Canada Places + Spaces

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“The basic premise of sustainable development is that human and natural systems are dynamically interdependent and cannot be considered in isolation in order to resolve critical issues. Human societies and ecological systems are so interconnected that they are co-adaptive, reacting to each other and to previous interactions and reactions in a network of feedbacks.”

Dale, A., Newman, L. (2005), "Sustainable development, education and literacy", International Journal of Sustainability in Higher Education, Vol. 6 Iss: 4 pp. 351 - 362

A proposal

“This infrastructure will allow political decision-makers, municipal planners, and policy-makers to ‘see’ the aggregate impacts of their decisions directly on their physical place and facilitate the design and re-design of their communities for sustainable development…”

An integrated decision-making tool

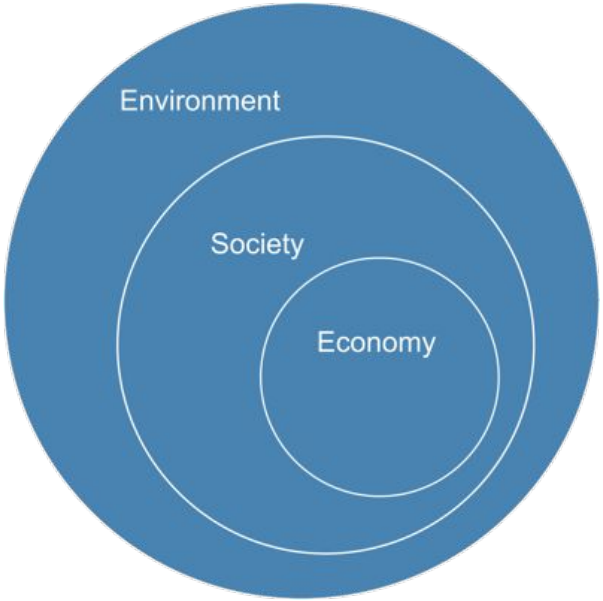
Quantitative

Systems

Ecological limits

Economic flows

Social indicators



The scope

The model

- has a **biophysical foundation** in that it represents: population and demographics; buildings and urban form; physical infrastructure and services (transportation, water, waste, energy);
- **social infrastructure and services** (education, healthcare, recreation); and economic activity (labour, products and services).
- attempts to account for the **financial states and activities** of the public sector, private sector and households within the community and financial flows leaving and entering the community.

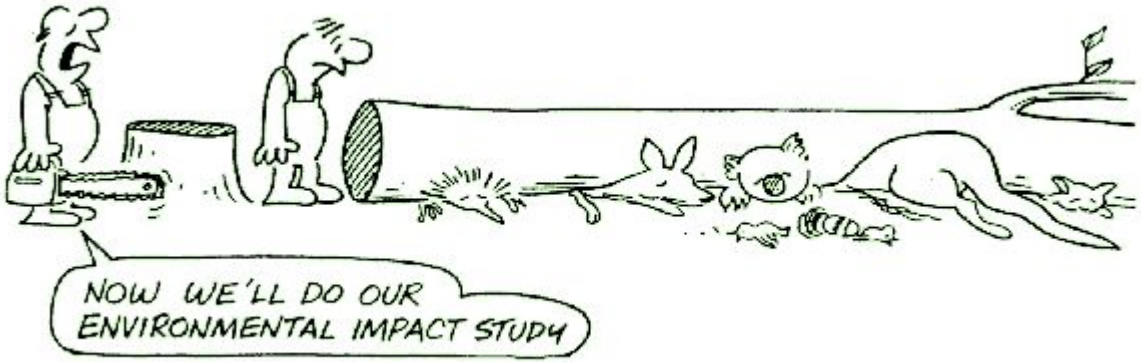
What does it look like?

A model whereby communities can evaluate development and policy options for sustainable community development…. A tool for communities to assess alternative development pathways.

Pathways are influenced by levers (policy options, investment choices in social and physical infrastructure) and impacts (built environment, resource consumption and financial viability).

The “engine” of this tool - which traces the complex relationships between levers and impacts - is an **integrated systems** simulation model of the community incorporating community-specific data and reflecting community-specific policies and scenarios.

Data gaps & Baseline Results



Key Challenges

Large data gaps

Asymmetries of scale between communities

Rural vs urban

Modelling a cityscale from building archetypes

Reducing model complexities

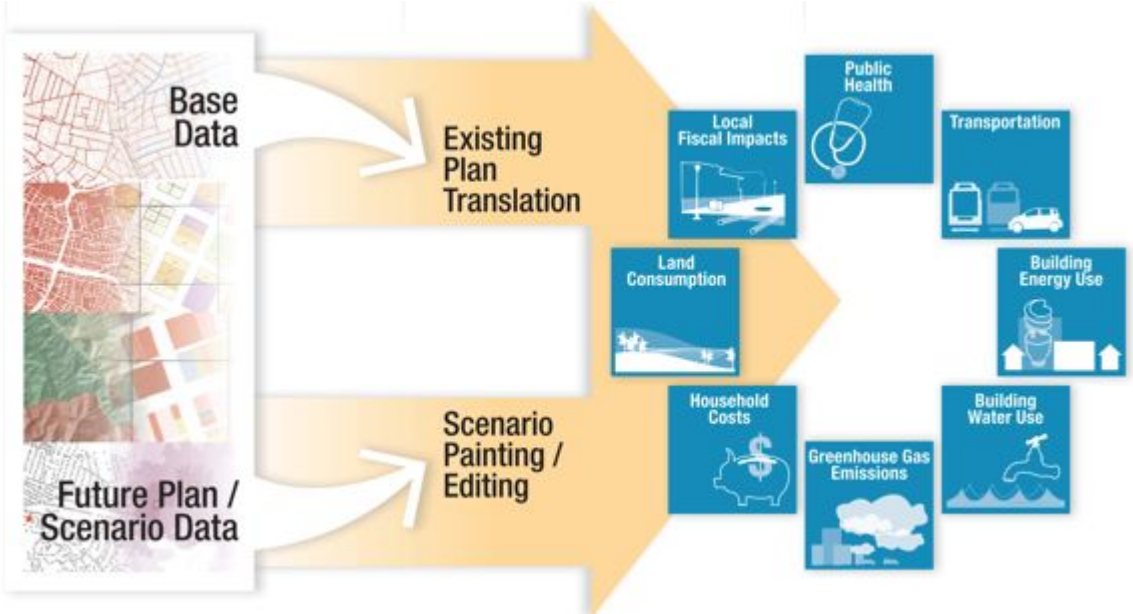
Making the data accessible to diverse decision-makers

The Methodology

1. Environmental scan of other models
2. Integrating the social and economic (financial) with the biophysical
3. Selection of case study communities
4. Iterative model design
5. Beta-testing with case study communities
6. Refinement and model calibration

Environmental Scan

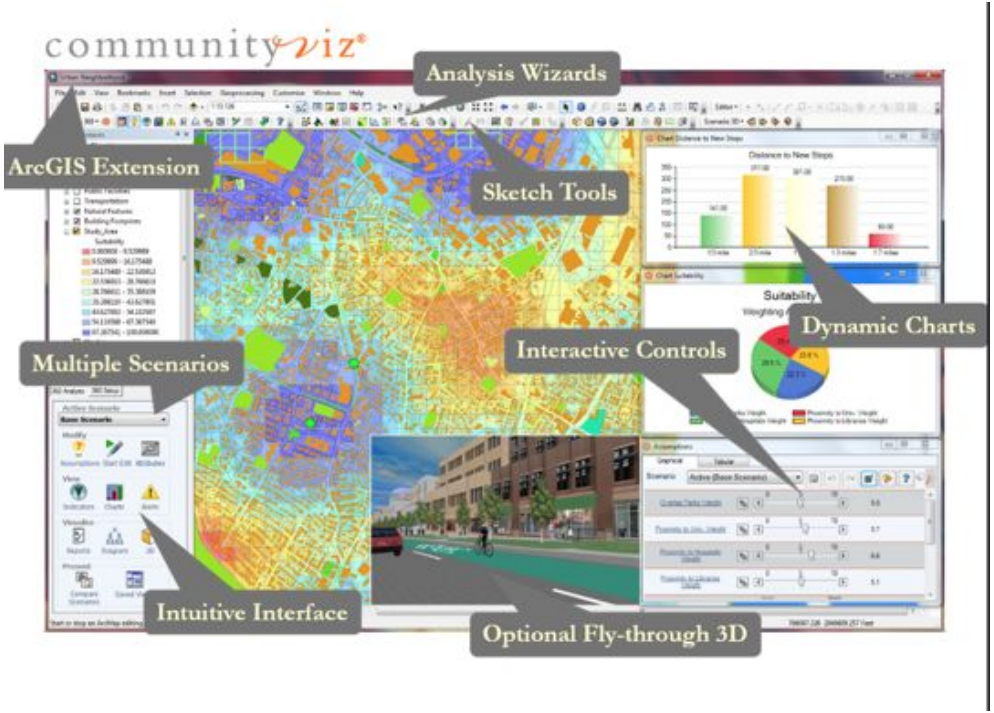
UrbanFootprint



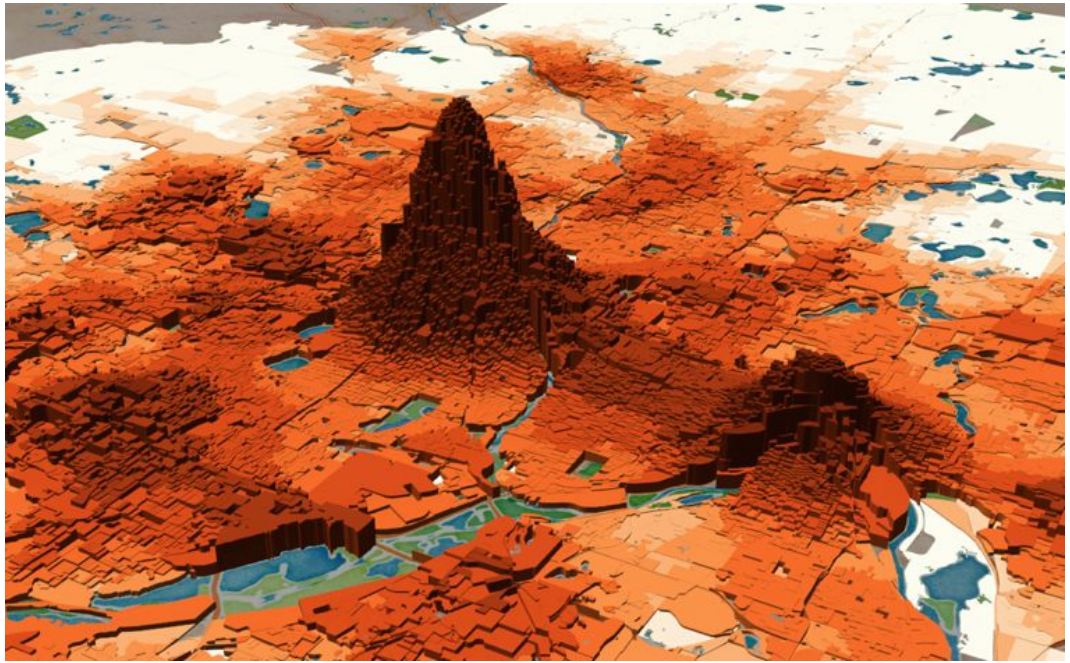
Rapidfire


Scenario Definition: Land Use Options & Policy Package Selection
1 DEFINE LAND USE OPTIONS
a. RESIDENTIAL LAND-USE OPTION DEFINITIONS
b. EMPLOYMENT LAND USE OPTION DEFINITIONS
c. LAND DEVELOPMENT CATEGORY (LDC) PROPORTIONS FOR RESIDENTIAL UNITS
Load Scenarios
Restore Default Scenarios
Restore Default LDC Proportions
2 SELECT POLICY PACKAGE(S)
FULL POLICY GROUPS
Click buttons to load policy group options:
TRANSPORTATION
TRANSPORTATION FUEL EMISSION RATES
CO2e EMISSION RATES
BUILDINGS

CommunityViz



UrbanSim

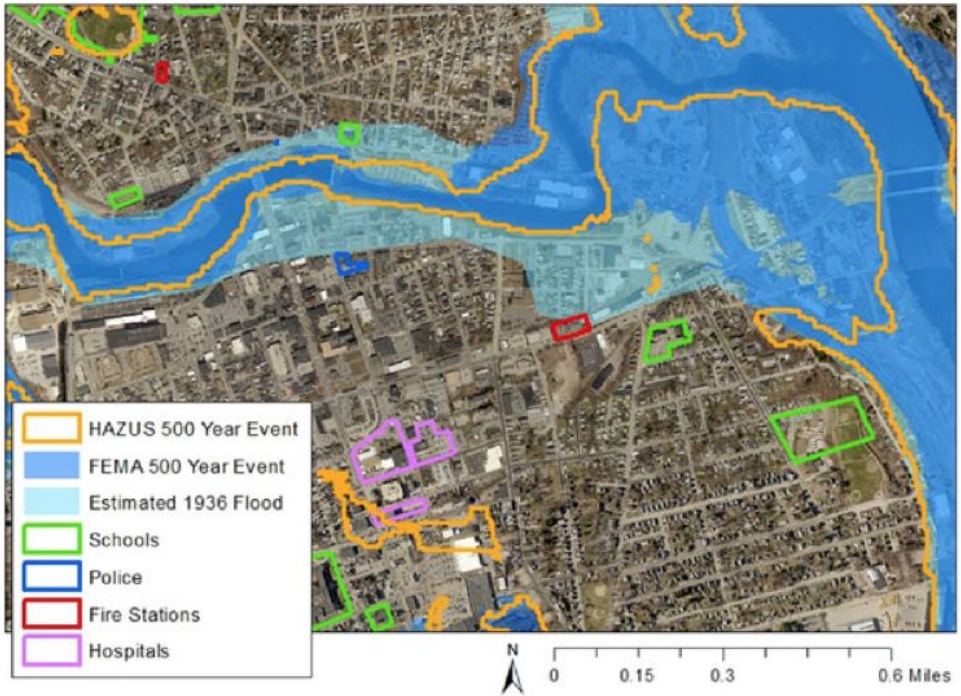


CityEngine

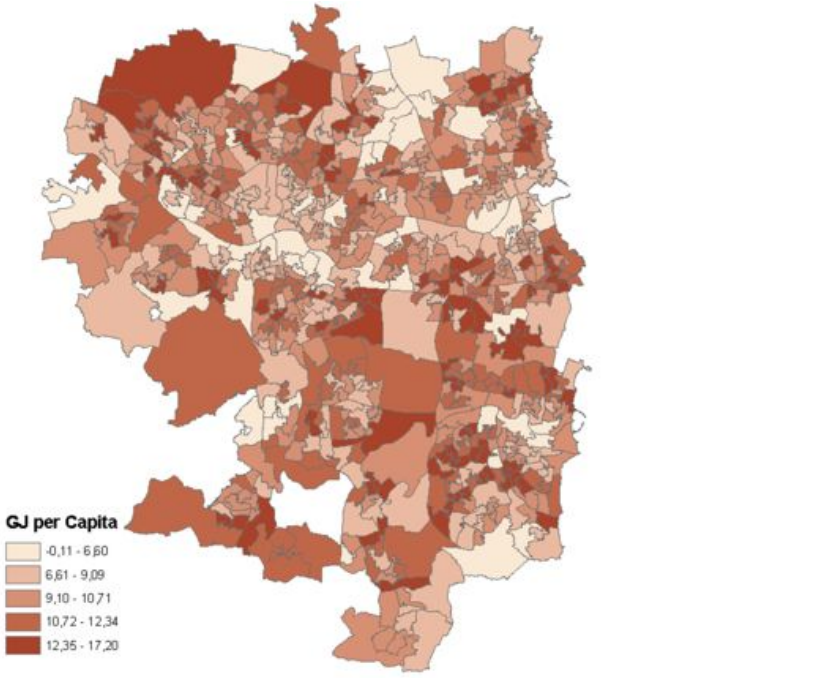

CityEngine
Esri Campus
Settings
Sunlight
Drag Slider
GMT-8
Spring (March 20)
Shadowing
Direct Shadow (cast by sunlight)
Diffuse Shadows (ambient occlusion)
esri

