SPACES, PLACES AND POSSIBILITIES

Refining the Systems Model and Community Development Scenarios

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BACKGROUND

Places, Spaces and Possibilities is a research project led by Rob Newell of Royal Roads University, working in collaboration with Ian Picketts of Quest University Canada.[1] The project explores community planning tools that can provide comprehensive understanding of the implications of developing Squamish in different ways. It consists of two major outputs:

PHASE I Developing and using a systems model[2] and a series of community development scenarios to examine potential outcomes of developing Squamish in different ways

PHASE II Developing tools for communicating the community scenarios and model outcomes, namely an interactive tool for exploring model outcomes and realistic, interactive visualizations that show how the scenarios would appear in certain neighbourhoods

Phase I has been completed, and it consisted of four stages:

1. Designing a system model and community development scenarios based on discussions with local government and community stakeholders
2. Modelling outcomes of the community scenarios to gain insight on the social, economic and environmental implications of different community development approaches
3. Assessing the model's relevance and usefulness for planning through local government and community stakeholder feedback
4. Refining the community scenarios and systems model based on the feedback.

Previous reports have captured methods and results of the first three stages of Phase I listed above.[3,4] This report focuses on the fourth and final stage of Phase I the refinement of the model and scenarios. We expect to complete and report on Phase II in the fall of 2019.

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[1] We would also like to acknowledge the contributions of Professor Ann Dale of Royal Roads University.

[2] Systems modelling refers to the use of models to understand complex processes. In this project, the systems model maps relationships between development patterns/approaches and factors related to human and environmental well-being. The model and extensive data are used to quantitively estimate indicators associated with well-being.

[3] Newell, R., and Picketts, I.M. (2018). Spaces, Places and Possibilities: Summary of systems model and scenario development. Royal Roads University. https://www.crcresearch.org/sites/default/files/imce/robertgnewell/SpacesPlacesPossibilities-ScenarioDevelopment_May2018.pdf

[4] Newell, R., and Picketts, I.M. (2019). Summary of community systems modelling and focus group feedback. Royal Roads University. https://www.crcresearch.org/sites/default/files/imce/robertgnewell/SpacesPlacesPossibilities-ScenarioModelling_February2019.pdf

SYSTEMS MODEL AND COMMUNITY SCENARIOS

Systems and Community Scenarios Modelling

The systems model and community scenarios were developed based on discussions with local government and community stakeholders. These discussions occurred during a preliminary project scoping meeting with the District of Squamish's Community Planning and Infrastructure Department (March 2018), and a broader community stakeholder meeting, including people from non-profit, local government, business interests, development, public transportation, and academia (April 2018). A community systems model and five scenarios were developed following the discussions. These scenarios consisted of the following:

1. Low-density residential development
2. Concentrating densification on the downtown area
3. High-density neighbourhood node development
4. Medium-density development consisting of a mix of different housing types
5. Medium-density development, and developing on hills and slopes to reserve valley floor land for commercial and agricultural purposes

Scenario modelling involved the use of ArcGIS, and it involved three major steps:

1. *Developing baseline scenarios* – The current conditions in Squamish (i.e., population distribution, employment, services and amenities, green spaces, etc.) were mapped using data primarily retrieved from the Statistics Canada 2016 Census and the Squamish Open Data Portal, and this served as a "Current Baseline" scenario. New residential, commercial and other forms of development were added based on planned development (as per the Squamish Development Showcase Map), and this served as a "Future Baseline" scenario.
2. *Building community development scenarios* – The five community scenarios were built upon the Future Baseline. These scenarios used a medium growth population projection, which estimates Squamish's population will be 34,000 by 2036.[5] The Future Baseline scenario can accommodate 29,920 people, and thus scenario modelling involved distributing approximately 4,100 people around the community in different ways. Based on discussions in the preliminary scoping meeting, the building of the scenarios and distribution of the population focused on three neighbourhoods in particular: Loggers East, Garibaldi Estates, and Dentville.
3. *Modelling community outcomes* – The relationships and elements in the systems model informed what and how community outcomes should be measured in a quantitative modelling exercise. A review of academic and grey literature identified a series of measurement methods,[6] and these were applied to measure relevant outcomes and indicators for each of the scenarios.

