Ground Surface Hardening

Indicator #7054

Overall Assessment

Status: Fair

Trend: Undetermined

Rationale: Impervious surfaces cover 8.5% of the Great Lakes Basin watersheds within U.S. borders and 1.3% within Canadian borders.

Lake-by-Lake Assessment

Lake Erie

Status: US - Poor, Canada - Good

Trend: Undetermined

Rationale: Impervious surfaces cover 15.6% (9,006 sq. km.) of the watershed located in the United States and 2.25% (539 sq. km.) of the Canadian portion of the watershed.

Lake Huron

Status: US - Fair, Canada - Good

Trend: Undetermined

Rationale: Impervious surfaces cover 7.37% (3,197 sq. km.) of the watershed located in the United States and 0.65% (606 sq. km.) of the Canadian portion of the watershed.

Lake Michigan

Status: US - Fair

Trend: Undetermined

Rationale: Impervious surfaces cover 8.14% (9,871 sq. km.) of the watershed, all of which is located within the United States.

Lake Ontario

Status: US - Fair, Canada - Fair

Trend: Undetermined

Rationale: Impervious surfaces cover 6.5% (2,370 sq. km.) of the watershed located in the United States and 5.79% (1,734 sq. km.) of the Canadian portion of the watershed.

Lake Superior

Status: US - Good, Canada - Good

Trend: Undetermined

Rationale: Impervious surfaces cover 2.9% (1,282 sq. km.) of the watershed located in the United States and 0.01% (12 sq. km.) of the Canadian portion of the watershed.

Note: The status for the overall assessment and for each watershed individually was based on the following categorization: 0-5% - Good, >5%, but less than or equal to 10% - Fair, >10% Poor

Purpose

- To indicate the degree to which impervious surfaces affect natural water drainage, that causes rapid run-off and erosion, which is the main source of non-point pollution.
- To measure the impact of land development on aquatic systems.

Ecosystem Objectives

A goal for the ecosystem is sustainable development. This would entail minimizing the quantities of impervious surface by using alternatives for replacement and future development.

State of the Ecosystem

Ground surface hardening, or imperviousness, is the sum of the area of roads, parking lots, sidewalks, roof tops, and other impermeable surfaces where water cannot be absorbed directly into the ground. These surfaces are mostly found in urban landscapes, and can serve as useful indicators with which to measure the impact of land development on aquatic ecosystems (Center for Watershed Protection 1994). With increasing population sizes, it is expected that ground surface hardening will increase as well.

In the U.S., a National Land Cover Database (NLCD) is created by satellite imagery which includes the percentage of impervious surfaces, and their associated impermeability rates, at a 30 meter resolution. The most recent available NLCD dataset is for the year 2001; however, the 2006 dataset is currently under development. This 2001 dataset along with U.S. Census county population data was used to calculate three key metrics (the total sq. km. of impervious surfaces, the percentage of the watershed consisting of impervious surfaces, and the sq. km. of impervious surfaces per capita) for each Great Lake watershed (Figure 1). Unlike the U.S., there is no existing Canadian impervious surface datasets available. It became necessary to use the "settled and developed land" land use classification, from the Ontario land cover data (1:250,000 scale) produced by the Ontario Ministry of Natural Resources, as an proxy for impervious surfaces within the Canadian region of the Great Lakes Basin. Additionally, the available Canadian census data was too course to accurately determine the sq. km. of impervious surface per capita for the Canadian portion of the Great Lakes Basin. However, the amount of impervious surfaces (based on the amount of "settled and developed land") was determined, as well as, the percentage of the Canadian portion of the watershed this area covers.

For the U.S., the percent impermeability ranged from 1-100%, thus it became necessary to categorize in an effort to make the findings useful to a large number of individuals. The four categories are as follows: <20%, 20-49%, 50-79%, and 80-100%, which correspond to the NLCD land use classifications of developed open space, low intensity development, medium intensity development, and high intensity development, respectively.

As seen in Figure 2, the amount of impervious surfaces of different impermeabilities varies from watershed to watershed. It was also evident that the majority of the impervious surfaces consisted of matrices of roads and buildings leading to and located in large cities (Figure 3). The Canadian data had a slightly different structure and could not be categorized based on different levels of impermeability. Figure 4 shows Toronto, Canada, is represented in the data with the amount of impervious surfaces equal to the amount of "settled and developed land."

