Regional Tree Canopy Cover and Impervious Surfaces

Analysis of Tree Canopy Cover and Impervious Surfaces in Metro Vancouver

metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION

Contents

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Executive Summary

Tree canopy cover refers to the leaves and branches that form a visible layer if one is viewing the region from the air, and the extent to which they cover the ground. Impervious surfaces, such as paved roads and buildings, are surfaces that allow very little or no water to pass through them.

Trees provide a range of important ecosystem services to people including shading, carbon storage, and stormwater management. Measuring tree canopy cover is a relatively simple way to determine the extent of the urban forest and the magnitude of services it provides. Impervious surfaces are associated with many of the negative effects of urbanization such as increased temperatures (the 'Urban Heat Island' effect) and flood risk, along with impacts to stream health through disrupted hydrological cycles and poor water quality. Measuring the level of landscape imperviousness gives an indication of the extents of these negative effects. Tree canopy cover and imperviousness are ecological health indicators but because of their connection to factors such as urban temperatures and stormwater management, they are also indicators of how resilient communities may be to climate-related impacts. Looking at whether these indicators are distributed equitably across cities or regions helps us to identify communities or populations more vulnerable to risks and receiving fewer ecosystem service benefits.

In this region, tree canopy cover measures 54% for the entire Metro Vancouver land base, and 32% for the portion of that land within the Urban Containment Boundary (UCB). These measurements are averaged, and there is great variation among neighbourhoods and land use types. Impervious surfaces total 20% of Metro Vancouver's land base and 50% of the UCB. Again, there is much variation in how impervious surfaces are distributed.

Against conventional wisdom, high density housing (e.g. condos and towers) has accommodated increasingly more trees in recent decades, with a corresponding decrease in impervious surfaces. These trends seem to have leveled off in recent years and it is uncertain what will happen in the future. Low density housing (especially single-family detached) appears to have shifted from a housing model that accommodated many trees to one that accommodates increasingly fewer trees and more impervious surface due to expanding home sizes and lot-splitting. These trends are likely to continue into the future.

Projected growth in the region over the next 20-30 years is expected to impact tree canopy cover within the UCB as lands planned for future urban growth are developed, and single-family detached housing stock is redeveloped. Tree canopy cover in the UCB is projected to decrease from 32% to 28% from these sources of loss.

Potential exists to 'offset' losses or increase canopy through tree planting in the UCB. The Metro Vancouver Potential Planting Area dataset summarizes how much area is potentially available for tree planting and can be used by member jurisdictions to assist with planning of the urban forest.

The report includes data and analysis for the entire Metro Vancouver region and was created using 5m resolution land cover data. This is a benchmark data analysis initiative and comparable historic data is not available to allow the estimation of change. However, several member jurisdictions of Metro Vancouver have measured tree canopy locally over time and report losses. In addition, Metro Vancouver's own Sensitive Ecosystem Inventory indicates a loss of about 240 hectares of young and mature forests between 2009 and 2014 in the UCB, and almost 1,000 hectares regionally. Fewer data

sources are available to help identify potential regional trends in impervious surfaces but it is likely increasing in urbanizing watersheds.

Measurement of tree canopy cover and impervious surfaces will be repeated with updated land cover data to enable tracking of change over time and identification of trends.

In conclusion, the regional tree canopy cover is in decline, measurably. Impervious surfaces are most likely increasing as parts of the region urbanize. There are opportunities to turn these trends around, and this report includes a number of recommendations to help do so, including continued monitoring to inform actions, adopting and enforcing tree protection bylaws, and implementing green infrastructure approaches.

Background

Key Terms

High Density Housing Stock: Apartment oriented parcels of type "Low-Rise Apartment" and "Mid/High-Rise Apartment".

Impervious Surfaces: Surfaces that allow very little to no water to pass through them. Paved roads and asphalt are examples of impervious surfaces.

Land Cover: Biophysical features on the earth's surface mapped using multispectral satellite imagery and LiDAR (where available). Classes include coniferous tree, deciduous tree, grass/herb, buildings, paved, and water (see Appendix 3 for information on Land Cover classes).

Land Use: The way in which land is used by humans for specific purposes. Examples of land use include residential land use and industrial land use.

Low Density Housing Stock: Ground oriented parcels of type "Single-family detached", "Multi Detached", and "Townhouse".

Metrics: Statistical information summarized categorically (e.g. zoning class) or spatially (e.g. Census blocks).

Potential Planting Area: Land that could theoretically be used to increase Tree Canopy Cover. % Potential Planting Area includes areas currently occupied by non-tree vegetation (grass, shrubs etc.), soil patches, barren surfaces, pavement that does not fall on roads, and that under the right circumstances, could be modified to increase tree canopy cover.

Tree Canopy Cover: The area covered by all deciduous and coniferous tree crowns (i.e. area occupied by leaves as viewed from the top), as measured from the air.

Urban Containment Boundary (UCB): Identified by *Metro 2040* as the area where 98% of future urban growth is to be contained.

Data and Methodology

The 2014 Metro Vancouver Land Cover Classification dataset was used to map and measure tree canopy cover and impervious surface across the Metro Vancouver region. The Land Cover is a 5m resolution GIS mapping dataset and was created using RapidEye satellite imagery and where available, LiDAR data[1].

Tree canopy cover is the area covered by all deciduous and coniferous tree crowns as measured from above. The Land Cover dataset includes Deciduous tree and Coniferous tree classes (i.e. categories) which were summed to provide the area of all tree canopy cover. Although accuracy of the Land Cover data is high (89%), potential sources of error with this type of data include misclassification (e.g. small trees vs tall shrubs) and the dataset resolution (e.g. small trees may be missed).

[1] Methodology available from Metro Vancouver – Ruan et al. (2017) Application of Geospatial Technologies to Improve Land Cover Assessment and Characterize Ecological Goods and Services across the Metro Vancouver Region. 132 pages.

Impervious surfaces are areas that let little or no water through them. The Land Cover dataset includes several classes which are, or tend to be, impervious and the area of these was summed to provide an estimate of total impervious surfaces. The Land Cover classes included as impervious are Buildings, Paved, Other Built, and Barren[2]. Potential sources of error include tree canopy obscuring areas of impervious surface and the dataset resolution resulting in small features being missed. Further, this approach designates everything impervious or pervious whereas in reality, many things are somewhere in-between, or their perviousness changes over time. For example, permeable pavement appears impervious but actually allows some water through; and, an area of bare soil would typically be considered permeable but once baked hard by the sun it can be quite impervious. To account for these nuances, impervious 'weightings' were applied to Land Cover classes when creating Figure 9 - impervious surfaces summarized by city block (see Appendix 3).

In this report, tree canopy cover and imperviousness are reported as a percentage of an area, for example, % Tree Canopy Cover by city block, or % Impervious Surface of the UCB.

The Metro Vancouver Generalized Land Use layer was used in order to assess tree canopy cover and impervious surface in relation to different land use types. The 2016 Generalized Land Use is a non-official 'regional reference map' that depicts land activities existing across Metro Vancouver.

Analysis Area

The Urban Containment Boundary, or UCB, is the area within Metro Vancouver where urban development and future urban growth are focused (see Figure 1). The UCB is used as the primary analysis area in this report because it is where most people in the region live and work. It is therefore an important area for the provision of ecosystem services by trees, and where most of the negative impacts from impervious surfaces will be experienced. It is also where losses in tree canopy cover and increases in impervious surfaces are most likely to occur through development and redevelopment.

Figure 1: Metro Vancouver's Urban Containment Boundary

[2] See Appendix 3 for descriptions of Land Cover classes

Section 1 – Tree Canopy Cover

Why Measure Tree Canopy Cover?

Trees provide a range of 'ecosystem services' – the benefits people obtain from ecosystems – including shading and cooling (which helps to mitigate the Urban Heat Island effect[3]), carbon storage, stormwater management, and wildlife habitat. There is also a growing body of evidence demonstrating that trees and other greenspace have significant human health and well-being benefits through disease prevention and promotion of health[4]. Measuring tree canopy cover is a relatively simple way to determine the extent of the urban forest and the magnitude of services it provides[5]. Healthy forests in both urban and natural areas are an important component of regional livability and resilience to climate change.

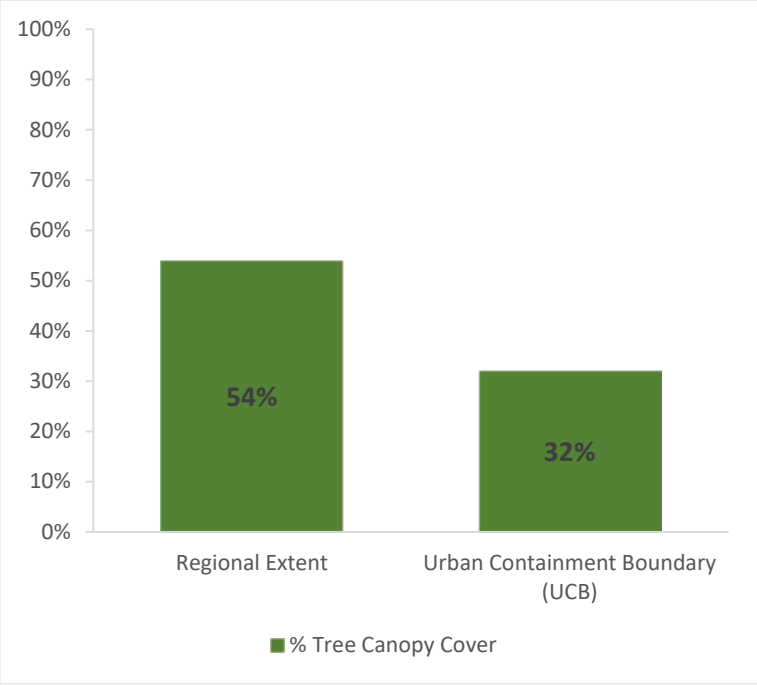

Figure 2: % Tree Canopy Cover for the Metro Vancouver region and within the Urban Containment Boundary.

[3] The term "Urban Heat Island" describes built up areas that are hotter than nearby rural areas

[4] Van den Bosch, M. & Ode Sang, A. (2017). Urban natural environments as nature-based solutions for improved public health - A systematic review of reviews. Environmental Research. 158: 373-384

[5] Leff (2016) The Sustainable Urban Forest – A Step-by-Step Approach

Tree Canopy Cover Levels – General Results

The analysis found that 160,400 ha of Metro Vancouver, and 29,000 ha of lands within the UCB are covered by tree canopy. This represents 54% of Metro Vancouver's land base and 32% of lands within the UCB (Figure 2).

Figure 3 shows % Tree Canopy Cover summarized by city block[6] within the UCB and illustrates the distribution of tree canopy cover within the UCB. Grey indicates very low tree canopy cover (less than 5%) and dark green indicates very high tree canopy cover (more than 60%). Concentrated areas of low tree canopy cover generally correspond to dense urban areas and industrial lands. Areas of high tree canopy cover within the UCB tend to be parks and currently undeveloped areas that are slated to accommodate planned future urban growth.

Maps of the spatial distribution of tree canopy cover (such as Figure 3) can be used by local governments in urban forest planning including determining priority planting locations and identifying underserviced communities.

[6] A dissemination block (DB) is an area "equivalent to a city block" bounded on all sides by roads and/or boundaries of standard geographic areas. The dissemination block is the smallest geographic area for which population and dwelling counts are disseminated. Dissemination blocks cover all the territory of Canada (Statistics Canada. (2018). Dissemination Block. *Dictionary, Census of Population, 2016.*).