[5] District of Squamish (2017). District of Squamish OCP Update. Phase 3: Community engagement summary report. https://squamish.ca/assets/OCP-Review/Phase-3-Engagement-Summary-FINAL-with-ADDENDA-Sep7.pdf

[6] For more information on these methods, see Newell and Picketts's (2019) report: Summary of community systems modelling and focus group feedback. https://www.crcresearch.org/sites/default/files/imce/robertgnewell/SpacesPlacesPossibilities-ScenarioModelling_February2019.pdf

Focus Group Feedback and Refinement of the Systems Model and Scenarios

Another focus group consisting of local government and community stakeholders was held in In October 2018 to gain feedback on the results of the modelling exercise. Some of the participants were involved in the previous focus group session and some were new to the project. Following the focus group, further feedback was obtained through meetings with the District of Squamish's Community Planning and Infrastructure Department and BC Transit. Several themes with important implications for refining and using the model as a tool for public engagement and planning were identified from this feedback, and the model and scenarios were refined accordingly. The themes and actions employed for refining the model and scenarios are discussed below:

Rethink what density means in terms of building heights – The mixed-use developments modelled in the high-density scenarios were 8 to 10 storeys tall; however, it was noted that this was beyond what would be considered "acceptable" in Squamish. In the refined scenarios, building heights do not exceed 6 storeys and follow a more gradual gradient from high to low density residential buildings.

Redesign the low-density scenario with a different sprawl pattern – The low-density residential scenario depicted sprawl extending upward through Paradise Valley; however, it was noted such growth in the floodplain is unlikely. The refined low-density scenario models a more realistic sprawl pattern, involving development east and northeast from Garibaldi Highlands.

Combine the high-density scenarios to create a single "density node" scenario – It was noted that the high-density scenario should involve a combination of the scenarios focused on concentrating densification on the downtown area and the high-density neighbourhood nodes. The refined scenarios include this combination, and it involves further densification of the downtown core in addition to neighbourhood densification.

Incorporate conservation and ecological values – A frequent topic of discussion in the focus group was how the model lacked ecological concerns and conservation values. In response to this feedback, new elements have been added to the systems model, including encroachment on habitat and riparian connectivity for species-at-risk such as the Pacific Water Shrew and the Northern Red-legged Frog. In addition, some scenarios were developed with greater sensitivity to local habitat in order to reflect how ecological values could/would be incorporated into land-use planning. In particular, the mapping of the scenarios in Loggers East was done in a manner that avoids heavy development in the riparian corridor. The potential of including ecosystem services related to carbon sinks was also discussed in the focus group, and accordingly, the model now includes the loss of stored carbon and sequestration due to the development of natural spaces.

Consider how technological and economic trends may influence community outcomes – The modelling exercise projects two decades into the future, and it was discussed that certain trends may affect the estimated outcomes. The model explorer will identify some of these trends and how they relate to model uncertainty; however, the refined model has also incorporated trends such as the effects of increasing housing prices on affordability.

Incorporate climate adaptation into the model – Focus group feedback included comments on climate adaptation planning, in particular flood and wildfire management. The refined model includes climate adaptation considerations, such as the percentage of population living in the floodplain below an elevation of 5m[7] and the amount of residential space (and residents) located within a 30m buffer of wildfire fuel[8] (i.e., forests).

Add more planned or "likely" infrastructure – It was noted that the scenarios could incorporate more schools and transit routes to better represent likely future conditions in Squamish. An elementary school was added in Paradise Valley to reflect plans for the area.[9] In addition, transit routes were extended (and bus stops were added) so that the main downtown bus exchange is in the Oceanfront neighbourhood and buses also run through Waterfront Landing and Scotts Crescent. The "Loggers East route" that was added to the original scenarios was altered as well, and in the refined scenarios, it travels into the neighbourhood rather than just down Loggers Lane (as was previously modelled).

Illustrate the key differences between development directions – Focus group feedback indicated that it was somewhat challenging to see the differences between the scenarios when looking at the model outcomes. This is largely a function of our decision to use a moderate population growth estimate for each scenario, which means that only the growth beyond the future baseline (approximately 4,100 people) differs between the scenarios. The interactive model explorer will be a useful tool for highlighting these differences; however, it is also worth noting that the refined scenarios consist of only three rather five scenarios. Reducing the number of scenarios makes the model simpler, thus allowing for clearer communication of the "stories" and outcomes associated with different development directions. In addition, some of calculation methods have changed to better capture differences between scenarios.[10]

Consider what community development scenarios mean when implemented on the ground – Showing the extent of neighbourhood development and redevelopment in the scenarios through maps was noted to be a useful. To highlight this model outcome, total areas of new development and redevelopment (i.e., development compared to Current Baseline) are now given as model outputs, and users of the model explorer will be able to see these values alongside the maps for each of the respective community scenarios.

