How Ice Shaped the Land Around the Great Lakes

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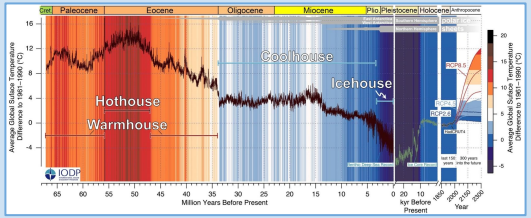
About 2 million years ago, the average temperature in North America dropped about 30 degrees allowing perennial snow to accumulate.

Since ice melts under pressure and the Laurentide Ice Sheet being over a mile thick, meltwater flowed rapidly under the glacier.

A combination of moraine and meltwater slowly dug the basins of the Great Lakes. When it receded, the meltwater filled the basins.



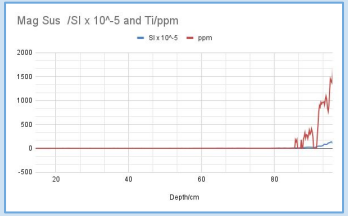
Glaciers are large accumulations of ice that exist year-round on land. They form when annual snowfall accumulated deep layers of snow that don't melt completely in the summer. As the layers of snow build, they compact into firn, a mass of ice crystals.

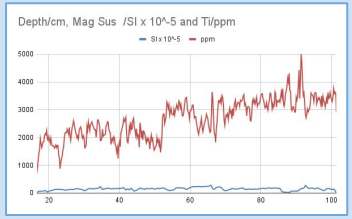
The mass of the ice sheet (an estimated 68 trillion tons) cause the northern half of North America to sink under its weight. This bulged up the southern half causing present-day Florida to rise out of the water. Currently, the continent is in a period of rebound with the northern half slowly rising and the southern half slowly sinking.

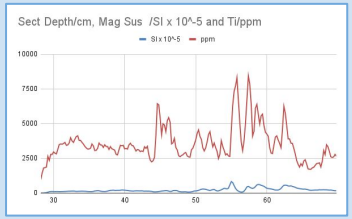
How Do We Know?

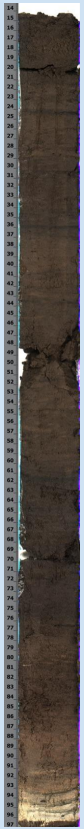
Moraine is the buildup of debris at the front of a glacier. When the glacier melts and recedes, it drops this debris, telling us how far the glacier traveled. Remnants of moraine are still evident across northeastern United States.

Collected lake cores tell us exactly when the glacier was present over a given area. The rapid deposit of organic material and large concentration of titanium in deeper cores indicates the presence of a glacier and the time range of about 2 million-20,000 years ago.









Modern Climate Around the Lakes

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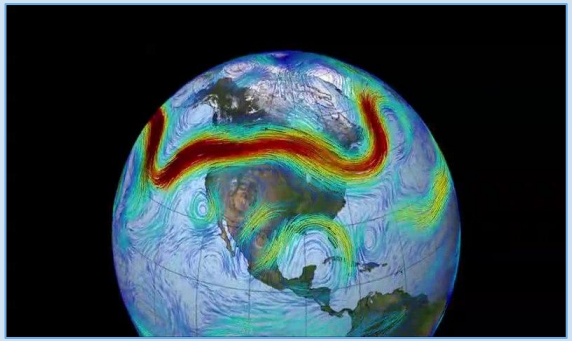


The image on the left is depicting the speed of the jet stream winds, the fastest in red and the slower in blue. Winds can reach greater than 110 mph.