CityEngine

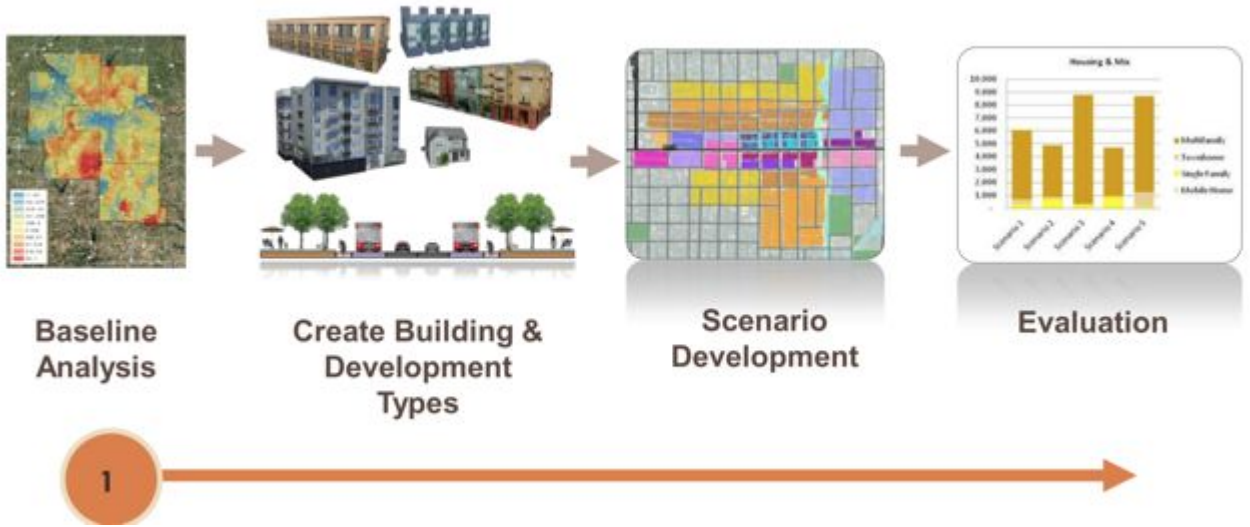
Hazus


HAZUS 500 Year Event
FEMA 500 Year Event
Estimated 1936 Flood
Schools
Police
Fire Stations
Hospitals
N
0
0.15
0.3
0.6 Miles

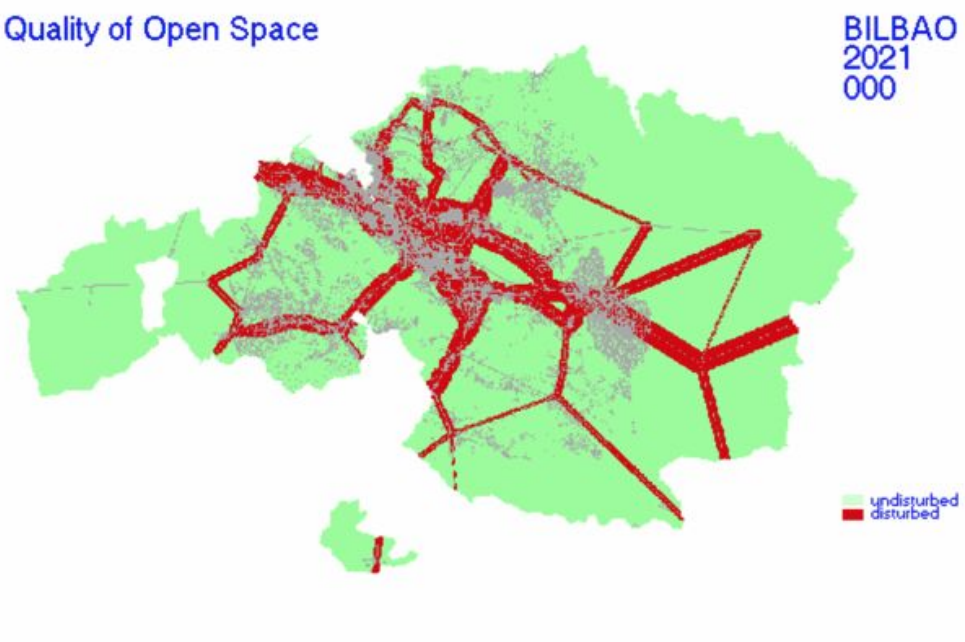
SUME



Envision Tomorrow



PROPOLIS


Quality of Open Space
BILBAO
2021
000
undisturbed
disturbed

Model Design

The proposed model infrastructure will be the first computer-based simulation model to integrate land, water, and energy use with the environmental, social, and economic imperatives for researchers and community decision-makers to assess the implementation of sustainable community development at the community level. The simulation model will consist of a series of interrelated sub-models describing individual processes and include scenario management, data visualization, collaborative multi-user access,
and extensibility.

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Vision

What are the effects and impacts of community development?

Development can refer to investment by the municipality (public space, new roads, water treatment) investment by households and community groups (community energy) or investment by private sector (condos, mall, etc.)

Geographical considerations: where and how is space being used?

Scale-based considerations: what is the magnitude of investment?

Effects (Direct)

Land-use

- Green space
- Dead space
- Agricultural land (urban and rural)
- Density
- Walkability/cyclability
- Accessibility
- Commercial space
- Mixed- use space (multi-functionality)
- Agricultural fertilizer usage

Transportation

- Mode split
- (walking/cycling/transit/driving)
- Transit use
- Average VKT
- Vehicle mix
- # of bike racks, bus bike racks

Demographics

- Population change
- # of dwellings by type
- # of people/household
- Age characteristics
- Diversity (age, gender, culture)

Economics

- # of direct jobs
- # of indirect jobs
- change in inequality
- # of people below poverty line
- Municipal tax revenues
- Municipal operating costs

Impacts (Indirect)

Ecological impacts

- Change in forest cover
- Change in air pollution (GHG emissions NOx, Sox, ozone, carbon monoxide, particulate)
- Change in water quality (contaminants, environmental – fertilizers and eutrophication)
- Change in water quantity (equitable and sufficient water supply)
- Change in biodiversity
- Change in waste production

Health impacts

- Change in cancer rates
- Change in heart disease
- Change in mental illness
- Change in obesity rates
- Change in asthma rates
- Change in osteoporosis
- Change in diabetes

Connectivity

- Change in # of coffee shops
- Change in people within walking
- Position and # of community centres
- Change in # of libraries

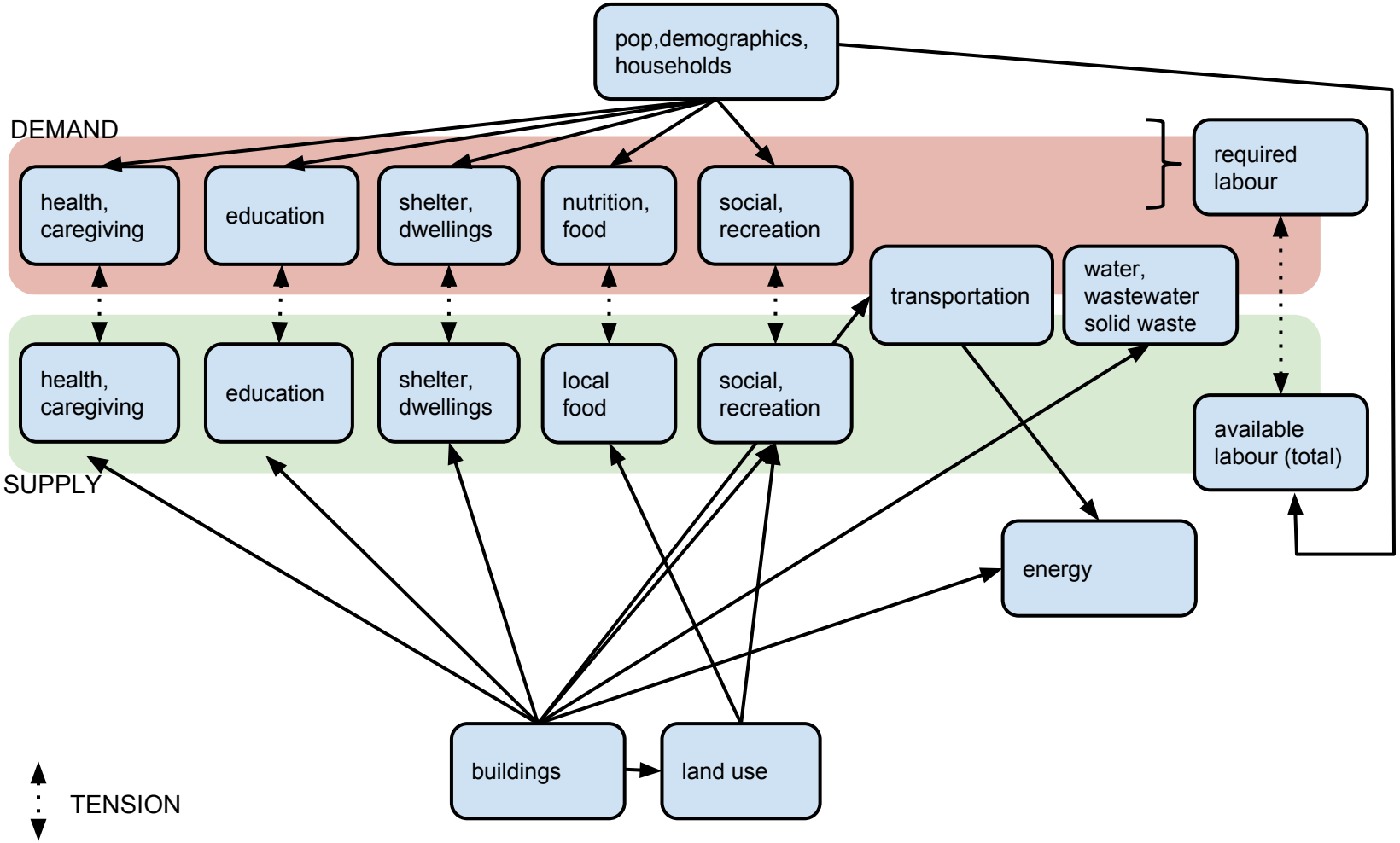
Accessibility

- Change in # of doctors/capita
- # of people within walking distance of
- green space
- Change in # of people within walking
- distance of grocery store.
- Change in # of people with access to
- agricultural land
- local food markets , community gardens

