The Great Lakes
An Environmental Atlas and Resource Book

Canada
Français

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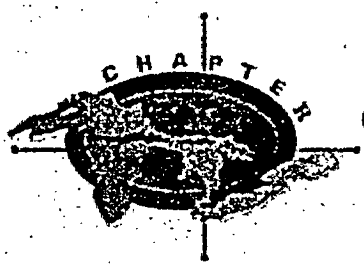


ONE

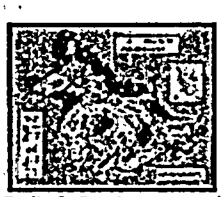
Introduction: The Great Lakes Top

The Great Lakes - Superior, Michigan, Huron, Erie and Ontario - are an important part of the physical and cultural heritage of North America. Spanning more than 1,200 kilometres (750 miles) from west to east, these vast inland freshwater seas have provided water for consumption, transportation, power, recreation and a host of other uses.

The water of the lakes and the many resources of the Great Lakes basin have played a major role in the history and development of the United States and Canada. For the early European explorers and settlers, the lakes and their tributaries were the avenues for penetrating the continent, extracting valued resources and carrying local products abroad.

Now the Great Lakes basin is home to more than one-tenth of the population of the United States and one-quarter of the population of Canada. Some of the world's largest concentrations of industrial capacity are located in the Great Lakes region. Nearly 25 percent of the total Canadian agricultural production and 7 percent of the American production are located in the basin. The United States considers the Great Lakes a fourth seacoast, and the Great Lakes region is a dominant factor in the Canadian industrial economy.

Physical Characteristics Of The System Top



Relief, Drainage and Urban Areas (470k GIF)

The magnitude of the Great Lakes water system is difficult to appreciate, even for those who live within the basin. The lakes contain about 23,000 km^3 (5,500 cu. mi.) of water, covering a total area of 244,000 km^2 (94,000 sq. mi.) The Great Lakes are the largest system of fresh, surface water on earth, containing roughly 18 percent of the world supply. Only the polar ice caps contain more fresh water.

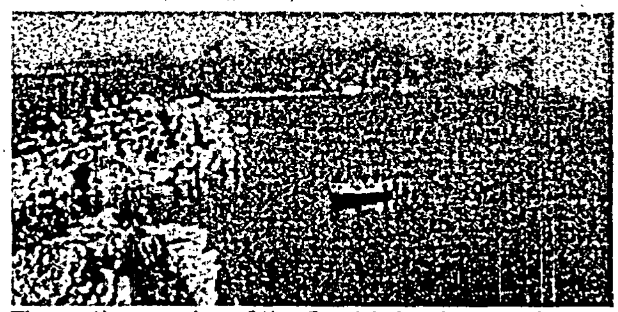
In spite of their large size, the Great Lakes are sensitive to the effects of a wide range of pollutants. The sources of pollution include the runoff of soils and farm chemicals from agricultural lands, the waste from cities, discharges from industrial areas and leachate from disposal sites. The large surface area of the lakes

also makes them vulnerable to direct atmospheric pollutants that fall with rain or snow and as dust on the lake surface.

Outflows from the Great Lakes are relatively small (less than 1 percent per year) in comparison with the total volume of water. Pollutants that enter the lakes - whether by direct discharge along the shores, through tributaries, from land use or from the atmosphere - are retained in the system and become more concentrated with time. Also, pollutants remain in the system because of resuspension (or mixing back into the water) of sediment and cycling through biological food chains.

Because of the large size of the watershed, physical characteristics such as climate, soils and topography vary across the basin. To the north, the climate is cold and the terrain is dominated by a granite bedrock called the Canadian (or Laurentian) Shield consisting of Precambrian rocks under a generally thin layer of acidic soils. Conifers dominate the northern forests.

In the southern areas of the basin, the climate is much warmer. The soils are deeper with layers or mixtures of clays, silts, sands, gravels and boulders deposited as glacial drift or as glacial lake and river sediments. The lands are usually fertile and can be readily drained for agriculture. The original deciduous forests have given way to agriculture and sprawling urban development.