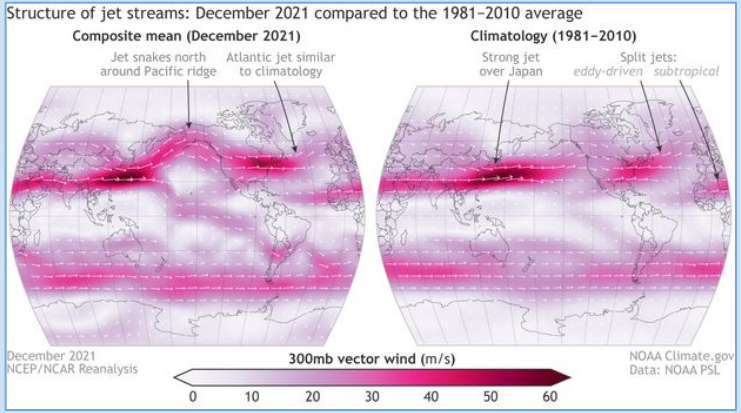
The picture on the right is a satellite image of clouds in the jet stream over Canada.

The strongest jet streams are the polar jets around the polar vortices, at 5.6–7.5 mi above sea level, and the higher altitude (and somewhat weaker) subtropical jets at 6.2–9.9 mi. The northern hemisphere polar jet flows over the middle to northern latitudes of North America, Europe, and Asia and the oceans in between.

Jet streams are the product of two factors: the atmospheric heating by solar radiation that produces the large-scale atmospheric circulation cells, and the action of the Coriolis force acting on those moving masses. The Coriolis force is caused by the planet's rotation on its axis.

The jet stream, commonly confused with the polar vortex, occurs in the troposphere about 5.6-9.9 miles above the surface. The jet stream is a large, fast-moving current flowing west to east and plays a large role in our daily weather. The jet stream acts as a mid-latitude steer for storms and precipitation. Areas where the jet stream meets the warmer, tropical air pushing from the south also impact on our daily weather.

The polar vortex is an area of cold, dry air that exists over each pole in the stratosphere about 30 miles over the surface. It can impact our weather but much less so than the jet stream. When the polar vortex and jet stream are focused in one area, right over the Great Lakes, it can create larger blizzards sometimes observed in harsh winters.



Modern Lake Topography and The Path of the Water

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The Great Lakes are the largest freshwater system in the world with approximately 5,500 cubic miles of freshwater, ⅛ of the world's drinking water.

Divers discovered rock paths along the lakebed similar to methods of human caribou hunting seen in indigenous populations today.

Features of the lake beds mapped with multibeam echosounder (MBES), a fanned sonar that measures the reflection of sound waves opposed to the intensity, giving us accurate measurements of the lakebed features rather than the silhouette, tell us lake levels were once much lower than they are today.. The Alpena Amberley Ridge in Lake Huron would've been dry land about 7,000-8,000 years ago.

Lake Superior is the largest and deepest lake, reaching depths over 1,300 ft. Hidden underwater land formations like ancient rivers in the Straits of Mackinac and underwater waterfalls are more evidence of ancient water levels being lower. Lower water levels to that extent would also mean each lake used to be a separate basin with little to no connection with each other.

Niagara Falls sits between Lake Erie and Lake Ontario on the Niagara River. Over 135 million litres of water flow over the falls every minute, slowly eroding at the soft limestone at its base pushing it back about a foot every year (although this number has been decreasing). There is debate on how long it will take for the falls to erode completely back into Lake Erie with an estimate between 15,000 and 50,000 years.