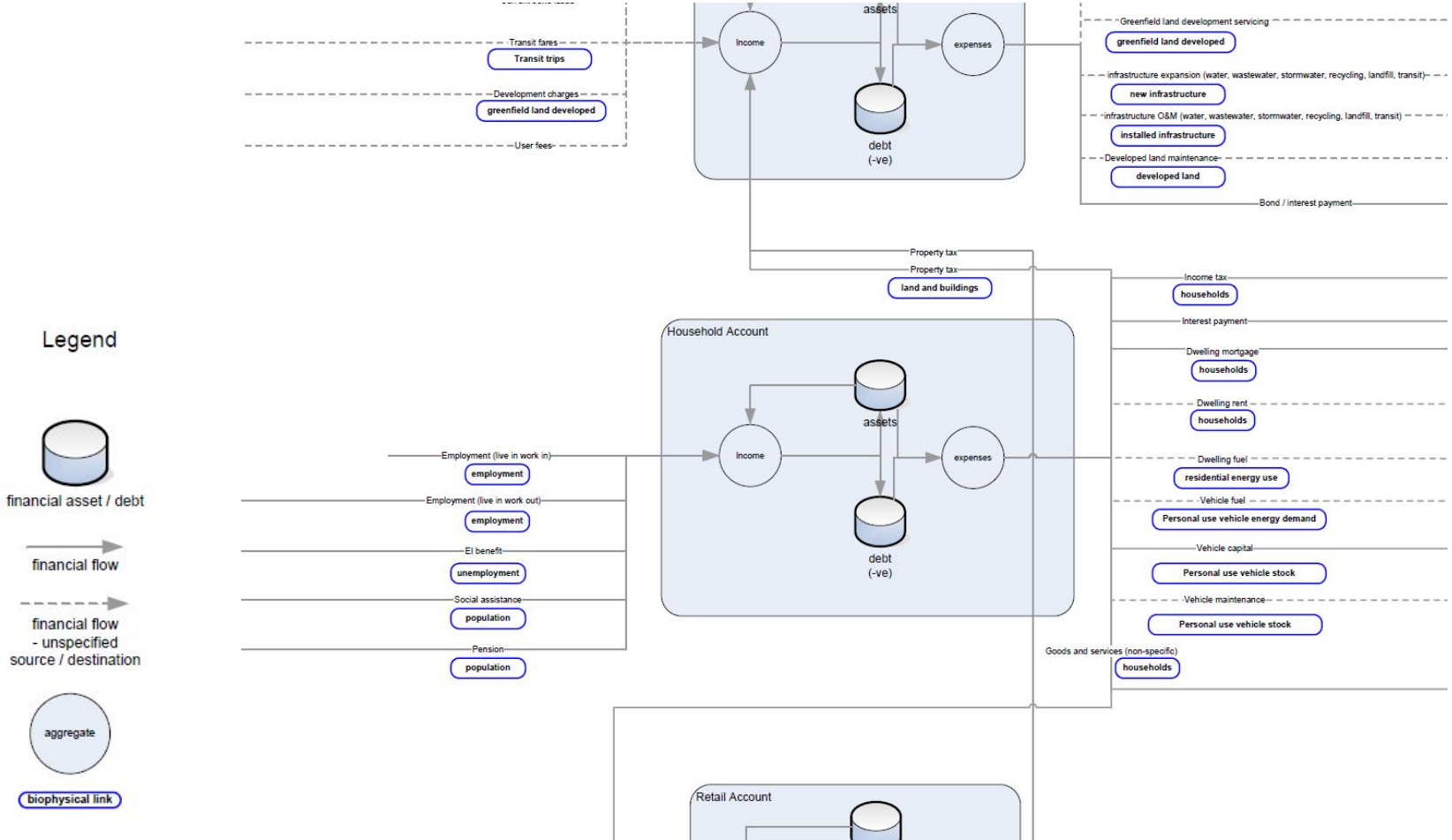
Infrastructure

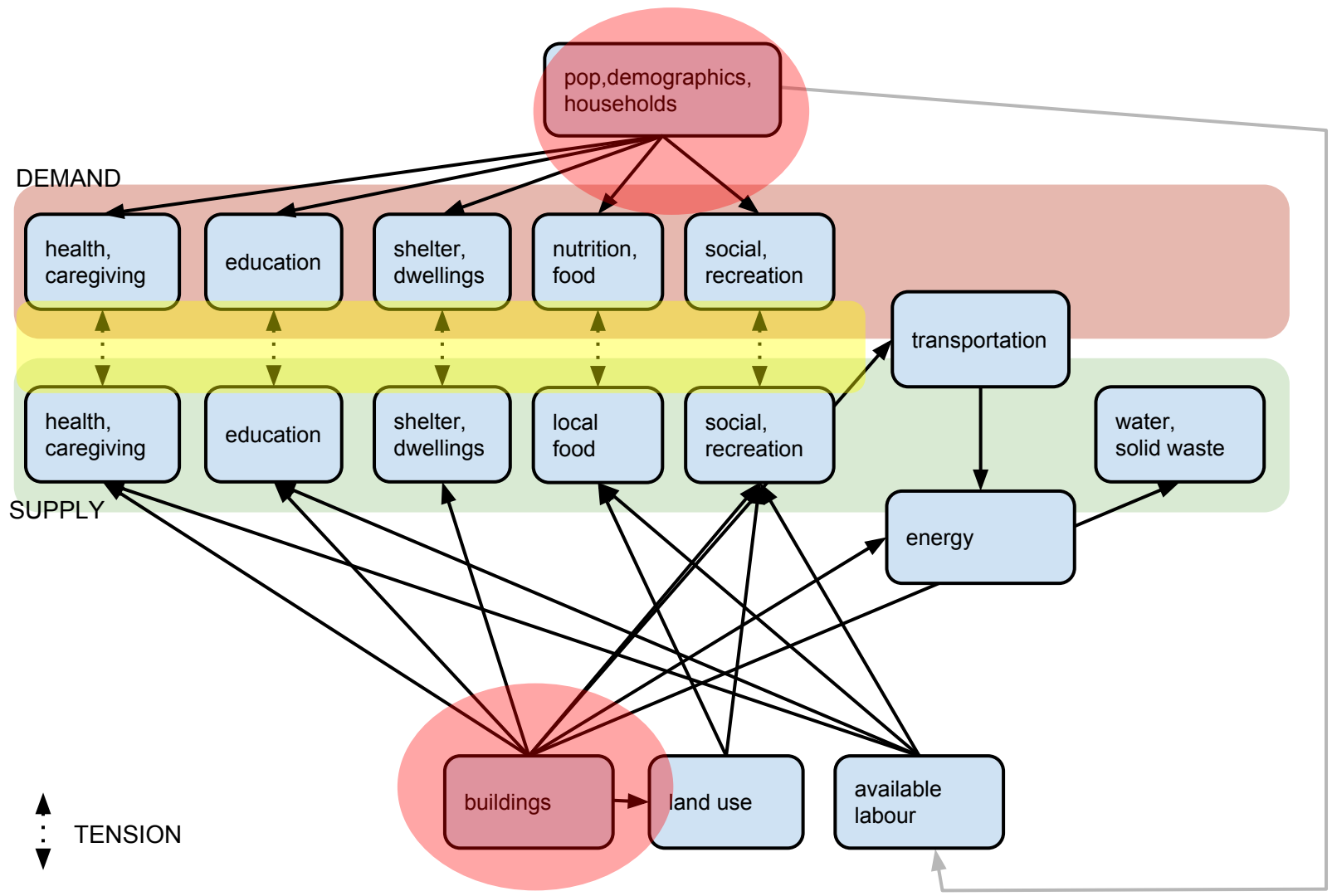
- Change in energy mix
- Change in energy cost
- Change in average age of buildings
- Change in average age of municipal infrastructure by type

BIO-PHYSICAL & SOCIAL INFRASTRUCTURE

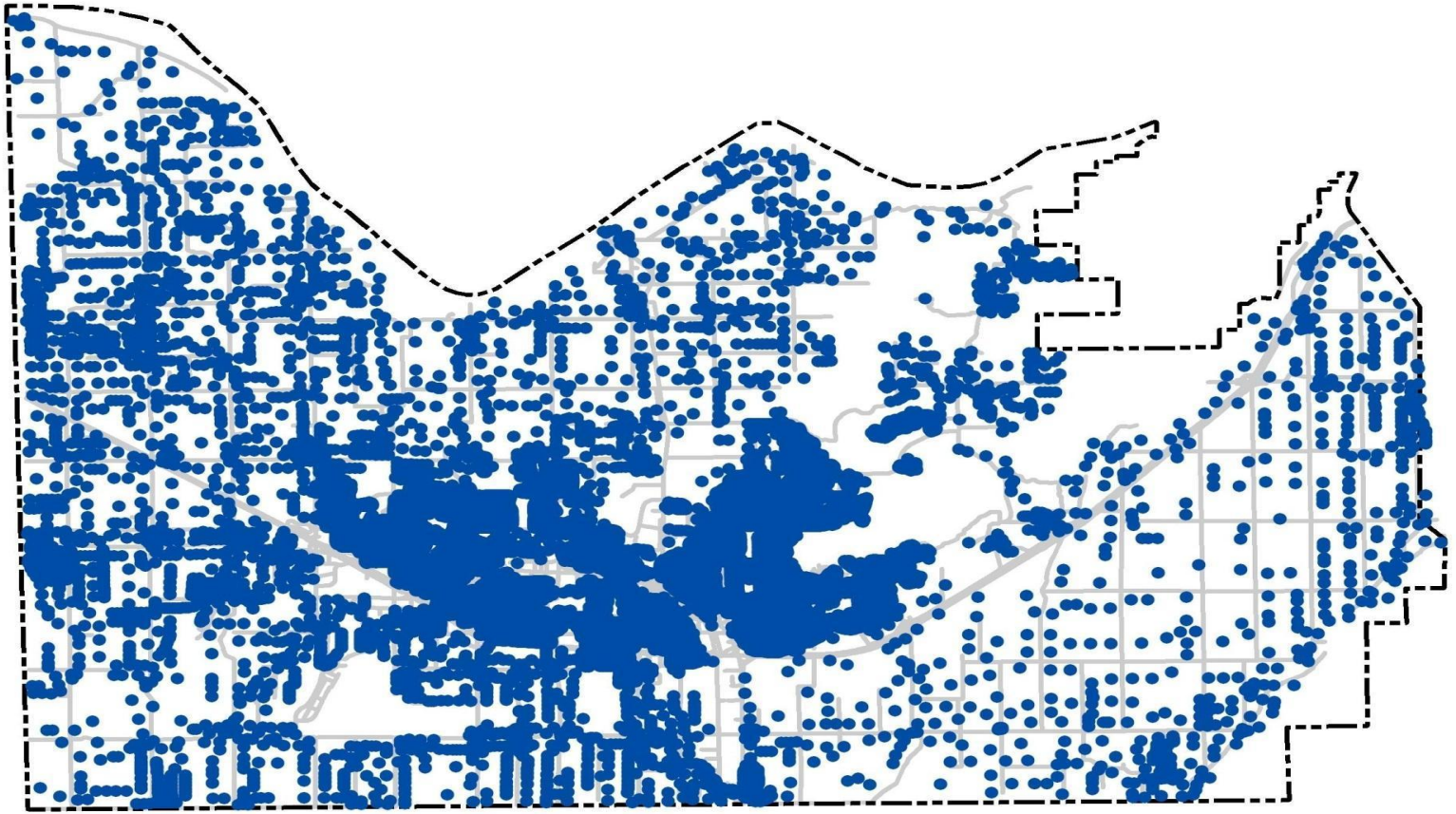


Institutional & Financial




pop,demographics,
households
DEMAND
health,
caregiving
education
shelter,
dwellings
nutrition,
food
social,
recreation
transportation
health,
caregiving
education
shelter,
dwellings
local
food
social,
recreation
water,
solid waste
SUPPLY
energy
buildings
land use
available
labour
TENSION

Building Archetypes - Pins on the Map



Design revisions

As with every project we made revisions along the way and we added the following to the structure of the initial model design

- District energy
- Seasonal populations
- Water accounting
- Municipal costs of different land-use patterns

Scenarios

Consistent and coherent descriptions of alternative hypothetical futures that reflect different perspectives on past, present, and future developments, which can serve as a basis for action. Scenarios are developed to ‘show’ decision-makers the development paths resulting from each scenario, for example, a low-growth, medium-growth and high-growth scenario.

Scenario development

	Population				Dwelling type						Land accounting			Employment					
	2013	2016	2021	2041	Single, 2013	Single, 2041	Double, 2041	Row, 2041	Apt_low, 2041	Apt_hi, 2041	Vacant land 2013	Additional land used	Available land	2013	2016	2021	2041	Agriculture, forestry, fishing and hunting [11]	N c a a e [
tion	69,891	3,494	6,082	27,413										62,330	*3,429*	*6,073*	*28,902*		
e	-	*-3,494*	*-6,082*	*-27,413*											*-3,429*	*-6,073*	*-28,902*		
1	-				76%	100%					214	-	214	-					
2	-				83%	100%					15	-	15	-					
3	-					100%					40	-	40	-					
4	-					100%					47	-	47	-					
5	-					100%					97	-	97	846					
6	-				83%	100%					121	-	121	2,200					
7	-				83%	100%					111	-	111	-					
8	-				79%	100%					48	-	48	134					
9	332				54%	100%					75	-	75	-					
10	55				35%	100%					220	-	220	-					
11	-				73%	100%					105	-	105	-					
12	685				39%	100%					56	-	56	-					
13	1,277				100%	100%					5	-	5	-					
14	33				66%	100%					515	-	515	-					
15	-				76%	100%					912	-	912	-					
16	532				63%	100%					91	-	91	127					
17	-				58%	100%					269	-	269	-					
18	200				100%	100%					80	-	80	302					
19	351				49%	100%					93	-	93	-					
20	140				32%	100%					146	-	146	-					
21	165				45%	100%					86	-	86	23					
22	45				63%	100%					49	-	49	219					
23	81				64%	100%					44	-	44	-					
24	269				44%	100%					119	-	119	-					
25	498				69%	100%					42	-	42	-					
26	-				7%	100%					20	-	20	1,178					

Engagement

Since sustainable development is never really achievable (Dale and Robinson 1995), as it inherently involves a dynamic relationship between two complex living systems, the human and the ecological, it requires sustained dialogue in every community about its particular dynamics. Critical to the social change that is necessary for its implementation is a literate, cognizant, and actively engaged civil society.

Dale, A. (2007). Governance for Sustainable Development as if it Mattered? Post-Brundtland 2007

Case study communities

Moncton, New Brunswick

Colwood, British Columbia

Tofino, British Columbia

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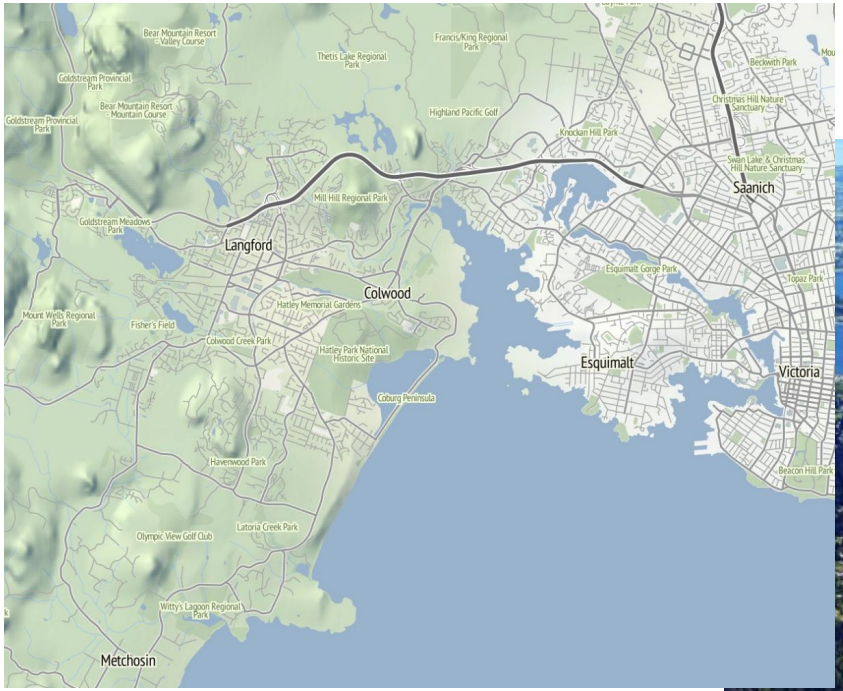
Moncton - Downtown Revitalization

Tofino - Seasonal Population

Colwood - Development

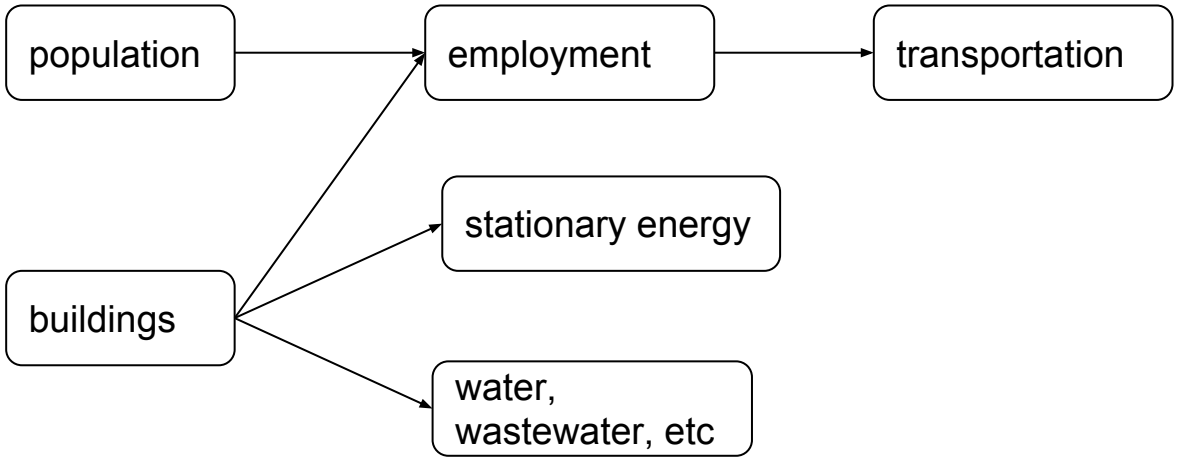


Calibration

- We calibrate the model to ensure the model outputs match our existing understanding of the community
- Internal model parameters are adjusted to produce outputs that reflect data collected from trusted reference sources.
- Calibration grounds the future scenarios within our current measured reality making scenario starting points historically consistent

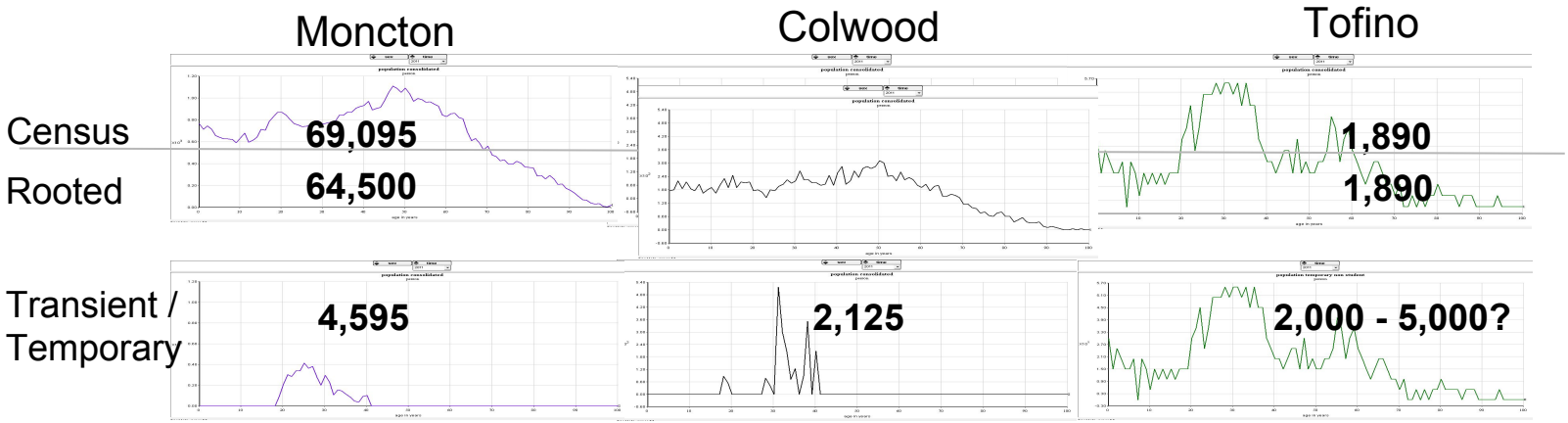
Calibration

Calibration is a staged process beginning with ensuring the population and building stocks are historically consistent.



