



The Great Lakes: The U.S. and Canada's Freshwater Treasures

4.1 Introduction

A massive sheet of ice, the last of the Ice Age **glaciers**, crept across the North American continent. It inched south, across the vast region that is now Canada. It glided heavily over what is today the northern United States. Finally, it slid to an icy stop near the present-day city of Chicago. All the while, the sheer weight of the huge glacier flattened mountains and reshaped the landscape.

After thousands of years, Earth began to warm. The vast blanket of ice began to retreat. It left behind high ridges and huge holes that the ice sheet had gouged into the land. As the ice melted, clear, fresh water filled the huge holes. In this way, the Great Lakes were born.

Over time, a rich **ecosystem** developed on the land left bare when the glaciers retreated. An ecosystem is a community of all the living things in an area. It includes plants, animals, and the physical environment in which they live. Ecosystems can be as small as a lawn or as large as the Earth. The Great Lakes make up the world's largest **freshwater** ecosystem.

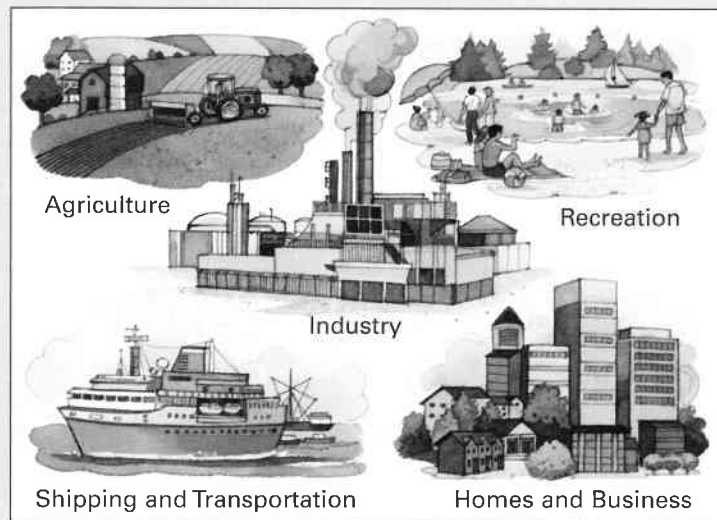
It took many thousands of years for the movement of glaciers to create the Great Lakes. In just decades, however, human activity has greatly changed this region. In this chapter, you will learn how people can upset an ecosystem. And you will find out what can be done to solve some of the problems that human activity has created in the Great Lakes ecosystem.

Essential Question

How can people best use and protect Earth's freshwater ecosystems?

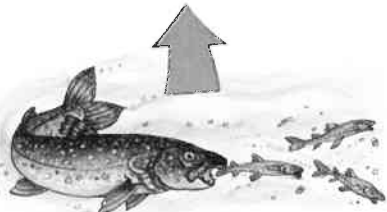
The diagram shows some of the main ways that people use the Great Lakes. All of these uses affect the lakes' ecosystem in some way, large or small. Keep this diagram in mind as you try to answer the Essential Question.

Graphic Organizer





Herring gull eggs: 124 ppm



Lake trout: 4.83 ppm



Smelt: 1.04 ppm



Phytoplankton: 0.025 ppm

Source: U.S. Environmental Protection Agency.

The Food Web and Toxic Waste

When poisons enter a waterway, they may also enter the food web. Some toxic chemicals are stored in living things. When a larger animal eats smaller animals, the poison becomes concentrated in the larger animal. In this diagram, notice how chemicals called PCBs build up within a food chain. PCBs are measured in parts per million, or ppm.

4.2 The Geographic Setting

Five lakes—Superior, Michigan, Huron, Erie, and Ontario—make up the Great Lakes. All of the Great Lakes, except Michigan, are shared by Canada and the United States. Together they form the world's largest group of freshwater lakes.

More than one tenth of the U.S. population and one quarter of the Canadian population live in the Great Lakes region. People in both countries use the lakes in many ways. They depend on them for drinking water. They use water from the lakes in factories. They use the lakes for shipping, fishing, and recreation. And they build cities on their shores.

One of North America's Largest Watersheds Think of standing on a hill and pouring water from a large container onto the ground. The water would flow downhill. While running downhill, some of the water would soak into the ground. If there were a hole along the way, water would fill it to form a tiny lake. You would have created your own tiny **watershed**.

A watershed is a geographic area that includes all of the land and waterways that drain into a body of water. Watersheds come in many shapes and sizes. They can include hills and valleys and cities and towns. Smaller watersheds can drain into larger watersheds. The Great Lakes region is one of the largest watersheds in North America.

The Great Lakes are so big that they look and act like oceans. In fact, people have called them "the fourth seacoast" of the United States. But unlike the oceans, the lakes are filled with fresh water that has little or no salt. That is why they are also called "the sweetwater seas."

A Vast and Varied Ecosystem The Great Lakes region is a vast ecosystem. One way to understand how the living things in the Great Lakes ecosystem are related to each other is to look at who eats what. These relationships make up what scientists call a **food web**. Food webs include both plants and animals that feed on each other.

Every ecosystem has its own food web. A food web is made up of many **food chains**. A food chain is a series of plants and animals, each of which depends on the next for food. In the Great Lakes ecosystem, for example, one food chain might begin with plants that grow in lakes and rivers. The next link in the chain might be insects that feed on those plants. These insects are eaten by tiny fish. The tiny fish are then eaten by larger fish. The larger fish, in turn, may be eaten by an eagle sitting at the top of the food chain. Another food chain might begin with tiny organisms known as algae and end with a river otter.

The food web is an important part of any ecosystem. If one part of the food web is harmed, it affects all of the living things in the ecosystem. For example, if a fish is poisoned by **pollution**, any animal that eats that fish will be poisoned as well. Or, if a type of plant or fish is lost from an ecosystem, all animals that feed on that plant or fish will lose part of their food supply. In this way, all living things in a food web depend on each other for their survival.