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[7] District of Squamish (2016). Zoning Bylaw Update 2016. https://squamish.ca/yourgovernment/projects-and-initiatives/completed-projects/2016-completed-projects/zoningupdate2016/

[8] FireSmart Canada (2018). Wildfire Exposure Assessment: A planning tool for identifying values at risk and prioritizing mitigation effort. FireSmart Canada, University of Alberta, and Alberta Wildfire Management Branch. https://www.firesmartcanada.ca/images/uploads/resources/FS_ExposureAssessment_Sept2018.pdf

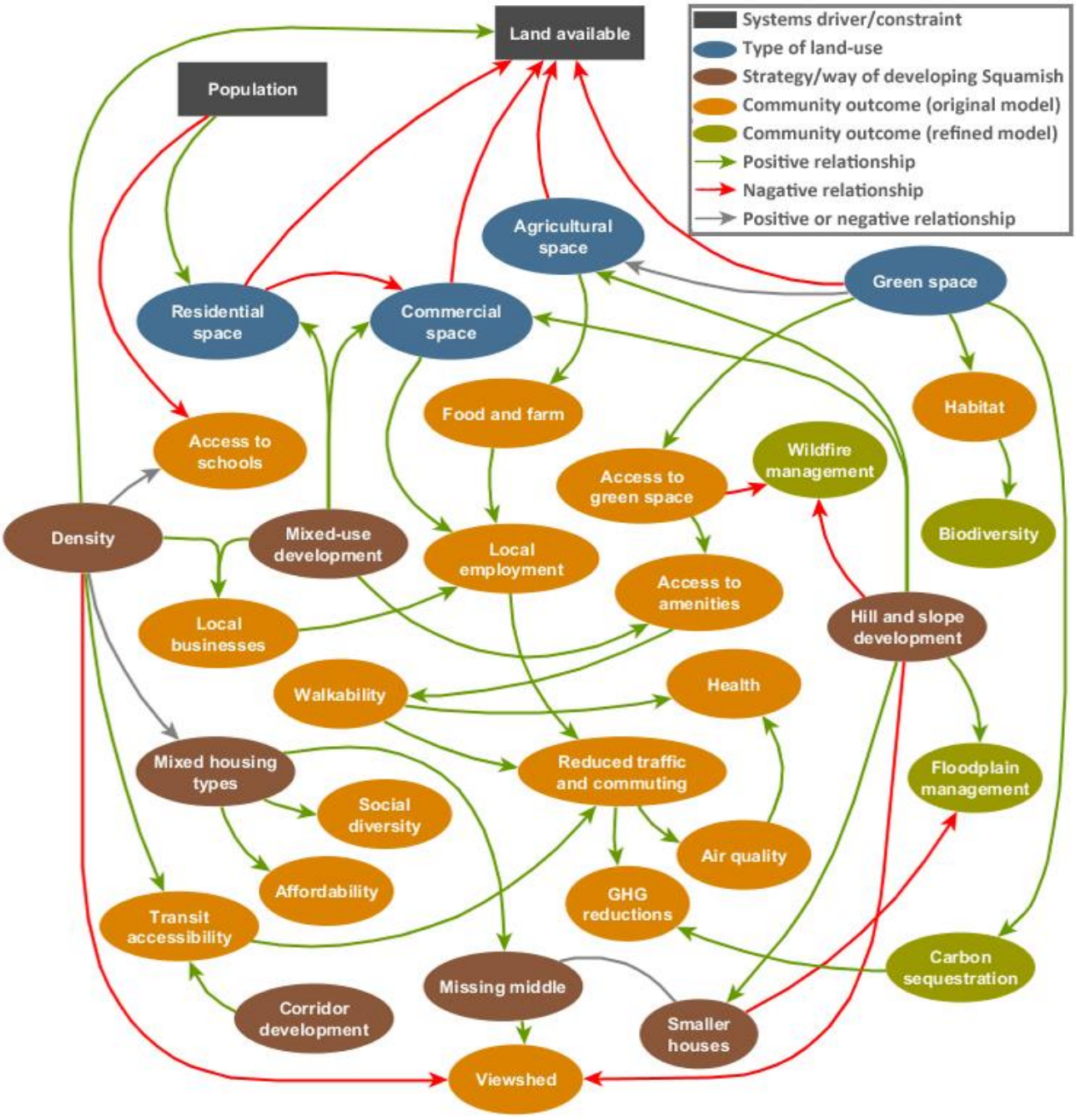
[9] Some future school sites discussed during the focus group were not added to the scenarios because they were either contingent on new residential developments that were not modelled (e.g., Cheekeye Fan and Cheema Lands) or no information could be found on the plans to build the school (e.g., Quest University).