Population - who's in the census?

- Population drives many of the activities and energy use in a community, therefore a good understanding of what community's population looks like is important.
  - What is a community's true population?
  - How do seasonal or transient visitors influence a community?

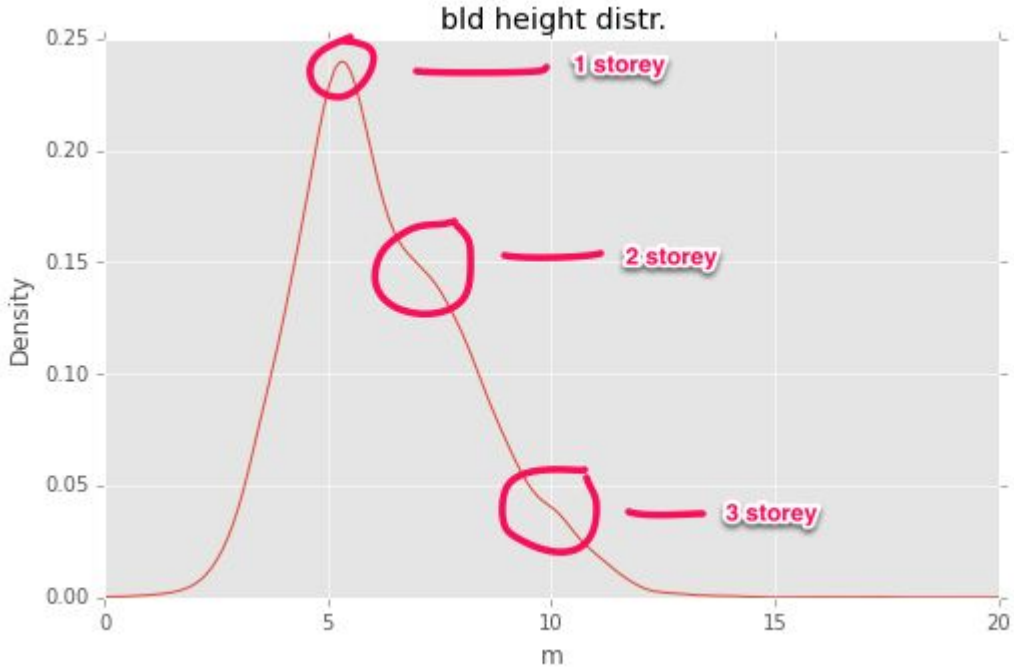


Buildings

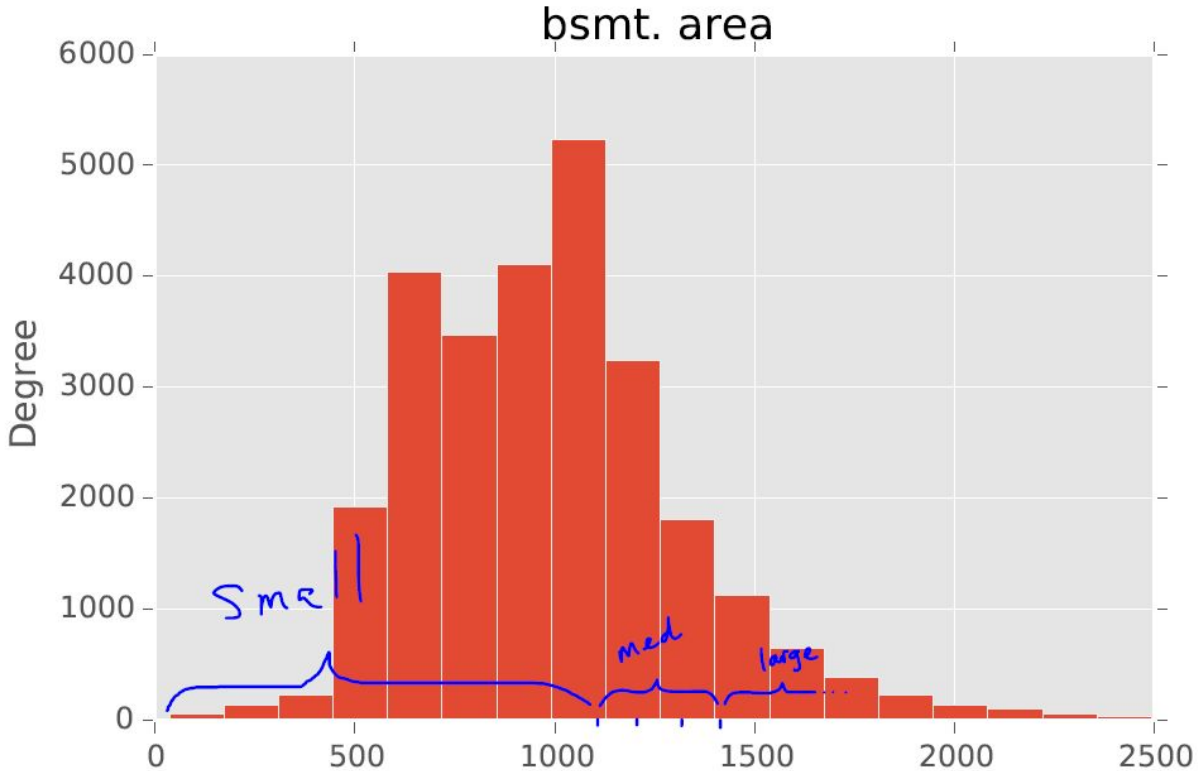
- Number, type and location of buildings drive energy required for space conditioning and transportation
- 32 residential building archetypes were developed to describe the community's residential building stock
- 54 non-residential building archetypes were developed to describe the community's non-residential building stock
- Each archetypes can be moved and placed in any zone within the community allowing planners to construct communities with various densities and urban forms

Moncton Building GIS data

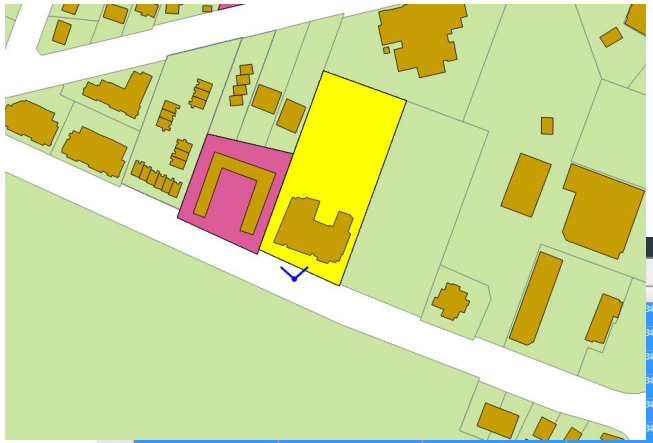
Building height: number of stories



Building footprint size classes

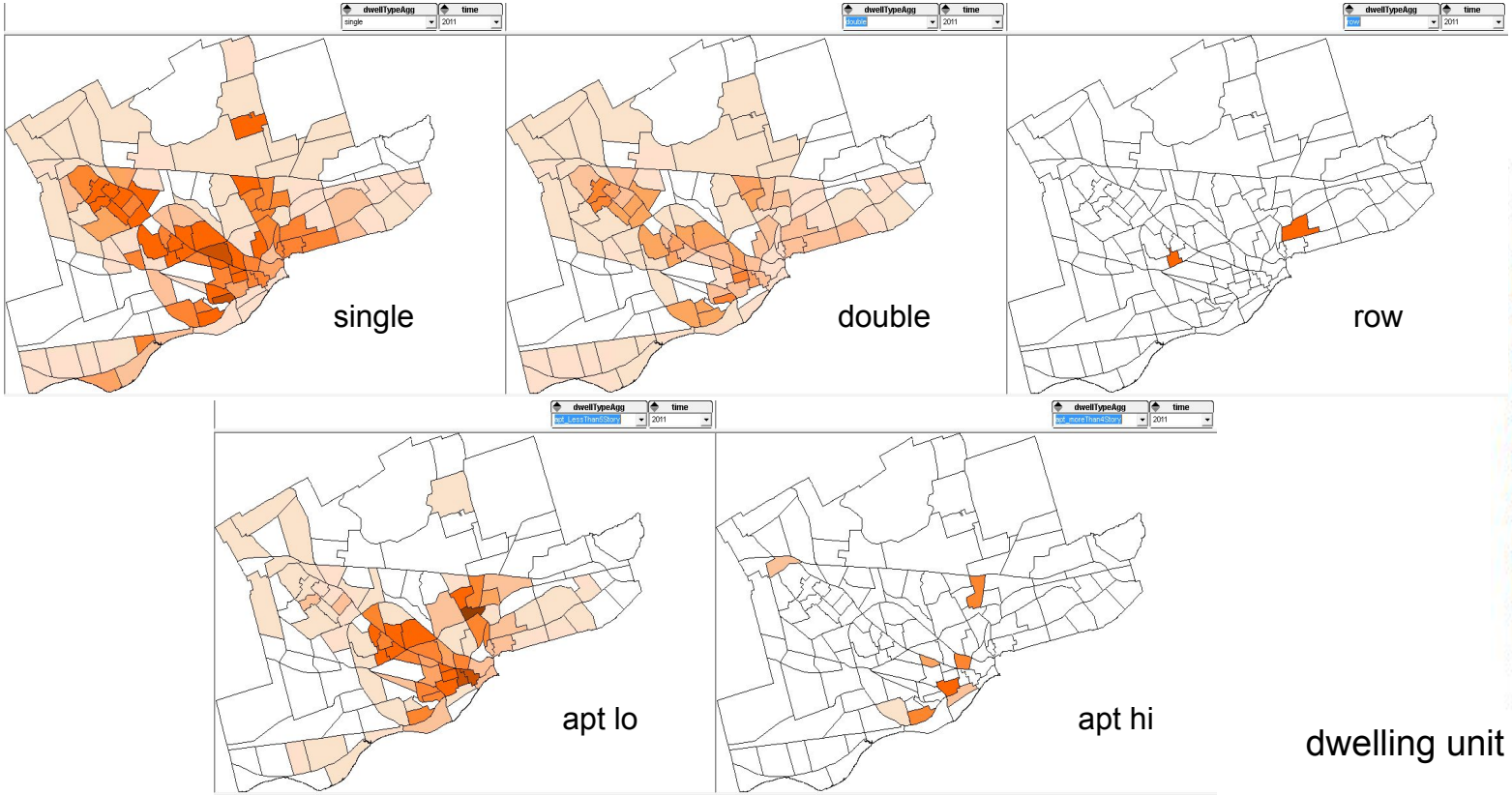


Buildings or dwelling units?



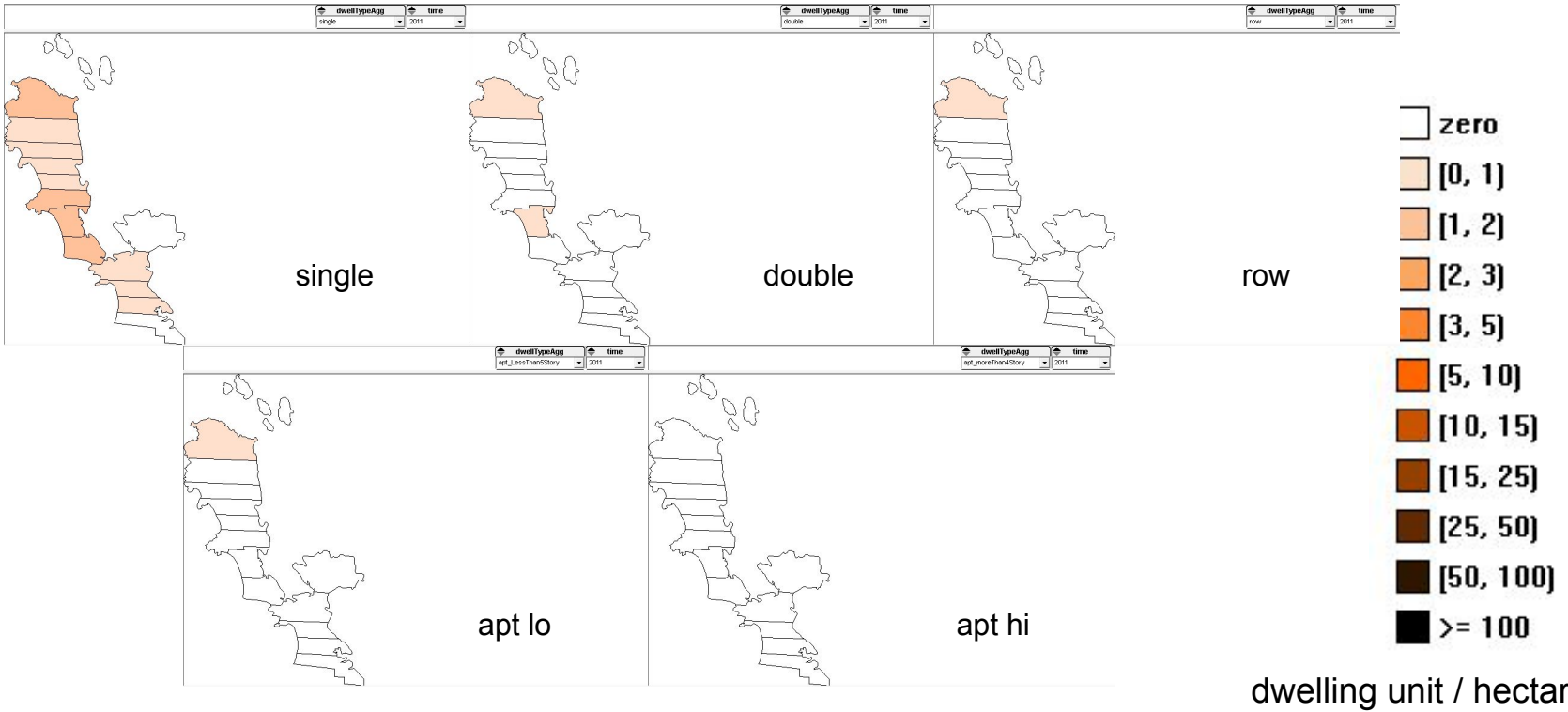
				CivicAddre		
				38 GOLDSTREAM AVE VICTORIA	019-007-451	Strata Lot 1, Plan VIS3486, Section 1, Esquimalt Land District...
				38 GOLDSTREAM AVE VICTORIA	019-007-469	Strata Lot 2, Plan VIS3486, Section 1, Esquimalt Land District...
				38 GOLDSTREAM AVE VICTORIA	019-007-477	Strata Lot 3, Plan VIS3486, Section 1, Esquimalt Land District...
				38 GOLDSTREAM AVE VICTORIA	019-007-485	Strata Lot 4, Plan VIS3486, Section 1, Esquimalt Land District...
				38 GOLDSTREAM AVE VICTORIA	019-007-493	Strata Lot 5, Plan VIS3486, Section 1, Esquimalt Land District...
				38 GOLDSTREAM AVE VICTORIA	019-007-507	Strata Lot 6, Plan VIS3486, Section 1, Esquimalt Land District...
190	1	213	83486070	Unit 211 338 GOLDSTREAM AVE VICTORIA	019-007-515	Strata Lot 7, Plan VIS3486, Section 1, Esquimalt Land District...
191	1	213	83486080	Unit 210 338 GOLDSTREAM AVE VICTORIA	019-007-523	Strata Lot 8, Plan VIS3486, Section 1, Esquimalt Land District...
192	1	213	83486090	Unit 208 338 GOLDSTREAM AVE VICTORIA	019-007-531	Strata Lot 9, Plan VIS3486, Section 1, Esquimalt Land District...
193	1	213	83486100	Unit 207 338 GOLDSTREAM AVE VICTORIA	019-007-540	Strata Lot 10, Plan VIS3486, Section 1, Esquimalt Land Distri...
194	1	213	83486110	Unit 201 338 GOLDSTREAM AVE VICTORIA	019-007-558	Strata Lot 11, Plan VIS3486, Section 1, Esquimalt Land Distri...
195	1	213	83486120	Unit 202 338 GOLDSTREAM AVE VICTORIA	019-007-566	Strata Lot 12, Plan VIS3486, Section 1, Esquimalt Land Distri...
196	1	213	83486130	Unit 203 338 GOLDSTREAM AVE VICTORIA	019-007-574	Strata Lot 13, Plan VIS3486, Section 1, Esquimalt Land Distri...
197	1	213	83486140	Unit 204 338 GOLDSTREAM AVE VICTORIA	019-007-582	Strata Lot 14, Plan VIS3486, Section 1, Esquimalt Land Distri...

