Spaces, Places and Possibilities: A participatory approach for developing and using integrated models for community planning

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Integrated models can support community planning efforts because they have the ability to elucidate social, economic and environmental relationships and outcomes associated with local development plans and strategies. However, deciding what to include in an integrated model presents a significant challenge, as including all aspects of a community and local environment is unfeasible, whereas including too few aspects leads to a non-representative model. This research aimed to address this challenge by incorporating community participation in an integrated modelling effort in Squamish (BC, Canada). The research consisted of four stages: (1) designing the model and community scenarios (i.e., different community development patterns), (2) modelling the scenarios, (3) evaluating the model through community focus groups, and (4) refining the model and scenario based on the feedback. The first stage involved assembling a local government and community stakeholder focus group to discuss issues and possible futures for Squamish. Analysis of focus group data informed the design of a community systems model and local development scenarios. The second stage applied the systems model to examine potential outcomes of the scenarios. Modelling primarily used ArcGIS and R, and explored a variety of factors including access to amenities and education, walkability, parks/trails, food and farm systems, public transit, housing affordability, threats to critical habitat, etc. The third and fourth stage involved another focus group to solicit feedback on the model and scenarios, and then refinement based on the feedback. The research found the participatory approach to beneficial for creating community planning tools that are relevant to local contexts and needs. It is important to develop these tools through iterative processes, where they are refined through multiple stages of feedback by a variety of actors, to better capture the local 'reality' of a place.

1. Introduction

Effective community planning is an inherently interdisciplinary and iterative process. Local government must continually work with practitioners and stakeholders to determine how to develop their community in a manner that reconciles ecological, socio-cultural and economic objectives. The consideration, or attainment, of these three objectives in concert is often referred to as 'sustainability' or 'sustainable development' (Dale, 2001). Models can support planning efforts by helping decision-makers understand the implications of different land-use decisions or development pathways (e.g., Eluru et al., 2008; Frank et al., 2009; Salvini and Miller, 2005;

Sperling and Berke, 2017; Wagner and Wegener, 2007). Planners can use these tools to understand (often quantifiably) how different options or 'scenarios' achieve or conflict with sustainability goals (Amer et al., 2013).

Strictly speaking, a model is an abstract representation of a complex phenomenon. Systems models are particularly useful for representing complexity, as they display elements and their interrelationships in a way that gives perspective on the entire system (Checkland, 1983). For example, a climate systems model can compute atmospheric, oceanic, cryospheric and terrestrial components (as well as the exchanges between these components) to project future conditions under various greenhouse gas emissions scenarios (Collins et al., 2006). Examples of systems models in planning include models of processes associate with burn management (e.g., Prell et al., 2017), and food and farm development (Woodward et al., 2008)

Systems thinking can be employed in integrated modelling efforts, that is, an integrated approach to modelling adds to scientific underpinnings by incorporating a wider range of factors, and it must be responsive to ongoing feedback (Gabor et al., 2008). The defining characteristic of integrated models is their ability to incorporate multiple social, economic and/or environmental considerations. Because of these attributes, integrated models can be a highly effective tool in community planning, and they have shown promise for different local decisions, such as transportation development (e.g., Bargh et al., 2012) and climate change adaptation (e.g., Picketts et al., 2012). There are several commonalities between the terms 'integrated and 'sustainable', and they are sometimes used interchangeably.

A major challenge with systems and integrated modelling is creating a representative and useful model, while also maintaining a reasonable scope of work (Newell et al., In review). While there are multiple urban systems modelling tools that can be used to guide local planning and decision-making, such models are often limited in scope as they focus on particular factors such as transportation, land-use, energy and/or greenhouse gas emissions (e.g., Eluru et al., 2008; Frank et al., 2009; Wagner and Wegener, 2007). Although insight into these sectors is useful for planning, questions remain whether the models have integrated the 'right things'. Some argue scoping of model is best done in close partnership with the people who will affected by planning decisions, specifically local stakeholders (e.g., Meliadou et al., 2012; Prell et al., 2007; Woodward et al., 2008). Stakeholder participation is an essential component of community planning, as it ensures a plan is grounded in local realities and social, cultural, political, economic and environmental contexts (Ling et al., 2009), and this approach to modelling aligns with this thinking.

