2015-03-06

Quick Analysis Technique to Estimate GHG Emissions Based on the Built Form and Street Grid Connectivity

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Author

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Presentation outline

- **Introduction**
- **Link between the urban form and travel greenhouse gas emissions (GHG)**
- **Technique for estimating GHG emissions based on travel activity and the effectiveness of different measures**
- **Conclusion**

Definitions

- **Alternative transport modes: other modes than driving alone which includes walking, cycling, transit and carpooling.**

- **GHG emissions: Greenhouse gas emissions into the atmosphere during a certain period (in CO2 equivalents)**

- **Vehicle-kilometres travelled (VKT): Total vehicular kilometres driven using a private vehicle by a study areas residents or other users.**

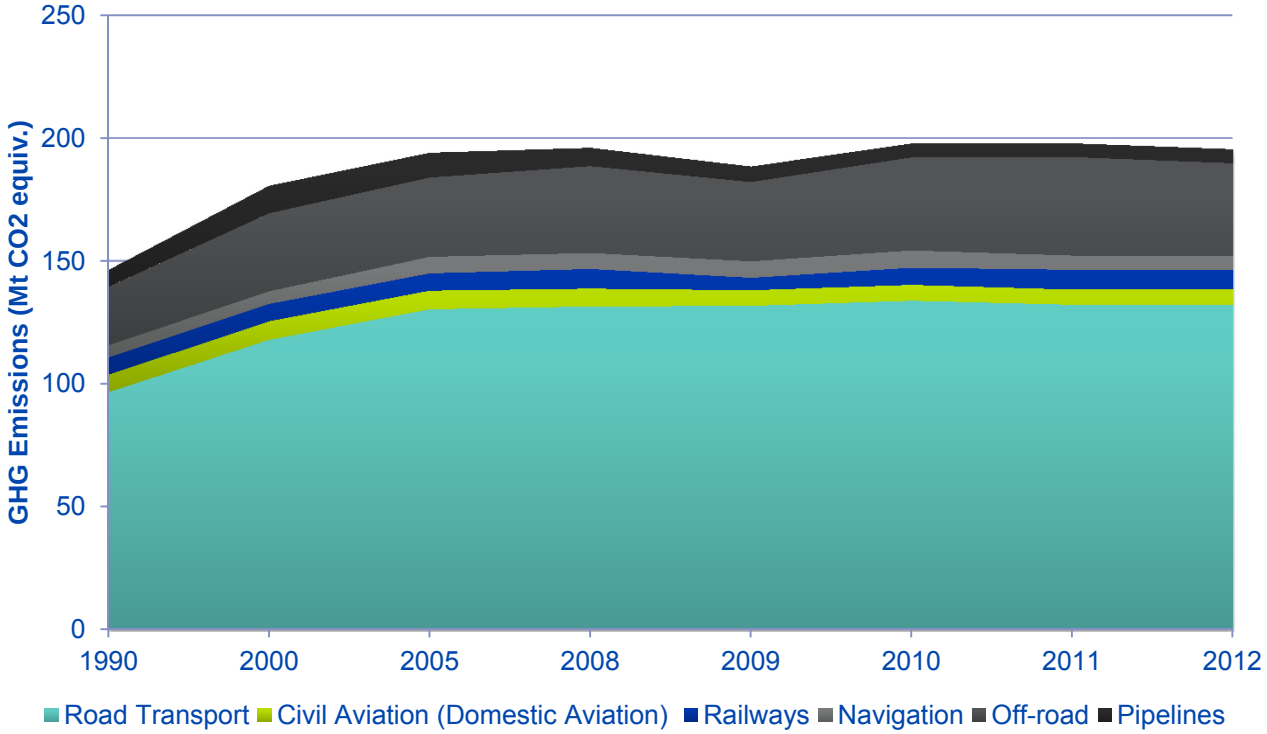
Study problem

→ **Identify efficient solutions that reduce GHG emissions by promoting alternative transport modes in a neighbourhood**

- Efficiency = measurable
- The impact of different is then assessed based on GHG emissions

GHG emissions and transport in Canada

- **Total GHG emissions in Canada (2012): 699 Mt CO2 equiv. (IPCC) - 20.3 tons/person**
- **Transport represents 28% of total emissions in Canada (43.5% in Quebec). 68% of this total is due to road transport (76% in Quebec).**
- **Transport emissions have increased by 33% between 1990 and 2012 (37% for road transportation)**



Source : Canada National Inventory Report - 2012 (Environnent Canada, 2014)

GHG emission and road transport

→ **Main factors driving road transport GHG emissions:**

- Energy efficiency | emissions by distance travelled (vehicle or fuel)
- Travel conditions and driver behaviour (e.g. higher emissions in congested areas or at high speeds)

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Factors influencing travel distances

