2022 VANCOUVER TREE CANOPY ASSESSMENT

Diamond Head Consulting

CITY OF VANCOUVER

VANCOUVER BOARD OF PARKS AND RECREATION

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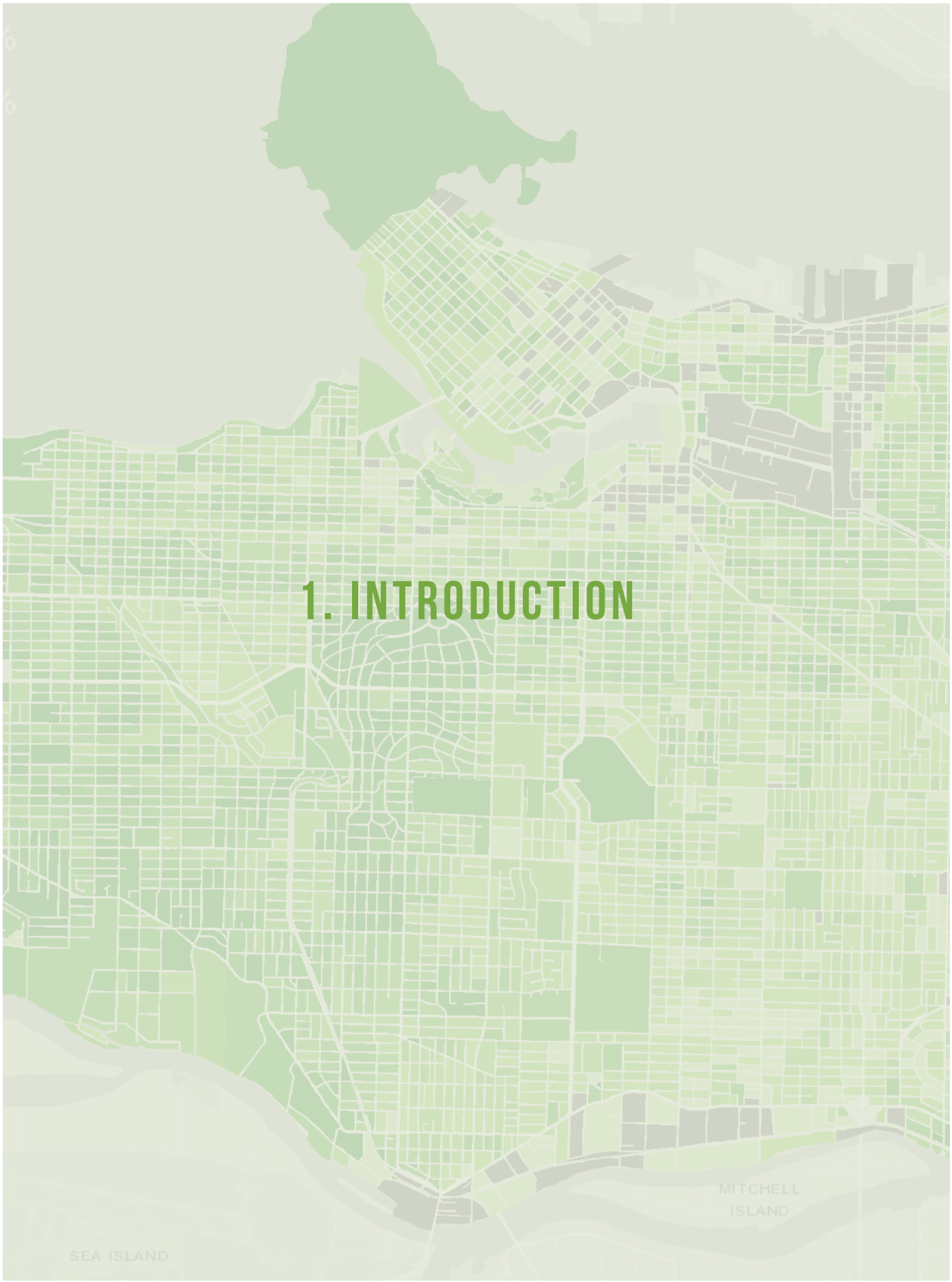
This report summarizes the City of Vancouver's tree canopy assessment for 2022 and updates the 2018 tree canopy assessment. The contents of this report describe the canopy assessment process and share key findings.

Mapping tree canopy helps the City understand the size and location of trees across Vancouver to inform future management. Tree canopy mapping is also used to measure the distribution of tree canopy and associated ecosystem services across the community. This information can be combined with other City datasets to examine issues of equity, access and climate resilience.



1. INTRODUCTION

VANCOUVER'S 30% TREE CANOPY COVER TARGET

The City of Vancouver recognizes that a healthy and resilient urban forest is an essential component of a sustainable city. Urban forests are increasingly recognized for their role in mitigating the impacts of climate change in cities. The 2021 heat dome event proved the devastating effects of extreme heat in BC. Trees can protect against extreme heat by providing shade and cooling, and protect against floods by slowing the flow of rainfall into storm drains. Additionally, trees in cities filter harmful pollutants, support the emotional well-being of citizens, and provide habitat for wildlife (Figure 2).

Canopy cover describes the area shaded by a tree's branches, stems, and leaves when viewed from above (Figure 1). It serves as a metric for assessing urban forest health and gauging the success of Vancouver's Urban Forest Strategy. The City of Vancouver has adopted a 30% canopy cover target by the year 2050. Other major cities in the Pacific Northwest have similar targets: Seattle has a 30% target by 2037 and Portland has a 33.3% target by 2035. Toronto's target is 40% by 2050.

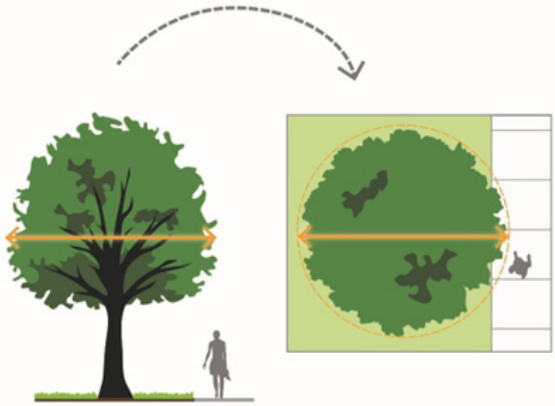


Figure 1: Canopy cover is the area occupied by tree crowns when viewed from above.