[10] For example, commuting by walking and biking was originally calculated using distance intervals where a percentage of commuters were expected to walk/bike if their commute falls within a certain interval. The refined model instead uses commuting-distance curves that more accurately model relationships between distance of commute and percentage of trips done via active transportation.

Refined Systems Model

Elements and relationships were added to the systems model, and these resulted in new model outcomes such as wildfire management, floodplain management, biodiversity and carbon sequestration. These outcomes were measured by (respectively speaking) calculating population living near wildfire fuel (i.e., wood, forests), population living in low-elevation floodplain, residential encroachment on species-at-risk habitat (i.e., Pacific Water Shrew and Northern Red-legged Frog), and loss of stored carbon and annual uptake of carbon dioxide due to developing natural areas that serve as carbon sinks. An interesting trade-off can be observed between the wildfire and floodplain management outcomes when applying the model to Squamish context because developing in hill and slope areas move people out of the floodplain but places them in closer proximity to forests.

Figure 1. *Refined integrated systems model for examining community scenarios*



Refined Community Scenarios

Scenario refinement resulted in three community scenarios, which combined elements of the original five but (somewhat) differed in terms of building types and development patterns. As with original modelling exercise, each scenario targeted a population of 34,000 and the Future Baseline accommodates 29,920 people; thus, scenario modelling involved distributing population in a community where 88% of people (i.e., 29,920 out of 34,000) are already established.

As noted in the *Systems and Community Scenarios Modelling* section, population distribution in the original community scenarios primarily focused on the neighbourhoods of Loggers East, Garibaldi Estates, and Dentville. The refined scenarios took a similar approach in how they also involved distributing the projected population that is not accommodated by the Future Baseline throughout these three neighbourhoods in different ways. However, as per the focus group feedback, some of the scenarios also involved increasing density in the downtown area, and thus the downtown population varied depending on the scenario. Table 1 displays the local neighbourhood populations for the refined scenarios, and detailed descriptions of these scenarios are given in the sections below.

Table 1. *Squamish and local neighbourhood populations for different community scenarios*

Scenario	Squamish	Loggers East	Dentville	Garibaldi Estates	Garibaldi and East Highlands[11]	Downtown[12]
Current baseline	19,608	213	1,391	1,182	3,947	2,261
Future baseline	29,920	796	1,829	1,450	4,252	6,193
High-density neighbourhood nodes	34,013	1741	2,303	3,437	4,252	6,880
Medium-density and increased agriculture	34,013	1230	2,372	4,181	4,270	6,569
Low-density residential development	34,001	796	1,829	1,450	8,333	6,193