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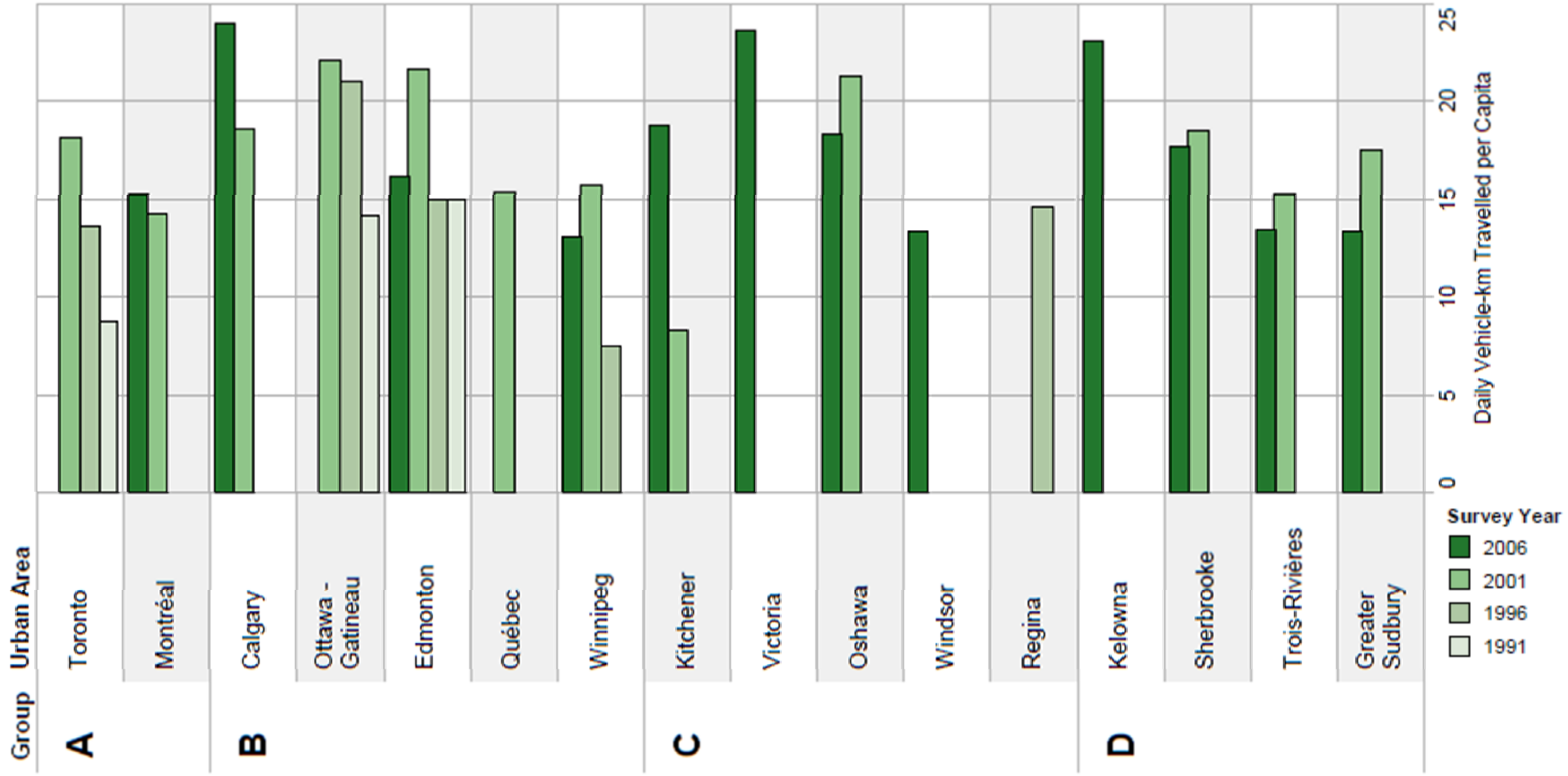
- Modal shares (walking, cycling, carpooling, transit, etc.)
- Length of travel by car
- Trips not taken or alternatives to travel

Factors influencing travel distances

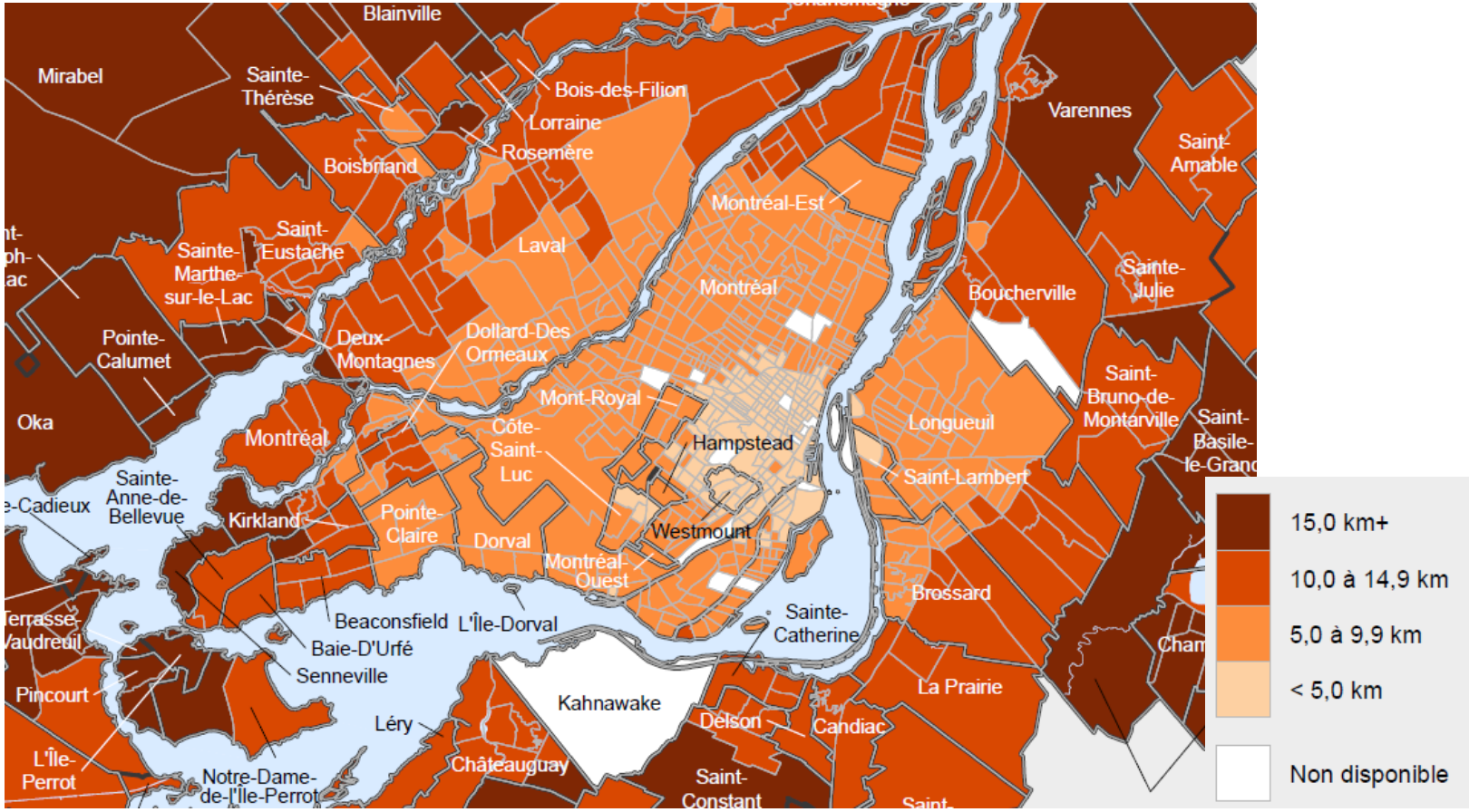
- **Large variation between regions**
- **Daily vehicle-kilometres travelled (VKT) per capita in select metropolitan areas in Canada.**