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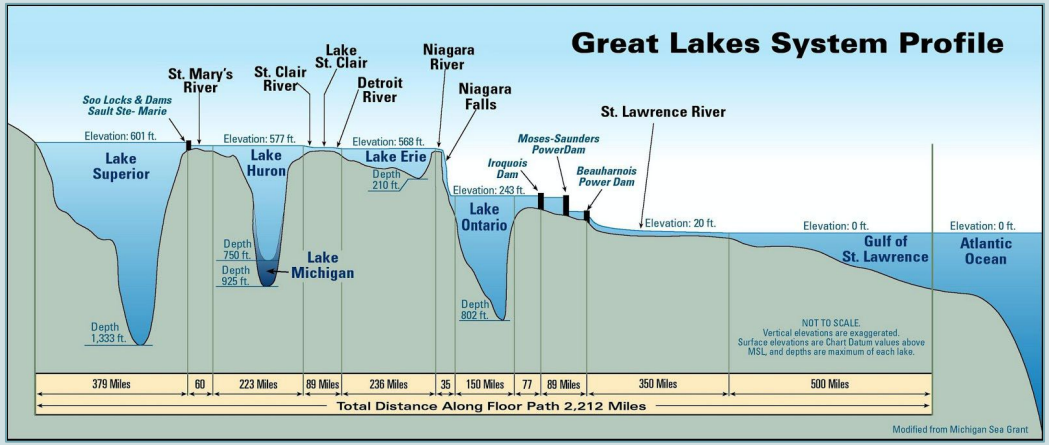
A drop of water entering Lake Superior will take an average of 204 years to reach the Atlantic Ocean. Starting in Lake Superior, the water will stay for 173-191 years before moving on to Lake Michigan where it will spend the next 62 years. After Lake Michigan, it will continue on to Lake Huron for about 22 years. Once it reaches Lake Erie, the shallowest lake, it will only take 8 years (2 in Erie and 6 in Ontario) to reach the Atlantic Ocean.
Lake Superior is the largest of the five lakes sitting at 31,700 mi^2 (about the size of Austria) and 2,903 mi^3 of water. In the winter, with the help of the jet stream, waves can reach 30 ft. This makes it one of the most dangerous with over 550 known ships to have gone down in its waters.

As Lake Michigan's water level has dropped over the years, exposed sandbars were whipped into the dunes found on the southern shore (Michigan City) and the eastern shore (the Sleeping Bear Dunes).
In a similar process, Lake Huron's 30,000 islands were exposed from lowering water levels. Manitoulin Island, with an area of 1,068 mi^2, is the largest lake island in the world, large enough to have over 100 lakes itself.



Wildlife In and Around the Great Lakes

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Gulf of St. Lawrence Estuary

Named the largest estuary in the world, the fleuve Saint-Laurent or St. Lawrence Estuary is home to at least ten species of whales including sperm whales, belugas, humpback whales, blue whales, and the northern bottlenose.

In the summer, whales benefit from the abundance of krill and capelin.

At the head of the Laurentian Channel, the abrupt rise in seabed creates upwelling, supporting diverse marine life.

Fish and other Aquatic Creatures

There are 139 species native to the Great Lakes. Sculpins, gizzard shad, singers, ciscoes, lake trout, walleye, bass, trout, and smaller lamprey. Northern madtoms, a species of catfish, are important markers of a healthy ecosystem. An abundance of madtoms signifies an abundances of the invertebrates they feed on.

Spotted salamanders live in the damp woodlands on the eastern sides of the Great Lakes. They are unique in their relationship with native algae and their use of it for reproduction. Since salamander eggs need oxygen before they hatch, to provide more oxygen to the eggs, algae has been observed living inside the eggs. The algae releases oxygen during photosynthesis, allowing the egg to breath freshly.

Invasive Species

Zebra mussels are an invasive species originating from Eurasia that arrived in the Laks from incoming ballast water. They eat phytoplankton, competitors for microcystis and the food source of many native species. Microcystis are one of the main causes of harmful algal blooms in nutrient-rich waters. Microcystis is a type of freshwater cyanobacteria that includes the harmful algal bloom-forming Microcystis aeruginosa. The blooms produce neurotoxins and hepatotoxins, such as microcystin and cyanopeptolin harming native fish.

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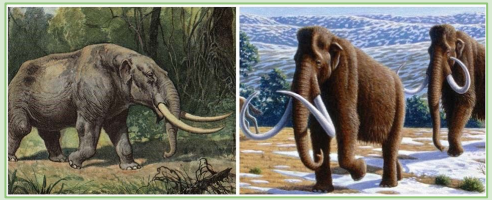
Mammoths and Mastodons



Mammoths and mastodons are both distinct species of megafauna living in the Great Lakes region as late as 13,000 years ago and in isolated populations further north until about 4,000 years ago. Both were large proboscideans related to modern elephants although their last common ancestor likely split up around 5 million years ago.
The most distinctive difference between the two creatures is their teeth. Mastodons had straighter tusks similar to modern elephants while mammoth tusks curved inward.

