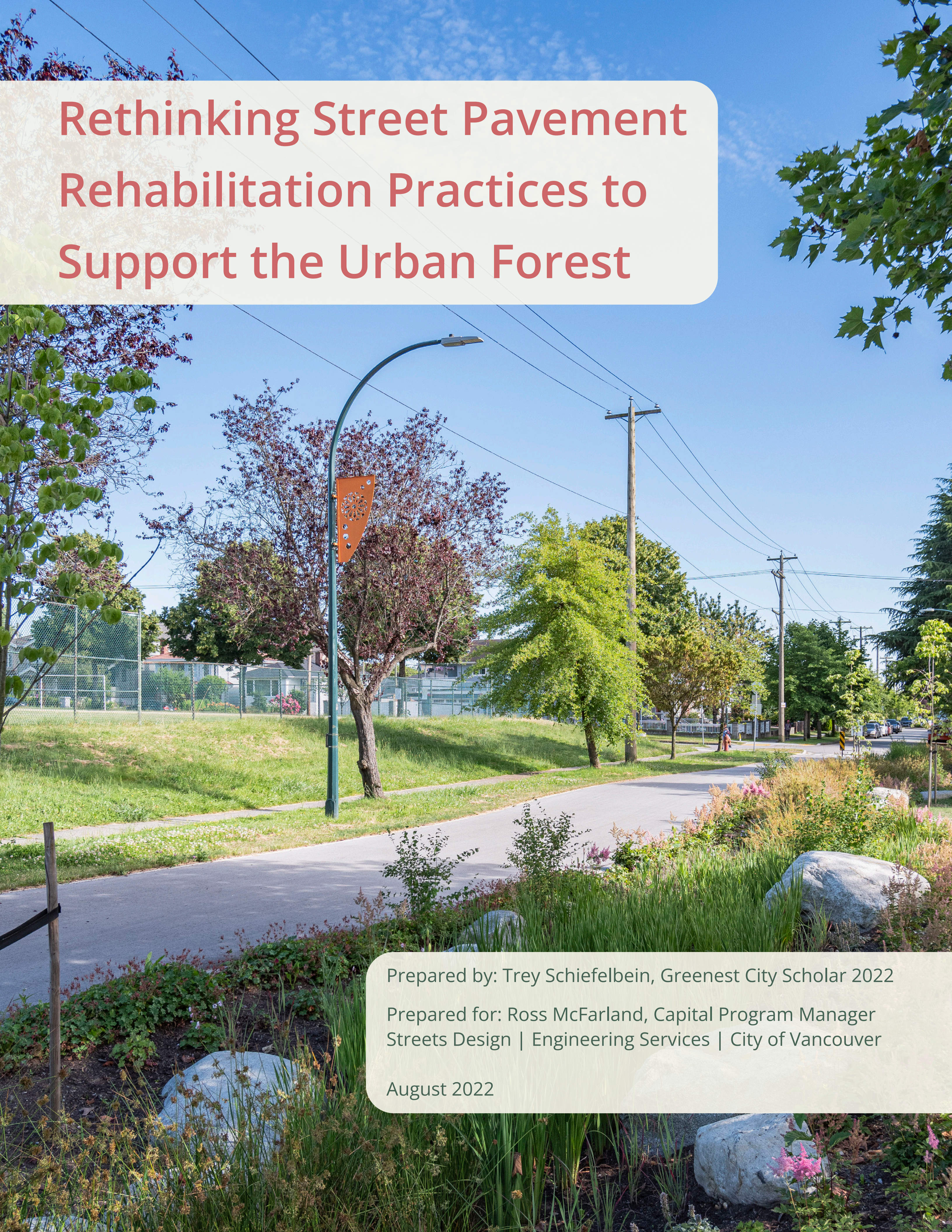
Rethinking Street Pavement Rehabilitation Practices to Support the Urban Forest



Prepared by: Trey Schiefelbein, Greenest City Scholar 2022

Prepared for: Ross McFarland, Capital Program Manager
Streets Design | Engineering Services | City of Vancouver

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Executive Summary

As more regions of the world experience extreme heat, cities must reassess long-standing strategies as they adapt to climate change. Street trees (defined as public trees grown on boulevards in the City of Vancouver) are one of the most powerful tools for combatting extreme heat, but they are difficult to grow and are typically planted in constrained environments. This report explores the relationship between street and sidewalk pavement rehabilitation and their impacts on the urban forest. At present, the relationship between paved surfaces and street trees is often characterized by conflict. This leads to the two fundamental questions addressed by this report:

1. How can the City of Vancouver preserve and sustain its street trees while also maintaining its streets and sidewalks in a good state of repair?

2. How can the City of Vancouver open space within the street right-of-way (property-line to property-line widths of public roads) to expand the urban forest and other ecological services?

These questions derive from three challenges posed by past and present paving practices. First, street trees are not given adequate conditions to grow (clearance, soil volume, nutrients, etc.) and subsequently damage infrastructure as they mature. In return, these constraints also damage street trees. Second, the amount of street right-of-way dedicated to impervious surface contributes to the urban heat island effect and produces urban rainwater runoff. This amplifies extreme weather events, as heat waves are more severe and flooding is more frequent. Finally, concrete and asphalt are carbon intensive materials, and the City of Vancouver should work to reduce their use wherever possible.

The Greenest City Action Plan of 2011 established Vancouver as a leader in environmentally engaged planning, and the City can continue this by rethinking paving practices to help create a more equitable and livable city. This project supports the City of Vancouver's Climate Emergency Action Plan, Urban Forestry Strategy, Rain City Strategy, and Climate Adaptation Strategy, and includes a review of each policy. An evaluation of academic work related to street and sidewalk asset management, green infrastructure and green streets, and urban forestry is also included to establish the context.

One of the primary objectives of this project is to assess streets in need of rehabilitation or replacement and ask whether those streets, instead of repaving like-for-like, can serve different functions that directly contribute to the City's Climate Emergency Action Plan targets. Overly paved urban environments do not reflect current values and are, in fact, counterproductive to confronting the urgency of the climate crisis. To reduce the urban heat island effect, expand the urban forest, better manage stormwater, and create a more resilient and sustain-

able street network, a new approach to street asset management is required.

A strategy of "depaving" guides this project, and several case studies from around the world are assessed. Depaving is any attempt to reduce paved surfaces from the urban environment and replace them with some form of permeable surface that serves an ecological function. While these projects use their own vocabulary and rarely (if at all) mention depaving, they each offer ecologically motivated strategies to reduce the amount of impervious surface in their city.

A GIS analysis is included to find potential intervention sites. This analyzed the pavement condition score of each street in Vancouver, tree canopy cover, exposure to extreme heat, and equity indicators. Areas of greatest need were identified, and the resulting overlays were then compared to areas that offer other co-benefits: park proximity, cycling routes, etc. A list of potential intervention sites is included, along with five recommendations for future depaving projects:

1. Work quickly and efficiently.
2. Consider different scales.
3. Expand opportunities to collaborate.
4. Involve the community.
5. Stay flexible.

The final discussion reflects on issues that require further research. When a street reaches the end of its service life, the City should consider whether the pavement requires replacing, or if the street can supply other ecological, social, and transportation services. While there is no silver bullet to address the effects of climate change, depaving is one of many available tools to create more environmentally and socially just cities today and into the future.

Vancouver's trees shedding their leaves in response to heat. Photo credit: Ben Nelms - CBC News.

Introduction

Background

In June 2021, a record-breaking heat wave settled over Western Canada. This weather event, also known as a heat dome, broke temperature records throughout Metro Vancouver as some cities passed the 40-degree mark (Nassar, 2021). The town of Lytton, BC, a few hours east of Vancouver, set a Canadian record of 49.6 degrees on June 28th and was destroyed by a fire two days later (Schmunk, 2021).

The BC Coroners Service concluded there were 619 heat related deaths during this time, making this the deadliest weather event in Canadian history. However, some populations were at greater risk than others. The coroner's report found that most deaths were older adults who lived alone, without air conditioning, and with previous health conditions. Nearly three quarters of all deaths occurred in the Vancouver Coastal and Fraser Health Authorities, which cover Metro Vancouver (Hunter & Woo, 2022).

As exceptional as this was, the changing climate means that this type of heat event will almost certainly happen again. On June 7, 2022, nearly one year after the heat wave, a full analysis of the heat related deaths was released. Three high level recommendations to prevent future deaths were given, with the third recommendation being the "[implementation of] extreme heat prevention and long-term risk mitigation strategies." Within this strategy, the Coroners Service specifically calls for new province-wide requirements related to the "protection and restoration of the urban tree canopy and permeable surface areas to absorb water" (The BC Coroners Service, 2022, p. 33).

However, supporting the urban forest is a challenging task. As the heat wave settled over Vancouver, some trees began to shed their leaves as a defence mechanism to conserve water (Kulkarni, 2021). While the heat and drought were to blame for this activity, the amount of pavement in the urban environment was also a factor as it raised surface temperatures and diverted water away from trees. In the face of such extreme environmental emergencies, what can cities do to preserve and expand their urban forests?

This report explores the relationship between street and sidewalk pavement rehabilitation and their impacts on the urban forest. At present, the relationship between paved surfaces and street trees (public trees grown on boulevards) is often characterized by conflict. Paved surfaces create constrained growing condition for trees, and the trees later damage the pavement as their roots search for space, water, and nutrition to survive. Ultimately this losing battle leaves cities with weakened trees and damaged streets and sidewalks. This leads to the two fundamental questions addressed by this report:

1. How can the City of Vancouver preserve and sustain its street trees while also maintaining its streets and sidewalks in a good state of repair?
2. How can the City of Vancouver open space within the street right-of-way (property-line-to property-line widths of public roads) expand the urban forest and other ecological services?

Exposed roots from a fallen tree in Vancouver. Photo credit: David Horemans - CBC News.

These questions derive from three challenges posed by past and present paving practices. First, street trees are not given adequate conditions to grow (clearance, soil volume, nutrients, etc.) and subsequently damage infrastructure as they mature. In return, these constraints also damage street trees. Second, the amount of street right-of-way dedicated to impervious surface contributes to the urban heat island effect and produces urban rainwater runoff. This amplifies extreme weather events, as heat waves are more severe and streets are prone to flooding. Finally, concrete and asphalt are carbon intensive materials, and the City of Vancouver should work to reduce their use wherever possible.

One of the primary objectives of this project is to identify streets in need of rehabilitation or replacement and ask whether those streets, instead of repaving like-for-like, can serve different functions that respond directly to the climate crisis and help the City meet its Climate Emergency Action Plan targets. Streets and sidewalks comprise a significant portion ($5.74 billion) of the City of Vancouver's asset portfolio, with a maintenance backlog of $160 million for streets and an additional $40 million for sidewalks. Furthermore, streets and sidewalks are rapidly aging (*Figure 1*), and the number of streets in very poor to fair condition is increasing. This will add to the existing maintenance backlog and create a greater challenge into the future.

Continuing with the status quo is not an option, as damaged streets and sidewalks negatively impact public life and services. Cracks in roadways can cause cycling accidents, heaved sidewalks create accessibility barriers, poor roads can cause delays for emergency vehicles, and the City's liability exposure increases. The tax pressure on residents also goes up, as deferred maintenance escalates future street rehabilitation costs.

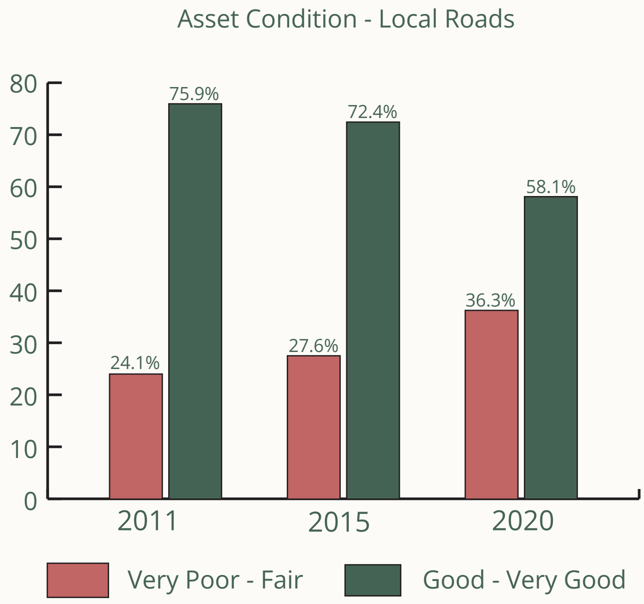


Figure 1

As the City of Vancouver is a leader in sustainable planning and engineering practices, this presents another opportunity to lead by rethinking pavement maintenance and rehabilitation practices to help create a more equitable and livable city. Overly paved urban environments do not reflect current values and are, in fact, counterproductive to confronting the urgency of the climate crisis. To reduce the urban heat island effect, expand the urban forest, better manage rainwater, and create a more resilient and sustainable street network, a new approach to street asset management is required. New strategies to reduce the amount of pavement and impervious surface on city streets will reduce the City's street asset portfolio, decrease future maintenance costs, and create new and resilient infrastructure.