Source: TAC (2010)

Factors influencing travel distances

- → **Regional and location factors have a large influence**
- → **Median Commuting Distance by Place of Residence**



Source: Statistics Canada (2006)

Factors influencing travel distances

→ **Factors influencing travel distances**

Regional	Neighbourhood Design	Individual	Trip
-Location of neighbourhood -Regional structure -Structure of transport networks -Accessibility to jobs and retail	-Density -Mixed uses -Street Grid (connectivity) -Proximity to local services and shops -Transit (proximity and quality of service) -Presence of pedestrian and cycling infrastructure	-Age -Sex -Auto-selection of households -Occupation -Revenue -Access to a vehicle	-Motive -Time of day -Constraints -Trip chaining -Trip frequency

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Actions/tools available at the neighbourhood level

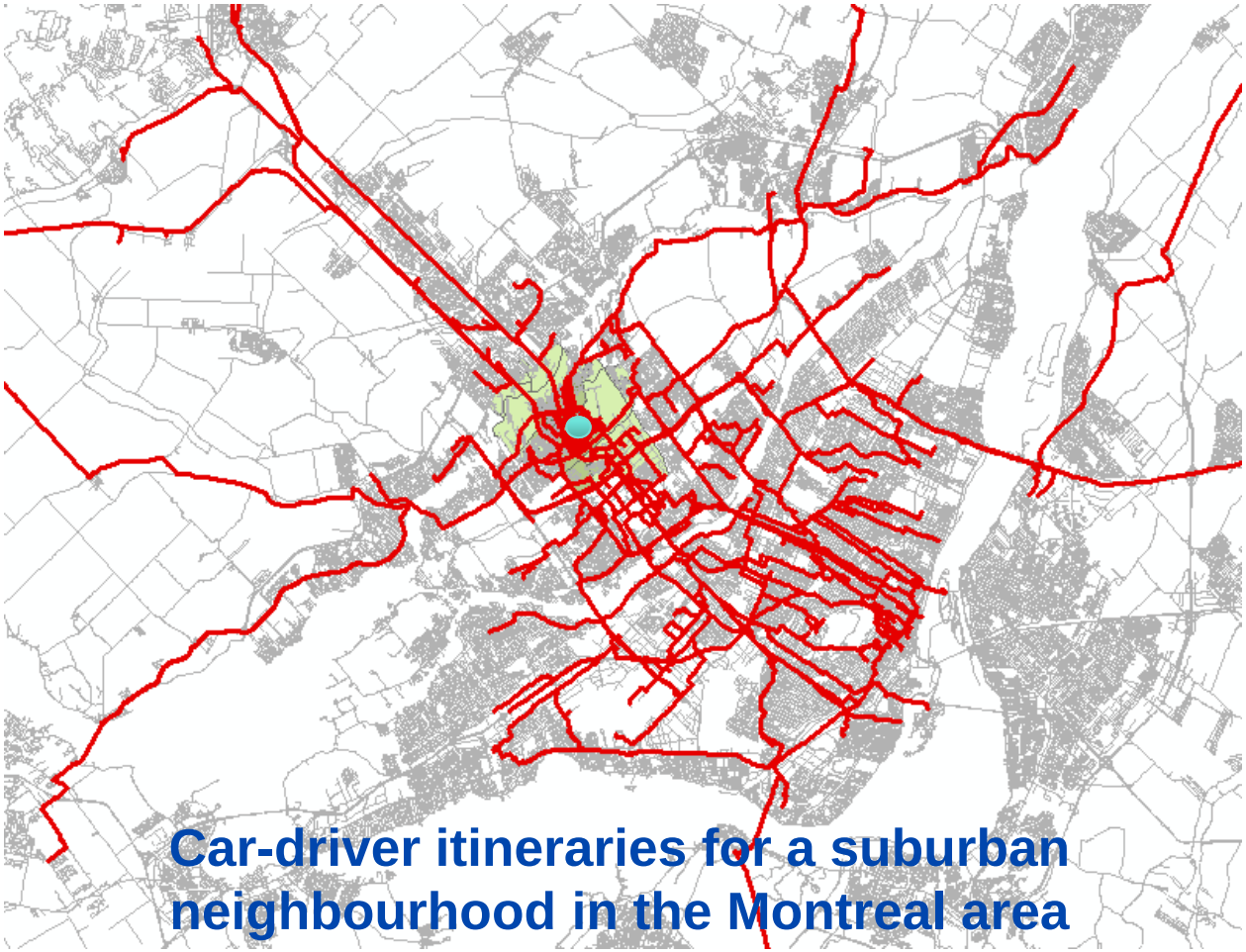
General methodology to assess the effectiveness of measures on GHG emissions

