Wackernagel and Rees (1996)

LESSENING THE FOOTPRINT OF BUILT URBAN ENVIRONMENTS

Presentation by Dr. T. Randall

Assoc. Professor of Geography and the Environment

Geography 4771

Oct 25, 2017

SUSTAINABILITY PREAMBLE

- Like an ecosystem, the planet has a finite **CARRYING CAPACITY**
- **Ecological Footprinting**
- As stewards of the planet, we are responsible to **strike a balance** between our activities and environmental preservation
- Sustainability is viewed as this balance between the **Environment**, the **Economy** and **Societal Well-Being**

SUSTAINABILITY CONCEPT

- Reduced consumption of ENERGY, RAW MATERIALS and LAND
- Achieved via:
  - Use of Renewable Forms of Energy (e.g., wind, solar)
  - Use of Recycled (rather than Virgin) Materials
  - Re-Use of Urban Land (Development of Brownfields and Greyfields rather than Continued Expansion onto Greenfields)
- Sustainable Community Design … through good urban design and integration with multi-modal transportation planning (ped – bike – transit – rail – auto)

SCALE FOR URBAN DESIGN, FUNCTION & FORM

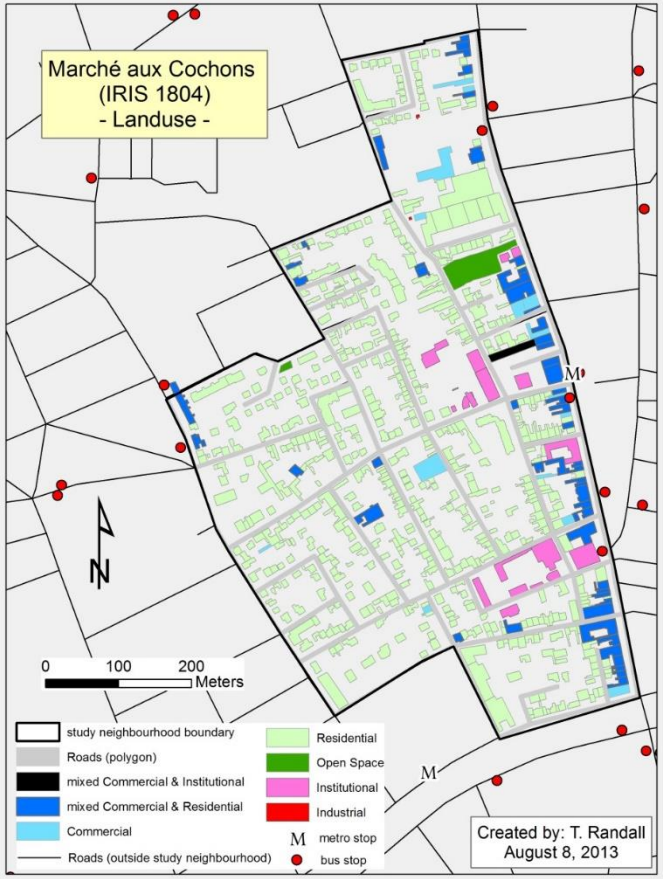
- Orientation of buildings
- Construction materials
- “Green building”
- Architectural form

- Neighourhood type
- Street patterns
- Traffic Calming
- Stormwater management
- Intensification (density)
- Mixed land use

- Land use planning
- Freeway networks
- Mass transit systems

LAND USE DIVERSITY

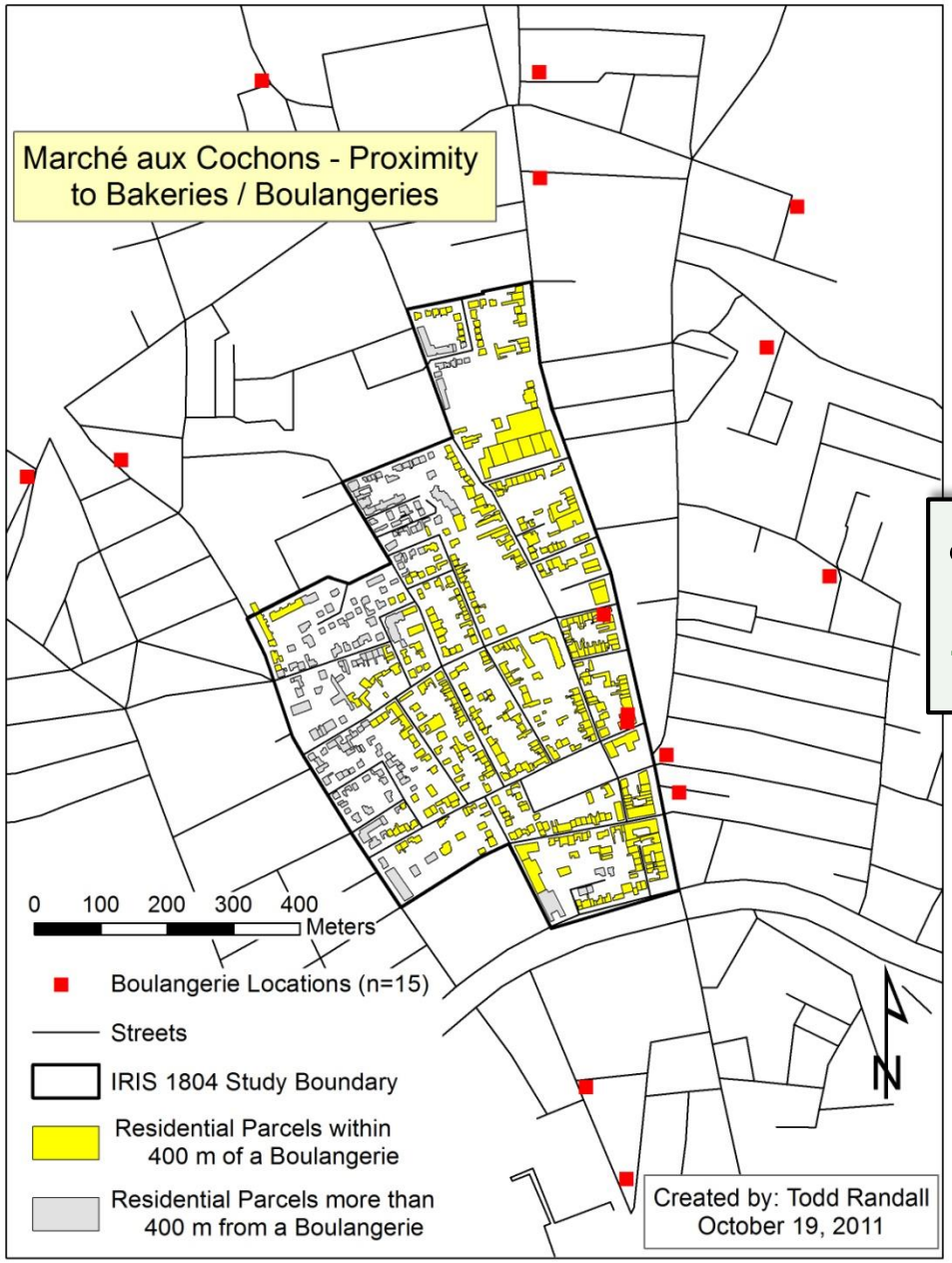
- GIS-based Land Use Diversity Index (Randall and Baetz 2015) as a measure of "urban sustainability:



omm., Inst., Open Space, …)

H, duplex, townhouse, apartments, condos

services, schools, …)



avg. route distance = 291 m

78% of Residents within 400 m

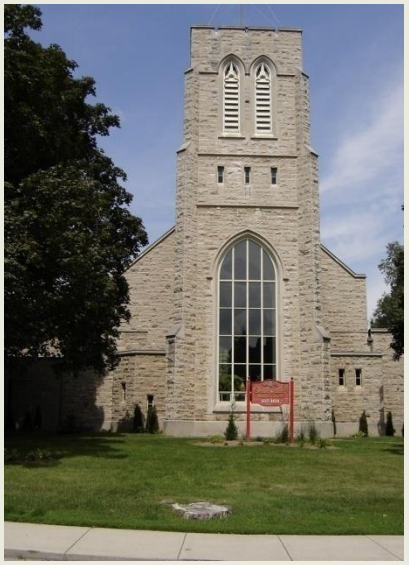
OUTLINE OF PRESENTATION

- Neighbourhood types (urban, suburban, exurban, rural)
- Auto-centricity in North American cities – the legacy of 20th Century Urbanism
- The American/Canadian Dream (re home/auto ownership)
- Characteristics of more *environmentally friendly* Urban Development
- Challenges of Sustainable Urban Development: 4 Factors

URBAN RESIDENTIAL FORMS

- In the Canadian context, **"urban" residential neighbourhoods** are those found within and near to the downtown core;
- Their typical characteristics:
  - **Older** areas (built in the early 20th Century, pre-WWII)
  - **Mixture of land uses**, including an active (or once active) commercial Main street
  - **Mixture of dwelling types** (including apartments, duplexes, rowhousing and detached single family homes)
  - **Modest residential density**
  - Density can support **efficient transit service**
  - **Better laid out to support pedestrian travel** within the neighbourhood to local amenities and destinations;

URBAN RESIDENTIAL NEIGHBOURHOOD (E.G., DUNDAS, ONTARIO)



- Photos depict various land uses present in a “traditional” urban residential neighbourhood;
- (top left) typical commercial street of **small town Main Street**; (3 central photos) **housing types and styles**; (2 photos on right) **institutional buildings** (Town Hall and Church);

- **traditional urbanism:**

  a concentrated urban form, typical of older patterns found in European cities.