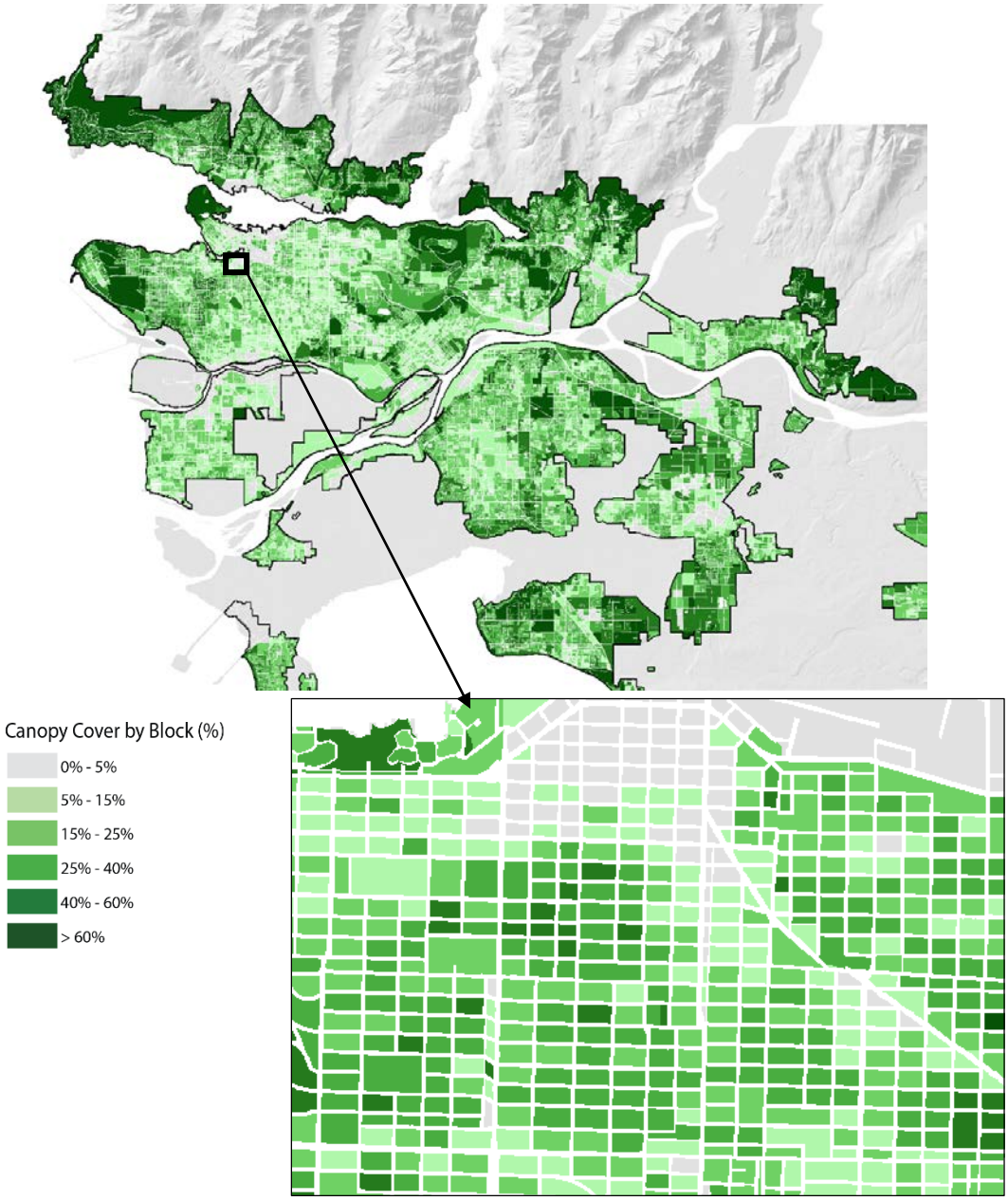

Figure 3: % Tree Canopy Cover summarized by city block within the Urban Containment Boundary.

Trends in % Tree Canopy Cover

It is not yet possible to assess trends in regional tree canopy cover because comparable historical data is unavailable. The regional Land Cover Classification dataset used to measure tree canopy cover will be updated in 2021 and at that point, regional trends will be assessed and reported.

However, other sources of information are available that provide an indication of how the region's tree canopy has changed over time. The Metro Vancouver Sensitive Ecosystem Inventory reported losses of 240 ha of young and mature forests between 2009 and 2014 within the Urban Containment Boundary (UCB) and almost 1,000 ha for the region. In addition, several member jurisdictions have measured their tree canopy cover over time and all have reported losses (Figure 4).

Available data therefore indicates that regional canopy cover is declining but the magnitude of this decline is not clear.

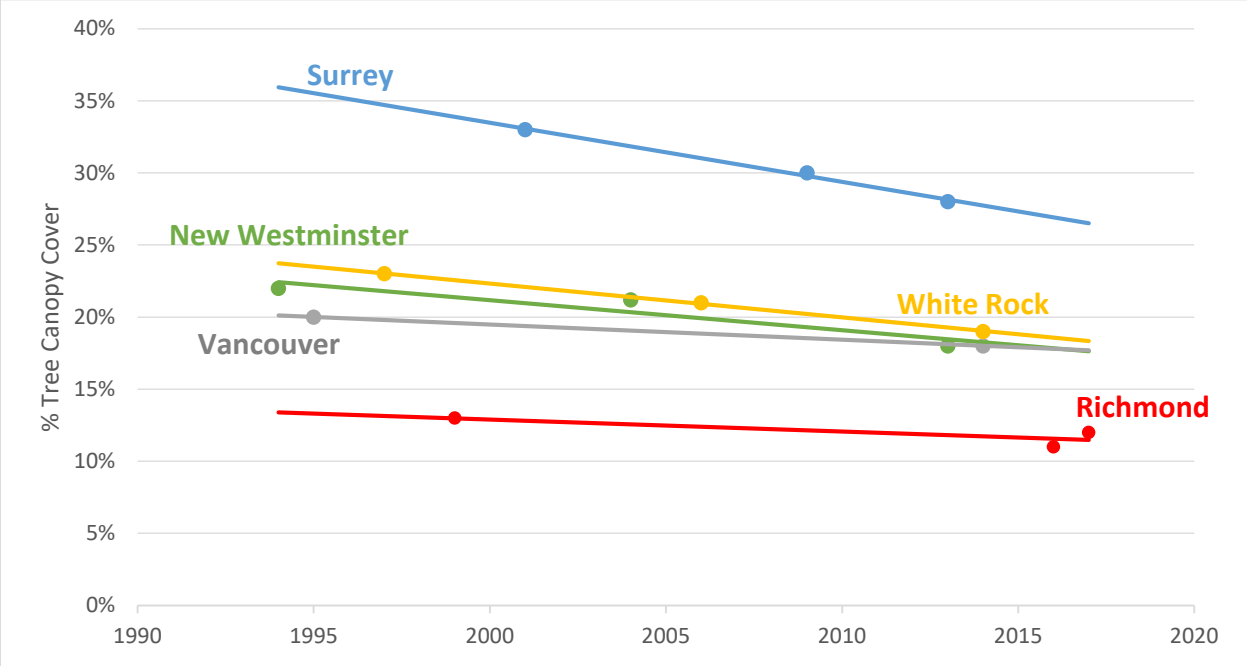

Figure 4: Reported change in % Tree Canopy Cover in Surrey[7], New Westminster[8], Vancouver[9], White Rock[10], and Richmond[11]

[7] City of Surrey Open Data website (visited August 2019)

[8] City of New Westminster Urban Forest Management Strategy

[9] Vancouver Board of Parks and Recreation, Urban Forest Strategy, 2018 Update

[10] City of White Rock Urban Forest Management Plan Workshop, 2015

[11] Email communication with City of Richmond (A. Kurnicki), 2019

% Tree Canopy Cover by Member Jurisdiction

Figure 5 shows % Tree Canopy Cover within the UCB for each member jurisdiction in 2014. Overall, nine member jurisdictions meet or exceed the UCB average of 32% tree canopy cover for lands within their boundaries and inside the UCB.

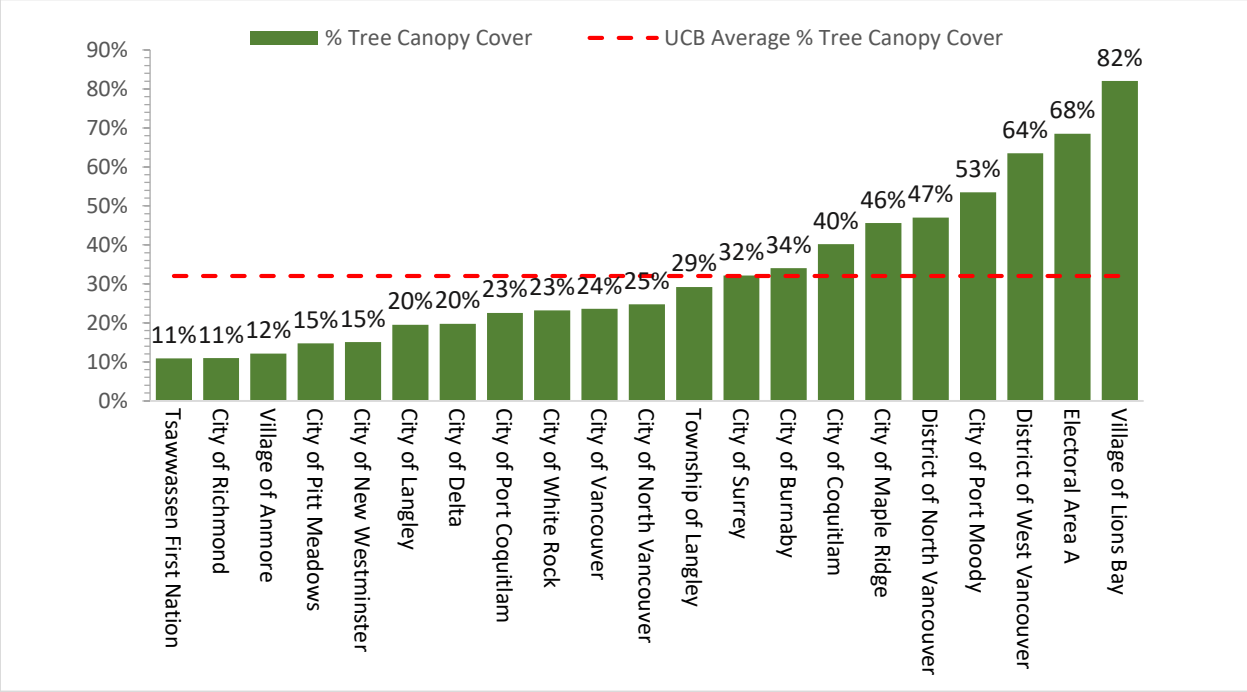

Figure 5: % Tree Canopy Cover within the Urban Containment Boundary by Metro Vancouver member jurisdiction (2014)[12]

Table 1 below provides a summary of each member jurisdiction's total tree canopy cover, and tree canopy cover within the UCB[13].

[12] Please note that Belcarra and Bowen Island are not included on Figure 5 because they fall outside the UCB - these results show % Tree Canopy Cover within the UCB only.

[13] Additional tables with tree canopy cover information are provided in Appendix 1

Member Jurisdiction	% Tree Canopy Cover	
	Within the member jurisdiction's boundary[14]	Within the UCB
Bowen Island Municipality	94%	Not in UCB
City of Burnaby	34%	34%
City of Coquitlam	62%	40%
City of Delta	15%	20%
City of Langley	20%	20%
City of Maple Ridge	72%	46%
City of New Westminster	16%	15%
City of North Vancouver	25%	25%
City of Pitt Meadows	19%	15%
City of Port Coquitlam	26%	23%
City of Port Moody	67%	53%
City of Richmond	15%	11%
City of Surrey	28%	32%
City of Vancouver	23%	24%
City of White Rock	23%	23%
District of North Vancouver	81%	47%
District of West Vancouver	78%	64%
Electoral Area A	80%	68%
Township of Langley	35%	29%
Tsawwassen First Nation	7%	11%
Village of Anmore	87%	12%
Village of Belcarra	94%	Not in UCB
Village of Lions Bay	83%	82%

Table 1: % Tree Canopy Cover for Metro Vancouver member jurisdictions (2014)

Differences between Regional and Member Jurisdiction Tree Canopy Cover Estimates

Regional and member jurisdiction tree canopy cover estimates will often differ by a few percentage points due to the different methodologies employed to generate the estimates. Available member jurisdiction estimates are provided alongside estimates generated from regional data in Table 2. Where estimates generated by member jurisdictions are available, they should be relied upon instead of the estimate created using regional data.

[14] Excluding ocean and the Fraser River

Member Jurisdiction	Member Jurisdiction Canopy Estimate (Year)	Regional Canopy Estimate (2014)
New Westminster	18% (2013)	16%
Richmond	12% (2017)	15%
Surrey	28% (2013) (excludes ALR)	28%
Vancouver	18% (2014)	23%
White Rock	19% (2014)	23%

Table 2: Comparison between Regional and Member Jurisdiction % Tree Canopy Cover Estimates

How Much Tree Canopy Cover is Enough?

In response to declines in tree canopy, many cities in Metro Vancouver and across North America have begun monitoring canopy cover and establishing targets. Targets set are highly variable, ranging between 20% and 60%[15]. This reflects the many factors that influence target-setting including climate and geography, the pre-development land cover (e.g. grassland vs forest) along with constraints such as existing development densities and land use patterns.

Tree canopy cover targets set in the Metro Vancouver region and Pacific Northwest include:

- City of Surrey – maintain canopy at 30% (excluding the ALR)[16]
- City of Vancouver – increase canopy from 18% to 22% by 2050[17]
- City of New Westminster – increase canopy to 27% by 2035 and an aspirational long-term goal of 40%[18]
- City of Victoria – increase canopy from 18% to 40%[19]
- Portland, Oregon – increase canopy from 26% to 33%[20]
- Seattle, Washington – increase canopy from 23% to 30% by 2037[21]

The North American average for urban tree canopy is 27%[22] (and declining[23]) so referring to Figure 5, about half of Metro Vancouver member jurisdictions are above this average.