CANOPY COVER TARGETS

VANCOUVER: 30% BY 2050
TORONTO: 40% BY 2050
SEATTLE: 30% BY 2037
PORTLAND: 33.3% BY 2035

THE BENEFITS OF URBAN TREES

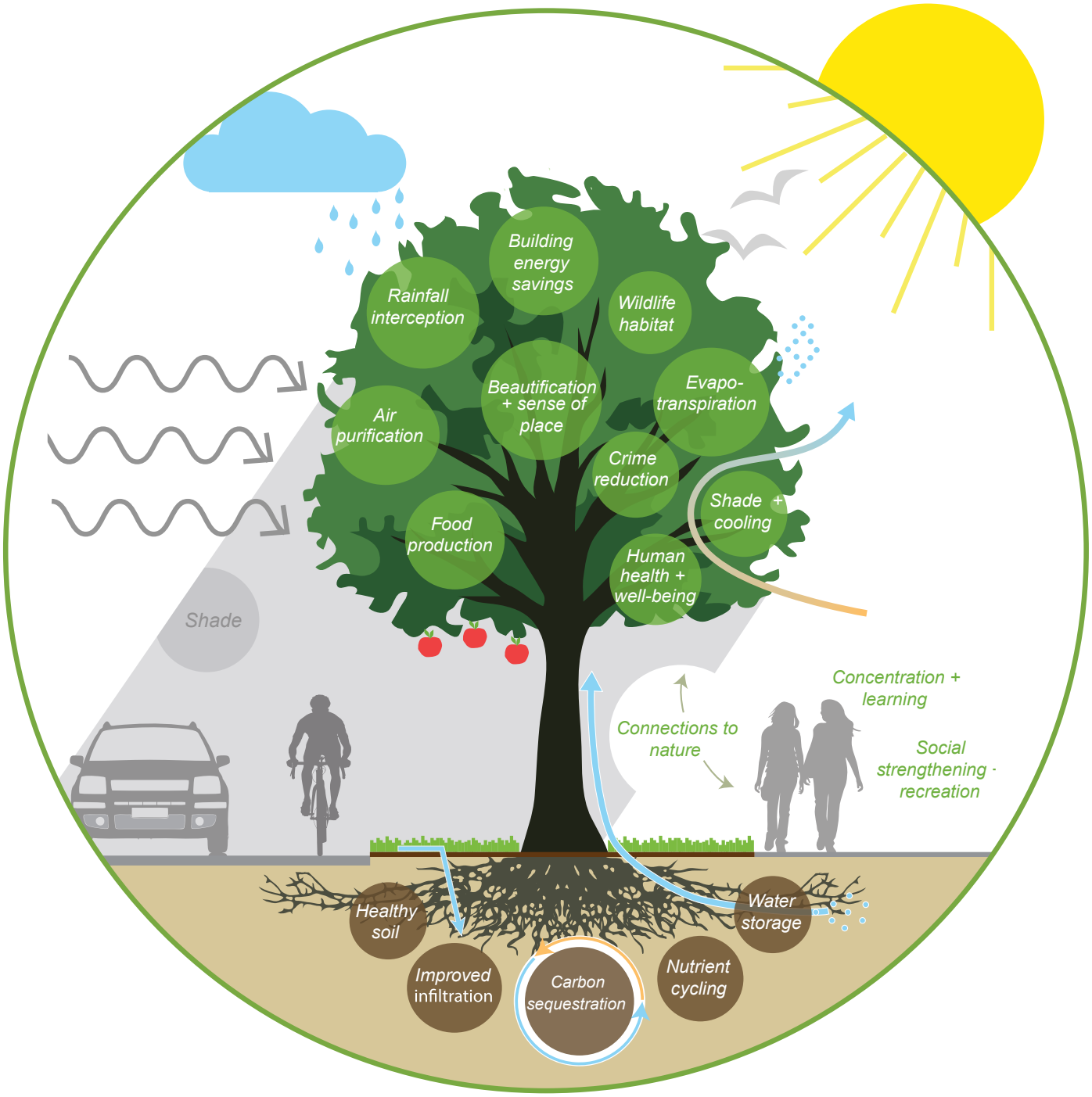


Figure 2: The benefits of urban trees in Vancouver.

MAPPING VANCOUVER'S TREE CANOPY

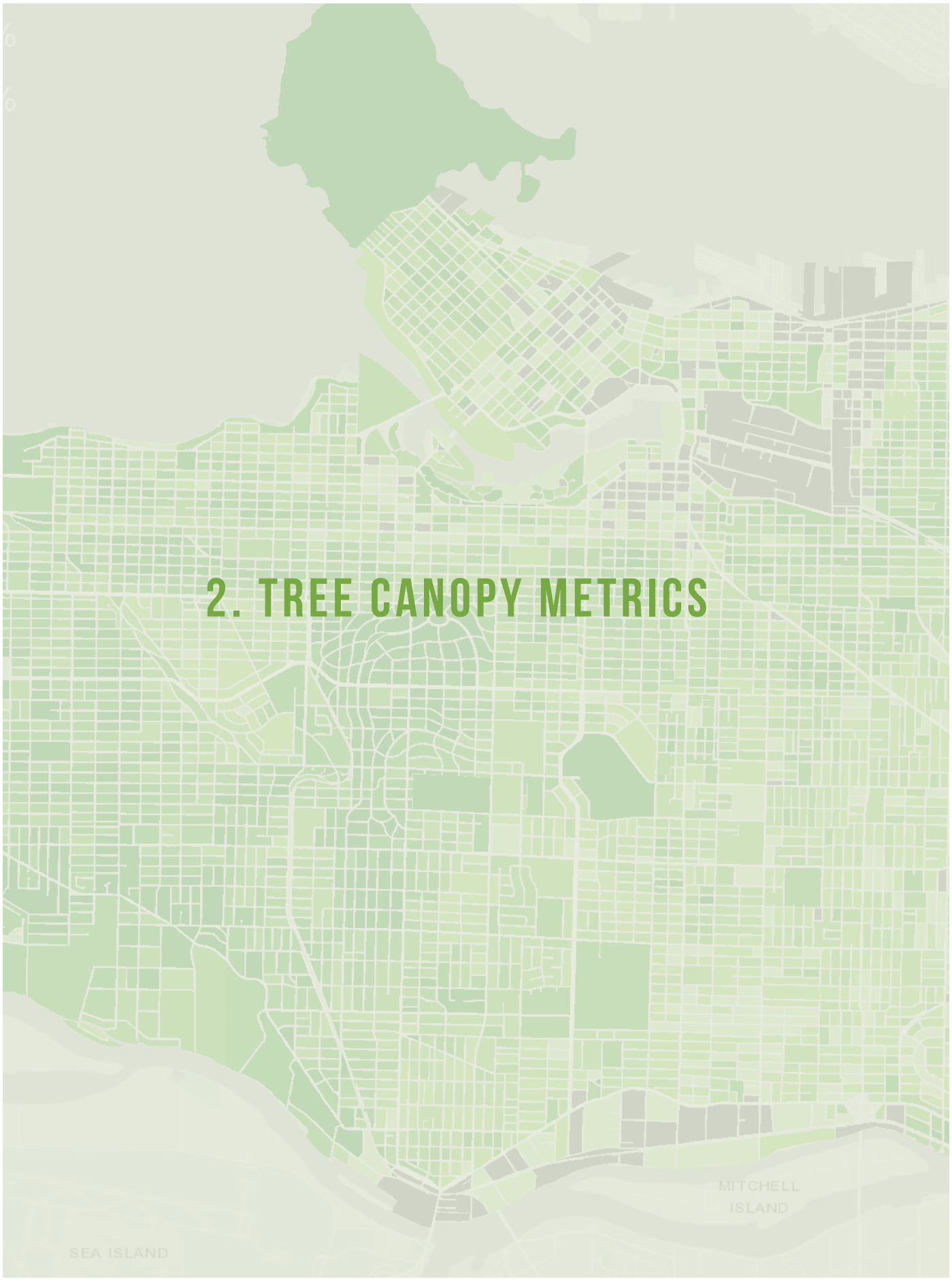
A tree canopy assessment is a method of mapping the urban tree canopy using aerial imagery and light detection and ranging (LiDAR) technology. Measuring the urban canopy periodically using remote sensing technology provides cities with important information about tree canopy growth and distribution as well as canopy loss due to removals.

The process of creating the geospatial canopy model is shown in Figure 3. Consultants used the 2022 LiDAR and ortho-imagery to generate segments and ultimately detect individual trees. The LiDAR aquisition dates and point density are summarized in Table 1. All vegetation with a mean height of 3 m or greater was captured as tree canopy. Canopy cover was then summarized for the entire City of Vancouver and an accuracy assessment was conducted to ensure validity. The detailed methodology can be found in the City of Vancouver 2018 Canopy Cover Assessment Methodology Report.

Table 1: LiDAR aquisition parameters.