This paper reports on study that employs a participatory process for developing an integrated modelling tool for community planning. This paper builds on previous work that developed a systems model and scenarios, and focuses on developing an integrated model and refining it through participatory processes.[1] It is important to note that this paper differentiates between 'systems models' and 'integrated models'. In this work, the former term refers the conceptual model that provided the structure for scenario modelling exercise, and the latter refers to the computational model. Other studies have taken similar approaches that first involve 'mapping' out

[1] More information on the full research project can be found on its webpage: https://www.crcresearch.org/spaces-places-and-possibilities

systems and then building an integrated model based on systems elements and relationships (e.g., Almeida et al., 2009). However, researchers have also presented systems models as computational tools for integrated analyses, without distinguishing between the terms (e.g., Kelly et al., 2013).

2. Materials and Methods

2.1 Study site

The District of Squamish (population 20,000) is situated in southwestern British Columbia (BC), Canada, approximately 50 kilometers north of the City of Vancouver on the traditional territory of the Squamish First Nation peoples. The region has a complex geography, being located at the terminus of Howe Sound at the Pacific Ocean and in the Coast Mountain range. The geography constrains growth and increases natural hazards, and also provides a wealth of recreational opportunities and viewsheds. Squamish is currently experiencing rapid population growth, largely due to its proximity to Vancouver.

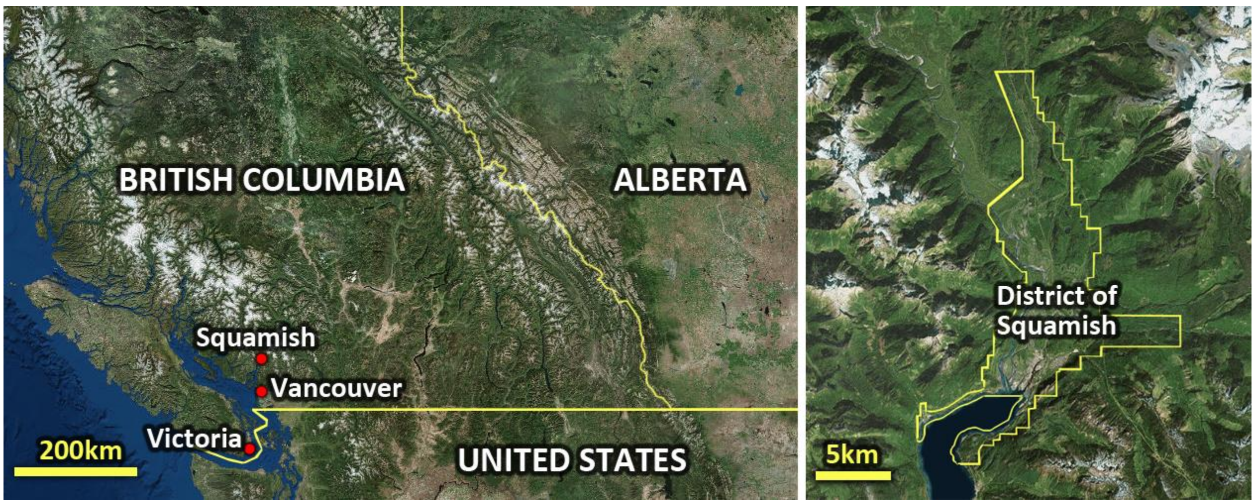

Figure 1. Location and map of Squamish (Souce: iMapBC, Province of British Columbia)

2.2 Systems model and scenario development

The systems model and community scenarios were developed through two focus groups. The first focus group engaged the District of Squamish's Community Planning and Infrastructure Department to provide scope and direction for the project. Main objectives of the session were to discuss local planning challenges, identify neighbourhoods of particular interest in terms of future development planning, and generate ideas for possible community development scenarios. Following the meeting, four scenario ideas were identified that captured multiple variables but were primarily defined through density.

The scenario ideas provided a useful 'starting point' for further scenario development, and this was done through a second focus group. The second group consisted of people who represented a range of community sectors and interests, including non-profit, local government, business interests, development, public transportation, and academia. The focus group discussions led to a systems model and finalized the community scenarios that were subsequently used for the scenario modeling exercise. More details can be found in Newell and Picketts (2018) and Newell et al. (Preprint).