Moncton dwelling distribution (2011)

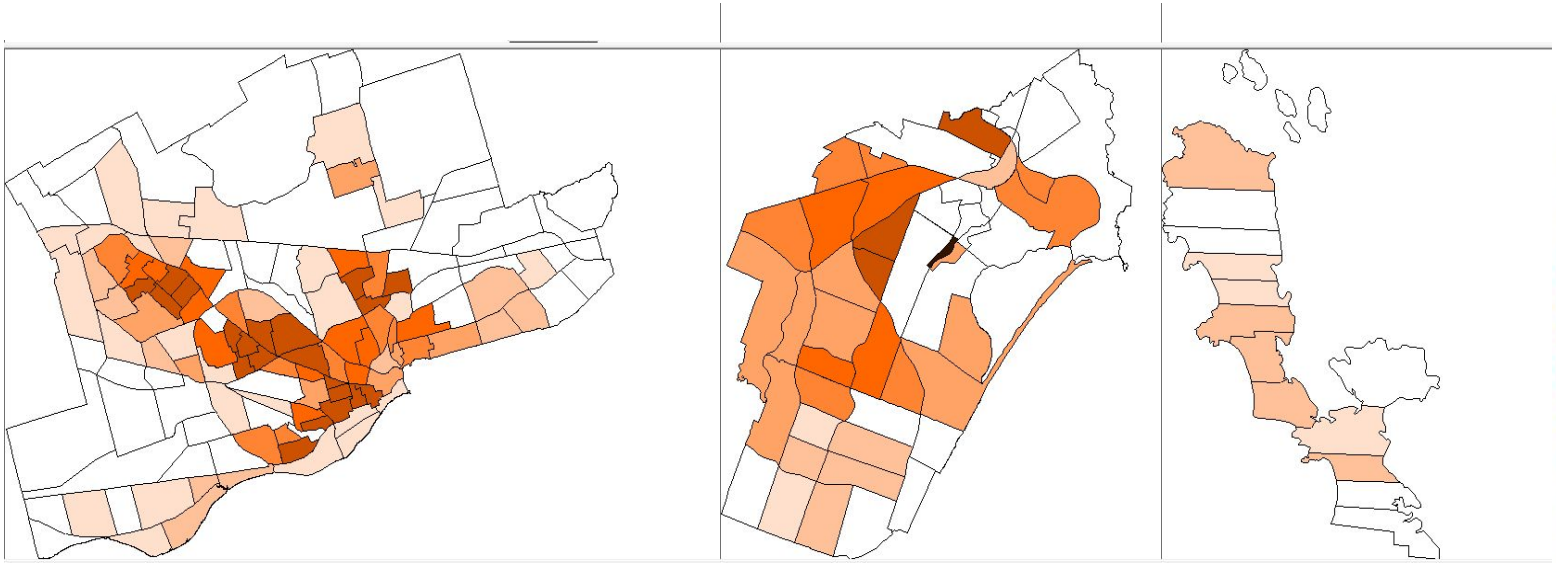


Colwood dwelling distribution (2011)

Tofino dwelling distribution (2011)



Population Distribution by Zone (2011)



Moncton Colwood Tofino

Non-Residential Buildings

- A number of non-residential buildings (municipal buildings, schools, government buildings) were not available in the building assessment data for various reasons.

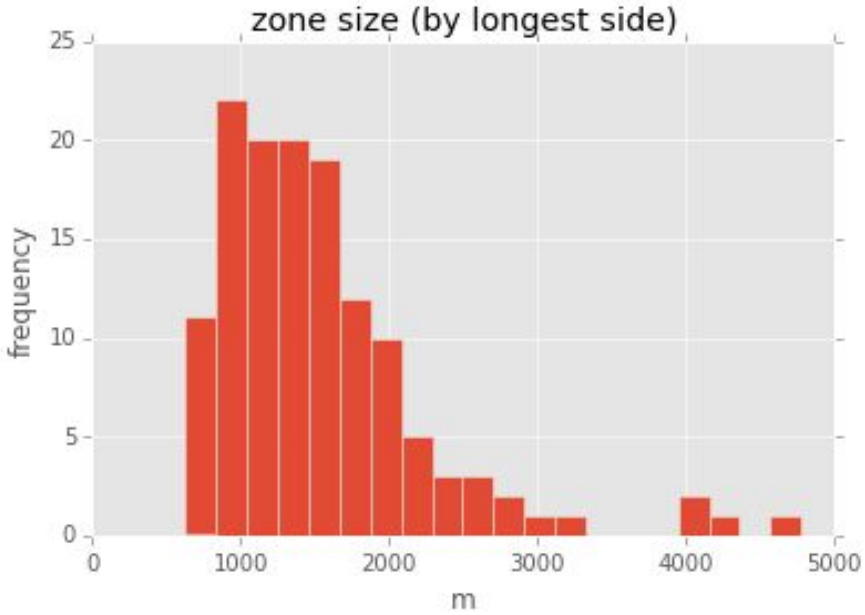
- This required a process of manually checking for data gaps and patching those buildings into the dataset.

- These are future possibilities exist to explore the data that is currently available to enhance this process

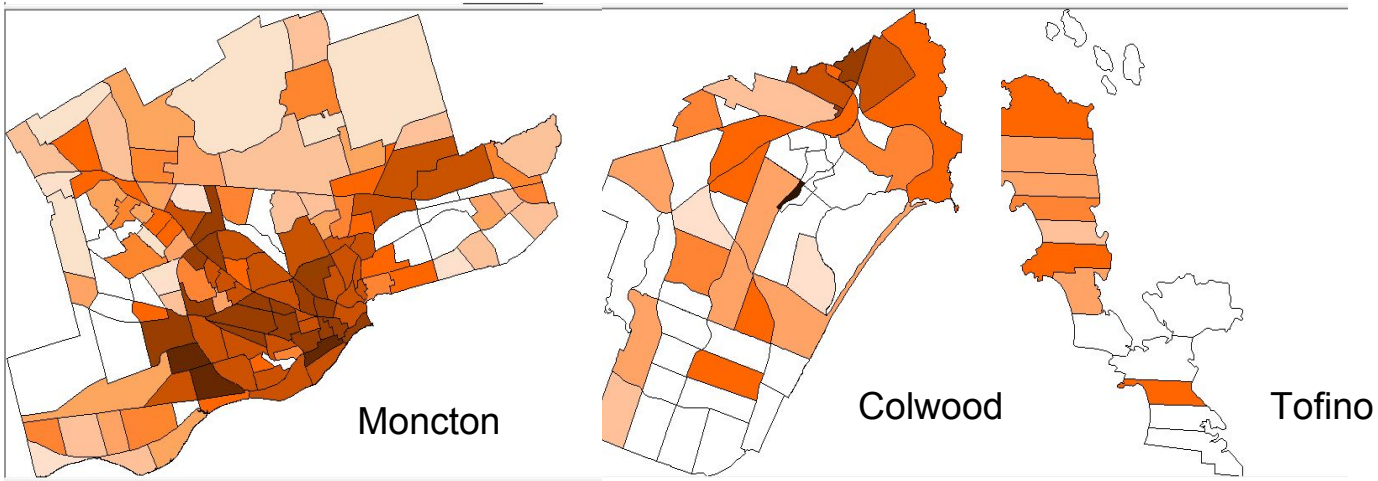
Selecting a zone system

Moncton has 133 traffic zones

Most greater than 1,000m - not great for active transportation analysis



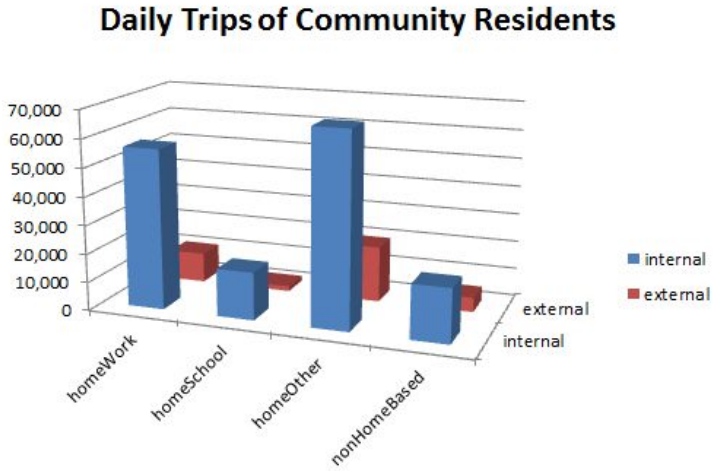
Non residential floorspace (2011)

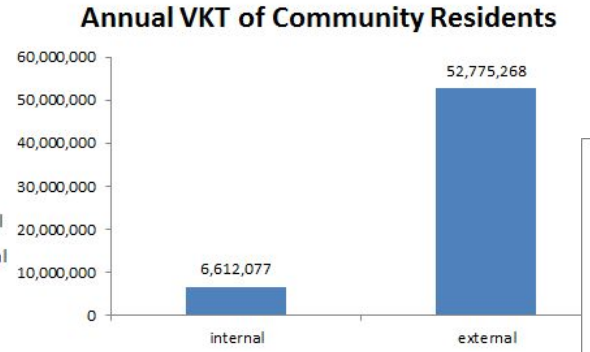


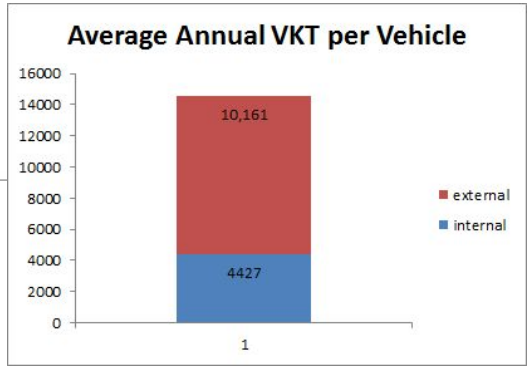
zero
[1, 5]
[5, 20]
[20, 50]
[50, 150]
[150, 500]
[500, 1500]
[1500, 4000]
[4000, 8000]
[8000, 12000]
>= 12000