LiDAR Aquisition Date	Point Density (point/m²)
2018 (Aug 27 - 28)	30
2022 (Sep 7 - 9)	49

Figure 3: Methodology used to complete the 2022 Canopy Mapping.



2. TREE CANOPY METRICS

OVERALL 2022 CANOPY DISTRIBUTION

This page describes the overall canopy distribution of the urban forest using the results from the updated 2022 canopy analysis.

Citywide canopy cover in 2022 was 25%, encompassing an area of roughly 29 km^2. As in 2018, there continues to be higher canopy cover in the city's west compared to the city's east (Figure 4).

25% Overall Tree Canopy Cover in 2022

OVERALL CANOPY COVER DISTRIBUTION BY BLOCK

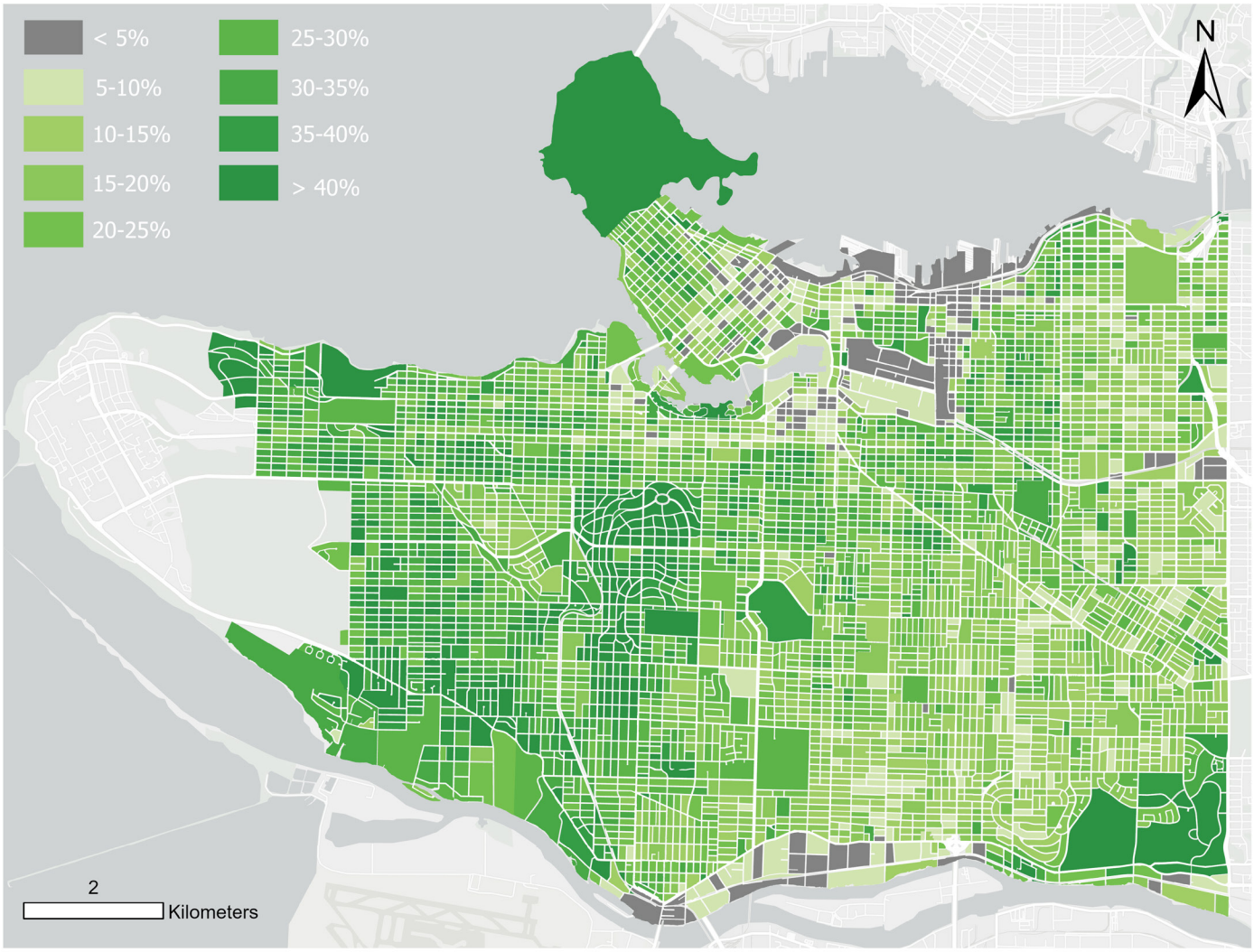


Figure 4: Urban forest canopy distribution by block using 2022 estimates.

CANOPY METRICS - LAND USES

Land covered by canopy

Approximately 35% of the City's public land was covered by trees compared to only 17% of private land uses (Figure 5). Private land had almost twice the land area of public land, but roughly half the canopy cover.

Parks had the highest canopy cover, followed by roads, City-owned properties, private land schools, and then laneways (Table 2).

Canopy area by land ownership

Of the 2,887 ha of canopy area in Vancouver, 1,805 ha or 63% was on public land and 1,082 ha was on private land (Figure 5).

Table 2: Canopy cover by public and private land uses.

Land use	Land Area (ha)	Canopy Area (ha)	Canopy Cover Percent (%)
Streets (ROWs)	2,891	1012	8.8%
Parks	1,295	623	5.4%
City-owned property	414	91	0.8%
Laneways	408	46	0.4%
Private	6,388	1082	9.4%
Schools	223	33	0.3%
Total	11,619	2,887	25%

63%
Of all canopy area is found on public land

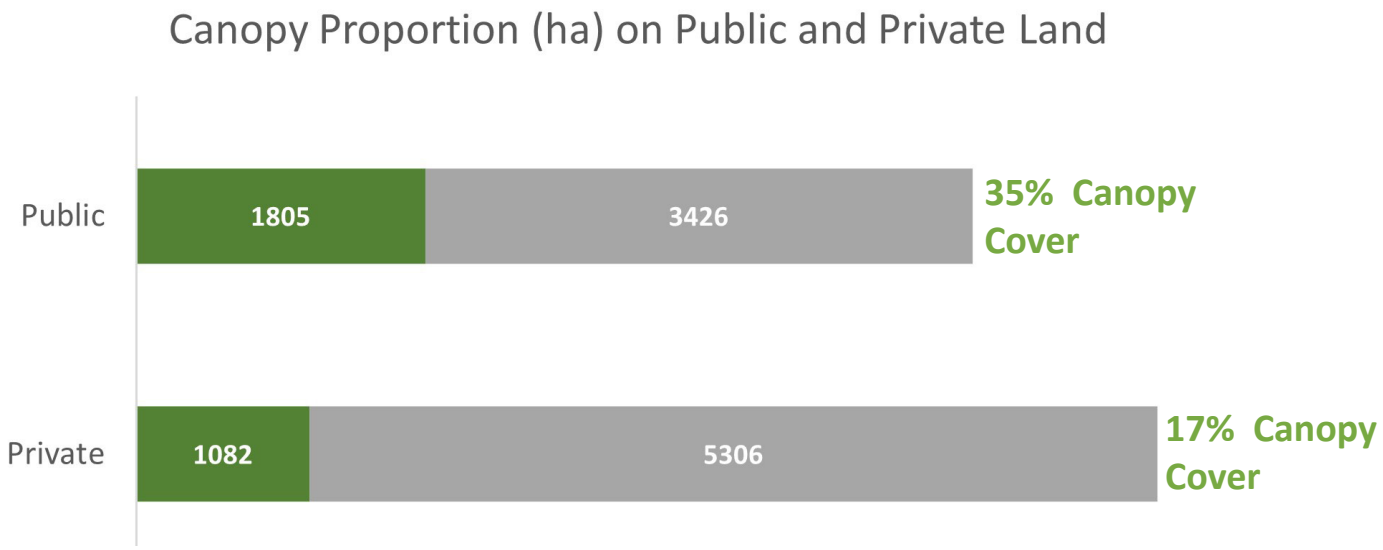


Figure 5: Proportion of tree canopy on public and private land.