It's largely believed that the Paleo-indigenous, the first humans to migrate to North America, were a very significant contributor to their extinction. It's likely Paleo-indigenous overhunting were responsible for the overhunting and eventual extinction of the megafauna in North America.

Terrestrial Animals

On the shores of Lake Superior, grey wolves and beavers have a unique relationship opening and closing the flow of water into the lake. An increase in beaver means an increase in damming, forming small ponds on the edge of the lake. Beaver is a primary source of food for grey wolves in the area and their increase in hunting weans the beaver population, causing less damming and waterways to open up again. The open and closing of the waterways allows the beavers to sustain the population of wolves without decreasing their own population significantly.

Migrations

Monarch migrations begin in southern Canada near Lake Erie in late September-early October before they travel thousands of miles to Mexico for the winter.

Decreasing day length and temperatures, along with aging milkweed and fewer nectar sources prompts the annual migration from southern Canada to Mexico. The migratory generation of monarch can live up to nine months compared to the summer generation of two to six weeks. Most monarch butterflies that emerge after about mid August in the eastern U.S. enter reproductive diapause and begin to migrate south in search of overwintering grounds. Along the way, they find refuge in stopover sites with abundant nectar sources and shelter from harsh weather.

Human Impact

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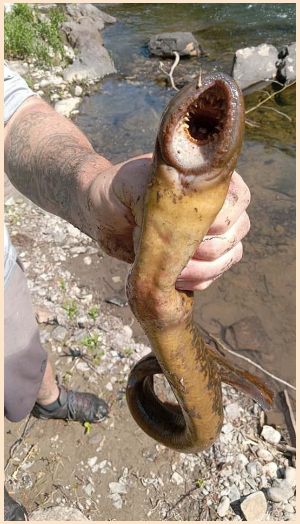
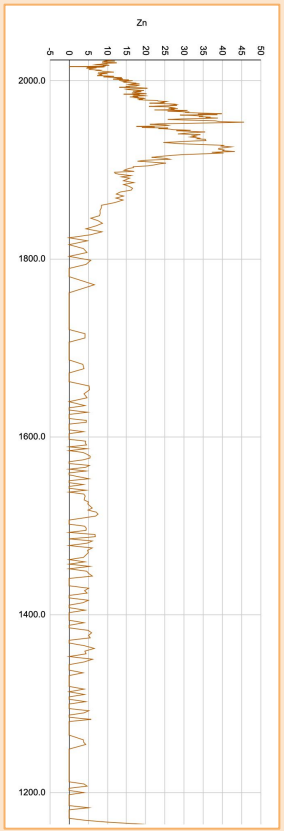


When Europeans first arrived in North America, commercial fishing in the Great Lakes was not profitable due to lack of accessible transportation. By the early 19th century, with the development of better transportation methods, commercial fishing began to take off. Overtime, technological advancements in fishing materials caused a sharp decline in fish populations and commercial fishing lessened. The introduction of sea lamprey, alewife, and other invasive species reduced fish populations so dramatically it may be irreversible, effectively ending the commercial fish markets in the Great Lakes.

Sea lamprey are large (about 24in-32in) parasitic fish that feed on the life fluids of medium to large fish. With no natural predators in the lakes, they quickly decimated native populations. Alewives are a smaller fish originally kept in check by larger, predatory fish. As the larger fish were wiped out by the lamprey, alewife populations grew, taking food supplies from other species.

Invasive species combined with the possible annoxidization of the water caused a reduced amount of fish, likely resulting in the gaps of separated sediment since there was less fish stirring up the mud.

Data regarding perfluoroalkyl and polyfluoroalkyl substances (PFAS) show persistent presence in waterways, air, and soil. The U.S Environmental Protection Agency (EPA) designated limits on the concentration of PFAS allowed in drinking water after labeling them hazardous chemicals. Since the Lakes are major sources of drinking water for millions of people, threats to water quality pose a threat not only to local animals and plants, but the people that rely on the water.