A strategy of "depaving" informs this project, which is any attempt to reduce paved surfaces and replace them with some form of permeable surface that serves an ecological function.

The report begins with a review of Vancouver's policy context, followed by a literature review focused on the intersection of street and sidewalk asset management, green streets and infrastructure planning, and urban forestry. It then highlights several case studies that show how cities are rethinking their paving strategies in favour of more environmentally sustainable practices. From there, a GIS analysis uncovers potential intervention sites in Vancouver, followed by recommended improvements. An underlying strategy of "depaving" guides these recommendations, which is any attempt to reduce paved surfaces and replace them with some form of permeable surface that serves an ecological function. The report concludes with a discussion of future opportunities beyond the scope of this project.

Policy Context

In July 2011, the City of Vancouver adopted the *Greenest City Action Plan* to become the greenest city in the world. While Vancouver fell short of this ambitious goal, it set the stage for other strategies that established Vancouver as a leader in environmentally engaged planning. Of significance for this project are the City of Vancouver's *Climate Emergency Action Plan* (2020), *Urban Forestry Strategy* (2018b), *Rain City Strategy* (2019), *Climate Adaptation Strategy* (2018a), *Transportation 2040* (2012), and Metro Vancouver's *Transport 2050* (2022).

Climate Emergency Action Plan

In November 2020, the City of Vancouver became one of the first cities in the world to declare a climate emergency. While the details are still being finalized, it set a target to reduce carbon pollution in half by 2030. The action plan is intended to be far reaching, with a range of goals for construction, renovation, transportation, and green infrastructure. With regards to transportation, the target is to have 90% of people living within walking or rolling distance of their daily needs, and two-thirds of all trips completed by active or public transportation. While these strategies reduce carbon emissions, others try to capture carbon through an expansion of the urban forest and tree canopy cover. The impacts of street and sidewalk rehabilitation on the urban forest sit at the intersection of these targets, and both strategies must be reconciled to support each other.

Urban Forestry Strategy

The mandate of the Urban Forestry Strategy is to protect all existing and future trees in the City of Vancouver, and to manage all tree assets more sustainably. The city's tree canopy was decreasing until 2013, and the Urban Forestry Strategy tries to reverse that trajectory by planting 150,000 new trees by 2020 (succeeded), increasing canopy cover from 18 to 22% by 2050, restoring and enhancing 25 hectares of natural areas by 2020, and doubling the density of trees in target areas like Marpole and the Downtown Eastside by 2030. A 2018 update on the strategy showed that over half of all new trees were planted on public land, with around 1500 new street trees planted each year. However, the easiest to plant sites are used up, and the remaining sites pose several challenges (poor soil, limited ground space, low clearance, etc.). This highlights the need for new public spaces where street trees can flourish.

Rain City Strategy

The Rain City Strategy reimagines stormwater infrastructure through a sustainable lens and prioritizes the creation of healthy urban ecosystems. It set a specific target of capturing and cleaning 90% of rainwater in the city, and a minimum of 48mm of rainwater per day. One obstacle is that streets are 30% of the city's area, and 37% of the city is impervious surface. As these surfaces cannot absorb rainfall, they become de facto tributaries that move polluted water directly to our waterways. Repurposing paved areas creates new opportunities for green infrastructure while decreasing the amount of impervious surface in the city.

Climate Change Adaptation Strategy

As the climate changes, cities must rethink their assets to create more robust infrastructure that is ready for the future. The first strategy was adopted in 2012, with comprehensive updates in 2018 and 2020 that reflect how rapidly the issue is evolving. Some of the most pressing concerns are tree loss due to drought, changing plant species that shift with the climate, coastal and inland flooding, and damage to infrastructure. Minimizing the impact of street and sidewalk rehabilitation on the urban forest and prioritizing street trees and green infrastructure creates opportunities for a climate resilient future.

Transportation Policies

Now 10 years old, the *Transportation 2040* strategy established several goals for the City of Vancouver. These include shifting most trips to active and public transportation, improving access to open spaces and the natural environment, and supporting public spaces that promote social interaction. These policies are supplemented by Metro Vancouver's *Transport 2050* strategy, which aims to make transportation convenient, reliable, affordable, safe, and carbon-free. Additionally, the City is studying ways to reallocate 11% of all street space for people-focused public spaces (City of Vancouver, 2020c). Depaving contributes to these goals by reallocating street space for natural services and (in many cases) improved facilities that encourage active transportation.

Sunset Park upgrades.
Photo credit: Trey Schiefelbein.

Literature Review

Street and Sidewalk Asset Management

Cost is a significant challenge for street and sidewalk repair. Azarijafari et al. (2016) found that by 2030 between $65-83 billion will be spent annually on road repair and maintenance in the United States. Investments in Quebec's Road networks accounted for 22.8% of the entire infrastructure budget from 2014 to 2024, and 70% of these funds were set aside for maintenance. In fact, road infrastructure investments in Quebec were greater than all investments in health and social services during the same period. Even in Denmark, one of the models for sustainable transportation planning in the world, more than 40% of the public sector's budget was set aside for roads.

Despite this spending, the condition of streets and sidewalks in many jurisdictions is still poor. Street and sidewalk rehabilitation budgets may appear higher than other services, but they are not enough to properly address the maintenance backlogs. Frangopol and Liu (2007) discuss how the common approach for street and sidewalk rehabilitation prioritizes cost minimization rather than performance maximization. Instead of maintaining and repairing streets to function at their full potential, cities opt for fast and cheap fixes that are more likely to fail with time. Similarly, Torres-Machi et al. (2017) describe how these budgetary constraints create a reactive rather than proactive approach to pavement maintenance and rehabilitation. This reactive strategy is more expensive for cities and harmful for the environment over a long period of time.

However, some jurisdictions are rethinking their priorities in a more strategic way. Yang et al. (2018) discusses integrated asset management and frames infrastructure as part of a larger system where each piece has an impact on another. In other words, when thinking about pavement maintenance and repair, the impacts on accessibility, stormwater management, and equity must also be considered. In the United Kingdom, strategies have shifted to prioritize the greatest value of a project (including social and environmental concerns) rather than the lowest cost.

The conversation is shifting elsewhere as well. Originally published by the American Society of Civil Engineers, Torres-Machi et al. (2019) attempt to develop a multi-criteria decision-making technique that considers the environmental implications of pavement and its alternatives. Similarly, Plati (2019) explores different paving materials, designs, and preservation strategies that weigh the economic, environmental, and social sustainability of each outcome. Lastly, Kothari et al. (2022) have developed a model that allocates highway maintenance and repair budgets based on the same three sustainability indicators.

As this previous research focused on roads and highways, there is a noticeable gap regarding sidewalks. Indeed, Gibson & Marshall (2022) argue that research on sidewalk infrastructure is limited but growing. However, existing research is typically focused on how to assess sidewalk conditions, rather than how sidewalks are managed. While the rest of their work focuses on US cities and has less application to Vancouver, the authors call for more work focused on sidewalks, equity, and project prioritization.

Reframing this discussion will allow the City of Vancouver to reallocate underutilized street pavements as they reach the end of their service life, and open more space for street trees and other ecological services.

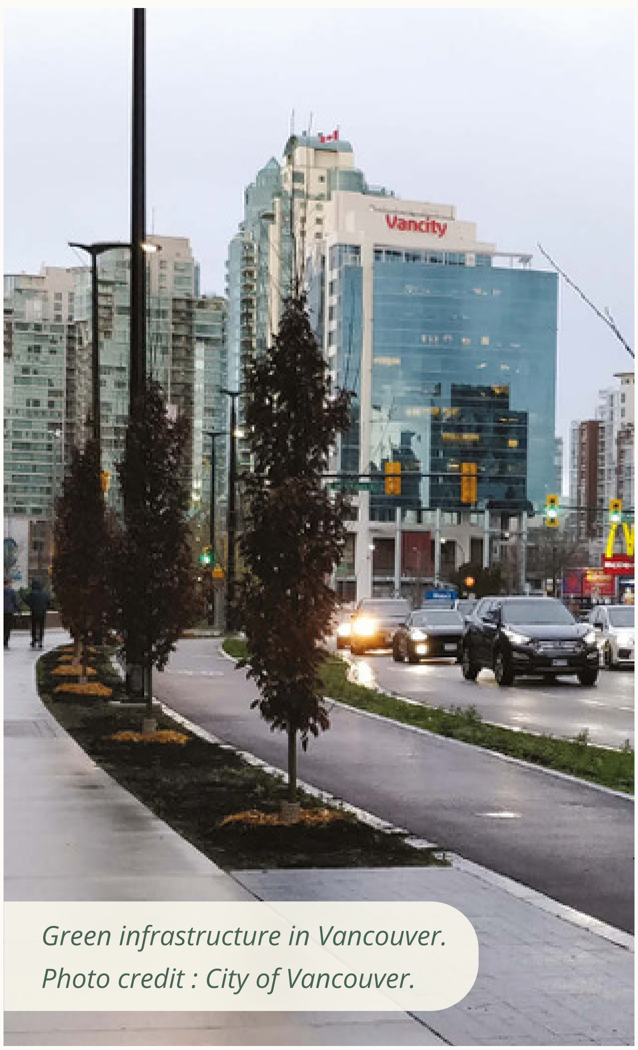
A final note is that nearly all the work on street and sidewalk management is concerned with where and how to pave, but not why. In a city like Vancouver where streets are 30% of the city's area and 37% of the city is impervious surface (City of Vancouver, 2019, p. 123), is there more pavement than necessary? What are the economic, social, and environmental implications of excessively paved areas? Reframing this discussion will allow the City of Vancouver to reallocate underutilized street pavements as they reach the end of their service life, and open more space for street trees and other ecological services.

Green Infrastructure and Environmental Justice

Green infrastructure (GI) is, according to the European Commission's widely accepted definition, a "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation" (European Commission, n.d.).

It can take the form of water or land-based projects with the goal of improving natural environments and the health of communities. GI can exist on a single street or across an entire city and is a necessary strategy for cities as they work towards a more sustainable future.

Urban infrastructure projects rarely start with a clean slate, and budgets are often restricted. As a result, GI is particularly well-suited for small interventions where resources are limited. For example, asphalt schoolyards were once the norm in Baltimore, but today the city is converting schoolyards to green spaces that cool temperatures and responsibly manage stormwater (Buckley et al., 2017). Similarly, while focused on developing countries, Cheshmehzangi et al. (2021) highlight several sustainable and low-cost/high-quality solutions that apply to the rest of the world (tree planting, day-lighting streams, creating open spaces, orientating buildings to prioritize shading and ventilation, etc.).



Green infrastructure in Vancouver.
Photo credit : City of Vancouver.

Streets are often the sites of GI interventions. Säumel et al. (2016) discusses the ability of roadside vegetation to improve air quality, regulate temperature, create wildlife habitats, and promote outdoor recreation. Rodriguez-Valencia and Ortiz-Ramirez (2021) explore three green streets projects from the United States (Portland, Seattle, and Philadelphia), and the multi-agency attempts to reallocate space within the street right-of-way. Similar studies have examined laneway transformations, but these changes often focus on paving techniques rather than alternatives to paving (Newell et al., 2013). Some projects have focused on the removal of excessive and underutilized pavement (Houston & Zuñiga, 2019), while others describe efforts to build green streets that minimize the impacts on traffic and the street right-of-way (Im, 2019).

The benefits of GI have received considerable coverage (Sandifer et al., 2014; Säumel et al., 2016), but the distribution of GI raises equity concerns. In Milwaukee, Wisconsin, research showed that the urban tree canopy was unequally distributed throughout the city. Racialized neighbourhoods experienced less tree cover, which had negative impacts on the quality of life (Heynen et al., 2006). Doiron et al. (2020) had similar findings in Montreal, Toronto, and Vancouver, as areas with higher levels of social deprivation were exposed to worse air and less green space.

There are efforts to address these inequalities through green infrastructure, but they often fall short. Hoover et al. (2021) argues that environmental justice is rarely discussed when developing green infrastructure, but green infrastructure has environmental justice implications. While GI can add greenspace to underserved areas, it can also gentrify these communities. Zuniga-Teran et al. (2021) raised similar concerns and proposed greater levels of community engagement to democratize the process and include those impacted by GI projects.

