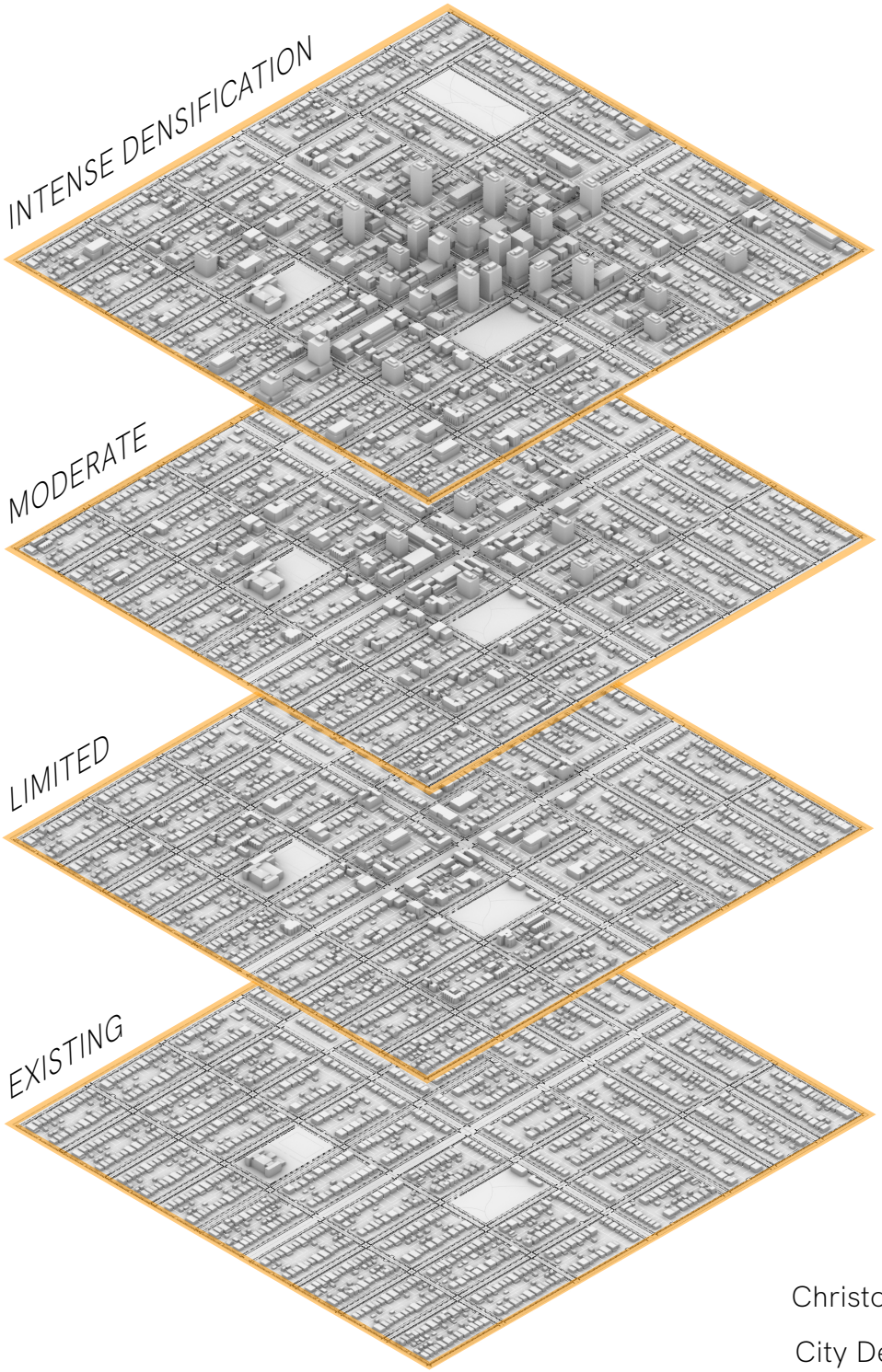
NEIGHBOURHOOD TYPOLOGIES

EVALUATING NEIGHBOURHOOD RESILIENCE FOR DENSIFYING GROWTH SCENARIOS



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AUGUST 2021

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This report was prepared on the traditional, ancestral, and unceded territory of the xwməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), Stó:lō and Səl̓ílwətaʔ/Selilwitulh (Tsleil-Waututh) Nations. The author recognizes that the models under consideration in this report inform the stewardship of these lands.

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

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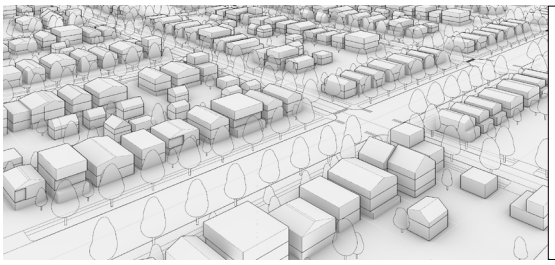
Executive Summary

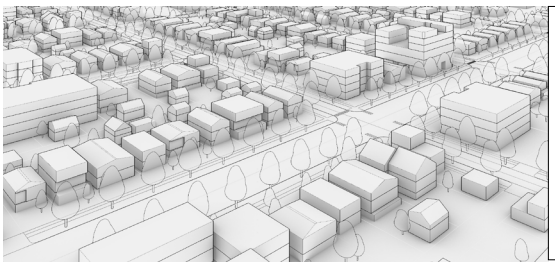
This project pilots holistic neighbourhood-scale resilience evaluation methods adapted from the City's Resilient Neighbourhood Design Tool (RNDT). A selection of holistic resilience and sustainability indicators are used to assess the performance of a typological model corresponding to an existing low-density Vancouver neighbourhood for three projective growth scenarios (i.e. limited, moderate, and intense densification). A literature and policy review informs metrics under consideration in the project, identifies potential benefits and challenges associated with the development of urban built environment models (UBEMs), and situates the project within contemporary global climate change discourse. Observations are made regarding neighbourhood performance and the project methodology respectively, with a focus on the potential of typological studies to offer insight into complex relationships between densification and livability through a combined rational and intuitive approach towards quantitative data. Recommendations are provided to increase the accuracy of data derived by the project, and to expand its scope to address additional holistic livability indicators relevant to neighbourhood densification.

NEIGHBOURHOOD TYPOLOGY PERFORMANCE PROFILES



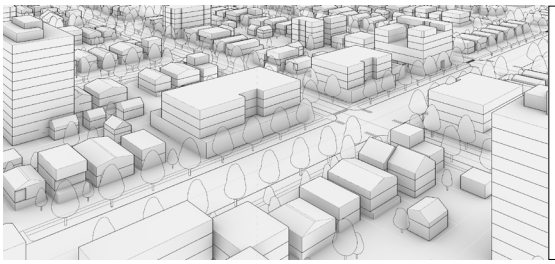
EXISTING CONDITIONS

- low density residential
- good access to retail
- very good access to very high capacity greenspace
- limited placement of residences on arterial



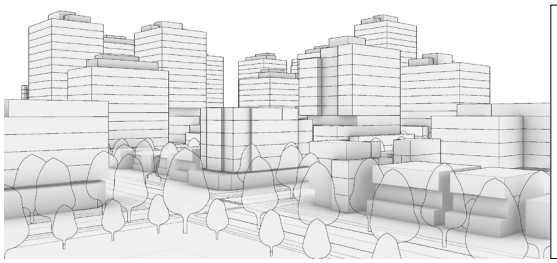
LIMITED DENSIFICATION

- low density residential & commercial
- very good access to retail
- very good access to high capacity greenspace
- limited placement of residences on arterial
- high potential for light woodframe construction



MODERATE DENSIFICATION

- medium density residential & commercial
- very good access to retail
- very good access to medium capacity greenspace
- limited placement of residences on arterial
- moderate potential for light woodframe construction



INTENSE DENSIFICATION

- high density residential & commercial
- excellent access to retail
- very good access to limited capacity greenspace
- moderate placement of residences on arterial
- limited potential for light woodframe construction

DAILY NEEDS Ddensification TRENDS

CONCENTRATED & FLEXIBLE

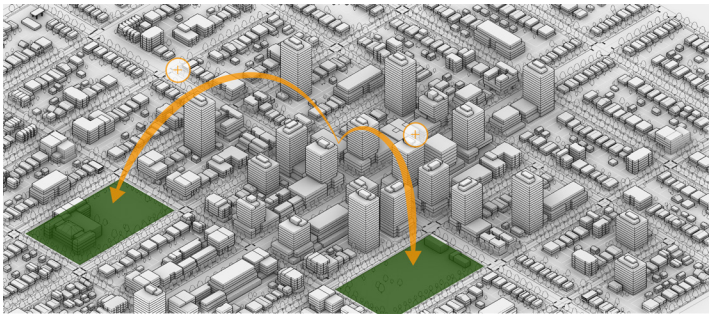
retail | groceries | transit

When density increases:

- residential proximity increases
- provision increases to meet demand

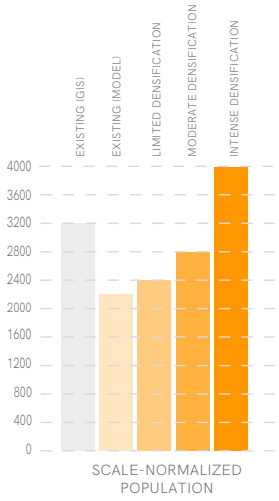
DISPERSED & FIXED

greenspace | childcare | schools | community facilities

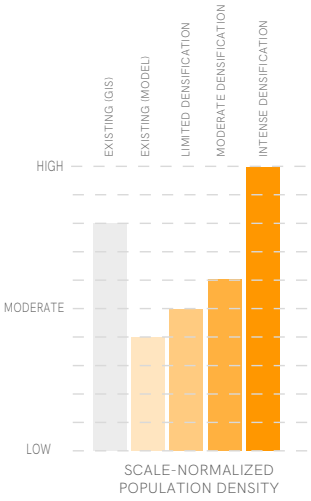


- residential proximity is unpredictable (may decrease if population is concentrated at a distant hub)
- fixed provision results in limited capacity

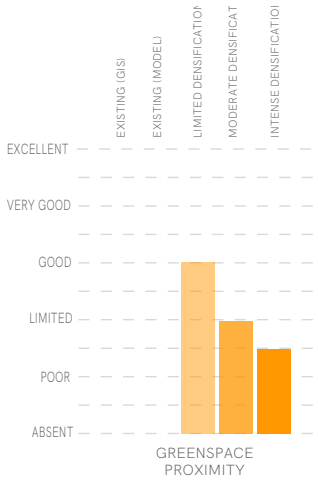
PERFORMANCE SUMMARY GRAPHS



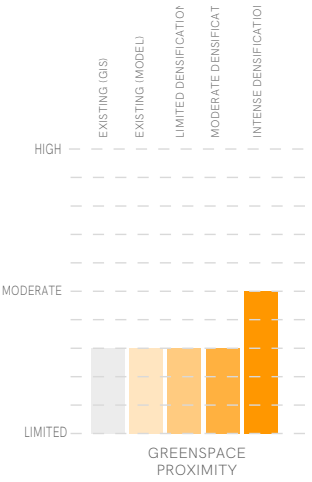
TOTAL POPULTATION



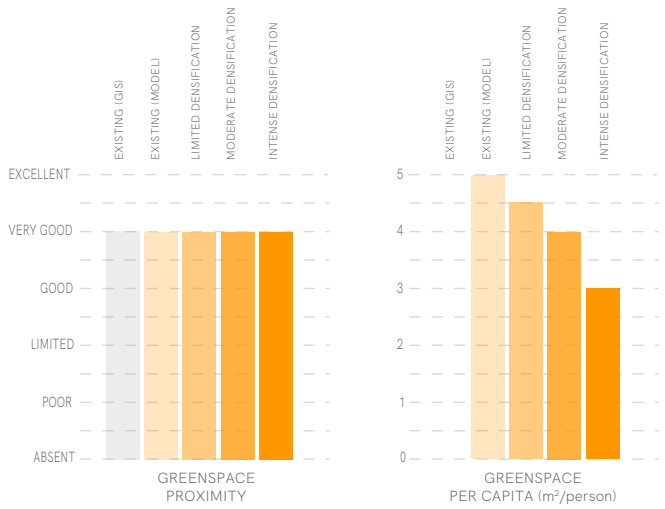
POPULATION DENSITY
doubled across scenarios