The northern region of the Great Lakes is sparsely populated and is characterized by coniferous forest and rocky shorelines. Above, the western shore of Georgian Bay in the Bruce Peninsula National Park. *(D. Cowell, Geomatics International, Burlington, Ontario.)*

Although part of a single system, each lake is different. In volume, Lake Superior is the largest. It is also the deepest and coldest of the five. Superior could contain all the other Great Lakes and three more Lake Eries. Because of its size, Superior has a retention time of 191 years. Retention time is a measure based on the volume of water in the lake and the mean rate of outflow. Most of the Superior basin is forested, with little agriculture because of a cool climate and poor soils. The forests and sparse population result in relatively few pollutants entering Lake Superior, except through airborne transport.

Lake Michigan, the second largest, is the only Great Lake entirely within the United States. The northern part is in the colder, less developed upper Great Lakes region. It is sparsely populated, except for the Fox River Valley, which drains into Green Bay. This bay has one of the most productive Great Lakes fisheries but receives the wastes from the world's largest concentration of pulp and paper mills. The more temperate southern basin of Lake Michigan is among the most urbanized areas in the Great Lakes system. It contains the Milwaukee and Chicago metropolitan areas. This region is home to about 8 million people or about one-fifth of the total population of the Great Lakes basin.

Lake Huron, which includes Georgian Bay, is the third largest of the lakes by volume. Many Canadians and Americans own cottages on the shallow, sandy beaches of Huron and along the rocky shores of Georgian Bay. The Saginaw River basin is intensively farmed and contains the Flint and Saginaw-Bay City metropolitan areas. Saginaw Bay, like Green Bay, contains a very productive fishery.

Lake Erie is the smallest of the lakes in volume and is exposed to the greatest effects from urbanization and agriculture. Because of the fertile soils surrounding the lake, the area is intensively farmed. The lake receives runoff from the agricultural area of southwestern Ontario and parts of Ohio, Indiana and Michigan. Seventeen metropolitan

areas with populations over 50,000 are located within the Lake Erie basin. Although the area of the lake is about 26,000 km^2 (10,000 square miles), the average depth is only about 19 metres (62 feet). It is the shallowest of the five lakes and therefore warms rapidly in the spring and summer, and frequently freezes over in winter. It also has the shortest retention time of the lakes, 2.6 years. The western basin, comprising about one-fifth of the lake, is very shallow with an average depth of 7.4 metres (24 feet) and a maximum depth of 19 metres (62 feet).

Lake Ontario, although slightly smaller in area, is much deeper than its upstream neighbor, Lake Erie, with an average depth of 86 metres (283 feet) and a retention time of about 6 years. Major urban industrial centers, such as Hamilton and Toronto, are located on its shore. The U.S. shore is less urbanized and is not intensively farmed, except for a narrow band along the lake.

Great Lakes Factsheet No. 1

Physical Features and Population

Settlement Top

The modern history of the Great Lakes region, from discovery and settlement by European immigrants to the present day, can be viewed not only as a progression of intensifying use of a vast natural resource, but also as a process of learning about the Great Lakes ecosystem. At first it was a matter of making use of the natural resources of the basin while avoiding its dangers. Not until much later, when the watershed was more intensively settled and exploited, was it learned that abuse of the waters and the basin could result in great damage to the entire system.