- Madrid and Granada

SUBURBAN RESIDENTIAL FORMS

- In the Canadian context, **"suburban" residential neighbourhoods** are newer forms built at increasing distances from the downtown core;
- Their typical characteristics:
  - **Newer** areas (built during the postwar period and continuing)
  - **Relatively homogeneous with respect to land use zoning** (primarily residential land) with only minor amounts of commercial and institutional;
  - More **automobile dependent** as efficient transit facilities are not feasible at lower densities;
  - Commercial form is typically along the major arterials servicing high traffic volumes; strip mall form
  - **Segregation (rather than integration) of different dwelling types** within the neighbourhood, thereby serving to segregate the population on socio-economic differences;
  - Largely a **lower residential density form** but does depend on dwelling types present;
  - Larger lots and greater amounts of green space per resident;
  - Land use homogeneity and lower density make **pedestrian travel less interesting and less feasible**;

SUBURBAN RESIDENTIAL NEIGHBOURHOOD (E.G., BERRISFIELD, ONTARIO)

- Photos depict various land uses present in a typical suburban residential neighbourhood;
- (top left) typical **"strip mall" commercial** along major arterial streets; (3 central photos) **housing types and styles**; (top right) **elementary school** in quiet, central location; (bottom right) **suburban park** and playing field;

SUBURBAN NEIGHBOURHOODS / POSTWAR SUBURBS

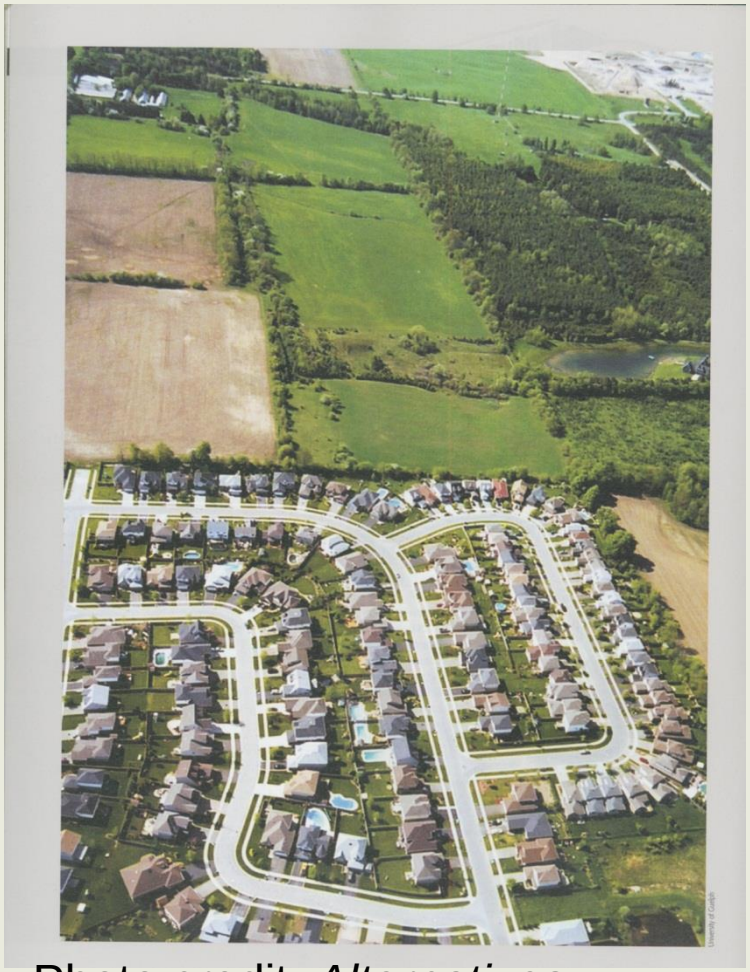
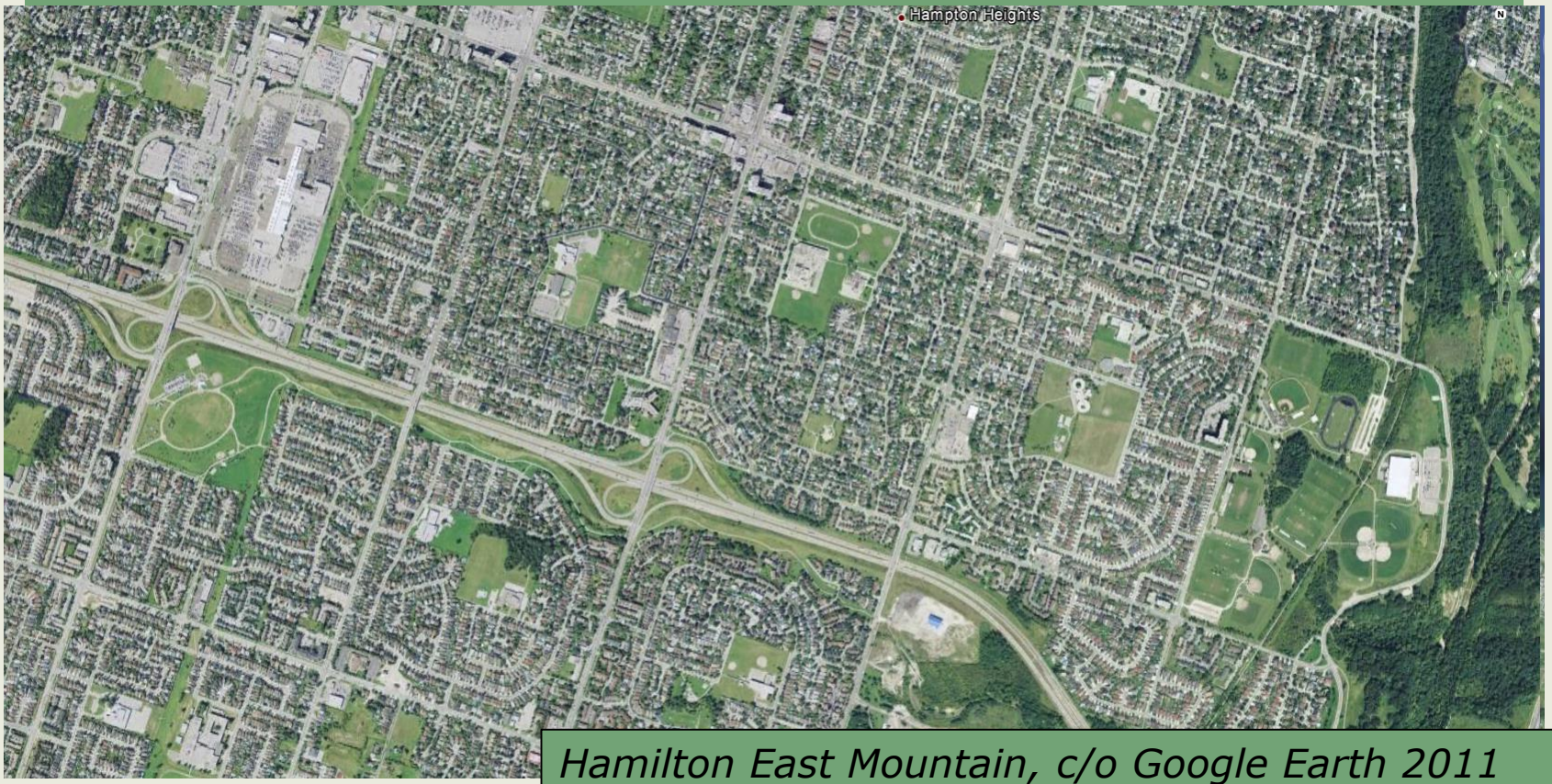


Photo credit: *Alternatives Journal* Vol. 34 Issue 3, 2008

Auto-centric infrastructure (freeways, parking lots, double garages)

Low density housing forms (neighbourhood centre); higher density forms, transit routes and non-residential functions (neighbourhood

