.2018.06.030

URBAN-NEXUS. 2012. "Health and Quality of Life Synthesis Report WP3". European Union. Accessed December 7, 2020. http://www.ectp-ceu.eu/images/stories/PDF-docs/Health%20and%20Quality%20of%20life%20Sythesis%20Report%20WP3.pdf

Van Aart, Carola J.C., Nathalie Michels, Isabelle Sioen, Annelies De Decker, Esmee M. Bijnens, Bram G. Janssen, Stefaan De Henauw, and Tim S. Nawrot. 2018. "Residential Landscape as a Predictor of Psychosocial Stress in the Life Course from Childhood to Adolescence." Environment International 120 (November): 456–63. https://doi.org/10.1016/j.envint.2018.08.028

Van Den Berg, Magdalena, Wanda Wendel-Vos, Mireille van Poppel, Han Kemper, Willem van Mechelen, and Jolanda Maas. 2015. "Health Benefits of Green Spaces in the Living Environment: A Systematic Review of Epidemiological Studies." Urban Forestry & Urban Greening 14 (4): 806–16. https://doi.org/10.1016/j.ufug.2015.07.008

Van den Bosch, M., and Å. Ode Sang. 2017. "Urban Natural Environments as Nature-Based Solutions for Improved Public Health – A Systematic Review of Reviews." Environmental Research 158 (October): 373–84. https://doi.org/10.1016/j.envres.2017.05.040

Van den Bosch, Matilda Annerstedt, and Michael H. Depledge. 2015. "Healthy People with Nature in Mind." BMC Public Health 15 (1): 1–7. https://doi.org/10.1186/s12889-015-2574-8

Van Der Jagt, Alexander P. N. van der, Luca R. Szaraz, Tim Delshammar, Rozalija Cvejić, Artur Santos, Julie Goodness, and Arjen Buijs. 2017. "Cultivating Nature-Based Solutions: The Governance of Communal Urban Gardens in the European Union." Environmental Research 159 (November): 264–75. https://doi.org/10.1016/j.envres.2017.08.013

Van Renterghem, Timothy, Jens Forssén, Keith Attenborough, Philippe Jean, Jérôme Defrance, Maarten Hornikx, and Jian Kang. 2015. "Using Natural Means to Reduce Surface Transport Noise during Propagation Outdoors." Applied Acoustics 92 (May): 86–101. https://doi.org/10.1016/j.apacoust.2015.01.004

Vienneau, Danielle, Kees de Hoogh, David Faeh, Marco Kaufmann, Jean Marc Wunderli, and Martin Röösli. 2017. "More than Clean Air and Tranquillity: Residential Green Is Independently Associated with Decreasing Mortality." Environment International 108 (November): 176–84. https://doi.org/10.1016/j.envint.2017.08.012

Villeneuve, Paul J., Michael Jerrett, Jason G. Su, Richard T. Burnett, Hong Chen, Amanda J. Wheeler, and Mark S. Goldberg. 2012. "A Cohort Study Relating Urban Green Space with Mortality in Ontario, Canada." Environmental Research 115 (May): 51–58. https://doi.org/10.1016/j.envres.2012.03.003

Vujcic, Maja, Jelena Tomicevic-Dubljevic, Mihailo Grbic, Dusica Lecic-Tosevski, Olivera Vukovic, and Oliver Toskovic. 2017. "Nature Based Solution for Improving Mental Health and Well-Being in Urban Areas." Environmental Research 158 (October): 385–92. https://doi.org/10.1016/j.envres.2017.06.030

Ward Thompson, Catharine, Jenny Roe, and Peter Aspinall. 2013. "Woodland Improvements in Deprived Urban Communities: What Impact Do They Have on People's Activities and Quality of Life?" Landscape and Urban Planning 118 (October): 79–89. https://doi.org/10.1016/j.landurbplan.2013.02.001

Weimann, Hanna, Lars Rylander, Matilda Annerstedt van den Bosch, Maria Albin, Erik Skärbäck, Patrik Grahn, and Jonas Björk. 2017. "Perception of Safety Is a Prerequisite for the Association between Neighbourhood Green Qualities and Physical Activity: Results from a Cross-Sectional Study in Sweden." Health & Place 45 (May): 124–30. https://doi.org/10.1016/j.healthplace.2017.03.011