It should be noted that although much of the Metro Vancouver region was historically forested, some areas (such as Richmond and Delta) would have been less treed, with large areas of grassland and

[15] Leff, M (2016) The Sustainable Urban Forest – A Step-by-Step Approach. See p.17 - Tree canopy cover levels and goals for selected cities
[16] City of Surrey Open Data website (visited August 2019)
[17] Vancouver Board of Parks and Recreation, Urban Forest Strategy, 2018 Update
[18] City of New Westminster Urban Forest Management Strategy
[19] City of Victoria Urban Forest Master Plan (2013)
[20] Portland Plan (2012)
[21] City of Seattle Urban Forest Stewardship Plan (2013)
[22] Dwyer, J., Nowak, D.(2000) *A national assessment of the urban forest: an overview.* Proceedings of Society of 1999 American Foresters National Convention, Portland, OR.
[23] Nowak, D.J., and E.J. Greenfield (2012) "Tree and impervious cover change in U.S. cities." Urban Forestry & Urban Greening, Vol. 11, 2012; pp 21-30

wetlands[24]. As a result of this historic context, the communities and urban centres now found in these areas often have lower levels of tree canopy cover.

Urban tree canopy extent is the focus of this report but not the only criteria to consider when assessing the health of the urban forest. A sustainable urban forest contains trees in good condition, with a diversity of ages and species, and considers climate resilience in tree selection. And an equitable distribution of trees across neighborhoods and income levels will ensure all residents receive the benefits provided by the urban forest.

% Tree Canopy Cover Distribution within the Urban Containment Boundary

Figure 6 shows the proportion of regional tree canopy cover by member jurisdiction (within the UCB). This chart reveals each jurisdiction's current contribution to regional canopy cover levels. Around half (54%) of Metro Vancouver's tree canopy cover within the UCB is located within four member jurisdictions; Surrey contributes 24% of all canopy cover within the UCB, followed by Burnaby (11%), West Vancouver (10%), and Vancouver (9%).

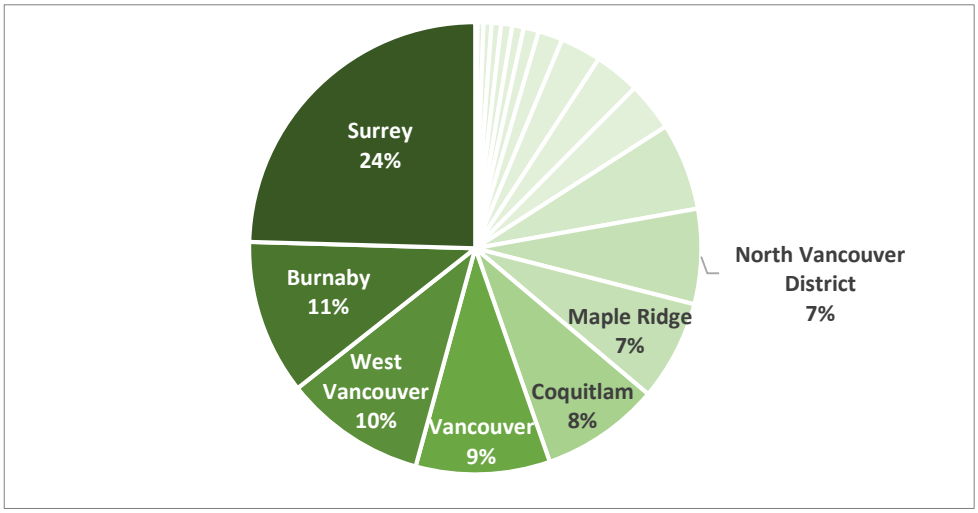

Figure 6: Proportion of tree canopy cover within the Urban Containment Boundary by member jurisdiction.

[24] North M.E.A. & Teversham, J.M. (1983) The vegetation of the floodplains of the Lower Fraser, Serpentine and Nicomekl Rivers, 1859 to 1890. Syesis 17: 47-66 + loose map

% Tree Canopy Cover within the Urban Containment Boundary: Land Use Patterns

To further understand the spatial distribution of tree canopy cover within the UCB, canopy was measured in relation to land use. Using the regional Generalized Land Use (2016) layer, % Tree Canopy Cover was calculated for different types of land use and the results are shown in Figure 7.

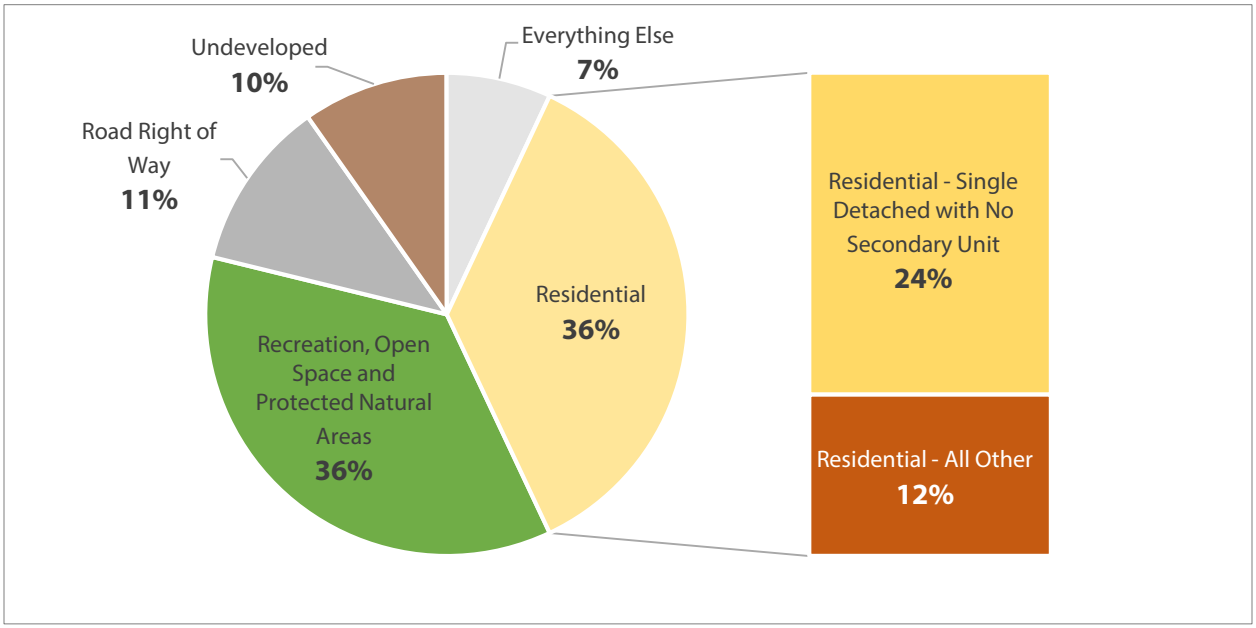

Figure 7: Distribution of tree canopy cover among land use types within the Urban Containment Boundary.

Points to note:

- Most of Metro Vancouver's tree canopy within the UCB is located within recreation and protected natural areas (36%) and residential areas (36%).
- 24% of tree canopy cover within the UCB is found within one particular type of residential area - "Residential – Single-family detached with No Secondary Unit". This residential type covers 30% of land within the UCB, so it is not surprising that most tree canopy is found here.

Some land use types have notably low tree canopy cover. For example, areas designated for 'Parking' have an average of 3% tree canopy cover; 'Retail and Other Commercial' areas have an average of 5% tree canopy cover[25] (see Table 6 in Appendix 1 for a detailed breakdown of tree canopy cover for all land use types).

[25] These land use types are small in overall area so are included within 'Everything Else' in Figure 7

Section 2 – Impervious Surface

Why Measure Levels of Impervious Surface?

The amount of impervious surface is a general measure of urbanization. It is also an ecological health indicator because increasing levels of imperviousness result in disrupted hydrological cycles and increased amounts of polluted runoff entering streams.

Increased imperviousness also results in increased temperatures compared to surrounding rural areas because there is less vegetation, which results in less shade and moisture (from plant evapotranspiration). This is known as the 'Urban Heat Island' effect and identifying areas with high imperviousness is a way of identifying communities at higher risk of potential impacts from heat – an issue of increasing concern as climate change results in increasing temperatures. Areas with high imperviousness may also be at greater risk of localized flooding as water is less able to infiltrate into the ground. This issue will also be exacerbated by climate change which is expected to bring more frequent extreme rain events.

Imperviousness is an indicator of ecological health, vulnerability to climate impacts, and human health and well-being.

Impervious Surface Levels – General Results

The analysis found that 58,000 ha of the Metro Vancouver region, and 45,000 ha of the UCB are covered by impervious surface. This corresponds to 20% of the Metro Vancouver region and 50% of the UCB (Figure 8).

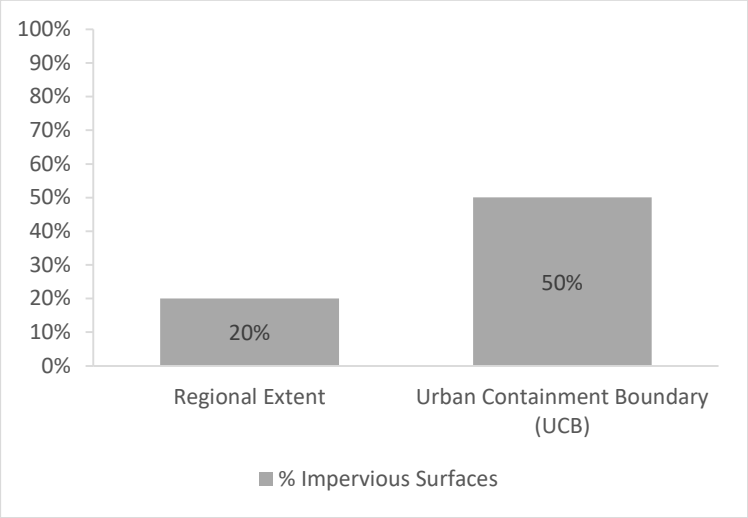

Figure 8: % Impervious Surface for the Metro Vancouver region and the UCB.

Figure 9 is a map of % Impervious Surface summarized by city block[26] within the UCB and illustrates the distribution of impervious surfaces within the UCB. Grey indicates very high levels of impervious surface (more than 80%) and turquoise indicates very low levels of impervious surface (less than 20%). Concentrated areas of high imperviousness generally correspond to urban centers. Areas of low imperviousness within the UCB tend to be parks or greenfield sites that are yet to have been developed.

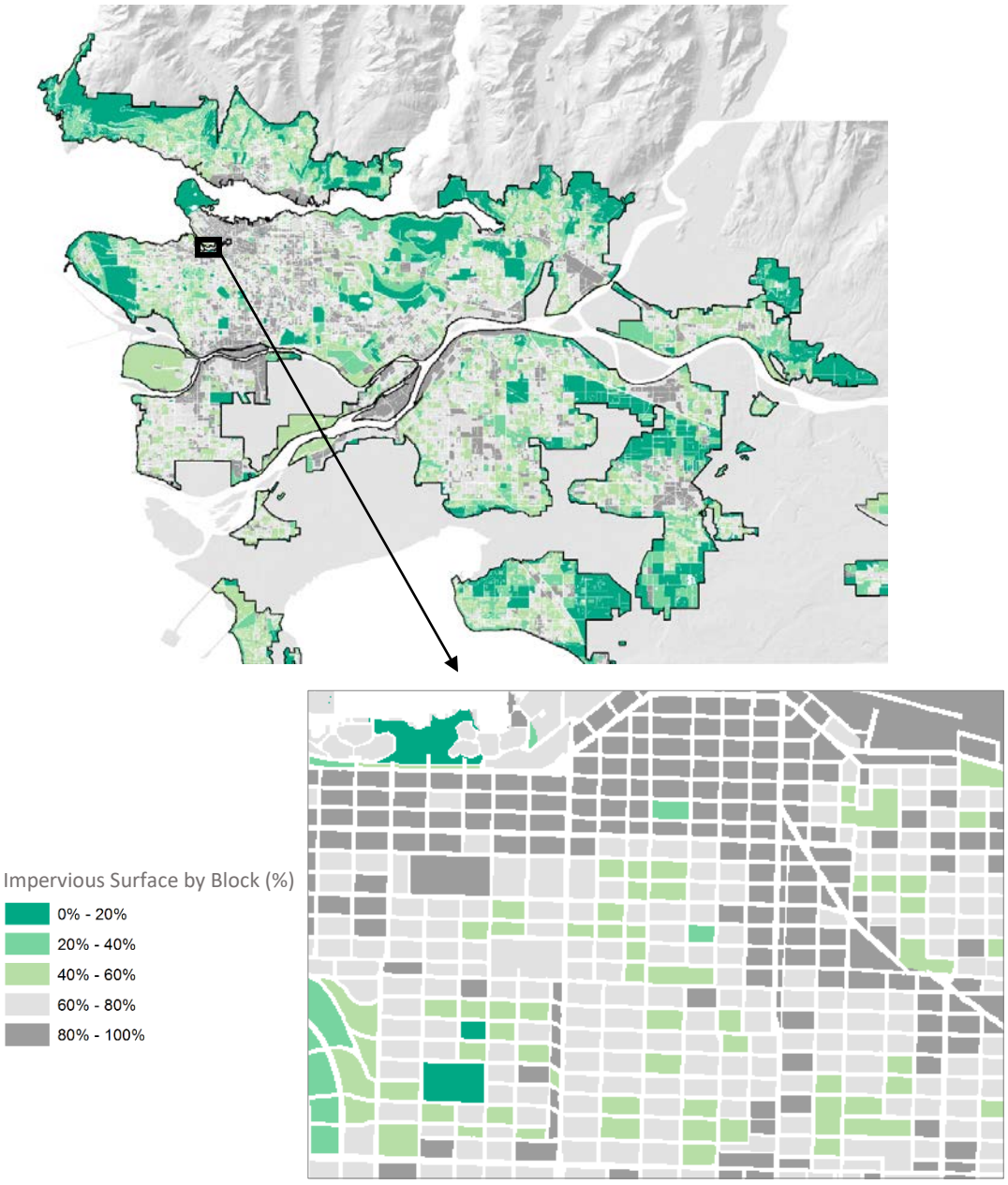

Figure 9: % Impervious Surface summarized by city block within the Urban Containment Boundary