→ **Four Steps:**

1. Establish baseline vehicle-kilometres travelled in the study area
2. Identify opportunities and constraints for interventions in the neighbourhood
3. Assess the effectiveness of different measures and alternatives (scenarios) on total VKT travelled
4. Identify and implement measures

Establishing baseline GHG emissions and total VKT

→ **Estimation based on origin-destination survey results**

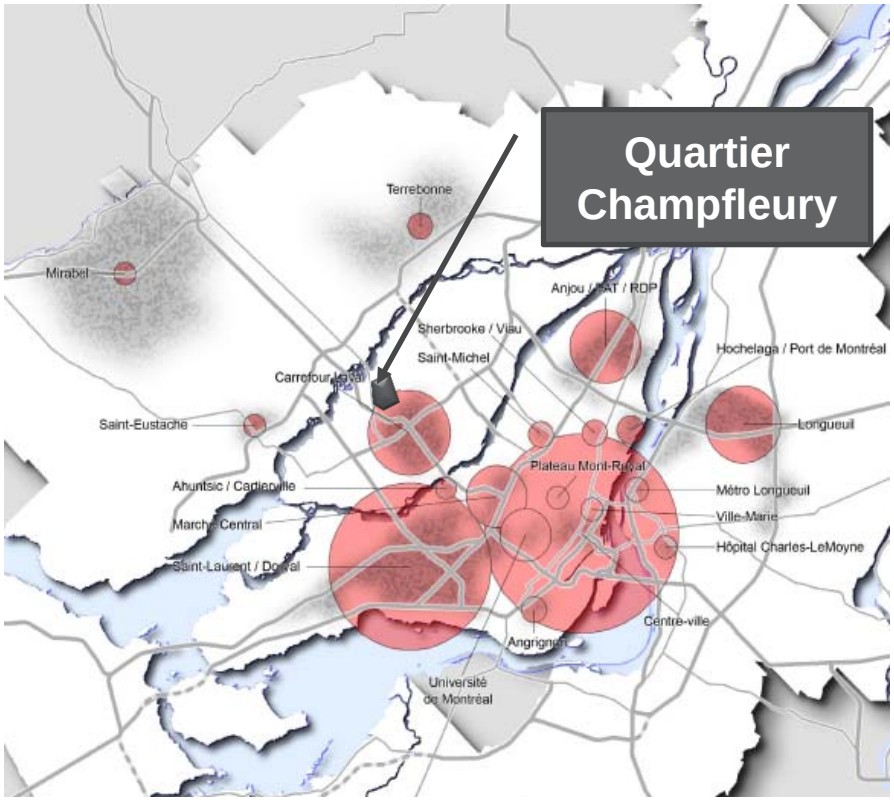


Car-driver itineraries for a suburban neighbourhood in the Montreal area during a typical workday (19.0 km per capita per day)

Identifying opportunities and constraints

→ **Two residential neighbourhoods were selected**

- One neighbourhood in suburban Montreal (19.0 km per day per resident)
- Second neighbourhood in suburban Sherbrooke (29.1 km per day per resident)



Identifying opportunities and constraints

→ **Urban Form**

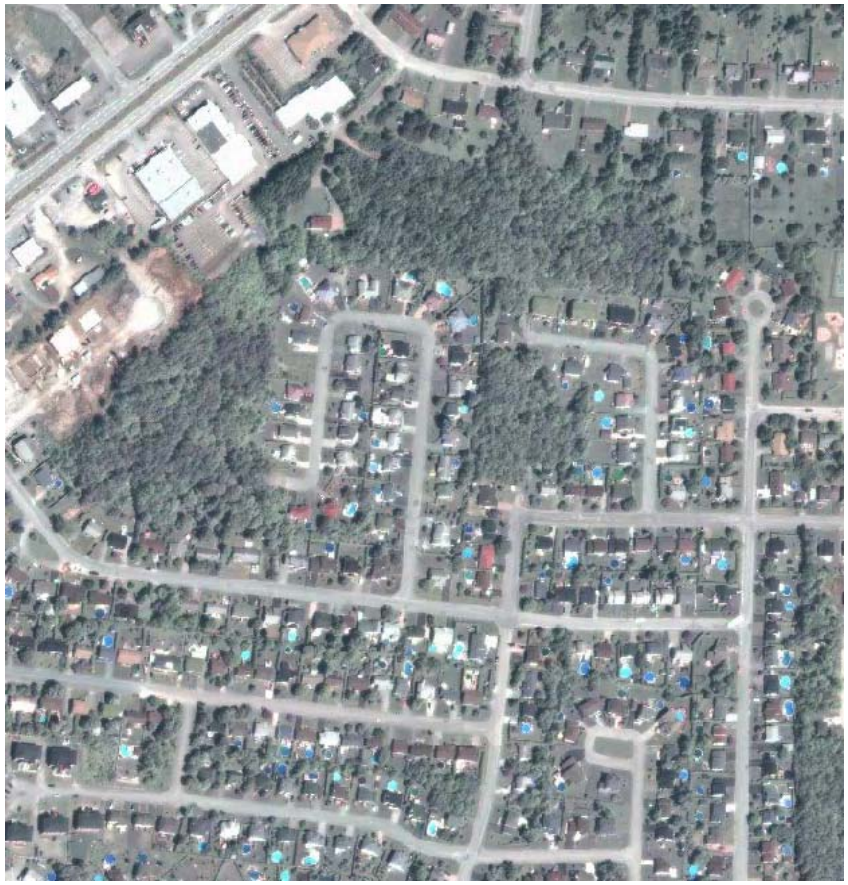
Champfleury (Laval)