In the U.S., the Great Lakes Basin watersheds of Lake Erie and Lake Michigan have the highest proportion (15.6% and 8.14%, respectively) of their watersheds consisting of impervious surfaces. Not surprisingly, the Lake Superior watershed contained the lowest proportion (2.92%) of impervious surfaces within the U.S. portion of the Great Lakes Basin. It should be noted however, that on a per capita basis, the Lake Superior watershed ranked the highest (100.54 sq. km. impervious surfaces per person) followed by the Lake Michigan, Erie, Ontario, and Huron

watersheds (51.07, 47.36, 29.99, and 27.68 sq. km./person, respectively) (Table 1). One possible explanation for the trend seen in the Lake Superior watershed is that extensive road networks were mostly likely built to reach fairly remote locations with low populations, and the large amount of summer homes present in the Upper Peninsula of Michigan are only inhabited seasonally. Thus, the owners of these seasonal homes may not be counted as residents of these Upper Peninsula counties by the U.S. Census.

The amount of impervious surfaces that are found within the Canadian portion of the Great Lakes Basin watersheds are an underestimate of the actual amount of impervious surfaces present, because road networks and some developed open lands were not classified for inclusion in the "settled and developed lands" land use classification. However, the watersheds located within Canada can still be compared to one another to identify trends between the watersheds. The highest proportion (5.79%) of impervious surfaces was found in the Lake Ontario watershed, in which much of the impervious surfaces can be attributed to large cited (ex: Toronto) which are located within the watershed. The Lake Erie, Lake Huron, and Lake Superior watershed consisted of 2.25%, 0.65%, and 0.01% of their land area being covered with impervious surfaces, respectively (Table 2).

Management Implications

Many solutions exist to mitigate ground surface hardening expansion or to retrofit existing impervious surfaces. Care should be taken to minimize the loss of ecological services due to increased imperviousness. For example, runoff from buildings can be controlled by green roofs, i.e. vegetated roofs, which have been shown to retain up to 80% of rainfall runoff for rainfall events of 1" or less. Additionally, green roofs, as well as green pavements, which are able to reflect more of the sunlight, are also known to decrease the urban heat island effect if widely used. Another often overlooked part of impervious surfaces is parking lots. One study, conducted at Purdue University, estimated that parking lots occupied 4.97% of the urban areas in the states of Illinois, Indiana, Wisconsin, and Michigan. This along with other studies (Wilson 1995 and Shoup 1995) call for revisions of parking lot ordinances which include maximum parking lot size recommendation in an effort to reduce the parking lot to building footprint ratios. Other possibilities for mitigating the effects of impervious surfaces on runoff include the use of concrete and pavement that is permeable to water. One such example can be seen in the city of Chicago, Illinois, where alleyways between buildings are being resurfaced to increase infiltration and decrease runoff of rainwater during storm events (Hawkins-Cox, 2008). The increased infiltration acts as a filter for the rainwater, thus decreasing the total amount of pollutants (via microbial and fungal metabolisis) before entering Lake Michigan via groundwater flow. Lastly, planning at the city level should also be focused on the reduction of urban sprawl, the development of reliable public transportation systems, and an increased emphasis on urban infilling. If mitigation techniques like those described above are employed throughout the Great Lakes Basin, ground surface hardening need not to increase at the rate of population growth.

Assessing Data Quality

Insert "x" under the statement that best corresponds with each data characteristic

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable
1. Data are documented, validated, or quality-assured by a recognized agency or organization	X					
2. Data are traceable to original sources	X					
3. The source of the data is a known, reliable and respected generator of data	X					

4. Geographic coverage and scale of data are appropriate to the Great Lakes basin		X				
5. Data obtained from sources within the U.S. are comparable to those from Canada				X		
6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report		X				

Clarifying Notes:

*The population data for Canada was on a sq. km. basis (http://geogratis.cgdi.gc.ca/), while the population data for the United States was by U.S. Census block group (www.census.gov).

*Additionally, the impervious surface data for Canada (http://geogratis.cgdi.gc.ca/) could not be broken down into percent impermeability like the U.S. impervious surface data (www. mrlc.gov) could. Thus, all land classified as "settled and developed land" by the Ontario Ministry of Natural Resources was considered impervious surfaces.

Acknowledgements

Authors: (2008)

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Sources

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List of Tables

Table 2. Total area (sq. km.) and proportion of watershed that contains impervious surfaces in the Canada portion of the Great Lakes region.
Source:

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Last Updated

State of the Lakes Ecosystem Conference (SOLEC) 2008

	Superior	Michigan	Huron	Erie	Ontario
Impervious Surface area	1283	9871	3197	9006	2370
Percent of Watershed	2.92%	8.14%	7.37%	15.60%	6.50%
Per capita	100.54	51.07	27.68	47.36	29.99

Table 1. Total area (sq. km.) and proportion of watershed that contains impervious surfaces and the amount of impervious surface per capita (sq. m. per person) in the U.S. region for each Great Lakes watershed.
Source:

	Superior	Huron	Erie	Ontario
Impervious Surface area	12	606	539	1734
Percent of Watershed	0.01%	0.65%	2.25%	5.79%