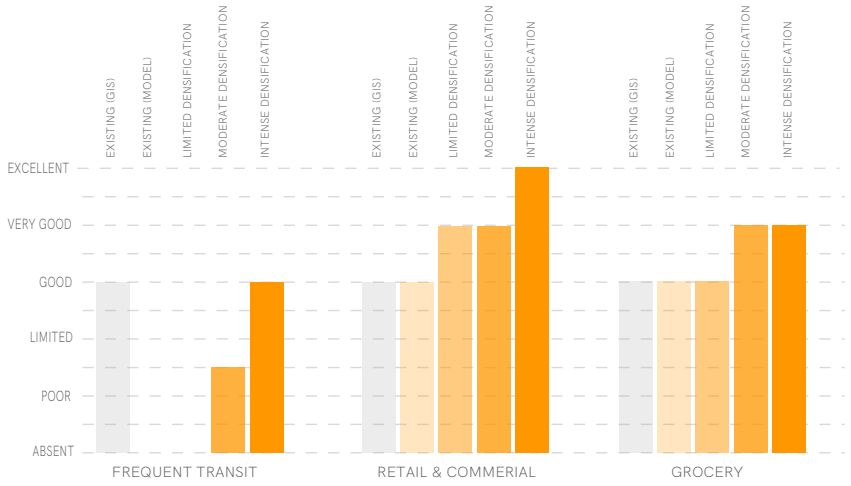
POTENTIAL LIGHT-FRAME WOOD CONSTRUCTION
negatively correlated with density



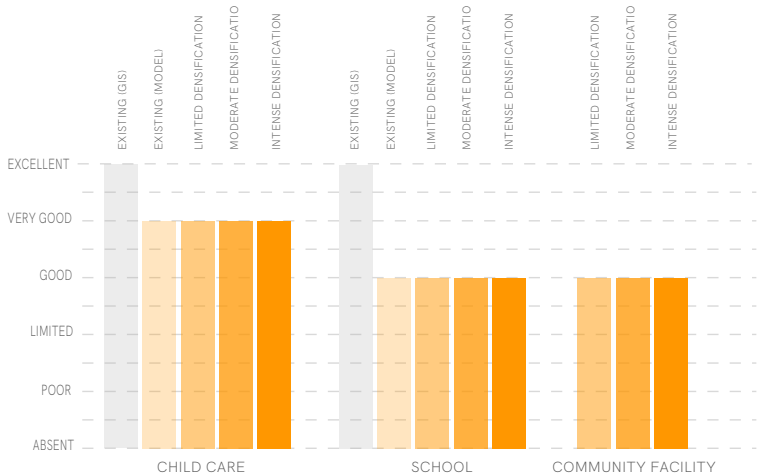
RESIDENTIAL FLOORSPACE ON ARTERIAL
controlled until intense density



GREENSPACE PROVISION & CAPACITY
disparity increased by densification



PROXIMITY TO CONCENTRATED & FLEXIBLE DAILY NEEDS
improved by densification



PROXIMITY TO DISPERSED & FIXED DAILY NEEDS
inelastic to densification

Introduction

Resilient Neighbourhood Design Tool (RNDT)

This project pilots holistic neighbouhood-scale resilience evaluation methods adapted from the City's Resilient Neighbourhood Design Tool (RNDT), building on a typological neighbourhood assessment methodology developed through a Social Sciences and Humanities Research Council of Canada (SSHRC) funded collaboration between Community Planning and UBC elementsLab.

The RNDT developed by the City Design Studio (CDS) consists of over 50 specific indicators by which the performance of existing and future neighbourhoods in early planning and design phases may be assessed. Indicators are related to various community resilience themes, such as complete walkable communities, sustainability and resiliency, living systems, and social equity. A subset of these indicators are under consideration in this project.

Through the use of typological neighbourhood models, this study is focussed on understanding the implications of walkable, complete neighbourhoods. Additionally, the quantitative approach under consideration has potential to inform the contribution of the City Design Studio and Complete Neighbourhoods team to the Vancouver Plan, and other major city planning initiatives.

Research Scope & Objectives

A literature review of policy documents and scholarly works is conducted. The review of policy documents informs indicators and metrics under consideration in this project. Meanwhile, scholarly works identify potential benefits and challenges associated with the development of urban built environment models (UBEMs), and situate the project within contemporary global climate change discourse.

The performance of a typological model corresponding to an existing low-density Vancouver neighbourhood is evaluated for three projective growth scenarios (i.e. limited, moderate, and intense densification), based on a selection of holistic resilience and sustainability indicators.

This project considers a selected subset of RNDT indicators based on their relation to the theme of walkable complete neighbourhoods, feasibility of quantitative estimation based on a typological neighbourhood model, and availability of workable data.

The Grasshopper visual programming language is used to derive quantitative data corresponding to selected RNDT indicators from typological neighbourhood models which have been developed by the CDS for this project in Rhinoceros 3D. Additionally, this project adjusts previously developed Grasshopper and Rhino models to conform to data from an existing Vancouver neighbourhood processed using Geographic Information Systems (GIS) in ArcMap.

INDICATOR	METRIC
Housing Continuum Affordability Index Housing Diversity	Simpson's Diversity Index Ranking Simpson's Diversity Index
Small Scale Development Green + Resilient Sectors Jobs Density Jobs Diversity	Parcel Size Ranking GFA of Jobs Space per Acre Simpson's Diversity Index
Preferred Sites Pedestrian Connectivity Proximity to Daily Needs Residential Density Land Use Diversity Jobs-Housing Balance	Preferred site (ranking) Number of pedestrian intersections / acre % of GFA within 400m of daily needs People per acre (net parks) Simpson's Diversity Index Job : Dwelling Ratio
Open Space Design People-First Streets Livable Built Form	Average Open Space Design Score Average Street Comfort Score Average Livability Score
Transit Proximity Cycling Infrastructure Parking Provision Embodied Carbon - Buildings Photovoltaic Potential Building Envelope Efficiency Carbon Sequestration Embodied Carbon - Infrastructure On-Site Renewable Energy	% GFA Within 400m of transit station % GFA Meeting Cycling Criteria # of Parking Stalls Per Inhabitant + Employee Average Embodied Carbon Score Photovoltaic Envelope to Floor Area Index Building Surface Area to Volume Index Urban Forest Volume Average Embodied Carbon Score % of On-Site Renewable Energy
On-Site Water Re-Use	Ranking
On-Site Waste Management	Ranking
Sea Level Rise Urban Heat Island - Buildings Urban Heat Island - Open Space Drought - Supply : Demand Flood - Mitigation	% GFA Built for 4.6m Sea Level Rise Non-Solar Heated Facade to Floor Area Index Summer Solar Exposure Storage Capacity : Demand Ratio Storage + Conveyance Capacity : Rainfall Ratio
Seismic Vulnerability - Location Disaster Hub Proximity Building Seismic Performance Critical Infrastructure	Average Seismic Vulnerability Score % GFA within 800m of a Disaster Hub Building Seismic Performance Average Critical Infrastructure Score
Effective Pervious Area Habitat Connectivity Natural Habitat	% Effective Pervious Area Habitat Connectivity (metric) % of Site Protected + Managed as Habitat
Green Space Proximity Green Streets Frontage Street-Level Air Quality	% GFA Within 400m of Green Space % GFA Fronting a Green Street % GFA Fronting Street With Poor Air Quality Score
Public Open Space Public Facilities Communal Amenity Space	Public Open Space Per Inhabitant Public Facilities Per Inhabitant % Multi-Family GFA With Communal Amenity Space
Access to Healthy Food Access to Healthcare Services Access to Mental Health Services	% GFA Within 400m of Healthy Food Options % GFA Within 400m of Healthcare Services % GFA within 1600m of Mental Health Services
Engagement Process Cultural Enhancement	Engagement Process (ranking) Cultural Enhancement (ranking)
Cultural Facilities Engagement Socio-Economic Opportunity	% GFA within 800m of cultural facility Quality of engagement (ranking) Quality of socio-economic opportunity (rank)
Access to Quality Childcare Access to Education	% GFA Within 400m of Quality Childcare % GFA Within Simultaneous Proximity of Schools

A selection of Resilient Neighbourhood Design Tool (RNDT) indicators and metrics.

PROJECT DATA TABLE

	Existing (GIS)	Existing (Model)	Limited Densification	Moderate Densification	Intense Densification
Total Neighbourhood Area	339791.3518	1000000	1000000	1000000	1000000
Total Residential Area	105382.9841	417729	471703	532508	772821
Total Residential Area (corrected for area)	105382.9841	141940.7016	160280.6	180941.6131	262597.8923
Total Population	3241	6318.809043	7135.251518	8307.961881	11806.75481
Total Population (corrected for area)	3241	2147.076666	2424.496758	2822.973598	4011.833178
Population Density (people/ha)	95.38206265	63.18809	71.352515	83.079619	118.067548
No. of Parcels	577.645298	1223	1158	1107	1019
Parcel Density (parcel/ha)	17	12.23	11.58	11.07	10.19
% Owner Occupied Area	0.36	0.4	0.4	0.374039	0.391752
% Purpose-Built Market Rental (+ % Secondary Unit) Area	0.49	0.48	0.48	0.500768	0.486598
% Non-Market Area	0.15	0.12	0.12	0.125192	0.12165
% Secondary Unit Area	0.1	[not in GH]	[not in GH]	[not in GH]	
Office Space per Capita	0.523912373	0	1.678056	7.040895	38.221983
Greenspace per Capita	0	5.266574	4.663952	4.005612	2.818596
Prox 800m Frequent Transit	0.784008549	0	0	0.746564	0.996276
Prox 800m Grocery	1	1	0.995857	0.993127	0.996276
Prox 800m Child Care	1	1	0.995857	0.993127	0.996276
Prox 800m Community Facility	0	0	0.995857	0.993127	0.996276
Prox 800m School	1	0.962353	0.958575	0.952749	0.959963
Prox 800m Greenspace	1	1	0.995857	0.993127	0.996276
Prox 800m Retail+Commercial	1	0.999216	0.995857	0.992268	0.995345
Prox 400m Frequent Transit	0	0	0	0.249141	0.558659
Prox 400m Grocery	0.5	0.536471	0.508699	0.729381	0.723464
Prox 400m Child Care	0.97	0.804706	0.789561	0.781787	0.843575
Prox 400m Community Facility	0	0	0.487987	0.476804	0.469274
Prox 400m School	1	0.538039	0.545153	0.524914	0.532588
Prox 400m Greenspace	0.82	0.971765	0.966031	0.962199	0.971136
Prox 400m Retail+Commercial	1	0.887843	0.980944	0.978522	0.986965
Prox 200m Frequent Transit	0	0	0	0.065292	0.155493
Prox 200m Grocery	0.091079422	0.130196	0.104391	0.314433	0.307263
Prox 200m Child Care	0.4	0.303529	0.270091	0.258591	0.3054
Prox 200m Community Facility	0	0	0.115162	0.094502	0.09311
Prox 200m School	0.3695828	0.173333	0.173985	0.180412	0.175047
Prox 200m Greenspace	0.194288313	0.593725	0.575808	0.567869	0.57635
Prox 200m Retail+Commercial	0.458213053	0.411765	0.612262	0.614261	0.719739
Percent ROW Tree Canopy	0.73	0.712126	0.712126	0.712126	0.712126
	0.27	0.287874	0.287874	0.287874	0.287874
Percent Effective Impervious Area	0.68	0.765634	0.765634	0.765634	0.765634
	0.32	0.234366	0.234366	0.234366	0.234366
Percent Area On Arterial	0.35	0.196593	0.196593	0.196593	0.196593
	0.65	0.803407	0.803407	0.803407	0.803407
Total Residential Area on Arterial	19494.3094	43565.92263	49219.34243	44263.58327	127337.3387
	-19493.3094	-43564.92263	-49218.34243	-44262.58327	-127336.3387
% Residential Area on Arterial	0.184985361	0.104292311	0.104343925	0.083122851	0.164769512
	0.815014639	0.895707689	0.895656075	0.916877149	0.835230488
Percent New Buildings =< 6 Storeys	0	0	0.438356	0.29703	0.233766
Percent New Buildings > 6 Storeys	0	0	0.561644	0.70297	0.766234

Selected Indicators and associated data derived in this project.