CANOPY METRICS - NEIGHBOURHOODS

Vancouver's canopy cover was not evenly distributed across neighbourhoods. Canopy cover was highest in neighbourhoods with larger properties containing more soil volume and space for trees. Shaughnessy, Dunbar-Southlands, West Point Grey, and Killarney all had canopy coverages of over 30% (Figure 6). Strathcona, Sunset and Downtown had the lowest canopy cover. Strathcona was the only neighbourhood with tree canopy cover of less than 10% as it contains impervious light industrial uses including food terminals as well as a rail corridor.

Table 3 shows the canopy cover by neighbourhood for 2018 and 2022, and whether the majority of canopy is public or private. While every neighbourhood saw an increase in canopy cover from 2018 to 2022, the disparity between areas with the most and least tree canopy has grown.

Table 3: Canopy cover by neighbourhood.

NEIGHBOURHOOD	2018 CANOPY	2022 CANOPY	MOST CANOPY IS...
SHAUGHNESSY	36%	41%	PRIVATE
DUNBAR-SOUTHLANDS	33%	35%	PRIVATE
WEST POINT GREY	31%	34%	PRIVATE
KERRISDALE	29%	33%	PRIVATE
KILLARNEY	29%	31%	PUBLIC
KITSILANO	25%	28%	PUBLIC
ARBUTUS-RIDGE	22%	25%	PRIVATE
RILEY PARK	22%	24%	PUBLIC
OAKRIDGE	21%	23%	PUBLIC
SOUTH CAMBIE	21%	23%	PUBLIC
WEST END	20%	23%	PUBLIC
FAIRVIEW	19%	21%	PUBLIC
MOUNT PLEASANT	18%	20%	PUBLIC
KENSINGTON-CEDAR COTTAGE	18%	20%	PUBLIC
GRANDVIEW-WOODLAND	18%	20%	PUBLIC
HASTINGS-SUNRISE	16%	18%	PUBLIC
MARPOLE	15%	17%	PUBLIC
RENFREW-COLLINGWOOD	15%	16%	PUBLIC
VICTORIA-FRASERVIEW	14%	16%	PUBLIC
SUNSET	13%	14%	PUBLIC
DOWNTOWN	12%	13%	PUBLIC
STRATHCONA	8%	9%	PUBLIC

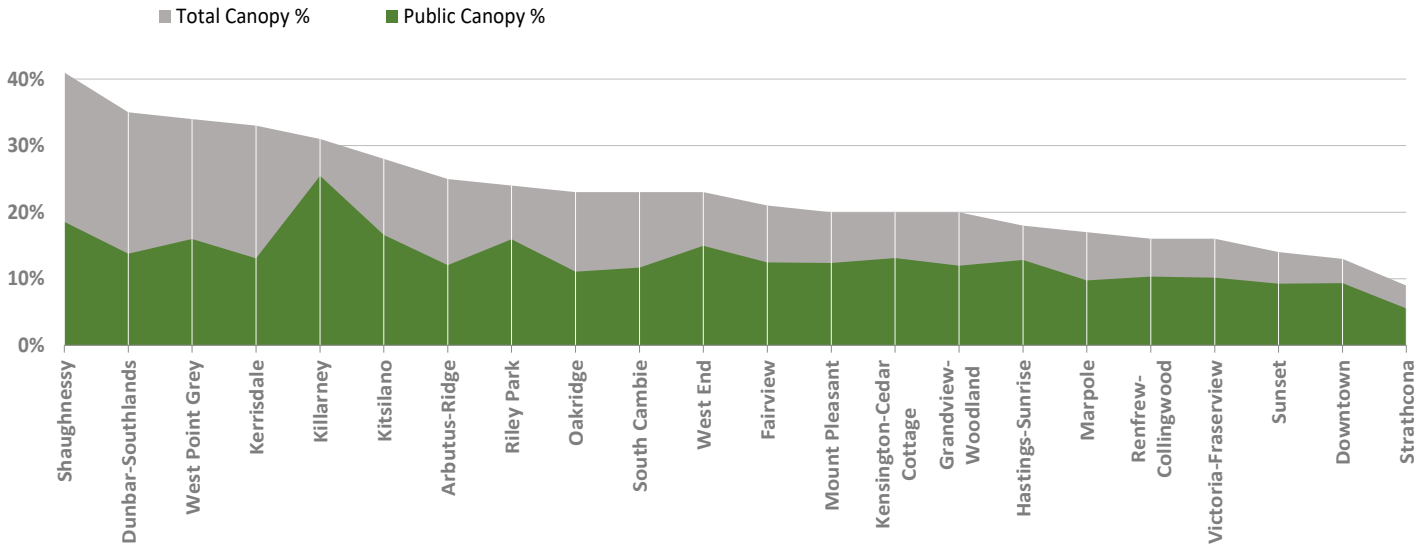


Figure 6: Distribution of tree canopy by neighbourhood with proportion of private vs. public canopy.

CANOPY METRICS - NEIGHBOURHOODS

The geographical trend was for neighbourhoods in the west to have higher canopy coverages than in the east (Figure 7). Killarney was a notable exception to this trend; the neighbourhood had a very high proportion of public tree canopy compared to other neighbourhoods due to the golf-course, parks and cooperative housing developments. The Appendix at the end of this report contains a comparison of the urban forest structure by neighbourhood.

