Pintail duck photo by Peter LaTourette

Climate Change, Wildlife, and Wildlands

Case Study

Chesapeake Bay and Assateague Island

Rising Seas, Changing Climate

When Captain John Smith and his crew sailed up Chesapeake Bay on the mid-Atlantic coast in 1608, they passed a large, low-lying island in the upper middle reaches of the bay, about 34 nautical miles south of today's Baltimore. Poplar Island, as it became known, covered more than 1,400 acres in Smith's time. The island eventually supported a small town, and later—in the 1930s and 1940s—an exclusive retreat for politicians, including Presidents Franklin D. Roosevelt and Harry Truman.

If Captain Smith could repeat his Chesapeake voyage today, he might be surprised to see what remains of Poplar Island. Instead of the substantial body of land he encountered in 1608, Poplar Island now consists of a small group of islets that together measure less than 5 acres. Dead trees rise from the water to mark where land stood only a few years before.

Rising seas and heavy erosion have flooded and eaten away more than 99.5 percent of Poplar Island during the past 150 years.

With the shoreline retreating by more than 13 feet annually, the island's remnants would have vanished under the sea by the year 2000 if it weren't for a $427 million restoration program launched in 1998 by a coalition of federal, state, and nongovernmental agencies.

Poplar Island's story is not unique. The University of Maryland's Laboratory for Coastal Research found that at least 13 islands in Chesapeake Bay have disappeared entirely since the region was first described and mapped by Europeans. Many more islands are in danger of drowning as the sea continues to rise. Even Captain Smith's namesake island near the mouth of the Potomac, which is large enough to support three small towns and a population of close to 400 people, has lost some 30 percent of its land since 1850. The formerly wooded tract is now a group of low-lying, mostly marshy islands. If scientists' predictions are accurate, Smith Island will be lost to the sea during the

Impacts at a Glance

- **Chesapeake Bay on the mid-Atlantic coast is rising twice as fast as the global average rate of sea level rise.**
- **Chesapeake Bay and the sea around Assateague Island are likely to rise 27 inches by 2100, and most likely will keep rising after that.**
- **Chesapeake Bay's islands are being submerged and eroded by the rising seas.**
- **Sand beaches and marshes along bay shores are vanishing in those developed areas where people armor the shoreline against the sea.**
- **Storms will do more damage as the sea level rises.**
- **Warmer or more saline waters could encourage the spread of oyster disease and affect fish in Chesapeake Bay.**
- **Global warming could have a major impact on the region's bird life, including migratory waterfowl that overwinter in Chesapeake Bay.**
- **Sea level rise might cause Assateague Island to become narrower and move landward.**

next century, along with a way of life for its watermen and crabpickers.

Why is the sea rising? Global warming causes water at the surface of the ocean to expand and adds sizable quantities of freshwater runoff from melting glaciers and ice sheets. In areas where the land is sinking due to changes in the Earth's crust, the effects of rising seas are even more pronounced. In the Chesapeake Bay area, scientists believe global warming accounts for about 6 inches of the sea level rise that has occurred in the past 100 years. Natural geologic subsidence of land, possibly exacerbated by the compaction of sediments as people withdraw excessive amounts of groundwater, may have contributed another 6 inches to sea level in the past century. The region's sea level as recorded by tide gauges is now more than a foot higher than it was in 1890.

EPA estimates that with additional global warming and continued subsidence, sea level in the Chesapeake Bay area probably will rise another 8 inches by 2025, 13 inches by 2050, and 27 inches by 2100, compared with the level in 1990. Such a rate of sea level rise would be approximately double that of the preceding century. There is even a small risk—a 5 percent chance based on current computer models—that the sea will rise as much as 44 inches by 2100.

For the past 5,000 years, the average rate of sea level rise in Chesapeake Bay was approximately 3 feet per 1,000 years. During the 21st century, global warming could cause the bay's level to rise at a rate closer to 3 feet per *100* years.

Marshes and Beaches at Risk

Rapid sea level rise could be devastating for most of Chesapeake Bay's islands, marshes, and beaches. The loss of these habitats in turn would affect birds, fish, terrapins, and other wildlife. The future Chesapeake Bay might lose some of its charm for the thousands of kayakers, boaters, anglers, windsurfers, and birders who spend time on and around the bay each year.

Salt marshes can keep up with moderate increases in sea level but may be drowned if the sea rises faster than sediments and peat can build up the marsh. In low-lying areas like the Eastern Shore or Virginia's Back Bay National Wildlife Refuge, new marsh develops naturally as rising seas flood the land. Similarly, beaches are able to migrate inland. But many Eastern Shore residents are armoring their property against the sea by building sea walls, bulkheads (retaining walls), and revetments (rocks piled along the shore). These structures prevent marshes and beaches from moving inland as the sea rises. Since 1980, Chesapeake Bay residents have built bulkheads and revetments along 350 miles of shoreline. If this trend continues, many of the bay's beaches and marshes will be lost, squeezed between the rising tide and the armored shore.