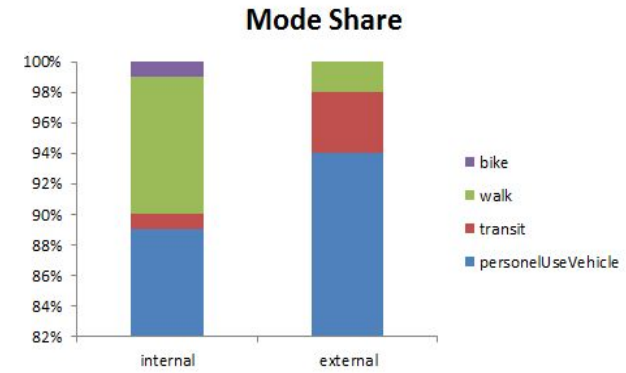
sqm / hectare

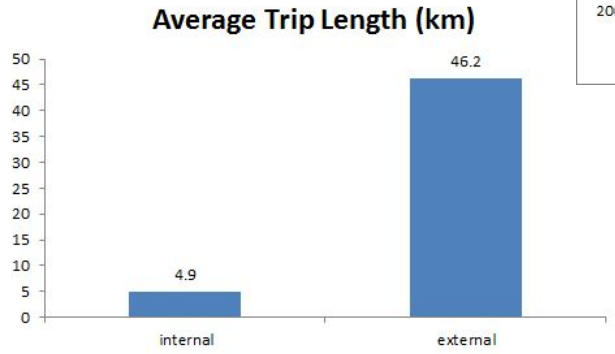
Moncton Base Year Transportation



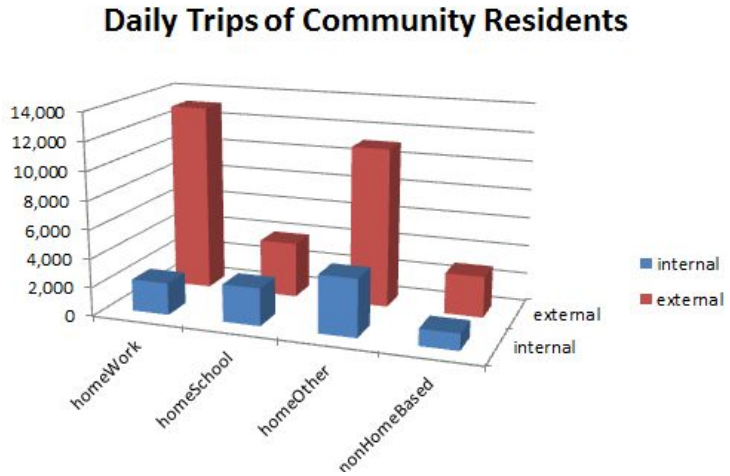


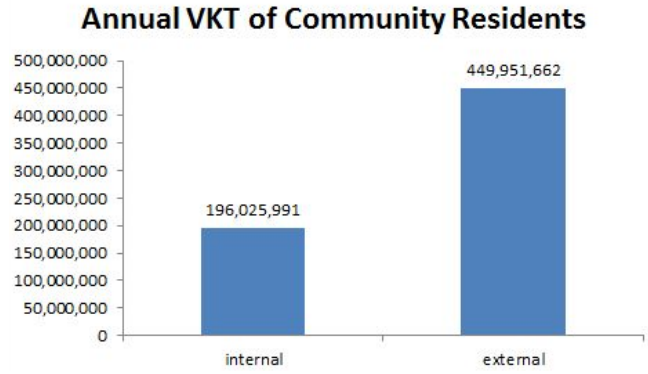


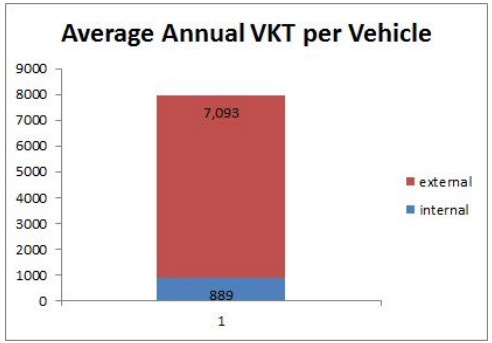


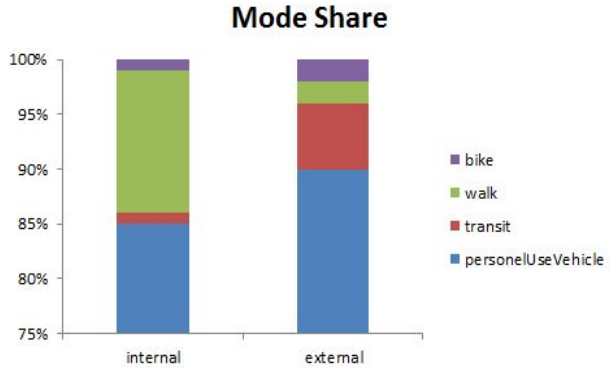


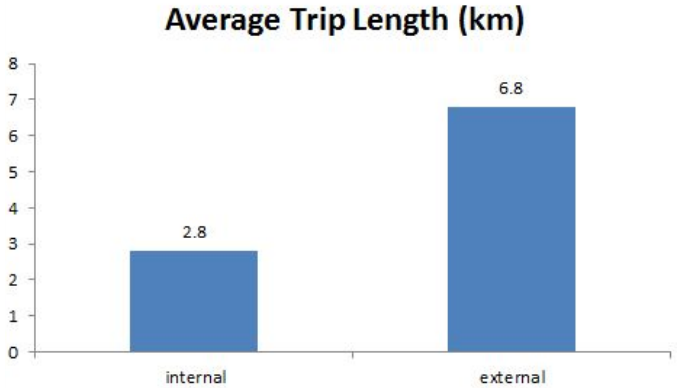
Colwood Base Year Transportation



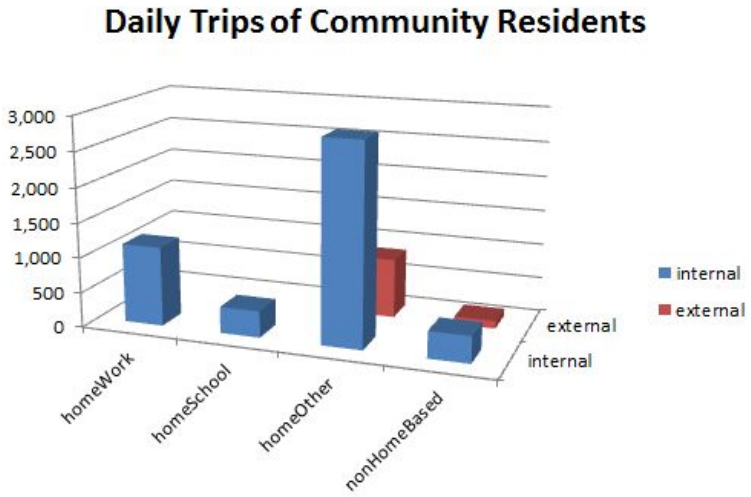


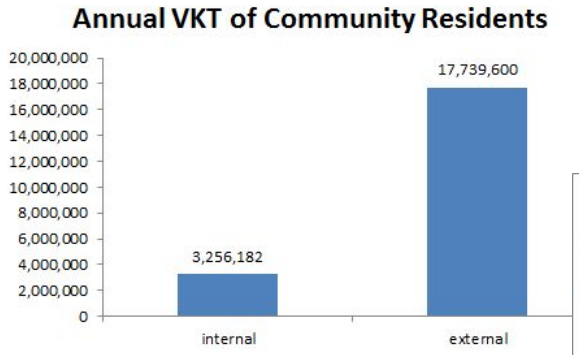


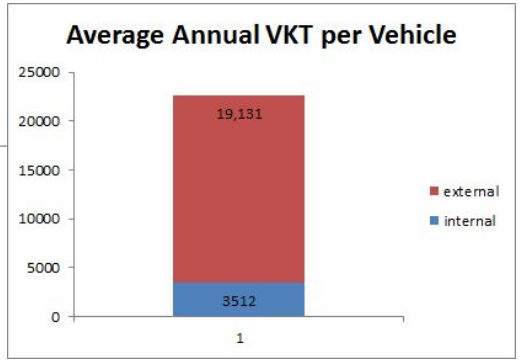


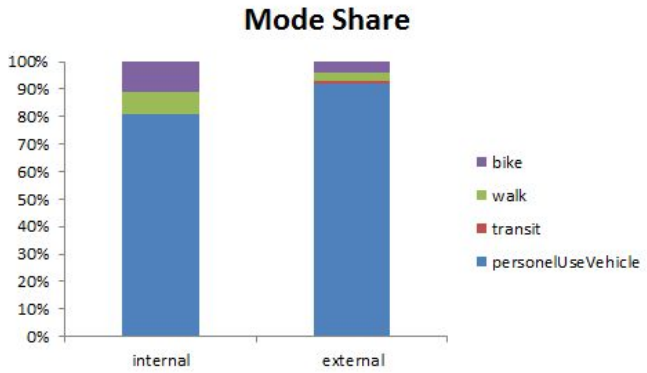


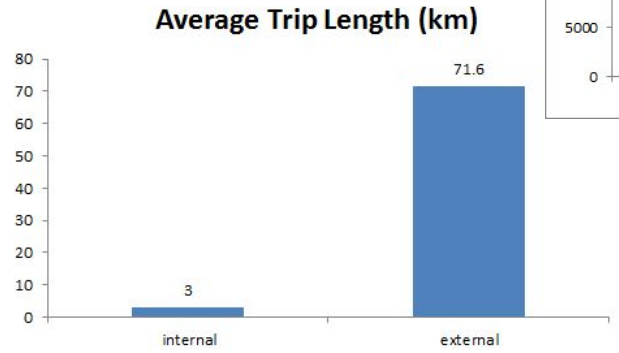
Tofino Base Year Transportation



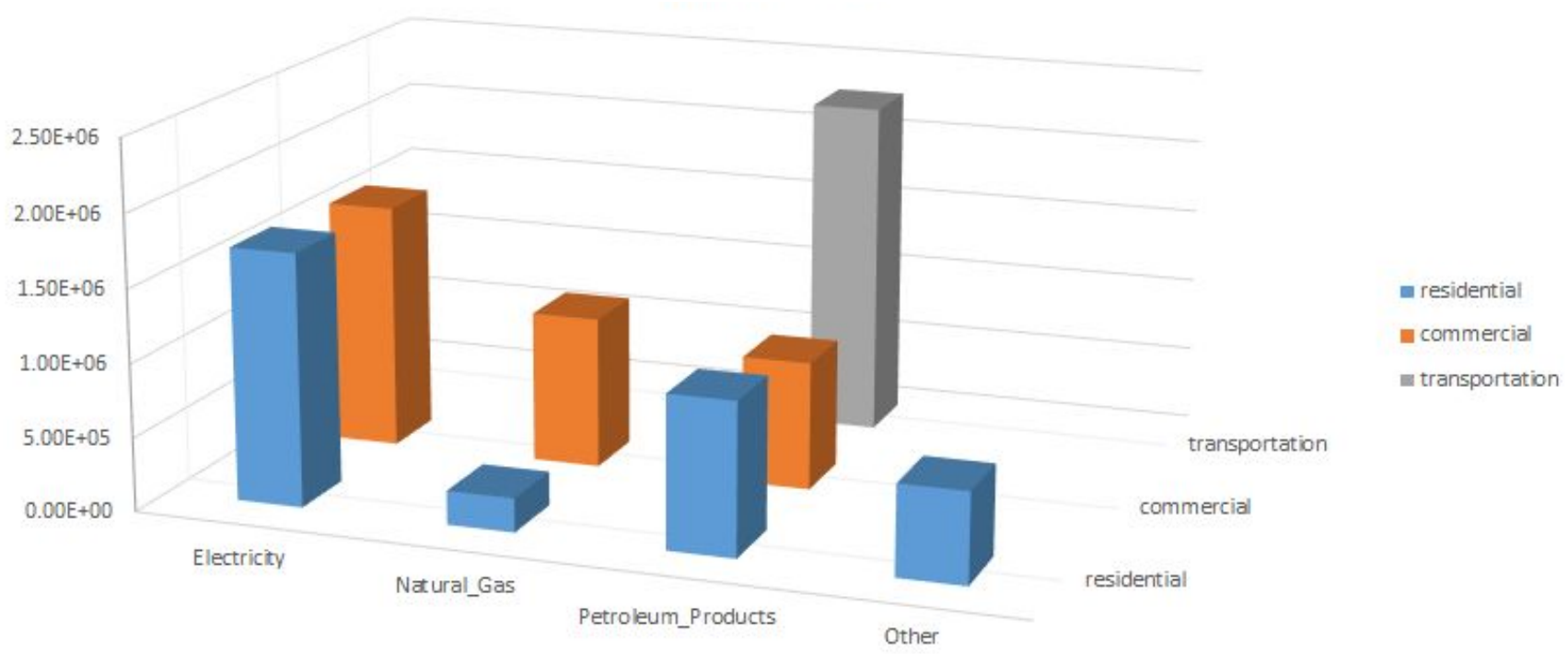




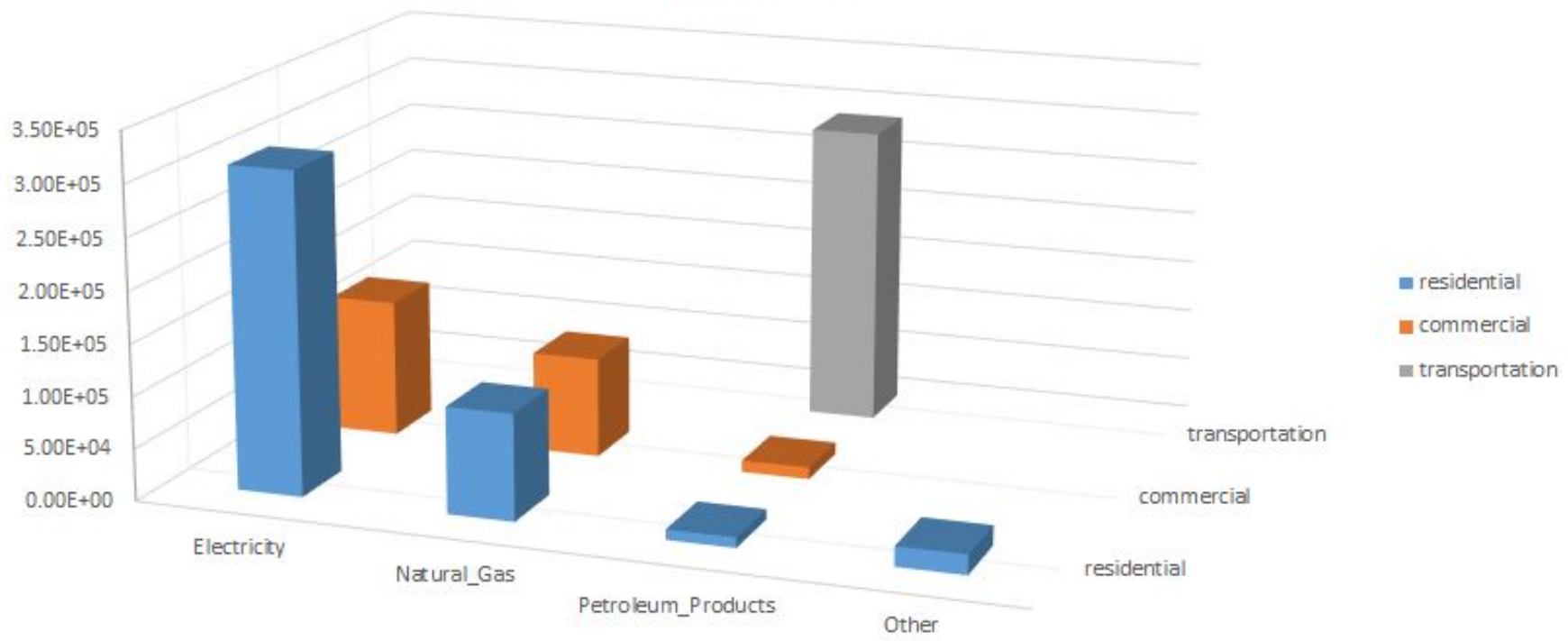




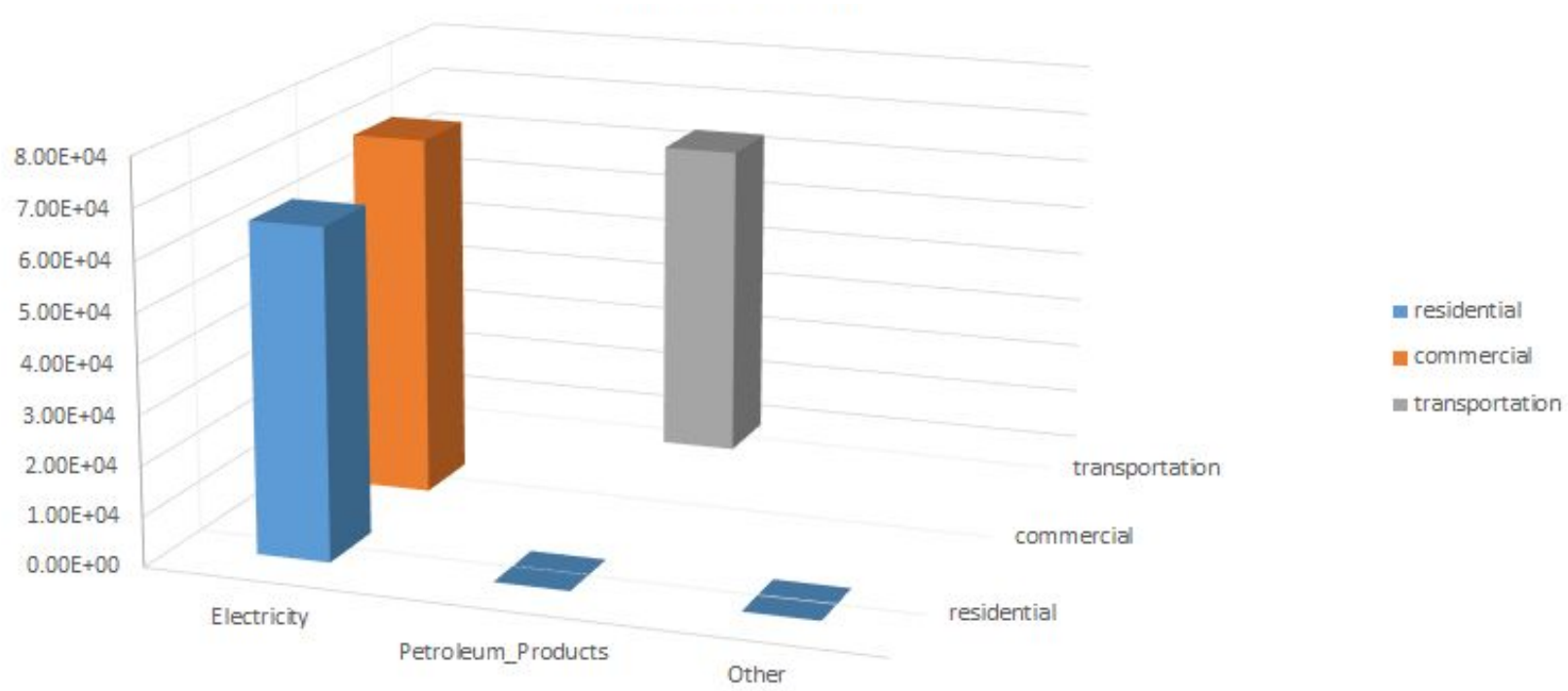
Moncton Base Year Energy Use - GJ



Colwood Base Year Energy Use - GJ

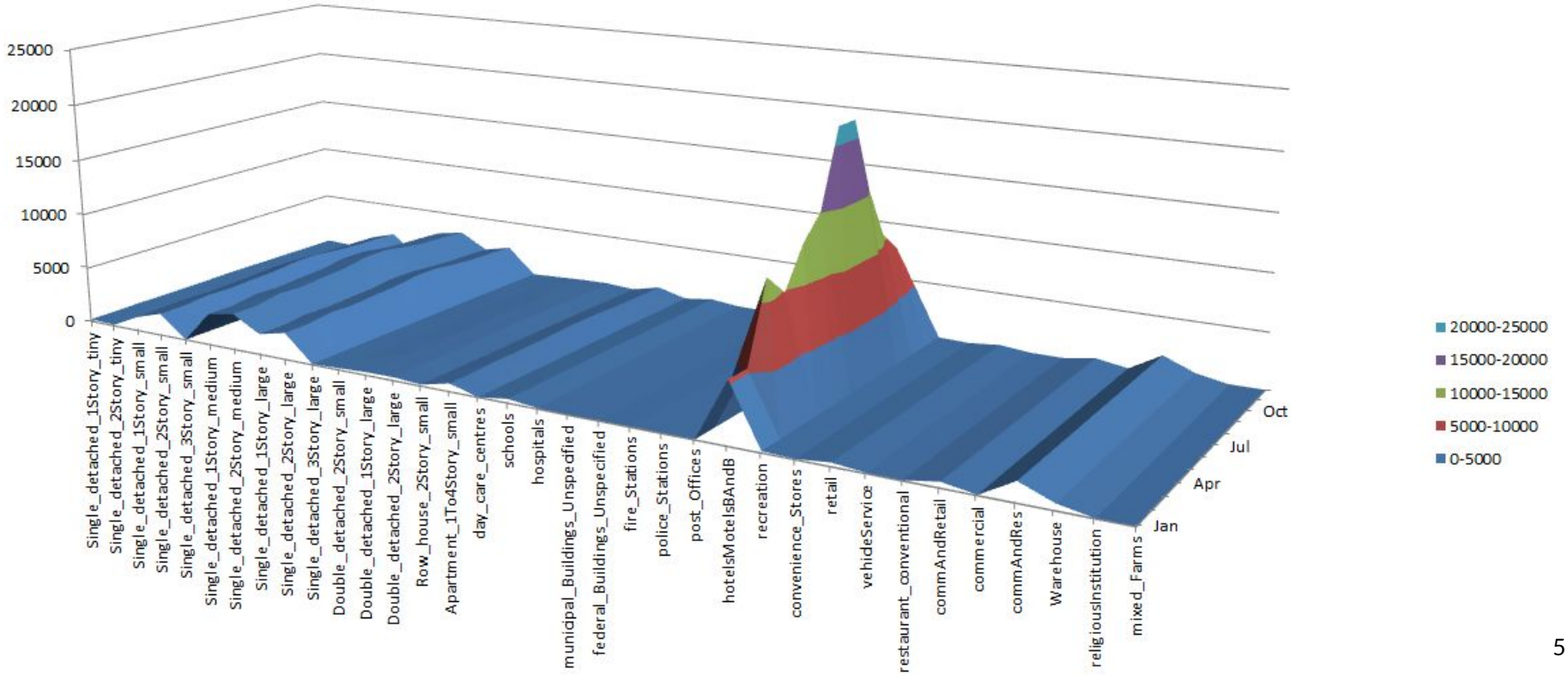


Tofino Base Year Energy Use - GJ



Tofino Base Year Water Consumption