2.3 Scenario modelling

Scenario modelling was done using an integrated model that was custom built to interrogate the relationships and elements featured in the systems model. The integrated model primarily used ArcGIS and R statistical software, and these programs were selected because (1) they are accessible to local governments, thereby increasing the model's usefulness as a community planning tool, and (2) they allow for a flexible modelling tool that can be easily changed/refined based on community input. The modelling process consisted of developing baseline scenarios, building community development scenarios upon the baselines, and modelling community outcomes using the integrated model.

2.3.1 Baseline scenarios

Two baseline scenarios were mapped in ArcMap, and the first baseline captured 'current conditions' in Squamish in terms of how the population and businesses are distributed. Using Statistics Canada 2016 Census data and the District of Squamish's GIS data, residents were distributed throughout the community, according to average household sizes of the Census dwelling classifications: single-detached, duplex townhouse, apartment in building of five storeys or more, apartment in building less than five storeys, mobile dwelling unit, and other attached units (e.g., a single dwelling attached to a non-residential structure). Business, services and other places of employment were then distributed throughout Squamish using GIS data on business licenses, schools and other employment locations. Employee numbers for these organizations/institutions were estimated using 2017 Business Registrar data.

The second baseline scenario modelled what the 'future conditions' in Squamish would be after building all approved residential and commercial developments. Residential development was added to the first baseline scenario in accordance with approved development in Squamish (District of Squamish, n.d.), and population growth was distributed throughout these new dwellings. New employment was also added based on both planned commercial development and potential developments identified through Squamish's Employment Land Strategy (District of Squamish, 2015).

Road and path networks were added to the baseline scenarios, and two networks were added to each scenario: only roads and both roads and paths. Adding both networks was necessary to ensure that the model can calculate (and differentiate between) travel by walking/cycling (i.e., roads and paths) and driving (i.e., only roads). New roads, paths and implied transit networks and bus stops were added to the future conditions baseline using publicly available plans for new developments.

Green space and park access points GIS data were added to the baseline scenarios, and new parks and access points were added to the future conditions baseline in accordance with development plans. The baseline scenarios also included agricultural land, and this was added using Squamish's Agricultural Land Inventory (BC Ministry of Agriculture, 2018). Agricultural land was classified using six categories: currently farmed, available for farming, agricultural support (e.g., farm buildings), limited farming potential (due to geographical constraints), community gardens, and unavailable for farming.

2.3.2 Community development scenarios

Community development scenarios were built upon the future conditions baseline. Each scenario targeted a population of (roughly) 34,000, based on a medium growth projection given by the District of Squamish (2017) that estimates this population level will be reached by 2036. The future conditions scenario can accommodate approximately 29,900 people, and thus scenario modelling involved distributing 4,100 people around the community in different ways (Figure 2), particularly in neighbourhoods identified in the first focus group as place of interests for future development planning