Captain Smith might be thoroughly astonished by a sail through Chesapeake Bay in the year 2100. He would hardly recognize the landscape before him. If present trends continue, the "many isles" described in his writings will have vanished, along with most of the marshes and beaches.

"We are once again at the threshold, as we were in the 1970s, facing the decline of the Chesapeake Bay."

— Sarah J. Taylor-Rogers, Assistant Secretary,
Maryland Department of Natural Resources, October 18, 1996

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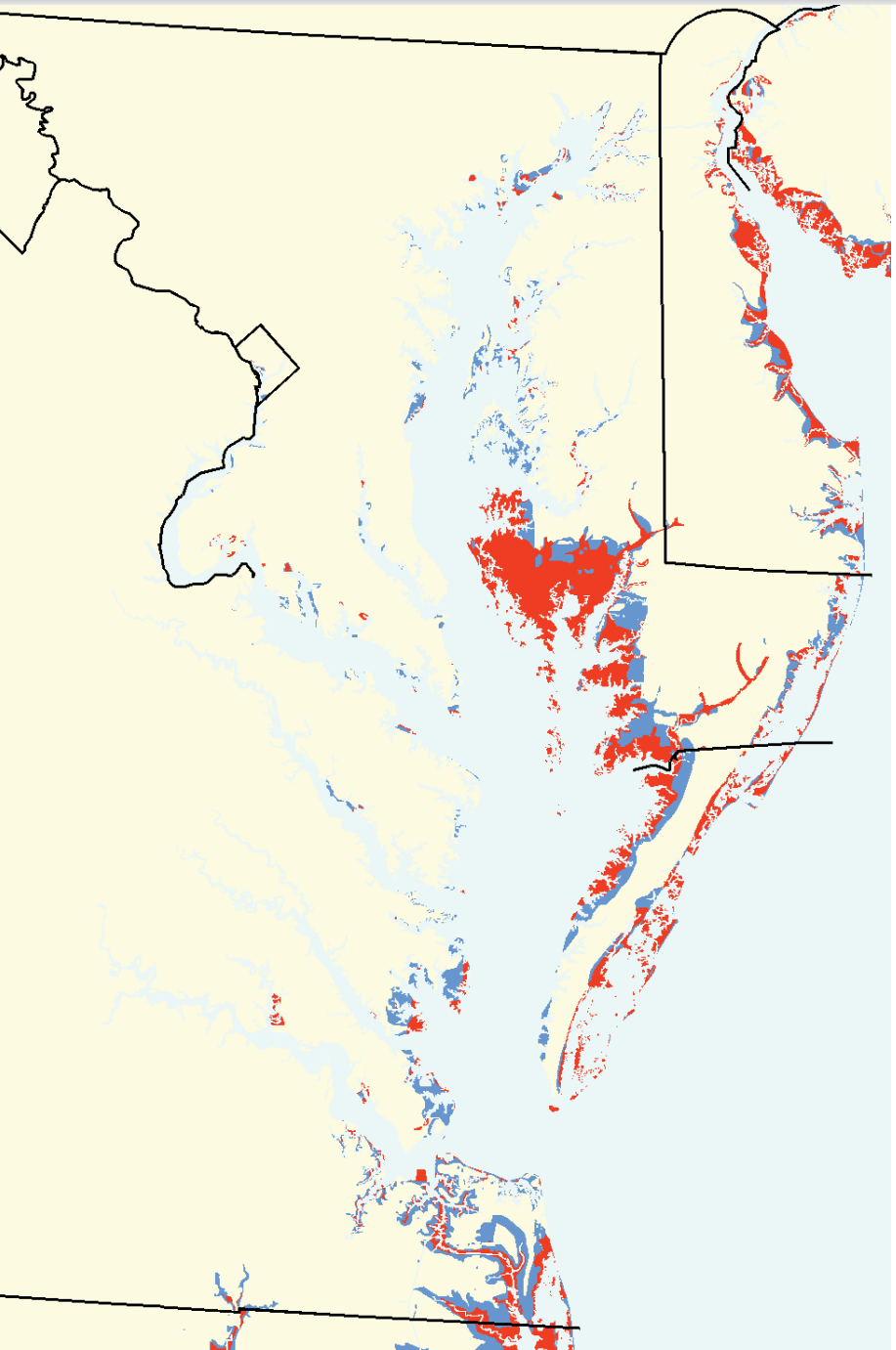


Chesapeake Bay Region

- **Some of the areas that could be flooded at high tide if global warming causes sea level to rise 2 feet by 2100.**
- **Areas that might be inundated over a period of several centuries.**