Literature Review

Synthesis

Resilience is an increasingly prevalent municipal urban design objective in response to global climate change (Salter et al., 2020; Allam et al., 2020; Calvano, 2017). However, while the need to restructure vital urban infrastructures in adapting to projected climatic futures is widely accepted, there is limited consensus on viable models to inform these processes (Allam et al., 2020). Consequently, ambiguities in definition, difficulty of measurement, and limited actionability often present limitations to the implementation of urban resilience (Allam et al., 2020; Calvano, 2017).

Systems theory offers guiding principles regarding spatial resilience, from which analytical models of urban form may be developed (Martino et al., 2021; Salter et al., 2020; Cumming, 2011). Typological urban built environment models (UBEMs) present an effective methodology for the quantitative evaluation of urban resilience against selected indicators (Salter et al., 2020). Accordingly, the evaluation of projective models using indicators derived from municipal urban design objectives has the potential to facilitate policymaking and design at various scales and timeframes (Salter et al., 2020).

Typological modelling based on the RNDT provides projective neighbourhood-scale evaluations of resilience that are specific to the urban form of the City of Vancouver, with the potential to inform the development and implementation of policies in response to climate change and an increasing urban population (Poskitt, 2019).

City Design Studio

Poskitt, Mark. 2019. "Resilient Neighbourhood Design: Exploring The Relationship Between Built Form And Performance". https://sustain.ubc.ca/about/resources/resilient-neighbourhood-design-exploring-relationship-between-built-form-and.

A report produced by 2019 Greenest City Scholar Mark Poskitt in collaboration with the Vancouver City Design Studio which provides a summary of research and policy documents to contextualize the key indicators and metrics underpinning the RNDT. This report is an effective introduction to the RNDT, and serves as a thorough literature review.

Relevance

- Thorough overview of the RNDT

Limitations

- Implementation and applications of the RNDT are outside the scope of the report

UBC elementsLab

Martino, Nicholas, Cynthia Girling, and Yuhao Lu. 2021. "Urban Form And Livability: Socioeconomic And Built Environment Indicators". Buildings And Cities 2 (1): 220-243. doi:10.5334/bc.82.

Martino et al. examine the relationship between urban form and livability for the Metro Vancouver region based on accessibility, social diversity, affordability, and economic vitality as key indicators. Morphological indicators of the intensity of urban form – as compared to indicators of centrality and diversity – were identified as the most significant determinant of socioeconomic metrics. However, spatial diversity and network centrality are identified as relatively underutilized indices in urban design processes. It is noted that models hold the potential to support policymaking at diverse scales and timeframes, and detailed examination of local-specific densification is identified as an area for further studies.

Salter, Jonathan, Yuhao Lu, Ju Chan Kim, Ronald Kellett, Cynthia Girling, Fausto Inomata, and Alix Krahn. 2020. "Iterative 'What-If' Neighborhood Simulation: Energy And Emissions Impacts". Buildings And Cities 1 (1): 293-307. doi:10.5334/bc.51.

Salter et al. employ typological urban built environment models (UBEM) to test the energetic outcomes of infill and retrofit scenarios in relation to policy objectives. Generic models representative of seven typological urban neighbourhood patterns are developed based on geospatial and census analysis of six cities in British Columbia, Canada. Typological analysis of UBEM is identified as an accessible and flexible approach to the evaluation of potential policy options for small to medium sized municipalities.

Policy Context

Existing Conditions

Vancouver Today: The City at a Glance | Vancouver Today: Reference Guide

These documents provide an overview of current conditions in the City of Vancouver. An outline of the Vancouver Plan and a list of key policy documentation are provided.

Indicators & Metrics

Greenest City Strategy | Healthy City Strategy | Housing Vancouver

Indicators and metrics underlying the RNDT are derived from these documents.

Actions

Transportation 2040 | Climate Emergency Action Plan | Climate Change Adaptation Strategy

Projective evaluations of urban resilience using the RNDT are aligned with the actions prescribed in these strategic documents. Key actions addressed by the RNDT include CEAP Big Move #1: 'A Walkable City' and CCAS Action Areas: 'Climate Robust Infrastructure' and 'Connected and Prepared Communities'.

Related Objectives

VanPlay | Renewable City Strategy

Typological studies based on the RNDT support objectives regarding Complete Communities and Renewable Transportation outlined in these documents.

Regional Context

Regional Context Statement | Regional Growth Strategy

Neighbourhood-scale evaluations based on the RNDT interface with regional urban design objectives outlined in these documents.

Extended Scope

Culture|Shift | Poverty Reduction Plan

While typological studies of neighbourhood resilience have potential to align with these documents, complete implementation has remained beyond the scope of the model at this stage of the project.

Additional Scholarly Materials

Allam, Zaheer, David Jones, and Meelan Thondoo. 2020. "Urban Resilience And Climate Change". Palgrave Studies In Climate Resilient Societies, 1-32. doi:10.1007/978-3-030-40727-8_1.

Allam et al. observe the lack of consensus regarding viable projective models to inform the restructuring of urban infrastructure in response to climate change. An overview of the socioeconomic implications of climate change and demographic expansion within urban centers is provided, alongside a review of key international policies.

Relevance

- Identifies a need for Research & Development towards projective models to inform the restructuring of urban infrastructure in response to climate change
- Situates municipal climate resilience within a larger global discourse

Limitations

- Discussions are primarily at a global to national scale, although the article calls for models at a municipal scale
- This article is largely focussed on prediction of hazards as compared to predictive evaluation of performance

Calvano, Ava G. 2017. "Putting Resilience On The Map: Toward The Development Of A GIS-Based Resilience Scorecard For Critical Urban Infrastructure Systems". Graduate, Villanova University.

Calvano observes that ambiguous definition, difficulty of measurement, and limited actionability are limitations to the adoption of resilience as an urban design objective, and looks to address these obstacles through the development of a Resilience Scorecard. A conceptual framework for urban resilience in relation to discourse within engineering and ecology serves to disambiguate the definition of resilience. A prototypical scorecard to evaluate the resilience of transportation infrastructure at a neighbourhood scale is produced to address difficulties in measuring resilience. Finally, a proof-of-concept GIS platform is employed to implement the scorecard.

Relevance

- High-level overview of resilience in relation to urban infrastructure
- Evaluation of neighbourhood resilience based on morphological indicators
- Highlights potential procedural challenges in evaluating resilience

Limitations

- Lack of empirical support for the proposed framework
- Lack of project alignment with policy objectives

Cumming, Graeme S. 2014. Spatial Resilience In Social-Ecological Systems. [Place of publication not identified]: Springer.

A book introducing key concepts related to spatial resilience in complex social-ecological systems (SES). Fundamental information regarding complex SESs and the modelling of spatial resilience is provided in Chapters 1-4. Chapters 5-10 address spatial modelling in greater depth, discussing analytical approaches, fragmentation analyses, and case studies. Chapter 11 offers a summary of spatial principles discussed in previous chapters.

Relevance

- Generalized principles of spatial resilience and fragmentation

Limitations

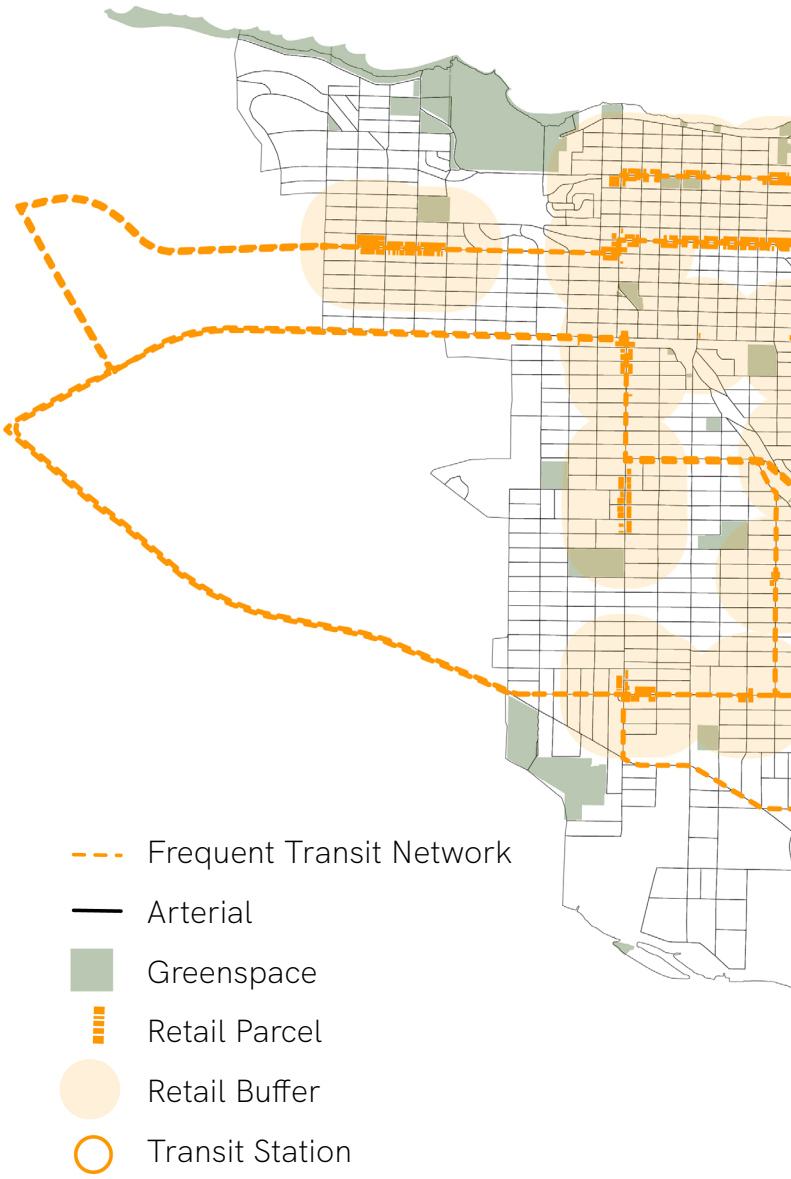
- High-level overviews which require further development to be operationalized
- Although examples present general principles applicable to a range of systems, they are largely based in the discipline of ecology