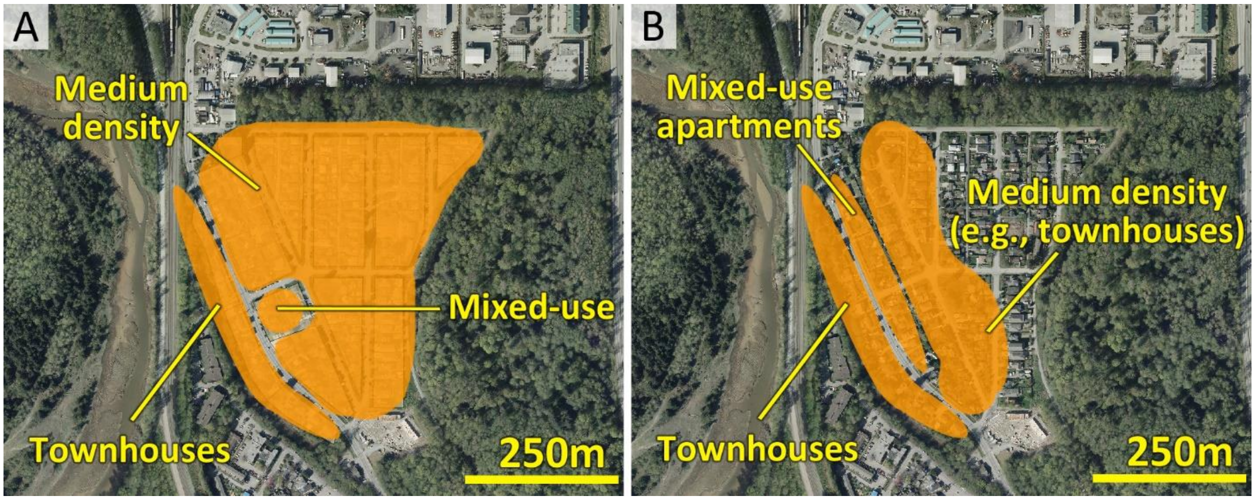

Figure 2. Squamish neighbourhood featuring maps of (A) medium-density and (B) high-density community scenarios.

2.4 Indicators and model outcomes

As noted above, a systems model was developed based on local government and community stakeholder discussions, and this model provided guidance on what should be measured (and how) in an integrated modelling exercise. Through a review of academic and grey literature, a series of measurement methods that identified model outcomes. These were subsequently calculated using a combination of ArcGIS-based tools created using ModelBuilder and R scripts. The workflow involved first running the ArcGIS tools on the mapped scenarios, and then importing this output into R to run scripts and calculate model outcomes.

2.5 Model evaluation

Another third focus group of local government and community stakeholders was assembled to gain feedback on the modelling exercise. The group consisted of 15 participants, and approximately half (i.e., 47%) were new to the project. The session last 2 hours, and it began with a presentation on the project, the scenario modelling process, and an overview of the model outcomes. The group then engaged in discussions that were guided by the following questions (they also provide written feedback on these questions using feedback forms):

- Do the scenarios represent plausible futures for Squamish? Are there any changes to the scenarios that would be worth exploring?

- What information produced from the model do you find most useful for understanding and thinking about the implications of Squamish developing in a certain way?
- Are there any model outcomes that find to be confusing and/or not informative?
- Is there anything missing from the model that you feel would increase its usefulness?

Following the focus group, further feedback was obtained through meetings with local government and community stakeholders. These meetings included participants who were unable to attend the session, and those who wished to discuss the model in further detail.

2.6 Model refinement

Data consisted of written feedback, research notes and transcripts of focus group discussions. These data were analyzed using a thematic coding methodology (Gibbs, 2007; Seidel and Kelle, 1995). Emergent themes were used to refine the model and scenarios. Specifically, new elements and relationships were added to the systems model, and the scenarios were redefined and remapped. The integrated model was updated and the refined scenarios were analyzed. A report was prepared on the refined model/scenarios (Newell and Picketts 2019), and this was sent to the participants for review and comment.

3. Results

The study employed an iterative process for conducting a scenario modelling exercises; thus, results were produced through multiple stages in the project. This paper focuses on the refinement of the model and scenarios, as well as outcomes for the scenario modelling work. Detailed information on the initial model and scenarios can be found in Newell and Picketts (2018) and Newell et al. (Preprint).

3.1 Evaluation of the model and focus group feedback

Several themes emerged through the third focus group, and these were used to refine both the model and scenarios. These themes are as follows:

- *Rethink what density means in terms of building heights* – The original scenarios incorporated building that were 8 to 10 storeys tall. It was noted that this was beyond what would be considered ‘acceptable’ in Squamish, and buildings would not exceed 6 storeys.
- *Redesign the low-density scenario with a different sprawl pattern* – The low-density residential scenario depicted sprawl extending northward through a valley area. Such growth in the floodplain was noted to be unlikely, and instead growth was directed north and east through mountainous areas.
- *Combine the high-density scenarios to create a single ‘density node’ scenario* – The original scenarios consisted of separate downtown and neighbourhood densification scenarios, whereas focus group participants expressed that these could occur in concert.

- *Incorporate conservation and ecological values* - A frequent observation in the focus group was how the model lacked ecological concerns and conservation values, and recommendations were made for the model to incorporate species-at-risk and ecological connectivity concerns.

- *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 (e.g., increased car electrification, gentrification and housing costs) may affect the modeled outcomes.

- *Incorporate climate adaptation into the model* – Focus group feedback included comments on how the model should include climate adaptation planning, in particular flood and wildfire management.

