Urban Density

Indicator #7000

Overall Assessment

Status:	**Mixed**
Trend:	**Undetermined**
Rationale:	**Insufficient data and analyses were available to determine if increases in urban populations and land area reflected sustainable development.**

Lake-by-Lake Assessment

Individual lake basin assessments were not prepared for this report.

Purpose

- To assess the urban human population density in the Great Lakes basin
- To infer the degree of land use efficiency for urban communities in the Great Lakes ecosystem

Ecosystem Objective

Socio-economic viability and sustainable development are the generally acceptable goals for urban growth in the Great Lakes basin. Socio-economic viability indicates that development should be sufficiently profitable and social benefits are maintained over the long term. Sustainable development requires that we plan our cities to grow in a way so that they will be environmentally sensitive, and not compromise the environment for future generations. Thus, by increasing the densities in urban areas while maintaining low densities in rural and fringe areas, the amount of land consumed by urban sprawl will be reduced.

State of the Ecosystem

Background

Urban density is defined as the number of people per square kilometer of land for urban use in a municipal or township boundary. Lower urban densities are indicative of urban sprawl; that is, low-density development beyond the edge of service and employment, which separates residential areas from commercial, educational, and recreational areas thus requiring automobiles for transportation (Transit Cooperative Research Program (TCRP)1998; TCRP 2003; Neill *et al*. 2003). Urban sprawl has many detrimental effects on the environment. The process consumes large quantities of land, multiplies the required horizontal infrastructure (roads and pipes) needs, and increases the use of personal vehicles while the feasibility of alternate transportation declines. When there is an increased dependency on personal vehicles, an increased demand for roads and highways follows, which in turn, promotes segregated land uses, large parking lots, and urban sprawl. These implications result in the increased consumption of many non-renewable resources, the creation of impervious surfaces and damaged natural habitats, and the production of many harmful emissions. Segregated land use also lowers the quality of life as the average time spent traveling increases and the sense of community, derived from public interaction, diminishes. For this assessment, the population data used were derived from the 1990-2000 U.S. census and the 1996 and 2001 Canadian censuses.

This indicator offers information on the presence, location, and predominance of human-built land cover and infers the intensity of human activity in the urban area. It may provide information about how such land cover types affect the ecological characteristics and functions of ecosystems, as demonstrated by the use of remote-sensing data and field observations.

Status of Urban Density

Within the Great Lakes basin there are 10 Census Metropolitan Areas (CMAs) in Ontario and 24 Metropolitan Statistical Areas (MSAs) in the United States. In Canada, a CMA is defined as an area consisting of one or more adjacent municipalities situated around a major urban core with a population of at least 100,000. In the United States, an MSA must have at least one urbanized area of 50,000 or more inhabitants and at least one urban cluster of at least a population of 10,000 but less than 50,000. The urban population growth in the Great Lakes basin shows consistent patterns in both the United States and Canada. The population in both countries has been increasing over the past five to ten years. According to the 2001 Statistics Canada report, between 1996 and 2001, the population of the Great Lakes basin CMAs grew from 7,041,985 to 7,597,260, an increase of 555,275 or 7.9% in five years. The 2000 U.S. census reports that from 1990 to 2000 the population contained in the MSAs of the Great Lakes basin grew from 26,069,654 to 28,048,813, an increase of 1,979,159 or 7.6% in 10 years.

In the Great Lakes basin, while there has been an increase in population, there has also been an increase in the average population densities of the CMAs and MSAs. However, using the CMA or MSA as urban delineation has two major limitations. First, CMAs and MSAs contain substantial rural land areas and by themselves result in over-estimation of the land area occupied by a city or town. Second, these area delineations are based on a population density threshold and hence provide information on residential distribution and not necessarily on other urban land categories such as commercial or recreational land. If within the CMAs and MSAs the amount of land being developed is escalating at a greater rate than the population growth rate, the average amount of developed land per person is increasing. For example, "In the Greater Toronto Area (GTA) during the 1960s, the average amount of developed land per person was a modest 0.019 hectares (0.047 acres). By 2001 that amount tripled to 0.058 hectares per person (0.143 acres)" (Gilbert *et al*. 2001).

Population densities illustrate the development patterns of an area. If an urban area has a low population density this indicates that the city has taken on a pattern of urban sprawl and segregated land uses. This conclusion can be made as there is a greater amount of land per person. However, it is important to not only look at the overall urban density of an area, but also the urban dispersion. For example, a CMA or MSA with a relatively low density could have different dispersion characteristics than another CMA or MSA with the same density. One CMA or MSA could have the distribution of people centered around an urban core, while another could have a generally consistent sparse dispersion across the entire area and both would have the same average density. Therefore, to properly evaluate the growth pattern of an area, it is necessary to examine not only urban density but also urban dispersion.

