



## Greenhouse Gas Emissions

### Overall Assessment

#### Trend: Undetermined

**Rationale:** Between 1990 and 2008, the long-term trend of greenhouse gas emissions in the Great Lakes region was increasing. In 2009, however, the region experienced its largest annual drop in emissions, resulting in the region's lowest greenhouse gas emission in nineteen years.

### Lake-by-Lake Assessment

Trends were not made on an individual lake basis.

### Purpose

- To provide greenhouse gas emissions trends in the Great Lakes region
- The greenhouse gas emissions indicator is used in the Great Lake indicator suite as a driving force indicator in the Economic/Social category

### Ecosystem Objective

A reduction in greenhouse gas emissions will contribute to achieving and maintaining environmental benefits, such as beneficial uses of the Great Lakes, as outlined in Annex 2 of the Great Lakes Water Quality Agreement.

### Ecological Condition

The greenhouse gas emissions presented are reflective of the emissions for the Great Lake region as defined in this report (the whole Ontario as well as the whole of the eight Great Lakes States). Greenhouse gas emissions estimates are extracted from Environment Canada (National Inventory Report) and the United States Environmental Protection Agency. In this report, the unit of analysis is million metric ton of carbon dioxide (CO<sub>2</sub>). The data only considers emissions from carbon dioxide (CO<sub>2</sub>) within the energy sector and the burning of fossil fuels, and not CO<sub>2</sub> emissions from other sources or from other greenhouse gases such as methane and nitrous oxide. While these sources are important and significant in calculating the total greenhouse gas emissions, they are not included in this report due to a lack of consistent data availability in the United States. Nonetheless, the measure in this report accurately illustrates the trends of greenhouse gas emissions in the Great Lakes region.

#### A) Great Lakes Region as a whole (Ontario and Eight Great Lakes States)

The total greenhouse gas emissions for the entire Great Lakes region (Ontario and the eight States) have fluctuated over the nineteen-year period (Table 1 and Figure 1). The long-term trend of the region is undetermined after the significant drop in greenhouse gas emission in 2009. Currently, when comparing the emission data from 1990 to 2009, the overall region has decreased by 1.7%. Despite the overall decrease in emission from 1990 to 2009, the region's long-term emissions trend has always been increasing. In fact, when comparing the 1990 emissions with 2008, the region increased by 6.8%. It was not until 2009 where emissions experienced the biggest decline of 8.3%, likely in response to difficult overall economic conditions. In examining the short-term trend, the region experienced fluctuation. More specifically, as seen in Figure 2, greenhouse gas emissions decreased by 4.0% from 2005 to 2006. While the region experienced a growth of 2.2% in its subsequent year, greenhouse gas emissions rate decreased again by 2.8% in 2008. In 2009, the region continued to decrease and had the biggest decline of 8.3%, resulting in the region's lowest greenhouse gas emission in nineteen years. Given the continuous fluctuation in the region, the short-term trend is undetermined.

#### B) Comparison between Ontario and Eight Great Lakes States

In Ontario, the total emission in 2009 was approximately 124.5 MMTCO<sub>2</sub> (Table 1). Since 1990, Ontario's emission has decreased by 0.6% with a yearly fluctuation rate range from a decline of 12.5% to a growth of 6.5% (Table 1 & Figure 4). In a national context, Ontario's greenhouse gas emission in 2009 represents 25.3% of the total emissions in Canada, a decrease of 5.0% from Ontario's 1990 national share (Environment Canada: Canada National Inventory Report) (Table 2). In the United States, the total emissions in the eight Great Lakes States in 2009 were

1441.7 MMTCO<sub>2</sub> (Table 1). This has increased by 1.8 % since 1990. The annual fluctuation rate over the years has ranged from a decline of 8.0% to a decline of 3.7% (Figure 3 and Figure 4). In a national context, the eight great lakes states represent 26.2% of the total emissions in the United States in 2009, a decrease of 2.6% from the region's 1990 national share (U.S. Environmental Protection Agency) (Table 3).

To obtain a greater understanding of greenhouse gas emissions within the region, the population data in 2009 have been included to examine the average greenhouse gas emissions per person. As gathered from the U.S. Census and Statistics Canada, the total population in 2009 within the Great Lakes region was 96,978,002 and total greenhouse gas emissions were 1566.1 MMTCO<sub>2</sub> (Table 4). That year, emissions usage per capita was 16.2 MMTCO<sub>2</sub> (Table 4). From 1990 to 2009, the Great Lakes region has experienced a 2.3% decrease in its overall greenhouse gas emissions per capita (Table 4 and 5).

## Linkages

Emissions of greenhouse gases from human activities are causing climate change on a global scale. Most greenhouse gas emissions are caused by the burning of fossil fuels for energy and by industrial processes such as petroleum refining and cement manufacturing (Boyd 2001). While the dominant greenhouse gas is carbon dioxide (CO<sub>2</sub>), other principal greenhouse gases that enter the atmosphere and are derived from human activities include methane released from landfills and agriculture, nitrous oxide from fertilizers, and fluorinated gases from industrial processes (EPA 2011).