Mi-Vallon (Sherbrooke)

Identifying opportunities and constraints

→ **Street Connectivity. Lack of connectivity concentrates traffic on major streets.**

Champfleury (Laval)



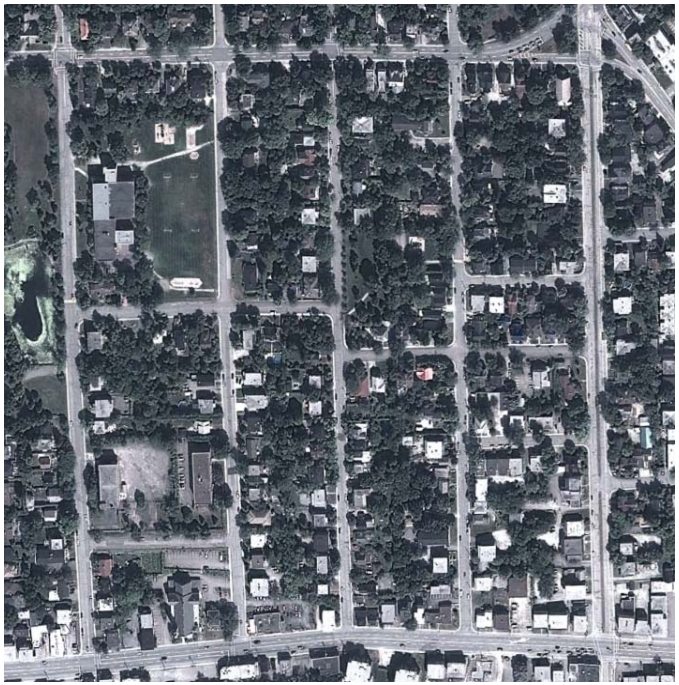
Mi-Vallon (Sherbrooke)

Identifying opportunities and constraints

→ **Street Grid**

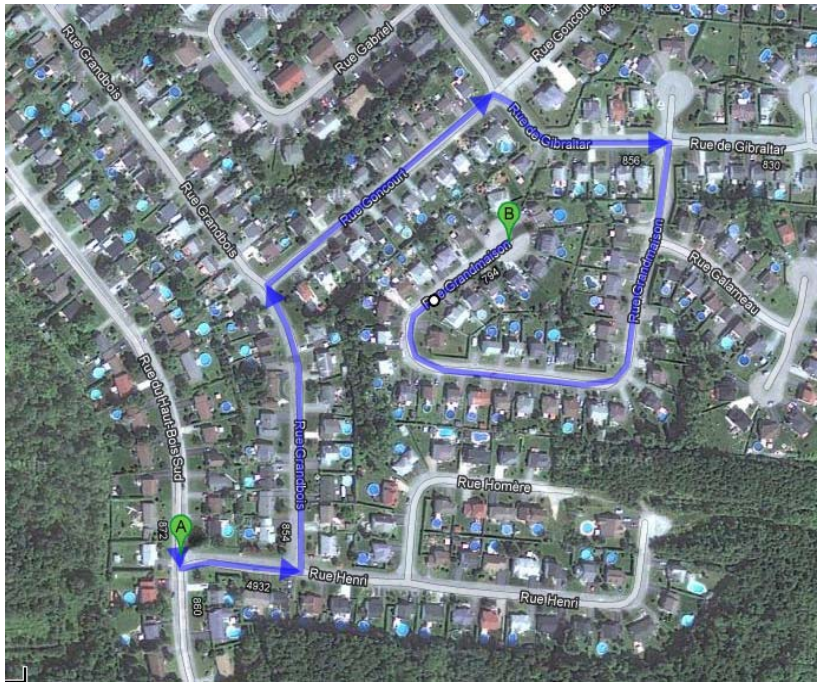
- Important influence on walking and cycling (shorter travel distances, improved accessibility), on transit (direct routes and shorter access) and car travel (shorter distance)