While density is a readily understandable measure, it is challenging to quantify because of the difficulty in estimating true urban extent in a consistent and unbiased way. The political geographic extents of MSAs and CMAs give approximate indications of relative city size. However, they tend to contain substantial areas of rural land use. Recently, satellite remote sensing data has been used to map land use of Canadian cities as part of a program to develop an integrated urban database, the Canadian Urban Land Use Survey (CUrLUS). In southern Ontario, a total of 11 cities have been mapped (using Landsat data acquired in the 1999 to 2002 timeframe) and their densities estimated using population statistics from the 2001 Canadian census (Figure 1). Population density tends to correlate positively with the city size. Bigger cities with higher population pressure have higher population density and more efficient land use. Comparing the population densities of 11 cities (or CMAs) in southern Ontario, derived from remote sensing mapping and 2001 census (Zhang and Guindon 2005), the Greater Toronto Area (GTA) has a higher population density (2848 people /km^2, 7376 people/mile^2) than other smaller cities.

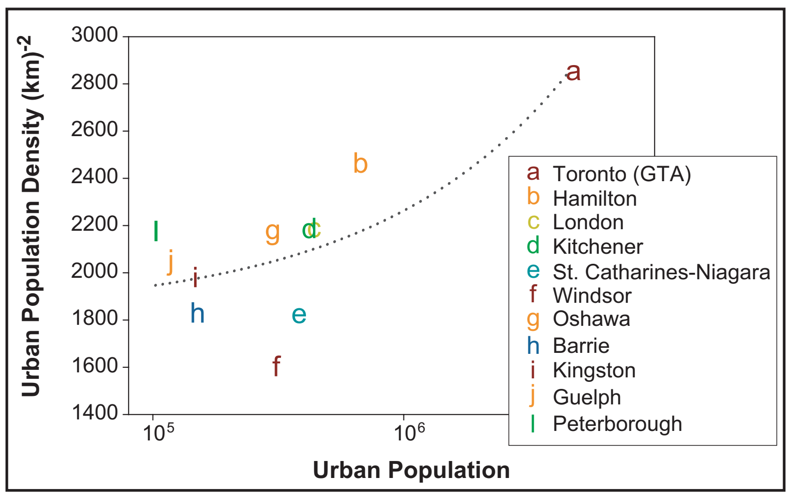

Figure 1. Population densities of cities with population more than 100,000 in southern Ontario of the Great Lakes watershed for 2001.
Source: Y. Zhang and B. Guindon, private communication

The growth characteristics of five large Canadian cities have also been studied for the period from 1986 to 2000. Preliminary analyses (Figure 2) indicate the areal extents of these communities have grown at a faster rate than their populations and thus that sprawl continues to be a major problem.

A comparison of the ten CMAs and MSAs with the highest densities to the ten CMAs and MSAs with the lowest densities in the Great Lakes basin shows there is a large range between the higher densities and lower densities. Three of the ten lowest density areas have experienced a population decline while the others have experienced very little population growth over the time period examined. The areas with population declines and areas of little growth are generally occurring in northern parts of Ontario and eastern New York State. Both of these areas have had relatively high unemployment rates (between 8% and 12%) which could be linked to the slow growth and decreasing populations.

Overall, the growing urban areas in the Great Lakes basin seem to be increasing their geographical area at a faster rate than their population. This trend has many detrimental effects as outlined previously, namely urban sprawl and its implications. Such trends may continue to threaten the Great Lakes basin ecosystem unless this pattern is reversed. However, there is a need for more