► Geotermis

ecosystem a community of all the living things in an area and the environment in which they live

food chain a series of plants and animals, each of which depends on the one below it for food. A food chain usually forms part of a much larger food web.

food web all of the feeding relationships within an ecosystem. Each living thing in a food web provides food energy to other living things within that ecosystem.

freshwater made up of water that is fresh, not salty. This term is also used to describe creatures that live in fresh water, such as freshwater fish.

watershed a geographic area that includes all of the land and waterways that drain into a body of water. Sometimes a watershed is also called a *drainage basin*.

An Enormous Ecosystem

The Great Lakes region includes eight U.S. states and one Canadian province. The lakes and waterways contain almost one fifth of the world's supply of fresh water.

The Great Lakes Region



4.3 The Great Lakes in 1969

For many years, people didn't worry about the Great Lakes ecosystem. The Great Lakes and its rivers were so large that most people didn't think human activity could affect them much. By the late 1960s, though, it was clear that there were problems. News articles similar to the one below made people aware that the Great Lakes were heavily polluted.

The Sad State of Our Once-Great Lakes

July 28, 1969

The Cuyahoga River in Cleveland, Ohio, looks like a melted chocolate mess. It is mud-brown, with a layer of oil on top. Gases bubble strangely on its surface. So it was not surprising when the filthy river, part of the Lake Erie watershed, burst into flames last month.

A Burning River and Dead Ducks

No one knows exactly what started the Cuyahoga River fire on June 22. It might have been a spark from a passing train. Whatever the source, the spark ignited picnic benches, piles of logs, and other garbage in the river. The burning debris set fire to oil floating on the river's surface. The flames blazed across the river and up in the air. They reached about five stories in height.

While the Cuyahoga River burned in Cleveland, another event was taking place on the Detroit River. A Detroit official was showing news reporters around the waterfront. As he assured them that the water was not as polluted as it looked, two ducks flew in for a landing. They paddled around the polluted river for a brief moment. Suddenly, they began choking, keeled over, and died.

These events show the terrible condition of the rivers that flow into the Great Lakes. But what of the Great Lakes themselves? Local residents have described the lakes as "cesspools" and "industrial wastebaskets." They claim that the lakes are used



A River in Flames

It's hard to believe that a river could catch on fire. But as this 1952 photograph shows, the Cuyahoga River did just that. It burned this year. Cleveland mayor Carl Stokes said that the river's polluted state is "a longstanding condition that must be brought to an end."

as dumping grounds for every kind of pollutant, from sewage to toxic chemicals.

Out-of-Control Algae

Television ads boast about the long-lasting suds of laundry detergents. Those suds may not cost a lot at the supermarket. But detergents are taking a toll on the Great Lakes.

Visitors to Lake Erie today see large mats of algae near the shore. This algae explosion is caused by phosphorus, a chemical in detergents. Algae need phosphorus to grow, but too much of it causes algae to grow out of control. Lake Erie is covered with algae mats that are up to two feet thick.

Algae mats create many problems. They choke fish. They clog filters in water treatment plants. They cover beaches in slime. And they make lake water taste like rotting vegetation.



Industrial Cesspools

Clean water is important to the health of all living creatures. But as more people and industries move to the Great Lakes region, keeping the waters clean is becoming more difficult. Some industries treat the lakes as cesspools where they can dump their wastes.

DDT Kills More Than Mosquitoes

For years, the pesticide DDT has been used in the Great Lakes region to control insects. It is sprayed on crops and on waterways to kill mosquitoes and other pests. But when DDT enters rivers and streams, it also enters the Great Lakes food web.

Today, America's national bird, the bald eagle, has almost disappeared from the Great Lakes because of DDT poisoning. The eagles feed on fish that live in water polluted with the pesticide. Over time, a toxic amount of DDT builds up in their bodies.

The DDT doesn't kill the adult birds. Instead, it weakens the eagles' eggshells. The shells of eggs laid by female eagles are so thin that most break before the young are ready to hatch. The few eaglets that do hatch may already have DDT in their blood.

Invading Lampreys and Alewives

Bald eagles are not the only disappearing species. For the past century, people have fished the lakes for fun and profit. Fishing boats once harvested millions of pounds of fish every year. Now, due partly to overfishing, whole populations of fish have almost disappeared.

While some fish are disappearing, species that are not native to this area are overrunning the lakes. The invasion of nonnative species began in 1829 when the Welland Canal connected the Great Lakes to the Atlantic Ocean. The canal allowed species from the Atlantic Ocean to swim or be carried by boats to the Great Lakes.

One deadly invader is an eel-like animal known as the sea lamprey. Lampreys act like vampires. They suck the blood out of fish. Over time, sea lampreys have killed most of the whitefish, lake trout, and other fish native to the Great Lakes.