Shaughnessy
Neighbourhood with the highest canopy cover

Strathcona
Neighbourhood with the lowest canopy cover

CANOPY COVER DISTRIBUTION BY NEIGHBOURHOOD

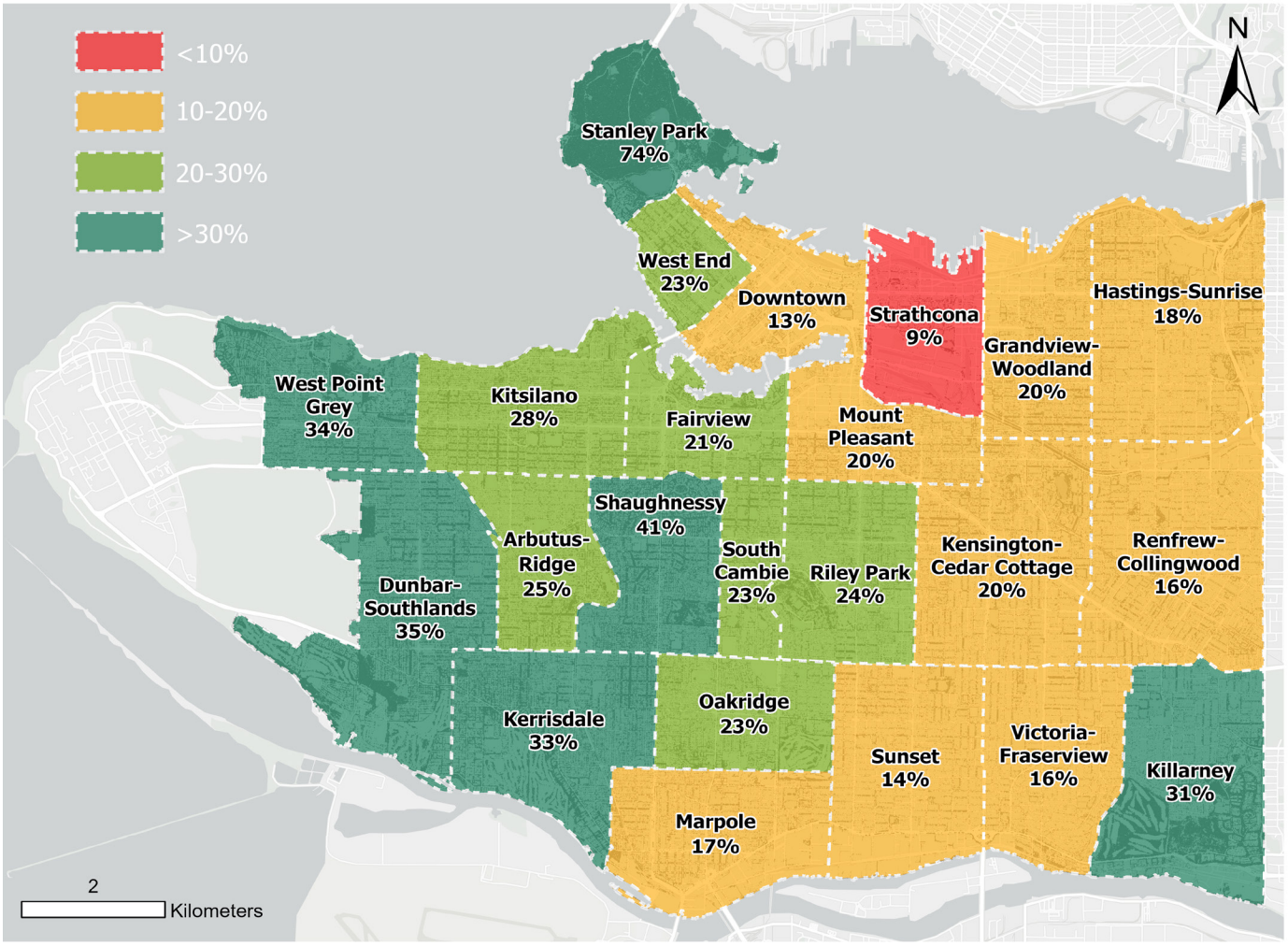


Figure 7: Map of canopy cover by neighbourhood using 2022 LiDAR analysis.

TREE METRICS

The 2022 LiDAR canopy methodology included individual tree detection. The process splits the tree canopy into segments based on what appear to be separate treetops (Figures 8 and 9). This information can be used to explore approximations of average tree sizes in different land uses and for different species.

Average canopy size and heights for each segment provide a good indication of the relative differences in urban forest structure between land uses. However, the algorithm tends to over-segment larger trees of certain species, so average canopy sizes may be underestimated.

Figure 8: 2022 canopy segments approximating individual trees shown over the orthophoto.

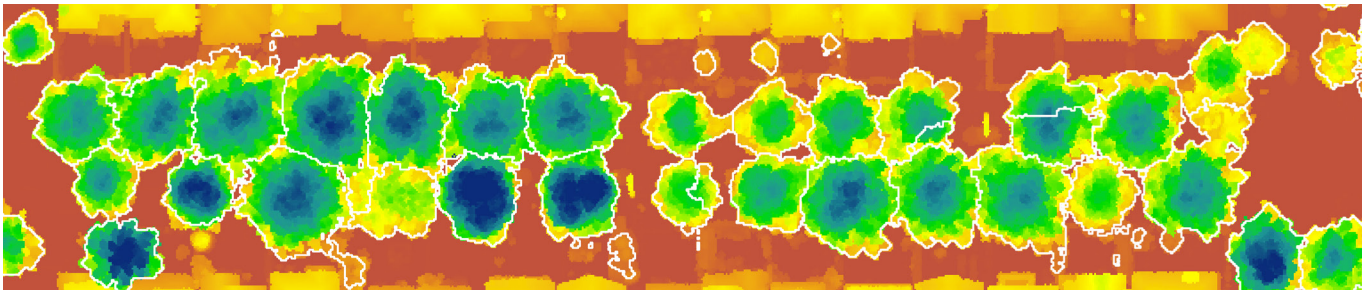


Figure 9: 2022 canopy segments approximating individual trees shown over the Digital Surface Model of elevations.

The average size of trees on different land uses was explored using the canopy segments (Table 4).

Trees in parks are, on average, larger than trees in all other land uses, particularly in terms of height. These values likely reflect both the unconstrained growing conditions in parks (no utility/building conflicts and large soil volume) and the very tall stands of trees in Stanley Park and other natural areas.

Trees in streets and on City-owned properties also average fairly large canopy areas but are approximately half the height of trees in parks.

Trees on private land are the smallest size on average, which reflects the prevalence of small trees and hedges on private property.

Table 4: Average canopy area and height per tree by land use.

Land use	Average Canopy Area per Tree (m^2)	Average Height per Tree (m)
Streets (ROWs)	66	13
Parks	102	25
City-owned property	64	14
Laneways	38	12
Private	48	11
Schools	65	13
Total	64	15

TREE METRICS

Estimating the number of trees required to increase tree canopy cover

To achieve a 1% increase in Vancouver's canopy cover, an additional 116 hectares of tree canopy is needed. Assuming a conservative canopy average, where one tree provides a canopy area of 50 square metres and a hectare comprises 10,000 square metres, approximately 200 trees would cover a hectare. Therefore, to realize a 1% increase in canopy cover, about 23,000 trees should be planted.

On a larger scale, elevating the citywide canopy cover from 25% to 30% necessitates adding 115,000 new, stand-alone trees with an additional 50,000 trees planted to account for attrition of existing public tees, translating to approximately 2,000 trees removed annually due to age, weather, pathogens, and pests.

However, a portion of this increase might be achieved naturally if existing trees grow at a rate that outpaces canopy removal.

Soil volume required to support healthy trees

Planting trees that will grow to a large size is a more efficient way to increase canopy cover. However, cities often face limitations in space and soil volume. Table 5 presents the minimum soil volume required to sustain healthy trees of various sizes, as recommended by the Urban Forest Climate Adaptation Framework for Metro Vancouver (2017)[1]. The guideline suggests providing 0.3 cubic meters of soil for every 1 square meter of tree canopy. This volume, based on sandy loam soil, ensures adequate moisture retention for trees during Vancouver's summer dry periods, a recommendation grounded in the research by Lindsey and Bassuk (1992)[2].

[1] *Diamond Head Consulting. (2017). Urban Forest Climate Adaptation Framework for Metro Vancouver - Tree Species Selection, Planting and Management. Retrieved from http://www.metrovancouver.org/services/regional-planning/conserving-connecting/urban-forests/Pages/default.aspx*

[2] *Lindsey, P., & Bassuk, N. (1992). Redesigning The Urban Forest From The Ground Below: A New Approach To Specifying Adequate Soil Volumes For Street Trees. Arboricultural Journal, 16(1), 25-39*

TREE METRICS

Tall trees (30 m or taller) accounted for 409 hectares (14%) of Vancouver's tree canopy. In 2022 there were an estimated 30,400 tall trees in Vancouver, many of which were found in the neighborhoods of Dunbar-Southlands, Shaughnessy, Kerrisdale and Killarney, and in Stanley Park (Figures 11). A number of tall trees were misidentified in downtown Vancouver because of trees on buildings.