Climate change is a major threat to the ecosystem with both direct and indirect effects on biological systems. Direct effects include increased temperature and increased CO<sub>2</sub> levels associated with global climate change (Clark and Sullivan 2007). These direct effects cause other indirect effects, such as changes to hydrologic cycles (precipitation and evaporation), changes in precipitation patterns, floods, and water shortages (Clark and Sullivan 2007). Other examples include lower water levels and an impact on the areal extent and diversity of shoreline wetlands (Alden and Mortsch 2004). Fluctuations in water levels within wetlands will likely cause changes in nutrient levels and may also enable the release of toxic metals such as mercury (Clark and Sullivan 2007).

The Great Lakes region has already started experiencing this warming effect and as additional warming occurs, a range of ecological changes and effects on wildlife are expected, with the most significant effects on aquatic and other species dependent on water bodies for breeding and feeding (Clark and Sullivan 2007). Changes in water temperature, water levels and flows, precipitation, air temperature, timing and duration of ice break up and disturbance hazards have all placed additional stress in the basin (Alden and Mortsch 2004). Higher air temperatures change the distribution and health of aquatic and terrestrial plants and animal species (Alden and Mortsch 2004). The geographic distribution of numerous fish species is likely to be altered. Under a climatic warming, both northern and southern boundaries of species' ranges in the Great Lakes region will shift northward. As a result, the fish communities of the Great Lakes will be altered due to invasion of warm water species and local extirpation of cool water and coldwater species (Mandrak 1989). The rise in water temperature will also enhance the growth of undesirable species (such as algal blooms). In many lakes, including Lake Michigan, changes in speciation are likely as water temperatures increase and water levels decline. Cold-water species such as salmonids (e.g. coho salmon and lake trout) will be under increased stress. Temperature increases also lowers oxygen levels in the summer, creating "dead zones" which cannot support life and if dead zones persist, they can give rise to toxic algal blooms, damaging fisheries and create risks to human health (Clark and Sullivan 2007).

## Management Challenges/Opportunities

There are many linkages between greenhouse gas emissions and stresses to ecosystem health. Great lakes community and decision makers should continue to support global, national, regional and local efforts to reduce greenhouse gas emissions.

## Comments from the author(s)

In Canada, the Canadian National Inventory Report uses CO<sub>2</sub> equivalent (CO<sub>2</sub>eq) as its official metric measure to examine greenhouse gases. The CO<sub>2</sub>eq value is calculated by multiplying the amount of the gas by its associated global warming potential. CO<sub>2</sub>eq is a more accurate way of displaying and understanding the emissions from various greenhouse gases and from various sectors. For more information on the official Canadian GHG data, table 6 outlines the CO<sub>2</sub> emissions used in this report and the official GHG data (CO<sub>2</sub>eq) extracted from the National

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Inventory Report and utilized by the Canadian Environmental Sustainability Indicators.

In comparison to the Great Lakes region, the total greenhouse gas emissions for the Great Lakes watershed would be less. Nonetheless, this data serves the indicator report's purpose well by illustrating a trend that is a driving force behind many of the pressures on Great Lakes conditions. The investment required to break-down greenhouse gas emission trends specifically for the Great Lakes watershed boundary and/or on a lake-by-lake level would only be worthwhile if formal emission reduction targets are set for that defined geographic boundary.

## 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:						

## Acknowledgments

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Source:

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Source:

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Source:

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States).

Source:

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Table 1: Total Greenhouse Gas Emissions in the Great Lakes Region's Energy Sector

Year	Ontario's Total Emissions (MMTCO <sub>2</sub> )	U.S. Great Lakes States Total Emissions (MMTCO <sub>2</sub> )	Entire Great Lakes Region Total Emissions (MMTCO <sub>2</sub> )
1990	125.2	1467.6	1592.8
1991	123.8	1450.1	1573.9
1992	127.2	1456.1	1583.2
1993	119.9	1485.8	1605.7
1994	120.2	1489.6	1609.8
1995	123.4	1516.4	1639.8
1996	130.3	1573.9	1704.3
1997	137.1	1588.7	1725.9
1998	140.1	1550.6	1690.8
1999	147.3	1577.9	1725.2
2000	157.6	1624.3	1781.8
2001	151.7	1563.9	1715.6
2002	156.0	1579.8	1735.8
2003	160.1	1604.8	1764.9
2004	151.1	1622.9	1774.0
2005	153.6	1638.3	1791.8
2006	144.9	1574.8	1719.6
2007	152.0	1605.8	1757.8
2008	142.2	1566.3	1708.4
2009	124.5	1441.7	1566.1