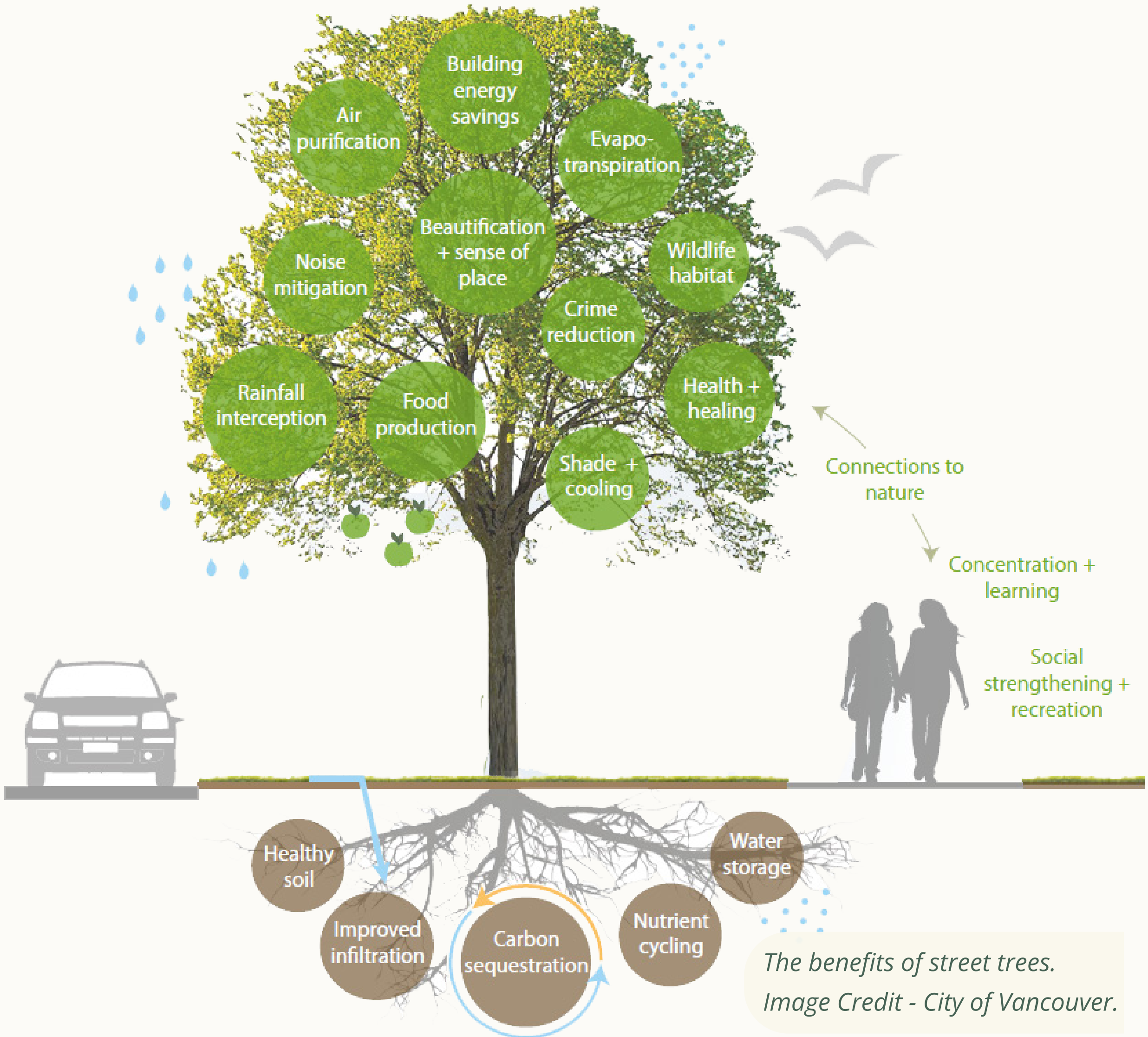
Some studies have taken a more spatial and data-driven approach to placing new green infrastructure (Meerow, 2019; 2020; Meerow & Newell, 2017; 2019). This work relied on a "Green Infrastructure Spatial Planning" (GISP) model to understand what, where, when, and for whom GI is planned. This model proposes sites for new GI based on the greatest environmental and social outcomes. The model relies on stormwater management, social vulnerability, green space, air quality, urban heat, and landscape connectivity to understand where the data points intersect and where gaps exist.

Meerow (2020) and Finewood et al. (2019) both discuss how the starting point for many GI projects is typically stormwater management. This is in part due to political realities; there are few (if any) arguments against improved stormwater infrastructure, so green stormwater upgrades are more likely to receive funding than other projects. As green stormwater infrastructure is more marketable, it takes centre-stage while other benefits (tree health, air quality, levels of physical activity, etc.) earn secondary status. A shift in focus to street trees in underserved areas recenters the discussion on ecological services that are occasionally overlooked and uses equity as the starting point for any future projects.

Supporting Street Trees

Trees have a significant role to play in GI but are often left out of the conversation. GI planning typically focus on the infiltration of stormwater through engineered solutions like rain gardens, bioswales and permeable pavements. However, trees also play a part in the hydrologic cycle, and may reduce stormwater volumes through canopy interception loss, transpiration, and improved infiltration. Although the body of research is still growing, it appears that trees can flourish when properly integrated with green infrastructure. This leads to larger and more mature trees that provide greater canopy cover in urban settings (Berland et al., 2017).

Healthy and mature street trees offer several benefits for cities. When properly planted and spaced apart, trees can improve air quality along streets (Abhijith et al., 2017; Jeanjean et al., 2017). Additionally, street trees are more effective at cooling air temperatures than grass surfaces and green roofs (Ng et al., 2012). Trees also sequester carbon, conserve energy, and promote social health (Roy et al., 2012). The economic benefits of street



The benefits of street trees.
Image Credit - City of Vancouver.

trees have been widely studied, with trees increasing property values and providing greater monetary returns than what is spent on their maintenance (Donovan & Butry, 2010; McPherson et al., 2005; 2011; Sander et al., 2010; Soares et al., 2011).

Poor soils and inadequate spacing are two of the greatest challenges when supporting street trees. As trees grow and their roots expand in their search for nutrients, conflicts with pedestrians increase. Structural soils, permeable pavements, and diverse types of pavers are promising solutions, but they are also prone to issues like clogging from sediments (Mullaney et al., 2014; 2015). Some studies have examined the health of trees before and after sidewalk repair, and the results are mixed. In one study tree health varied based on the species, age, and site of the tree, with some trees performing worse after reconstruction (North et al., 2017). Similarly, another study saw no benefits for tree health after replacing impervious pavement with a pervious substitute, but the authors acknowledge that the study was limited to a single tree species over a two-year period (Volder et al., 2009).

Cities must also think strategically about the locations of trees. Some sites are better suited than others, and careful consideration can maximize any impact on heat and air quality (Bodnaruk et al., 2017). For example, Donovan & Butry (2009) found that trees planted on the south and west sides of a property in California can reduce electricity use by 5%, while trees planted on the north side of a property can increase the use of electricity. However, as urban space is limited, cities do not have the luxury of selecting from multiple tree planting sites. Haaland & van den Bosch (2015) argue that as private trees are lost, cities struggle to replace them in the public realm. One solution is to rethink difficult to plant sites (specifically streets) as sites for greening. This point is emphasized by the work of Marshall et al. (2019) who found that one third of all public green space in Melbourne, Australia is in the street boulevard (or road verge, curb strip, median, parkway, etc.). Since then, Melbourne has launched a pilot project to remove pavement and support biodiversity within city streets (Tan et al., 2022).

With that said, the impacts of the urban forest on cities are most understood at regional scales. However, cities are increasingly working at small and site-specific scales to expand their urban forests. Salmond et al. (2016) argue that research on the benefits of street trees at regional scales is “reductionist,” and that it overlooks localized issues with tree canopy cover. While a city may have a healthy and expansive urban forest across its area, there may be pockets of the city that experience significantly less tree cover. By shifting the focus to these localized sites, cities can improve their urban forests in the areas that need it most.

Depaving in Hamilton, Ontario.
Photo credit: Green Venture.

Case Studies

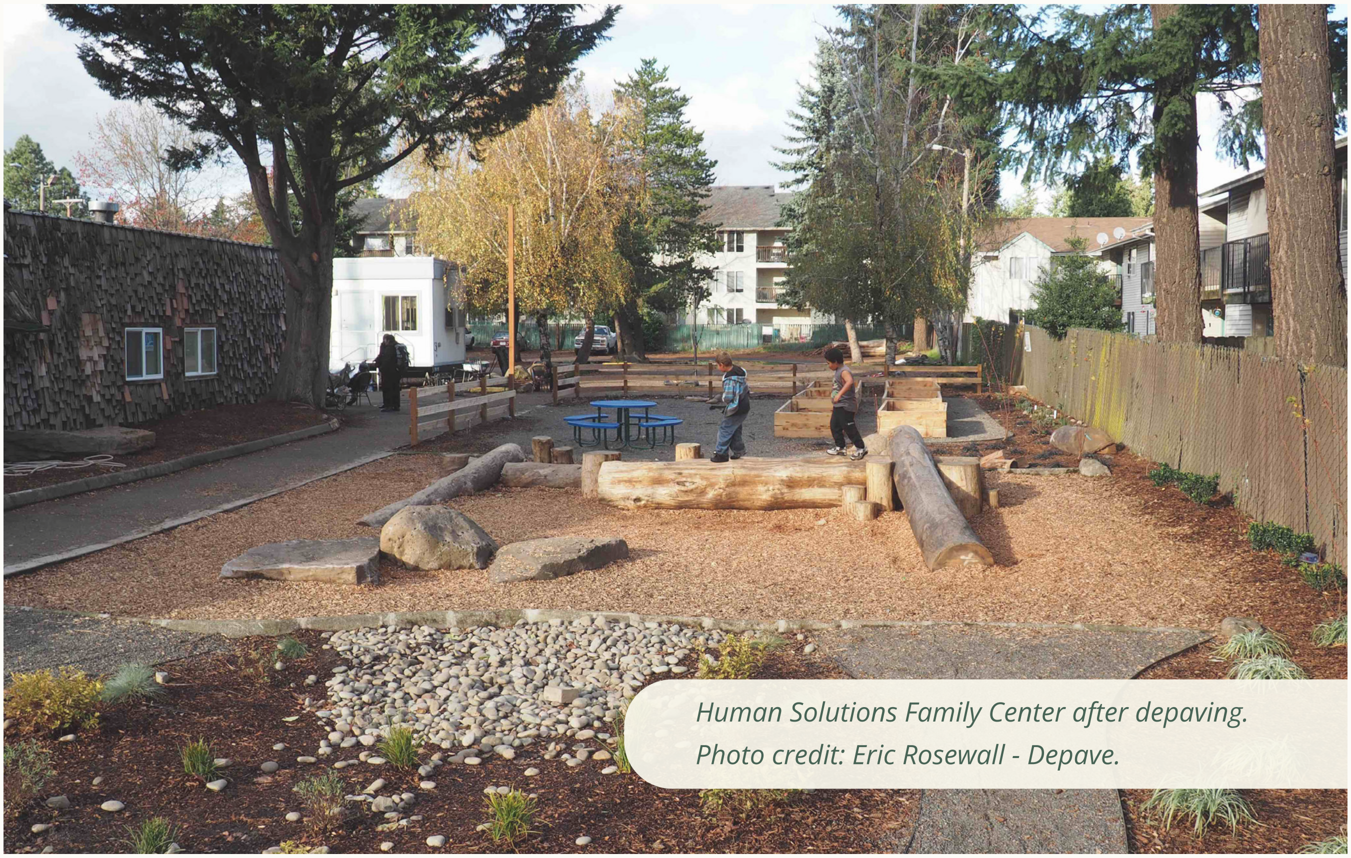
Depaving is often an unstated strategy, and it is rarely the distinguishing feature of a project. However, examples of depaving are found throughout the world, though cities and community organizations may use different vocabularies when defining their goals. Precedents exist with diverse aspirations, strategies, and applications. What unites these projects are their attempts to reduce the amount of pavement in cities and to restore natural processes in highly paved areas.

Community Depaving

Community organizations are at the forefront of depaving. One of the most prominent organizations is Depave, founded in 2007 in Portland, Oregon. The explicit goal of Depave is to empower disenfranchised communities in highly paved areas to overcome social and environmental injustices through depaving. Community engagement is key, as Depave collaborates with stakeholders to identify and re-green paved surfaces, promote education and workforce development, create more resilient neighbourhoods, and advocate for policy changes that resist systemic racism (Depave, n.d.).

Depave promotes green spaces that enhance biodiversity, cool cities, and mitigate the impacts of climate change. However, their efforts are highly motivated by stormwater management. They describe how “paved surfaces contribute to stormwater pollution, whereby rainwater carries toxic urban pollutants to local streams and rivers.” Additionally, they argue that the “removal of impervious pavements will reduce stormwater pollution and increase the amount of land available for habitat restoration, urban

Human Solutions Family Center before depaving.
Photo credit: Eric Rosewall - Depave.



Human Solutions Family Center after depaving.
Photo credit: Eric Rosewall - Depave.

farming, trees, native vegetation, and beauty, thus providing us with greater connections to the natural world."

In 2019, Depave engaged with 450 volunteers to remove 1360 m^2 of pavement and reduce stormwater runoff by 1.5 million litres annually.