Exploitation Top

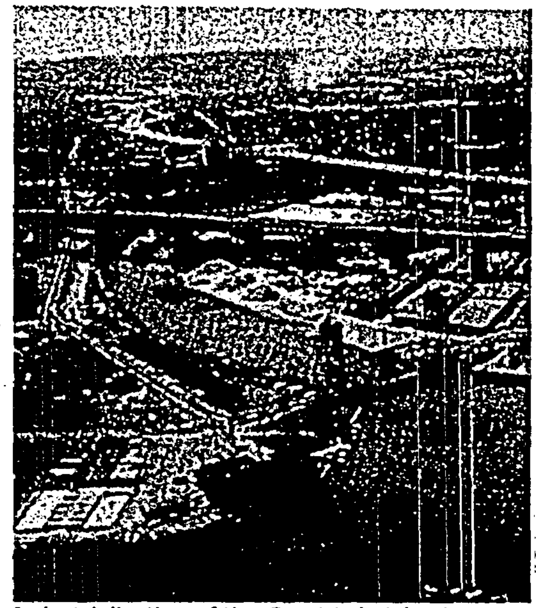
The first Europeans found a relatively stable ecosystem, which had evolved during the 10,000 years since the retreat of the last glacier; a system that was only moderately disturbed by the hunting and agricultural activities of the native peoples. The first European arrivals had a modest impact on the system, limited to the exploitation of some fur-bearing animals. However, the following waves of immigrants logged, farmed and fished commercially in the region, bringing about profound ecological changes. The mature forests were clear-cut from the watersheds, soil was laid bare by the plow, and the undisturbed fish populations were harvested indiscriminately by an awesome new predator - humans with nets.

As settlement and exploitation intensified, portions of the system were drastically changed. Logging removed protective shade from streams and left them blocked with debris. Sawmills left streams and embayments clogged with sawdust. When the land was plowed for farming the exposed soils washed away more readily, burying valuable stream and river mouth habitats. Exploitive fishing began to reduce the seemingly endless abundance of fish stocks, and whole populations of fish began to disappear.

Industrialization Top

Industrialization followed close behind agrarian settlement, and the virtually untreated wastes of early industrialization degraded one river after another. The growing urbanization that accompanied industrial development

added to the degradation of water quality, creating nuisance conditions such as bacterial contamination, putrescence and floating debris in rivers and nearshore areas. In some situations, the resulting contaminated drinking water and polluted beaches contributed to fatal human epidemics of waterborne diseases such as typhoid fever. Nonetheless, the problems were perceived as being local in nature.



Industrialization of the Great Lakes basin followed early settlement and the growth in agriculture. Above, a river winds its way through an industrial city in the basin (ca. 1970). *(Great Lakes Program Office, U.S. EPA, Chicago, Illinois.)*

As industrialization progressed and as agriculture intensified after the turn of the 20th century, new chemical substances came into use, such as PCBs (polychlorinated biphenyls) in the 1920s and DDT (dichloro-diphenyl-trichloroethane) in the 1940s. Non-organic fertilizers were used to enrich the already fertile soils to enhance production. The combination of synthetic fertilizers, existing sources of nutrient-rich organic pollutants, such as untreated human wastes from cities, and phosphate detergents caused an acceleration of biological production (eutrophiction) in the lakes. In the 1950s, Lake Erie showed the first evidence of lake-wide eutrophic imbalance with massive algal blooms and the depletion of oxygen.

The Evolution Of Great Lakes Management Top

In the late 1960s, growing public concern about the deterioration of water quality in the Great Lakes stimulated new investment in pollution research, especially the problems of eutrophication and DDT. Governments responded to the concern by controlling and regulating pollutant discharges and assisting with the construction of municipal sewage treatment works. This concern was formalized in the first Great Lakes Water Quality Agreement between Canada and the U.S. in 1972.

Major reductions were made in pollutant discharges in the 1970s. The results were visible. Nuisance conditions occurred less frequently as floating debris and oil slicks began to disappear. Dissolved oxygen levels improved, eliminating odor problems. Many beaches reopened as a result of improved sewage control, and algal mats disappeared as nutrient levels declined. The initiatives of the 1970s showed that improvements could be made and provided several important lessons beyond the cleanup of localized nuisance conditions.

First, the problem of algal growth in the lakes caused by accelerated eutrophication required a lake-wide approach to measure the amount of the critical nutrient, phosphorus, entering and leaving each lake from all sources and outlets. This approach of calculating a 'mass balance' of the substance was then combined with other research and mathematical modeling to set target loading limits for phosphorus entering the lake (or portions of the lake). The target load is the amount of phosphorus that will not cause excessive algal growth (i.e., an amount that could safely be assimilated by the ecosystem).