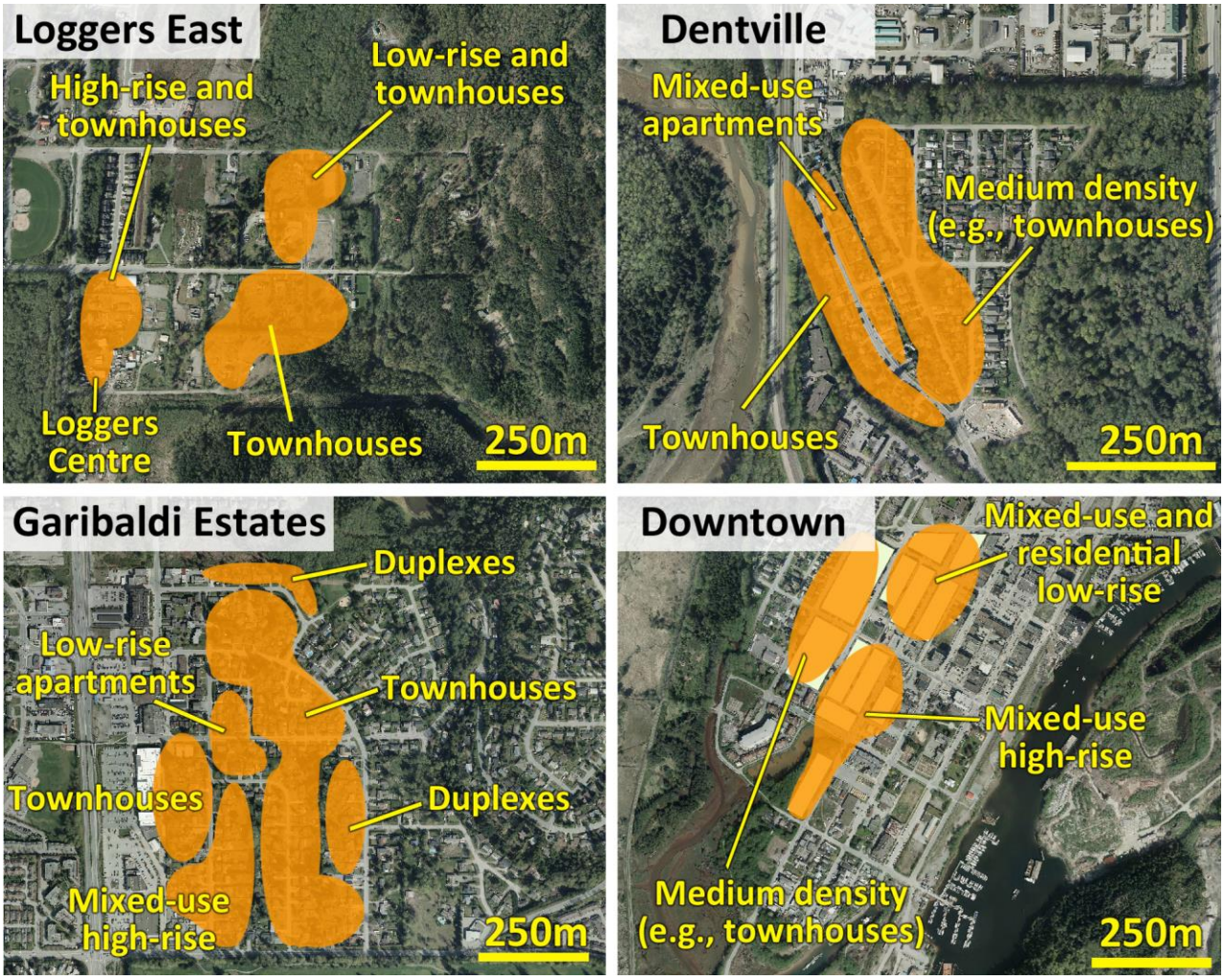
[11] "East Highlands" refers to the area north and northeast of Garibaldi Highlands, which was populated with single-detached housing in the Low-density Residential Development scenario.

[12] Populations in downtown for the Current Baseline and Future Baseline scenarios are different from those presented in the previous report because Waterfront Landing was previously included in this calculation but has been excluded here. It has been excluded to better represent the downtown area as a cohesive neighbourhood unit in terms of geographical boundaries, densification approach and transit service.

High-density neighbourhood nodes – This scenario combined aspects of the original scenarios that involved densifying neighbourhoods and downtown. Loggers East, Dentville, and Garibaldi Estates were redeveloped as high-density walkable neighbourhood communities with local amenities, and development was placed toward transit lines to increase transit access and viability. Densification redevelopment was also done downtown, where new mixed-use apartment, townhouses and duplexes were added. Buildings did not exceed 6 storeys, and densification followed a gradient from 6-storey buildings to low-rise apartments to medium density (e.g., townhouses, duplexes).

This scenario includes the most commercial space of all three, and thus it also captures the commercial aspect of the original commercial and agricultural enhancement scenario. Mixed-used buildings were added to Loggers East, Dentville, Garibaldi Estates, and downtown, and Loggers East includes a "Loggers Centre" mixed-use building that is primarily commercial. A park and community garden were also added to Loggers East for the increased local population, and these were placed under the transmission line (which is acceptable land use in transmission corridors[13]). It is worth noting that the scenario was designed specifically to minimize encroachment on riparian habitat.