[26] A dissemination block (DB) is an area "equivalent to a city block" bounded on all sides by roads and/or boundaries of standard geographic areas. The dissemination block is the smallest geographic area for which population and dwelling counts are disseminated. Dissemination blocks cover all the territory of Canada (Statistics Canada. (2018). Dissemination Block. *Dictionary, Census of Population, 2016.*).

General Trends in % Impervious Surface

It is not yet possible to assess trends in regional impervious surface coverage because comparable historic data is unavailable. However, increasing imperviousness is typically associated with urbanization and has been recorded by stream health monitoring studies within the region[27]. It is likely therefore that the trend within Metro Vancouver and particularly the UCB is towards increasing imperviousness. The regional Land Cover Classification dataset used to measure imperviousness will be updated in 2021 and at that point, regional trends will be assessed and reported.

% Impervious Surface by Member Jurisdiction

Figure 10 shows % Impervious Surface within the UCB for each member jurisdiction in 2014. Overall, twelve member jurisdictions are below the UCB average of 50% impervious surface for lands within their boundaries and inside the UCB.

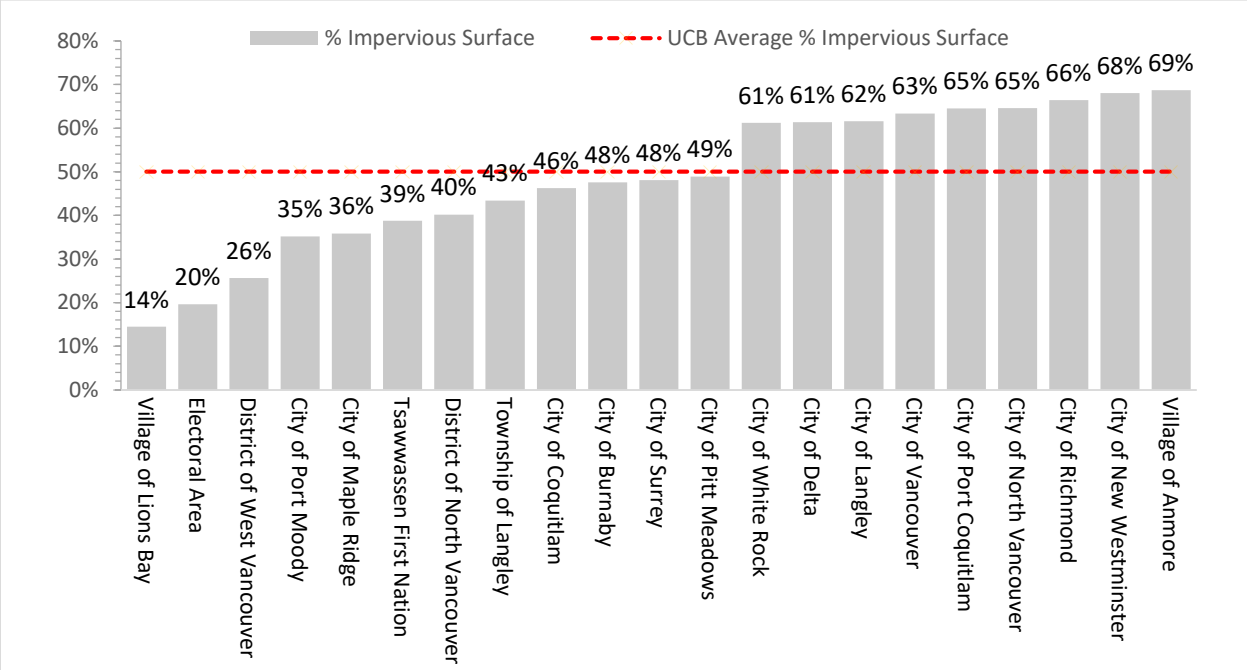

Figure 10: % Impervious Surface within the Urban Containment Boundary by member jurisdiction (2014)[28]

Table 3 below provides a summary of each member jurisdiction's total amount of impervious surface, and amount of impervious surface within the UCB[29].

[27] Raincoast Applied Ecology (2013) Stream health monitoring in Metro Vancouver. Report to Metro Vancouver.
[28] Please note that Belcarra and Bowen Island are not included on Figure 4 because they fall outside the UCB - these results show % Impervious Surface within the UCB only.
[29] Additional tables with impervious surface information are provided in Appendix 1

Member Jurisdiction	% Impervious Surface	
	Within the member jurisdiction's boundary[30]	Within the UCB
Bowen Island Municipality	4%	Not in UCB
City of Burnaby	48%	48%
City of Coquitlam	24%	46%
City of Delta	27%	61%
City of Langley	59%	62%
City of Maple Ridge	9%	36%
City of New Westminster	67%	68%
City of North Vancouver	65%	65%
City of Pitt Meadows	13%	49%
City of Port Coquitlam	49%	65%
City of Port Moody	23%	35%
City of Richmond	47%	66%
City of Surrey	35%	48%
City of Vancouver	61%	63%
City of White Rock	61%	61%
District of North Vancouver	11%	40%
District of West Vancouver	14%	26%
Electoral Area A	6%	20%
Township of Langley	16%	43%
Tsawwassen First Nation	29%	39%
Village of Anmore	3%	69%
Village of Belcarra	5%	Not in UCB
Village of Lions Bay	15%	14%

Table 3: % Impervious Surface for Metro Vancouver member jurisdictions (2014)

How Much Impervious Surface is Too Much?

Research has shown there to be 'an empirical correlation between a watershed's total impervious area and its health, where the health of a watershed decreases as its unmitigated imperviousness increases'[31].

Many thresholds of biological degradation (e.g. invertebrate and fish diversity) and physical degradation (e.g. hydrology and geomorphology) in streams are associated with 10-20% impervious surface within the watershed[32].

This report has provided impervious surface measures with respect to administrative boundaries (member jurisdiction boundary, urban containment boundary, etc.) rather than watershed boundaries,

[30] Excluding ocean and the Fraser River

[31] Metro Vancouver (2017) Region-wide Baseline for On-site Stormwater Management

[32] Paul, M.J. and Meyer, J.L. (2001) Streams in the Urban Landscape. Annual Review of Ecology and the Systematics. 32:333-65

so further analysis would be required to determine where in the region has exceeded 10-20% imperviousness. However, given the high levels of impervious surface documented (Figure 10), many watersheds coinciding with the region's urban areas likely exceed thresholds for degradation.

% Impervious Surface Distribution within the Urban Containment Boundary

Figure 11 shows the proportion of regional impervious surface by member jurisdiction (within the UCB). This chart reveals each jurisdiction's current contribution to regional impervious surface levels. Around half (49%) of Metro Vancouver's impervious surface within the UCB is located within three member jurisdictions; Surrey contributes 23% of all impervious surface within the UCB, followed by Vancouver (16%), Richmond (11%), and Burnaby (10%).

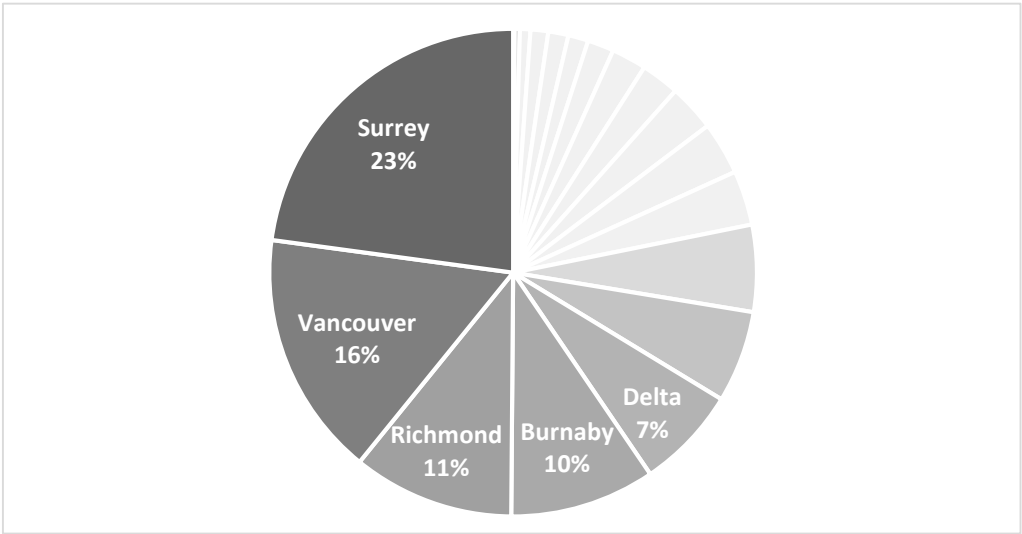

Figure 11: Proportion of impervious surface within the Urban Containment Boundary by member jurisdiction

% Impervious Surface within the Urban Containment Boundary: Land Use Patterns

To further understand the spatial distribution of impervious surface within the UCB, amount of impervious surface was measured in relation to land use. Using the regional Generalized Land Use (2016) layer, % Impervious Surface was calculated for different types of land use and the results are shown in Figure 12.

Points to notes:

- Most of Metro Vancouver's impervious surface is located within residential areas (42%) and road right of ways (25%).
- 30% of impervious surface within the UCB is found within one particular type of residential area - "Residential – Single-family detached with No Secondary Unit". This residential type covers 30% of land within the UCB, so it is not surprising that most tree canopy is found here.

Some land use types have notably high levels of impervious surface. For example, areas designated for 'Parking' have an average of 90% impervious surface; 'Retail and Other Commercial' land use types have an average of 92% impervious surface (see Table 6 in Appendix 1 for a detailed breakdown of impervious surface for all land use types).

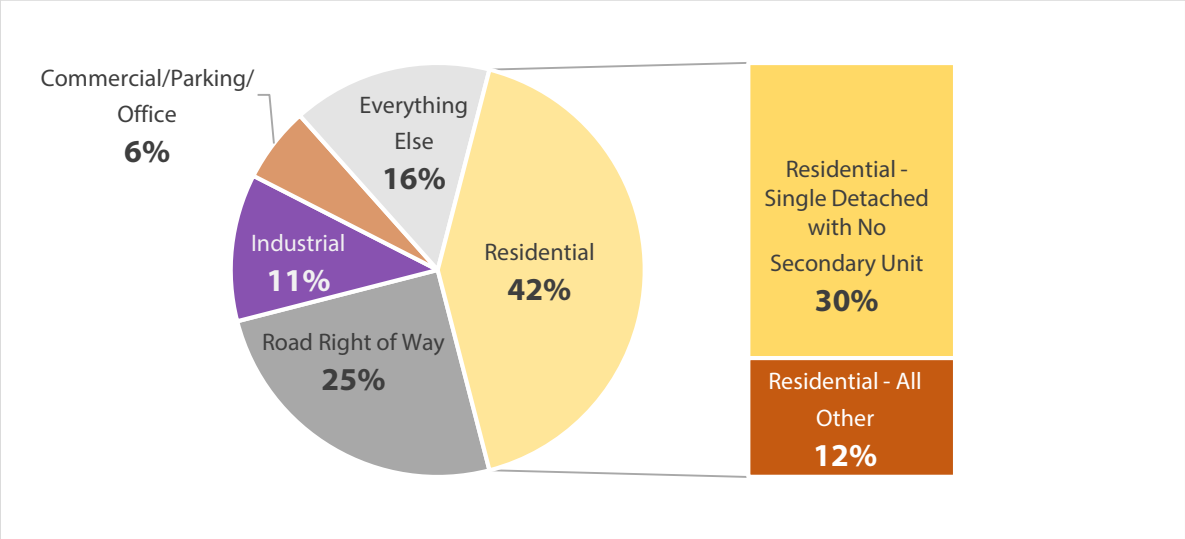

Figure 12: Distribution of impervious surface among land use types within the Urban Containment Boundary

Section 3 - The Relationship between Tree Canopy Cover, Impervious Surfaces, and Residential Density - Temporal Analysis and Future Projections

To explore how tree canopy cover and impervious surface has been influenced by trends in residential building practices, the following analysis looked at the relationship between the year of construction for residential parcels, and the amount of tree canopy cover and impervious surface currently found there.