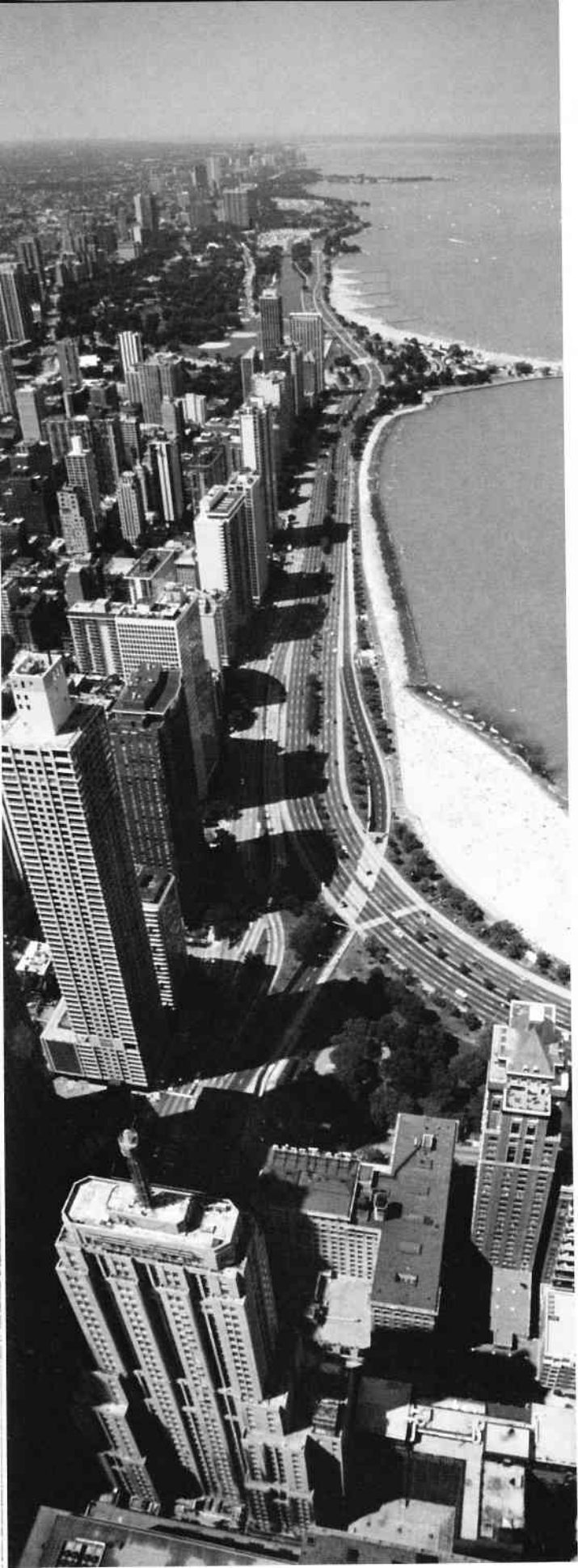
Another invader is the alewife, a type of herring. Alewives are small but have huge appetites. They have devoured entire species of fish. They also compete with other fish for food. The first alewife wasn't discovered in Lake Michigan until 1949. Yet by the mid-1960s, alewives made up 9 pounds of every 10 pounds of fish swimming in the lake.

Alewives die off in the spring. Every year, tons of dead alewives wash up on lake beaches. Clouds of flies lay eggs on the rotting fish. Soon, the smelly fish are riddled with maggots. As a result, most beaches are unbearable during the die-off season.

Can the Lakes Be Saved?

Scientists today have begun to talk about the death of the Great Lakes. They warn that unless the lakes are cleaned up soon, they may become lifeless ponds. The question is, will people do what is needed to save them?

A week ago, two American astronauts became the first humans to walk on the moon. If the United States can accomplish such an incredible feat, then surely Americans can meet the challenge of restoring the Great Lakes.



4.4 The Great Lakes Today: Pollution

During the 1960s and 1970s, the state of the Great Lakes worried many people. Dr. Seuss, the famous children's author, wrote about Lake Erie in his book *The Lorax*. In this 1971 book, fish living in a polluted lake decide to look for a new home. Dr. Seuss wrote,

*They'll walk on their fins and get woefully weary,
In search of some water that isn't so smeary.
I hear things are just as bad up in Lake Erie.*

By 1991, however, Lake Erie had improved so much that this last line was removed from *The Lorax*. This amazing change was due to cleanup work done on both sides of the U.S.-Canada border.

Making Laws to Reduce Pollution In 1972, the United States and Canada created the first Great Lakes Water Quality Agreement. They pledged to clean up and protect the Great Lakes ecosystem. The first cleanup efforts involved **point-source pollution**. This is water pollution from a single place, such as a discharge pipe at a sewage treatment plant or a factory.

New laws put strict limits on the amount of phosphorus and other chemicals that industries and sewage treatment plants could release into the waters. Soap makers stopped putting phosphorus into detergents. Industries stopped dumping oil and other pollutants into rivers. Other laws banned the use of a number of toxic chemicals, like PCBs and DDT.

The new laws worked. The Cuyahoga River was no longer flammable, or easy to catch on fire. Algae growth was greatly reduced. The lakes turned from green back to blue. PCBs and DDT in the food chain declined. And, as the amount of DDT in fish dropped, the bald eagle made a comeback.

The Chicago Waterfront

The city of Chicago lies on the shores of Lake Michigan. For years, the city dumped untreated sewage and factory wastes into the lake. At the same time, it depended on the lake for its water supply. By 2003, the city was drawing 1 billion gallons of water a day from the lake. This water met the needs of Chicago and 124 neighboring towns. Today, Chicago treats its wastewater. The result is a cleaner lake and safer drinking water for millions of people.

Continuing Pollution Challenges One great challenge in the Great Lakes today is **non-point-source pollution**. This is pollution that does not come from a single location. When rainfall, snowmelt, and irrigation water run across the land, the water picks up **pollutants** from the soil. **Runoff** from storms also picks up waste from industrial and construction sites.

Old toxic waste dumps also pollute. Many contain poisons that leak into waterways. There are as many as 250 dumps on the shores of the Niagara River alone.

Pollution from the air damages watersheds as well. Mercury, among other things, is released into the air when coal is burned. This highly toxic metal falls back to Earth mixed with rain or as dust. It then enters waterways and the food web.

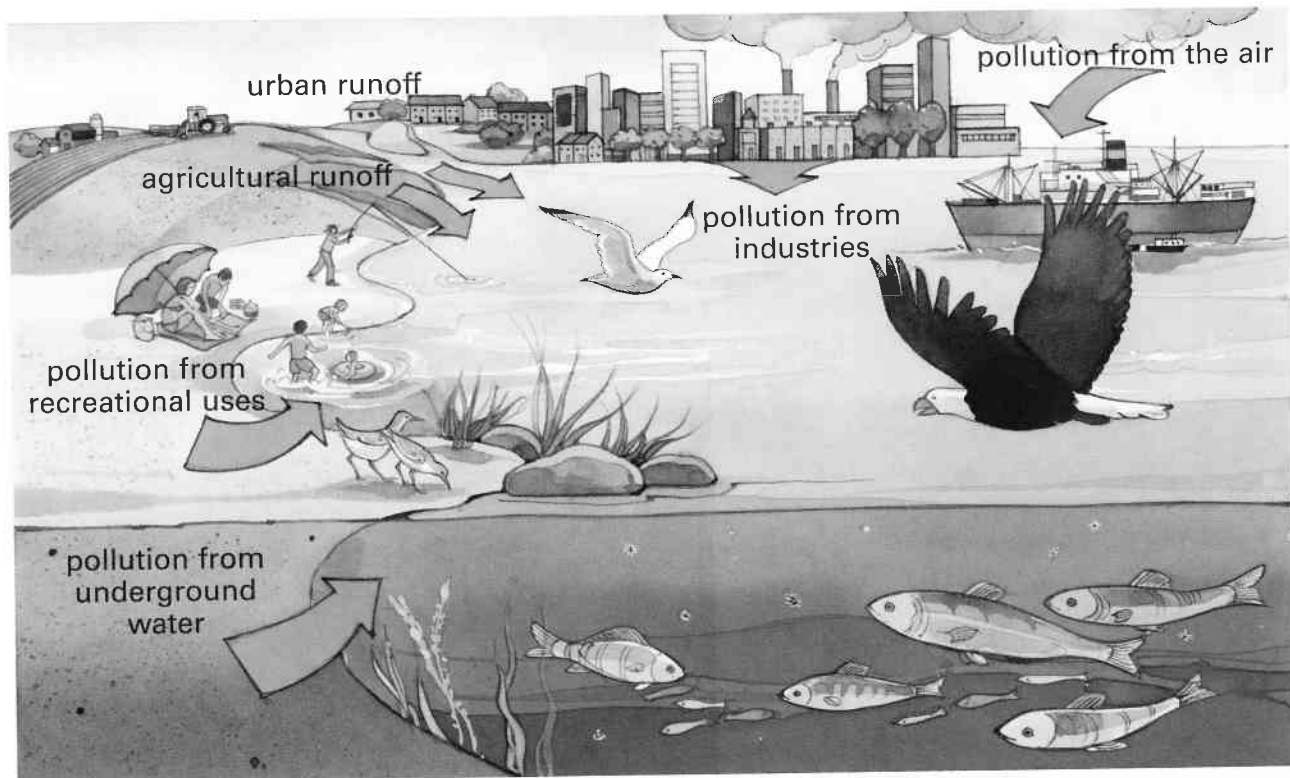
Canada and the United States are working to clean up non-point-source pollution. They have made new laws to limit harmful chemicals that go into the air, water, and soil. They are also cleaning up toxic **sediment** in waterways. Toxic sediment is polluted soil that has settled to the bottom of lakes and rivers. Removing such sediment is both difficult and costly.

The best way to deal with pollution is to prevent it. Today, education programs encourage prevention. People in industry and farming are using fewer harmful chemicals. Consumers are also choosing products that are safer for the environment.



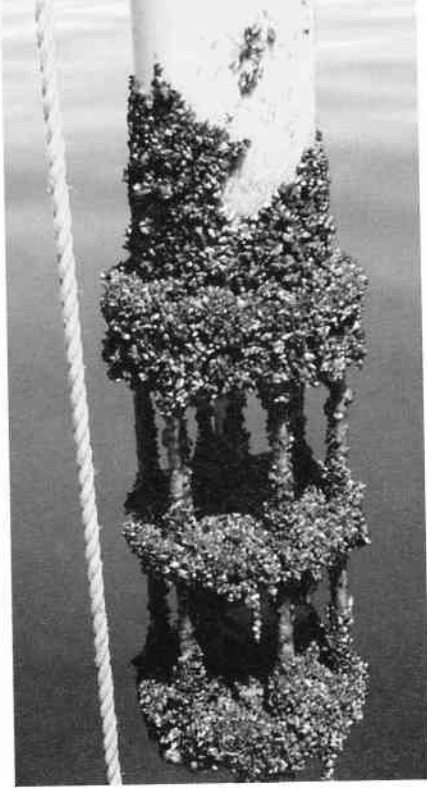
The Toronto Skyline

Toronto lies on the shores of Lake Ontario. The Great Lakes provide drinking water for three fourths of Ontario's people.



Sources of Pollution in the Great Lakes

This diagram shows several sources of pollution in the Great Lakes region. The United States and Canada have both passed laws to reduce pollution of the air, water, and soil.



Invasive Zebra Mussels

Zebra mussels are native to Eastern Europe. They are a threat to the food supplies of native fish in the Great Lakes. One problem they cause for humans is clogging water pipes.

Invading Asian Carp

Asian carp invaded the Mississippi, Missouri, and Ohio rivers in the 1980s. They pose a danger to boaters and water skiers. They jump into the air and slam into boats and people.



4.5 The Great Lakes Today: Invasive Species

Scientists estimate that there are more than 170 **invasive species** in the Great Lakes today. These are nonnative plants and animals that invade a new ecosystem. The sea lamprey described earlier is one such invader.

Most Invaders Arrive by Sea Most invasive species travel to the Great Lakes by water. Some come in the ballast water of ships. Ballast water is water pumped into the bottom of a ship to keep it stable. When the ship arrives at a port, it releases the water. It also releases any creatures in the water.

Other invaders, like the zebra mussel, hitch rides on the bottom of ships. Once zebra mussels reach a place they like, they multiply madly. Up to 70,000 mussels can thrive in a single square meter of water.

Invasive Species Upset the Ecosystem Invaders like the zebra mussel, sea lamprey, and alewife have all damaged the Great Lakes ecosystem. Zebra mussels, for example, steal food from native species. They clog water pipes. They attach to docks and make swimming dangerous because of their sharp shells.

The Asian carp is another big threat to the Great Lakes. Catfish farmers in the American South brought this large fish from Asia to clean their ponds. Some carp have escaped into rivers and are migrating toward Lake Michigan. Many people fear that the Great Lakes will someday become giant carp ponds.

Canada and the United States are working to prevent more non-natives from entering the lakes. Shippers are being asked to treat their ballast water more carefully. A barrier has been built to keep nonnative fish in the Mississippi River from entering the Great Lakes. Several states have banned the sale of live Asian carp for fear they will destroy the Great Lakes food chain.

Another approach has been to stock the lakes with species that will eat the invaders. Pacific salmon have been introduced to the Great Lakes to control alewives. Alewife numbers have dropped greatly as a result. And native fish have begun to recover.

4.6 The Great Lakes Today: Habitat Loss

A century ago, loggers in the Great Lakes region told folktales of a giant lumberjack named Paul Bunyan. Bunyan was a giant who could cut down a forest in minutes. One tale tells how he scooped out ponds to provide drinking water for his big blue ox, Babe. Today, those ponds are the Great Lakes.

In Paul Bunyan's day, dense forests covered the Great Lakes region. Nobody worried about **habitat** loss. A habitat is the natural environment in which a plant or an animal lives. But habitat loss is a big worry in the region today.

Restoring Forest Habitat When settlers moved into the Great Lakes region in the 1800s, they cleared patches of forest for farms. Later, loggers cut down more trees. Still later more land was cleared for factories and cities. In time, almost half of the region's original forest was lost to development. When habitats are lost, the plants and animals that live there are often lost as well.

Today people are working to reverse forest loss in the Great Lakes watershed. Timber companies are cutting trees in ways that are less harmful to forests. They also replant trees in areas that have been logged. The result is that forests around the Great Lakes are now expanding instead of shrinking.

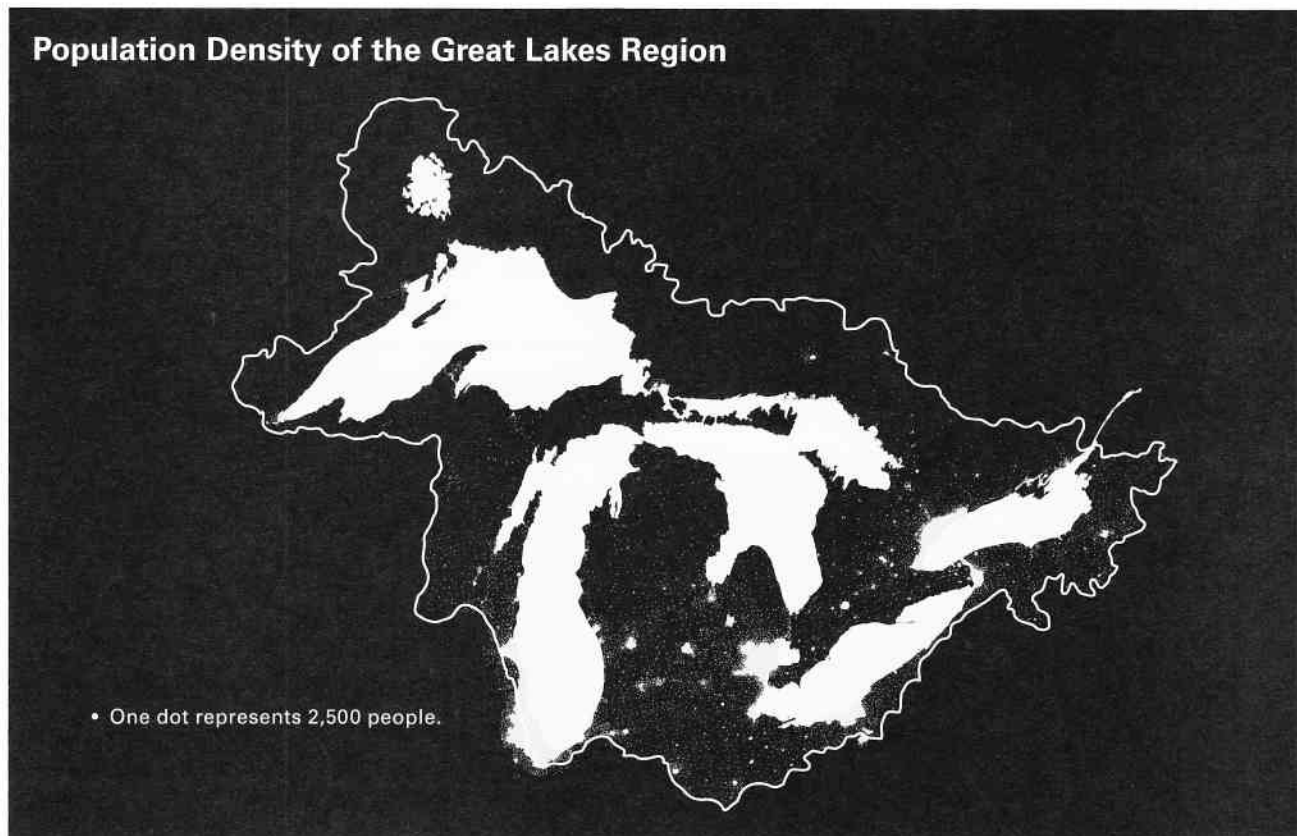
Protecting Precious Wetlands Like forests, **wetlands** were also lost during the settlement of the Great Lakes region. A wetland is an area where the soil is usually wet all year. Examples are marshes, bogs, and swamps. Wetlands provide habitats for a wide variety of wildlife. They also help to control flooding during storms.

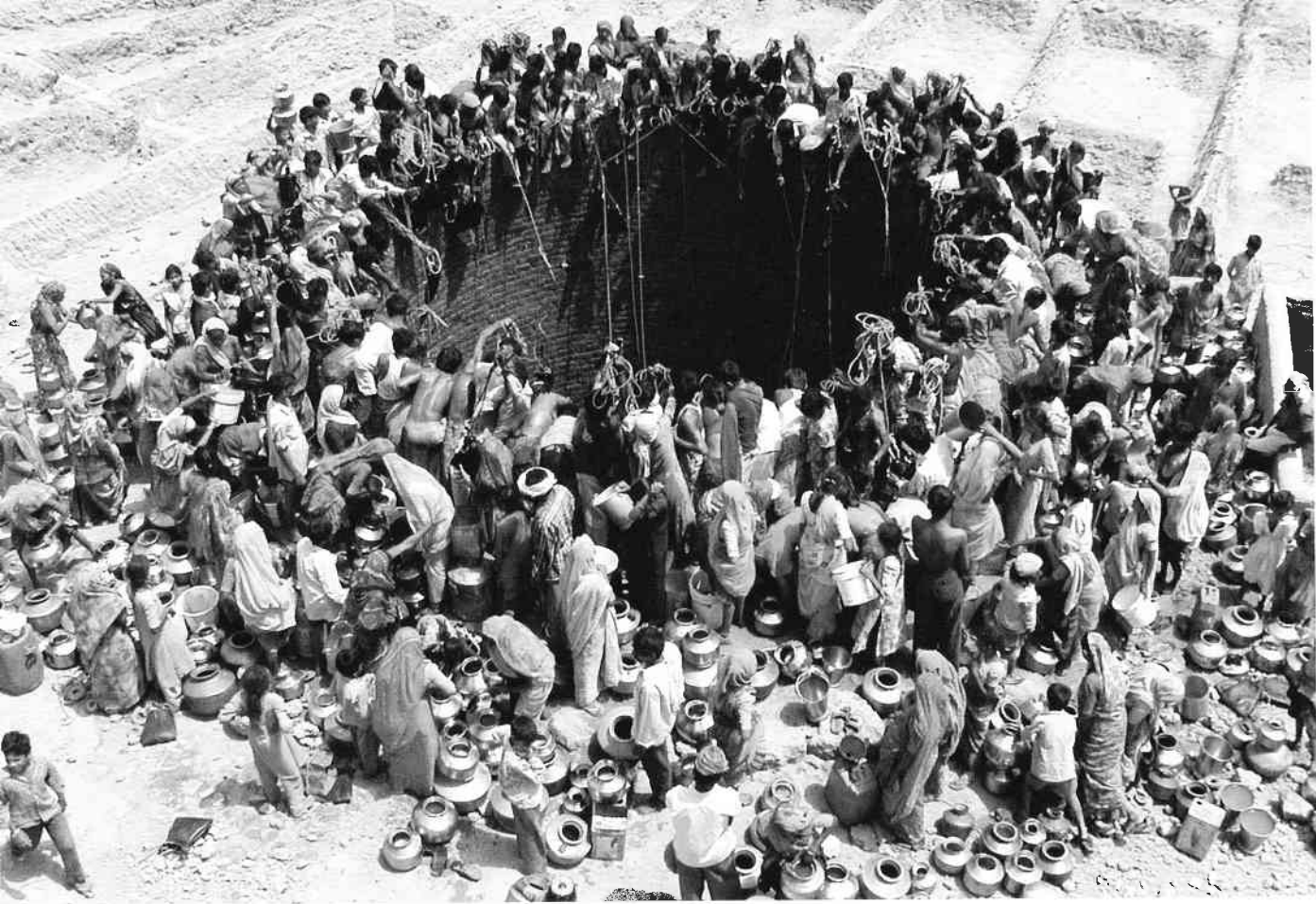
In the past, wetlands were viewed as worthless bogs. Over time, more than half of the wetlands in the region disappeared. Only in recent years did people begin to see the value of wetlands habitat.

Today, public and private groups are working to protect wetland habitats. One way is by creating nature preserves on existing wetlands. Another is by teaching landowners how to protect wetland areas. In some places, developers must create more than one acre of new wetland for every acre they destroy.

Population Pressures

The Great Lakes region has become densely populated. Each yellow dot below represents 2,500 people. The areas that are almost solid yellow have the most people. As the population has grown, forests and wetlands have disappeared. More habitats will be lost unless they are protected from development.





Getting Water from a Well

This well in India draws large crowds every day. In many rural areas, the task of finding water falls to women. They often walk many miles each day to get water for their families.

4.7 Beginning to Think Globally

In this chapter, you read that the Great Lakes are the world's largest freshwater ecosystem. You saw how plants and animals in this ecosystem form a complex food web. You learned how pollution and invasive species are threatening the health of the Great Lakes. And you found out how people are working to clean up and preserve this large watershed.

Water Is Essential to Life Managing freshwater ecosystems is important around the world. All living things need water. About 70 percent of Earth's surface is covered by water. But nearly 98 percent of that water is too salty for human use. Of the remaining 2 percent that is fresh water, three fourths is frozen in ice caps. That leaves less than 1 percent of Earth's water to meet human needs.

People get fresh water from many sources. Some draw water from rivers, lakes, and streams. Others depend on wells that tap into underground water supplies. In still other places, people collect and store rainwater to meet their needs.

Not all fresh water is safe for human use. Of the more than 6 billion people in the world, at least 1 billion don't have a steady supply of clean, safe drinking water. Unsafe water creates huge health problems. Every day, 6,000 children die from diseases that could have been prevented by having clean water to drink. Every year, more than 2.2 million people die from diseases tied to unsafe drinking water.

Water Shortages Are Increasing Every year, the number of people on Earth grows larger. The supply of fresh water, however, is not increasing. As a result, 31 countries now face water shortages.

China is one of those countries. To meet the water needs of its large population, China is pumping large amounts of water out of underground supplies. However, these supplies are slowly shrinking. This is happening because more water is being pumped out than is replaced by rainfall each year. Also, some rivers in China are so polluted that their water can't be used to irrigate crops.

Competition for limited water supplies can cause conflict. Some rivers flow through many countries. When one country dams a river for irrigation water, it may reduce the amount of water flowing to countries downstream.

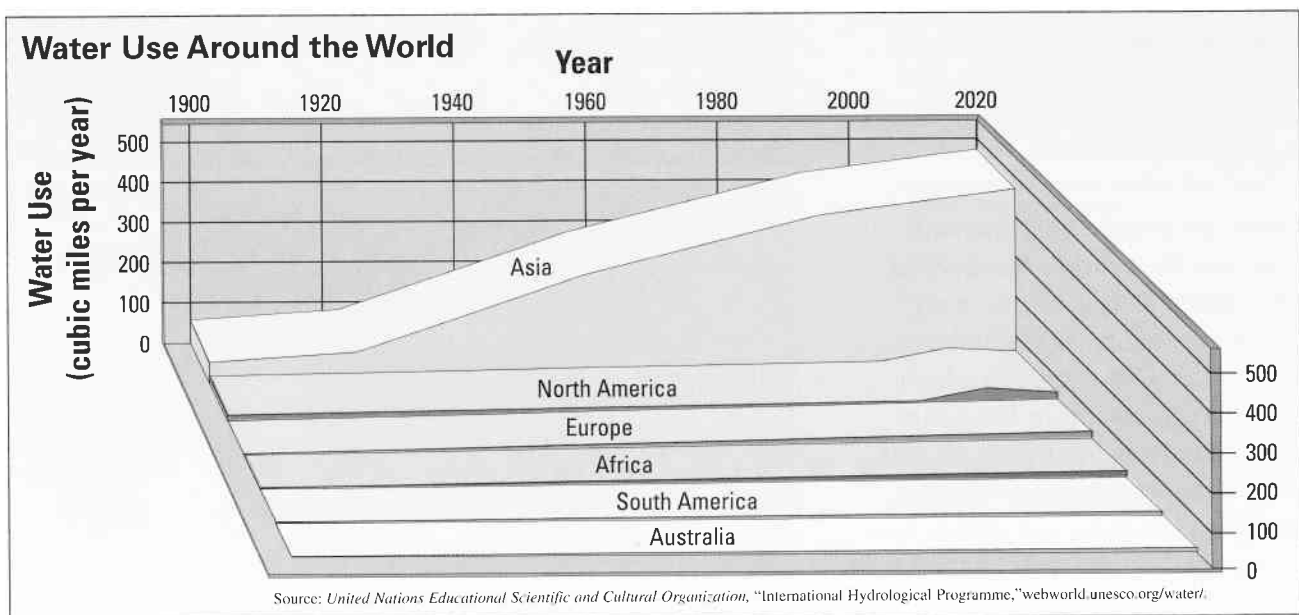
Egypt, for example, has a population of over 77 million people. However, it receives almost no rainfall. Instead, Egyptians depend on the Nile River to meet all of their water needs. Before reaching Egypt, the Nile travels through several countries. If any of those countries reduced the flow of the Nile, Egypt could be starved for water. This result could be a water war.

Climate Change May Shrink Water Supplies In the last 25 years, Earth's climate has warmed slightly. Many scientists believe that this warming trend will continue. This change in climate may affect water supplies. Some areas might get less rainfall than they do today. Others might see more frequent floods.

If these changes occur, managing water supplies will become more important than ever. Countries with shortages will need to improve their water collection and storage methods. Those with too much water will need to improve their flood defenses. Think about these possible problems as you look at maps showing changes in the world's freshwater supplies in the next section.

A Thirsty World

Asia uses more water than any other continent, in part because it has such a large population. However, North Americans and Europeans use more water *per person* than people in other continents.



4.8 Global Connections

The maps show the world's freshwater supplies for three different years. Each map shows the amount of water available per person in each country. The maps do not show the total amounts of water available in each year. The map for the year 2025 is based on population estimates for that year.

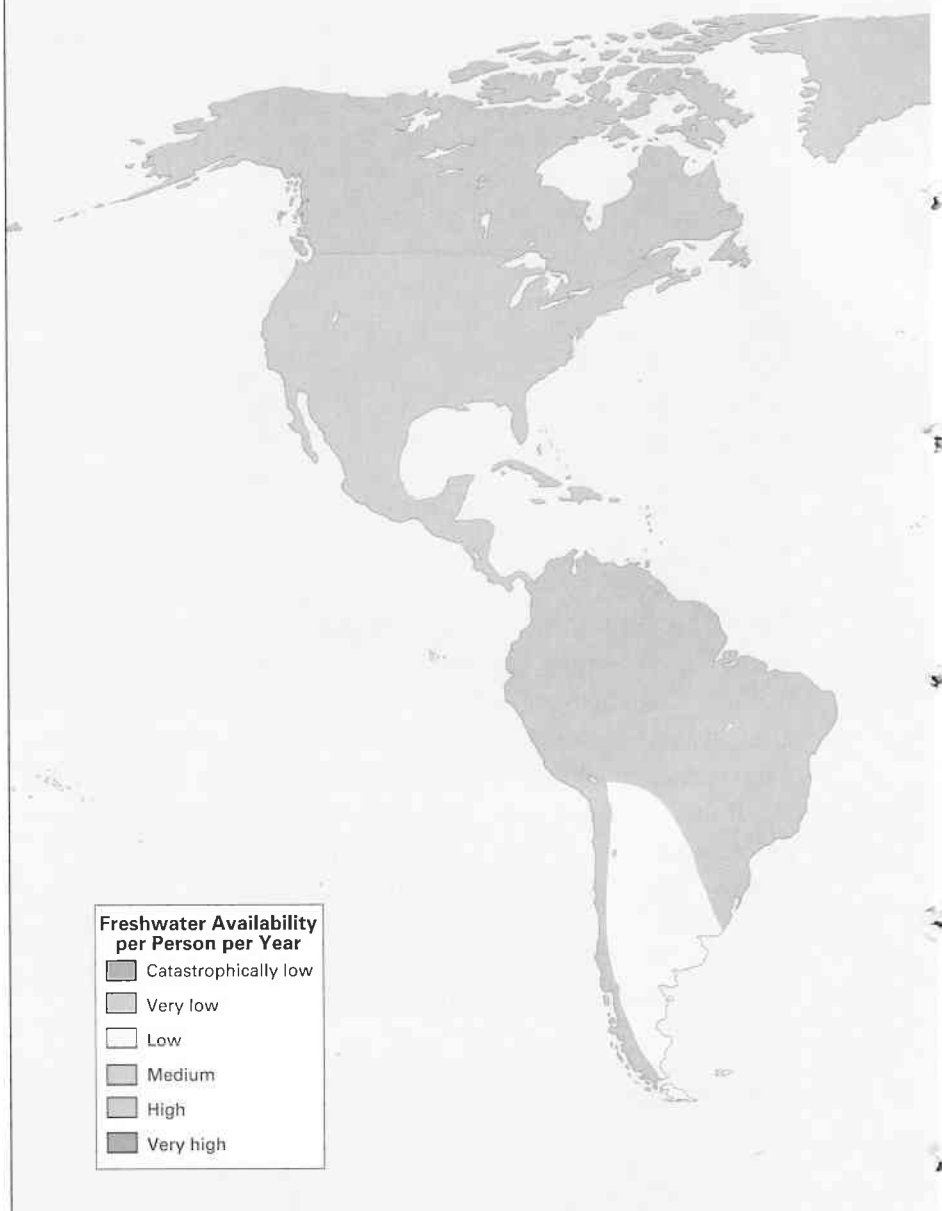
What factors might cause the changes in freshwater availability you see in the maps? Population is growing rapidly in places like India and Africa. But the amount of fresh water is not growing. So the same amount of water must be shared by far more people. Climate changes in the future may also reduce the amount of clean, fresh water available. In addition, some sources of fresh water, such as wells, have been polluted. These sources of water are no longer safe.