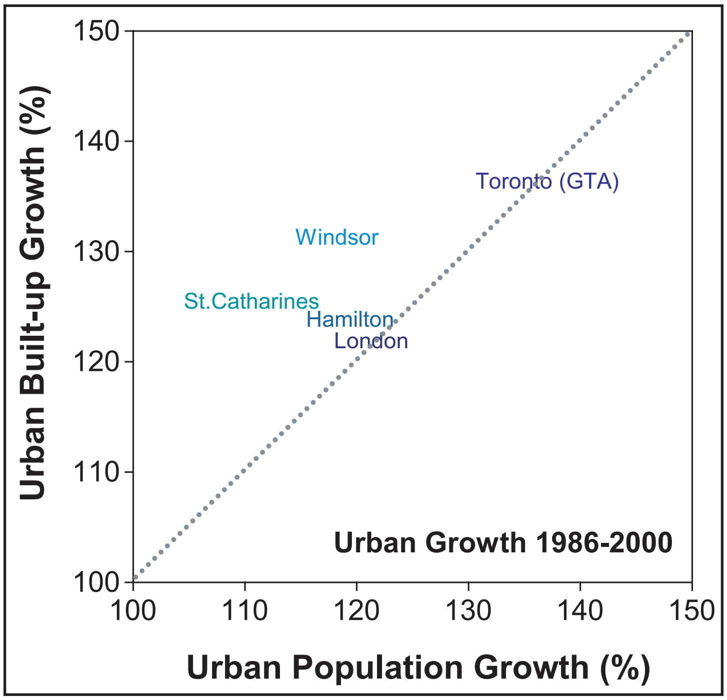

Figure 2. Growth characterization of 5 urban areas in the period of 1986-2001.
Source: Y. Zhang and B. Guindon, private communication

definitive information about relying on relatively fine-scale urban delineation data as it pertains to broad-scale trends for the Great Lakes region.

Pressures
Under the pressure of rapid population growth in the Great Lakes region, mostly in the metropolitan cities, urban development has been undergoing unprecedented growth. For instance, the urban built-up area of the GTA has doubled since 1960s. Sprawl is increasingly becoming a problem in rural and urban fringe areas of the Great Lakes basin, placing a strain on infrastructure and consuming habitat in areas that tend to have healthier environments than those that remain in urban areas. This trend is expected to continue, which will exacerbate other problems, such as increased consumption of fossil fuels, longer commute times from residential to work areas, and fragmentation of habitat. For example, at current rates in Ontario, residential building projects will consume some 1,000 km^2 (386 $mile^2$) of the province's countryside, an area double the size of Metro Toronto, by 2031. Also, gridlock could add 45% to commuting times, and air quality could suffer due to a 40% increase in vehicle emissions (Loten 2004). The pressure urban sprawl exerts on the ecosystem has not yet been fully understood. It may be years before all of the implications have been realized.

Management Implications
Urban density impacts can be more thoroughly explored and explained if they are linked to the functions of ecosystems (e.g., as it relates to surface water quality). For this reason, interpretation of this indicator is correlated with many other Great Lakes indicators and their patterns across the Great Lakes. Urban density's effects on ecosystem functions should be linked to the ecological endpoint of interest, and this interpretation may vary as a result of the specificity of land cover type and the contemporaneous nature of the data. Thus, more detailed land cover data are required.

To conduct such measures at a broad scale, the relationships between land cover and ecosystem functions need to be verified. This measure will need to be validated fully with thorough field-sampling data and sufficient *a priori* knowledge of such endpoints and the mechanisms of impact (if applicable). The development of indicators (e.g., a regression model) is an important goal, and requires uniform measurement of field parameters across a vast geographic region to determine accurate information to calibrate such models.

The governments of the United States and Canada have both been making efforts to ease the strain caused by pressures of urban sprawl by proposing policies and creating strategies. Although this is the starting point in implementing a feasible plan to deal with the environmental and social pressures of urban sprawl, it does not suffice. Policies are not effective until they are put into practice, and, in the meantime, our cities continue to grow at unsustainable rates. In order to mitigate the pressures of urban sprawl, a complete set of policies, zoning bylaws and redevelopment incentives must be developed, reviewed and implemented. As noted in the Urban Density indicator report from 2000, policies that encourage infill and brownfields redevelopment within urbanized areas will reduce sprawl. Compact development could save 20% in infrastructure costs (Loten 2004). Comprehensive land use planning that incorporates transit, while respecting adjacent natural areas, will help alleviate the pressure from development.

For sustainable urban development, we should understand fully the potential negative impacts of urban high density development. High urban density indicates intensified human activity in the urban area, which could produce potential threats to the quality of the urban environment. Therefore, the urbanization strategies should be based on the concept of sustainable development with a balance of the costs and benefits.

Comments from the author(s)
A thorough field-sampling protocol, properly validated geographic information, and other remote-sensing-based data could lead to successful development of urban density as an indicator of ecosystem function and ecological vulnerability in the Great Lakes basin. This indicator could be applied to select sites, but would be most effective if used at a regional or basin-wide scale. Displaying U.S. and Canadian census population density on a GIS-produced map will allow increasing sprawl to be documented over time in the Great Lakes basin on a variety of scales. For example, the maps included with the 2003 Urban Density report show the entire Lake Superior basin and a closer view of the southwestern part of the basin.

To best quantify the indicator for the whole Great Lakes watershed, a watershed-wide consistent urban built-up database is needed.

Acknowledgments
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