Tree canopy cover and impervious surface levels are typically related - as the amount of one falls, there is often a corresponding rise in the other. Areas of impervious surface in urban areas include buildings, driveways, paths, and roads. This section explores the relationship between tree canopy cover and impervious surfaces in the Metro Vancouver context.

For this analysis, housing types were split into two categories:

- 'High Density Housing' is defined as apartment oriented parcels with 'Low-Rise Apartment' and 'Mid/High-Rise Apartment'.
- 'Low Density Housing' is defined as ground oriented parcels with 'Single-family detached', 'Multi Detached', and 'Townhouse'.

Average % Tree Canopy Cover by Residential Density: Temporal Trends

Figure 13 illustrates the relationship between amount of tree canopy today on parcels with low density housing and high density housing, and the year in which they were constructed. It demonstrates that for low density housing, there has been a decline in tree canopy cover for parcels constructed in more recent years.

The decline in average % Tree Canopy Cover for low density housing stock parcels has been consistent, from 36% for those built in 1970 to 18% for those built in 2000. This decline indicates that fewer, or smaller, trees are being retained or planted during construction of low density housing over time.

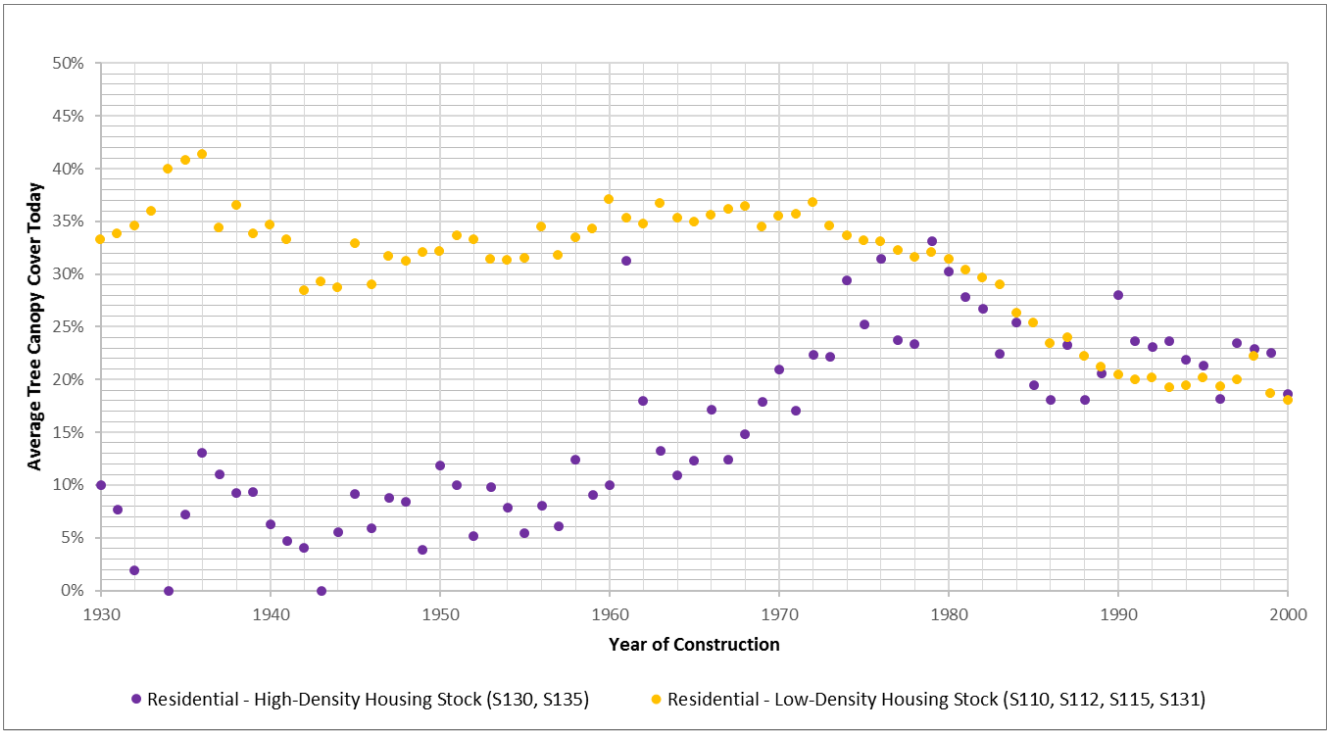

Figure 13: Average % Tree Canopy Cover for low density housing stock and high density housing stock parcels by year of construction.

In contrast, tree canopy is higher for high density housing constructed more recently. Although the relationship is less strongly linear, the data indicates that there has been an overall increase in the number of trees planted or retained for high density housing over time.

Figure 13 only displays results up to the year 2000 because more recently constructed parcels are likely to have a higher proportion of younger, newly planted trees, which have not yet grown a full canopy.

Average % Impervious Surfaces by Residential Density: Temporal Trends

Figure 14 illustrates the relationship between the amount of impervious surface within low density housing and high density housing, and the year in which they were constructed. For almost every year since 1970, the average low density housing parcel has more % Impervious Surface today than the average parcel for the previous year. The analysis shows that there has been a consistent increase in average % Impervious Surface within the low density housing stock, from 49% for parcels built in 1970 to 75% for parcels built in 2012.

In contrast, average % Impervious Surface has been decreasing over time within the high density housing stock. As with % Tree Canopy Cover, the relationship between % Impervious Surface and year of construction for high density housing stock is less linear; but overall there has been a clear trend of decline in levels of impervious surfaces since the 1950's, although this trend has levelled out in recent years.

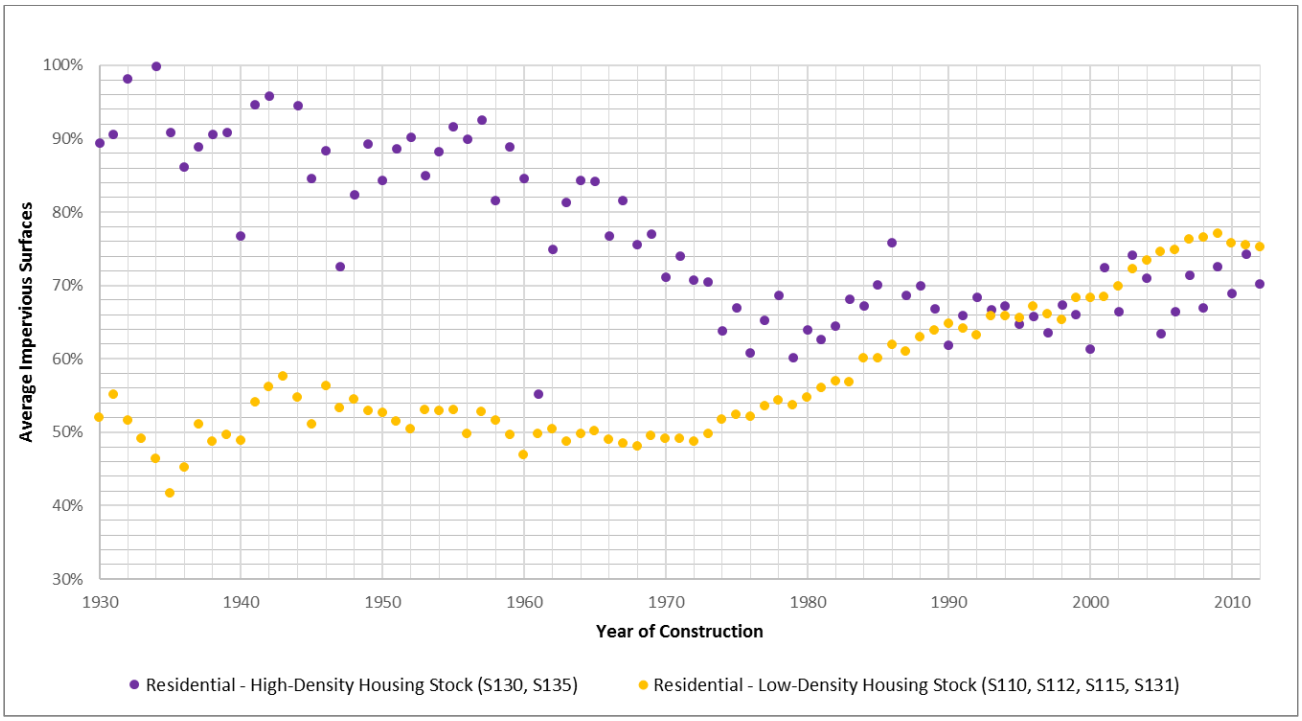

Figure 14: Average % Impervious Surface for low density housing stock and high density housing stock parcels by year of construction.

Observed Relationship Between Tree Canopy Cover and Impervious Surfaces

These results show the amount of tree canopy cover is closely connected to the amount of impervious surface. Comparing Figures 13 and 14 shows that the pattern of change for % Impervious Surface over time mirrors that of % Tree Canopy Cover for both parcels with high density housing and low density housing. As average tree canopy cover has decreased over time within low density housing there has been a corresponding increase in impervious surface. For high density housing this relationship is reversed, and as average tree canopy cover has increased, levels of impervious surface have decreased over time.

Trend Analysis – Historical Context

Low Density Housing: The region experienced rapid urban population growth starting in the 1960's, which resulted in the subdivision of parcels in urban areas to accommodate more housing growth. While lot sizes shrunk, demand for bigger homes increased, resulting in increased lot coverage. This has resulted in less space for trees and an increase in impervious surfaces on low density housing parcels. If these housing trends continue (which seems likely), they may result in ongoing declines in tree canopy and increases in impervious surface.

Figure 10: Examples of low density housing (left) with very low % Tree Canopy Cover (80 people/ha, 0% Tree Canopy Cover), and high density housing (right) with high % Tree Canopy Cover (600 people/ha, 36% Tree Canopy Cover).

High Density Housing - High density housing prior to the 1960's was composed of low-rise apartments which typically had high lot coverage and little greenspace. Economic growth and technological advancement in the region triggered a 'skyscraper' boom in 1960s, 1970s, and 1980s[33], . The new skyscrapers were characterized by tall and slender buildings with low Floor to Area Ratio (FAR), and enough space between them to preserve view corridors[34]. This *Vancouverism* architectural model featured residential buildings that used up little lot coverage and allowed abundant greenspace, street trees and other public space at the bottom[35]. This may explain the observed increase in % Tree Canopy Cover, and decline in % Impervious Surface during the decades leading up to 1980 (Figures 13 and 14). The West End neighborhood in the City of Vancouver is a good example of this phenomenon, where the majority of its residential high rises were constructed between 1960 and 1980[36].

After 1980, % Tree Canopy Cover on high density housing parcels shows a slight decline (Figure 13) but this is not matched with a corresponding increase in % Impervious Surface which have remained relatively steady (Figure 14). This suggests that since 1980, trees have been replaced by other types of vegetation (e.g. grass, shrubs) rather than increased lot coverage by buildings or other impervious surface.