- *Add more planned or 'likely' infrastructure* – It was noted that the scenarios could incorporate more buildings and infrastructure to better represent likely future conditions in Squamish, particularly schools and transit routes.

- *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 was largely a function of all scenarios incorporating approved residential development, which accounts for most of the project population growth.

- *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.

- *Link the model to the community objectives and plan* – It was noted that the model's relevance to local planning would increase if it linked to the District of Squamish's objectives and plans, in particular the indicators and targets identified in the Official Community Plan.

3.2 Systems model

The systems model was refined with new elements and relationships added based on focus group data analysis (Figure 3). Added elements included wildfire and floodplain management concerns, carbon sequestration, and biodiversity. Biodiversity was discussed in the focus group in terms of local species-at-risk, particularly the Pacific Water Shrew and Northern Red-legged Frog, and it was noted these could serve as indictor species for ecological outcomes of model.

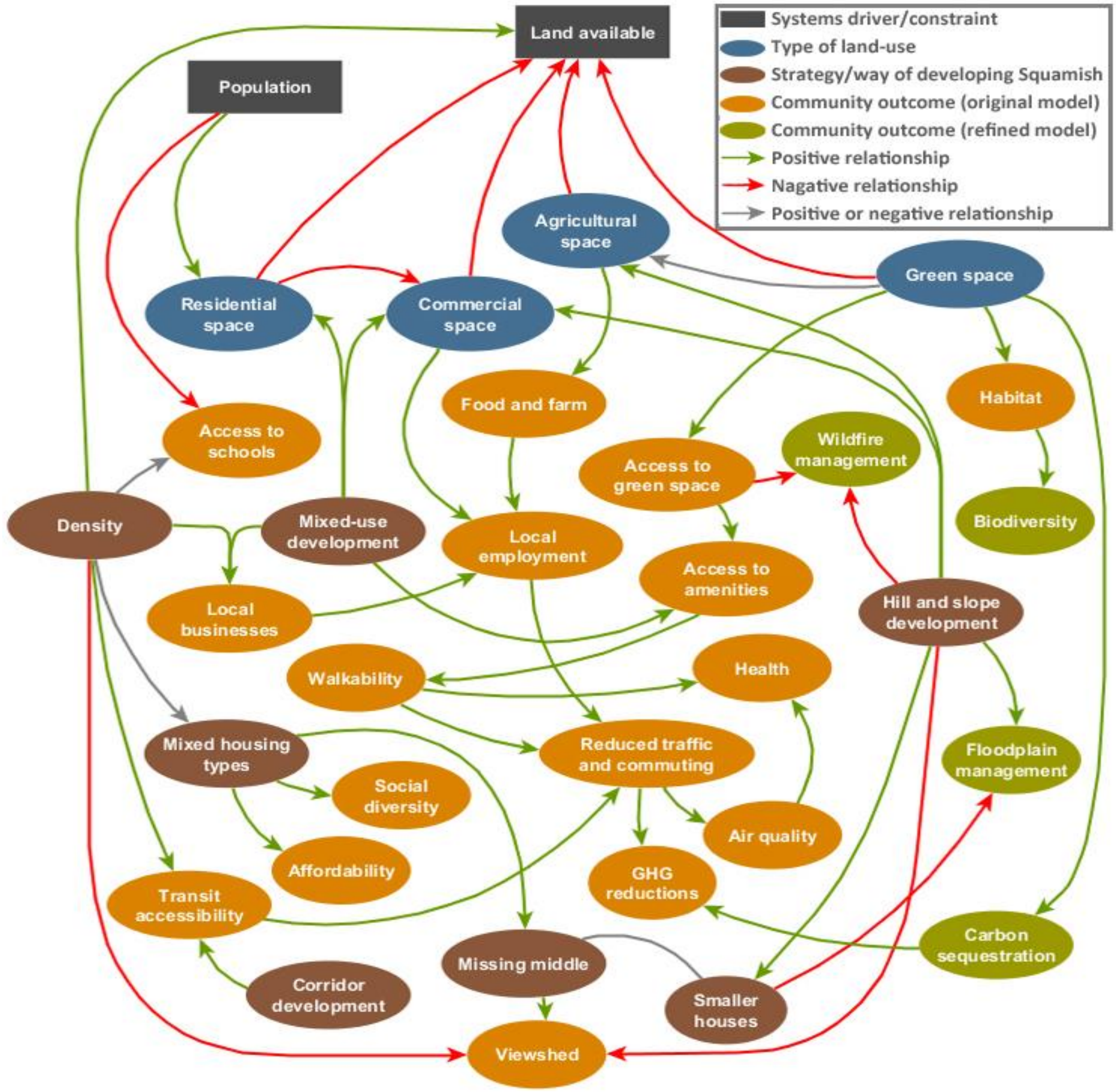

Figure 3. Community systems model for examining local development scenarios.