Depave's Impact Report from 2019 highlights their success. In 2019 alone, Depave worked with over 450 volunteers for a total of 1800 volunteer hours. 1360 m^2 of pavement was depaved, which reduces annual stormwater runoff by around 1.5 million litres. This contributes to the 20,400 m^2 of surface that has been depaved since 2007, and a 60 million litre reduction in stormwater runoff. In addition to the stormwater reductions, Depave was also able to add 1600 trees, shrubs, and plants in 2019 to previously paved surfaces. This work was spread across 8 projects in 2019, and cost approximately $65,000 USD ($83,600 CAD) of Depave's $165,000 USD ($212,000 CAD) annual expenses (Depave, 2019).

The success of Depave has influenced other organizations. Green Venture in Hamilton, Ontario and Depave Paradise in Peterborough, Ontario have partnered to depave communities within the Golden Horseshoe region of Ontario. Although Depave Paradise credits Depave as its original influence, there is less emphasis on social justice and a greater focus on the environment. Since the start of their collaboration in 2012, Green Venture and Depave Paradise have depaved over 1400 m^2 of surface at 13 sites which absorb almost 1.6 million litres of water annually. As with Depave in Portland, the projects are typically small scale and focused on underutilized spaces like parking lots (Green Venture, n.d.).

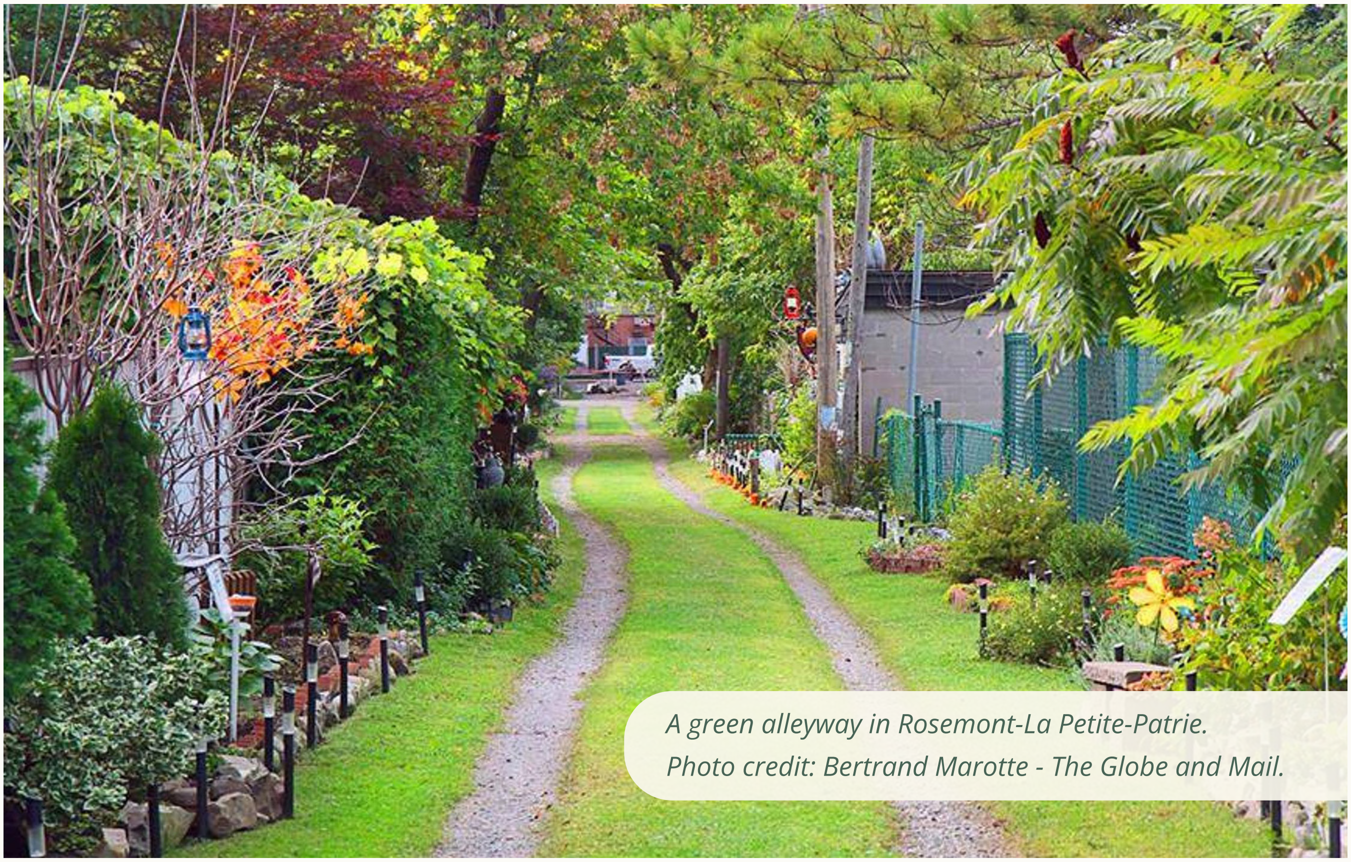
Another organization is Space to Grow in Chicago, Illinois. Space to Grow focuses specifically on schools as it works to reverse a decades long practice of paving schoolyards in the city. The legacy of this practice is 760 acres (or over 3 km^2, approximately 75% the size of Stanley Park) of paved and impermeable surfaces managed by Chicago Public Schools alone. From 2014 to 2019, Space to Grow has transformed 34 schoolyards in Chicago into areas that prioritize physical activity, learning, community engagement, and flood mitigation. In some cases, storm-water runoff and its associated pollutants were reduced by nearly 100% (Space to Grow, n.d.). Also in Chicago, Depave Chicago (modeled on the original Depave organization) is preparing for its imminent launch in 2022 and 2023 (Depave Chicago, n.d.).

These organizations, spread across communities and countries, highlight the demand for depaving at the community level. When communities are engaged in the outcomes and volunteers help with the process, the costs of depaving are minimal. Pavement can be removed and replaced with natural vegetation at small sites for only a few thousand dollars. Depaving becomes an effective, fast, and affordable tool to transform communities and restore natural systems that were previously lost.

Montreal: Ruelles Vertes/ Green Alleyways

Bridging the gap between community and government-led depaving projects is the Ruelles Vertes (or Green Alleyways) program in Montreal. The Green Alleyways program is an official program offered by the City of Montreal that encourages residents to rethink their alleys in a sustainable way. The intent is to promote social interaction among residents (over half of the residents along an alley must approve the project), reduce urban heat, limit traffic, improve air quality, and promote biodiversity. As these are community-led projects that are sanctioned by the City, each Green Alleyway is different with a wide range of possibilities. While depaving is not specifically mentioned by the City of Montreal or Eco-Quartier (the community organization that helps administer the program), it is a frequent feature of Green Alleyways (City of Montreal, 2022).

The first Green Alleyway was completed in 1995 as a pilot project for residents to beautify their neighbourhood. Since then, alley greening has evolved into a formal policy to address economic, environmental, and social sustainability goals. However, it is up to communities to define their specific goals and how to address them. Once plans are approved, the respective borough of Montreal funds and supervises the implementation stage. Funding from the borough ranges from $5000 to $20,000 CAD to green an alley, with added human resource and material costs covered by the local government (Regroupement des Eco-Quartiers, 2018b).



A green alleyway in Rosemont-La Petite-Patrie.
Photo credit: Bertrand Marotte - The Globe and Mail.

Green Alleyways have also evolved into other strategies. One significant approach is the Blue-Green Alleyway, which is a GI project focused on capturing stormwater. Given the higher level of planning and engineering that goes into these projects, Blue-Green Alleyways typically need more municipal involvement (but not at the expense of community engagement). Green Alleyways have also expanded into Green and Active Alleyways, which combine the environmental goals of the original Green Alleyways with the promotion of safe and healthy play areas for children. Traffic calming is central to each strategy, as the City of Montreal encourages residents to construct barriers, hang traffic signs and mirrors, and cover any remaining paved areas with playful paint and ground markings (Regroupement des Eco-Quartiers, 2018a).

Green Alleyways have spread across Montreal since the first pilot was completed in 1995, and their popularity is growing rapidly. From 2011 to 2017 an average of 44 alleyways were greened each year (Regroupement des Eco-Quartiers, 2018b). By 2019 there were 350 Green Alleyways in Montreal, which equaled 68 kilometers of alleyways across the city (Pham et al., 2022). This rapid growth continued into 2020, as the total number of Green Alleyways jumped from 350 to 450 in a single year (Surprenant, 2021).

By 2019 there were 68 km of Green Alleyways in Montreal, which is approximately the distance from Vancouver's City Hall to Squamish, BC.

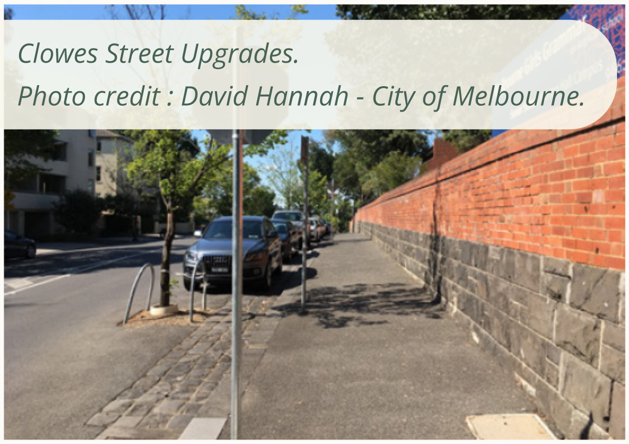
Like Depave in Portland, Space to Grow in Chicago, and Depave Paradise in Ontario, Montreal's Green Alleyways underscore how communities can reimagine pavement in their neighbourhoods. Residents are creating green landscapes that combat heat, restore biodiversity, and create safe neighbourhoods for everyone, while also reclaiming underutilized alleyways in the process. Montreal's Green Alleyways highlight the possibilities when residents are given control over their communities. The demand for Green Alleyways has accelerated in recent years, and there are no signs of slowing down.

Melbourne: Streetscape Biodiversity Project

The City of Melbourne, Australia is taking bold moves to expand its urban forest and biodiversity. These strategies have recently shifted to streets and streetscapes, as they are both plentiful and underutilized. Nearly one third of all public green space in Melbourne is found within the road verge or boulevard (Marshal et al., 2019). Since 2009, several streets have been depaved and replaced with parks (Salt, 2015). In 2015 the Melbourne City Council agreed to spend $15 million AUD ($13.3 million CAD) over three years to convert underperforming roads to parks (Dow, 2015).

A recent pilot in Melbourne was the Streetscape Biodiversity Project (City of Melbourne, 2020). The Streetscape Biodiversity Project focused on restoring ground level vegetation to create habitats for bats, birds, and insects, with the goal of increasing natural habitats on public

Clowes Street Upgrades.
Photo credit : David Hannah - City of Melbourne.



Original condition as a bitumen footpath (April 2017).

Plant installation (April 2018).

Post-plant installation (November 2018).

Post-plant installation (November 2019). Photo: David Hannah.

land by 20% before 2027. However, due to the protected and heritage status of many parks in Melbourne, the City needed to look elsewhere for sites. Streetscapes were targeted due to their abundance and despite their difficult growing conditions.

The City of Melbourne accepted these challenges and partnered with landscape architects at University of Melbourne to rethink street greening projects. The team prioritized native vegetation and created an inventory of plant species that were particularly suited for harsh conditions and street environments. Co-benefits of each species were also considered, with preference for species that support wildlife. Following this, four pilot sites were selected in Melbourne, and each with their own implementation strategies. One of the largest projects was along Clowes Street, where an uncharacteristically wide asphalt sidewalk was redesigned to include a garden bed that was 2 meters wide and 106 meters long (City of Melbourne, 2020).

The City of Melbourne was able to improve biodiversity at 4 different sites for a total cost of $211,000 CAD over 5-years.

The design, implementation, maintenance, and evaluation stages of the Streetscape Biodiversity Project took place over a 5-year period. The total cost for all four projects was $236,540 AUD ($211,000 CAD), which was higher than expected due to the initial work of researching and selecting plant species, as well as miscommunications during the implementation stage. However, the benefits were almost immediate. There was a substantial increase in the bee population, which is especially noteworthy as no bees were recorded prior to the interventions. The number of butterflies also increased, but there was little change in the bird population. This was expected for the first few years, as the plant species that support birds take more time to mature (City of Melbourne, 2020). The biodiverse streetscapes also require little attention and care, as they are each maintained with approximately 4 hours of labor each week (Tan et al., 2022).

The Streetscape Biodiversity project in Melbourne shows how underutilized streets and sidewalks can be repurposed to strengthen biodiversity and expand greenspace. Redesigning streetscapes offers a unique set of challenges, but plants can flourish in harsh environments when carefully selected. While these considerations may take time and money, they can be replicated with time to improve efficiency and decrease costs. Also, with minimal maintenance, natural landscapes create an economically and environmentally sustainable alternative to paved surfaces.

