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Great Lakes Update

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Carbon Dioxide, Nitrous Oxide and Climate Change

This article continues the series on climate change. Last time we discussed water vapor and its affect on climate change. Again, this material is taken from "Reporting on Climate Change, Understanding the Science," published by the Environmental Health Center, National Safety Council, in November 1994.

Carbon dioxide (CO_2) is probably the most important greenhouse gas resulting from human activity, because its impacts are large and we generate so much of it. CO_2 is a very "natural" ingredient in the atmosphere -- so natural that we have only recently begun to think of human-induced carbon dioxide as a "pollutant." CO_2 is a good thing, but the key question is: How much is too much of a good thing? (Some environmentalists fear CO_2 buildup will bring about catastrophic changes to the climate.)

Today CO_2, makes up only about 0.03% of the atmosphere, and the highest estimates are that it could rise to 0.09% by the year 2100 as a result of human activities. About 4.5 billion years ago, some scientists think it may have made up as much as 80% of Earth's atmosphere.

Human life as we know it today would have been impossible in such a CO_2-rich atmosphere. Fortunately, most of this CO_2 was removed from the atmosphere later in Earth's history by photosynthesis. Eventually, most of the carbon element combined to form carbonate minerals, oil shale, coal, and petroleum in Earth's crust. What was left in the atmosphere is the oxygen we breathe today.

Atmospheric CO_2 comes from many sources -- most of them natural -- but it is usually brought into balance with "sinks" that drain carbon out of the atmosphere (Figure 1 roughly charts these carbon flows). When talking about such large amounts of carbon dioxide, scientists translate them into gigatons (a billion metric tons) of carbon (GtC) for convenience.

Quantities of carbon dioxide in the atmosphere are constantly being dissolved in the surface waters of the oceans, and conversely, the sea releases carbon dioxide back into the atmosphere. The amount released to the atmosphere is estimated at 2 GtC/year less than it takes in, making it a "sink" for atmospheric CO_2.

Plants "breathe" CO_2 through the process of photosynthesis -- about 102 GtC worth every year. But plants, animals, and other organisms also "breathe" out carbon dioxide. Together, all the living things on land are estimated to exhale about 50 GtC/year. When plants and animals die, the organic carbon compounds they have stored break down through many kinds of chemical decomposition and microbial action. As they break down, an estimated 50 GtC/year are released back into the atmosphere.

As such, the carbon dioxide taken out of the atmosphere every year by plants is almost perfectly balanced by the CO_2 put back into the atmosphere by respiration and decay. The