Figure 2. *Development patterns for the high-density neighbourhood node scenario*

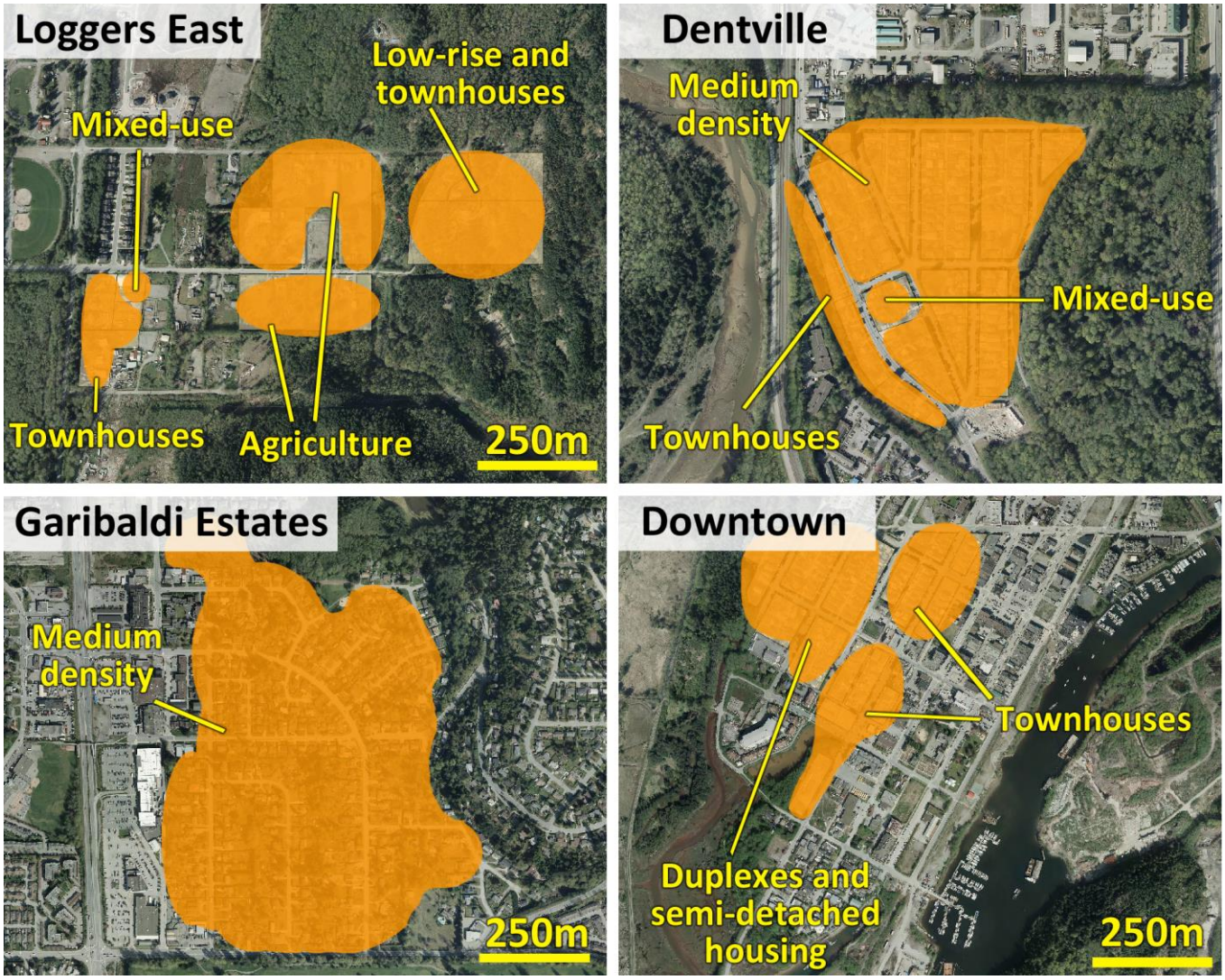


[13] BC Hydro (2017). BC Hydro rights of way guidelines: Compatible uses and development near power lines. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/safety/row-guidelines-2017.pdf

Medium-density and increased agriculture – This scenario combined elements of the original medium density and agricultural enhancement scenarios, and it aimed to densify while both maintaining "small town" character and increasing agricultural space. Dentville, Garibaldi Estates, and single-detached housing areas of downtown were redeveloped to follow a "missing middle" residential form, which consists of a mix of duplexes, fourplexes, multiplexes, townhouses, bungalow court and semi-detached houses. Some commercial space was added (e.g., a mixed-use building in Dentville); however, most of the development in these neighbourhoods was comprised of residential buildings.