3.3 Measuring community outcomes

Measurement methods for the model outcomes are displayed in Table 1, with the relevant academic and grey literatures. ArcGIS tools and R scripts were added/edited to refine the integrated model and include calculations related to wildfire management, floodplain management, carbon sequestration, and biodiversity considerations. The model was also refined to incorporate other focus group comments, such as future trends in housing affordability due to gentrification. In addition, some calculation methods were altered to better illustrate differences between scenarios, for example, commuting by walking and biking was originally calculated using distance intervals, whereas the refined model used commuting-distance curves that more finely modelled relationships between trip distance and likelihood of walking/biking (e.g., Iacono et al., 2008; Larsen et al., 2010).

Table 1. Model outcomes and measurement methods

Model outcome	Measurement methods	Relevant literature
Access to amenities	• Distance to green space, schools, health, restaurants, grocery stores	Burke and Brown (2007); Manaugh et al. (2013); Sturm and Cohen (2014)
Access to schools	• Distances from residences to schools • School capacity and occupancy	Burke and Brown (2007); BC School District 48 (2015)
Access to green spaces	• Distances from residences to parks and trails • Park area per person in neighbourhoods	Cohen et al. (2007); Sturm and Cohen (2014)
Preserving natural spaces	• Residential, commercial/industrial and agricultural land encroaching on green space and habitat • Residential density near critical habitat and sensitive ecosystems	BC Ministry of Water, Land and Air Protection (2004); Wade and Theobald (2010)
Transit accessibility	• Density around transit stops and routes • Distances from residences to transit stops (both existing and potential) • Estimated public transportation ridership	Millward et al. (2013); Ontario Ministry of Transportation (2012); Vuchic (2005)
Commute reduction	• Estimated change in number of vehicle kilometers travelled	Larsen et al. (2010); Iacono et al. (2008)
Air quality	• $PM_{2.5}$ emissions based on vehicle kilometers travelled	Cai et al. (2013); Peitzmeier et al. (2017)
Greenhouse gas emissions	• CO_2e emissions based on vehicle kilometers travelled	BC Ministry of Environment (2016)
Health	• Air quality outcomes • Estimated numbers of people walking based on distances from residences to employment	Cai et al. (2013); Peitzmeier et al. (2017); Larsen et al. (2010); Iacono et al. (2008)
Food and farm systems	• Amount of land reserved for agriculture • Distance from residences to food services • Distance from high-density residences to community gardens	Baker (2004); Mendes et al., (2008); Millward et al. (2013)
Local businesses	• Amount of space reserved for commercial/industrial • Number of nearby residents to support local businesses	District of Squamish (2015); Easton and Owen (2009)
Local employment	• Amount of space reserved for commercial/industrial purposes • Number of potential jobs produced through new businesses and employment space • Percent of population commuting outside of Squamish	Ali et al. (2011); Lange and McNeil (2004); District of Squamish (2015)
Social diversity	• Inferred through the level of diversity in housing types within a neighbourhood	Talen (2006)
Housing affordability	• Inferred through using average prices for different housing types and mixes of housing types	Aurand (2010)
Wildfire management	• Amount of residential space (and residents) located within a 30m buffer of wildfire fuel (i.e., forests).	FireSmart Canada (2018)
Floodplain management	• Percentage of population living in the floodplain below an elevation of 5m	District of Squamish (2016)
Carbon sequestration	• Loss of stored carbon and annual uptake of carbon dioxide due to developing natural areas that serve as carbon sinks	IPCC (2006); Wilson (2010)
Biodiversity	• Residential encroachment on species-at-risk habitat (i.e., Pacific Water Shrew and Northern Red-legged Frog)	BC Ministry of Environment, Lands and Parks (1995); Environment Canada (2016)
Viewshed	• Assessed through visualization	Newell et al. (2017a,b)

The integrated model did not define a quantitative indicator for viewshed impacts. This was deemed to be a qualitative consideration that is better assessed through other means, such as visualization (i.e., Newell et al., 2017a,b).