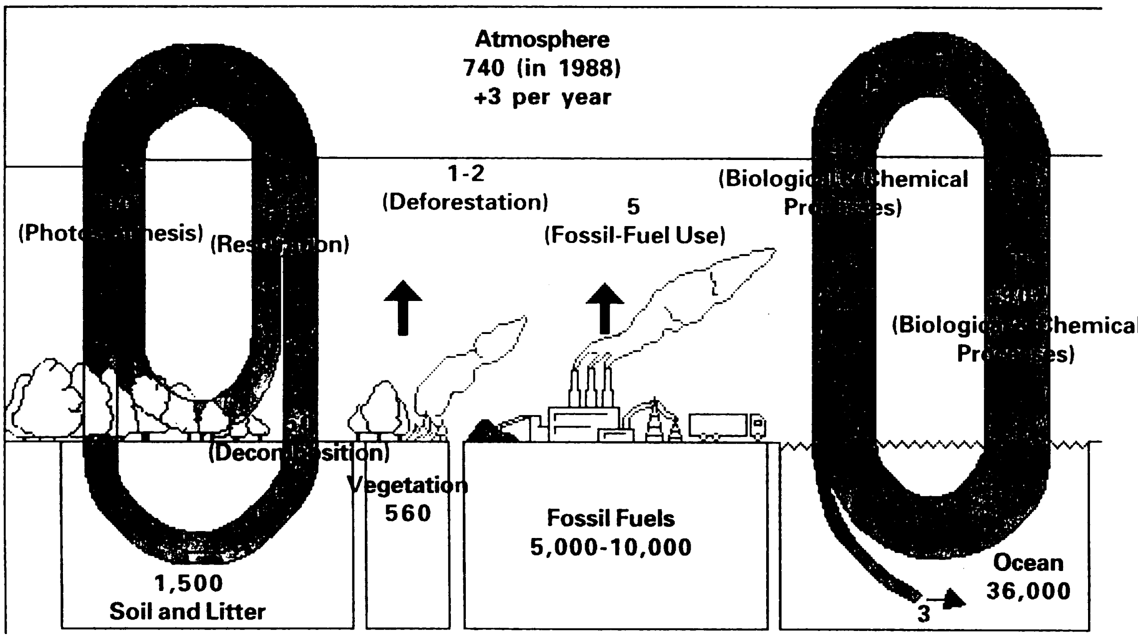

Figure 1. The Global Carbon Cycle. Note: The carbon fluxes and reservoirs are shown in billions of metric tons of carbon. Source: *Office of Technology Assessment,* Changing by Degrees: Steps to Reduce Greenhouse Gases, February, 1993.

powered automobiles and engines were invented and widely used across the globe, and farmer-settlers cleared native vegetation from vast expanses of the Americas, Australia, and parts of Asia.

During this same period, the atmospheric concentration of CO_2 increased from a pre-industrial 1750's level of about 280 parts per million by volume (ppmv), to about 353 ppmv, an increase of about 25 percent. That's enough to make a significant difference, if climate is as sensitive to greenhouse gases as many scientists suspect. Precise measurements at the isolated Mauna Loa Observatory in Hawaii (Figure 2), far removed from industrial pollution, charted

magnitude of this cyclic flow of carbon is also important, because small disturbances in the balance can have large implications.

By comparison, the amount of carbon dioxide added directly to the atmosphere as a result of human activities seems at first inconsequential. By burning coal, oil, and natural gas, society takes an estimated 5.7 GtC/year out of the Earth and puts it into the atmosphere, according to the Intergovernmental Panel on Climate Change. By cutting down and burning forests, humans release perhaps another 2 GtC/year, although there is some uncertainty about this amount.

Nevertheless, these amounts do matter because the natural carbon cycle (the air-sea exchange and the biological processes) have been in good balance, at least on the time scales of immediate relevance to humans. Today's industrial and agricultural activities seem to be significantly tipping the balance of the carbon cycle.

Many kinds of scientific measurements show that the concentration of carbon dioxide in the atmosphere has been increasing over the past several centuries. During this time the human population increased geometrically, the steam engine was put to industrial use, gasoline-

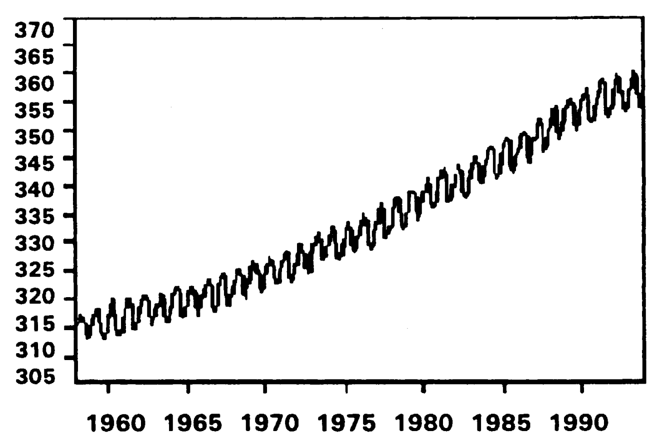

Figure 2. Monthly Average CO_2 Concentration at Mauna Loa Observatory, Hawaii. *Source: Fifth Annual Climate Assessment 1993, U.S. Department of Commerce, National Weather Service, National Meteorological Center, and Climate Analysis Center, 1993.*

Table 1
Number of Riparian Homeowners and Property Damages by State for the Period October 1, 1994 to April 30, 1995

State	Number of Total Surveys	Number of Different Counties Surveyed	Number of Owners Surveyed	Total Reported Damages	Projected Damages for all Riparians
IL	2	1	30	$100	$800
IN	2	2	27	$2,300	$9,100
MI	13	24	1,001	$192,880	$1,998,000
NY	8	8	503	$102,810	$1,057,200
OH	6	4	214	$24,300	$232,100
PA	3	1	157	$7,830	$82,600
WI	4	5	125	$2,430	$28,900
Total	38	45	2,057	$332,650	$3,408,700

Note: Storm survey reports numbers 34, 41, and 59 contain counties in multiple states, those surveys are counted for each state in which they were conducted.