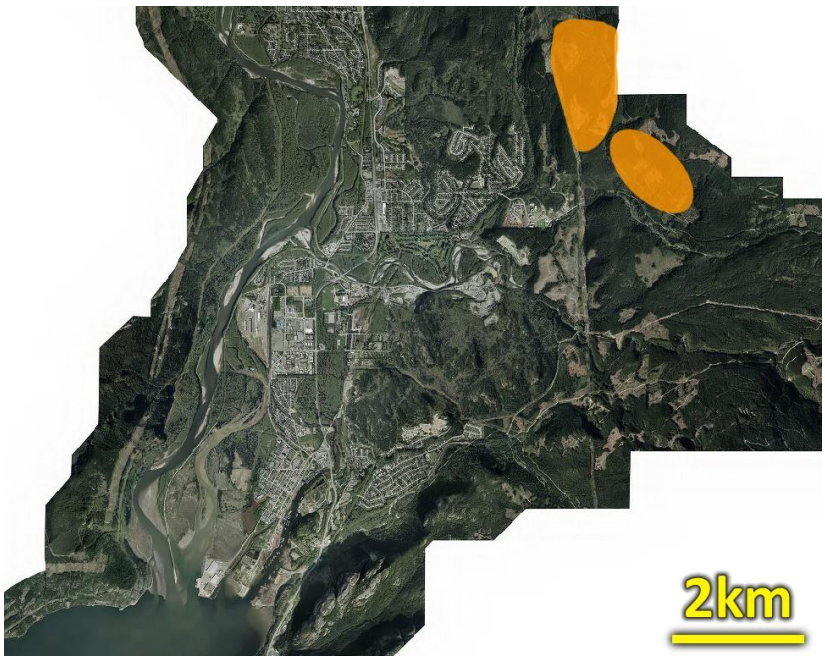
The Loggers East was developed in a different manner to the other neighbourhoods. Much of the valley floor in the neighbourhood was designated for small-scale agriculture. A few townhouses and a mixed-use building were added near Loggers Lane, but most residential development was done on sloped/hilly parcels, following a density similar to the Skyridge development (i.e., low-rise and townhouses). The Loggers East park that was added to the high-density scenario was also included in this scenario, but because this scenario involves a lower population density in Loggers East, the local community garden was not included.

Figure 3. *Development patterns for the medium-density and increased agriculture scenario*



Low-density residential development - This scenario is similar to the low-density scenario in the original modelling exercise in how all dwellings built beyond the Future Baseline were single-detached units; however, the development patterns differ. Instead of developing parcels northward up Paradise Valley (as done in the original exercise), the refined low-density scenario models residential development outside the District of Squamish's growth management (and municipal) boundaries in areas east and northeast of the Garibaldi Highlands. Residential development added to this area assumed a density of 6.2 units per hectare, which falls between the densities of Garibaldi Highlands and Crumpet Woods. The scenario focuses primarily on residential development, and no commercial, parks, gardens or other amenities were added beyond the Future Baseline.

Figure 4. *Development patterns for the low-density residential development scenario*



Modelling Outcomes

As with the first modelling exercise, extensive output was produced through the scenario modelling work, and this report only features a sample that is representative of each of the major community outcomes seen in the systems model (see Figure 1). The full set model outcomes will be available through the model explorer.

The high-density and medium-density scenarios showed similar trends with several of the model outcomes, such as transit accessibility/viability, user density around local parks, pressure on wildlife habitat, and living within floodplain and wildfire zones. This is perhaps unsurprising as both scenarios follow a similar distribution of population, and more dramatic differences can be seen with the low-density scenario that involves a significantly different development pattern (i.e., developing land outside of growth management boundaries). However, this being said, some differences can be seen between the high and medium density scenarios, particularly in terms of outcomes that relate to local commercial development and residential density around commercial areas, such as business viability, commuting by walking/biking, and vehicle-based emissions.