Street Edge Alternatives.
Photo credit: Seattle Public Utilities

Seattle: Street Edge Alternatives

Seattle, Washington has one of the earliest examples of a North American city questioning the environmental possibilities of a street. The Street Edge Alternatives (SEA) was completed in 2001 and reduced the width of a neighbourhood street to make way for GRI and native vegetation. The project was a partnership between Seattle Public Utilities and the Seattle Department of Transportation, and involved the community through the design and implementation stages. The SEA focused on the co-benefits of all parts of the project, as each aspect was part of a larger integrated system that functions

Street Edge Alternatives.
Photo credit: Seattle Public Utilities

together (for example grading to help absorption, soil to support plant health, plants that help the salmon population, etc.).

The street width of the SEA was reduced by 11% and resulted in a street 14 feet wide with an added 2-foot flat curb on each side of the street. This allowed emergency vehicles to access the street safely and without obstacles. The project stretches for 660 feet and includes a 100-foot right-of-way within a 2.3-acre drainage area. This created space for bioswales, raingardens, 100 trees, 1100 shrubs, and ultimately reduced rainwater runoff in the area by 99% (City of Seattle, n.d.). The project was originally designed to accommodate rain events up to .75 inches, but has overperformed and can divert 1.68 inches of rain in a 24-hour period (National Association of City Transportation Officials, n.d.).

The SEA pilot was expensive with a final cost of $850,000 USD ($1.1 million CAD). As with other projects, the high cost is partially attributed to the pilot status of the SEA, and costs will decrease with time and repetition. There was also an extensive community engagement budget, as the pilot was shaped by stakeholders and residents of the surrounding neighbourhood. Despite the high budget, it was estimated that similar projects will cost less in the future than traditional street improvements. One estimate shows that designs that incorporate natural drainage systems may cost 25% less than traditional rainwater management systems (City of Seattle, n.d.).

Reducing the street width by 11% reduced stormwater runoff by 99% and created space for 100 trees, 1100 shrubs, and other green infrastructure.

The SEA project from Seattle offers several lessons when considering depaving. It marks a significant turning point in conversations about infrastructure, and challenges commonly held beliefs about streets and their purpose. Instead of prioritizing traffic and movement, those concerns are secondary to the natural environment of the surrounding area. The role of the community is also emphasized, as engagement created buy-in for what may have otherwise been a controversial project. Lastly, while start-up costs may be high, they decrease with time and may even outperform traditional street and sewer rehabilitation.

Vancouver: Lilian To and Sunset Parks

Several precedents are also found locally in Vancouver. One of the most prominent is Lilian To Park in Vancouver's Riley Park neighbourhood. Lilian To Park opened in 2016 at the intersection of Yukon St and 17th Ave. The park is .15 acres in size and was originally limited to a vacant lot, but later doubled in size when part of Yukon St was reallocated for the park. As Yukon is one of the City's cycling routes, a separated cycling path was preserved while the rest of the street was converted into green infrastructure and park space (Vancouver Board of Parks and Recreation, 2015a).

The site was selected for its proximity to a park deficient area of the city. Areas are considered park deficient if they are greater than 500m from the nearest park, which included a few blocks along Cambie St to the west and north of the park. The community helped shape the final design of the park, which included 12 new trees, native grasses, wildflowers, and shrubs, and preserved mature trees that were already on site. When the design was presented at a final open house, 90% of survey respondents supported the closure of Yukon St, and 87% of respondents supported the design of the park. The complete project cost around $600,000 CAD, but maintenance expenses are minimal as plant species and infrastructure were selected for their durability and longevity (Vancouver Board of Parks and Recreation, 2015b).

Street upgrades at Sunset Park reduce flooding, collect 4 million litres of rainwater annually, and will capture 2100kg of carbon over 50 years.

Yukon St transformed into Lilian To Park.
Photo credit: Ken Ohrn - Viewpoint Vancouver.

Sunset Park before upgrades.
Photo credit: Google Street View.

Sunset Park after upgrades.
Photo credit: Trey Schiefelbein

A similar approach was taken on Prince Edward St in Sunset Park. Like Yukon St, Prince Edward St is a shared bicycle and vehicular route that bisects Sunset Park from 51st to 53rd Ave. The street was in poor condition, and often flooded during heavy rain events due to a lack of curb and gutter. Prince Edward St was ultimately upgraded to make way for green rainwater infrastructure and a separated cycling path. This included rain gardens, bioswales, and 3 new trees that will collectively sequester 2100 kg of carbon over 50 years, capture 4 million litres of rainwater runoff annually, and manage 4500 m^2 of impervious area. The final cost of the project was $450,000 CAD (split roughly 40/60 between green infrastructure and street improvements) which is significantly less than Lilian To Park. A similar project will be completed in the summer of 2022 at Woodland Dr and 2nd Ave with a budget exceeding $700,000 CAD, but it is expected to finish 20-30% under budget.

These projects show how depaving contributes to other strategies across the city. Depaving Yukon allowed for Lilian To Park to double in size and serve residents who live in a park deficient area. Additionally, by depaving streets and supporting active transportation routes, the City can expand its network of AAA cycling infrastructure. Reducing the amount of space given to streets and cars also makes room for green infrastructure, trees, and biodiverse landscapes. Although these interventions may look small on a map, they contribute to long-term strategies like the Transportation 2040 Plan, the Greenest City Action Plan, the Urban Forestry Strategy, and the Rain City Strategy.

Vancouver's urban forest.
Photo credit: Aditya Chinchure - Unsplash.

Situating Streets, Sidewalks, and the Urban Forest

Methodology

A multi-criteria GIS analysis was conducted to understand the relationship between paving, the urban forest, urban heat, and equity indicators. The method was influenced by *Green Infrastructure Spatial Planning (GISP)* (Meerow & Newell, 2017) to find locations for green infrastructure in Detroit, and included data on stormwater management, social vulnerability, access to green space, air quality, urban heat, and landscape connectivity. These data sets were divided into 10 quantiles to rank their respective conditions, then combined to find areas with the greatest need for new green infrastructure.

The same principles apply in the context of Vancouver, but there were a few modifications in the application. As the study explores the relationship between paved surfaces and street trees in Vancouver, the primary datasets were pavement conditions, tree canopy cover, surface temperatures, and the disproportionately impacted populations index. However, while data inputs for the original GISP model were uniformly organized into census tracts, this was not possible in Vancouver. Data sets were left in their original formats (lines, points, polygons, etc.), but still ranked by their severity.

One of the primary goals of the project was to find streets in poor condition that may require repair or replacement, and the first dataset was the pavement conditions of all streets in Vancouver. The

Pavement Condition Index (PCI - *Figure 2*) was last collected in 2020 and assigns a score of 0-100 for every street segment in Vancouver, and qualitatively ranges from "failed" to "good." The index is widely used across the world but was first developed by the Army Corps of Engineers in the United States and later standardized by the American Society for Testing and Materials. The PCI highlights several forms of distress, including cracking, potholes, depressions, swelling, and more.

The next dataset was the Disproportionately Impacted Populations index (DIP - *Figure 3*). The DIP was created by the City of Vancouver's Transportation Planning Team and shows where residents are more likely to experience some form of systemic oppression. Data is separated into census tracts, and considers the number of seniors, Indigenous people, visible minorities, single-parent households, people with limited knowledge of English, rent-burdened households, and the median household income in each area. The intersection of these data points is then identified, and each area is ranked with an equity score ranging from 1-10 (low impact to high impact). These areas are then split into priority areas, which helps the City invest in historically underserved areas.

A third data set was Urban Heat Watch (*Figure 4)* from the City of Vancouver. The data shows surface temperatures on August 16th, 2020, from 3-4pm, one of the hottest days of the year. A high level of temperature variation is seen throughout Vancouver, with a clear division between the east and west Sides of Vancouver. As one of the best tools for combatting urban heat is trees and shade, this data must be considered with the final piece of data: tree canopy cover (*Figure 5*). Tree canopy cover shows the percentage of an area where tree canopies shelter the ground when viewed from above.

A model (*figure 6)* was constructed to combine these four data sets and find

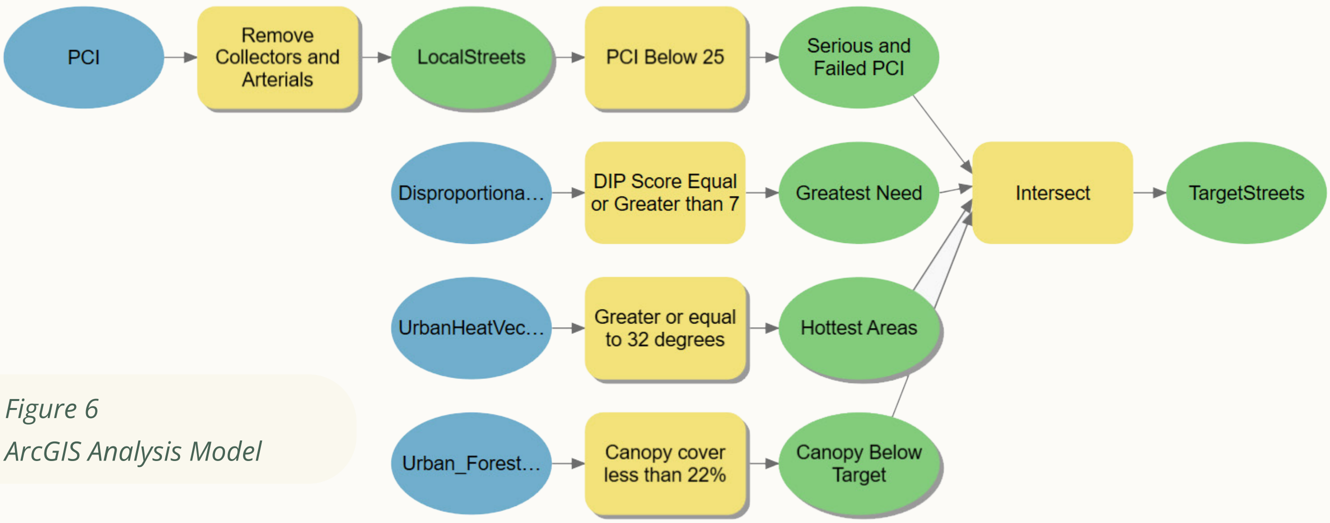
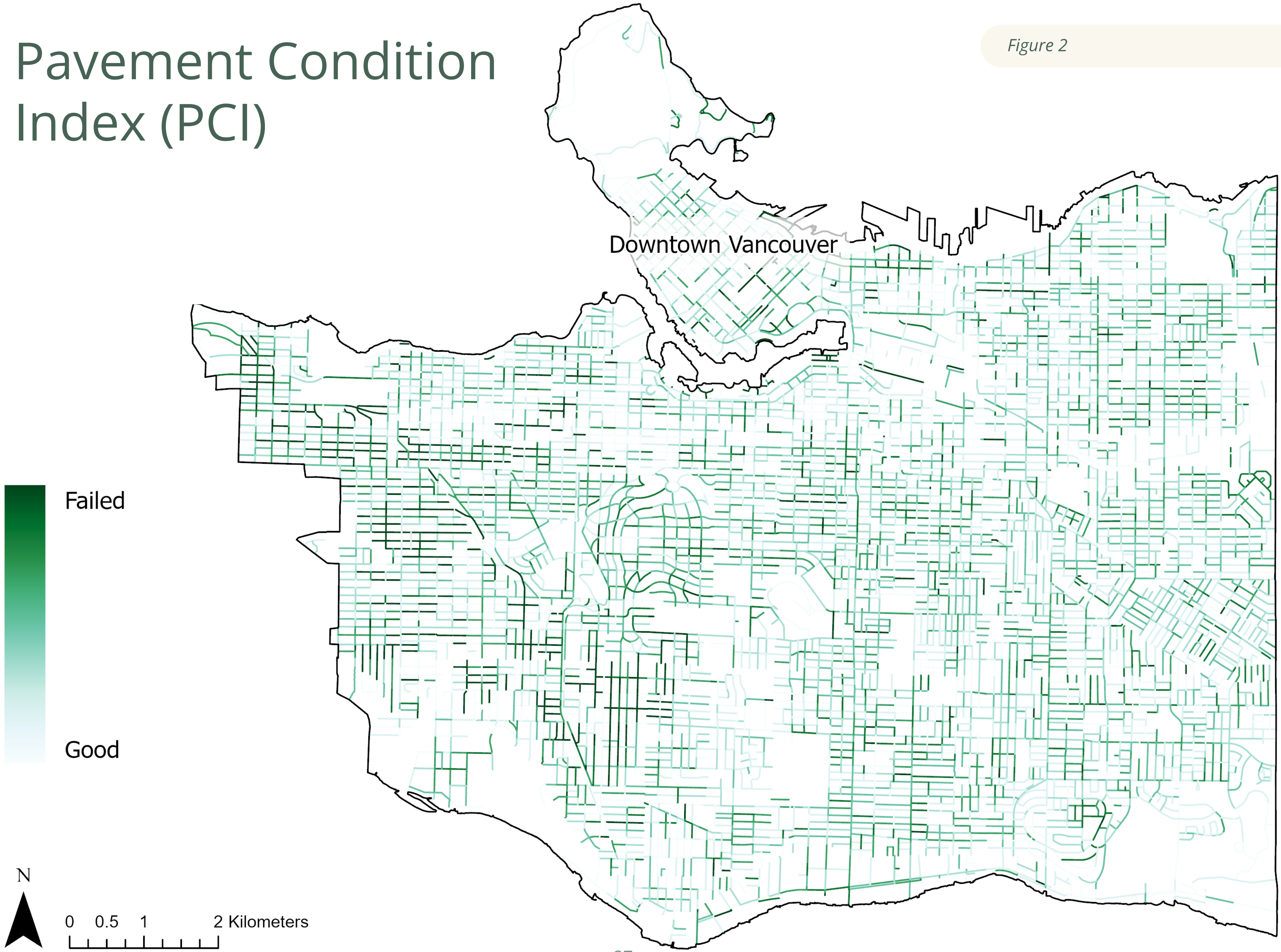