What concerns for the future can be drawn from the maps?

The maps show that water shortages are likely to increase over time. This could lead to rising water costs. It could lead to less food production, since many crops require irrigation. Public health problems could also arise as people turn to less safe water supplies to survive.

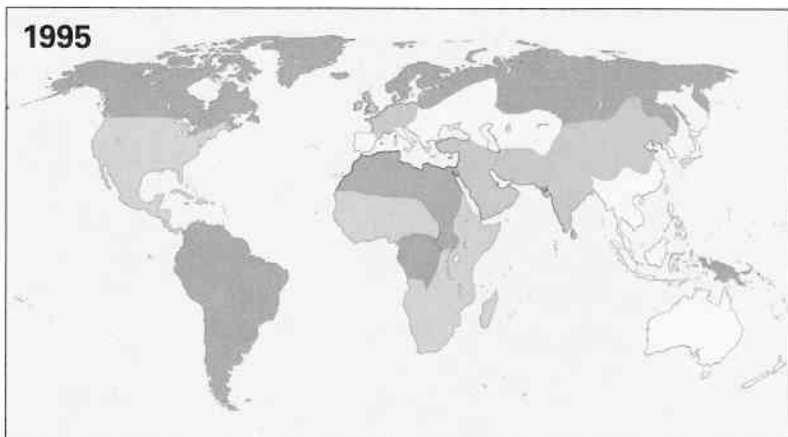
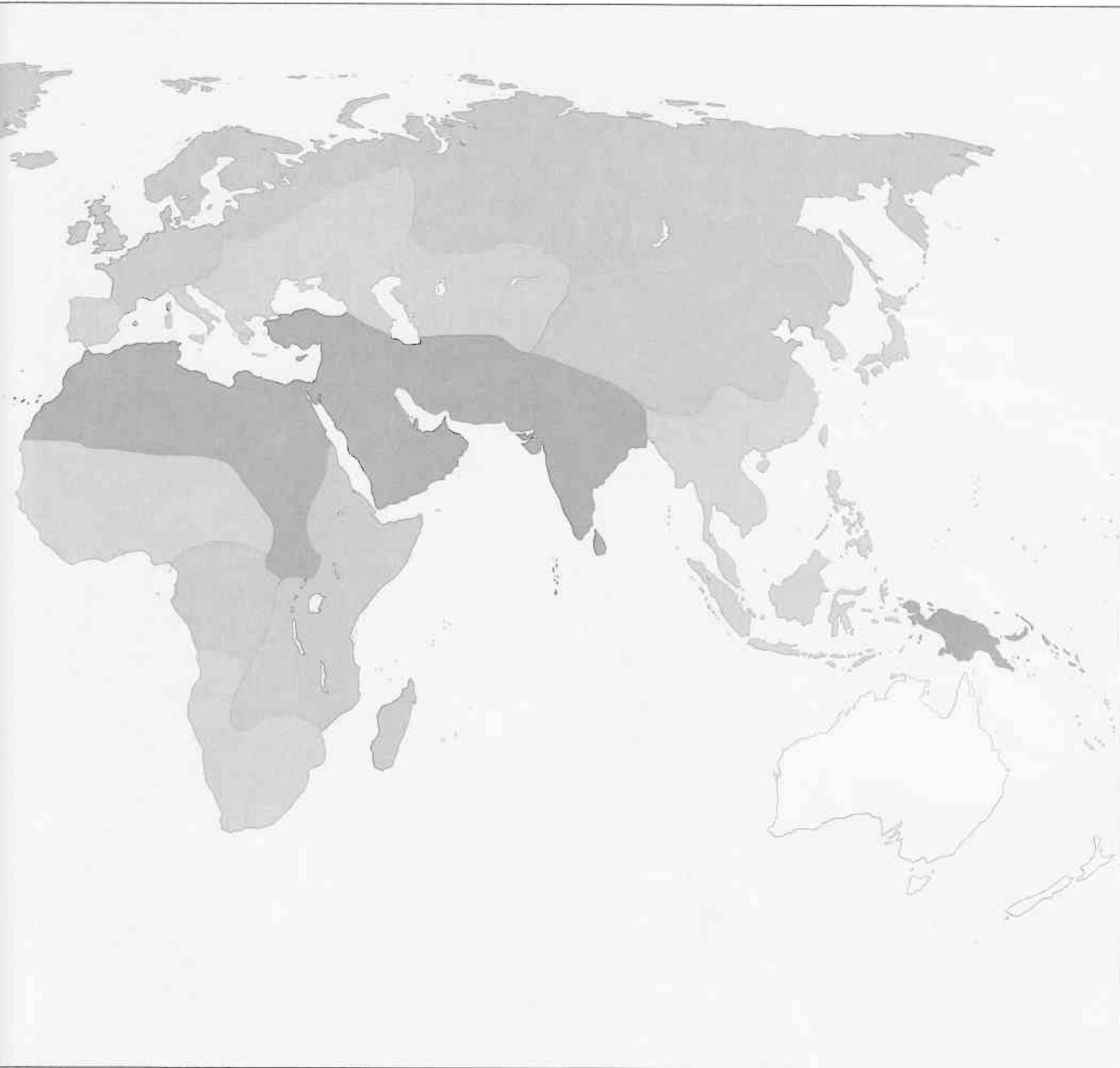
How can people best use and manage the world's freshwater resources? People can do many things to better manage sources of fresh water. One is to reduce water pollution. Another is to find better ways to store and distribute existing water supplies. Using less water in homes and on farms can stretch limited supplies. So can recycling water so that it is used again and again.

Freshwater Availability Around the World, 2025



1950





Source: Sustainable Development Networking Programme, "International Year of Freshwater," www.sdnbd.org.