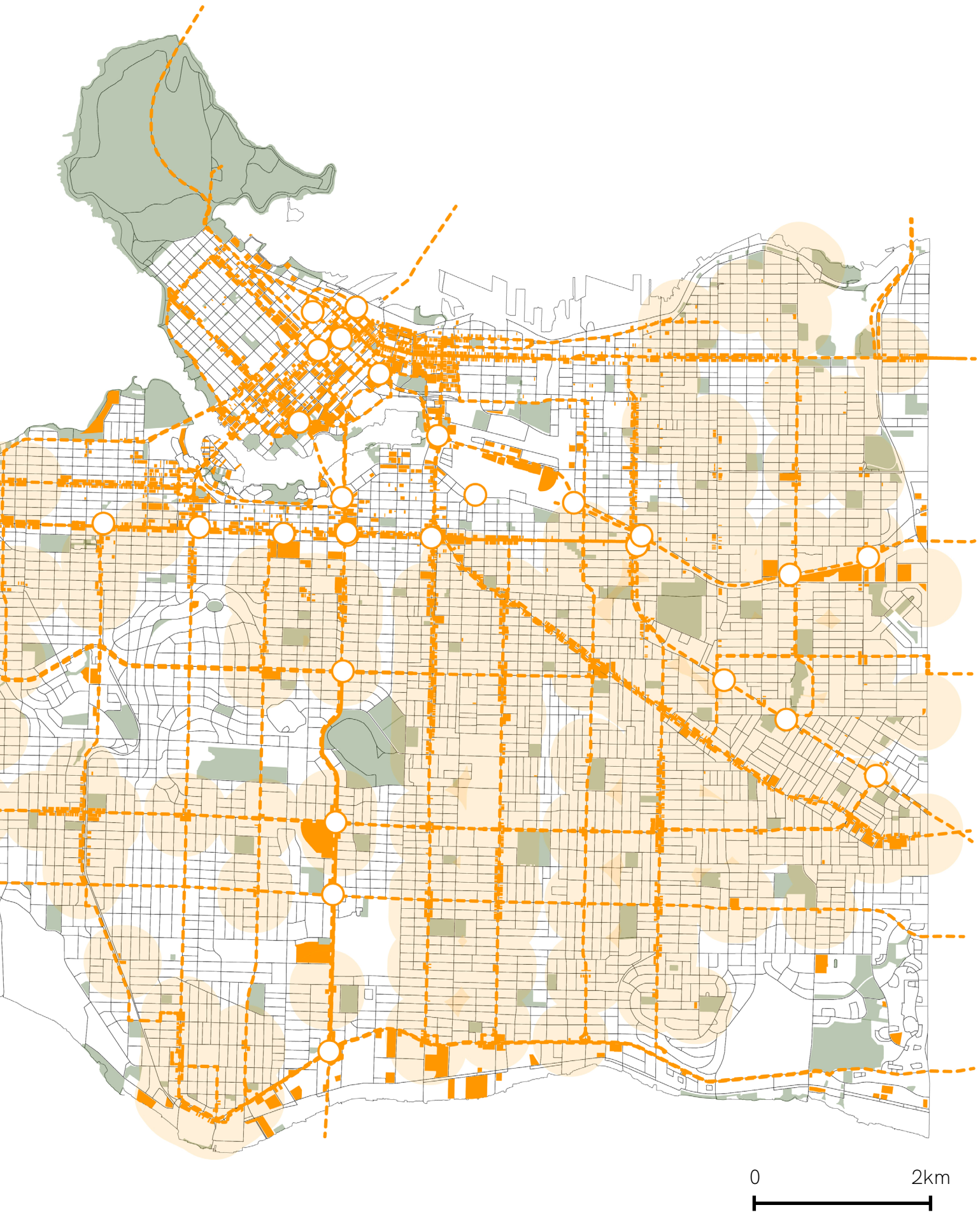
Research Methodology

GIS Low-Density Neighbourhood Definition & Selection

A holistic and intuitive approach is utilised to define neighbourhoods based on quantitative spatial data for this study. Neighbourhoods are assumed to occupy a 400m catchment extending from retail areas, and are often located along frequent transit routes. Schools, parks, and childcare are often grouped within areas continuous with the retail hub. Arterials which are not retail highstreets act as neighbourhood edges. Districts (e.g. industrial areas, campuses, master-planned communities, etc.) have a distinct character, separate from the neighbourhoods under consideration in this model. Neighbourhoods are further distinguished based on urban form (e.g. land-use, building types, street type, parcel size, etc.).

Specific GIS data was extracted for five sample neighbourhoods. A final sample neighbourhood was identified for typological evaluation from this shortlist, as selected based on active neighbourhood edges, proximity to daily needs, and scale relative to the typological model.

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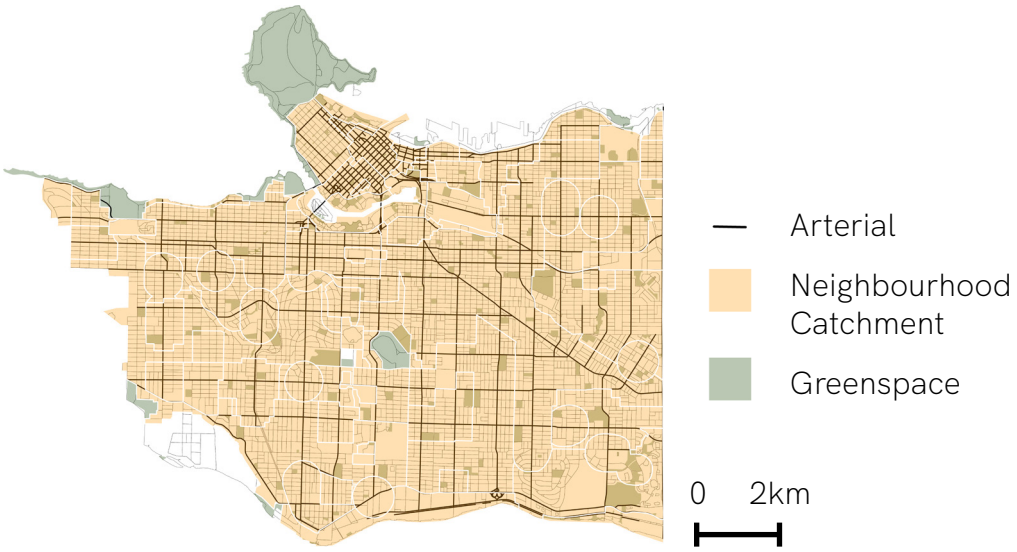
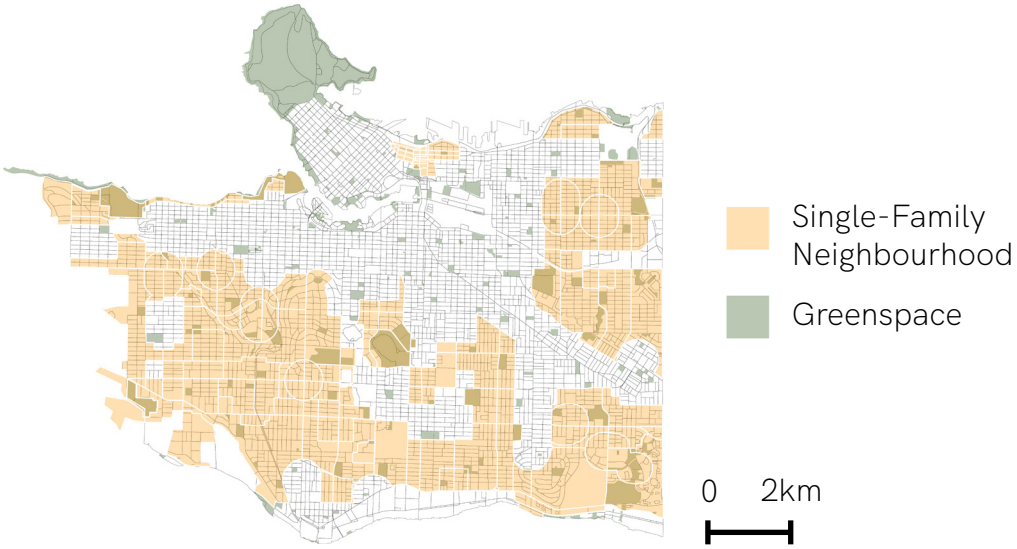
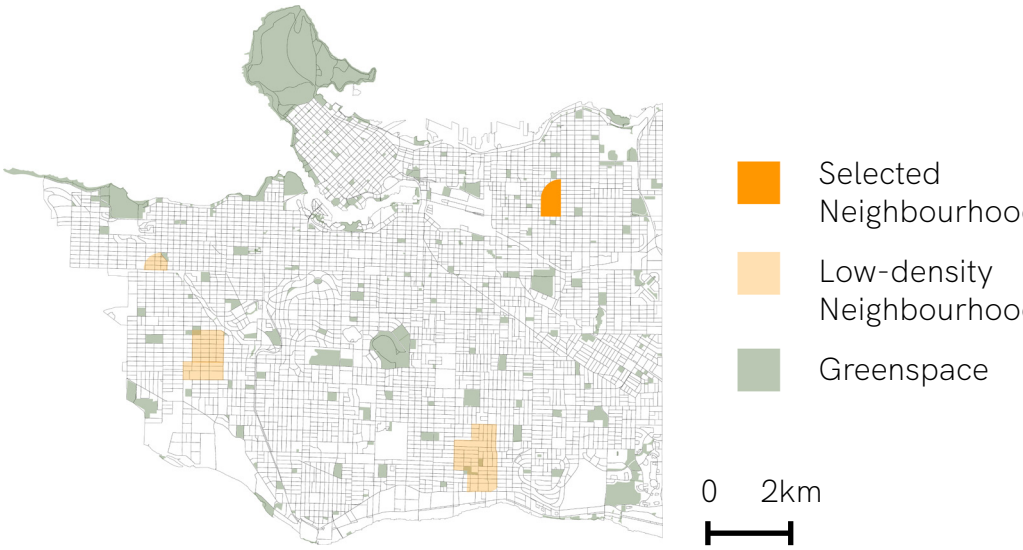


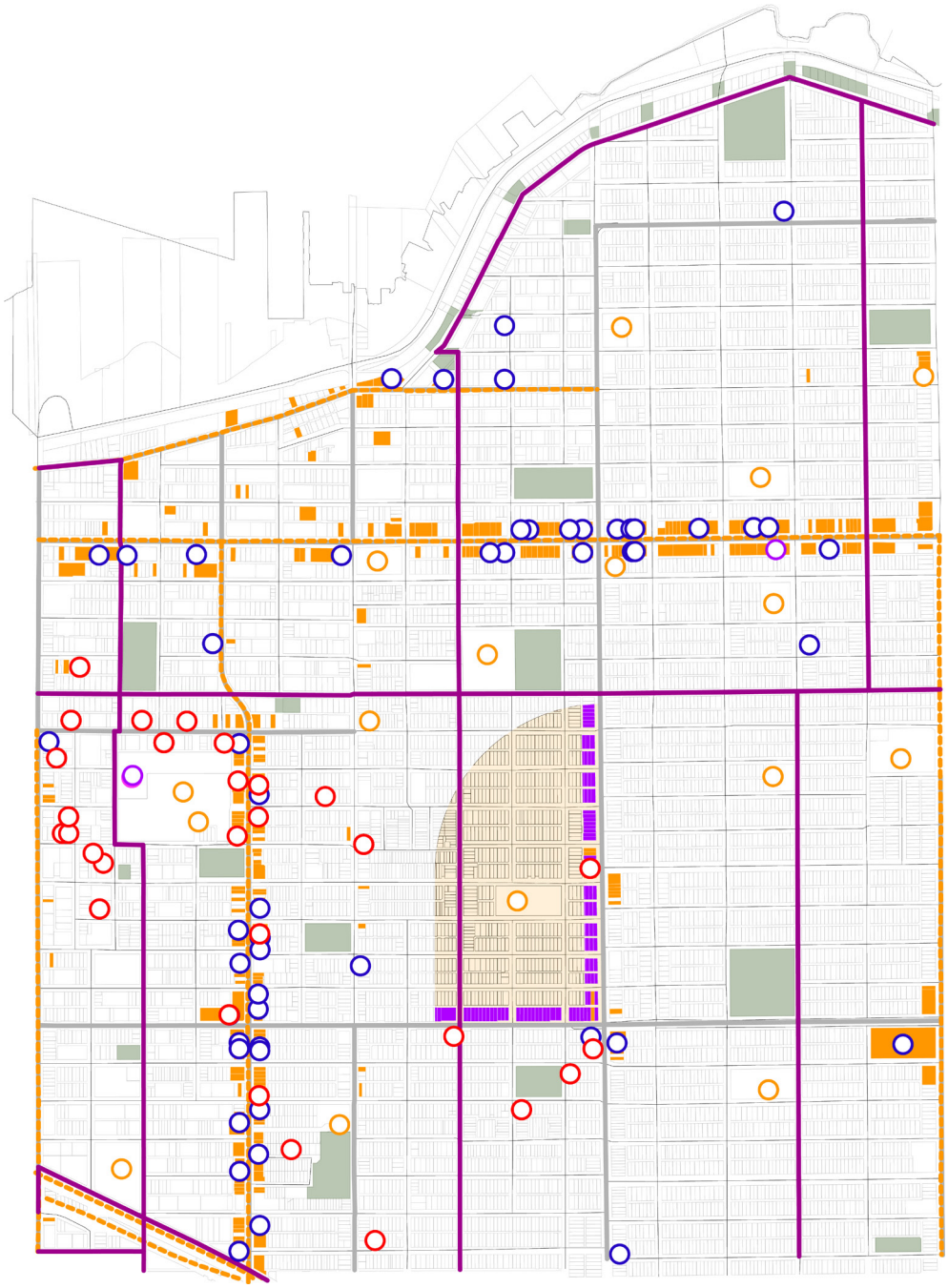
Adjusting neighbourhood boundaries based on arterial edges.