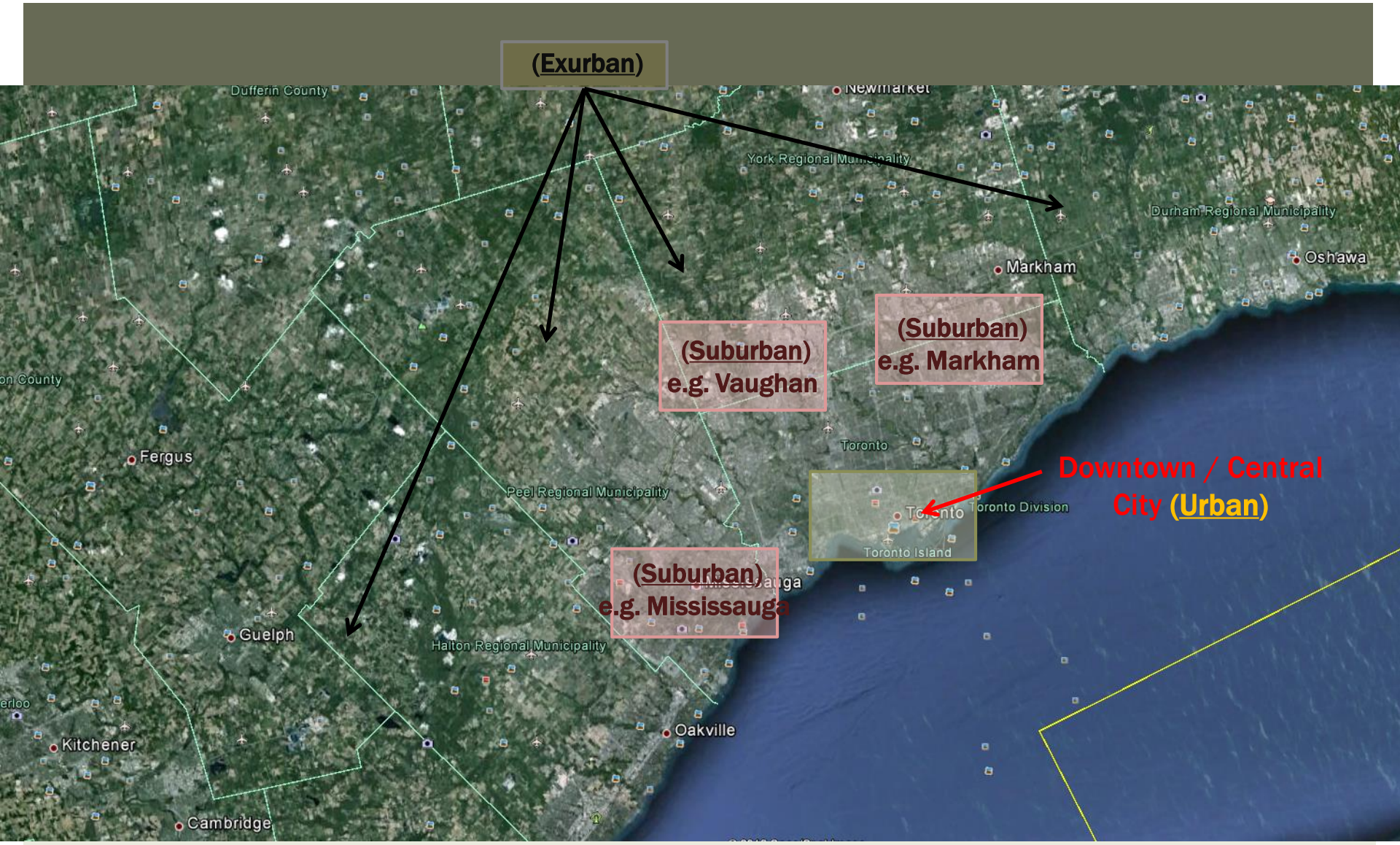


Hamilton East Mountain, c/o Google Earth 2011

- **Postwar sprawl:**

  car-oriented, segregated land use, suburban sprawl around many cities

(Photo: sprawl in Colorado)



Metro Toronto (viewed on Google Earth, image date 5/8/2004).

Selected urban, suburban, exurban and rural areas noted.

EXURBAN FORM/ NON-FARMERS IN RURAL SETTING

- Residential areas along concessions & regional roads, cul-de-sacs, etc…
- Very low density, 1-2+ acre lots;

Woodburn (15+ minutes SE of Hamilton); Google Earth image date 3/18/2010.

Cadillac Circle (rural Thunder Bay); Google Earth image date 4/21/2010.

EXURBIA – NON-FARMERS IN RURAL

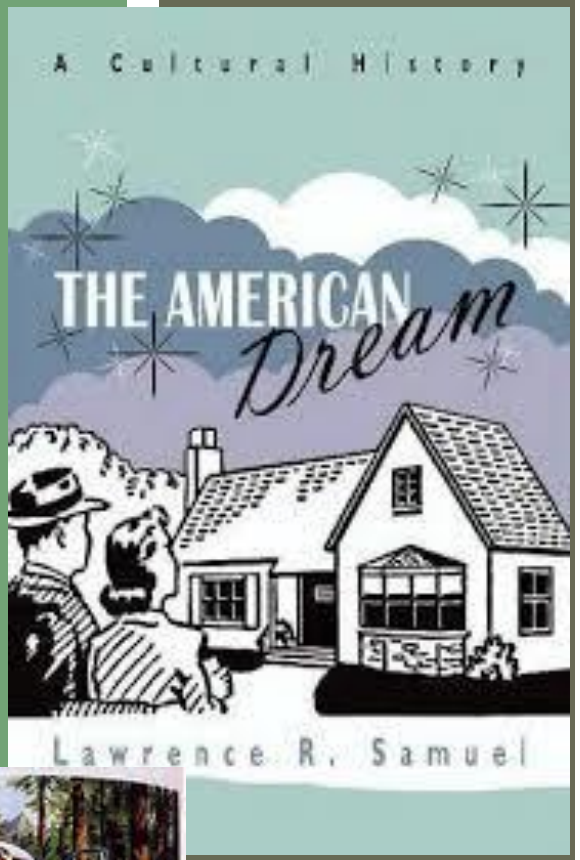
Caistor Centre (20 minutes SE of Hamil

Google Earth image date 3/18/2010.

Exurban developments (non-farming, rural properties within commuting distance). Photo SE of Winnipeg (credit T. Randall, circa 2005)

AUTO DEPENDENCE & THE (NORTH) AMERICAN DREAM

McMaster University Medical Centre (corridor ad) (*briefly* in Aug. 2001)



Gasoline use per capita versus urban density in 1990

($R^2 = 0.8594$)

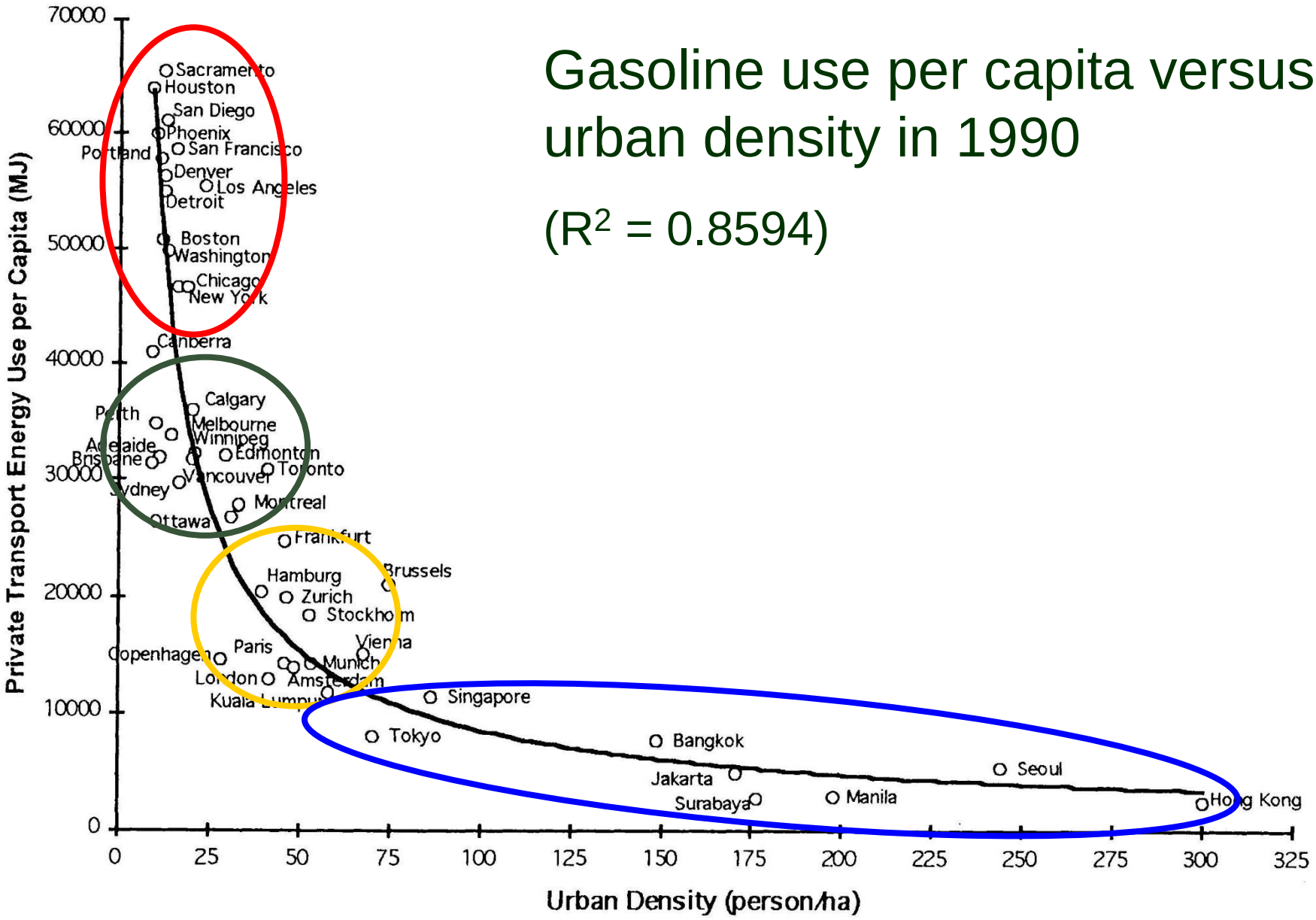


Figure 3.2. Energy use per capita in private passenger travel versus urban density in global cities, 1990.

Source: Newman and Kenworthy (1999)

Table 2.3: Transportation use in world cities in 1980 (Newman and Kenworthy, 1989)