Other major lessons learned about the system resulted from research on toxic substances, initially the pesticide DDT. Toxic contaminants include persistent organic

chemicals and metals. These substances enter the lakes directly from discharges of sewage and industrial effluents and indirectly from waste sites, diffuse land runoff and atmospheric deposition. As a result of increased research, sampling and surveillance, toxic substances have been found to be a system-wide problem.

Toxic Contaminants Top

Toxic contaminants pose a threat not only to aquatic and wildlife species, but to human health as well, since humans are at the top of many food chains. Some toxic substances biologically accumulate or are magnified as they move through the food chain. Consequently, top predators such as lake trout and fish-eating birds - cormorants, ospreys and herring gulls - can receive extremely high exposures to these contaminants. Concentrations of toxic substances can be millions of times higher in these species than in water. As a result, the potential for human exposure to these contaminants is far greater from consumption of contaminated fish and wildlife than from drinking water.

Aquatic and wildlife species have been intensively studied, and adverse effects such as cross-bills and egg-shell thinning in birds, and tumors in fish are well documented. There is less certainty about the risk to human health of long-term exposure to low levels of toxic pollutants in the lakes, but there is no disagreement that the risk to human health will increase if toxic contaminants continue to accumulate in the Great Lakes ecosystem. Long-term, low-level exposures are of concern because of subtle effects that toxic contaminants may have on reproduction, the immune system and development in children. Relationships between environmental contaminants and diseases such as cancer are also of concern.

Understanding The Lakes From An Ecosystem Perspective Top

The ecosystem approach, together with an increased emphasis on toxic substances, was given formal recognition in the second Great Lakes Water Quality Agreement, signed in 1978. In 1987, management aspects of the ecosystem approach were further defined in revisions to the Agreement, calling for management plans to restore fourteen beneficial uses. The beneficial uses to be restored include unimpaired use of the ecosystem by all living components, including humans.

The Agreement called for Remedial Action Plans (RAPs) to be prepared for geographic Areas of Concern (AOCs) where local use impairments exist. It also called for Lakewide Management Plans to be prepared for critical pollutants that affect whole lakes or large portions of them. The purpose of these management plans is to clearly identify the key steps needed to restore and protect the lakes.

To measure restoration of ecosystem recovery, the 1987 Agreement revisions added a call for ecosystem objectives and indicators to complement the chemical objectives already provided in the Agreement. These biological measures of ecosystem integrity provide an important element of the ecosystem approach and are being developed as part of the process for developing lake-wide management plans. Ecosystem

indicators have already been adopted for Lake Superior. These indicators are organisms (such as bird or fish populations) that tell us whether the ecosystem is healthy and whether these populations are stable and self-reproducing.

(Harold Murphy, Hamilton Harbour RAP Office, Burlington, Ontario.)

The concepts of mass balance, system-wide contamination and bioaccumulation in the food chain have become essential components in understanding the lakes from an ecosystem perspective. For example, the mass balance approach to phosphorus control has been used to formulate target pollutant loadings for the lower lakes.

Over 33 million people who live in the Great Lakes basin and their governments face an immense challenge for the future of the basin. The wise management needed to maintain the use of Great Lakes resources requires greater public awareness, the forging of political will to protect the lakes, and creative government action and cooperation. It will not be easy.

The Great Lakes are surrounded by two sovereign nations, a Canadian province, eight American states and thousands of local, regional and special-purpose governing bodies with jurisdiction for management of some aspect of the basin or the lakes. Cooperation is essential because problems such as water consumption, diversions, lake levels and shoreline management do not respect political boundaries.

With this in mind, public consultations that include residents, private organizations, industry and government are considered to be an essential part of the decision-making process for managing the resources of the Great Lakes ecosystem. Residents of the basin have been empowered to participate in the problem-solving process, promote healthy sustainable environments and reduce their personal exposure to Great Lakes contaminants.

Humans are part of and depend on the natural ecosystem of the Great Lakes, but may be damaging the capacity of the system to renew and sustain itself and the life within it. Protection of the lakes for future use requires a greater understanding of how past problems developed, as well as continued remedial action to prevent further damage.