Table 2
Number of Riparian Homeowners and Property Damages by Lake for the Period October 1, 1994 to April 30, 1995

Lake	Number of Total Surveys	Number of Different Counties Surveyed	Number of Owners Surveyed	Total Reported Damages	Projected Damages for all Riparians
Superior	2	7	140	$10,890	$123,900
Michigan	11	17	432	$17,500	$147,600
Huron	6	7	421	$166,130	$1,733,100
St. Clair	1	1	190	$3,190	$32,200
Erie	10	7	586	$97,270	$976,300
Ontario	4	6	288	$37,670	$395,600
Total	34	45	2,057	$332,650	$3,408,700

atmospheric nitrogen (into the usable form of nitrate or ammonium) by industrial processes. When this artificially enriched soil is denitrified, or when fertilizers leach into groundwater, nitrous oxide goes into the atmosphere.

Yearly estimates of the amount of N_2O put into the atmosphere from fertilizers vary wildly -- from as low as 10,000 metric tons to as high as 2.2 million metric tons. This kind of uncertainty makes it hard to assess the role of nitrous oxide in any human-induced greenhouse warming. The estimated range of N_2O going into the atmosphere annually from all sources is 4.4 to 10.5 million metric tons per year. That total includes N_2O from oceans, tropical and temperate forest soils, fossil fuel combustion, biomass burning, and fertilizer.

In our next issue on climate change we will start to get into whether the climate is changing and, if so, how fast and where we might be headed.

Meetings with the Public

The International St. Lawrence River Board of Control will be holding meetings with the public the evenings of September 18, 19 and 20. The purposes of the meetings are: to discuss two potential alternative regulation plans being tested by the Board; and, discuss a draft scope of work to consider changes in the regulation criteria used by the Board. The meetings will be held as follows:

September 18 at 7:00 pm
Holiday Inn - Rochester Airport
911 Brooks Avenue
Rochester, New York

September 19 at 7:00 pm
Kingston City Hall
216 Ontario Street
Kingston, Ontario

September 20 at 7:00 pm
Cornwall Civic Complex
100 Water Street East
Cornwall, Ontario

A similar meeting was held in Alexandria Bay, New York on August 9 which was attended by about 150 people.

The International Niagara Board of Control will hold its annual meeting with the public the evening of September 28, starting at 7:30 pm. The purpose is inform the public of the Board's current activities and to hear public comments and suggestions regarding the Board's work. It will take place at Navy Hall, Ricardo Street (below Fort George), in Niagara-on-the-Lake, Ontario.

Do You Know?

The answer to last month's question is: Lake Superior contains approximately 2,500 cubic miles of water.

The query for this month is: How many kilowatt-hours (KWH) of hydroelectric power are generated each year using water from the Great Lakes?

(a) 10 million KWH
(b) 100 million KWH
(c) 50 billion KWH

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Colonel, EN
Commanding

Table 1

Possible Storm Induced Rises (in feet) at Key Locations on the Great Lakes
September 1995