[33] https://www.theguardian.com/cities/2017/sep/27/wipe-out-era-1970s-vanish-vancouver

[34] Walsh, R.M. (2013) The Origins of Vancouverism: A Historical Inquiry into the Architecture and Urban form of Vancouver, British Columbia

[35] Walsh, R.M. (2013) The Origins of Vancouverism: A Historical Inquiry into the Architecture and Urban form of Vancouver, British Columbia; Skyrise Vancouver web article (visited August 2019)

[36] Walsh, R.M. (2013) The Origins of Vancouverism: A Historical Inquiry into the Architecture and Urban form of Vancouver, British Columbia

Section 4 – Future Projections of Tree Canopy Cover within the Urban Containment Boundary

Metro Vancouver's population is projected to increase by about 1 million people over the next 30 years and this growth will be accommodated through both new urban development and intensification of established areas within the UCB[37]. This section considers how projected regional growth trends may impact tree canopy cover by looking at where growth is expected to occur. The following information and assumptions were included:

1. *Development on remaining General Urban land*
    - There are currently about 6,500 hectares of lands with the regional land use designation 'General Urban' within the UCB, that are undeveloped or rural and planned for future urban growth[38] (see Figure 15)
    - The remaining General Urban lands contain 3,900 hectares of tree canopy.
    - It is assumed that the remaining urban lands within the UCB will be largely developed over the next 15-20 years.
    - These areas are expected to be developed as mainly low density housing with some higher density areas but the relative proportions of housing types is unknown.
    - It is assumed that tree canopy cover levels on parcels developed over the next 20-30 years will have comparable tree canopy cover to parcels developed between 1990-2000 (see Figures 13 and 14)[39]. The post 1990's average % Tree Canopy Cover for all housing types (low and high density) is 20%.
    - For the purposes of this analysis, it is assumed that by 2040, the remaining General Urban lands planned for future urban growth will be developed to housing types with an average of 20% tree canopy cover.
    - This would result in a loss of over 3,000 ha of tree canopy.
2. *Redevelopment of single-family detached housing within the General Urban regional land use designation*
    - The amount of single-family detached housing (one unit, one lot) is projected to decrease significantly by 2050, mostly as a result of intensification and redevelopment[40]. For this analysis, a conservative estimate of 25% redevelopment is applied.
    - Redevelopment is projected to focus on multi-unit ground-oriented structures (secondary units, laneway, x-plexes, row houses) and apartments (low rises, mid rises, high rises).
    - Currently, single-family detached housing contains 6,900 hectares of tree canopy within the UCB.

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[37] Projected regional growth trends are documented in 'Metro Vancouver Growth Projections – A Backgrounder' (2018)

[38] For this analysis, 80% of District of West Vancouver's upper lands special study area was not included within the area considered developable, given the District's commitment to transfer much of this area to the Conservation and Recreation designation

[39] This is the most recent timeframe we have tree canopy cover data for residential housing types

[40] Metro Vancouver Growth Projections – A Backgrounder (2018)

- On average, housing built after 1990 has 37% less tree canopy cover than single-family detached housing built before 1990.
- If over the next 30 years, 25% of single-family detached housing is redeveloped to housing types with 37% less tree canopy cover than the current single-family detached housing, the result will be a loss of 650 ha tree canopy cover.

Taking into account only the above two sources of loss, tree canopy cover within the UCB is projected to decrease from 32% to 28% by 2040.

'Offsetting Losses through Tree Planting

Municipalities (including several Metro Vancouver member jurisdictions) often use tree planting programs as a way to maintain or expand their canopy, and actions such as these could help to offset anticipated future losses. To offset the projected decline in UCB tree canopy cover from 32% to 28% would require 1,100 to 3,000 hectares of the UCB to be dedicated to tree planting[41].

Analysis indicates that about 30,000 hectares within the UCB is *potentially* available for tree planting[42]. Site-level analysis would be required to determine what area is *actually* available, but it does suggest that the 3,000 hectares required to offset projected losses is attainable.

Potential planting availability was calculated using the 'Potential Planting Area' dataset which is detailed in Appendix 2 and is available to member jurisdictions to assist with urban forest planning.

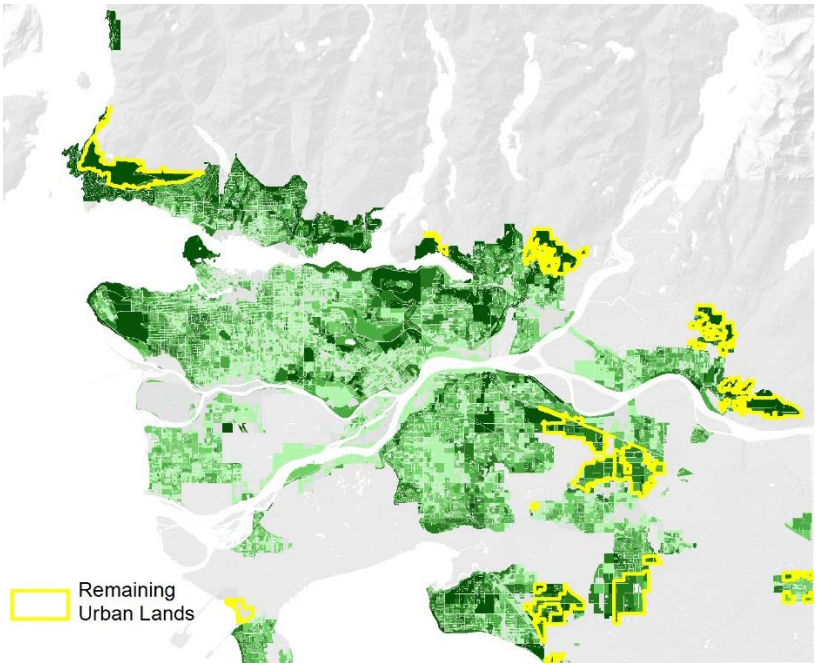

Figure 15: Remaining General Urban areas within the Urban Containment Boundary[43]

[41] The actual area required depends on the ground-to-crown ratio of trees planted so a range is provided.
[42] i.e. areas currently occupied by non-tree vegetation (grass, shrubs etc.), soil patches, barren surfaces, and pavement that does not fall on roads. Assessed using the 'Potential Planting Area' dataset – see Appendix 2
[43] For this analysis, 80% of District of West Vancouver's upper lands special study area was not included within the area considered developable, given the District's commitment to transfer much of this area to the Conservation and Recreation designation

Conclusion

This report provides consistent regional measurements of tree canopy cover and impervious surfaces, which allow for cross-regional comparison and will be repeated with updated land cover data in the future to enable tracking of change over time and identification of trends.

Trees provide a range of important ecosystem services to people including shading, carbon storage, and stormwater management. Measuring tree canopy cover is a relatively simple way to determine the extent of the urban forest and the magnitude of services it provides. Impervious surfaces are associated with many of the negative effects of urbanization such as increased temperatures (the 'Urban Heat Island' effect) and flood risk, along with impacts to stream health through disrupted hydrological cycles and poor water quality. Measuring impervious surfaces gives an indication of the extents of these negative effects. Tree canopy cover and imperviousness are indicators of ecological health but because of their connection to factors such as urban temperatures and stormwater management, they are also indicators of how resilient communities may be to climate-related impacts. Looking at whether these indicators are distributed equitably across cities or regions helps us to identify communities or populations more vulnerable to risks and receiving fewer ecosystem service benefits.

Metro Vancouver's regional tree canopy cover is 54% and for the Urban Containment Boundary (UCB) it is 32%. Canopy is unevenly distributed across the UCB and land use types, with concentrations of canopy within protected natural areas and residential areas. Regional trends will be confirmed when the analysis is repeated with new data but indications from other data sources are that canopy is declining.

For impervious surfaces, 20% of Metro Vancouver and 50% of the UCB is impervious. Most of Metro Vancouver's impervious surface is located within residential areas and road right of ways. Again, regional trends will be confirmed after future updates of the analysis but imperviousness is likely increasing in urbanizing watersheds.

Analysis of the relationship between tree canopy cover, impervious surfaces and residential density showed that over the past few decades, low density housing (especially single-family detached) has shifted from a housing model that accommodated many trees to one that accommodates increasingly fewer trees due to shrinking lot sizes and increasing lot coverage from buildings. This trend is expected to continue. Decreasing tree canopy has been mirrored by increases in amount of impervious surface as higher proportions of lots are covered by buildings, driveways and other paved surfaces. Since the 1960's high density housing has accommodated increasingly more trees with a corresponding decrease in impervious surfaces. This trend seems to have leveled off in recent years, and it is uncertain whether high density housing will continue to accommodate more trees in the future.

Projected growth in the region over the next 20-30 years is expected to impact tree canopy cover within the UCB as lands planned for future urban growth are developed, and single-family detached housing stock is redeveloped. Tree canopy cover in the UCB is projected to decrease from 32% to 28% from these sources of loss.

Potential exists to 'offset' losses or increase canopy through tree planting in the UCB. The Metro Vancouver Potential Planting Area dataset can be used by member jurisdictions to assist with planning of the urban forest.

Recommendations

Metro Vancouver, member jurisdictions and other land owners and managers all have a role to play in maintaining tree canopy cover and reducing imperviousness. The following recommendations are provided for consideration, as appropriate:

1. Monitor the extent, distribution and status of the tree canopy cover and imperviousness to inform planning and management.
2. Establish urban forest management plans that consider how to reduce impacts of future development on tree canopy.
3. Consider focusing tree planting efforts in areas of low canopy cover, particularly when these coincide with areas of high density and vulnerable populations in support of regional and municipal equity.
4. Use Metro Vancouver's Potential Planting Area dataset to develop realistic and achievable planting plans and targets.
5. Adopt and enforce bylaws that protect trees wherever possible, and require trees to be replaced when development results in loss.
6. Prioritize the retention of existing mature trees wherever possible when planning new urban communities as these provide the greatest amount of canopy cover and ecosystem services.
7. Implement on-site stormwater management and green infrastructure approaches throughout urban areas as effective ways of improving water quality and reducing the amount of runoff.
8. Look for opportunities to integrate the objectives of maintaining tree canopy cover and reducing imperviousness into a broad range of departments, plans, and strategies so responsibilities become a shared goal.
9. Given how much tree canopy and impervious surfaces fall within residential areas in the UCB, engage with the public about the importance of tree canopy and its protection, along with the benefits to maintaining permeability. These efforts could be supported with programs to encourage tree planting and maintenance of existing trees on private land.

Appendix 1: Additional tables for % Tree Canopy Cover, % Impervious Surface and % Potential Planting Area

Table 4: % Tree Canopy Cover and % Impervious Surface by member jurisdiction

	% Canopy Cover			% Impervious Surface		
Member Jurisdiction	**as a % of the member jurisdiction[44]**	**as a % of the total regional area[45]**	**as a % of the region's total tree canopy [46]**	**as a % of the member jurisdiction[47]**	**as a % of the total regional area[48]**	**as a % of the region's total impervious surface[49]**
Bowen Island Municipality	94%	2%	3%	4%	0%	0%
City of Burnaby	34%	1%	2%	48%	1%	3%
City of Coquitlam	62%	3%	5%	24%	0%	2%
City of Delta	15%	1%	2%	27%	1%	4%
City of Langley	20%	0%	0%	59%	0%	0%
City of Maple Ridge	72%	7%	13%	9%	0%	2%
City of New Westminster	16%	0%	0%	67%	0%	1%
City of North Vancouver	25%	0%	0%	65%	0%	0%
City of Pitt Meadows	19%	1%	1%	13%	0%	1%
City of Port Coquitlam	26%	0%	0%	49%	0%	1%
City of Port Moody	67%	1%	1%	23%	0%	0%
City of Richmond	15%	1%	1%	47%	1%	5%
City of Surrey	28%	3%	5%	35%	1%	8%
City of Vancouver	23%	1%	2%	61%	1%	3%
City of White Rock	23%	0%	0%	61%	0%	0%
District of North Vancouver	81%	4%	8%	11%	0%	1%
District of West Vancouver	78%	2%	4%	14%	0%	1%
Electoral Area A	80%	23%	43%	6%	2%	8%

[44] For example, 34% of the City of Burnaby is covered by tree canopy
[45] For example, the City of Burnaby's tree canopy makes up 1% of the region's total area
[46] For example, 2% of the region's tree canopy is found within the City of Burnaby
[47] For example, 48% of the City of Burnaby is impervious surface
[48] For example, the City of Burnaby's impervious surfaces make up 1% of the region's total area
[49] For example, 3% of the region's impervious surfaces are found within the City of Burnaby

	% Canopy Cover			% Impervious Surface		
Member Jurisdiction	**as a % of the member jurisdiction**	**as a % of the total regional area**	**as a % of the region's total tree canopy**	**as a % of the member jurisdiction**	**as a % of the total regional area**	**as a % of the region's total impervious surface**
Township of Langley	35%	4%	7%	16%	1%	4%
Tsawwassen First Nation	7%	0%	0%	29%	0%	0%
Village of Anmore	87%	1%	2%	3%	0%	0%
Village of Belcarra	94%	0%	0%	5%	0%	0%
Village of Lions Bay	83%	0%	0%	15%	0%	0%

Table 5: % Tree Canopy Cover and % Impervious Surfaces by member jurisdiction within the Urban Containment Boundary[50]

