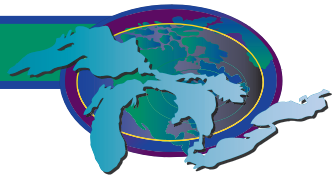

Land Cover - Land Conversion

Indicator #7002

Overall Assessment

Status:	**Mixed**
Trend:	**Undetermined**
Rationale:	**Low-intensity development increased 33.5%, road area increased 7.5%, and forest decreased 2.3% from 1992 to 2001. Agriculture lost 210,000 ha (520,000 acres) of land to development. Approximately 50% of forest losses were due to management and 50% to development.**

Lake-by-Lake Assessment

Lake Superior

Status: Good
Trend: Undetermined
Rationale: Lowest conversion rate of non-developed land to developed and highest conversion rate of non-forest to forest. Of the 4.2 million ha (10.4 million acre) watershed area on the U.S. side, 1,676 ha (4141 acres) of wetland, 2,641 ha (15,422 acres) of agricultural land, and 14,300 ha (35,336 acres) of forest land were developed between 1992 and 2001.

Lake Michigan

Status: Mixed
Trend: Undetermined
Rationale: Intermediate to high rate of land development conversions. Of the 1.2 million ha (3.0 million acre) watershed, 9,724 ha (24,028 acres) of wetland, 78,537 ha (193,624 acres) of agricultural land, and 57,529 ha (142,157 acres) of forest land were developed between 1992 and 2001.

Lake Huron

Status: Fair
Trend: Undetermined
Rationale: Second lowest rate of conversion of land to developed. Of the 4.1 million ha (10.1 million acre) watershed area on the U.S. side, 4,314 ha (10,660 acres) of wetland, 17,881 ha (44,185 acres) of agricultural land, and 17,730 ha (43,812 acres) of forest land were developed between 1992 and 2001.

Lake Erie

Status: Poor
Trend: Undetermined
Rationale: Highest conversion rate of non-developed to developed area. Of the 5.0 million ha (12.4 million acre) watershed area on the U.S. side, 3,352 ha (8,283 acres) of wetland, 52,502 ha (129,735 acres) of agricultural land, and 27,869 ha (68,866 acres) of forest land were developed between 1992 and 2001.

Lake Ontario

Status: Mixed
Trend: Undetermined
Rationale: Intermediate to high conversion rate of non-developed to developed land use coupled with the lowest rates of wetland development. Of the 3.4 million ha (8.4 million acre) watershed area on the U.S. side, 458 ha (1,132 acres) of wetland, 24,883 ha (61,487 acres) of agricultural land, and 20,670 ha (51,076 acres) of forest land were developed between 1992 and 2001.

Purpose

- To document the proportion of land in the Great Lakes basin under major land use classes
- To assess the changes in land use over time
- To infer the potential impact of existing land cover and land conversion patterns on basin ecosystem health

Ecosystem Objective

Sustainable development is a generally accepted land use goal. This indicator supports Annex 13 of the Great Lakes Water Quality Agreement (United States and Canada 1987).

State of the Ecosystem

Binational land use data from the early 1990s were developed by Bert Guindon (Natural Resources Canada). Imagery data from the North American Landscape Characterization and the Canada Centre for Remote Sensing archive were combined and processed into land cover using Composite Land Processing System software. This data set divides the basin into four major land use classes: water, forest, urban, and agriculture and grasses.

Later, finer-resolution satellite imagery allowed an analysis to be conducted in greater detail with a larger number of land use categories. For instance, the Ontario Ministry of Natural Resources has compiled Landsat TM (Thematic Mapper) data, classifying the Canadian Great Lakes basin into 28 land use classes.

On the U.S. side of the basin, the Natural Resources Research Institute (NRRI) of the University of Minnesota – Duluth has developed a 25-category classification scheme (Table 1) based on 1992 National Land Cover Data (NLCD) from the U.S. Geological Survey supplemented by 1992 WISCLAND, 1992 GAP, 1996 C-CAP and raw Landsat TM data to increase resolution in wetland classes (Wolter *et al*. 2006). The 1992 Topologically Integrated Geographic Encoding and Reference (TIGER) data were also used to add roads on to the map. Within the U.S. basin, the NRRI found the following:

Between two nominal time periods (1992 and 2001), the U.S. portion of the Great Lakes watershed has undergone substantial change in many key land use/land cover (LU/LC) categories (Figure 1). Of the total change that occurred (798,755 ha, 2.5% of watershed area), salient transition categories included a 33.5% increase in area of low-intensity development, a 7.5% increase in road area, and a decrease of forest area by over 2.3%, the largest LU/LC category and area of change within the watershed. More than half of the forest losses involved transitions into early successional vegetation (ESV), and hence, will likely remain in forest production of some sort. However, nearly as much forest area was, for all practical purposes, permanently converted to developed land. Likewise, agriculture lost over 50,000 more hectares (125,000