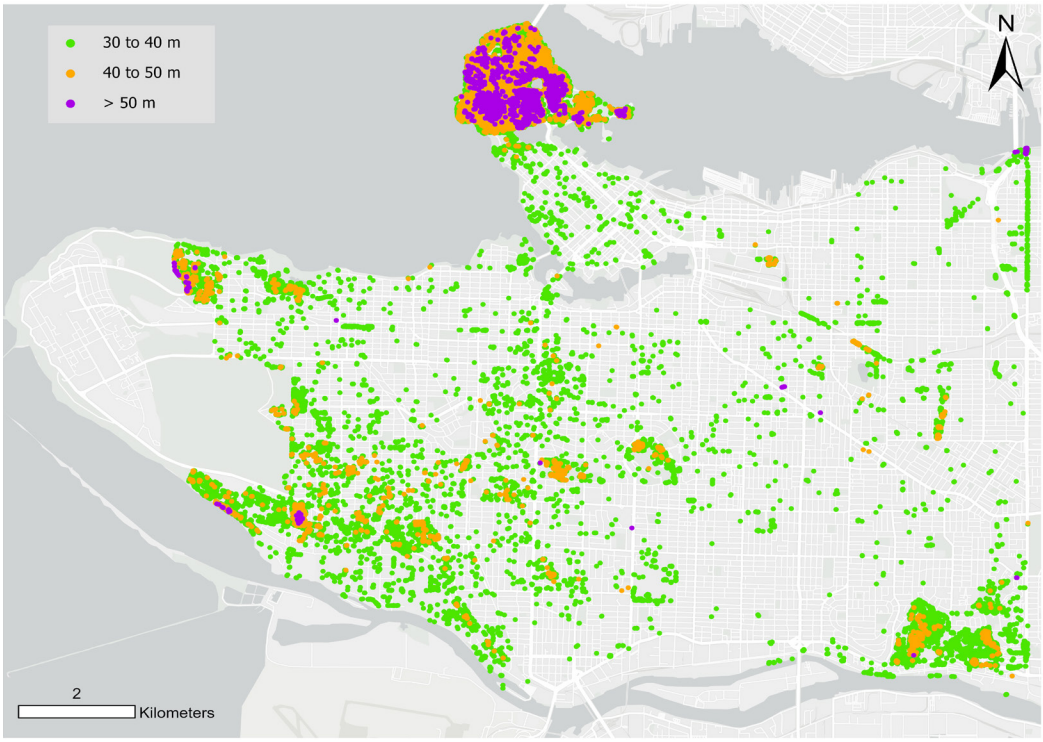


Figure 11: Map of trees 30 m or taller in Vancouver using 2022 LiDAR data.

66 m
Tallest Tree in Vancouver

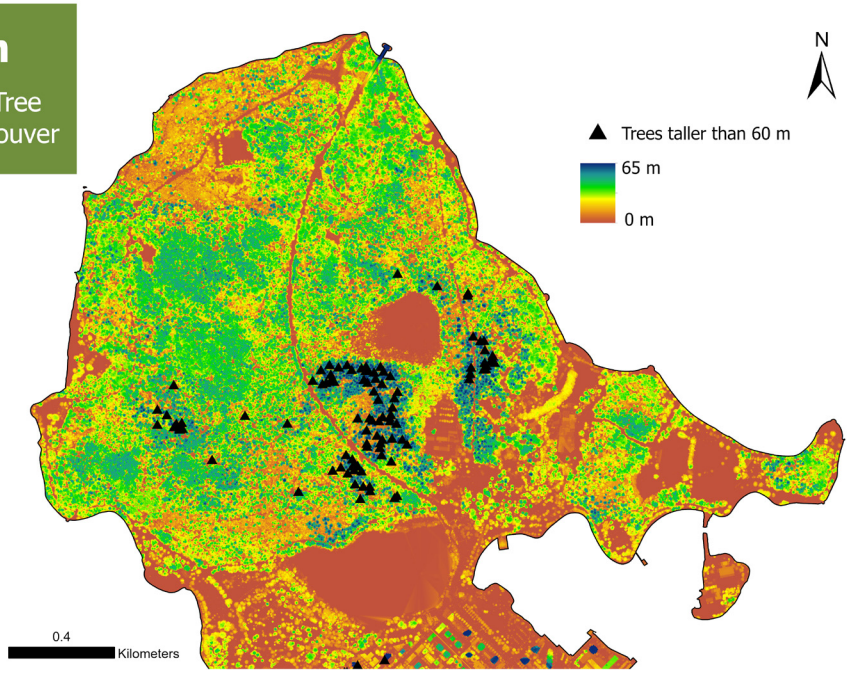


Figure 12: Map of tall trees in Stanley Park, identified using the 2022 LiDAR.

STANLEY PARK TALL TREES

Stanley Park is home to the tallest trees in Vancouver. The predominantly second-growth forest is made up of tall Douglas-fir, western hemlock, and western redcedar and has the largest number of trees taller than 30 m on City land. Assessment using the 2022 LiDAR data identified 100 trees taller than 60 m in Stanley Park. They are predominantly located in the southeast part of the park (Figure 12).

FOREST HEALTH IN STANLEY PARK

Stanley Park forest health has been declining in recent years due to a number of environmental stessors. Among these stressors are:

- hemlock looper outbreak
- drought conditions
- high temperatures
- windstorm events
- compaction on informal/unsanctioned trails.

The 2022 canopy analysis detected a significant amount of dead/dying trees in Stanley Park (Figure 14). The major hotspots of tree mortality are in the northern portion of the park and just south of third beach on the west side of the park (Figure 13). These observations are only representative of the year 2022 and are subject to change. The City will be developing a mitigation plan for Hemlock looper and wildfire risks in the park over the coming years.