by building type - m^3/month



Financial Calibration

- Municipal finances
  - consolidated financial statements
  - published residential and business tax rates
  - CANSIM
  - various reports
- Household & other accounts
  - data sources
  - survey of household spending
  - challenges

The Story of Moncton

There scenarios where created for the Moncton

- Business as usual (or reference) scenario
- Smart Growth (SG)
- Employment Concentration (EC)

The following slides show the impacts these decisions had to the building make up of Moncton.

The Story of Moncton - population projection

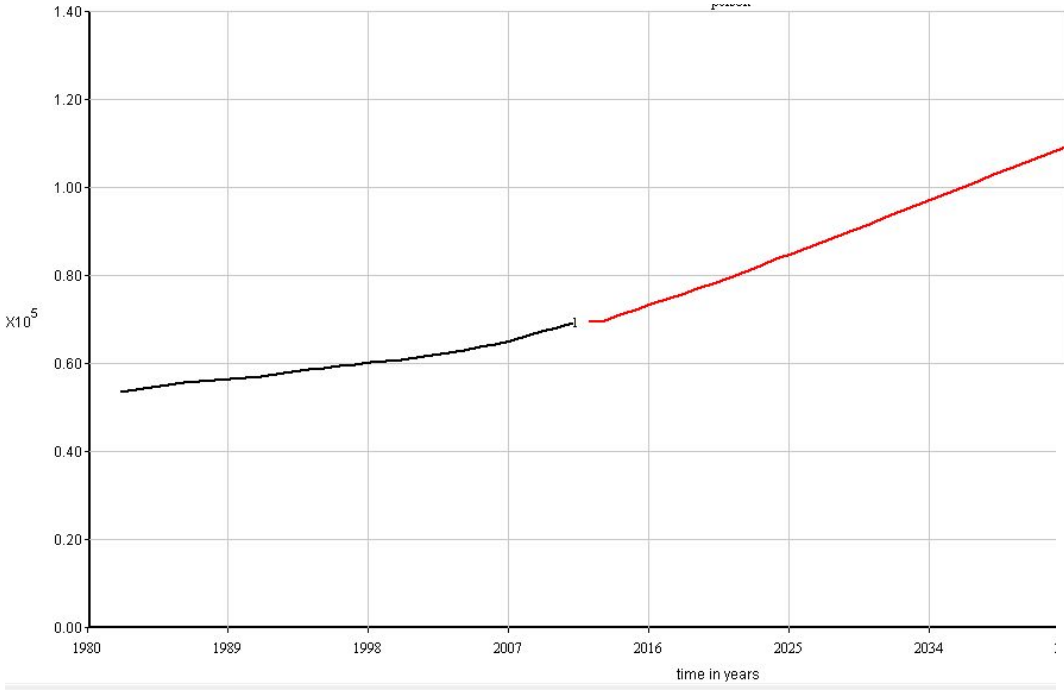
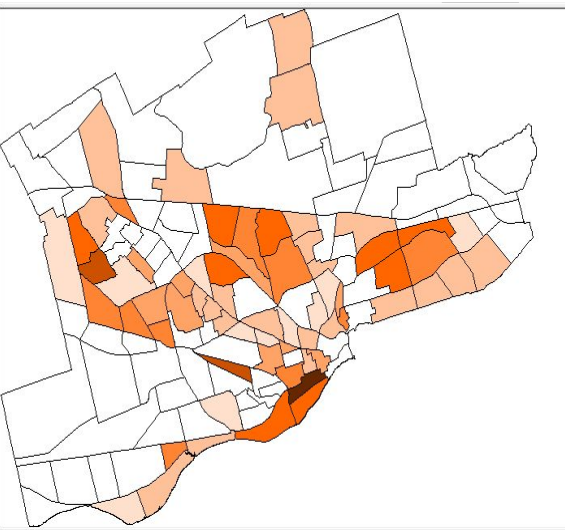


Table 3-1: Population growth

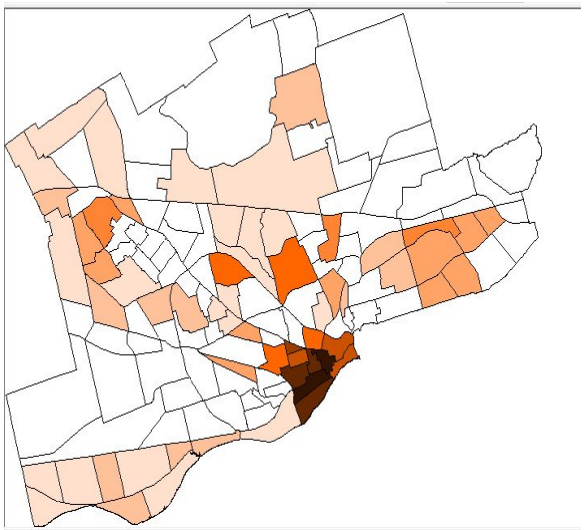
Year	Moncton	Dieppe	Riverview	CMA
2013	69,891	25,650	19,665	142,820
2016	73,385	26,819	20,574	149,312
2021	79,467	28,853	22,156	160,611
2041	106,881	38,020	29,285	211,536