(1)	Low Intensity Residential	1 Developed
(1)	High Intensity Residential	2 Agriculture
(1)	Commercial/Industrial	3 Early Successional Vegetation
(1)	Roads (Tiger 1992)	4 Forest
(3)	Bare Rock/Sand/Clay	5 Wetland
(1)	Quarries/Strip Mines/Gravel Pits	6 Miscellaneous Vegetation
(6)	Urban/Recreational Grasses	
(2)	Pasture/Hay	
(2)	Row Crops	
(2)	Small Grains	
(3, 6)	Grasslands/Herbaceous	
(2, 6)	Orchards/Vineyards/Other	
(4)	Deciduous Forest	
(4)	Evergreen Forest	
(4)	Mixed Forest	
(3, 6)	Transitional	
(3, 6)	Shrubland	
(5)	Open Water	
(5)	Unconsolidated Shore	
(5)	Emergent Herbaceous Wetlands	
(5)	Lowland Grasses	
(5)	Lowland Scrub/Shrub	
(5)	Lowland Conifers	
(5)	Lowland Mixed Forest	
(5)	Lowland Hardwoods	

Table 1. Classification scheme used to analyze LU/LC change in the U.S. portion of the Great Lakes basin.

Original 25 classes are listed in the left column and aggregated LU/LC categories are listed in the right column. Numbers in parentheses indicate aggregated class membership. Miscellaneous vegetation class was generated (code 6) to represent land that was vegetated, but not mature forest or annual row crop.

Source: Wolter *et al*. 2006

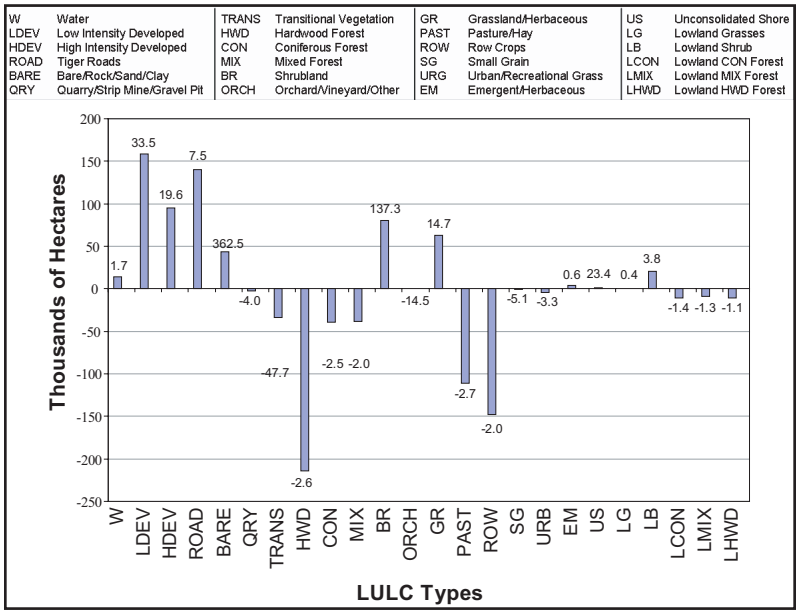

Figure 1. LU/LC type changes for the U.S. Great Lakes basin by area and percent change since 1992 (numbers above and below bars).

Source: Wolter *et al*. 2006

acres) of land to development than forestland, much of which involved transitions into urban/suburban sprawl (Figure 2). Approximately 210,068 ha (81%) of agricultural lands were converted to development, and 16.3% of that occurred within 10 km of the Great Lakes shoreline.

LU/LC transitions between 1992 and 2001 within near-shore zones of the Great Lakes (0-1, 1-5, 5-10 km) largely paralleled those of the overall watershed. While the same transition categories dominated, their proportions varied by buffered distance from the lakes. Within the 0-1 km zone from the Great Lakes shoreline, conversions of forest to both ESV (9,087 ha, 5.0% of total category change (TCC)) and developed land (8,657 ha, 5.6% of TCC) were the largest transitions, followed by conversion of 3,935 ha (1.9% of TCC) of agricultural land to developed. For the 1-5 km zone inland from the shore, forest to developed conversion was the largest of the three transitions (17,049 ha, 11.0% of TCC), followed by agricultural to developed (14,279 ha, 6.8% of TCC) and forest to ESV (13,116 ha, 7.3% of TCC). Within the 5-10 km zone from shoreline, transition category dominance was most similar to the trend for the whole watershed, with 16,113 ha (7.7% of TCC) of agriculture converted to developed, 14,516 ha (8.0% of TCC) of forest converted to ESV, and 14,390 ha (9.3% of TCC) of forestland being developed by 2001. When all buffers from shoreline out to 10 km are combined, the forest to developed transition category was the largest (40,099 ha, 25.9% of TCC), followed by forest to ESV (36,726 ha, 20.3% of TCC), and agricultural to developed (34,328 ha, 16.3% of TCC).