Table 2. Total area (sq. km.) and proportion of watershed that contains impervious surfaces in the Canada portion of the Great Lakes region.
Source:

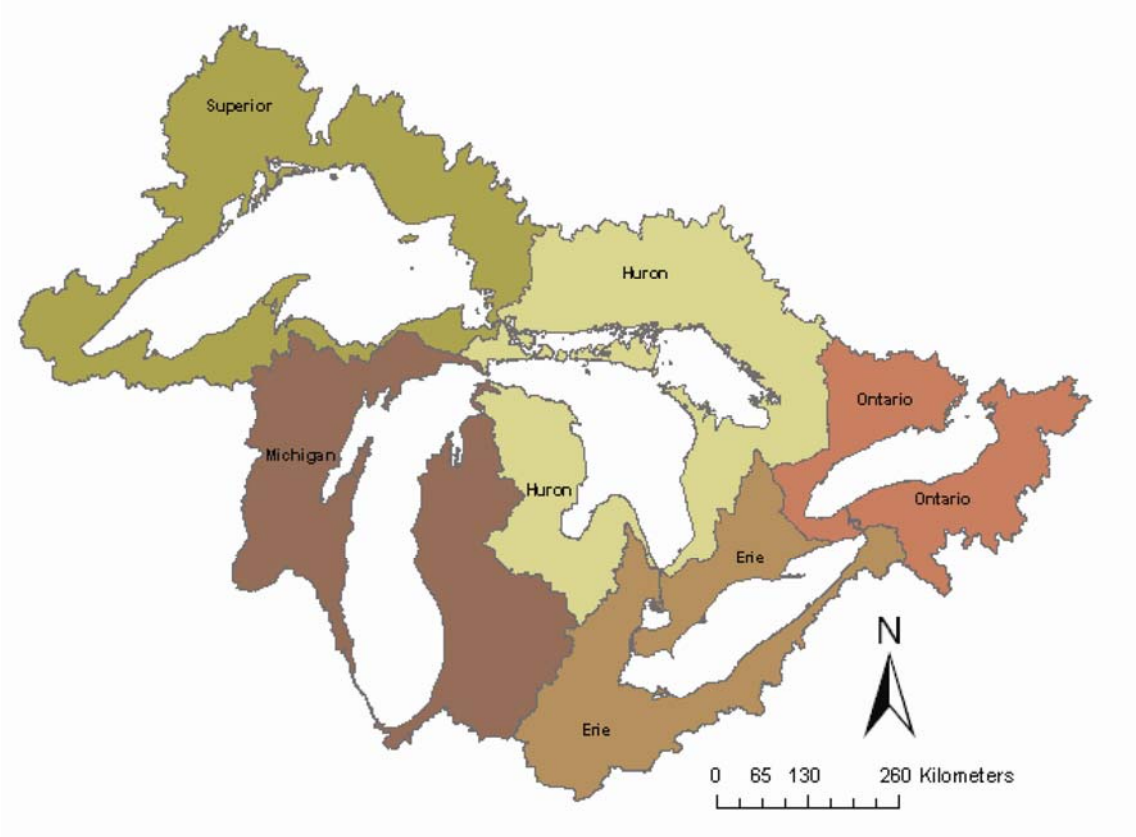

Figure 1. Map showing the 5 different Great Lakes watersheds located within both the U.S. and Canadian portions of the Great Lakes Basin.
Source:

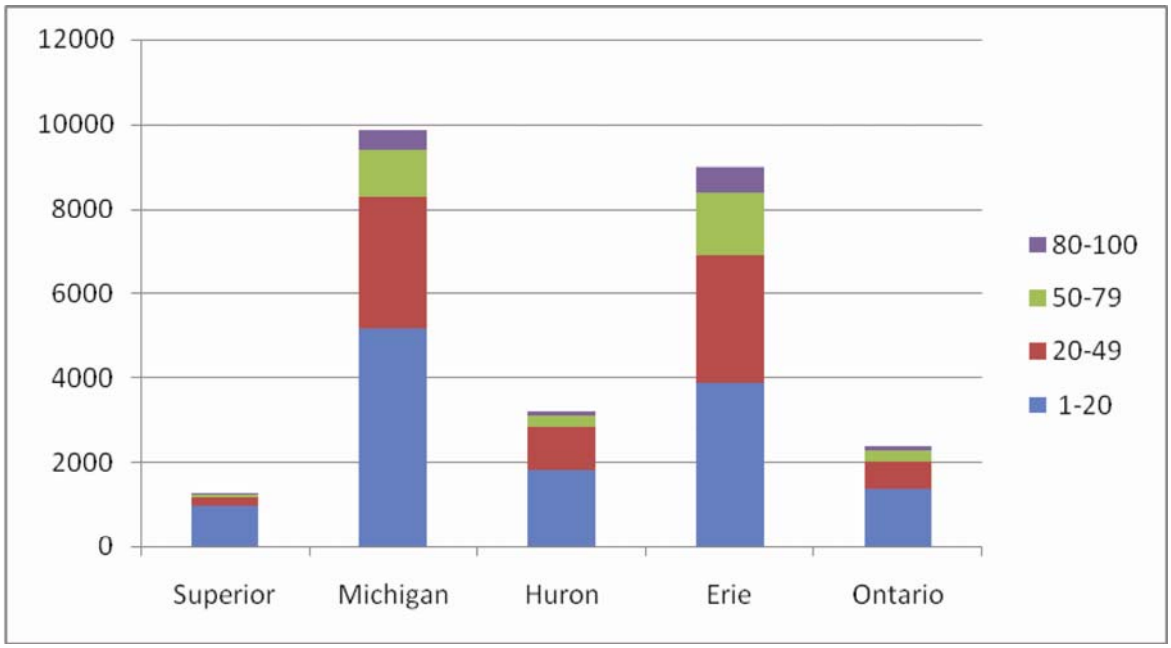

Figure 2. Lake-by-Lake amounts of impervious surface area (sq. km.) categorized by percent for their respective watershed areas in the USA.
Source:

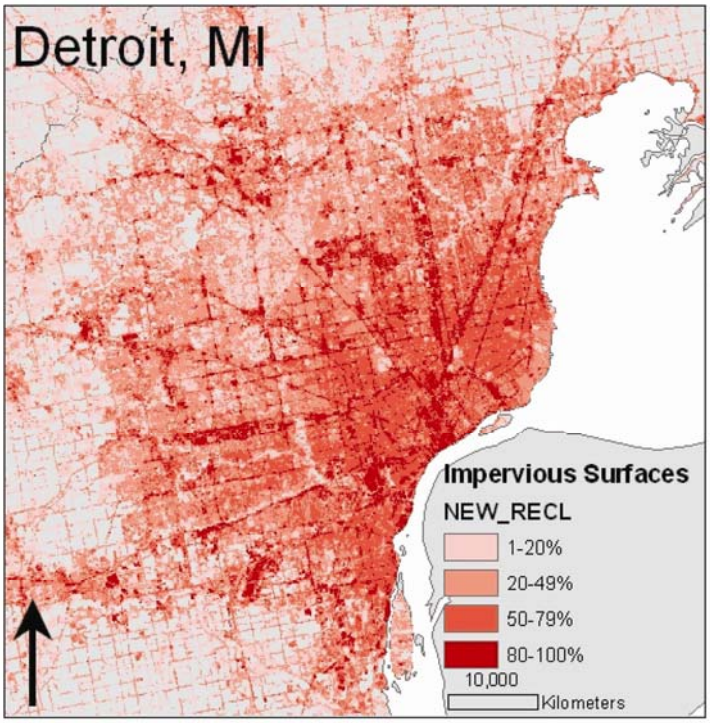

Figure 3. Detroit Michigan, United States showing percent impervious in NLCD categories.
Source:

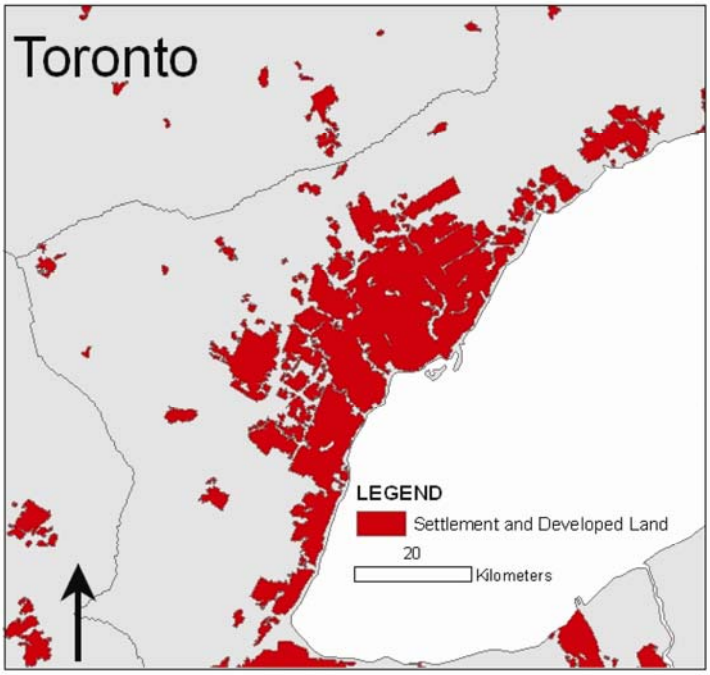

Figure 4. Toronto, Canada showing the area that is classified as settlement and developed land.
Source: