LESSENING THE FOOTPRINT OF BUILT URBAN ENVIRONMENTS

Presentation by Dr. T. Randall
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Wackernagel and Rees (1996)
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**
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

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

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

City / Region
- Land use planning
- Freeway networks
- Mass transit systems
GIS-based **Land Use Diversity Index** (Randall and Baetz 2015) as a measure of "urban sustainability:

- Mix of land uses (Res., Comm., Inst., Open Space, ...)
- Mix of housing types (SFH, duplex, townhouse, apartments, condos)
- Mix of amenities (stores, services, schools, ...)
- Proximity to amenities
Marché aux Cochons - Proximity to Bakeries / Boulangeries

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
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
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 centre)
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 Hamilton) 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.

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

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

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

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

<table>
<thead>
<tr>
<th>Commute Type</th>
<th>Time on each leg of Home-Work-Home Trip (min/day)</th>
<th>Total Time Spent Commuting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(hour/year)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(week/year)</td>
</tr>
<tr>
<td>light</td>
<td>15</td>
<td>183</td>
</tr>
<tr>
<td>medium</td>
<td>30</td>
<td>365</td>
</tr>
<tr>
<td>heavy</td>
<td>60</td>
<td>730</td>
</tr>
</tbody>
</table>

sizeable

From: Randall (2002)
AUTO DEPENDENCE IS CULTURALLY ENGRAINED …

WHY NOT BIKE LANES, TRANSIT ROUTES AND GREENWAYS?
... 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
... 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.
<table>
<thead>
<tr>
<th>Country</th>
<th>Per Capita Eco-Footprint (global ha)</th>
<th>Per Capita Domestic Biocapacity (gha)</th>
<th>Overshoot Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>2.7</td>
<td>2.1</td>
<td>1.3</td>
</tr>
<tr>
<td>United States</td>
<td>9.4</td>
<td>4.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Australia</td>
<td>7.8</td>
<td>15.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Canada</td>
<td>7.1</td>
<td>20.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Greece</td>
<td>5.9</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>5.3</td>
<td>1.6</td>
<td>3.3</td>
</tr>
<tr>
<td>France</td>
<td>4.9</td>
<td>3.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Japan</td>
<td>4.9</td>
<td>0.6</td>
<td>8.2</td>
</tr>
<tr>
<td>Germany</td>
<td>4.2</td>
<td>1.9</td>
<td>2.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>4.0</td>
<td>1.1</td>
<td>3.6</td>
</tr>
<tr>
<td>Hungary</td>
<td>3.5</td>
<td>2.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Mexico</td>
<td>3.4</td>
<td>3.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Malaysia</td>
<td>2.4</td>
<td>2.7</td>
<td>0.9</td>
</tr>
<tr>
<td>Brazil</td>
<td>2.4</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>2.1</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>2.1</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Peru</td>
<td>1.6</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>1.4</td>
<td>1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1.3</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.9</td>
<td>1.4</td>
<td>0.6</td>
</tr>
<tr>
<td>India</td>
<td>0.9</td>
<td>0.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>0.6</td>
<td>0.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Malawi</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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 utilitarian purposes is partly to blame” (Gilliland 2010, pp. 391)

From: Gilliland (2010)
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.
“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”
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
• 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)
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;

Figure 8.5 Transit Mode Splits by Destination and Trip Purpose, Toronto, 1996


From: Miller, E. 2000
Building Design affects Energy Efficiency

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

Energy Use affects GHG Emissions

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)

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
ANNUAL ENERGY CONSUMPTION
Giga Joules Per Year

Electrical
Domestic Hot Water
Space Heating
Total

Source: Breathe Architects (2007)
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

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

South Richmond, BC
A compact urban form is most environmentally desirable.
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.

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

photo credits: TR, Nov 2011
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.

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;
Addressing (reducing) auto dependence of the built environment would lead to greater environmental sustainability (less energy consumption, pollution, etc.) and improve personal health (via more active lifestyles using Active Transportation). This likely would benefit the economy with lower environmental pollution and associated health care costs attributable to pollution and sedentary 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
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?