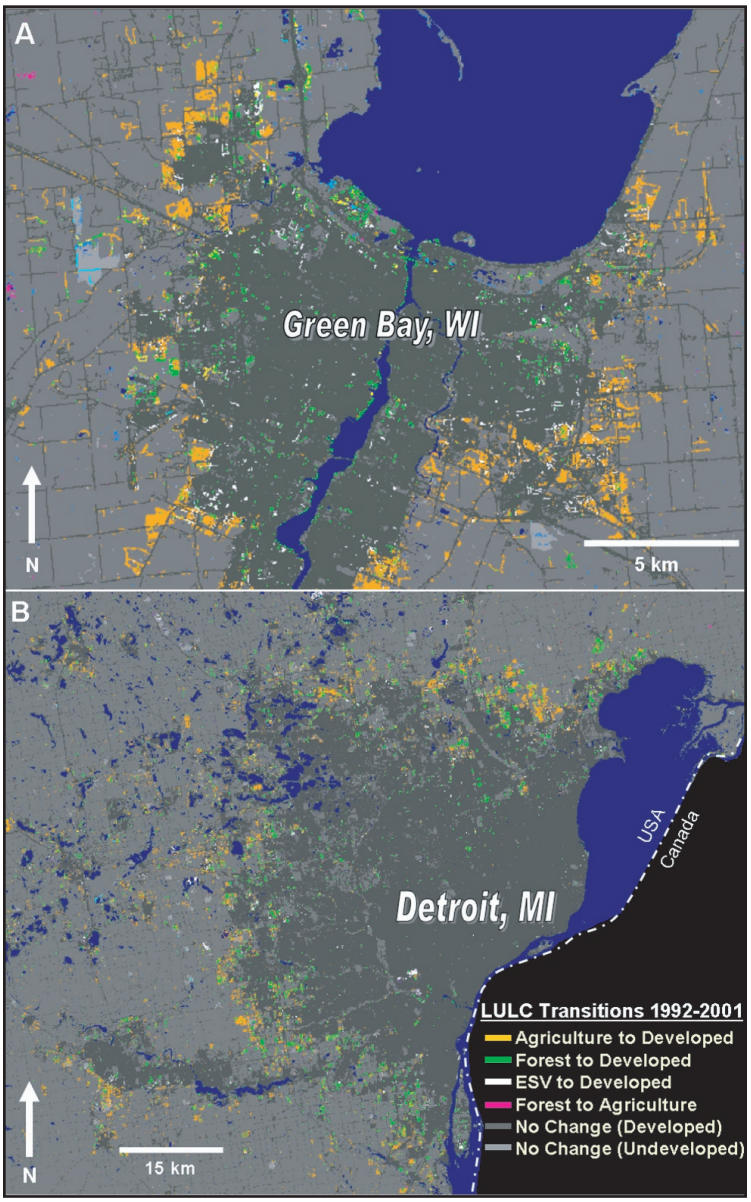

Figure 2. LU/LC change in the lower Green Bay basin of Lake Michigan (A) and the area surrounding Detroit, MI (B).
Source: Wolter *et al.* 2006

Contrary to previous decadal estimates showing an increasing forest area trend from the early 1980s to the early 1990s, due to agricultural abandonment and transitions of forest land away from active management, there was an overall decrease (~2.3%) in forest area between 1992 and 2001. Explanation of this trend is largely unclear. However, increased forest harvesting practices in parts of the region coupled with forest clearing for new developments may be overshadowing gains from the agricultural sources observed in previous decades.

When analyzed on a lake-by-lake basis (Figure 3, Table 2), Lake Michigan's watershed naturally has shown the greatest area of change from 1992 to 2001 (286,587 ha, ~2.5%), because its watershed is entirely within the U.S., and hence, the largest analyzed. Lake Michigan's watershed leads in all LU/LC transition categories but two: 1) miscellaneous vegetation to flooded and 2) ESV to forest (Figure 3). When normalized by area, however, Lake Michigan's proportion of LU/LC change is intermediate when compared to the other Great Lakes watersheds on the U.S. side of the boarder. Although Lake St. Clair is not a Great Lake, and the U.S. part of its watershed is largely metropolitan (see Figure 2), Lake St. Clair's watershed shows the highest rates of change into development from wetland, ESV, agriculture, and forest sources (Figure 4).