Figure 6
ArcGIS Analysis Model

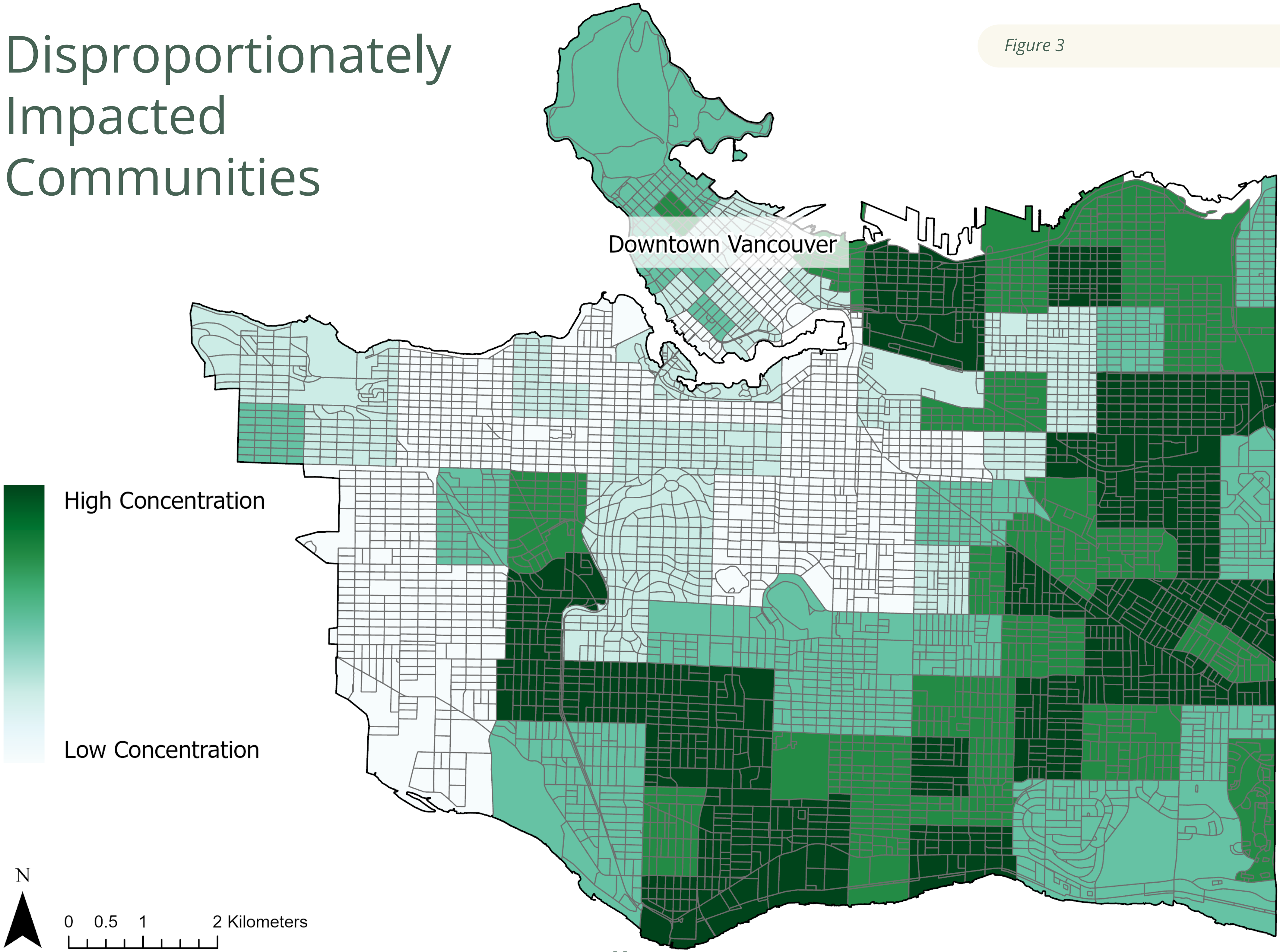
Pavement Condition Index (PCI)

Figure 2



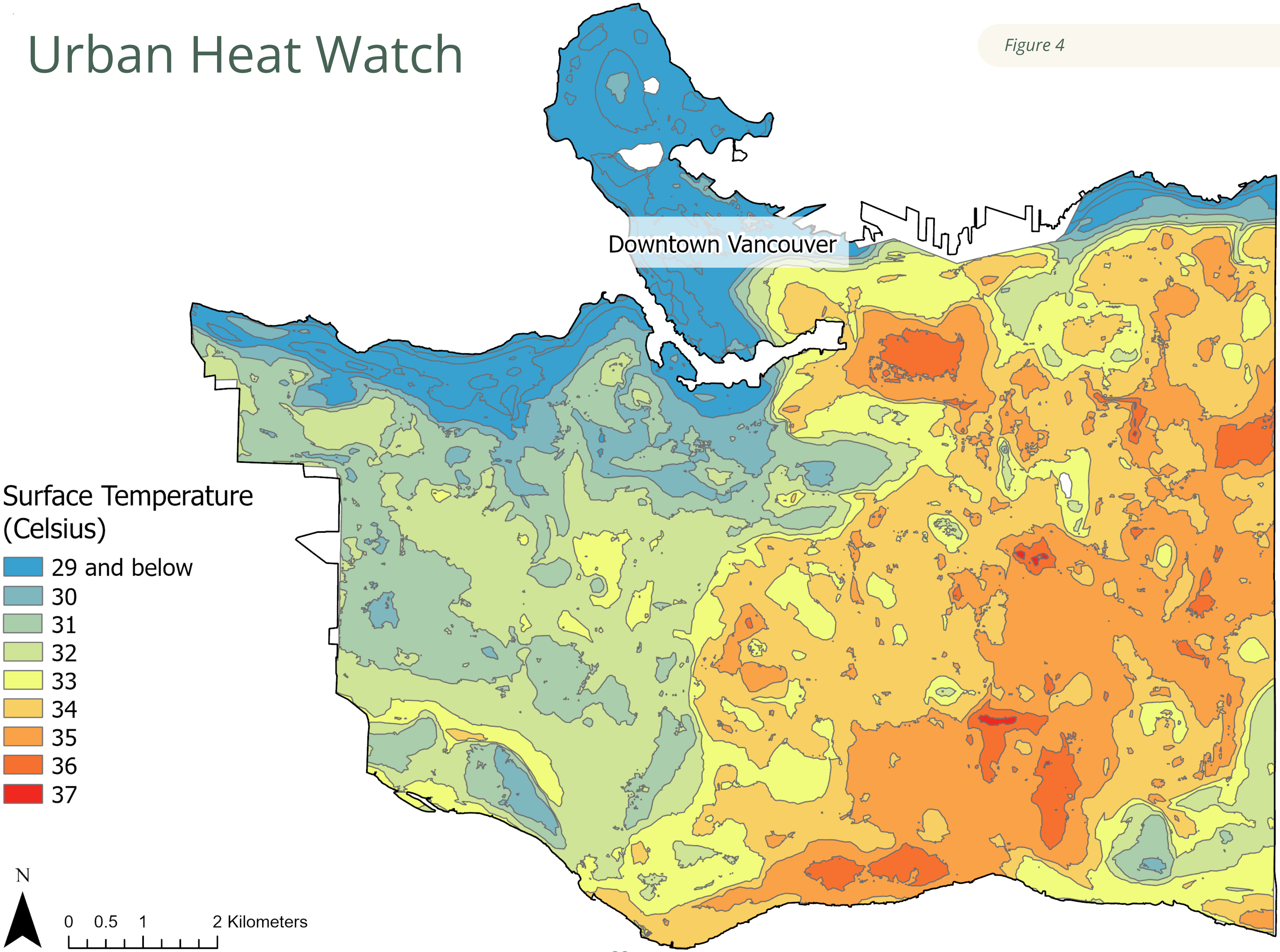
Disproportionately Impacted Communities

Figure 3



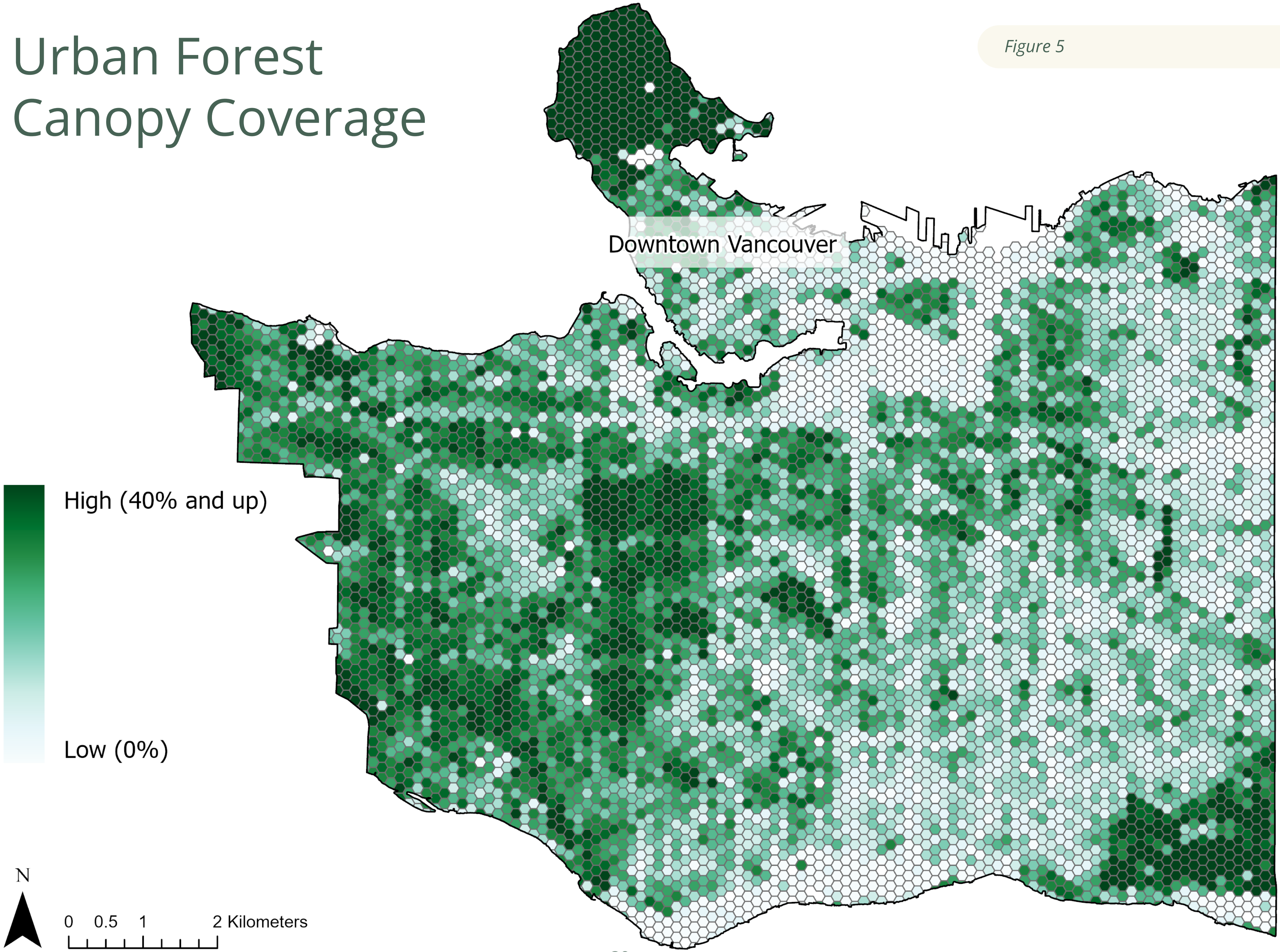
Urban Heat Watch

Figure 4



Urban Forest Canopy Coverage

Figure 5



areas with the greatest need. Arterial and collector streets were excluded from the analysis, as depaving interventions are better suited for low-traffic streets. Additionally, only streets with a PCI score of 25 or below were included (serious and failed conditions), as streets of this condition are more likely to require complete reconstruction rather than repair. The model also incorporated areas with DIP equity scores of 7 and above, as these are the areas of the city that are most likely to experience some form of historical and systemic oppression. Lastly, surface temperatures above 32 degrees Celsius were featured as they show the most extreme heat, and areas with a canopy coverage below 22% (the city-wide target from the Urban Forestry Strategy) were included.