Orthogonal street grid



Central Area

Grid with dead-ends



Suburban Street Grid

Identifying opportunities and constraints

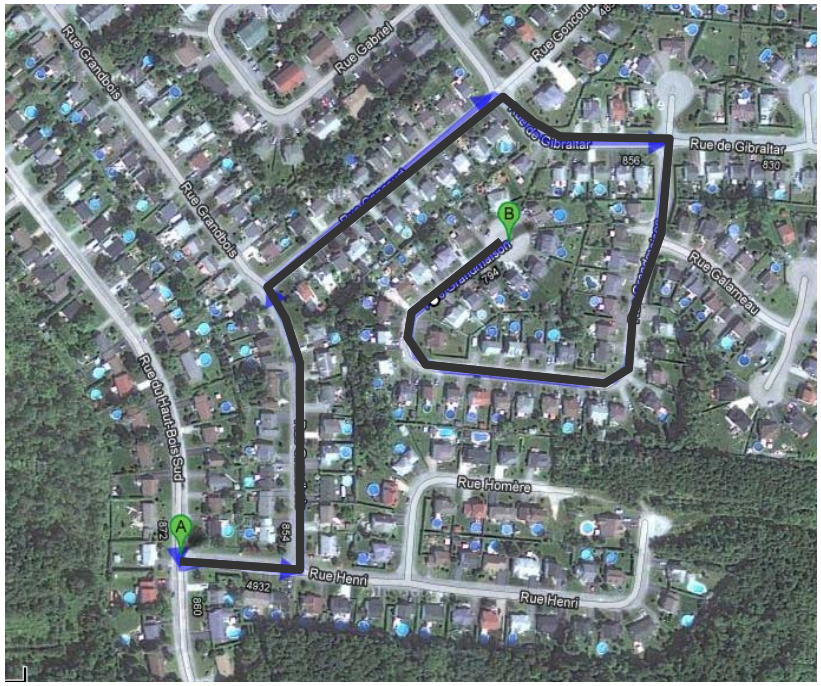
→ **Street Grid**

- Important influence on walking and cycling (shorter travel distances, improved accessibility), on transit (direct routes and shorter access) and car travel (shorter distance)

Orthogonal street grid

4.8 intersections/km

Grid with dead-ends



3.7 intersections/km

Identifying opportunities and constraints

→ **Walking and cycling facilities**

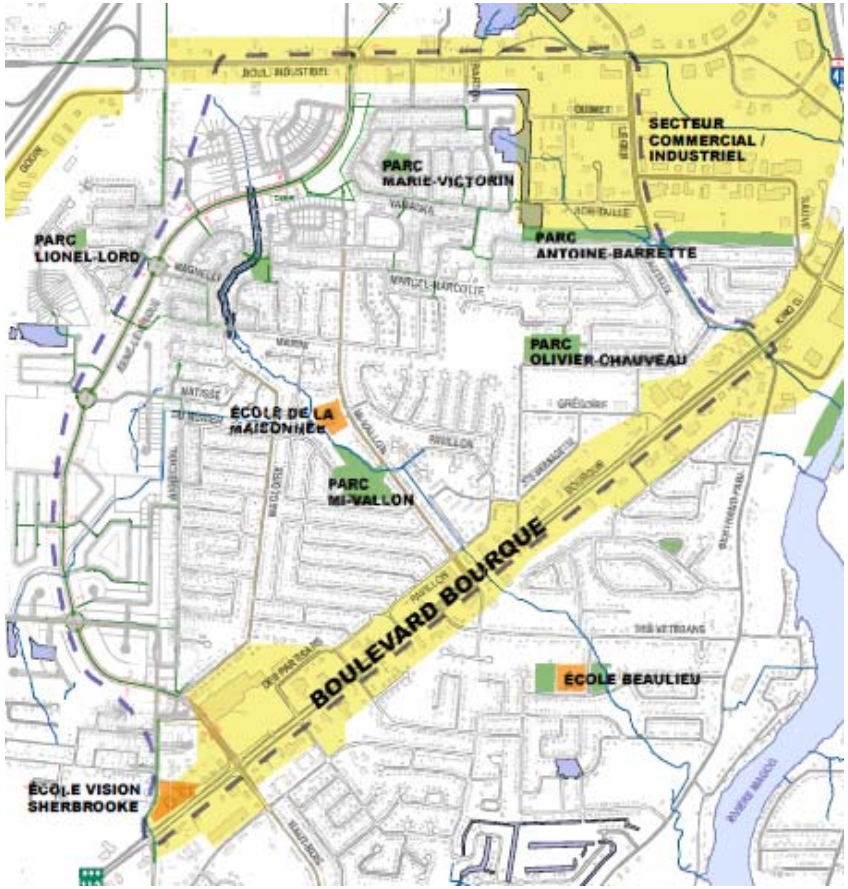
0.29 street/sidewalk ratio (2.0 = sidewalks on both sides throughout)

0.08 street/sidewalk ratio

Identifying opportunities and constraints

→ **Location of local shops and services: segregated from residences**

Champfleury (Laval)



Mi-Vallon (Sherbrooke)

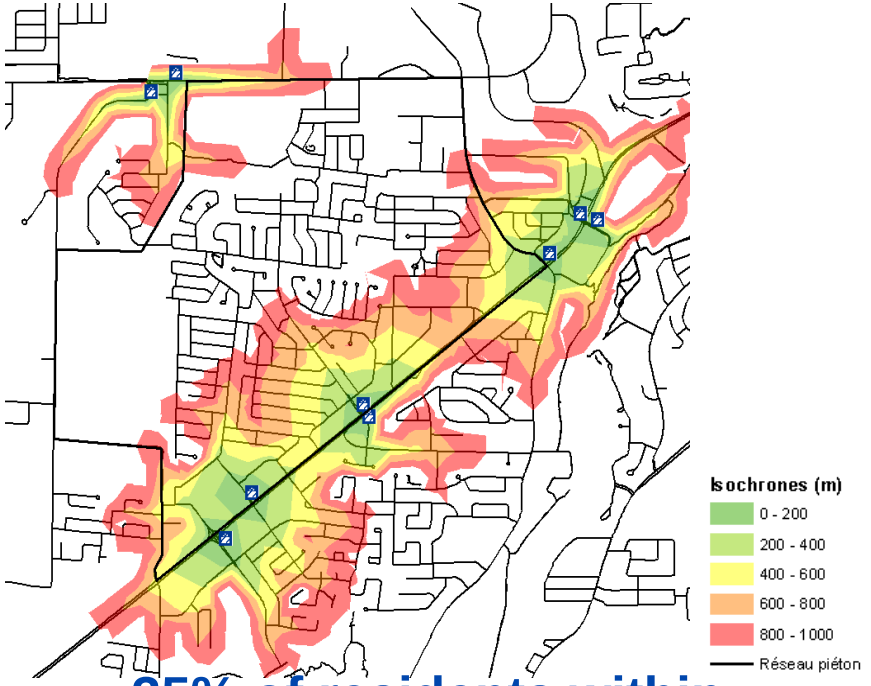
Identifying opportunities and constraints

→ **Mixed-Use and Proximity to Services**

- Greater influence on walking and cycling use than transit use
- Can also reduce car travel distances by providing closer destinations

Access distances to the closest shops

36% of residents within 800m of a shop



35% of residents within 800m of a shop

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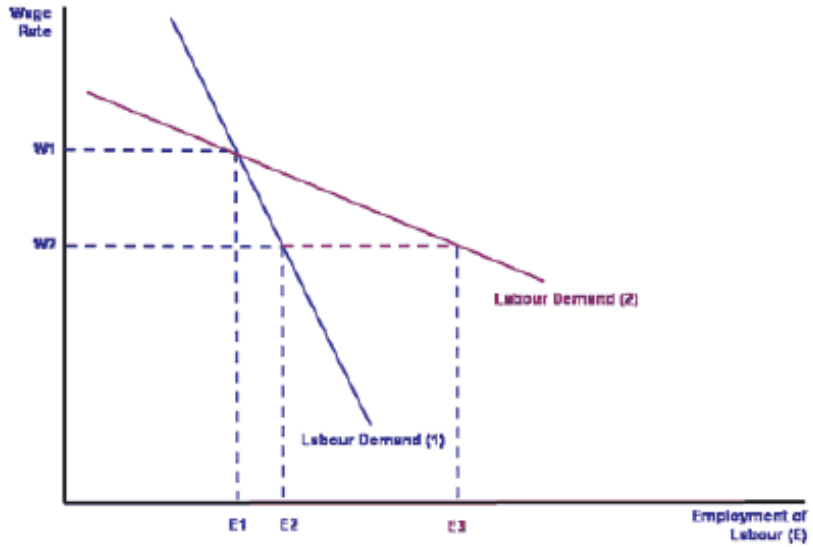
Measures to reduce GHG emissions

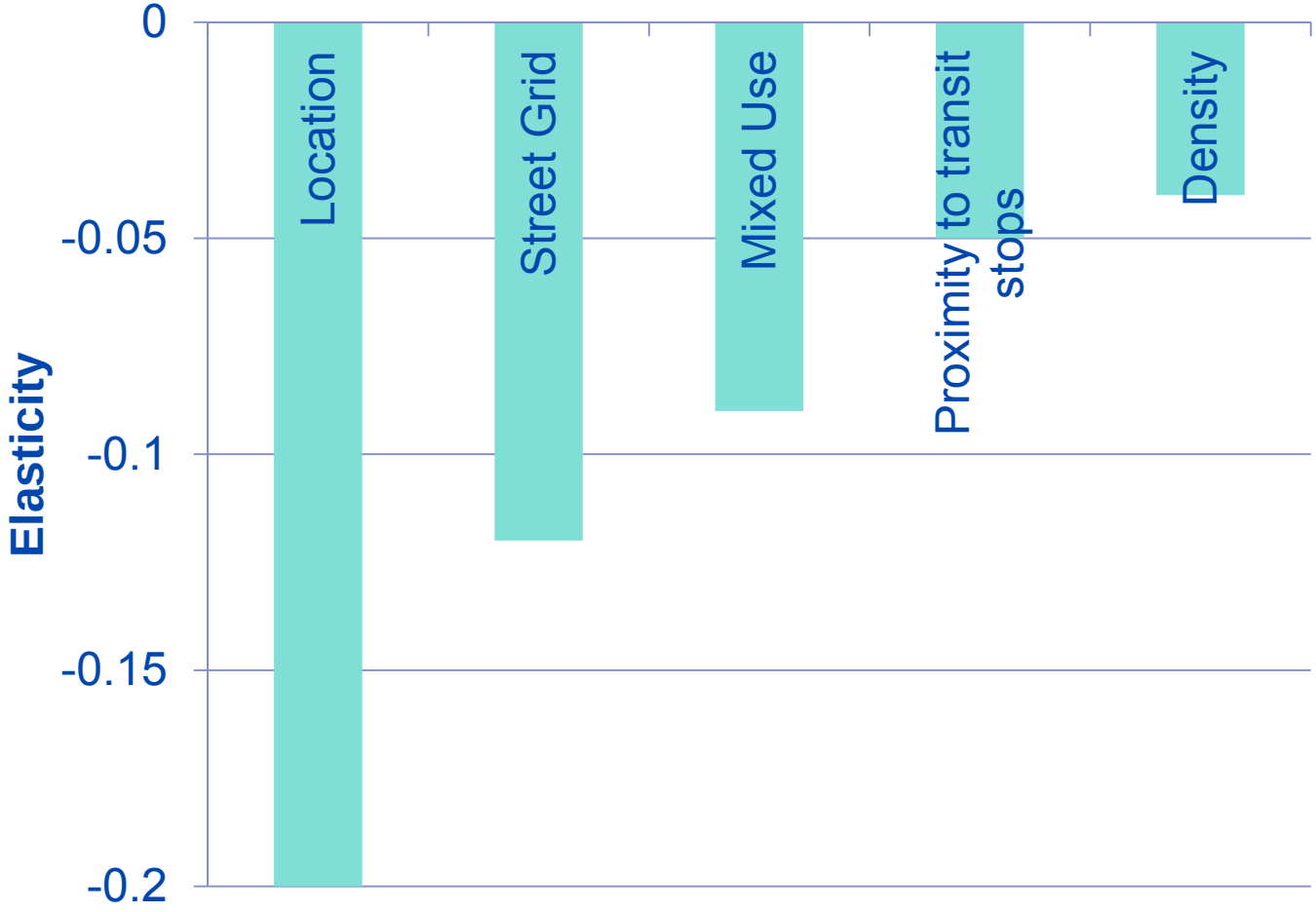
- **Effectiveness of measures was assessed using travel-distance elasticity from different sources (Ewing & Cervero, 2010; Moving Cooler, 2009, etc.)**
- **Based on assessments of built form and travel activity research**
- **Elasticity is a measure of the rate of change of one variable vs. another**