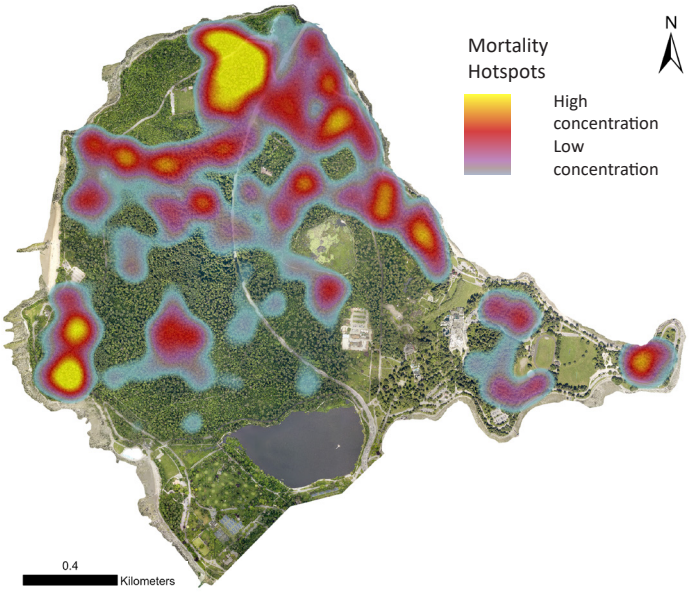
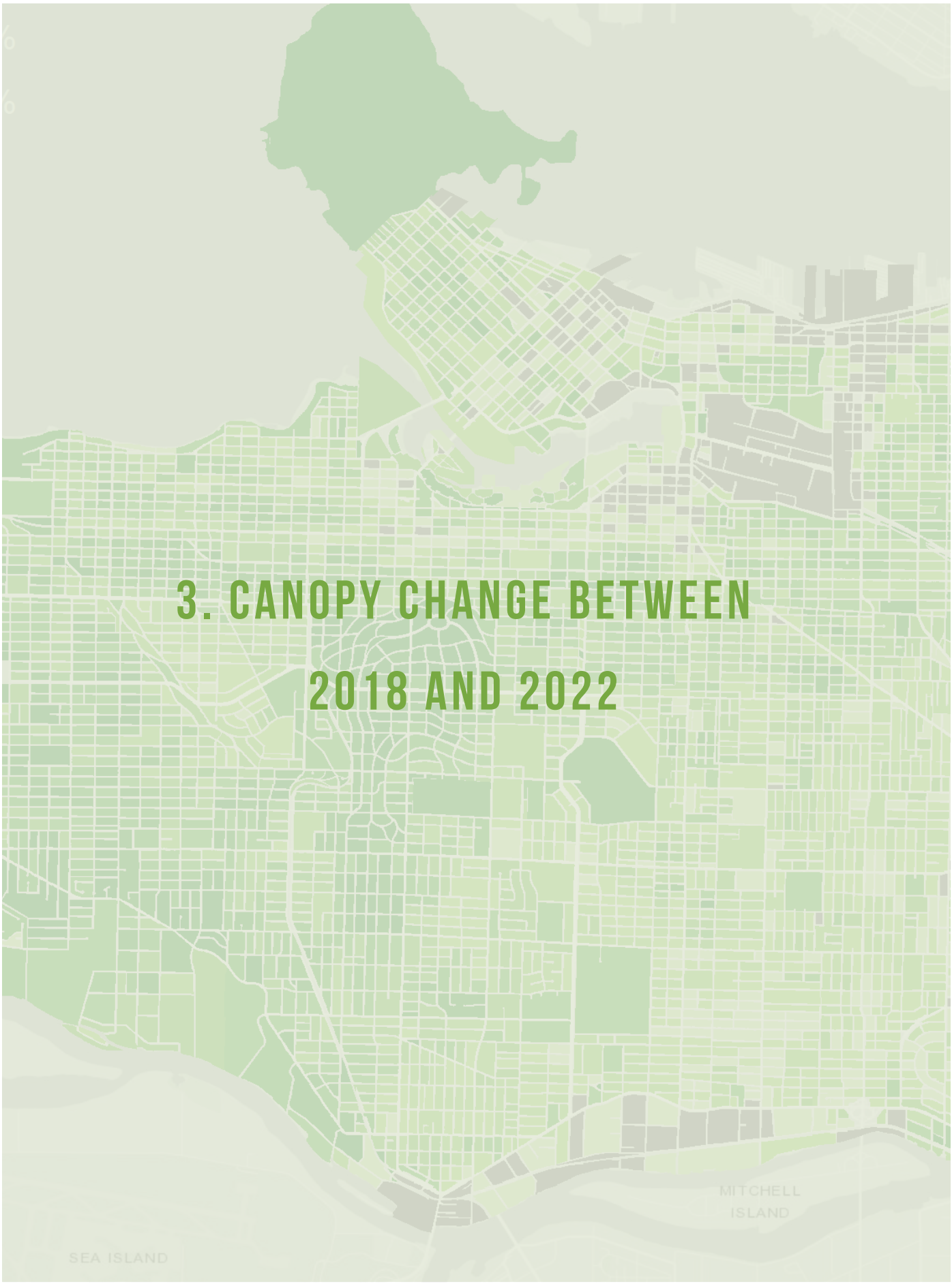


Figure 13: Heatmap of tree mortality in Stanley Park.

Figure 14: Near infrared band from 2022 with dead/dying trees in grey (top), aerial imagery from 2018 (bottom left) and 2022 (bottom right).

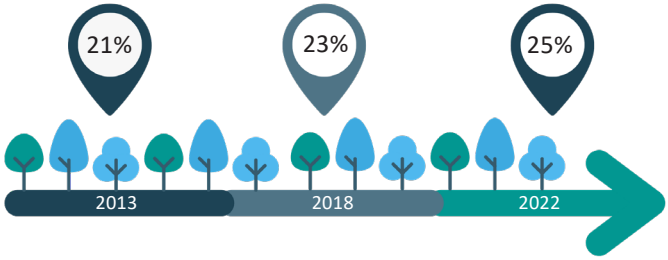


3. CANOPY CHANGE BETWEEN 2018 AND 2022

CANOPY GROWTH FROM 2018 TO 2022

Vancouver's city-wide canopy cover has increased from 21% in 2013 to 23% in 2018 and 25% in 2022. This 4% increase was distributed among both public and private land. Streets (ROWs), parks, and private land showed the highest increases in canopy, while laneways and City-owned properties showed a more modest increase in canopy cover (Figure 16).

Increases in the canopy size of street trees are widespread across the City's streetscapes (Figure 15A). Increases in park canopy cover can be attributed to tree regeneration prompted also by restoration efforts in parks such as Everett Crowley Park in Killarney (Figure 15B).



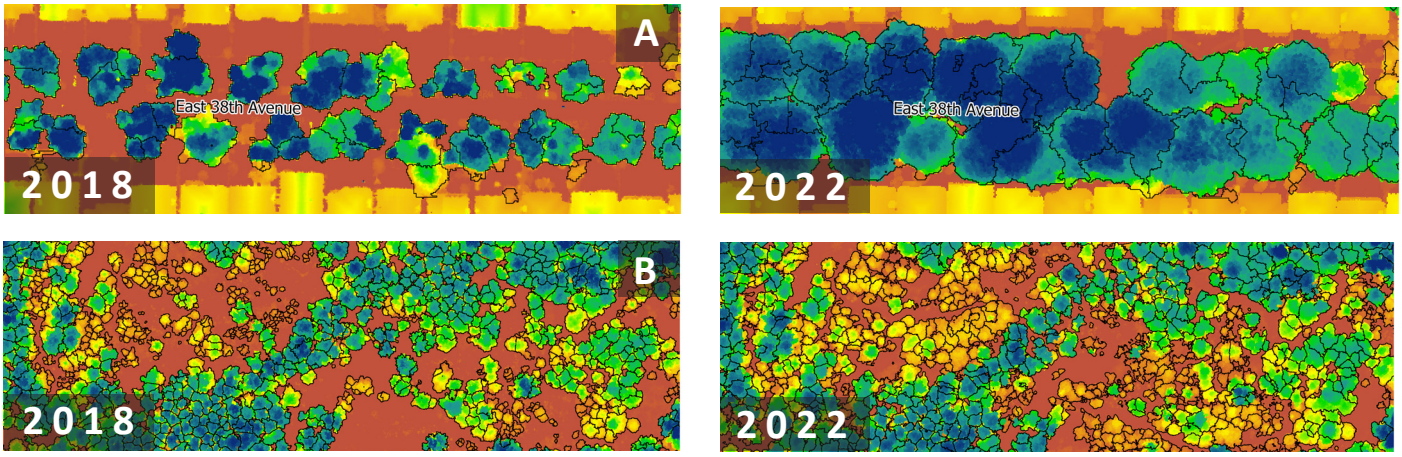


Figure 15: Horizontal canopy growth of street trees on East 38th and Prince Albert Street (A) and tree regeneration on the south-western extent of Everett Crowley Park (B).