Low density neighbourhoods (misclassification of Kerrisdale in this graphic was corrected later in the project).



North eastern neighbourhood selected for further study out of five prospective neighbourhoods..



Unprocessed data for the selected low-density neighbourhood.

0 2km

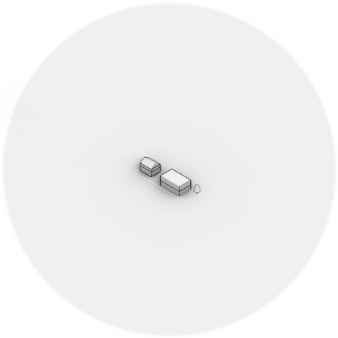
- Arterial
- Greenspace
- Bikeway
- Greenspace
- Retail Parcel
- Arterial Adjacent Parcel
- Business
- School
- Community Facility
- Library
- Grocery

Rhino Model Development and Sensitivity Testing

Typological models were developed to represent existing neighbourhood conditions, as well as three projective growth scenarios of increasing density: limited, moderate, and intense densification. The models and associated Grasshopper scripts were iteratively adjusted to correspond to the existing conditions of the sample neighbourhood as observed through GIS data.

SINGLE FAMILY/DUPLEX

3 | 4 storey

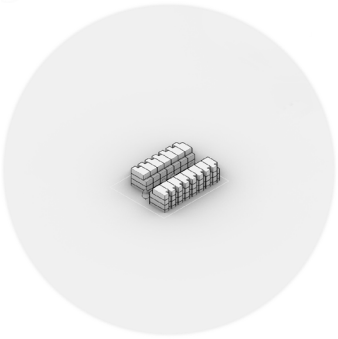


MID-RISE WITH
RETAIL AT GRADE

3 | 4 | 6 storey

TOWNHOUSE/MULTIPLEX

3 | 4 storey

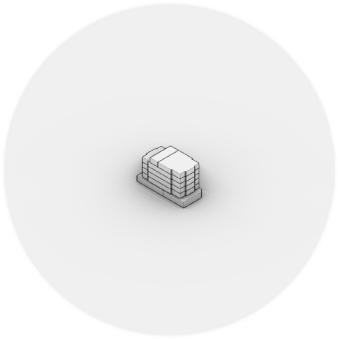


OFFICE BUILDING

12 storey

SMALL LOT LOW-RISE

4 | 6 storey