Wild, T. C., J. Henneberry, and L. Gill. 2017. "Comprehending the Multiple 'Values' of Green Infrastructure – Valuing Nature-Based Solutions for Urban Water Management from Multiple Perspectives." Environmental Research 158 (October): 179–87. https://doi.org/10.1016/j.envres.2017.05.043

Wilson, Jeffrey. 2020. "Case Study: Downtown Urban Park, Peterborough, Ontario." Ecohealth Ontario Alliance. Accessed March 15, 2021. https://static1.squarespace.com/static/5c3cebfd45776eee4408f72d/t/603b1bd56822245313f10573/1614486488711/GB_Ecohealth_PETERBOROUGH_casestudy_E-ver.pdf

Wilson, Jeffrey[b]. 2020. "Case Study: Increasing Tree Canopy, Brampton, Ontario." Ecohealth Ontario Alliance. Accessed March 15, 2021. https://static1.squarespace.com/static/5c3cebfd45776eee4408f72d/t/603b1d6a73d375051e0b4d6f/1614486893019/GB_Ecohealth_BRAMPTON_casestudy_E-ver.pdf

Wolch, Jennifer, Michael Jerrett, Kim Reynolds, Rob McConnell, Roger Chang, Nicholas Dahmann, Kirby Brady, Frank Gilliland, Jason G. Su, and Kiros Berhane. 2011. "Childhood Obesity and Proximity to Urban Parks and Recreational Resources: A Longitudinal Cohort Study." Health & Place, Health Geographies of Voluntarism, 17 (1): 207–14. https://doi.org/10.1016/j.healthplace.2010.10.001

Wolf, Kathleen L., and Alicia S.T. Robbins. 2015. "Metro Nature, Environmental Health, and Economic Value." Environmental Health Perspectives 123 (5): 390–98. https://doi.org/10.1289/ehp.1408216

Yang, Bo-Yi, Li-Wen Hu, Bin Jalaludin, Luke D. Knibbs, Iana Markevych, Joachim Heinrich, Michael S. Bloom, et al. 2020. "Association Between Residential Greenness, Cardiometabolic Disorders, and Cardiovascular Disease Among Adults in China." JAMA Network Open 3 (9): e2017507. https://doi.org/10.1001/jamanetworkopen.2020.17507

Yang, Bo-Yi, Iana Markevych, Joachim Heinrich, Michael S. Bloom, Zhengmin Qian, Sarah Dee Geiger, Michael Vaughn, et al. 2019. "Residential Greenness and Blood Lipids in Urban-Dwelling Adults: The 33 Communities Chinese Health Study." Environmental Pollution 250 (July): 14–22. https://doi.org/10.1016/j.envpol.2019.03.128

Zanchetta, Margareth S., Christine Maheu, Olesya Kolisnyk, Mohamed Mohamed, Sepali Guruge, Diana Kinslikh, Joneet J. Christopher, et al. 2017. "Canadian Men's Self-Management of Chronic Diseases: A Literature Analysis of Strategies for Dealing With Risks and Promoting Wellness." American Journal of Men's Health 11 (4): 1077–95. https://doi.org/10.1177/1557988315577674

Zhang, Renyi, Yixin Li, Annie L. Zhang, Yuan Wang, and Mario J. Molina. 2020. "Identifying Airborne Transmission as the Dominant Route for the Spread of COVID-19." Proceedings of the National Academy of Sciences 117 (26): 14857–63. https://doi.org/10.1073/pnas.2009637117

Zölch, Teresa, Lisa Henze, Patrick Keilholz, and Stephan Pauleit. 2017. "Regulating Urban Surface Runoff through Nature-Based Solutions – An Assessment at the Micro-Scale." Environmental Research 157 (August): 135–44. https://doi.org/10.1016/j.envres.2017.05.023

Smart Prosperity Institute

institute.smartprosperity.ca

ACKNOWLEDGEMENTS

The author would like to thank Health Canada for their funding and support for this project. Thanks to Shirra Freeman, Kathleen Wolf, Jacob Cramer, Melissa Lem, and Thomas Bowers for providing helpful comments on earlier drafts of this report, and to Brian Buchardt and Adrina Bardekjian for providing key insights during many stimulating conversations. Thanks also to Smart Prosperity Institute's Alice Irene Whittaker, Mathias Schoemer, and Mac Radburn for their editing and production support, to Jared Bell and Diane Torlone for additional editing and design support, and to the entire SPI nature team for their ongoing effort in furthering the message around the importance of improving environmental health in Canada.