Findings

The model identified where these conditions intersect, and the resulting map shows local street segments with poor pavement condition, in areas with a high DIP score, high surface temperatures, and low canopy cover (*Figure 7)*. This new dataset was then compared to other co-benefits of depaving, or specific qualities that make a depaving project more practical (*Figure 8*). These include sidewalk deficiencies, proximity to parks, concurrence with bike routes, and alignment of underground utilities.

The first map shows target street segments with an evident density of priority locations in the south and east of the city, but with some isolated pockets to the west. The highest concentrations of potential intervention sites are in Sunset, Kensington-Cedar Cottage, Hastings-Sunrise, Grandview-Woodland, and the Downtown Eastside. The identified streets are distributed relatively equally through those neighbourhoods.

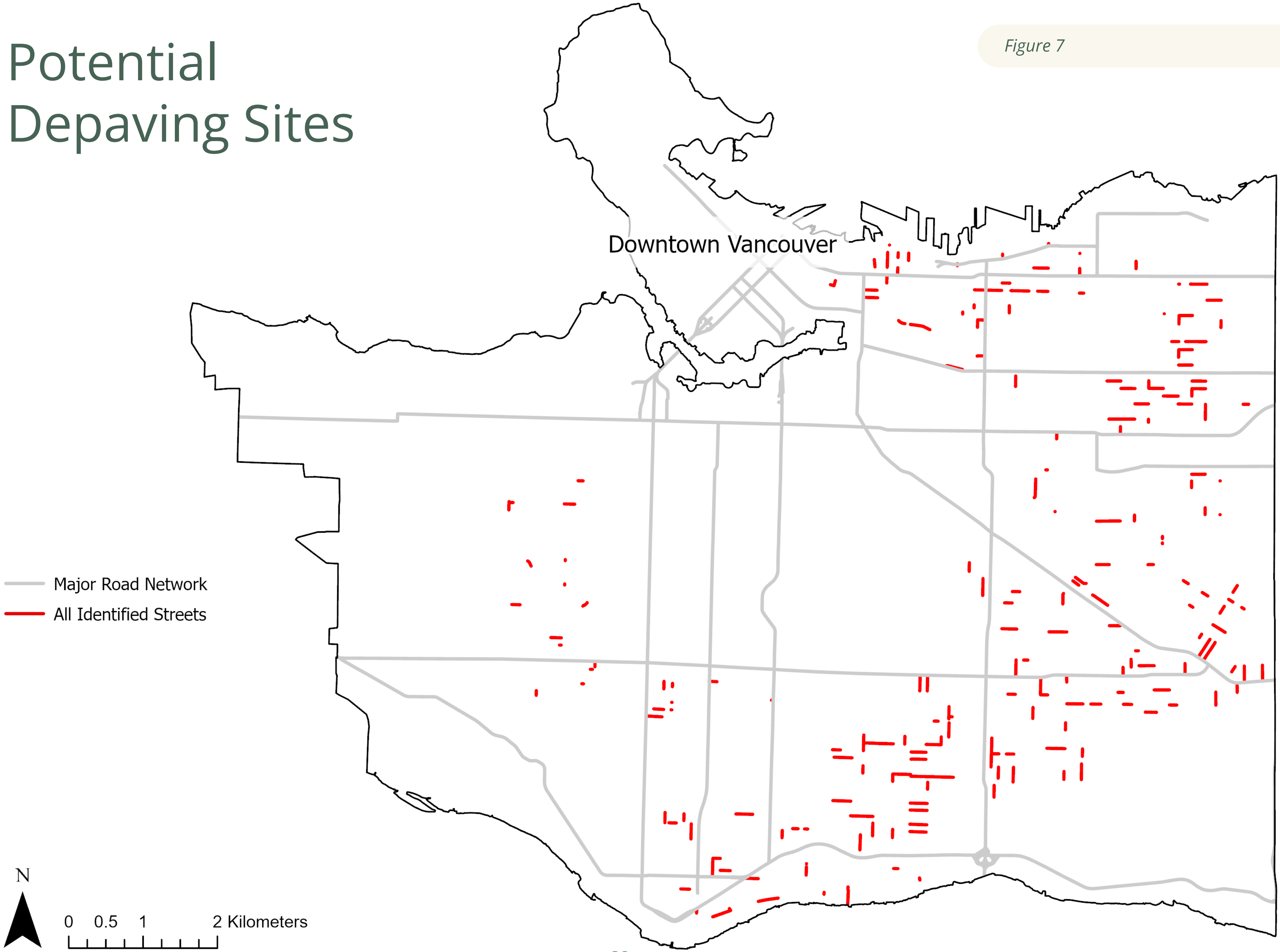
Sidewalks also add a significant amount of pavement to the right-of-way. However, unlike PCI which ranks the condition of an entire street segment, the currently available sidewalk condition data is limited to point data. A complete inventory of sidewalks (similar to PCI) is expected in 2023, but until then the sidewalk condition data shows specific points that include the severity of defects (heaving from tree roots, map cracking, joint spalling, etc.). As there are nearly 40,000 sidewalk defects recorded across the city, this study only includes points where the defect severity is high. Sidewalk defect data points are then correlated with adjacent street segments, which highlights areas where both the streets and sidewalks are in greater need of repair.

The overlap with bicycle routes is also identified. As bicycle routes are already traffic calmed and divert automobile traffic to other streets, the impacts of depaving on traffic are minimized. There are a few sites worth investigating, with a noticeable concentration in the Killarney, Kensington-Cedar Cottage, and Renfrew-Collingwood neighbourhoods.

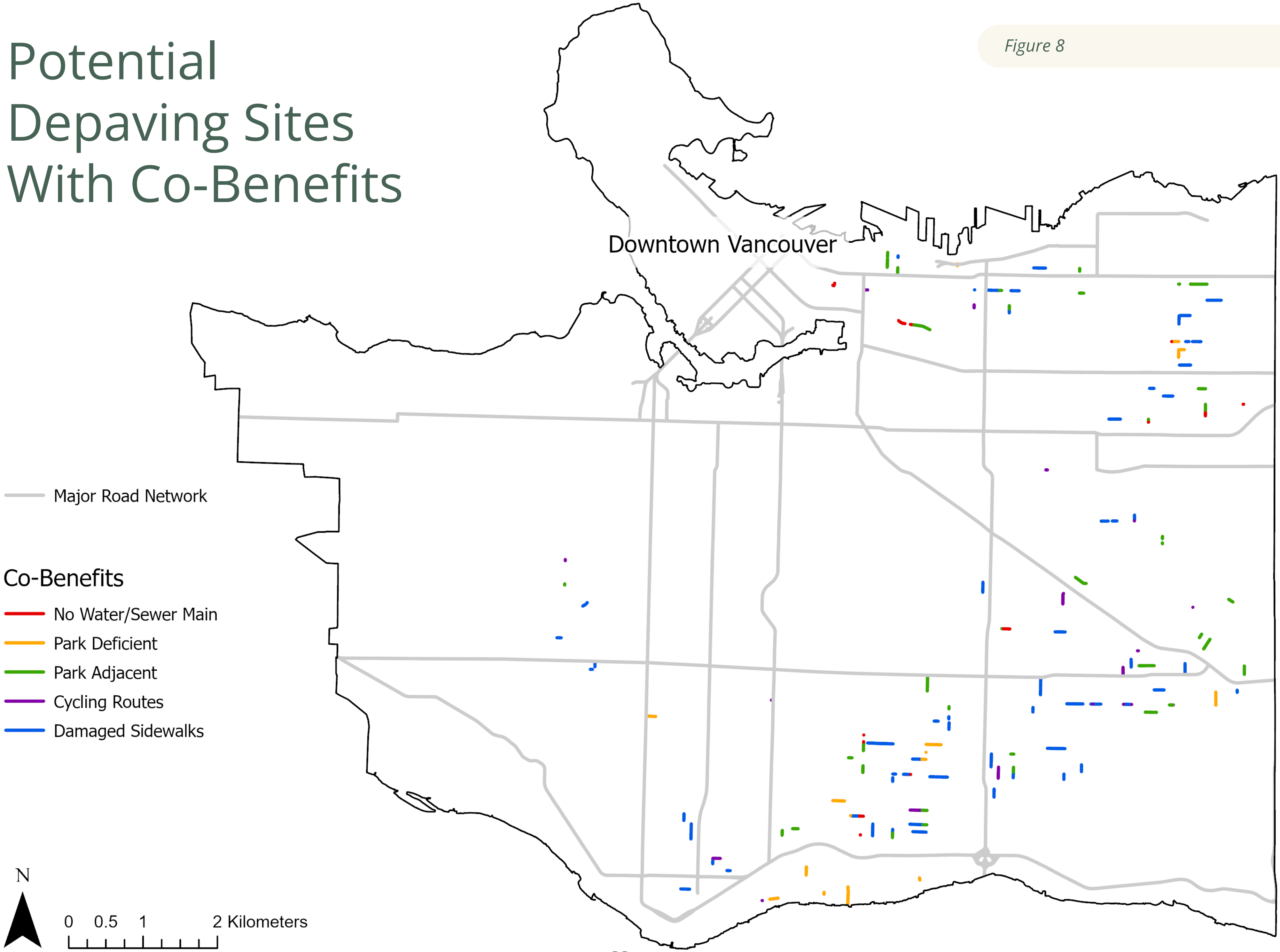
Another consideration is the relationship between depaving and parks. Depaving can be a tool to create small parks in deficient areas (greater than 500 meters from a park), as was the case with Lilian To Park. Depaving can also expand the footprint of parks like recent upgrades in in Sunset Park and Alice Townley Park. A small number of street segments are

Potential Depaving Sites

Figure 7



Potential Depaving Sites With Co-Benefits



in park deficient areas, but there are a substantial number of streets that border or connect directly to parks.

A final strategic opportunity is to depave streets without buried utilities. Streets without sewer or water mains do not require major utility reconfigurations, upgrades, or replacements in the future unless the utilities are rerouted entirely. Sewer and water mains touch nearly every street in Vancouver, but there are few streets without either.

Streets where these features overlap are strong candidates for depaving, but there are unfortunately few of them. Most of the overlap is found between a single layer and streets that have deficient sidewalks, as it is the largest data set. There is also some overlap between bicycle routes and parks. The potential for depaving should be explored further on streets that address these relationships.

While not exhaustive, the following is a list of street segments that satisfy many of the priority factors and could be considered for pavement removal/reduction projects (*continues on next page*):

Potential Sites

Address	Opportunities	Challenges
2200 block of Windermere Google Street View	No water or sewer main, south facing slope is exposed to the sun, no sidewalk on one side of the street.	No existing traffic calming measures, some houses require street access as they are not on the laneway.
2800 block of 46th Ave Google Street View	Killarney cycling route, adjacent to park, street and sidewalk are in poor condition.	Canopy cover is low but there are already many trees, utilities are buried under the street, there is a fair amount of street parking.
2200 block of Turner St Google Street View	Adjacent to a park, adjacent to a school, several traffic calming measures already in place.	Utilities are buried under the street, recent utility work already repaired some pavement.
200 block of Dunlevy Ave Google Street View	Adjacent to park, streets and sidewalks are in poor condition, low canopy, target area for tree planting.	High levels of street parking, buried utility lines.
2900 block of Charles St Google Street View	Park deficient area, wide residential street, no utilities under half of the street, intersects 1300 block of Nootka (below).	Recent utility work repaired half of the street, no traffic calming.
1300 block of Nootka Google Street View	Park deficient area, no water or sewer mains, intersects 2900 block of Charles St (above).	PCI is near 50, some houses are not on the laneway and require street access.
Adanac-Vernon Plaza Google Street View	Closed to traffic, cycling route, highly paved area.	Several utility conflicts, little if any room for street trees.
E 40th Ave at Earles Park Google Street View	No sidewalks, adjacent to a school and park, minimal utility conflicts, functionally a laneway.	Few utility conflicts, two hours require laneway access. This street was recently repaved so it is no longer a candidate, but it is included to highlight what could have been.
4700 block of Gladstone Google Street View	No sidewalk on one side of the street, traffic calmed, part of “Slow Streets” network.	Water main along entire length of the street, high levels of street parking.
5900 block of Latta St Google Street View	Park deficient area, sidewalk on one side of the street, few water or sewer mains, no through streets.	Some water main conflicts, misaligned street layout creates access issues for some houses.

Recommendations

The previous case studies and analysis of the local context inform several recommendations for depaving in Vancouver. The intent of these recommendations is to depave and open space within the right-of-way relatively quickly, but also produce long-term results that support street trees and other ecological/social benefits. These recommendations are not exhaustive, but they are key considerations as the City evaluates street segments where impervious pavements can be reduced.