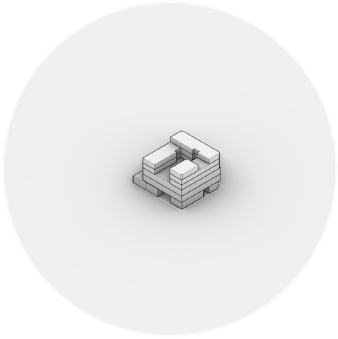


TOWER

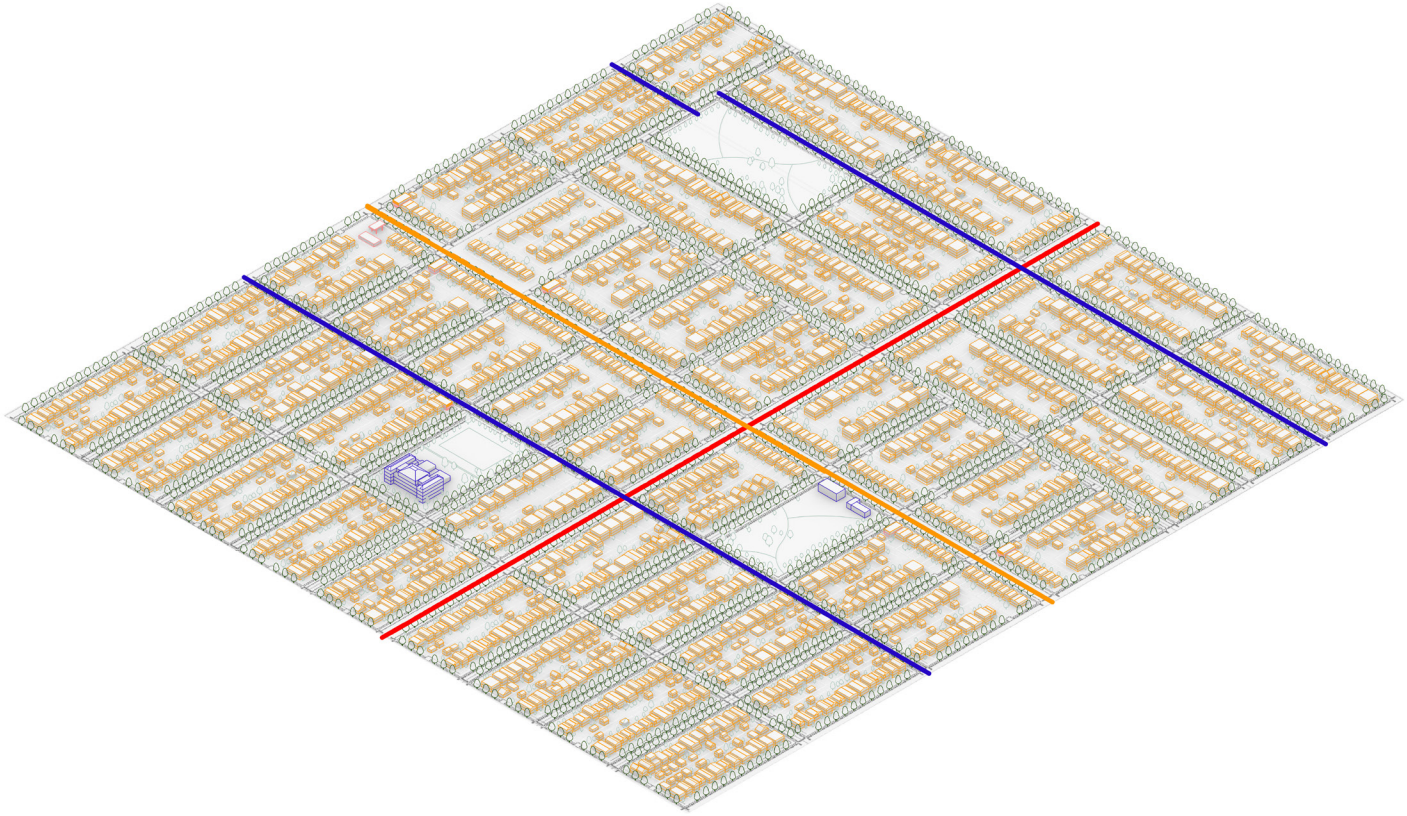
12 | 18 | 24 | 30 storey

COURTYARD BUILDING

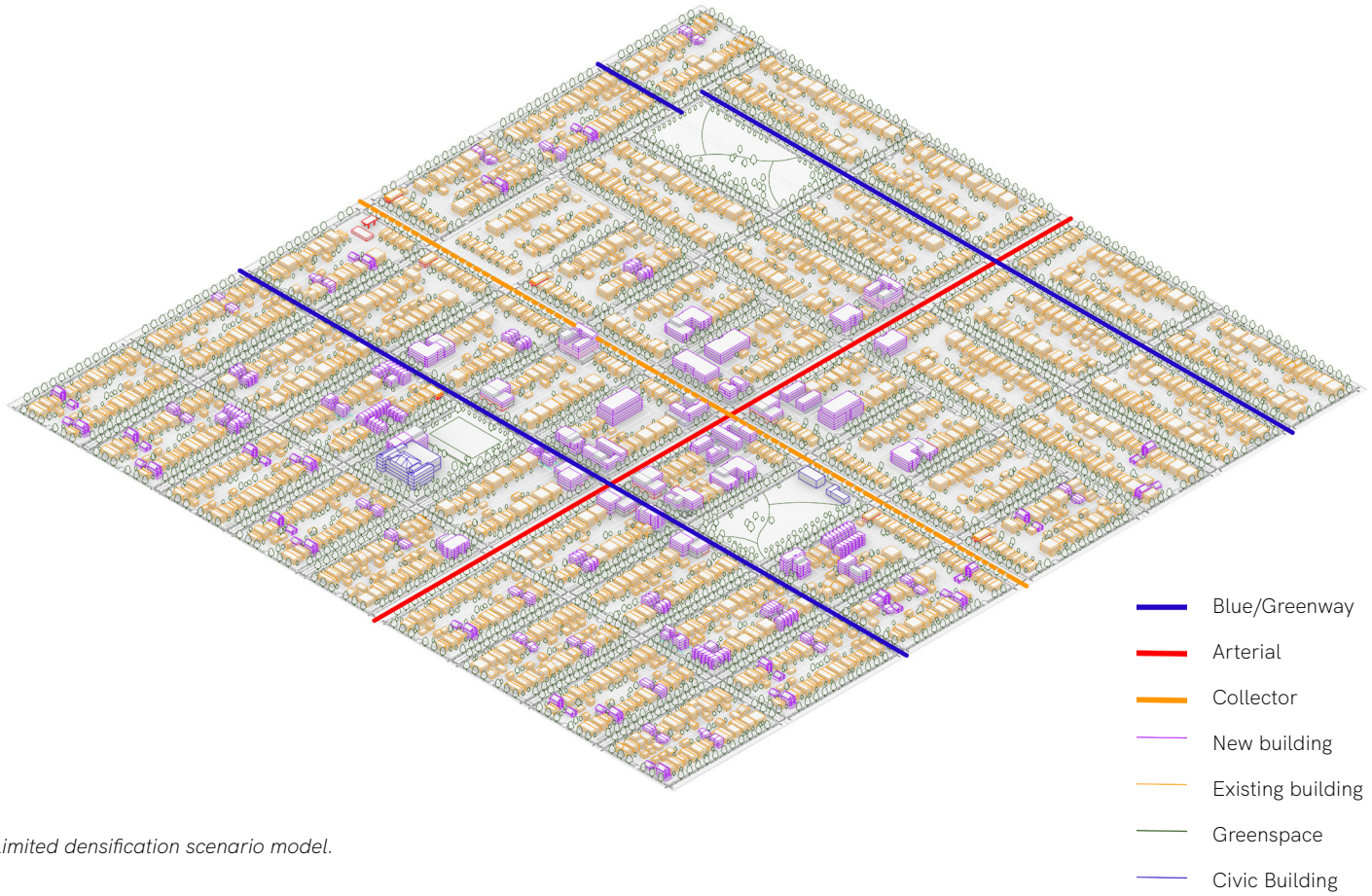
4 | 6 storey



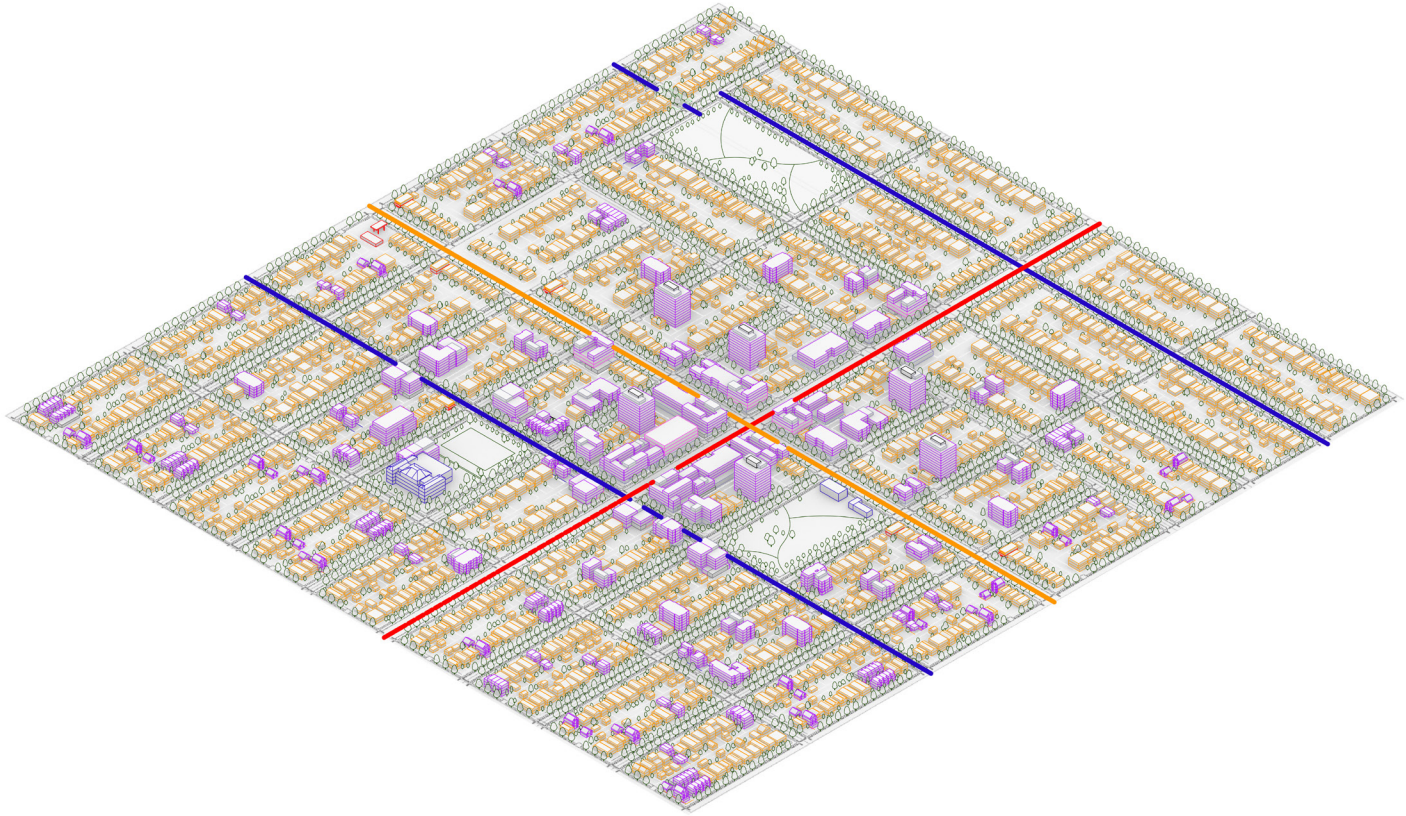
A selection of typical building models which constitute the typological neighbourhood models.



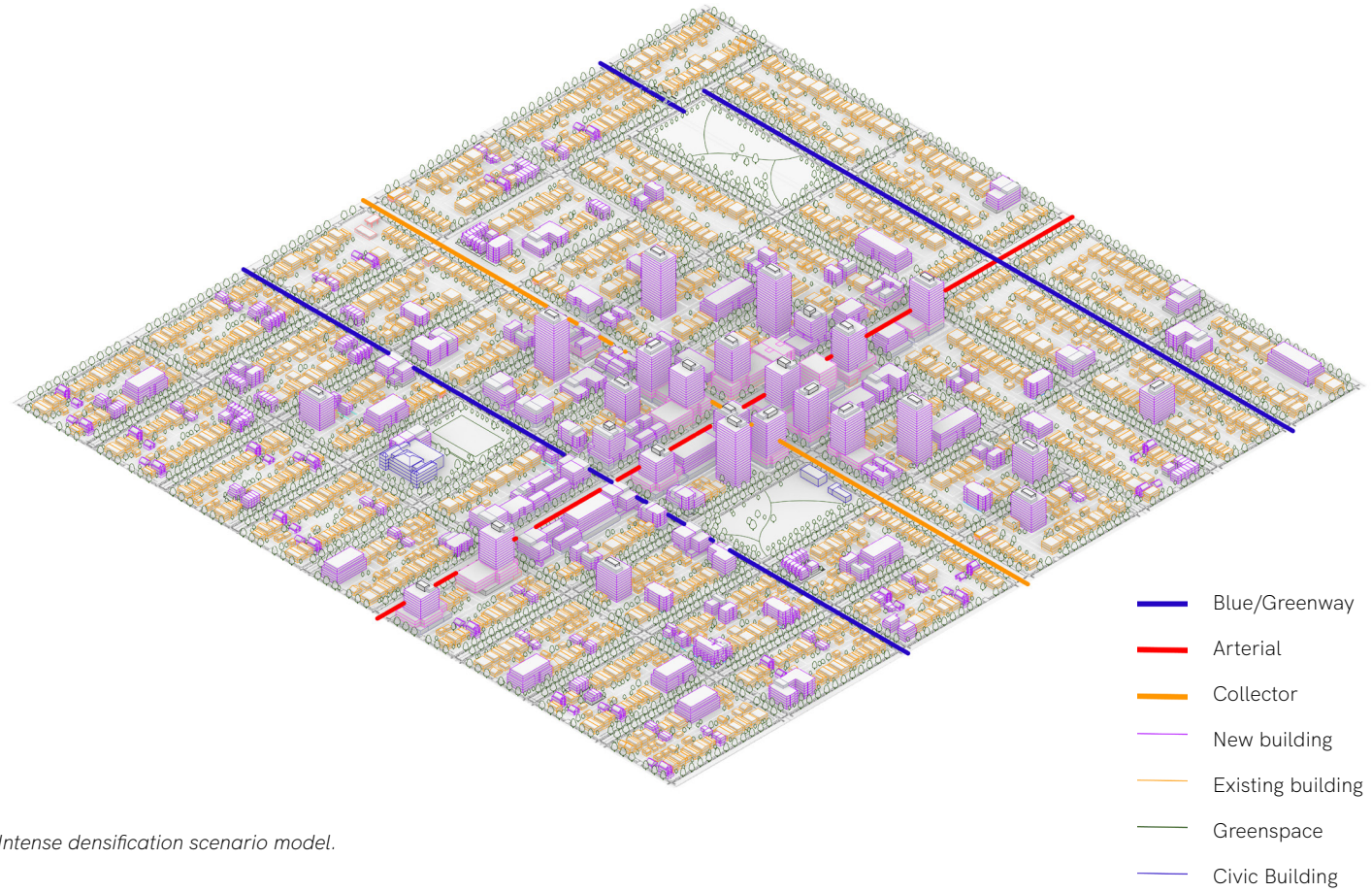
Existing conditions model.



Limited densification scenario model.



Moderate densification scenario model.



Intense densification scenario model.

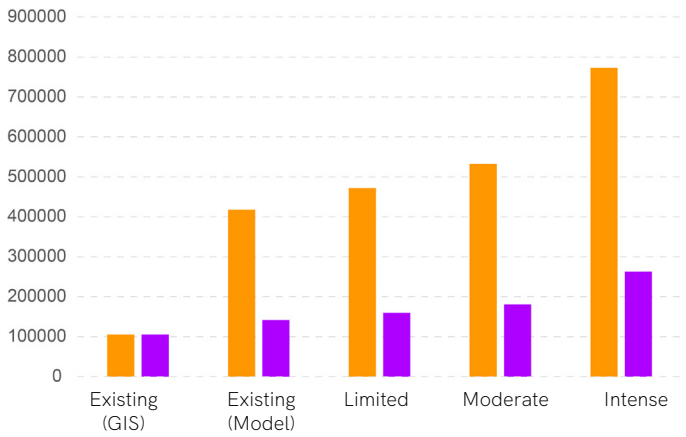
Typological Neighbourhood Evaluation Pilot

Findings on Neighbourhood Performance

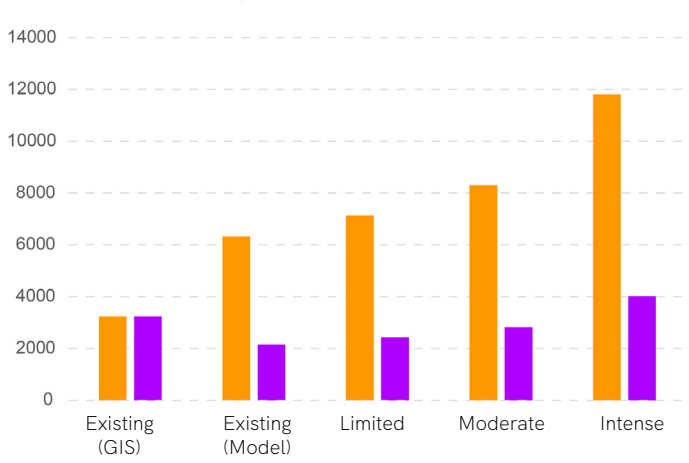
Estimated Population & Tenure

The population density and residential area of the intensely densified model are twice those of the existing-conditions model. Meanwhile, parcel density decreases as the models densify, as parcels are combined to accommodate larger buildings. The tenure breakdown remains relatively unchanged across models due to inelastic assumptions in the underlying Grasshopper script.

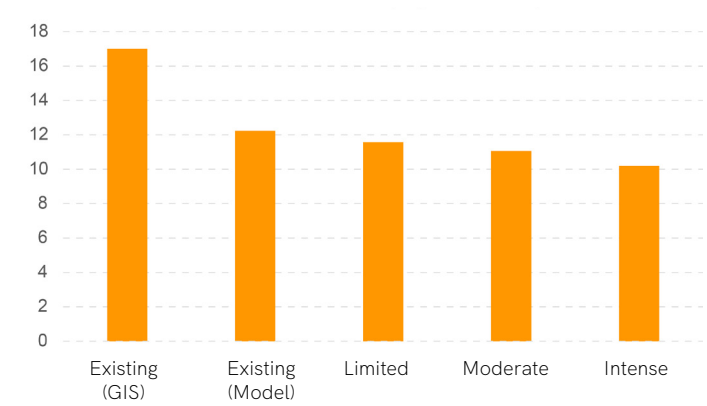
Total Residential Area & Scale-Normalized (m^2)