Table 2. *Sample of scenario modelling output for different community outcomes*

Community outcome	Community outcome variable (Example of model output)	High-density neighbourhood nodes	Medium-density and increased agriculture	Low-density residential development
Extent of development	Total additional residential area developed/redeveloped (ha)	162	180	338
Walkability	Population (%) can access four amenities[14] within 400m	30	26	17
Access to schools	Student body capacity (%) at Squamish Elementary	298	280	248
Access to green space	Park user density based on residents living within 800m (people/ha)[15]	1,610	1,538	501
Biodiversity and wildlife habitat	Residential pressure on species-at-risk[16] habitat (people x ha developed within 100m)	24,386	24,114	37,890
Transit accessibility	Bus stops (%) within 400m of transit supportive density (50 [people + jobs]/ha)	15	15	8
Reduced commuting	Total annual commuted distances (million VKT/year)	117	128	133
GHG emissions	CO_2e emissions produced through commuting (t/year)	30,695	33,535	35,043
Air quality	$PM_{2.5}$ emissions produced through commuting (kg/year)	712	778	813
Health	Average daily commutes by walking or biking (trips)	1,085	900	735
Food and farm systems	Change in actively farmed land from current conditions (%)	-2	15	0
Local businesses viability	Local business employees within walkable area (400m radius) of 25 people/ha density	1,642	1,326	921
Local employment	Home-based and locally employed residents (people)	11,640	10,954	10,870
Social diversity	Diversity of housing types within neighbourhoods (Simpson Index)	0.62	0.63	0.53
Affordability	Average prices for dwellings projected using 10-year trends[17] ($)	1,351,000	1,400,000	1,450,000
Floodplain management	Population residing in areas below 5m elevation (%)	33	32	27
Wildfire management	Population residing within 30m of wildfire fuel (%)	35	34	44
Carbon sequestration	Loss of carbon dioxide (equivalent) uptake from land clearing (t/year)	33.3	40.9	304.6

[14] Nine amenities were considered: restaurants/cafes, retail (non-food), health, social and mental health, exercise, childcare, grocery, parks and trails, and elementary schools.

[15] "Park user density" is a measure that captures residential distribution around parks of different sizes. It gives a hypothetical user density that would occur if all residents within a half mile walking distance of a local park decide to visit it at the same time. The user density is reduced when residents have walking access to multiple parks.

[16] "Species-at-risk" in this modelling exercise refers to the Pacific Water Shrew and Northern Red-legged Frog.

[17] Averages prices for dwellings are rounded to the nearest thousand. Projections are based on 10-year trends of benchmark prices for different housing types. 10-year trends were used rather than 20-year trends due to availability of reliable data.

INTERACTIVE MODEL EXPLORER AND VISUALIZATION

Model Explorer

The next stage of the project will involve developing an interactive user interface for exploring model outcomes. This "model explorer" will be an HTML5-based tool that will be available to the public online, and it will allow users to explore the system model, scenario maps, and modelling outcomes. In addition, based on comments made during the focus group, the explorer will include features and supplementary information that will enhance the users' understanding of the implications of the different scenarios and the model's outputs, assumptions, and uncertainties. Some of these features have already been discussed in the *Focus Group Feedback and Refinement of the Systems Model and Scenarios* section; however, there are two additional ideas that emerged from the focus group that will inform the development of the model explorer:

Communicate model assumptions and outcomes more clearly – Some focus group comments indicated that it was challenging to get a clear sense of all the assumptions and inputs used to create the model. The model explorer will allow users to access information on methods used to calculate the model outcomes, factors contributing to variation, sensitivity to changes in parameters (for example, what is considered to be "walking distance"), model limitations, and sources of uncertainty. In addition, the model explorer will highlight and give detail on where significant differences can be seen between the scenarios, as well as provide some discussion and ideas on the implications of these differences.

Link the model to the Squamish's Official Community Plan – The potential to link the model to indicators and targets identified through Squamish's Official Community Plan[18] was discussed, and it was mentioned that doing so would increase the relevance of the model to the community's planning goals and needs. Such information will be incorporated into the interactive model explorer tool, and relevant indicators and targets will be displayed alongside the different model outcomes in the model explorer.

Visualization

Interactive visualizations will be created for Garibaldi Estates and (if time permits) Loggers East. The Garibaldi Estates visualization will allow users to walk around the block bordered by Diamond Head Road, Kalodon Road, and Mamquam Road. The Loggers East visualization will allow users to walk around an area bordered by Loggers Lane, Finch Drive, Robin Drive, and the transmission corridor. These particular areas were selected for visualization because they are reasonable in scope and will provide a decent impression of differences between scenarios.

The visualizations will be developed throughout the summer with the help of two research assistants. A final focus group will be assembled in the fall of 2019, where we will use and discuss the model explorer and visualization tools.

[18] District of Squamish (2017). Squamish 2040: Official Community Plan Schedule "A". Bylaw 2500. https://issuu.com/squamish/docs/ocp_dec_1_first_reading