3.4 Community development scenarios

The scenarios were also refined based on the analysis of the stakeholder focus group data (Table 2). A major change in the scenarios was they were reduced from five to three. This was done in response to focus group feedback on creating a combined downtown and neighbourhood densification scenario and comments about how it would be useful to highlight differences between scenarios more clearly. Reducing the number of scenarios resulted in fewer outputs, which allowed for clearer communication of the 'stories' and outcomes associated with different development directions.

The refined scenarios were redesigned and remapped in accordance with the focus group feedback. In the densification scenarios, building heights no longer exceeded 6 storeys and followed a more gradual gradient from high to low density residential buildings. In addition, the low-density assumed a more realistic sprawl pattern away from the floodplain. Furthermore, scenarios involving neighbourhood redevelopment were redesigned with greater sensitivity to local habitat in order to reflect current plans on how ecological values could/would be incorporated into land-use planning. Finally, infrastructure was also added as per focus group recommendations, specifically schools and transit routes.

Table 2. Original and refined community development scenarios

Scenario density	Original scenario	Refined scenario
Low density	1. Single-detached family housing development in valley areas	1. Single-detached family housing development in mountainous areas
Medium density	2. Medium-density with a mix of housing types 3. Medium-density and hillside development to reserve valley floor for commercial and agricultural purposes	2. Medium-density with a mix of housing types and hillside development to reserved land for agricultural purposes
High density	4. Concentration of densification in downtown area 5. High-density neighbourhood nodes	3. Mixed-use densification of neighbourhoods and downtown

3.5 Model outcomes

Extensive output was produced through the scenario modelling work and it is impractical to present the entirety of it. Thus, this report only features a representative sample from each of the major community outcomes featured in the systems model (Table 3).

Table 3. Sample of scenario modelling output for different community outcomes

Model outcome	Outcome indicator	High-density	Medium-density	Low-density
Walkability	Population (%) can access four amenities within 400m	30	26	17
Access to schools	Student occupancy compared to capacity (%) at a downtown elementary school	298	280	248
Access to green space	Park user density based on residents living within 800m (people/ha)	1,610	1,538	501
Biodiversity and wildlife habitat	Residential pressure on species-at-risk 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)	142	157	163
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 ($)	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

The high-density and medium-density scenarios show many similar outcomes, including transit accessibility/viability, user density around local parks, pressure on wildlife habitat, and dwellings within floodplain and wildfire zones. This is perhaps unsurprising as both scenarios follow a similar distribution of population (i.e., redevelopment and densification of existing neighbourhoods), whereas more dramatic differences can be seen with the low-density scenario that involves a significantly different development pattern (i.e., sprawling outside of existing neighbourhoods). However, this being said, some differences can be seen between the high and medium density scenarios, particularly outcomes related to local commercial development and residential density around commercial areas, such as business viability, commuting by walking/biking, and vehicle-based emissions. Some outcomes were extreme for all modeled scenarios (e.g., all scenarios projected an elementary school near downtown to be over double its capacity).

4. Discussion

The integrated model employed in this study was developed through an iterative participatory process, and this 'iterative' aspect was particularly valuable for creating a tool that is representative of community values and concerns. In the preceding study, Newell and Picketts (In review) hypothesized that the initial systems model likely excluded elements that were key to community values due to certain invitees with specific interests and knowledge being unable to participate in the first focus group. The current study confirmed this hypothesis, as ecological values and climate adaptation were unrepresented in the initial model. This research finding aligns with Newell et al. (2017a), who argue that planning tools should regarded as items that can be continually developed as more user engage with it, rather that a 'final product'. By developing models as flexible tools, researchers and practitioners can continually improve them as more community members and stakeholders provide feedback, thereby increasing their representativeness, local relevance and (ultimately) usefulness.