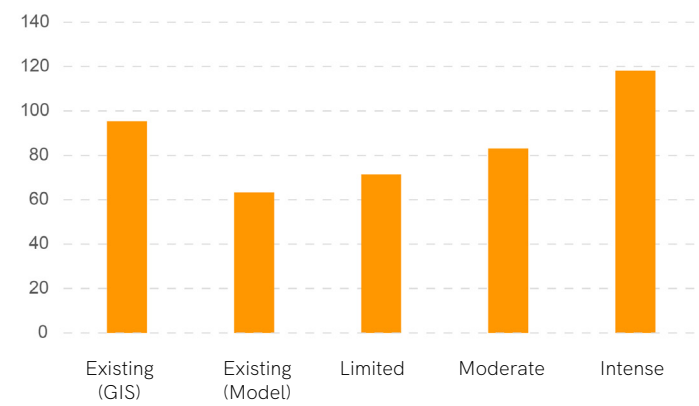
Total Population & Scale-Normalized



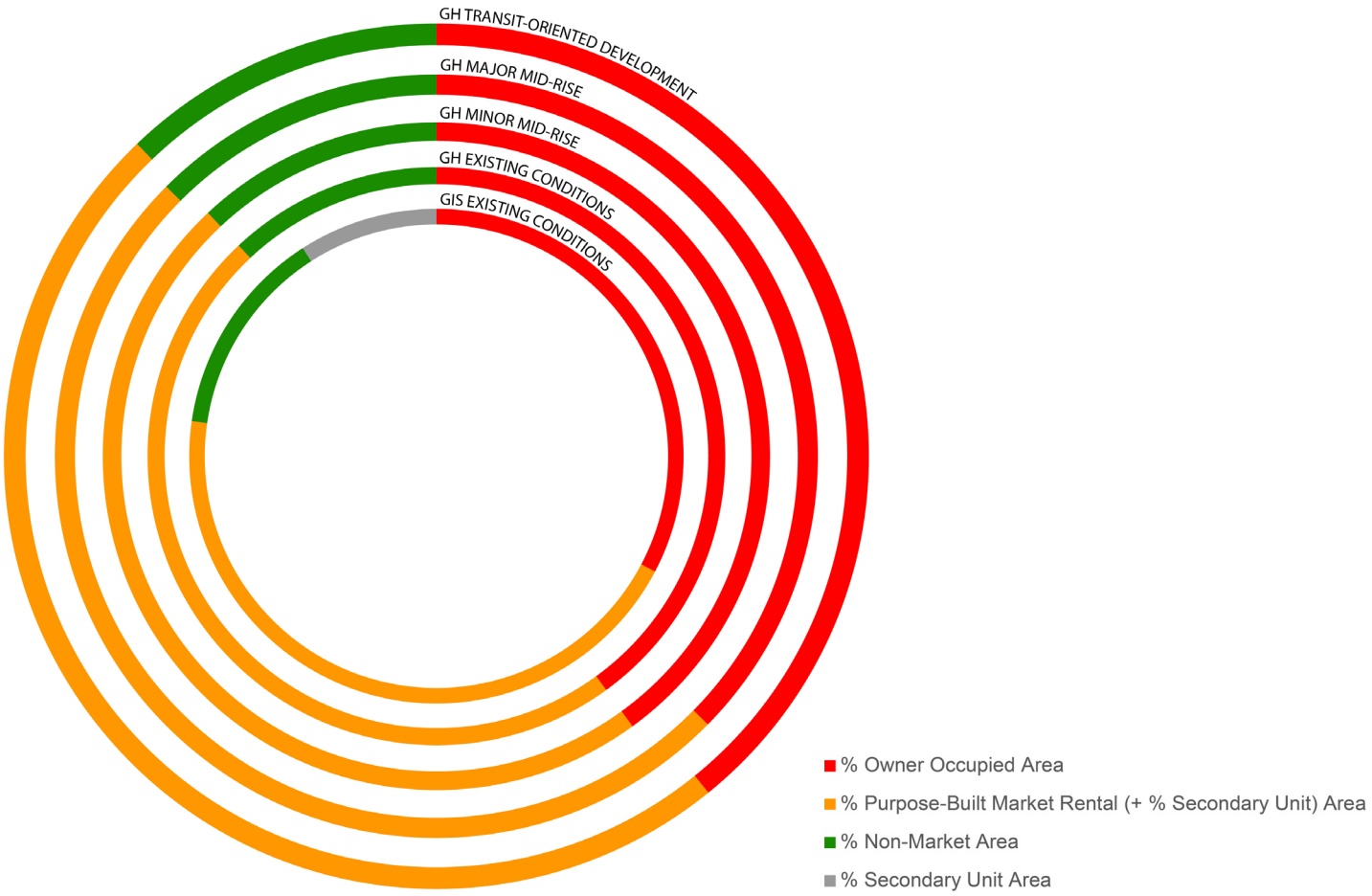
Parcel Density (parcels/ha)



Population Density (persons/ha)



Residential Tenure Breakdown



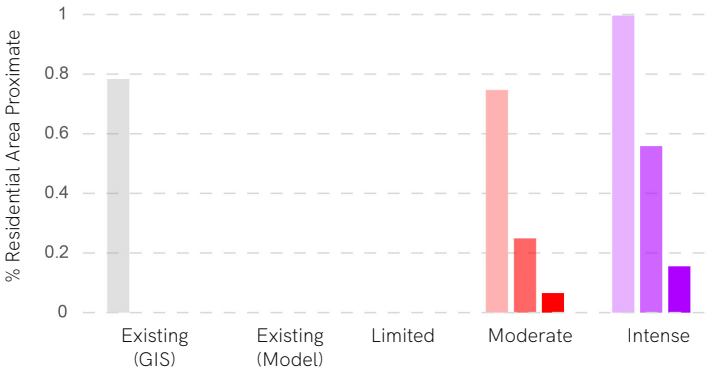
Proximity to Daily Needs

The 800m proximity buffers offer limited information regarding neighbourhood performance, as they easily consume the entire 1000m x 1000m model area. However, the 200m and 400m proximity buffers offer insight into the extent to which daily needs categories are affected by densification.

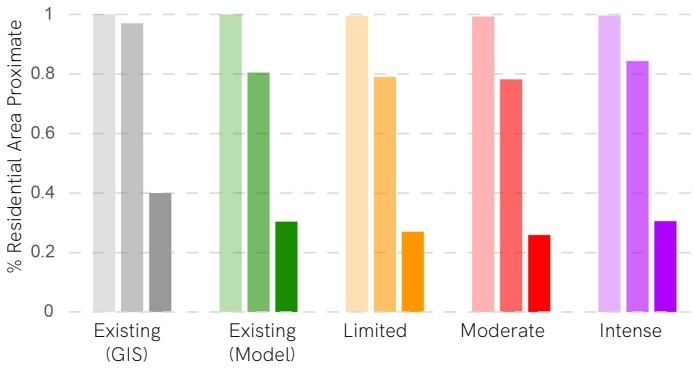
Proximity to retail, commercial, and grocery services is seen to be positively correlated with residential density. In contrast, proximity to greenspace sees a fractional decrease as the model is densified, as new buildings establish community hubs further away from greenspace.

Access to fequent transit and community facilities improves as new resources are introduced to the model in response to increasing density. These facilities are often located near community hubs, and are consequently highly responsive to concentrated approaches to densification. In contrast, schools are often dispersed throughout neighbourhoods, with many residences accessing schools in adjacent neighbourhoods (as calculated by placing points outside the model boundaries). As a result, proximity to schools is not easily increased through the densification of community hubs.

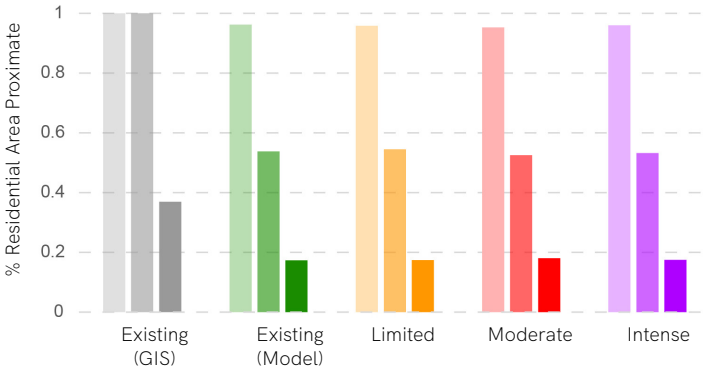
Frequent Transit



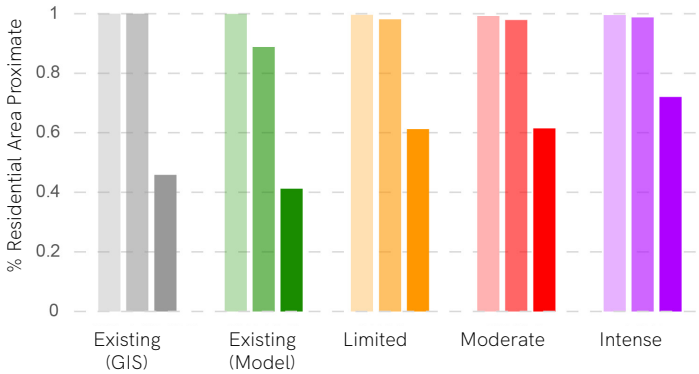
Child Care



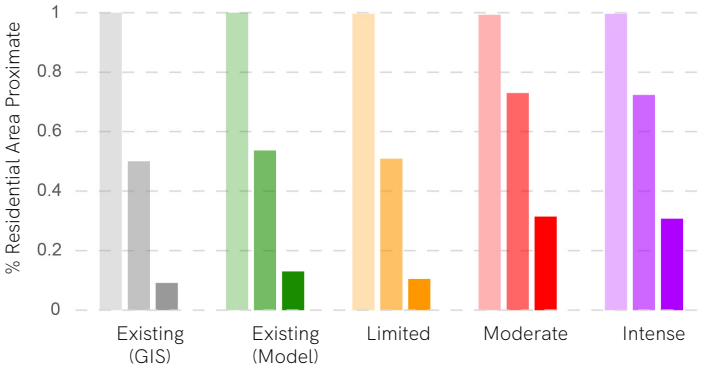
School



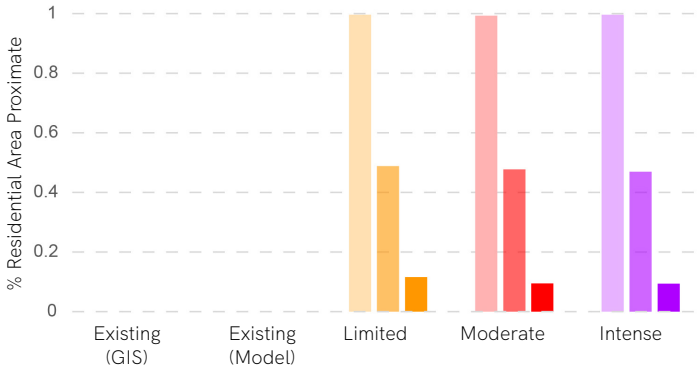
Retail & Commercial



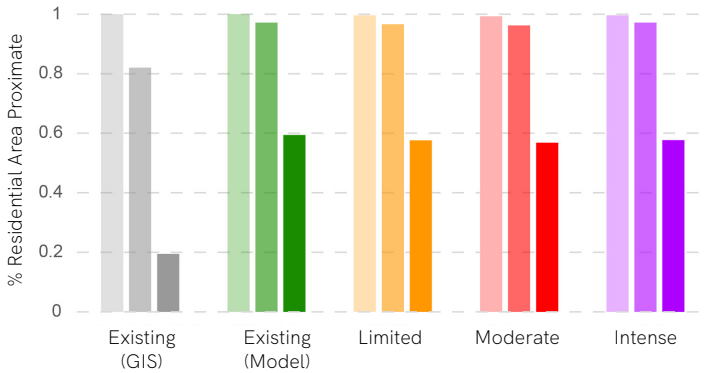
Grocery



Community Facility



Greenspace



Greenspace Proximity & Provision

While greenspaces maintain a high proximity score as the models are densified, the area of greenspace per capita for the existing-conditions model is nearly double that of the intensely densified model. This suggest that while densification may improve access, neighbourhood resources may lack capacity to accommodate the corresponding increase in demand.

Building Performance

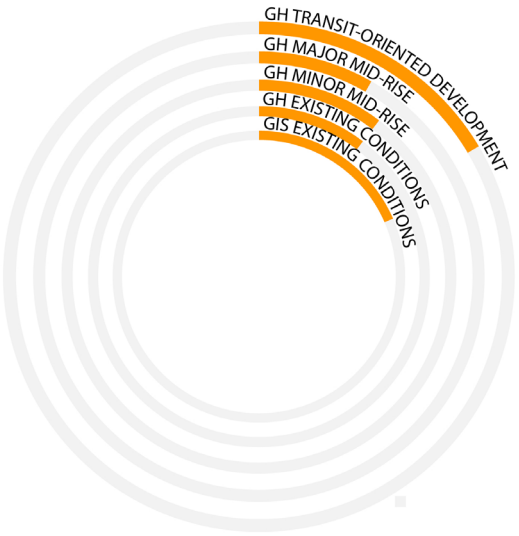
New buildings at or below six storeys in height may be eligible for light-frame wood construction, associated with lower levels of embodied carbon. Data derived from the model indicates that densification is negatively correlated with light-frame wood construction.