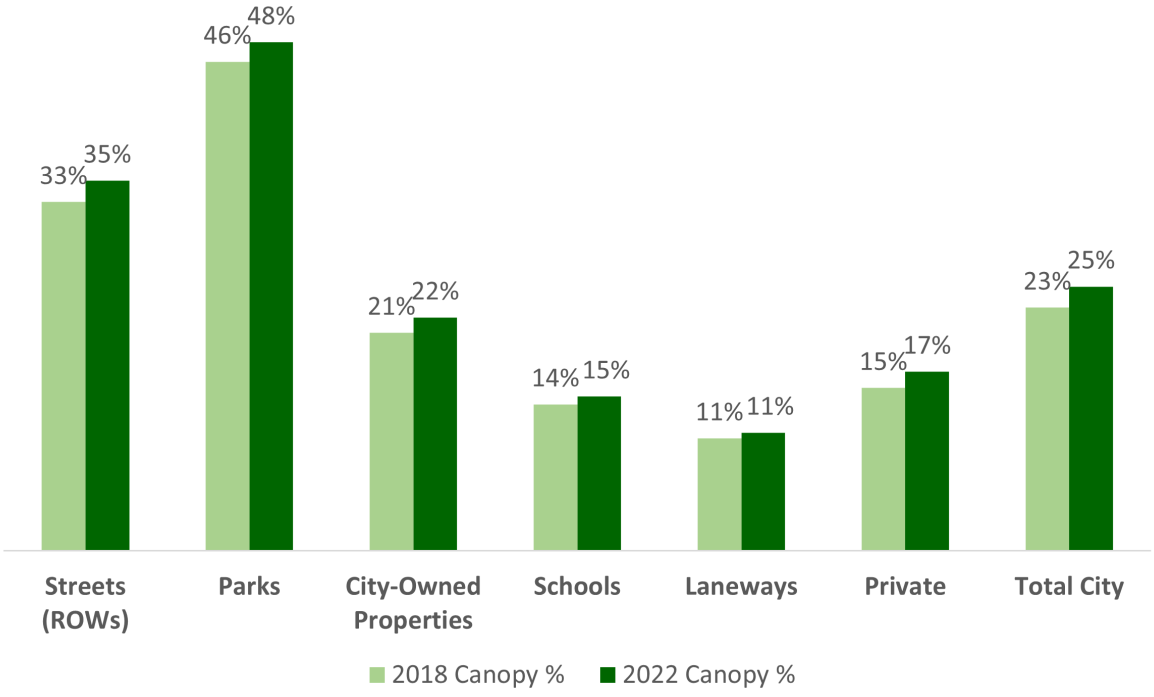


Figure 16: Canopy cover estimates from 2018 LiDAR and 2022 LiDAR for different land uses.

CARBON SEQUESTRATION AND STORAGE CHANGE BETWEEN 2018 AND 2022

Carbon stored and sequestered in Vancouver's urban forest increased between 2018 and 2022 (Table 6). The estimates of carbon stored and sequestered in Table 6 were based on i-Tree Canopy's base values for carbon stored and sequestered in each square metre of canopy.

Table 6: Canopy and carbon sequestered and stored for 2018 and 2022 LiDAR canopy estimates.

	2018			2022		
Land use	Estimated Canopy Area (ha)*	Carbon sequestered annually (kt)	Carbon stored in trees (kt)	Estimated Canopy Area (ha)	Carbon sequestered annually (kt)	Carbon stored in trees (kt)
Streets (ROWs)	954	2.5	73.4	1012	2.6	77.8
Parks	601	1.5	46.2	625	1.6	48.0
City-owned property	84	0.2	6.5	92	0.3	7.1
Laneways	43	0.1	3.3	46	1.1	3.5
Private	1013	2.6	77.9	1112	2.9	85.4
Total	2,700	6.9	207.3	2,887	8.5	221.8

*i-Tree canopy areas do not sum to the whole City exactly due to the error range in the estimates.

LOCATIONS OF CANOPY NET LOSS

While Vancouver gained tree canopy overall between 2018 and 2022, there were some blocks in the City that had a net loss. Figure 16 shows blocks with a net loss of tree canopy between 2018 and 2022.

Maintaining a stable tree canopy requires the steady replacement of trees as they are removed for development, as they die or to manage risk. Private tree removals made up most of the canopy loss detected between 2018 and 2022. Under the Protection of Trees Bylaw, replacement trees must be planted for trees removed but it is often not possible to replace the canopy area lost on a development site. In these cases the canopy loss is usually permanent unless it is compensated for with new trees on public land or on other private properties.

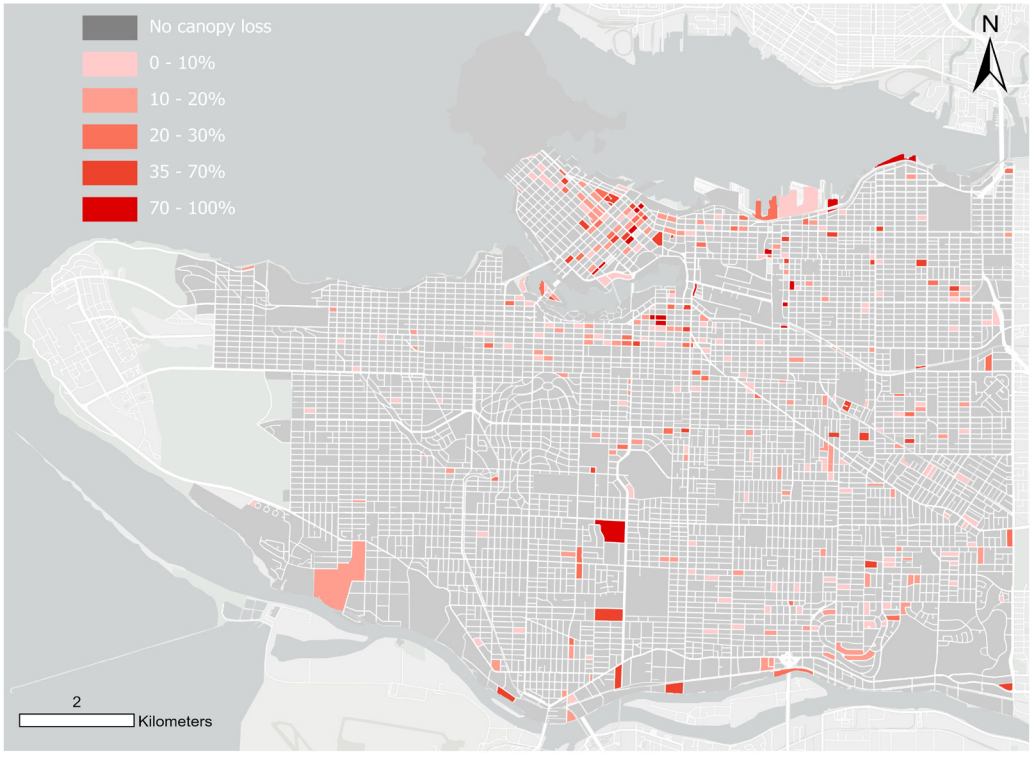


Figure 17: Map of the percentage of canopy loss by block throughout Vancouver between 2018-2022.

4. FINDINGS

1) Between 2018 and 2022, Vancouver's canopy cover increased from approximately 23% to 25%.

2) 63% of Vancouver's canopy area is located on public property.

3) Strathcona continues to be the neighbourhood with the lowest canopy cover having light industrial uses limiting space for trees.

4) Generally, canopy cover increases from east to west across the City.

5) According to i-Tree Canopy values, Carbon storage and annual sequestration increased by 23% between 2018-2022.

6) Parks have the largest trees on average, and the tallest trees are in Stanley Park.

5. RECOMMENDATIONS

1) To avoid temporal discrepancies, collect orthoimagery and LiDAR data during same flight. Conduct canopy monitoring flights during peak leaf-on conditions (e.g. July/ August).

2) In the future, if cost effective, collect hyperspectral data to enable the potential identification of tree species, tree health detection and calculation of ecosystem services.

3) Update the tree inventory more regularly and take ground measurements of canopy extent and heights at the time of the LiDAR flight to enable validation and accuracy assessment of the canopies derived from LiDAR.

4) To improve the comparability of canopy measurements over time, use repeatable workflows. Use consistent height thresholds to differentiate between trees and shrubs.

5) Include a 4th near-infrared band for all orthoimagery used in vegetation monitoring to increase classification accuracy and enable green-ness metrics to be calculated.