	Degrees of Possibility				
	20%	10%	3%	2%	1%
LAKE SUPERIOR					
Duluth	0.8	0.9	1.0	1.1	1.2
Grand Marais	0.6	0.6	0.7	0.7	0.7
Marquette	1.0	1.2	1.4	1.5	1.6
Ontonagon	0.7	0.9	1.1	1.3	1.5
Point Iroquois	1.0	1.2	1.4	1.5	1.6
Two Harbors	0.7	0.9	1.1	1.3	1.5
LAKE MICHIGAN					
Calumet Harbor	1.3	1.5	1.9	2.2	2.5
Green Bay	1.7	2.0	2.3	2.6	2.9
Holland	0.7	0.8	0.9	1.0	1.1
Kewaunee	0.8	1.1	1.7	2.2	2.7
Ludington	0.7	0.8	0.9	0.9	1.0
Milwaukee	0.8	0.9	1.0	1.0	1.1
Port Inland	1.0	1.1	1.2	1.3	1.4
Sturgeon Bay	0.8	0.9	1.0	1.1	1.2
LAKE HURON					
Detour Village	0.5	0.5	0.6	0.6	0.6
Essexville	1.6	1.8	2.0	2.2	2.3
Harbor Beach	0.7	0.8	0.8	0.9	0.9
Harrisville	0.5	0.6	0.6	0.6	0.7
Lakeport	1.1	1.3	1.7	2.0	2.3
Mackinaw City	0.8	1.0	1.1	1.3	1.4
LAKE ST. CLAIR					
St. Clair Shores	0.4	0.5	0.5	0.6	0.6
LAKE ERIE *					
Barcelona	1.5	1.7	2.0	2.3	2.5
Buffalo	3.0	3.6	4.4	5.0	5.6
Cleveland	1.1	1.3	1.6	1.8	2.0
Erie	1.4	1.5	1.8	1.9	2.0
Fairport	0.8	0.9	1.1	1.2	1.3
Fermi Power Plant	1.5	1.6	1.9	2.0	2.2
Marblehead	1.2	1.3	1.5	1.6	1.7
Sturgeon Point	2.3	2.7	3.1	3.4	3.7
Toledo	1.9	2.2	2.7	3.0	3.4
LAKE ONTARIO					
Cape Vincent	0.7	0.8	0.9	1.0	1.1
Olcott	0.5	0.6	0.8	0.9	1.0
Oswego	0.6	0.7	0.8	0.9	1.0
Rochester	0.6	0.6	0.7	0.8	0.8

* The water surface of Lake Erie has the potential to tilt in strong winds, producing large differentials between the ends of the lake.

Note: The rises shown above, should they occur, would be in addition to the still water levels indicated on the Monthly Bulletin. Values of wave runup are not provided in this table.

Great Lakes Basin Hydrology

During the month of August precipitation was above average on the Lake Superior, Michigan-Huron and Lake Ontario basins, and below average on the Lake Erie basin. For the year to date, precipitation is about 2% below average for the entire Great Lakes basin. The net supply of water to Lakes Superior, Erie and Ontario was below average in August, while the sup to Lakes Michigan-Huron was above average. Table 2 lists August precipitation and water supply information for all of the G Lakes.

In comparison to their long-term (1918-1994) averages, the August monthly mean water level of Lake Superior was 7 inches below average, Lakes Michigan-Huron, St. Clair and Erie were 2, 8 and 7 inches above average respectively and Lake Ontario was at its average. Shoreline residents are cautioned to be alert whenever adverse weather conditions exist, as these could cause rapid short-term rises in water levels. Should the lakes approach critically high levels, further information and advice will be provided by the Corps of Engineers.

TABLE 2
GREAT LAKES HYDROLOGY[1]

PRECIPITATION (INCHES)								
BASIN	AUGUST				YEAR-TO-DATE			
	1995[2]	Average (1900-1994)	Diff.	% of Average	1995[2]	Average (1900-1994)	Diff.	% of Average
Superior	4.1	3.2	0.9	128	19.3	19.6	-0.3	98
Michigan-Huron	4.3	3.1	1.2	139	21.1	20.7	0.4	102
Erie	2.8	3.2	-0.4	88	22.4	23.6	-1.2	95
Ontario	3.8	3.1	0.7	123	19.7	22.9	-3.2	86
Great Lakes	4.0	3.1	0.9	129	20.6	21.0	-0.4	98

LAKE	AUGUST WATER SUPPLIES[3] (CFS)		AUGUST OUTFLOW[4] (CFS)	
	1995[2]	Average (1900-1989)	1995[2]	Average (1900-1989)
Superior	75,000	101,000	69,000	84,000
Michigan-Huron	78,000	55,000	191,000[5]	195,000
Erie	-21,000	-12,000	209,000[5]	207,000
Ontario	-8,000	8,000	244,000	253,000

[1]Values (excluding averages) are based on preliminary computations.
[2]Estimated.
[3]Negative water supply denotes evaporation from lake exceeded runoff from local basin.
[4]Does not include diversions.
[5]Reflects effects of ice/weed retardation in the connecting channels.

CFS = cubic feet per second.

For Great Lakes basin technical assistance or information, please contact one of the following Corps of Engineers District Offices:

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