Right-of-Way Performance

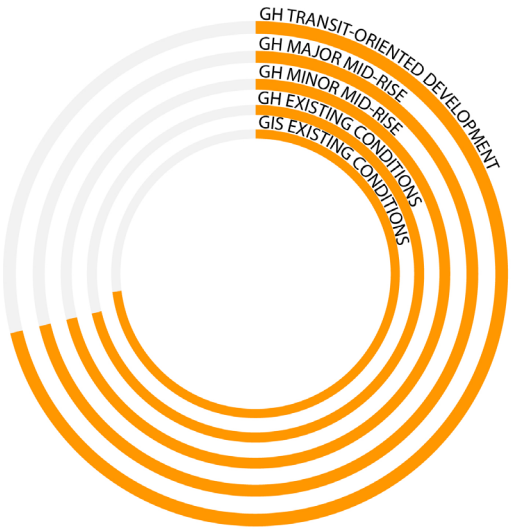
The percentage of residential area on arterials is not significantly altered by mid-rise development. Strategic placement of residences allows the moderate densification scenario to reduce the percentage of residential floor area on arterials in comparison to the existing conditions model.

Meanwhile, a high-density transit-oriented approach is seen to significantly increase residential floor area adjacent to arterials through the placement of towers on commercial corridors and intersections. However, the magnitude of this correlation may be overestimated by the current Grasshopper script, which does not provide a cut-off for storeys high above ground level where adjacency to an arterial has limitied impacts on livability.

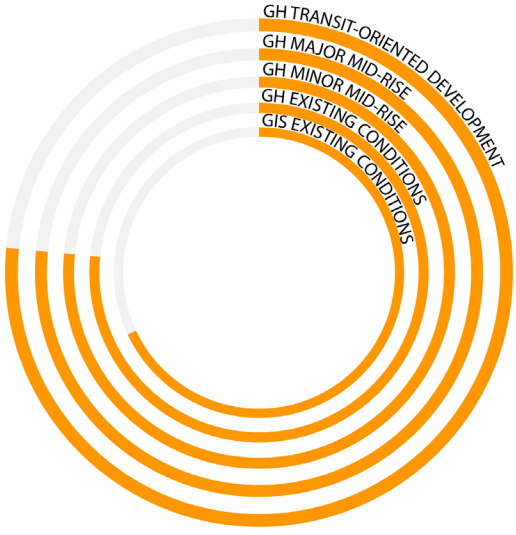
The tree canopy and effective impervious area values for the model remain unchanged regardless of densification, as steet trees and streets were not altered to accommodate densification in the model.



Residential Floorspace on Arterial

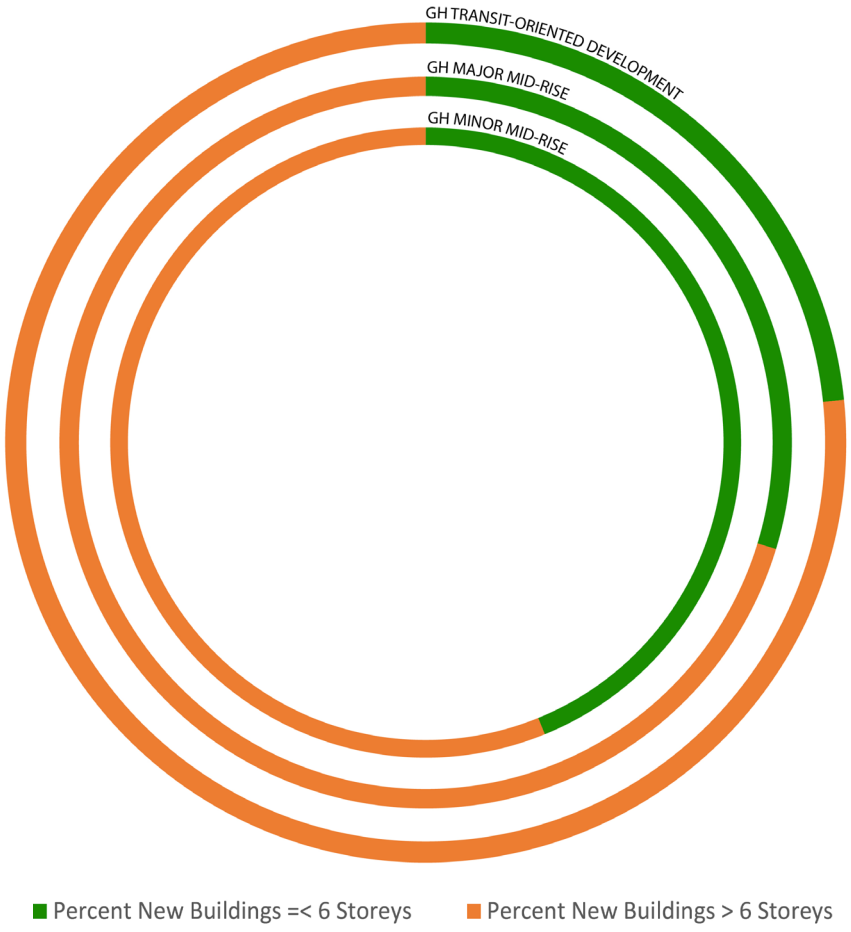


Right-of-Way Tree Canopy

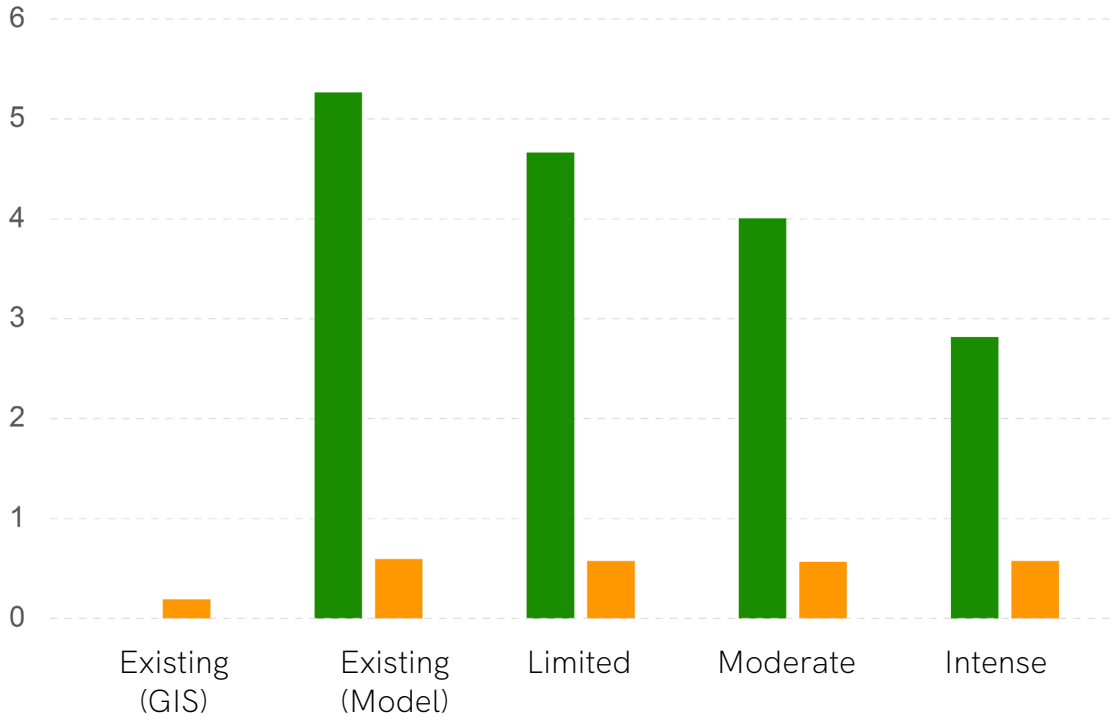


Right-of-Way Effective Impervious Area

New Buildings Less Than 7 Storeys (%)



Greenspace per Capita (ha) & Greenspace Proximity (%)



Summary

Typological Neighbourhood Evaluation

This pilot successfully derives quantitative data corresponding to holistic resilience indicators adapted from the RNDT for a set of projective growth models which are representative of an existing neighbourhood. The Vancouver-specific typological models allow for adjustments according to diverse municipal planning scenarios, balancing a need for generalized yet locally-specific quantitative data. Continued development of Grasshopper scripts and associated methodologies holds potential to further advance typological evaluation as a method towards holistic and quantitatively informed conversations regarding neighbourhood resilience planning.

Density & Livability

Typological evaluation offers insight into the complex relationship between urban density and livability. The correlation between density and livability indicators is often non-linear, and differs across indicators. For example, proximity indicators for concentrated and flexible community resources (e.g. retail) are improved through densification, while dispersed resources which may not be readily increased (e.g. greenspace) may lie outside of densifying neighbourhood hubs or encounter a lack of capacity in accommodating increasing demand. The typological evaluation method would benefit from continued development of Grasshopper scripts to quantify typically qualitative livability indicators which may be correlated with densification.

Intuitive & Rational Methodologies

The apporach to typological evaluation employed in this project combines intuitive and rational methodologies in studying quantitative neighbourhood data. This combined approach is reliable, yet adequately accessible to efficiently inform planning decisions. Importantly, the combined approach is supplemented by highly rational studies and specialized methods developed by research partners and other organizations. Continued use of a combined intuitive and rational approach alongside research collaborations would be appropriate as development of the typological evaluation method proceeds.

Recommendations

Sensitivity Testing

While this study develops and utilizes a method of sensitivity testing to ensure typological models correspond to an existing sample neighbourhood, the accuracy of typological evaluations may be improved through further refinement of this process. A reduction in the number and complexity of typological building models may facilitate this process, and adjustment of scripts to calculate population and tenure data such that they conform more closely to population growth assumptions is recommended.

Interface Accessibility

Grasshopper scripts which write to Excel require further development to promote readily workable data arrangements, and to enable reliable updating of spreadsheets when switching across models. Additionally, completion of all calculations in Grasshopper with minimal use of functions in the target Excel spreadsheet would simplify the evaluative workflow. Development of a user-friendly interface for the Grasshopper scripts may also increase accessibility of the typological evaluation process.

Proximity to Daily Needs

The calculation of proximity to daily needs should be adjusted to return a percentage of either floor area or population, as compared to the current percentage of discrete buildings within a buffer.

Additionally, the manual placement of reference points for community resources within the model should be carefully considered in future projects. This project has tested a limited set of intuitive placements as a proof-of-concept.

Model Scale

The 1000x1000m scale of the typological models present difficulties in assessing proximity indicators whose buffers easily consume the entire neighbourhood area. The development of larger models should be considered in future applications of this evaluative method, alongside the continued use of staggered buffer distances to derive supplementary insights regarding proximity indicators.

Densification Patterns

The models under consideration in this project represent increasing levels of densification concentrated around a neighbourhood centre. Further studies regarding the application of the typological evaluation method towards the assessment of alternative dispersed growth patterns are recommended.

Livability Indicators

The implementation of additional livability indicators correlated to neighbourhood density would improve the potential of typological evaluation to holistically inform complex planning decisions. In addition to the data presented in this report, the project has partially implemented building compactness and heat-gain Grasshopper scripts as potential livability indicators which may be completed in future.

Indigenous Resources

The typological evaluation method has potential to inform discussion regarding RNDT indicators which are specifically relevant to the wellbeing of Indigenous communities. This is a potential area for further development, which has remained beyond the scope of this pilot research project.

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