Recommendation #1: Work quickly and efficiently.

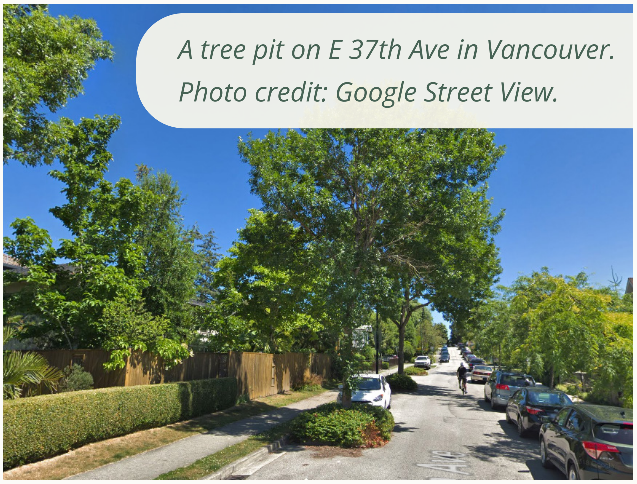
A small and efficient project in Melbourne. Photo credit: City of Melbourne.

Depaving projects in Vancouver (Lilian To Park, the Sunset Park upgrades, and the Woodland Dr upgrade next to Alice Townley Park) are all large projects that involve several stakeholders and significant levels of investment. The upgrades at Sunset Park cost $450,000 CAD and included street improvements, lighting improvements, and green rainwater infrastructure on an approximately 80m stretch of Prince Edward St. Similarly, $687,000 CAD was budgeted for the Woodland Dr upgrades, though it is expected to finish 20-30% under budget. The results of this spending are undeniably great projects that are showcase pieces worth replicating. However, more nimble and economical interventions should also be pursued to realize the benefits of depaving in more locations across Vancouver.

Cities like Melbourne and organizations like Depave show how to get results at a fraction of the cost. Four different sites were depaved in Melbourne as part of a pilot project, and at an average cost of $59,000 AUD ($52,500 CAD) each. As these projects focused on biodiversity rather than engineered green infrastructure, costs were reduced and an increase in wildlife was immediate. Additionally, Depave in Portland, Oregon was able to depave eight sites in 2019 for $65,000 USD ($84,000 CAD). Volunteers were able to complete many of these projects in as little as a weekend, and ultimately depaved 1300 m^2 of surface, reduce annual runoff my 1.5 million litres, and plant thousands of trees, shrubs, and plants. For comparison, Lilian To Park is 1500 m^2 and cost $600,000 CAD.

The City of Vancouver should continue to invest in large projects, but not at the expense of smaller projects that produce more immediate results. In addition to projects like Lilian To and Sunset Parks that span multiple years and cost hundreds of thousands of dollars, the City can find sites for fast and efficient depaving projects that simply remove impervious surface and open space for ecological services. If Vancouver is to reduce its emissions by 50% by 2030 and meet its other Climate Emergency Action Plan targets, then near-term, less design-intensive solutions will play a critical role. Precedents from across the world show that working quickly and efficiently can produce effective results with an impressive return on investment.

Recommendation #2: Consider different scales.



A tree pit on E 37th Ave in Vancouver. Photo credit: Google Street View.

Depaving in Vancouver is typically at the scale of an entire street segment. This is more expensive as the intervention sites are large, may raise concerns about reductions to parking and road width, and require more extensive design around existing utilities and other infrastructure. Despite these hurdles, depaving at a large scale is still a worthwhile endeavor. However, it is not the only option.

In addition to strategically selecting specific streets for depaving, the City can take a more targeted approach to depave smaller areas. This is already the case with tree planting strategies in the Downtown Eastside and Marpole and can be replicated elsewhere. As in Melbourne, a section of the Clowes Street sidewalk was exceptionally wide, and the City was able to reduce its width by 2 metres while still preserving adequate space for pedestrians. There are opportunities to depave individual parking spaces, partially reduce the width of streets, and reconfigure sidewalks that reduce the amount of impervious surface in the city. While these smaller scale interventions are not as grand as larger projects, they still make meaningful contributions to the goal of depaving and can open space for street trees and other uses that support biodiversity.

Recommendation #3: Expand opportunities to collaborate.

Conversations with stakeholders at the City of Vancouver highlight that different teams are often working towards similar goals, but there is room to continue improving the coordination and communication across teams within such a large organization. Lilian To Park, for example, is a highly regarded project among City staff that brought together transportation design, parks planning, traffic management, green infrastructure, urban forestry, streets design, and others, and is often cited as the type of project staff would like to repeat. Each team has their own set of rationales and mandates to guide their work, but there are several opportunities for collaboration when the end goal for each team converges on a single design typology.

Clear lines of communication and information sharing will help teams collaborate in the future and find ways to support each other's goals. There are co-benefits to every project, and involving other teams helps plans move forward and improve their outcomes. While the focus of this project was specifically on the relation between paving strategies and the urban forest, it has application elsewhere. Depaving can support traffic calming on cycling routes, or it can help restore watersheds like Still Creek. There is an opportunity to create infrastructure that is resilient and serves more than a single purpose.

Recommendation #4: Involve the community.

Depave volunteers in Portland.
Photo credit: Katya Reyna - Depave.

This project relied on a desktop analysis to find potential intervention sites. However, there are also opportunities for community engagement. In Montreal, for example, residents can create Green Alleyways if more than half of the residents along an alley agree to the changes. This strategy is a success as it has resulted in over 450 Green Alleys since the 1990s, and the speed at which new alleys are created is increasing every year. Additionally, organizations like Depave Paradise in Ontario can recruit hundreds of volunteers for depaving projects in their own communities.

Involving the community allows cities to share the responsibilities of designing and maintaining depaving projects. The City of Vancouver already has an established Green Streets Program that connects volunteer gardeners with traffic calmed spaces on local streets. These gardens may fill traffic circles, corner bulges, and street boulevards, and create biodiverse habitats and valuable green space in dense urban environments. Depaving sites can be selected with feedback from residents, and the sites can be handed over to volunteer gardeners to create more vibrant neighbourhoods.

Recommendation #5: Stay flexible.

Creating space for community participation requires flexibility when planning depaving projects. While an ideal project may involve a complete handoff to the community, it is unfortunately not always possible. Some aspects of depaving will always require technical expertise from the City – tree planting, utility maintenance, bioswale development, etc. Once these issues are resolved, Vancouver can implement plans that address long-term engineering needs and are compatible with community-led design and maintenance.

Street trees in Vancouver's West End.
Photo credit: City of Vancouver.

Discussion

This project serves as a starting point for conversations around depaving in the City of Vancouver. The findings are not definitive, as they will continue to evolve with time and may be applied at different scales. The GIS analysis may serve as a reference point for future projects, and users can customize the GIS model with new data layers to help inform their work. For example, how can depaving support the health of a specific watershed? Can depaving serve as a traffic calming tool on streets that are used as shortcuts? If these questions are asked when a street reaches the end of its service life, new opportunities for depaving may open across the city.

Asking the right questions when a street reaches the end of its service life creates new opportunities for depaving.

There are of course obstacles. The cost of paving a street is relatively cheap in the short-term, and benefits from decades of standardization, optimization, and information sharing from across the world. Depaving, on the other hand, is still in its infancy, and modern green infrastructure planning goes back as far as the 1990s (though we see precedents throughout human history). Using the Sunset Park upgrade in Vancouver as an example, replacing the same stretch of pavement with more pavement would have cost around $50,000 CAD. The actual cost of the new rainwater infrastructure and street improvements was approximately $450,000 CAD. There are benefits and challenges for each strategy. Traditional paving practices are less expensive but worse for the environment (urban heat, rainwater runoff, carbon-intensive production, and so on), while depaving streets for trees and green infrastructure is more expensive upfront but supplies several social and ecological benefits into the future. While cost is a major consideration, the power of volunteers may help reduce depaving costs. Moving forward, the City must determine which trade-offs it is willing to make.

There is still much to learn about the effectiveness of depaving and street trees. Most of the work so far has focused on rainwater management, which offers immediate results. When a green stormwater system is finished it instantly redirects water and the outcomes are immediately measurable. However, trees take time to grow, and in dense urban environments trees may struggle for several years before they either take hold or eventually die. The health of street trees and trees in depaved environments requires continued monitoring and experimentation to better understand what strategies work best.

The role of and impact on different communities is also important, and more work is needed on how to meaningfully engage the community in depaving projects. As the removal of parking and street access can be contentious issues, community engagement may increase buy-in for depaving. There is also an opportunity to move beyond engagement alone when shaping a project, as community-led depaving projects are successful across the world. However, depaving and green infrastructure may also contribute to the gentrification of an area, especially when placed in underserved areas. This is a complicated issue and requires further analysis.

There is no silver bullet to address climate change, but depaving is one of the many available tools to create a more environmentally and socially just city today and into the future.

It is also important to remember that depaving is not limited to the street right-of-way. Schools, parking lots, and private driveways all contribute to the amount of impervious surface in cities, and there are opportunities to partner with public and private organizations to depave their property. Additionally, while this project prioritized locations in historically underserved neighbourhoods across the south and east sides of Vancouver, it is worth noting there are also streets in poor condition in the more privileged west side of the city. While these streets were not the focus of this analysis, they should also be considered as potential depaving sites.

Another question relates to the language of “depaving.” Depaving is not a widely used term, and at face value it implies the removal of pavement without anything in return. This raises questions about the impacts of depaving on neighbourhoods, as residents may interpret it to mean the City is taking something away from their community. However, as depaving is about improving communities by replacing pavement with street trees and green infrastructure, there are ways to communicate these goals more effectively. Phrases like regreening or redesigning streets from grey to green carry positive connotations that highlight the motives behind depaving.

As Vancouver experienced record-breaking heat in the summer of 2021 and as Europe, China, and other parts of the world have experienced their own extreme heat events in 2022 (Landler, 2022), rising temperatures are becoming the world's new normal. Cities, including metro Vancouver, suffered hundreds of heat related deaths in 2021 and must adapt to combat the worst effects of climate change. Trees are one of the most powerful tools for keeping cities cool, but easy planting sites are used up. As streets and sidewalks are one of the greatest obstacles for planting trees in public spaces, Vancouver must rethink its street and sidewalk rehabilitation strategies to make way for more green infrastructure and street trees. When a street's pavement reaches the end of its service life, the City must ask whether the pavement requires replacing, or if the street can supply greater ecological, social, and transportation services. While there is no silver bullet to address the effects of climate change, depaving is one of the many available tools to create a more environmentally and socially just city today and into the future.

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Appendix: Potential Depaving Sites

Address: 2200 block of Windermere

Opportunities: No water or sewer main, south facing slope is exposed to the sun, no sidewalk on one side of the street.

Challenges: No existing traffic calming measures, some houses require street access as they are not on the laneway.

Source: Google Street View

Address: 2800 block of 46th Ave

Opportunities: Killarney cycling route, adjacent to park, street and sidewalk are in poor condition.

Challenges: Canopy cover is low but there are already many trees, utilities are buried under the street, there is a fair amount of street parking.

Source: Google Street View

Address: 2200 block of Turner St

Opportunities: Adjacent to a park, adjacent to a school, several traffic calming measures already in place.

Challenges: Utilities are buried under the street, recent utility work already repaired some pavement.

Source: Google Street View

Address: 200 block of Dunlevy Ave

Opportunities: Adjacent to park, streets and sidewalks are in poor condition, low canopy, target area for tree planting.

Challenges: High levels of street parking, buried utility lines.

Source: Google Street View

Address: 2900 block of Charles St

Opportunities: Park deficient area, wide residential street, no utilities under half of the street, intersects 1300 block of Nootka (below).

Challenges: Recent utility work repaired half of the street, no traffic calming.

Source: Google Street View

Address: 1300 block of Nootka St

Opportunities: Park deficient area, no water or sewer mains, intersects 2900 block of Charles St (above).

Challenges: PCI is near 50, some houses are not on the laneway and require street access.

Source: Google Street View

Address: Adanac-Vernon Plaza

Opportunities: Closed to traffic, cycling route, highly paved area.

Challenges: Several utility conflicts, little if any room for street trees.

Source: Google Street View

Address: E 40th Ave at Earles Park

Opportunities: No sidewalks, adjacent to a school and park, minimal utility conflicts, functionally a laneway.

Challenges: Few utility conflicts, two hours require laneway access.

This street was recently repaved so it is no longer a candidate, but it is included to highlight what could have been.

Source: Google Street View

Address: 4700 block of Gladstone

Opportunities: No sidewalk on one side of the street, traffic calmed, part of "Slow Streets" network.

Challenges: Water main along entire length of the street, high levels of street parking.

Source: Google Street View

Address: 5900 block of Latta St

Opportunities: Park deficient area, sidewalk on one side of the street, few water or sewer mains, no through streets.

Challenges: Some water main conflicts, misaligned street layout creates access issues for some houses.

Source: Google Street View