**Table 1.** Total Greenhouse Gas Emissions in the Great Lakes Region's Energy Sector

State/Province	Ontario's Greenhouse Gas Emissions (MMTCO <sub>2</sub> )	Total Greenhouse Gas Emissions in Canada (MMTCO <sub>2</sub> )	Greenhouse Gas Emissions in National Context
Ontario (1990)	125.2	412.5	30.3%
Ontario (2009)	124.5	490.1	25.3%

**Table 2.** Per Capita Greenhouse Gas Emissions in Ontario's Energy Sector – 1990 and 2009

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State/Province	Eight Great Lakes States Greenhouse Gas Emissions (MMTCO <sub>2</sub> )	Total Greenhouse Gas Emissions in US (MMTCO <sub>2</sub> )	Greenhouse Gas Emissions in National Context
Eight Great Lakes States (1990)	1467.6	5099.7	28.8%
Eight Great Lakes States (2009)	1441.7	5505.2	26.2%

**Table 3.** Per Capita Greenhouse Gas Emissions in the Eight Great Lakes States' Energy Sector – 1990 and 2009

State/Province	Total Greenhouse Gas Emissions in the Great Lakes Region (1990) – MMTCO <sub>2</sub>	Population within the Great Lakes Region (1990)	Per Capita 1990
Ontario	125.2	10,085,000	12.4
Illinois	194.9	11,430,602	17.1
Indiana	205.3	5,544,159	37.0
Michigan	180.4	9,295,297	19.4
Minnesota	79.6	4,357,099	18.3
New York	208.8	17,990,455	11.6
Ohio	246.8	10,847,115	22.8
Pennsylvania	265.5	11,881,643	22.4
Wisconsin	86.2	4,891,769	17.6
Total:	1592.8	86,323,139	18.5

**Table 4.** Greenhouse Gas Emissions by Great Lakes and Province (Energy Sector) in 1990

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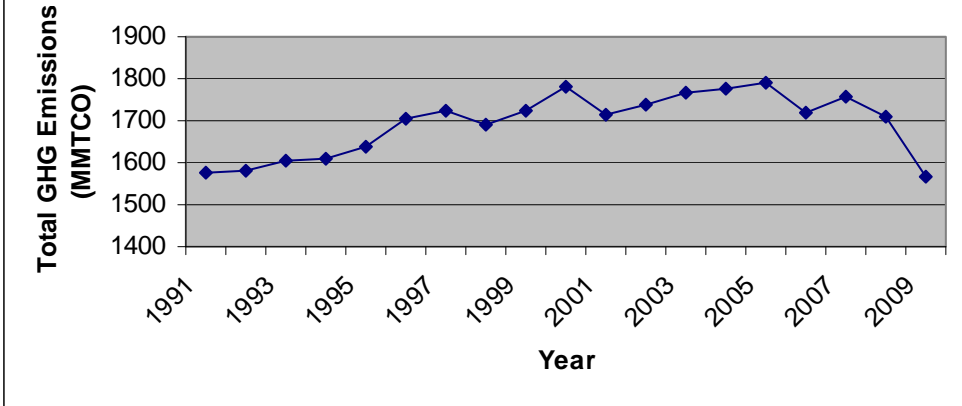
State/Province	Total Greenhouse Gas Emissions in the Great Lakes Region (2009) MMTCO	Population within the Great Lakes (2009)	Per Capita 2009
Ontario	124.5	13,064,900	9.5
Illinois	226.4	12,910,409	17.5
Indiana	205.5	6,423,113	32.0
Michigan	164.2	9,969,727	16.5
Minnesota	92.2	5,266,214	17.5
New York	176.9	19,541,453	9.1
Ohio	236.8	11,542,645	20.5
Pennsylvania	243.4	12,604,767	19.3
Wisconsin	96.3	5,654,774	17.0
Total:	1566.1	96,978,002	16.2

**Table 5.** Greenhouse Gas Emissions by Great Lakes and Province (Energy Sector) in 2009

Year	CO2 Emissions in Ontario (MMTCO2)	Official GHG Emissions in Ontario (MMTCO2eq)
1990	125.2	176.5
1991	123.8	176.2
1992	127.2	180.1
1993	119.9	170.7
1994	120.2	172.6
1995	123.4	177.3
1996	130.3	184.7
1997	137.1	190.3
1998	140.1	189.6
1999	147.3	194.4
2000	157.6	204.2
2001	151.7	196.7
2002	156.0	202.9
2003	160.1	206.8
2004	151.1	200.8
2005	153.6	202.1
2006	144.9	193.7
2007	152.0	199.6
2008	142.2	189.6
2009	124.5	165.1

**Table 6.** Comparison between Ontario's CO2 emissions in report, and official GHG data from 1990 to 2009

**Figure 1: Total Greenhouse Gas Emissions in the Great Lakes Region's Energy Sector from 1990 to 2009**



**Figure 2: Short-Term Trend: Total Greenhouse Gas Emissions in the Great Lakes Region's Energy Sector (2005-2009)**