	% Canopy Cover			% Impervious Surface		
Member Jurisdiction	**as a % of the member jurisdiction, within the UCB[51]**	**as a % of the total UCB area[52]**	**as a % of the UCB's total tree canopy[53]**	**as a % of the member jurisdiction, within the UCB[54]**	**as a % of the total UCB area[55]**	**as a % of the UCB's total impervious surface[56]**
City of Burnaby	34%	3%	11%	48%	2%	3%
City of Coquitlam	40%	3%	8%	46%	1%	2%
City of Delta	20%	1%	3%	61%	1%	3%
City of Langley	20%	0%	1%	62%	0%	0%
City of Maple Ridge	46%	2%	7%	36%	1%	1%
City of New Westminster	15%	0%	1%	68%	0%	1%
City of North Vancouver	25%	0%	1%	65%	0%	1%
City of Pitt Meadows	15%	0%	1%	49%	0%	1%
City of Port Coquitlam	23%	1%	2%	65%	1%	1%
City of Port Moody	53%	1%	3%	35%	0%	1%
City of Richmond	11%	1%	3%	66%	3%	5%
City of Surrey	32%	8%	24%	48%	4%	9%
City of Vancouver	24%	3%	9%	63%	2%	4%
City of White Rock	23%	0%	0%	61%	0%	0%
District of North Vancouver	47%	2%	7%	40%	1%	1%

[50] Bowen Island Municipality and Village of Belcarra are not included in this table because they are not within the UCB
[51] For example, 40% of the City of Coquitlam's UCB area is covered with tree canopy
[52] For example, the City of Coquitlam's tree canopy makes up 3% of the UCB's total area
[53] For example, 8% of tree canopy within the whole UCB is located in the City of Coquitlam
[54] For example, 46% of the City of Coquitlam's UCB area is impervious surface
[55] For example, the City of Coquitlam's impervious surface makes up 1% of the UCB's total area
[56] For example, 2% of impervious surface within the whole UCB is located in the City of Coquitlam

District of West Vancouver	64%	3%	10%	26%	1%	1%
Electoral Area A	68%	1%	3%	20%	0%	0%
Township of Langley	29%	2%	6%	43%	1%	2%
	% Canopy Cover			**% Impervious Surface**		
Member Jurisdiction	**as a % of the member jurisdiction, within the UCB**	**as a % of the total UCB area**	**as a % of the UCB's total tree canopy**	**as a % of the member jurisdiction, within the UCB**	**as a % of the total UCB area**	**as a % of the UCB's total impervious surface**
Tsawwassen First Nation	11%	0%	0%	39%	0%	0%
Village of Anmore	12%	0%	0%	69%	0%	0%
Village of Lions Bay	82%	0%	1%	14%	0%	0%

Table 6: % Tree Canopy Cover and % Impervious Surface metrics by land use type within the Urban Containment Boundary

	% Canopy Cover			% Impervious Surface		
Land Use Type	**as a % of the land use type's total area within the UCB[57]**	**as a % of the total UCB area[58]**	**as a % of the UCB's total tree canopy[59]**	**as a % of the land use type's total area within the UCB[60]**	**as a % of the total UCB area[61]**	**as a % of the UCB's total impervious surface[62]**
Agriculture	21%	0%	0%	14%	0%	0%
Airport/Airstrip and Ferry	0%	0%	0%	43%	1%	1%
Cemetery	23%	0%	0%	11%	0%	0%
Civic and Other Institutional	14%	0%	0%	76%	0%	0%
Exhibition, Religious and Other Assembly	17%	0%	0%	70%	0%	1%
Health and Education	17%	0%	1%	75%	1%	2%
Hotel, Motel and Rooming House	8%	0%	0%	85%	0%	0%
Industrial	11%	1%	2%	82%	6%	11%
Industrial - Extractive	9%	0%	0%	58%	0%	0%
Lakes, Large Rivers and Other Water	16%	0%	0%	4%	0%	0%
Mixed Residential (Low-rise Apartment) Commercial	5%	0%	0%	92%	0%	0%
Mixed Residential (Mid-Rise or High-Rise Apartment) Commercial	7%	0%	0%	89%	0%	0%
Office	12%	0%	0%	82%	1%	1%
Parking	3%	0%	0%	90%	0%	0%
Protected Watershed	94%	0%	0%	3%	0%	0%
Recreation, Open Space and Protected Natural Areas	63%	11%	36%	12%	2%	4%

[57] For example, 11% of Industrial land within the UCB is covered with tree canopy
[58] For example, tree canopy on Industrial land makes up 1% of the UCB's total area
[59] For example, 2% of tree canopy within the whole UCB is located on Industrial land
[60] For example, 82% of Industrial land within the UCB is impervious surface
[61] For example, impervious surface on Industrial land makes up 6% of the UCB's total area
[62] For example, 11% of impervious surface within the whole UCB is located on Industrial land

	% Canopy Cover			% Impervious Surface		
Land Use Type	**as a % of the land use type within the UCB**	**as a % of the total UCB area**	**as a % of the UCB's total tree canopy**	**as a % of the land use type within the UCB**	**as a % of the total UCB area**	**as a % of the UCB's total impervious surface**
Residential - Institutional and Non-Market Housing	25%	0%	0%	61%	0%	0%
Residential - Low-rise Apartment	19%	0%	1%	72%	1%	2%
Residential - Mid/High-rise Apartment	22%	0%	0%	67%	0%	1%
Residential - Mobile Homes	18%	0%	0%	73%	0%	0%
Residential - Multi Detached	24%	0%	0%	65%	0%	0%
Residential - Rural	56%	2%	6%	9%	0%	1%
Residential - Single-family detached with No Secondary Unit	28%	8%	24%	55%	15%	30%
Residential – Single-family detached with One Secondary Unit or Duplex	22%	1%	2%	61%	2%	3%
Residential - Townhouse	22%	1%	2%	68%	2%	5%
Retail and Other Commercial	5%	0%	0%	92%	2%	5%
Road Right-of-Way	20%	4%	11%	69%	12%	25%
Transit, Rail and Other Transportation	17%	0%	1%	66%	1%	2%
Undeveloped and Unclassified	59%	3%	10%	15%	1%	2%
Utility, Communication and Work Yards	20%	0%	0%	60%	0%	1%
Vancouver Fraser Port	3%	0%	0%	89%	1%	2%

Table 7: % Potential Planting Area metrics by member jurisdiction within the Urban Containment Boundary[63]

	% Potential Planting Area - Total			% Potential Planting Area - Vegetated			% Potential Planting Area - Impervious		
Member Jurisdiction	**as a % of the member jurisdiction, within the UCB[64]**	**as a % of the total UCB area[65]**	**as a % of the total Potential Planting Area within the UCB[66]**	**as a % of the member jurisdiction, within the UCB[67]**	**as a % of the total UCB area[68]**	**as a % of the total Potential Planting Area within the UCB[69]**	**as a % of the member jurisdiction, within the UCB[70]**	**as a % of the total UCB area[71]**	**as a % of the total Potential Planting Area within the UCB[72]**
City of Burnaby	33%	3%	10%	16%	2%	5%	17%	2%	5%
City of Coquitlam	32%	2%	6%	13%	1%	2%	19%	1%	4%
City of Delta	43%	2%	7%	17%	1%	3%	26%	1%	4%
City of Langley	41%	0%	1%	18%	0%	1%	23%	0%	1%
City of Maple Ridge	28%	1%	4%	17%	1%	2%	11%	1%	2%
City of New Westminster	43%	1%	2%	15%	0%	1%	28%	0%	1%
City of North Vancouver	28%	0%	1%	9%	0%	0%	19%	0%	1%
City of Pitt Meadows	61%	1%	2%	35%	0%	1%	25%	0%	1%
City of Port Coquitlam	42%	1%	3%	12%	0%	1%	30%	1%	2%
City of Port Moody	23%	0%	1%	9%	0%	1%	14%	0%	1%
City of Richmond	54%	4%	13%	22%	2%	5%	32%	3%	8%
City of Surrey	36%	9%	25%	18%	4%	12%	18%	4%	12%
City of Vancouver	26%	3%	9%	11%	1%	4%	15%	2%	5%

[63] Bowen Island Municipality and Village of Belcarra are not included in this table because they are not within the UCB

[64] For example, 43% of the City of Delta's UCB area is potentially available for planting (Potential Planting Area)

[65] For example, the City of Delta's potentially available planting area makes up 2% of the UCB's total area

[66] For example, 7% of the total area potentially available for planting within the UCB is found within the City of Delta

[67] For example, 17% of the City of Delta's UCB area that is potentially available for planting is currently vegetated (but not treed)

[68] For example, the City of Delta's potentially available planting area that is currently vegetated makes up 1% of the UCB's total area

[69] For example, the City of Delta's potentially available planting area that is currently vegetated makes up 3% of the UCB's total potentially available planting area

[70] For example, 26% of the City of Delta's UCB area that is potentially available for planting is currently impervious surface

[71] For example, the City of Delta's potentially available planting area that is currently impervious surface makes up 1% of the UCB's total area

[72] For example, the City of Delta's potentially available planting area that is currently impervious surface makes up 4% of the UCB's total potentially available planting area

	% Potential Planting Area - Total			% Potential Planting Area - Vegetated			% Potential Planting Area - Impervious		
Member Jurisdiction	**as a % of the member jurisdiction, within the UCB**	**as a % of the total UCB area**	**as a % of the total Potential Planting Area within the UCB**	**as a % of the member jurisdiction within the UCB**	**as a % of the total UCB area**	**as a % of the total Potential Planting Area within the UCB**	**as a % of the member jurisdiction within the UCB**	**as a % of the total UCB area**	**as a % of the total Potential Planting Area within the UCB**
City of White Rock	37%	0%	1%	15%	0%	0%	22%	0%	0%
District of North Vancouver	24%	1%	3%	11%	0%	1%	14%	1%	2%
District of West Vancouver	20%	1%	3%	10%	0%	1%	10%	1%	1%
Electoral Area A	18%	0%	1%	10%	0%	0%	7%	0%	0%
Township of Langley	42%	3%	8%	25%	2%	5%	17%	1%	3%
Tsawwassen First Nation	80%	0%	1%	49%	0%	1%	31%	0%	0%
Village of Anmore	76%	0%	0%	19%	0%	0%	57%	0%	0%
Village of Lions Bay	9%	0%	0%	2%	0%	0%	7%	0%	0%

Table 8: % Potential Planting Area metrics by land use type within the Urban Containment Boundary

Land Use Type	% Potential Planting Area - Total			% Potential Planting Area - Vegetated			% Potential Planting Area - Impervious		
	as a % of the land use type's total area within the UCB[73]	as a % of the total UCB area[74]	as a % of the total Potential Planting Area within the UCB[75]	as a % of the land use type's total area within the UCB[76]	as a % of the total UCB area[77]	as a % of the total Potential Planting Area within the UCB[78]	as a % of the land use type's total area within the UCB[79]	as a % of the total UCB area[80]	as a % of the total Potential Planting Area within the UCB[81]
Agriculture	73%	0%	1%	64%	0%	1%	9%	0%	0%
Airport/Airstrip and Ferry	89%	1%	3%	56%	1%	2%	32%	0%	1%
Cemetery	74%	0%	1%	65%	0%	1%	10%	0%	0%
Civic and Other Institutional	55%	0%	0%	10%	0%	0%	45%	0%	0%
Exhibition, Religious and Other Assembly	56%	0%	1%	13%	0%	0%	43%	0%	1%
Health and Education	48%	1%	2%	8%	0%	0%	40%	1%	2%
Hotel, Motel and Rooming House	47%	0%	0%	6%	0%	0%	40%	0%	0%
Industrial	54%	4%	11%	7%	0%	1%	48%	3%	9%
Industrial - Extractive	84%	0%	0%	33%	0%	0%	51%	0%	0%
Lakes, Large Rivers and Other Water	30%	0%	1%	28%	0%	1%	3%	0%	0%

[73] For example, 54% of Industrial lands within the UCB is potentially available for planting (Potential Planting Area)
[74] For example, the potentially available planting area on Industrial land makes up 4% of the UCB's total area
[75] For example, 11% of the total area potentially available for planting within the UCB is found on Industrial lands
[76] For example, 7% of the area potentially available for planting on Industrial land within the UCB is currently vegetated (but not treed)
[77] For example, the potentially available planting area on Industrial land that is currently vegetated makes up 0% of the UCB's total area
[78] For example, the potentially available planting area on Industrial land that is currently vegetated, makes up 1% of the UCB's total potentially available planting area
[79] For example, 48% of the area potentially available for planting on Industrial land within the UCB is currently impervious surface
[80] For example, the potentially available planting area on Industrial land that is currently impervious surface makes up 3% of the UCB's total area
[81] For example, the potentially available planting area on Industrial land that is currently impervious surface makes up 9% of the UCB's total potentially available planting area