Of the Great Lakes, Lake Erie's watershed shows the greatest proportion of land conversion to development (87,077 ha, 1.74%), while

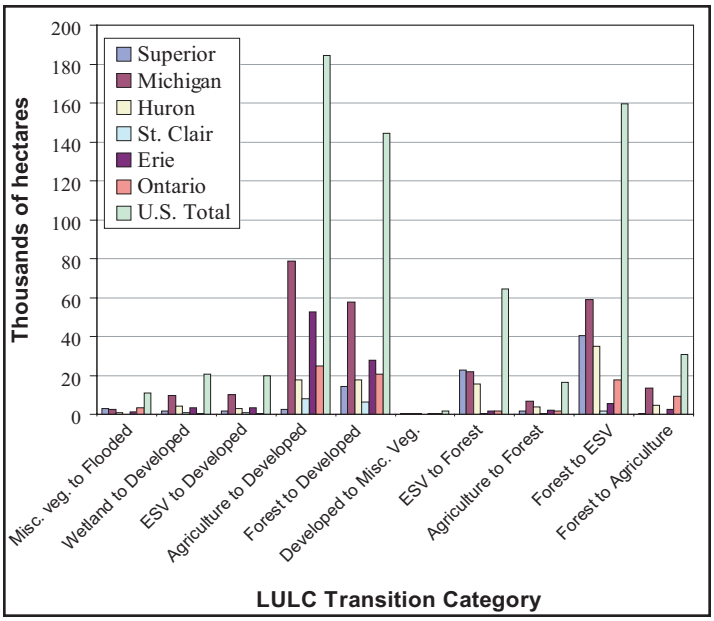

Figure 3. Lake-by-lake LU/LC transitions for the U.S. portion of the Great Lakes basin.
Source: Wolter *et al.* 2006

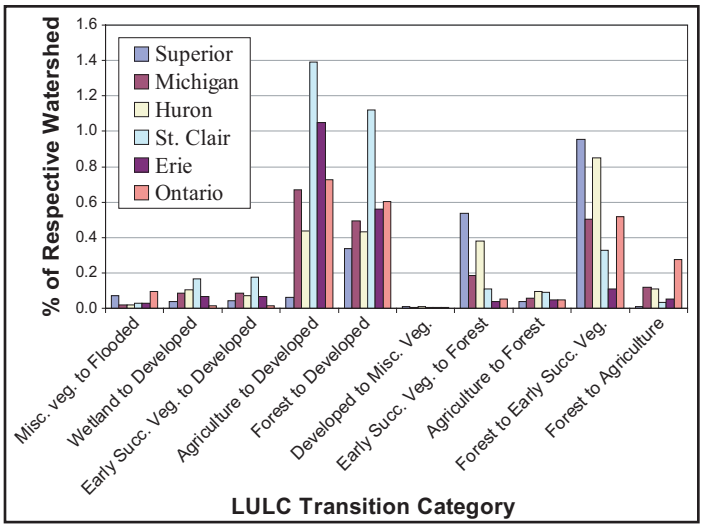

Figure 4. Lake-by-lake LU/LC transitions for the U.S. portion of the Great Lakes basin as a percent of respective watershed area.
Source: Wolter *et al.* 2006

	Erie	Huron	Michigan	Ontario	Superior	St. Clair	Erie/ St.Clair
Total watershed area	4994413	4114697	11702442	3428229	4226924	564825	5559238
Non-dev. to developed	87077	42857	155936	46507	20351	16112	103189
% of watershed	1.74	1.04	1.33	1.36	0.48	2.85	1.86

Table 2. Total area (ha) and proportion of watershed converted from non-developed to developed LU/LC from 1992 to 2001 for each of the Great Lakes and Lake St. Clair.
Source: Wolter *et al.* 2006

Lake Superior's watershed had the lowest proportion (20,351, 0.48%, Table 2). For example, Lake Erie's watershed had the highest proportion of agricultural land conversion to development. However, Lake Ontario's watershed showed the greatest proportion of forest conversion to development (Figure 4). Lake Superior's watershed reflects a high proportion of lands under forest management in that it has both the highest proportion of forest conversion to ESV and *vice-versa*. Lastly, Lake Huron's watershed had the highest proportion of wetlands being converted to development, followed closely by watersheds for Lake Michigan and Lake Erie (Figure 4).

Management Implications

As the volume of data on land use and land conversion grows, stakeholder discussions will assist in identifying the associated pressures and management implications.

Comments from the author(s)

Land classification data must be standardized. The resolution should be fine enough to be useful at lake watershed and sub-watershed levels. LU/LC classification updates need to be completed in a timely manner to facilitate effective remedial action if necessary.

Acknowledgments

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Sources

Data courtesy of:
Bert Guindon (Natural Resources Canada)

Lawrence Watkins (Ontario Ministry of Natural Resources)
Peter Wolter (Natural Resources Research Institute at the University of Minnesota – Duluth)

Forest Inventory and Analysis statewide data sets downloaded from USDA Forest Service website and processed by the author to extract data relevant to Great Lakes basin.

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