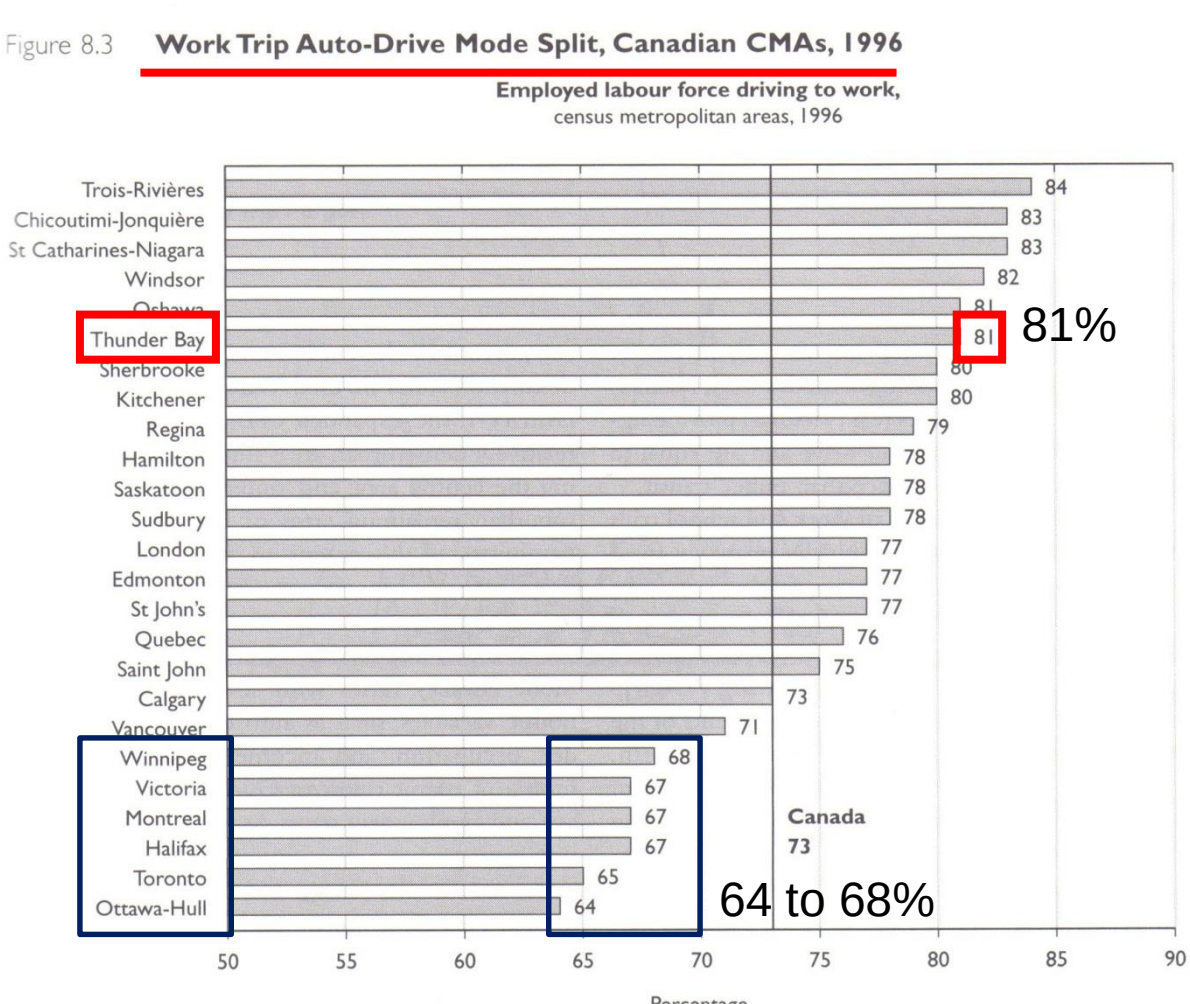
Form of Transport	Toronto	U.S. Cities	Australian Cities	European Cities	Asian Cities
Annual car use per capita	9850 km	12507 km	10680 km	5595 km	1799 km
Annual transit use per capita	1976 km	522 km	856 km	1791 km	3059 km
Percentage of workers using private transport	63.0	82.9	75.9	44.2	14.7
Percentage of workers using public transport	31.2	11.8	19.0	34.5	60.3
Percentage of workers walking and cycling	5.8	5.3	5.2	21.3	25.1

Recall: Toronto is one of our "best" cities !!, and these data only for central Toronto…

d from Newman and Kenworthy 1989
(table compiled in Randall 2002)

RATES OF COMMUTE BY CAR IN CANADIAN CITIES

Is there a real alternative to cars here in Thunder Bay?



From: Miller (2000)

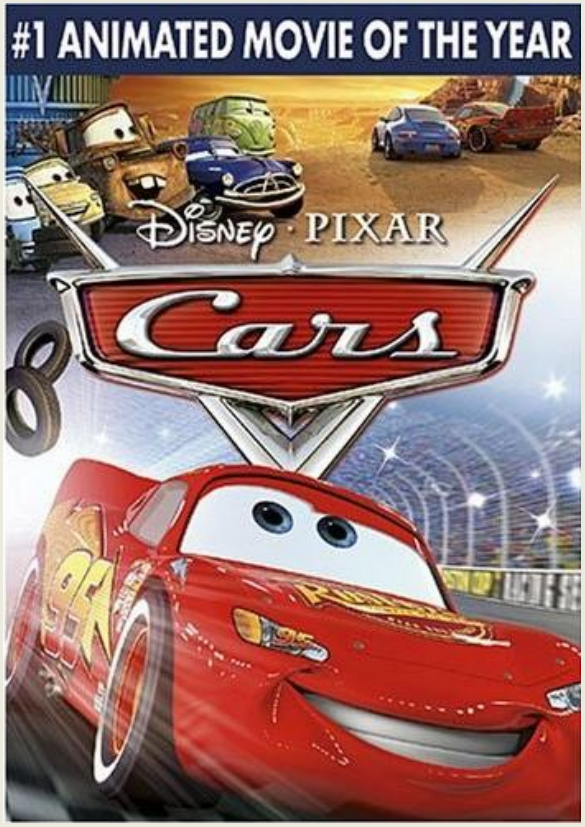
Table 3.6: Calculated commuting times for three hypothetical commute types

Commute Type	Time on each leg of Home-Work-Home Trip (min/day)	Total Time Spent Commuting	
		(hour/year)	(week/year)
light	15	183	1.1
medium	30	365	2.2
heavy	60	730	4.3

sizeable

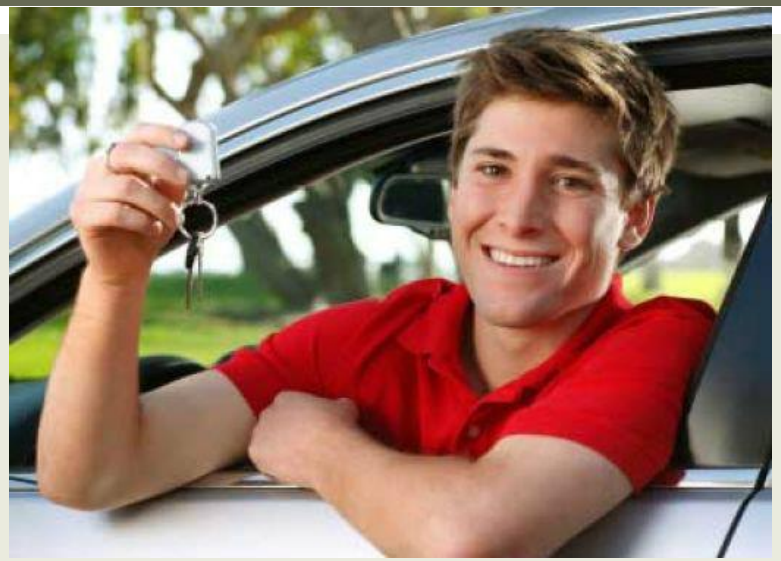
From: Randall (2002)

AUTO DEPENDENCE IS CULTURALLY ENGRAINED …



WHY NOT BIKE LANES, TRANSIT ROUTES AND GREENWAYS?

IT'S WHAT (THE MOBILITY, FREEDOM) WE ASPIRE TO …



- … but it has significant financial implications …
  - direct costs (several $1000 per year) and numerous indirect costs …

RELATIONSHIP TO SUSTAINABLE URBAN DEVELOPMENT

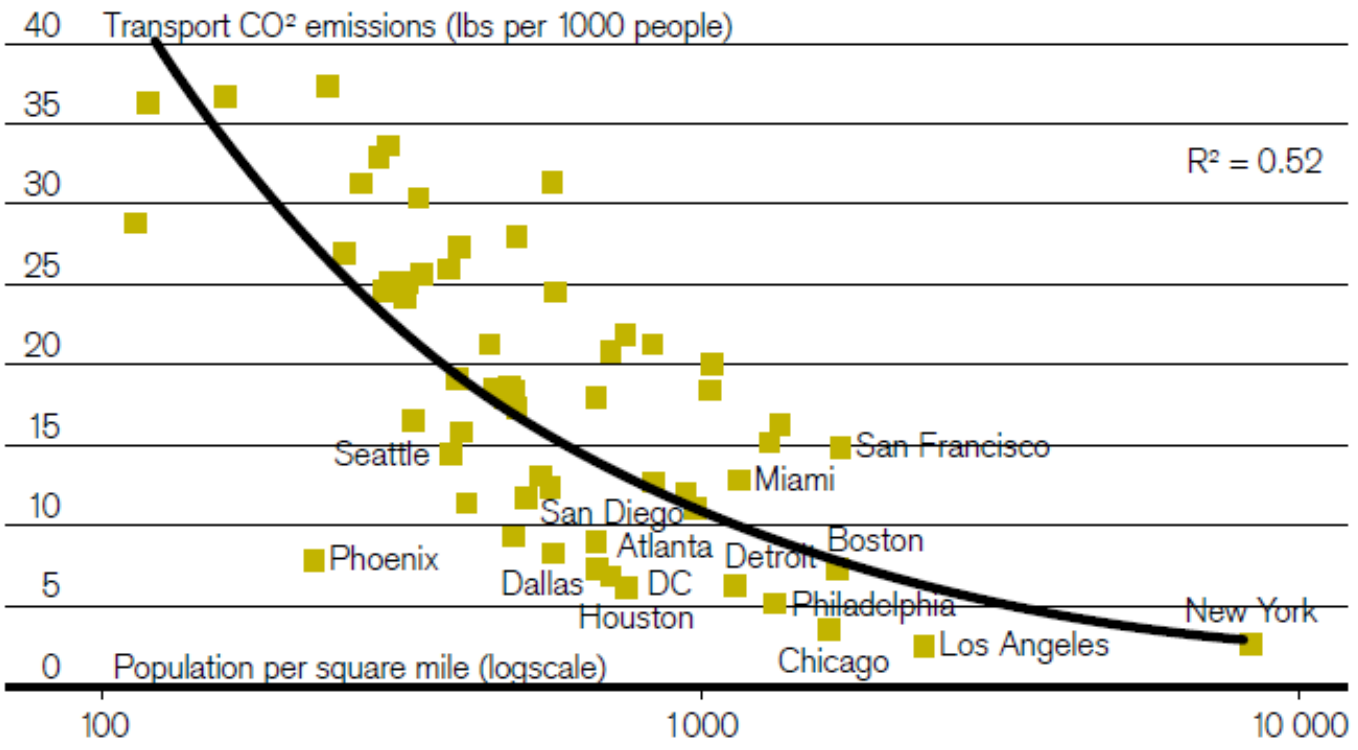
WHAT CHARACTERISTICS MAKE URBANIZATION "ENVIRONMENTALLY FRIENDLY"?

1. Urban form
   - Density; Land use mix; Housing mix
2. Transportation choices
3. Per capita consumption of {land, energy, consumer goods}
4. Social mix
5. Others?

photo credits: TR, Nov 2011

Emissions from transportation (public and private) versus population density for US metropolitan statistical areas

Source: US Census Bureau 2000 Census, Credit Suisse



… similar trend among US metropolitan areas *(to emerging cities shown earlier).*

- How do US (and North American) cities compare with Global Cities?

Gasoline use per capita versus urban density in 1990

($R^2 = 0.8594$)

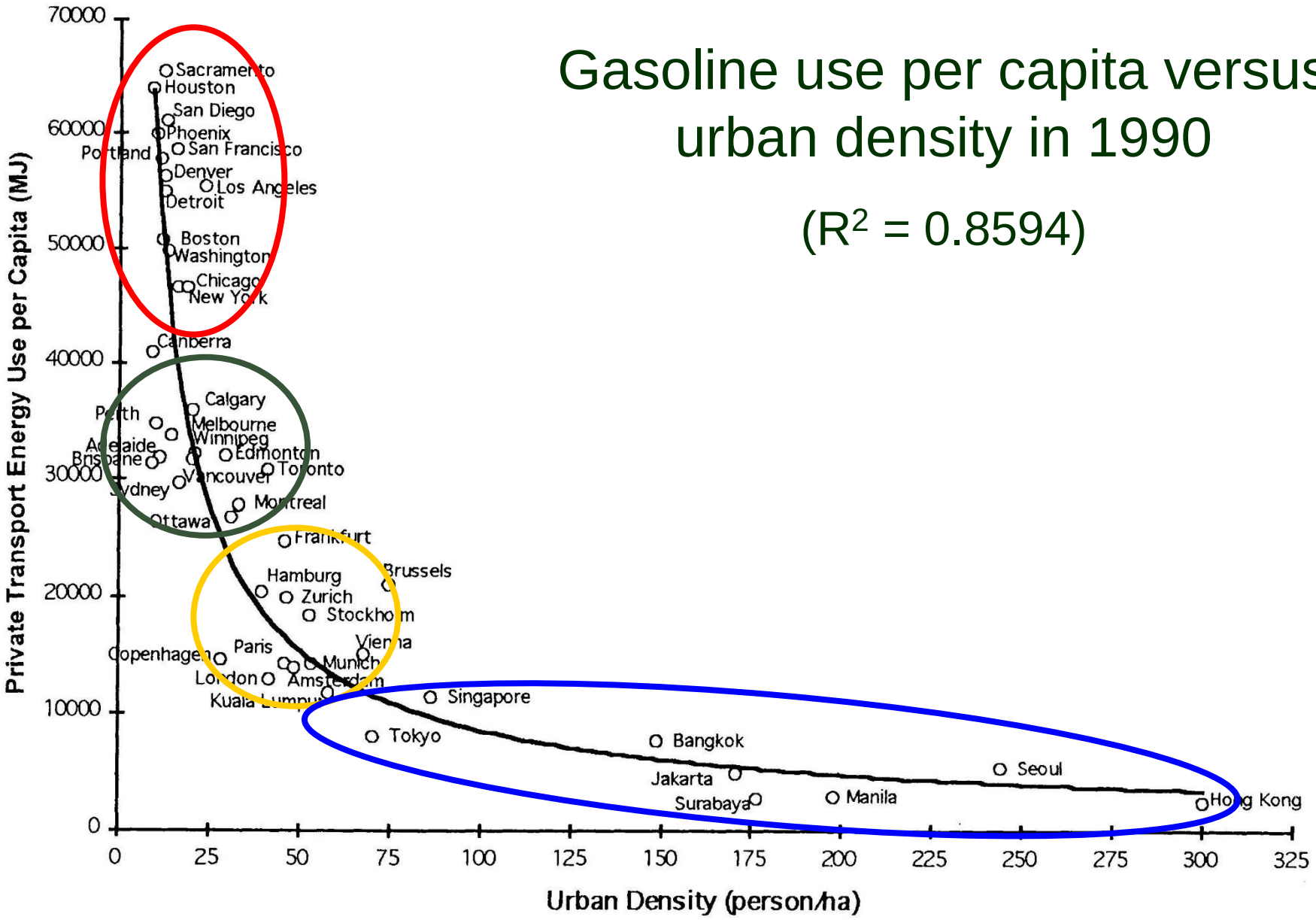


Figure 3.2. Energy use per capita in private passenger travel versus urban density in global cities, 1990.

Source: Newman and Kenworthy (1999)

Table 5.1 The Eco-Footprints and Biocapacities of Selected Nations

Country	Per Capita Eco-Footprint (global ha)	Per Capita Domestic Biocapacity (gha)	Overshoot Factor
World	2.7	2.1	1.3
United States	9.4	4.9	1.9
Australia	7.8	15.4	0.5
Canada	7.1	20.0	0.4
Greece	5.9	1.7	3.5
United Kingdom	5.3	1.6	3.3
France	4.9	3.0	1.6
Japan	4.9	0.6	8.2
Germany	4.2	1.9	2.2
Netherlands	4.0	1.1	3.6
Hungary	3.5	2.8	1.3
Mexico	3.4	3.3	1.0
Malaysia	2.4	2.7	0.9
Brazil	2.4	7.3	
China	2.1	0.9	
Thailand	2.1	0.8	
Peru	1.6	4.0	
Ethiopia	1.4	1.0	1.4
Nigeria	1.3	1.0	1.3
Indonesia	0.9	1.4	0.6
India	0.9	0.4	2.3
Bangladesh	0.6	0.3	2.0
Malawi	0.5	0.5	1.0

Source: WWF (2008).

Wackernagel and Rees (1996)

ECOLOGICAL FOOTPRINT: A MEASURE OF SUSTAINABILITY

Source: Rees (2010)

BUILT ENVIRONMENT ←→ OBESITY

Table 23.1 Proportion of Adults Who Are Overweight or Obese, Canadian CMAs, 2004

CMA	Population (000s)	Overweight (BMI >25)*	Obese (BMI >30)
Hamilton	452	74.3	34.6
Kingston	81	70.1	28.9
St John's	159	70.0	36.4
St Catharines–Niagara	346	69.3	23.1
Saint John	124	68.9	34.7
Saskatoon	147	64.5	27.0
Gatineau	199	63.6	n/a
Oshawa	208	63.5	29.6
Victoria	251	62.6	19.0
Kitchener	450	62.3	30.7
Edmonton	946	62.2	20.1
Greater Sudbury	72	62.1	26.1
Ottawa	636	62.0	19.7
London	470	61.6	26.6
Thunder Bay	185	60.0	32.6
Abbotsford	110	58.3	25.0
Winnipeg	525	58.2	25.2
Regina	151	58.1	31.8
Quebec	552	56.8	17.3
Trois-Rivières	139	56.6	n/a
Windsor	99	56.5	33.2
Calgary	765	53.8	25.7
Sherbrooke	97	52.4	n/a
Saguenay	141	52.3	18.9
Vancouver	1,720	51.8	11.7
Montreal	2,577	51.6	21.2
Toronto	3,772	50.9	15.6
Halifax	284	47.8	18.4

*Includes obese

Source: Statistics Canada, 2004 Canadian Community Health Survey.

- **1 in 4 Canadian children** (2-17 yrs) and **6 of 10 adults** (>18 yrs) are either overweight or obese (Gilliland 2010);
- similar to rates observed in other auto-dependent countries (e.g., US, UK)
- "**increasing auto dependence and limited opportunities to walk for ultilitarian purposes** is *partly* to blame" (Gilliland 2010, pp. 391)

From: Gilliland (2010)

DRIVING ←→ OBESITY

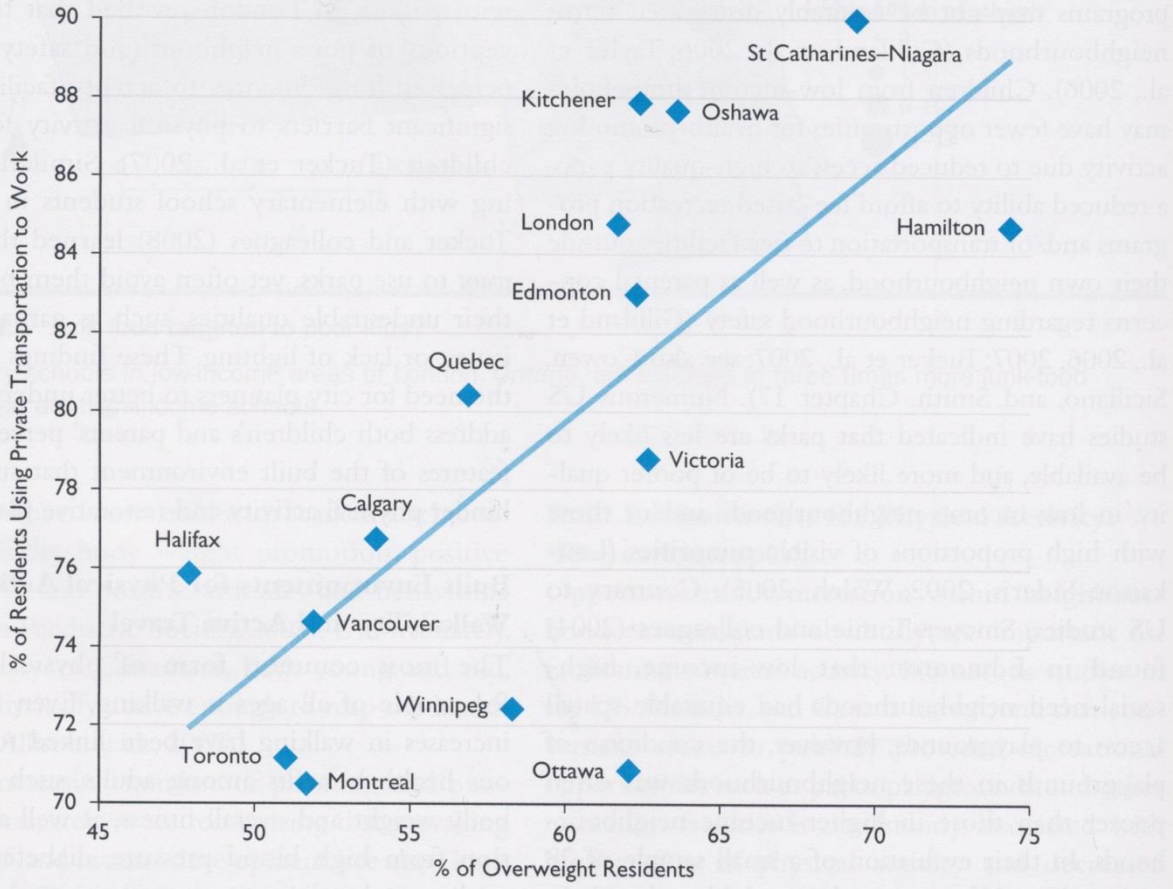


Figure 23.5 The relationship between driving and obesity

Cities with a high proportion of workers commuting by private automobile also tend to have a high proportion of overweight or obese residents ($r^2 = 0.5$).

Source: Data on 15 largest CMAs from 2006 census.

From: Gilliland (2010)

From: Gilliland (2010)

STREET PATTERNS ←→ WALKABILITY

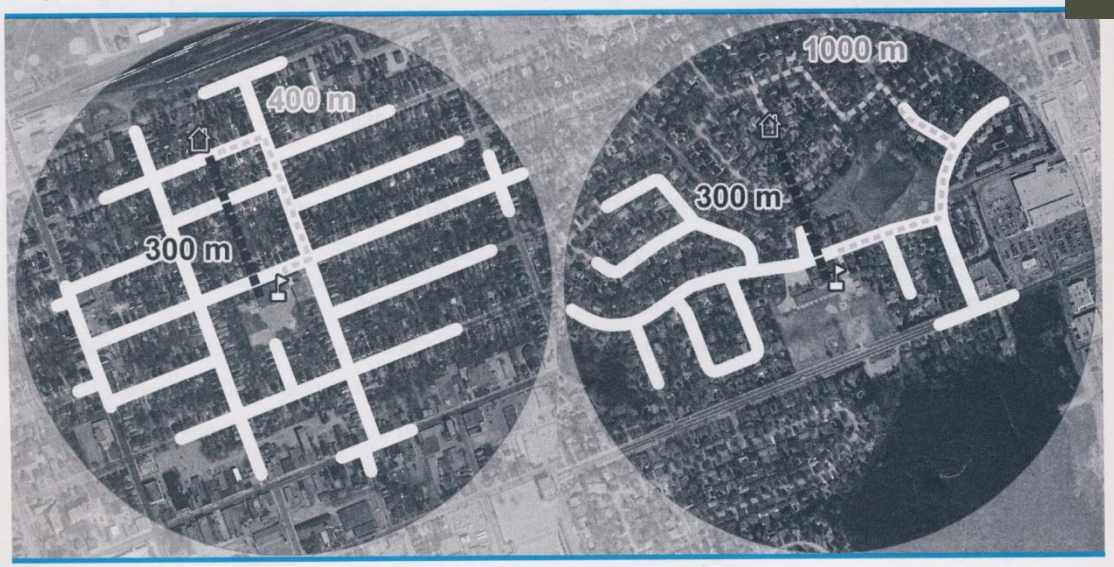
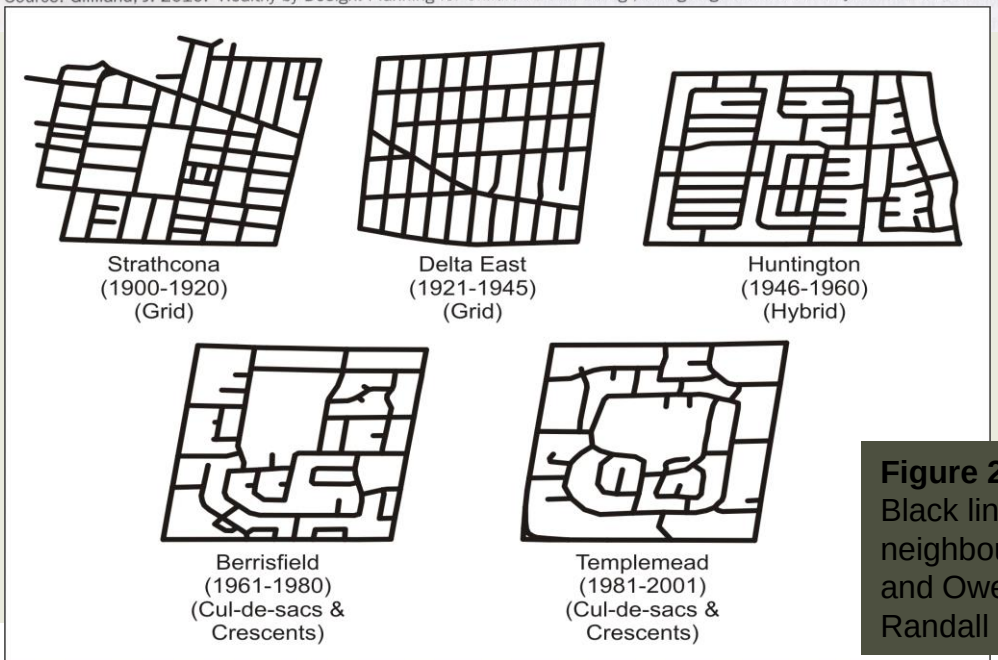


Figure 23.6 Street network patterns and neighbourhood walkability

In school neighbourhood B, the student must travel 2.5 times farther from home to school than in A, even though they are the same distance apart (300 metres) 'as the crow flies'.

Source: Gilliland, J. 2010. 'Healthy by Design: Planning for Children's Well-Being', Designing Auckland: A Mayoral Conversation, City of



"What we know is the likelihood of someone being obese is much lower where they can walk to shops and services near to where they live"

- K. Tomic, Geographer, U. Alberta (2003)

Figure 2: Street pattern and classification by neighbourhood. Black lines indicate actual road layouts for the neighbourhoods. Classification scheme based on Southworth and Owens (1993) and Berman (1996). From: Smith and Randall (2008).

- 4 factors needing attention to meet the challenges of **sustainable urban development**:
  1. Urban Form;
  2. Transportation
  3. Energy Use
  4. Waste Management

URBAN FORM (1)

- **Urban form**
  - the type and distribution of infrastructure in cities;
  - a key factor influencing environmental quality
  - Examples: urban vs suburban vs exurban vs 'un-serviced'

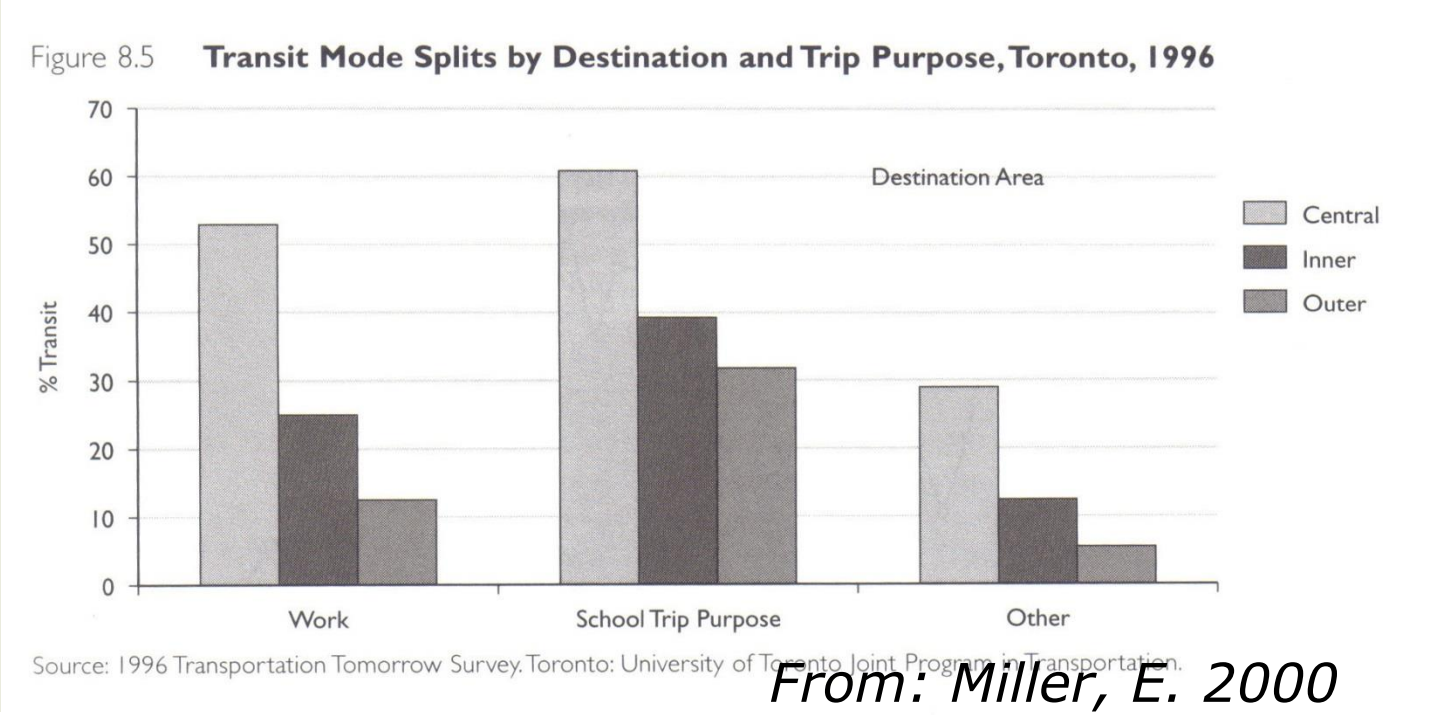
Transportation Configuration → affects → Energy Use

- Neighbourhood layout
- Density
- Street Patterns
- Degree of walkability

From: Dearden and Mitchell (2012)

URBAN FORM (2)

- Influence on choice of travel mode in central Toronto versus "inner" and "outer" ring of suburbs
- Greater transit choice made in central city for trips to work and school;



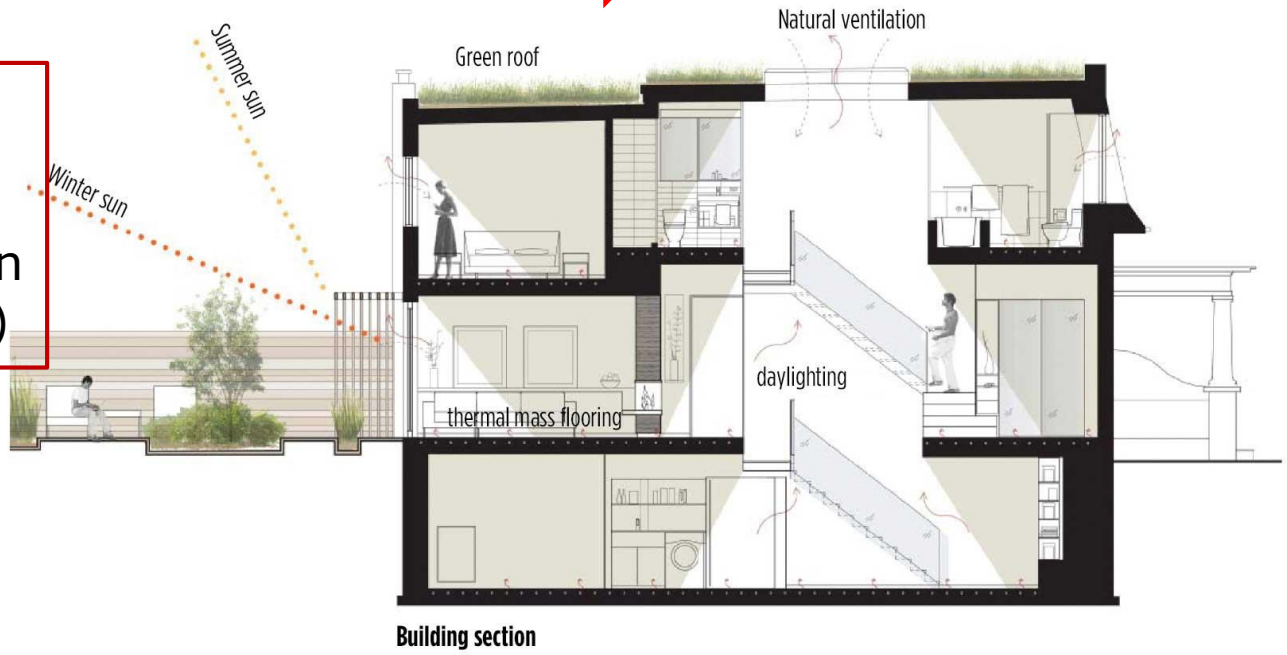
From: Miller, E. 2000

URBAN FORM

Building Design → affects → Energy Efficiency

- Building materials
- Insulation
- Size
- Structure orientation (solar potential?)

Energy Use → affects → GHG Emissions



http://www.sabmagazine.com/blog/2013/06/25/ecohouse-3-through-house-2013-canada-green-building-award-residential-winning-project/

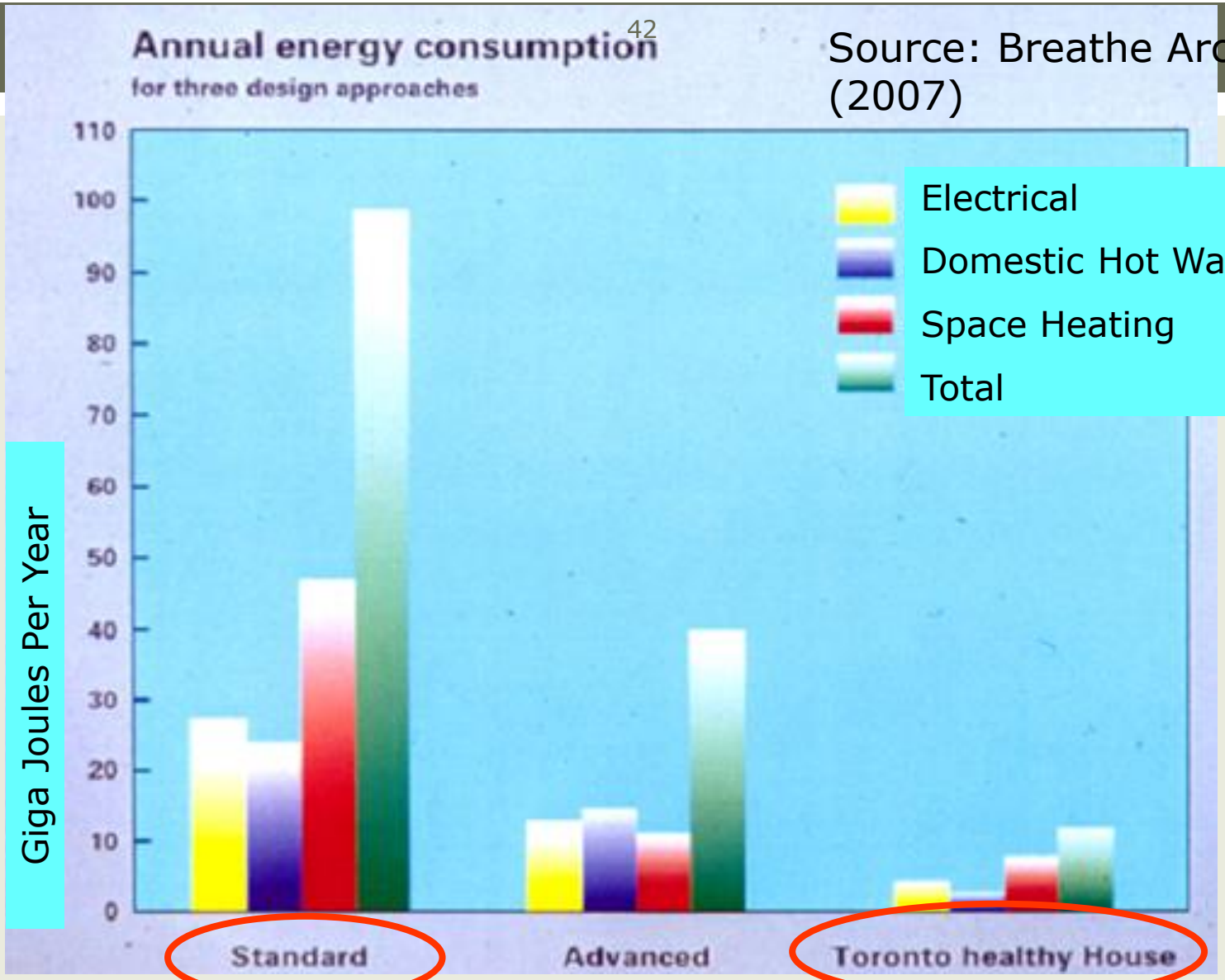
Eco-extraordinaire Simon Dale went into the woods one day and built a sustainable, eco-friendly, and above all functional hobbit house for him and his family to live in whilst they worked on an ecological woodland management project. (in Wales)

From: http://www.nerdlikeyou.com/man-builds-fully-functional-hobbit-house-in-wales/olympus-digital-camera-5/

TORONTO "HEALTHY HOUSE" KEY FEATURES

1. Off-grid – completely self-sufficient with respect to: water, energy, wastewater;
2. All concrete was 78% recycled natural materials;
3. 1700 sq. foot semi-detached home;
4. Built in 1997
5. Infill location, on a laneway in urban Toronto

Photo credit:
www.fims.uwo.ca/newmedia/newmedia2004/energy

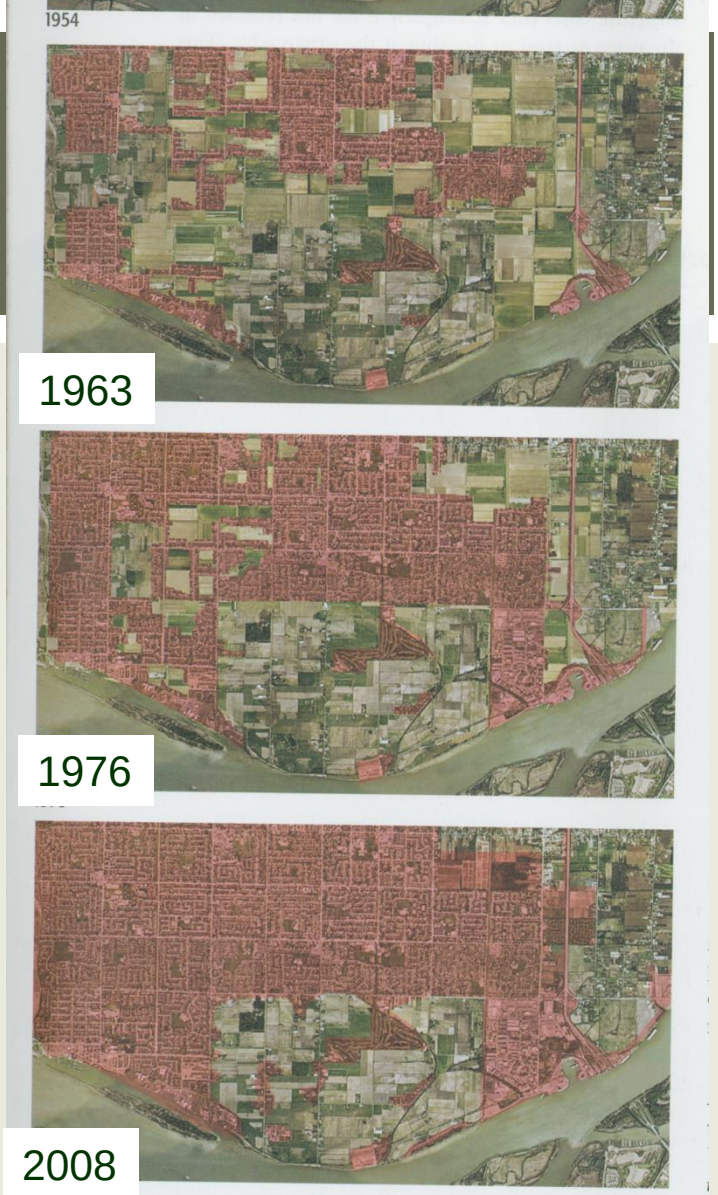


Source: Breathe Architects (2007)