Land Use Type	% Potential Planting Area - Total			% Potential Planting Area - Vegetated			% Potential Planting Area - Impervious		
	as a % of the land use type's total area within the UCB	as a % of the total UCB area	as a % of the total Potential Planting Area within the UCB	as a % of the land use type's total area within the UCB	as a % of the total UCB area	as a % of the total Potential Planting Area within the UCB	as a % of the land use type's total area within the UCB	as a % of the total UCB area	as a % of the total Potential Planting Area within the UCB
Mixed Residential (Low-rise Apartment) Commercial	32%	0%	0%	2%	0%	0%	29%	0%	0%
Mixed Residential (Mid-Rise or High-Rise Apartment) Commercial	29%	0%	0%	3%	0%	0%	26%	0%	0%
Office	47%	0%	1%	5%	0%	0%	42%	0%	1%
Parking	75%	0%	0%	7%	0%	0%	68%	0%	0%
Protected Watershed	5%	0%	0%	3%	0%	0%	2%	0%	0%
Recreation, Open Space and Protected Natural Areas	34%	6%	17%	24%	4%	12%	9%	2%	5%
Residential - Institutional and Non-Market Housing	38%	0%	0%	12%	0%	0%	26%	0%	0%
Residential - Low-rise Apartment	32%	1%	2%	8%	0%	0%	25%	0%	1%
Residential - Mid/High-rise Apartment	37%	0%	0%	9%	0%	0%	28%	0%	0%
Residential - Mobile Homes	39%	0%	0%	8%	0%	0%	31%	0%	0%
Residential - Multi Detached	25%	0%	0%	9%	0%	0%	16%	0%	0%
Residential - Rural	38%	1%	4%	33%	1%	4%	4%	0%	0%
Residential - Single-family detached with No Secondary Unit	33%	9%	25%	15%	4%	11%	18%	5%	14%
Residential – Single-family detached with One Secondary Unit or Duplex	36%	1%	3%	15%	0%	1%	21%	1%	2%
Residential - Townhouse	35%	1%	3%	8%	0%	1%	26%	1%	3%
Retail and Other Commercial	59%	1%	4%	3%	0%	0%	55%	1%	4%

Land Use Type	% Potential Planting Area - Total			% Potential Planting Area - Vegetated			% Potential Planting Area - Impervious		
	as a % of the land use type's total area within the UCB	as a % of the total UCB area	as a % of the total Potential Planting Area within the UCB	as a % of the land use type's total area within the UCB	as a % of the total UCB area	as a % of the total Potential Planting Area within the UCB	as a % of the land use type's total area within the UCB	as a % of the total UCB area	as a % of the total Potential Planting Area within the UCB
Road Right-of-Way	14%	3%	7%	10%	2%	5%	4%	1%	2%
Transit, Rail and Other Transportation	66%	1%	3%	16%	0%	1%	50%	1%	2%
Undeveloped and Unclassified	39%	2%	6%	26%	1%	4%	14%	1%	2%
Utility, Communication and Work Yards	64%	0%	1%	18%	0%	0%	45%	0%	1%
Vancouver Fraser Port	78%	1%	2%	6%	0%	0%	71%	1%	2%

Appendix 2: % Potential Planting Area

As part of the analysis on Tree Canopy Cover, possible areas of opportunity for new tree canopy were considered. The additional metric, % Potential Planting Area, is the amount of land that could theoretically be used to increase % Tree Canopy Cover. % Potential Planting Area considers non-tree vegetation (grass, shrubs etc.), soil patches, barren surfaces, and pavement that does not fall on roads, that under the right circumstances, could be modified to increase % Tree Canopy Cover. It is a measure of what is ***physically possible****, given the current land cover.* ***Physically possible*** *planting area does not necessarily translate into* ***feasible*** *planting area. Other factors, such as land use, also determine the feasibility of a site for tree planting. However, this tool is meant to remain general, in consideration that any conversion of land cover/land use types to tree canopy requires site specific assessments by land managers. This tool is intended to support discussions about how much and where land owners, member jurisdictions and Metro Vancouver might be able to increase canopy cover.*

As with % Tree Canopy Cover and % Impervious Surfaces, % Potential Planting Area was mapped and quantified for the Metro Vancouver region, and the UCB. The analysis found that an area of 89,667 Ha (27%) of the Metro Vancouver region qualifies as % Potential Planting Area. More specifically, 19% of the Metro Vancouver region was found to be vegetated potential area and 8% is impervious potential area. In the regional core, 78,621 Ha (47%) qualifies as % Potential Planting Area. 34% of the regional core was found to be vegetated potential area and 13% is impervious potential area. Finally, 31,710 Ha (35%) of the UCB was found to be vegetated potential area and 19% is impervious potential area. For each of the three study areas, Figure 16 shows the proportion of existing % Tree Canopy Cover, % Potential Planting Area – vegetated and % Potential Planting Area – Impervious. The pink area of the chart corresponds to the proportion of land that was found to be generally unsuitable for the establishment of new tree canopy (e.g. buildings, roads, other built features).

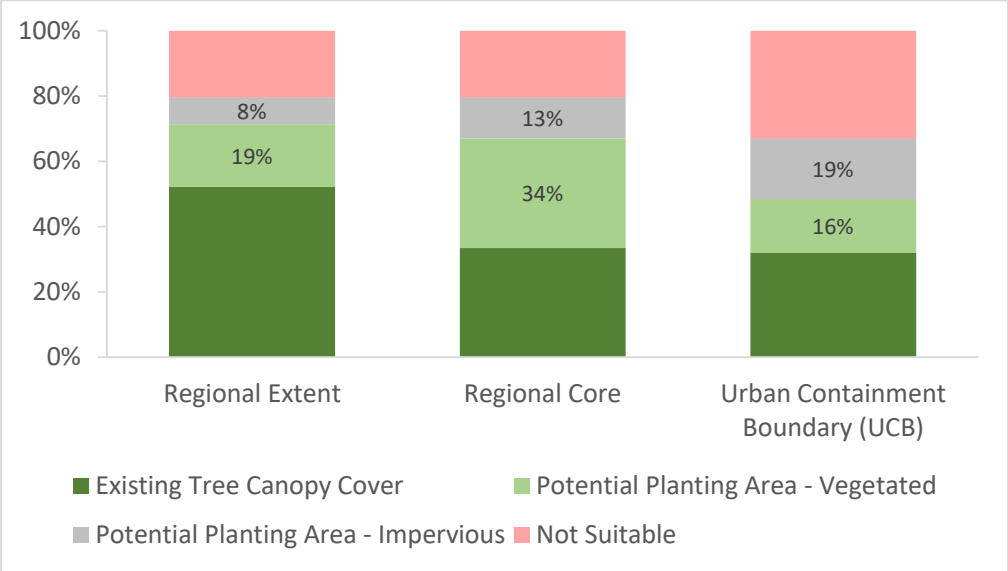

Figure 16: % Potential Planting Area for the Metro Vancouver region and the Urban Containment Boundary.

Figure 17 shows the % Potential Planting Area summarized by census block within the UCB. Beige indicates low % Potential Planting Area (less than 20%) and dark brown indicates high % Potential Planting Area (more than 40%).

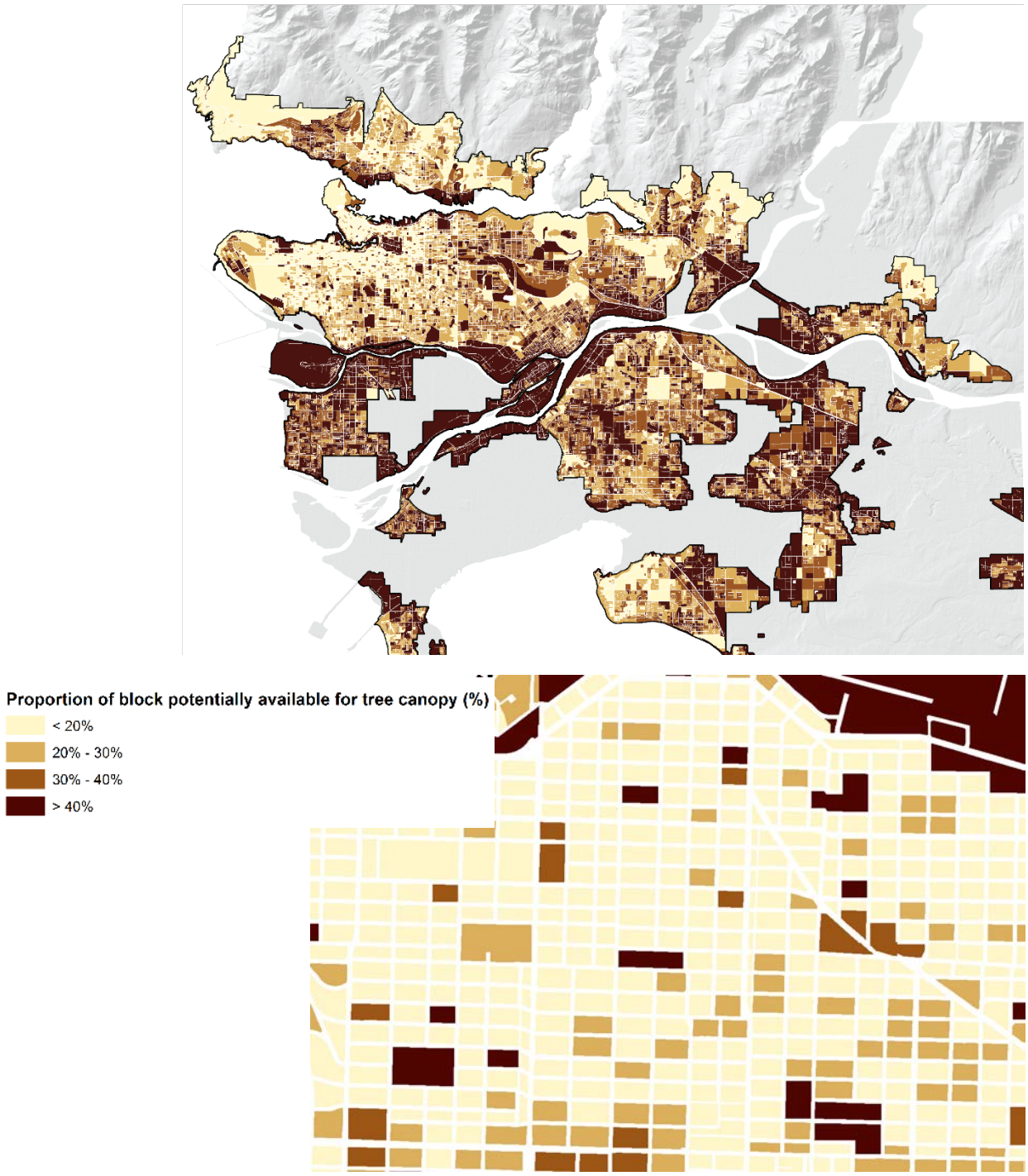

Figure 17: % Potential Planting Area summarized by city block (Urban Containment Boundary)

Appendix 3: Land Cover classes and impervious weightings

Land Cover Class	Criteria
Buildings	Identified using shape/size, shadow cast, height, relative canopy height, texture.
Paved	Everything from sidewalks and alleys to highways.
Other Built	*Not* concrete/asphalt built surfaces or building roofs. Sports surfaces (artificial turf and running tacks), possibly transit or rail areas, other impervious surfaces, etc.
Barren	Beaches, alpine rock, shoreline rock, etc. Lack of vegetation. Likely not soil (colour/context suggests no organic matter and/or imperviousness). Also quarries, gravel pits, dirt roads.
Soil	Agricultural soils (could be light or dark), cleared/open areas where darker colours indicate organic matter present (as compared to, e.g. sand), potentially riverine/alluvial deposits.
Coniferous	Predominantly coniferous (>75%)
Deciduous	Predominantly deciduous (>75%)
Shrub	Woody, leafy, and generally rough-textured vegetation shorter than trees (approx. <3-4m), taller than grass.
Modified Grass-herb	Crops, golf course greens, city park grass, lawns, etc.
Natural Grass-herb	Alpine meadows, near-shore grass areas, bog/wetland areas.
Non-photosynthetic vegetation	Dead grass, drought stressed vegetation, could include log booms.
Water	Lakes, rivers, inlets, irrigation channels, retention ponds, pools, etc.
Urban Shadow	Dark pixels with v/ low reflectance values. Image features not easily visible. Compare w/ RapidEye image for shadow locations. Urban areas
Non-Urban Shadow	Dark pixels with v/ low reflectance values. Image features not easily visible. Compare w/ RapidEye image for shadow locations. Non-urban areas
Clouds/Ice	Very bright pixels, that are not high-reflectance features from built-up areas.

The following impervious weightings were applied to Land Cover classes in the creation of Figure 9 (% Impervious Surface summarized by city block within the Urban Containment Boundary)

Land Cover Class	Impervious weighting
Buildings, Other Built, Paved, Urban Shadow	100%
Barren	75%
Soil, Non-photosynthetic Vegetation	50%
Modified Grass Herb, Natural Grass Herb	10%
Coniferous, Deciduous, Shrub, Non-Urban Shadow, Clouds/Ice	0%