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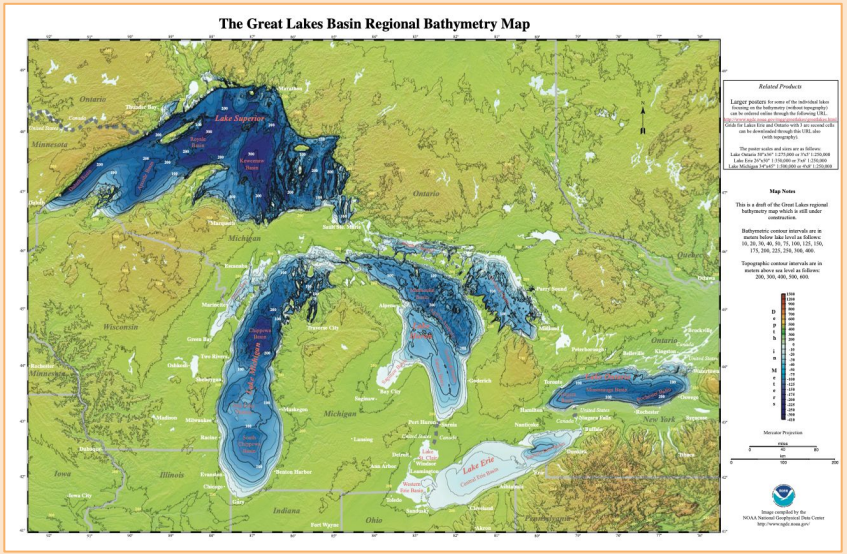
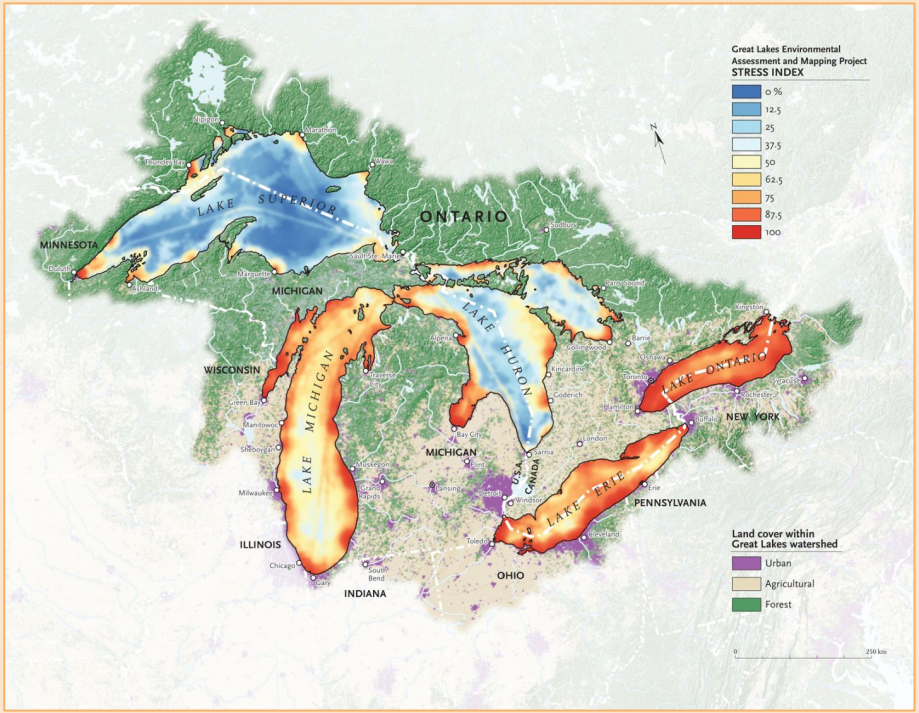


The graph below visualizes the degree of human impact on each lake calculated using multiple variables.



Heavy industrial presence along the shores of the Great Lakes have been a massive contributor to the significant rise in pollution in the last two hundred years. Lake Erie and Lake Ontario are considered the most polluted of the five with a sharp drop in fish populations in Lake Erie in the early 20th century. Fire retardants like polybrominated diphenyl ethers (PBDE) are very present in the water, air, sediment, and surrounding wildlife. PBDE is persistent and bioaccumulative posing a threat to human populations as it's also been linked to thyroid disorders, birth defects, infertility, cancer, and neurobehavioral disorders.