URBAN FORM

- **Urban sprawl** contributes to loss, disruption, or degradation of adjacent agricultural land, environmentally sensitive areas, natural habitats, and water and air quality

Suburb-Farmland Interface

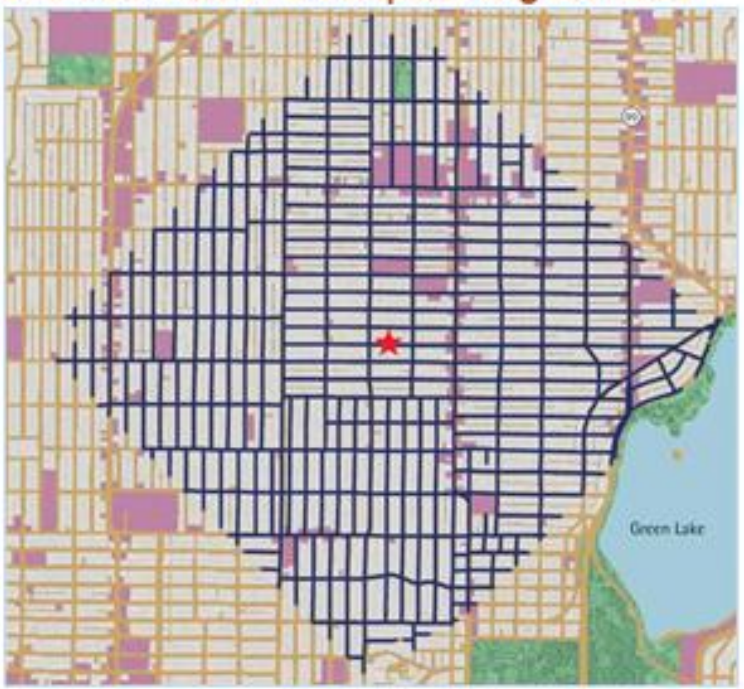


South Richmond, BC

Photo credits: *Alternatives Journal* Vol. 34 Issue 3, 2008

- A compact urban form is most environmentally desirable

One-Mile Walk in a Compact Neighborhood



A one-mile walk in Seattle's Phinney Ridge takes you through a grid-like street network with a mix of residences and businesses.

One-Mile Walk in a Sprawling Suburb

A one-mile walk in Bellevue, WA with cul-de-sacs and winding streets has few shops and services within walking distance.

Maps courtesy of Lawrence Frank & Co. and the Sightline Institute.

TRANSPORTATION (1)

- Urban areas with **high population density in their cores** lead to more efficient and effective land use;
- They are also much more likely to be able to provide **effective** (and economically viable) **public transit**


photo credits: TR, Nov 2011

City Density (du/ha)	Level of Transit Service (Pushkarev & Zupan, 1982) [based on Net Residential Density]
< 10	No Viable Transit Service
10.1 - 17.5	Minimal Bus Service
17.6 - 22.5	Intermediate Bus Service
22.6 - 37.5	Intermediate Bus or Light Rail Service
> 37.5	Frequent Bus or Light Rail Service

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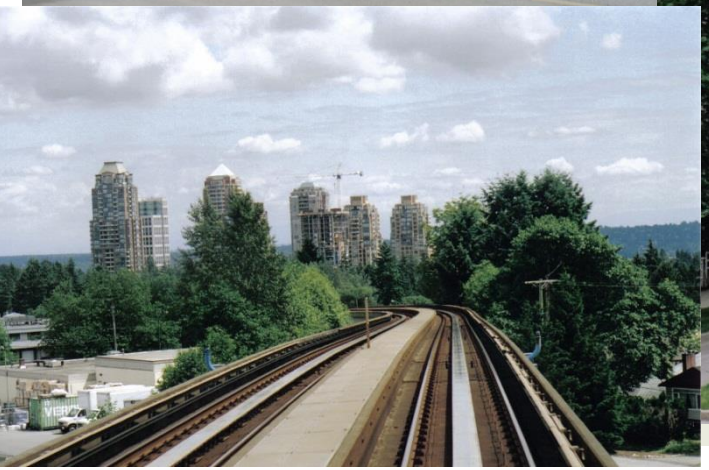
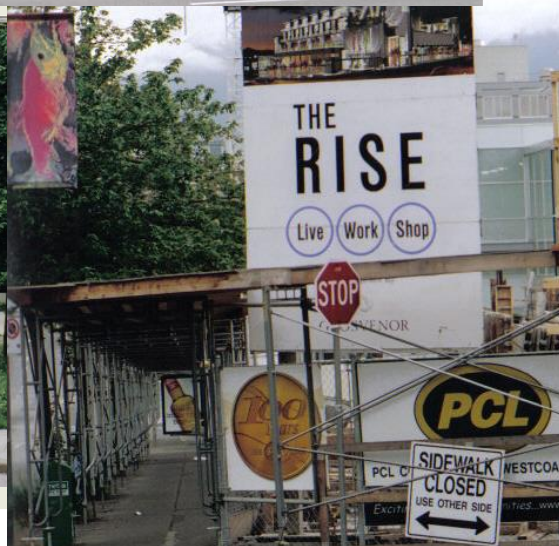
> 37.5	Frequent Bus or Light Rail Service

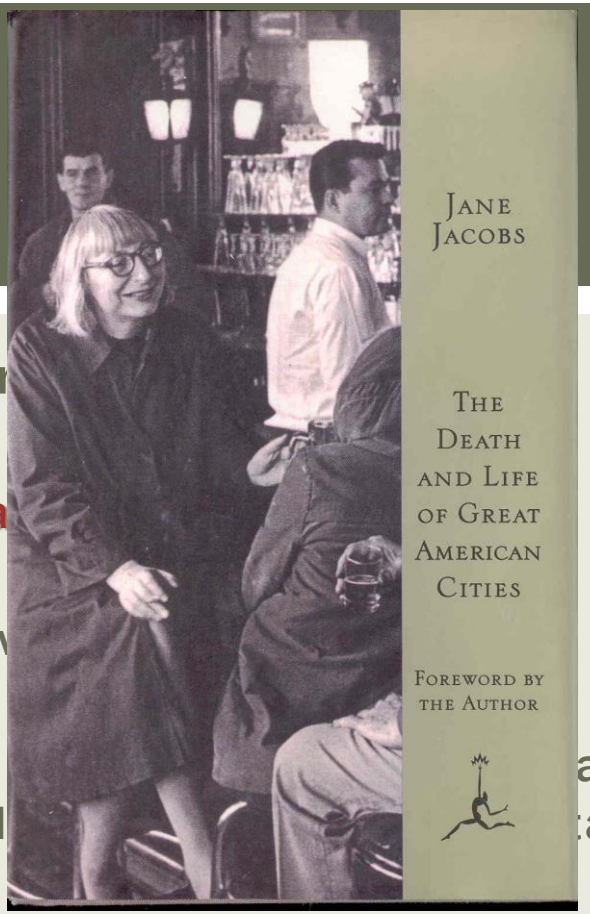
Densities to support economically viable transit service (based on Puskarev and Zupan, 1982)

AND THE SOLUTION IS …

- Build places which encourage ‘active transportation’ (walking, cycling, transit) that reduce per capita energy use ….
- Neighbourhood design {mix land uses, sufficient *but not excessive* concentration of people to support neighbourhood retail, neighbourhood schools;







lifestyles

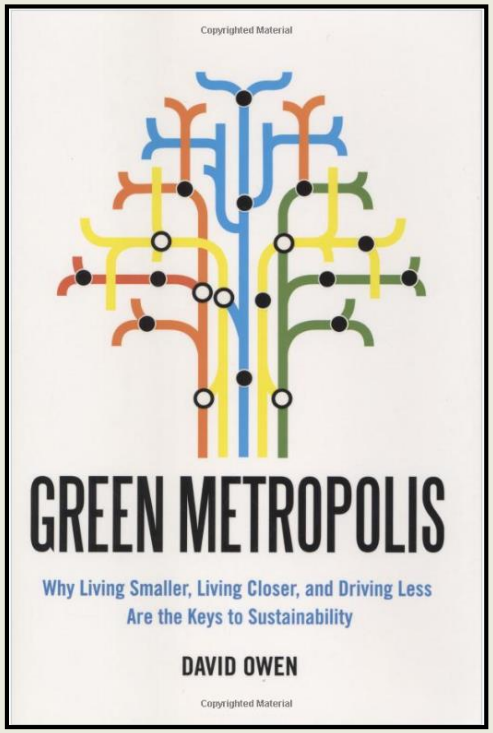
- **These 'sustainability' concepts are nothing new** … critically acclaimed book is still highly relevant on how to create / plan for 'exuberant diversity' in cities (how to make cities thrive);

Jane Jacobs (1961)

The Death and Life of Great American Cities

DISCUSSION QUESTIONS

1. If one accepts that more intensive urban development is the way to house a growing global population, how do we convince North Americans to “buy in” with their housing and transportation choices?



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