Iterative participatory processes are useful for ensuring models can incorporate concerns and values from users that did not initially contribute to its development; however, they can also be valuable for allowing initial contributors the opportunity to re-examine their original ideas. Integrated models are complex, and accounting for all considerations associated with a particular development direction or strategy can be an overwhelming challenge for planners and stakeholders alike (Sperling and Berke, 2017). It is therefore useful to employ a model development process that includes the presentation of preliminary results followed by refinement stages, so that stakeholders can assess an initial model version and determine what they may have missed when first contributing ideas. In this study, approximately half the participants in second focus group had previously participated in the project, and after assessing the first version of the model, many of these participants provided new ideas for strengthening its local relevance. For example, building heights were limited to 6 storeys and transit routes were added. Ultimately, this approach allowed both researchers and stakeholders to explore, refine and evolve the modelling tool, enabling the sharing and co-creation of knowledge typical of effective participatory processes (Greenhalgh et al., 2016).

Processes that explicitly include stakeholder input are posited to increase buy-in for plans and strategies (e.g., Raymond and Brown, 2007; Robinson et al., 2011; Sheppard et al., 2011), and in a similar vein, this research found that its participatory approach increased stakeholder investment in the project. Throughout the research, local government and stakeholders have attended multiple focus groups and made themselves available for meetings outside the sessions. Such discussions and meetings directed the researchers toward studies, documents and data that improved the model. This was useful, as integrated models require a large amount of data and data gaps are a common issue in this type of work (Prell et al., 2007; Sperling and Berke, 2017).

Some focus group comments referred to a need for communicating model assumptions and outcomes more clearly, and this indicated that the integrated model alone was not an adequate tool for participatory planning. To improve its usefulness, the tool requires an engaging and effective method for users to understand the model outcomes and their implications. Such a method could involve creating an interactive model interface, which allows users to explore model outcomes (e.g., Summers et al., 2015). The researchers are currently developing such a tool (Newell and Picketts, 2019) for users to learn about how the model was developed, view scenario maps, and explore model outcomes. In addition, developing the interactive interface has opened new opportunities for more clearly illustrating relevance of the model to local planning, and (as per the focus group feedback) the researchers are including links with the model outcomes related to District of Squamish performance indicators (District of Squamish, 2019). Following the participatory approach, the 'model explorer' also incorporates recommendations from local government and stakeholders, for example, highlighted development/redevelopment areas in scenario maps were changed from parcel shapes to amorphous shapes (see Figure 2) in order to avoid conveying that the scenarios target specific properties.

Improved model outcome communication could result in a powerful planning tool, as the model produced a number of valuable insights. In particular, the model highlighted the differences between densification and urban sprawl, and the disadvantages of developing in the latter form. Equally as interesting, the output demonstrated many similarities between the high-density and medium-density scenarios, indicating that opportunities exists to receive the benefits from densification while maintaining a 'small town character'. The model output also can be used to identify co-benefits associated with certain strategies. For example, climate action strategies can produce community benefits that extend beyond mitigation and adaptation (Newell et al., 2018), and in this case, the high-density scenario resulted in reductions in commuter-related emissions while also increasing walkability, health and local business viability. Such insight is valuable for communities attempting to implement integrated strategies that can achieve a multitude of social, economic and environmental goals.

The techniques employed in this research provided an effective method for developing an integrated model based on local government and stakeholder values, interests and concerns, as the systems model essentially served as method of translating qualitative focus group data into a quantitative modelling process. The process did result in the viewshed outcome that was more qualitative in nature and difficult to incorporate into the quantitative model; however, this does not mean that this element should be disregarded. In cases where qualitative and quantitative elements are present in a systems models, multiple planning tools can be employed to provided a more comprehensive understanding of the implications of a strategy or plan (Newell et al., 2018). For the viewshed-related outcomes, visualizations can serve as an effective method for evaluating potential impacts (Newell et al., 2017a,b), and accordingly, such a method is being employed in this project for subsequent studies (Newell and Picketts, 2019).

5. Conclusion

Community engagement and participation is a necessary component of effective community planning and (more broadly) sustainable community development (Ling et al., 2009). Accordingly, the tools and techniques used to support planning efforts should also incorporate participatory processes in their design and application. To effectively engage stakeholders and incorporate their knowledge and ideas, these tools should have flexibility to ensure that they can be iteratively developed and refined. It is through such processes that planning tools can continually evolve to more accurately capture community needs and values, thereby increasing their effectiveness for supporting integrated community planning and sustainable development.

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