The Story of Moncton - new dwellings projections

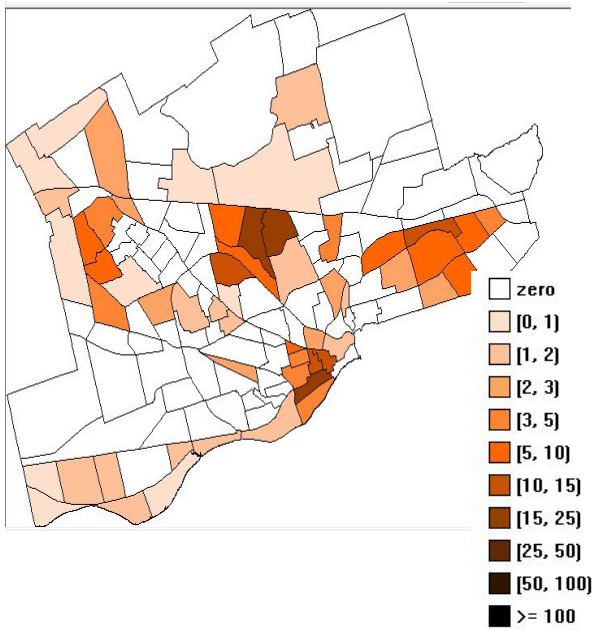
Reference



Smart Growth



Employment Concentration



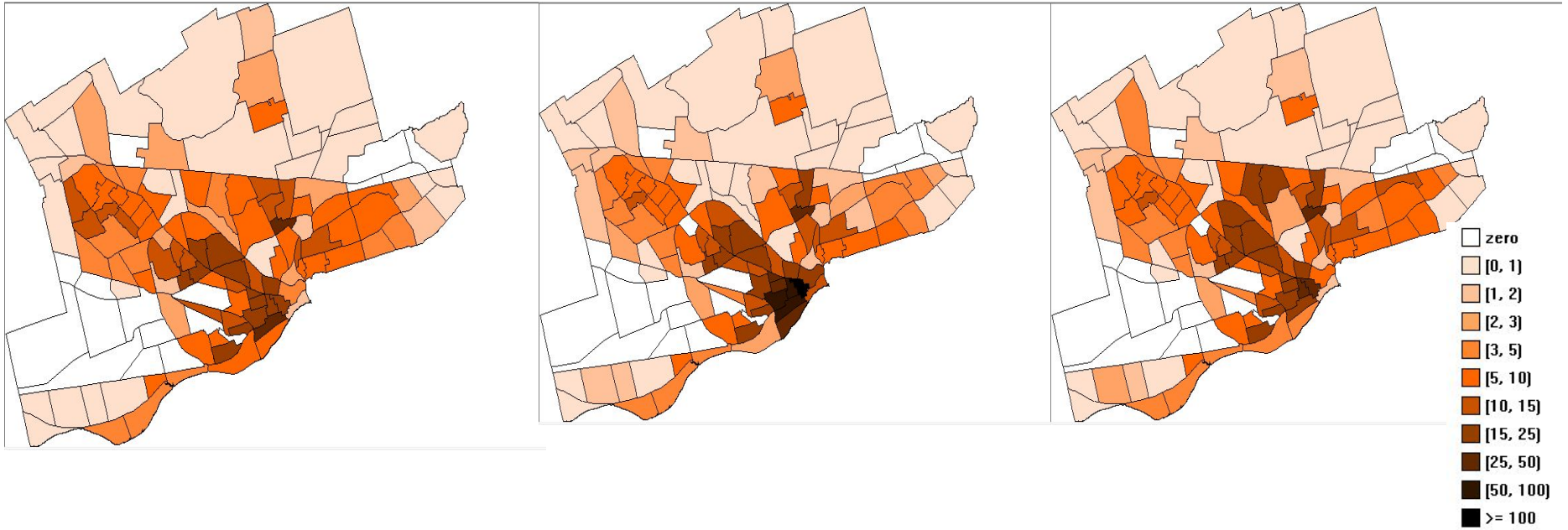
dwelling unit / hectare

The Story of Moncton - total dwellings

Reference

Smart Growth

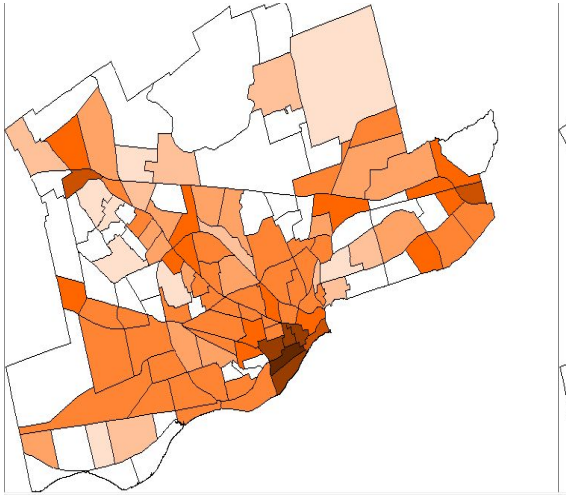
Employment Concentration



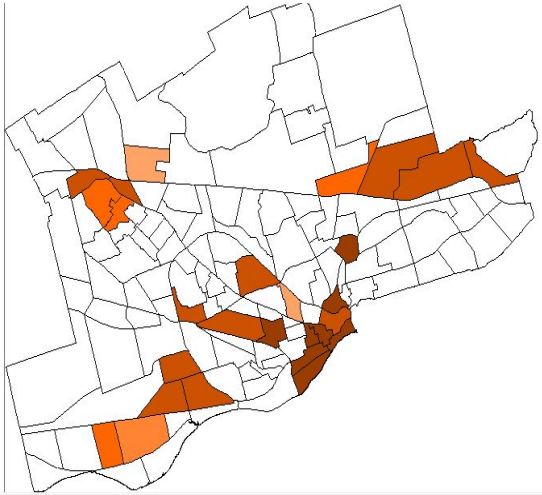
dwelling unit / hectare

The Story of Moncton - new non res floorspace

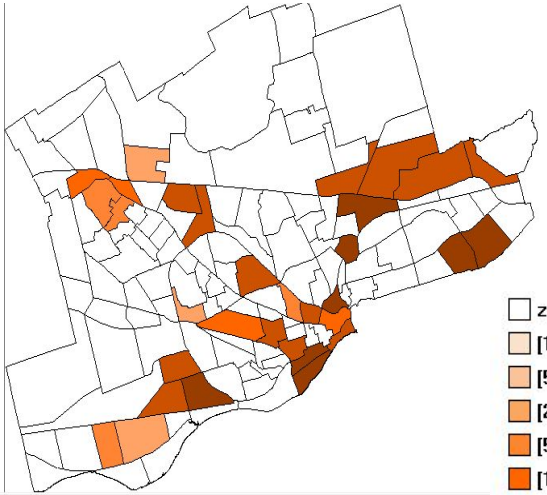
Reference



Smart Growth

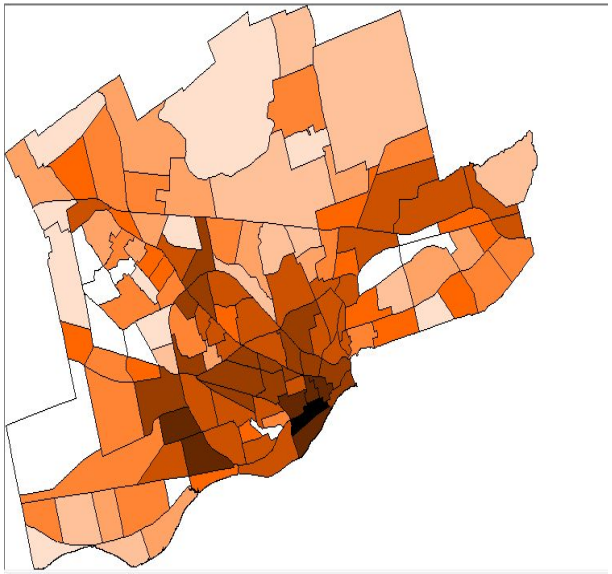


Employment Concentration

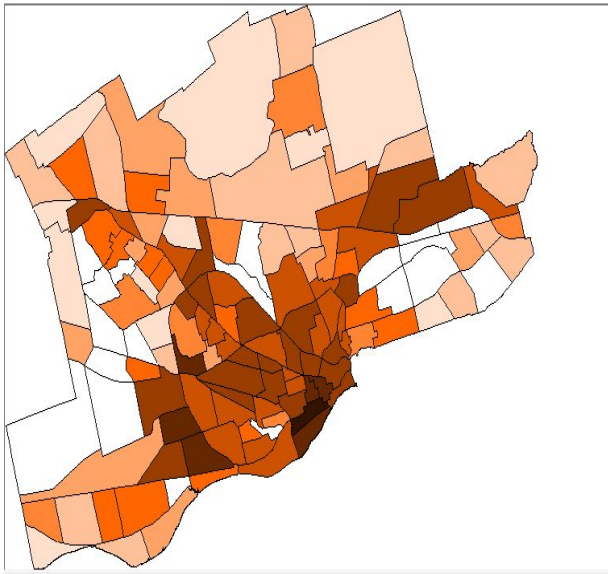


The Story of Moncton - total non-Residential floorspace

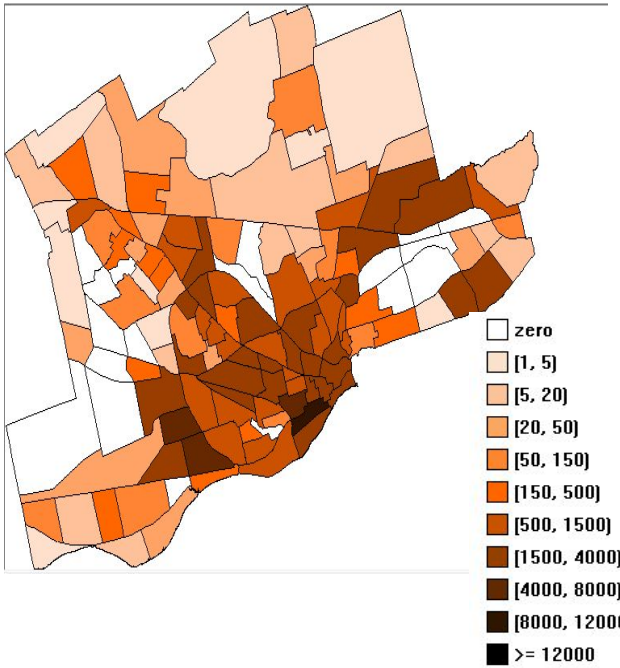
Reference



Smart Growth



Employment Concentration



The Story of Moncton - Infrastructure costs

The addition and removal of buildings is not free, there are infrastructure costs associated with these decisions such as:

Roads

- road
- sidewalk
- bike path

Infrastructure

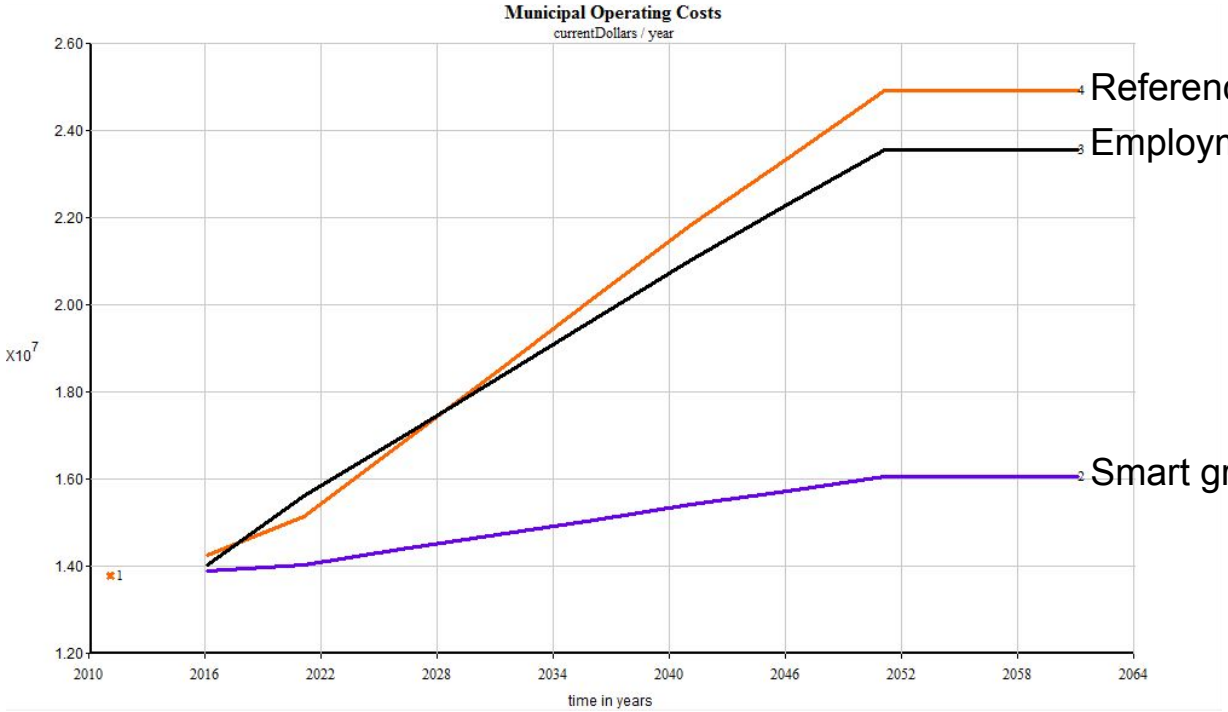
- water distribution
- wastewater collection
- storm water collection
- green space
- water treatment capacity
- wastewater treatment capacity
- storm water treatment capacity

Services

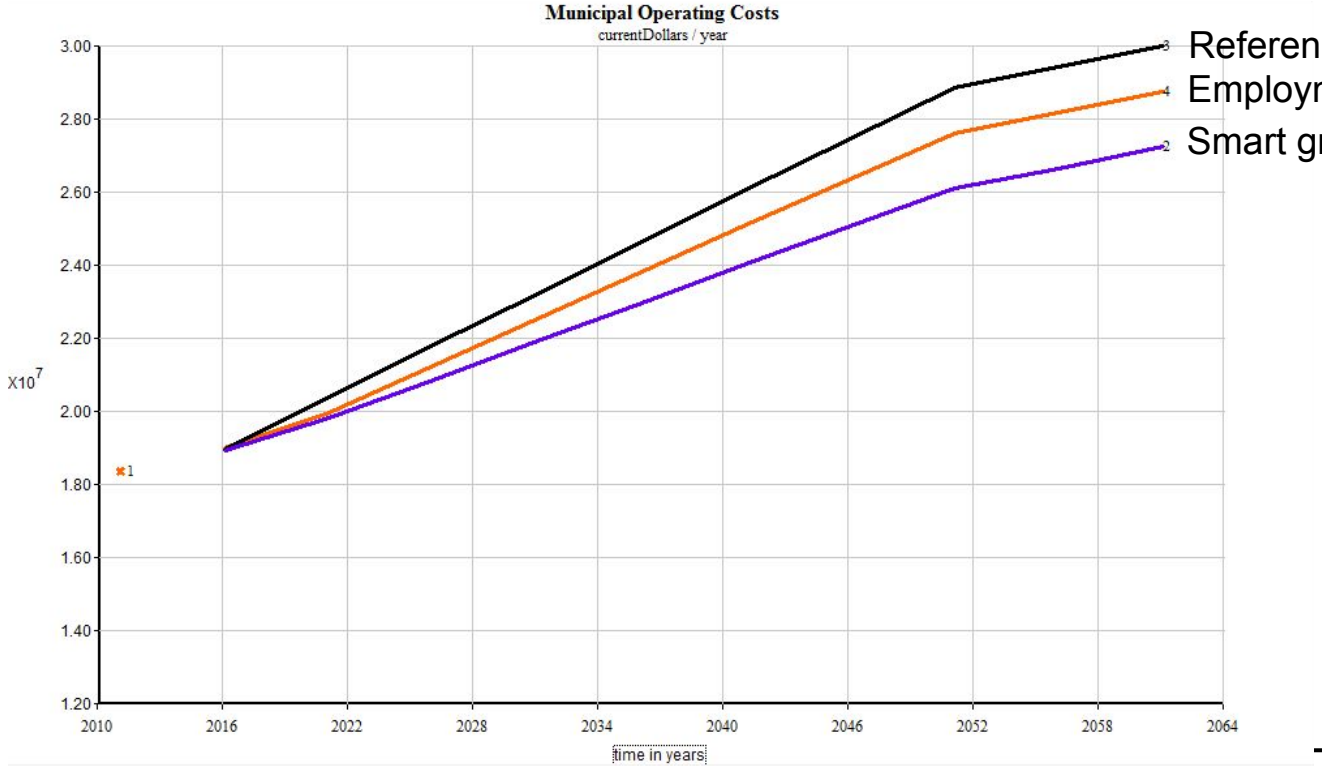
- recycling capacity
- landfill capacity
- transit stock
- transit infrastructure
- protection services (police and firefighters)
- other municipal services (parks, museums, government, etc.)

The following slides explore some of the impacts that the addition of buildings has on the infrastructure of Moncton

The Story of Moncton - roads operating costs

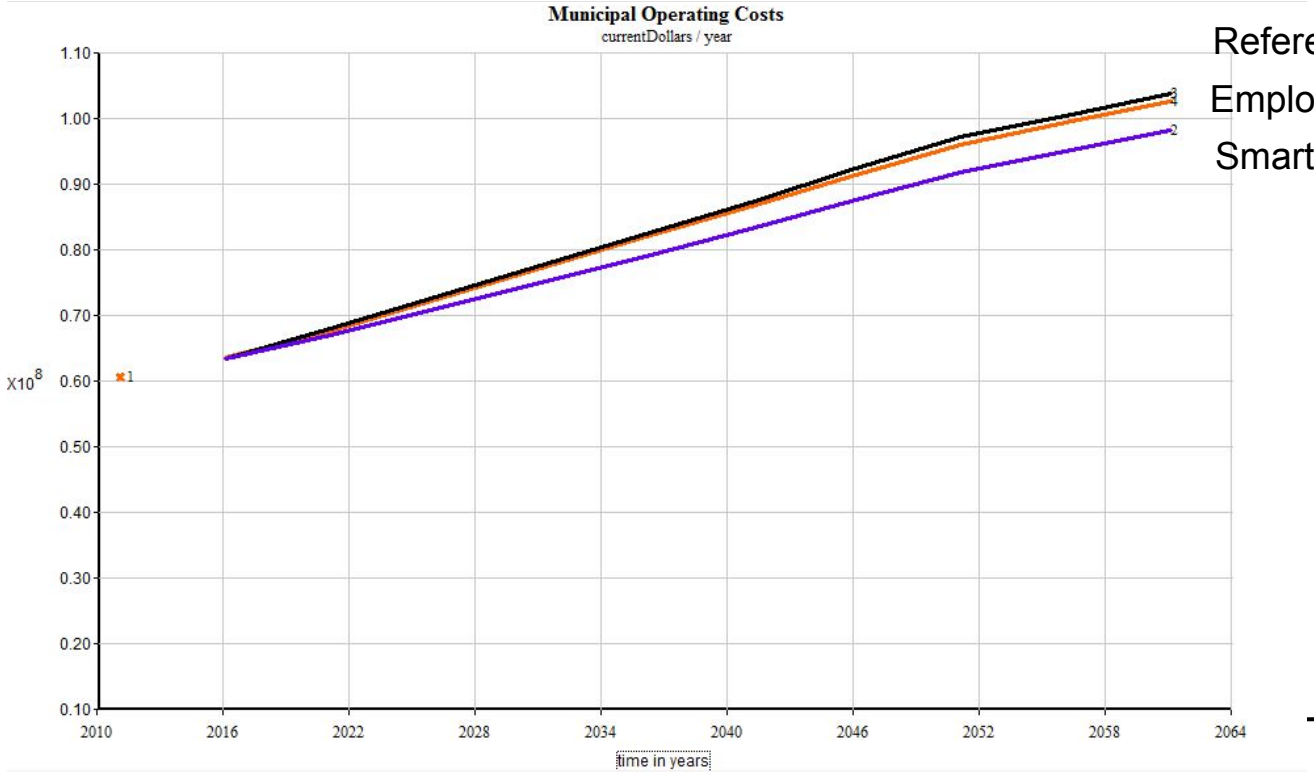


The Story of Moncton- infrastructure operating costs



Reference
Employment Concentration
Smart growth

The Story of Moncton- services operating costs



Reference

Employment Concentration

Smart growth

Learning Outcomes

“Although ecological and economic aspects of sustainability have been addressed by several writers….the social aspect of a sustainable community has received less attention. It has been said that the social dimension is the weakest “pillar” of sustainable development.”

Dale, A. and Newman, L. (2006). “Sustainable Community Development, Networks and Resilience”. Environments Journal Volume 34(2) 2006

Lessons

- Detailed record-based datasets take significant (but worthwhile) effort to inform a model infrastructure such as Places+Spaces model implementation.
- Where standard datasets are available (e.g. province-wide assessment, transportation survey in standard format, province-wide emissions inventory), subsequent data import is much faster.
    - Part of the value of this project will be in open sourcing this processing logic
- Communities struggle with choice of units with which to express growth/change (population, dwellings, jobs, floorspace, etc). The model infrastructure provides an open framework in which to explore those options in an internally consistent way.

Research Outcomes

1. Development of a semi-integrated model infrastructure, v. 1.0
2. Model infrastructure website, open-source platform
3. Development of financial calibrations, integration finalized in v 2.0.
4. Ongoing scenario development, issue-specific, v. 2.0
5. Data visualizations
6. Issue specific scenarios
7. Commercial spin-off of a GHG emissions model, CityinSight
8. On-going private/public sector business partnership between whatifTechnologies and Sustainability Solutions Group
9. Model infrastructure presentations to FCM, ICLEI, CPI and QUEST

Canada Places + Spaces