$$e = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$$



Measures to reduce GHG emissions

→ **Possibility to reduce VKT. Low individual effect, but can be important when combined**



Source: Ewing and Cervero (2010)

Measures to reduce car travel distances

→ **Car-travel distance elasticity**

Measure	Elasticity
Density (residents/households)	-0.04
Employment density	0.00
Mixed-use factor	-0.09
Intersection density	-0.12
% intersections with	-0.12
Distance to closest transit stop	-0.05
Accessibility to jobs by car	-0.20
Accessibility to jobs by transit	-0.05
Distance to downtown	-0.22

Neighbourhood Land-Use

Source : Ewing et Cervero (2010)

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Measures to reduce car travel distances

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Measure	Elasticity
Density (residents/households)	-0.04
Employment density	0.00
Mixed-use factor	-0.09
Intersection density	-0.12
% intersections with 4 branches	-0.12
Distance to closest transit stop	-0.05
Accessibility to jobs by car	-0.20
Accessibility to jobs by transit	-0.05
Distance to downtown	-0.22

Neighbourhood Transport Network

Source : Ewing et Cervero (2010)

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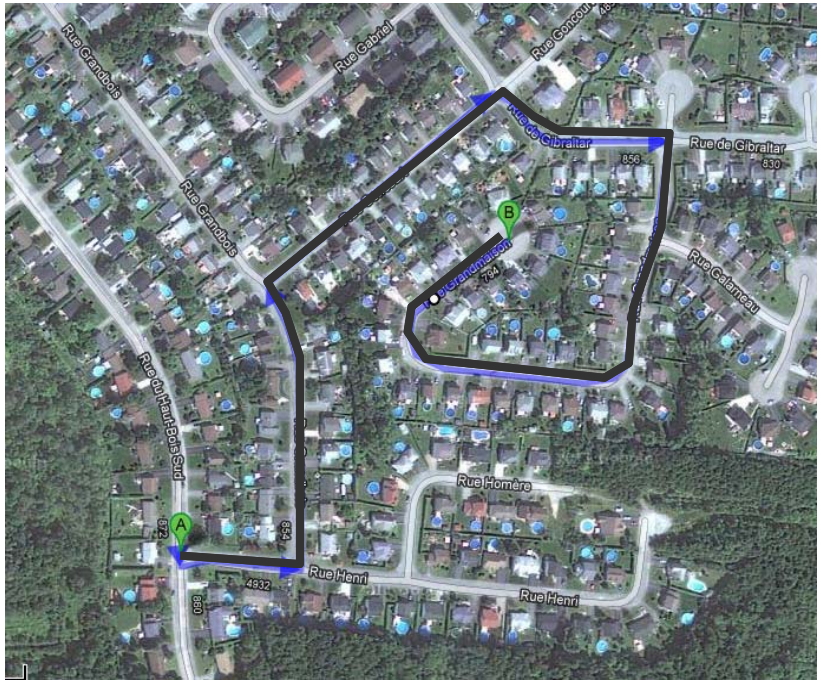
Measures to reduce car travel distances

→ **Street grids: High potential, but little possibility for intervention in an existing area**

Orthogonal street grid

4.8 intersections/km (+30% or 4% less VKT vs. dead-ends)
63% 4 way intersections

Grid with dead-ends



4.7 intersections/km
12% 4 way intersections

Measures to reduce car travel distances

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Regional Factors

Source : Ewing et Cervero (2010)

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Impact of scenarios

- **Large array of measures implemented at the neighbourhood level (transit, land use, walking, street grid) could reduce vkt per person by 4% to 5% per capita**
- **More important VKT/GHG emissions reductions could be expected if there were fewer constraints**

Measure	VKT var. per capita – Suburb in large region	VKT var. per capita – Suburb in medium-sized city
Active transport and connectivity	-1.2%	-1.2%
Transit	-0.8%	+0.2%
Land use (density, mixed-use)	-2.7%	-3.3%
Total	**-4.7%**	**-4.3%**

Conclusion

- **Few measures individually are very efficient at reducing VKT and GHG emissions, especially in an existing neighbourhood**
- **Reducing VKT and GHG emissions in an existing neighbourhood requires a number of measures (land use, active transport, street grid, transit services, etc.)**
- **The most effective measures depend on a neighbourhood's unique context (location, constraints and opportunities)**
- **Implementing measures in an existing neighbourhood is very difficult (time, cost, feasibility, demand, etc.). This is especially the case in neighbourhoods developed without considering how it will change over time**
- **Method can be applicable to new developments**
- **Regional planning is essential to reducing GHG emissions and VKT**

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Questions?

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