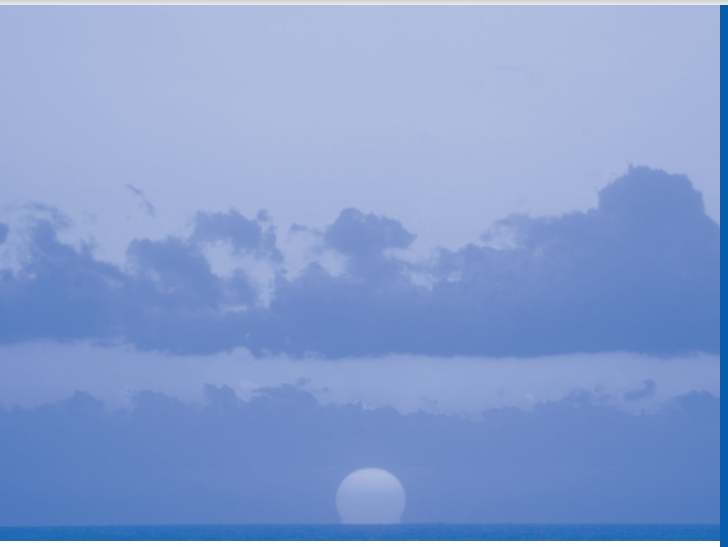
The indicated areas account not only for the effects of global warming, but also for other effects such as tidal variations and land subsidence.

Other Changes in Store

The loss of marshes, beaches, and islands are only some of the potential impacts of global warming in the Chesapeake Bay region. Other changes also are possible, including warmer temperatures, increases in precipitation, more frequent and more damaging floods from coastal storms, lower oxygen levels in the bay, and lower water quality. Not all of the changes may be harmful: for example, an increase in rainfall could bolster the region's freshwater supply. Scientists cannot predict future climate or its effects with certainty, but the best research available today suggests that global warming could have significant impacts on the mid-Atlantic region.

The diverse habitats of Chesapeake Bay and its surrounding watershed—including underwater grass beds, salt marshes, forested wetlands, and upland forests—provide homes for more than 2,700 species of animals and plants. Many of these habitats will be affected by climate change.

During the past 100 years, the average temperature in the mid-Atlantic region has risen by nearly 1°F, and precipitation has increased by up to 10 percent. Compared with today's temperatures, climate models project that the region's climate may become approximately 2°F warmer by



2030, with an additional 3°F to 8°F average temperature increase by the end of the 21st century. Models project that precipitation in the region also will increase during the next 100 years.

More precipitation might bring more freshwater and nutrient runoff into Chesapeake Bay, which may reduce the bay's salinity and the amount of oxygen available for fish and other aquatic life. High nutrient levels can lead to algal blooms, reducing the water's clarity and the amount of light available to submerged aquatic vegetation. Excess nutrients also stimulate the growth of algae on the leaf blades of submerged vegetation, further reducing the amount of light available to the plants for growth.

What is Global Warming?

The Earth's climate has changed in the past, and will continue to change naturally in the future. Ice ages, long warm periods, and short-term fluctuations in temperature and precipitation are all elements of the global climate's natural variability.

Today, the average global temperature is rising. Is that natural? Some of the temperature increase can be explained by natural factors. But many scientists believe that a portion of the warming trend may be caused by humans. Human activities are creating a buildup of greenhouse gases—primarily carbon dioxide, methane, and nitrous oxide—in the atmosphere. The heat-trapping property of these gases is undisputed. Although scientists do not know exactly how the Earth's climate responds to increases in greenhouse gases, they do know that the current warming trend is consistent with changes that would be expected from the increase in greenhouse gases.

Scientists generally believe that the burning of fossil fuels and other human activities are the primary reason for the increased concentration of carbon dioxide in the atmosphere. Fossil fuels burned to run cars and trucks, heat homes and businesses, and power factories are responsible for almost 99 percent of U.S. anthropogenic carbon dioxide emissions and about 20 percent of our nitrous oxide emissions. Of the carbon dioxide emissions, industrial activity accounted for 33 percent in 1997. Personal and commercial transportation accounted for 30 percent, and residential and commercial energy use accounted for 19 and 16 percent, respectively. Increased agriculture, deforestation, landfills, industrial production, and mining also contribute a significant share of carbon dioxide, methane, and other greenhouse gas emissions.

Average global temperatures at the Earth's surface have increased 0.6–1.2°F since the late 19th century. The 10 warmest years in the 20th century all occurred in the last 15 years. Snow cover in the northern hemisphere, floating ice in the Arctic Ocean, and the areas covered by mountain glaciers have all decreased. Globally, sea level has risen 4–10 inches during the past century. Worldwide precipitation over land has increased by about 1 percent, and the frequency of extreme rainfall events has increased throughout much of the United States.

Although it is impossible to predict future changes in climate with certainty, many scientists believe that the continued addition of greenhouse gases to the atmosphere is likely to raise the Earth's average temperature by several degrees in the next 100 years. Rising global temperatures are expected to raise sea level and change precipitation and other local climate conditions. Changing regional climate could alter forests, crop yields, and water supplies. It also could threaten human health and harm birds, fish, and many types of ecosystems.

Finally, high nutrient levels in the bay may be linked to outbreaks of the toxic organism *Pfiesteria*, which some scientists believe killed many bay fish in 1997.

Oysters also may suffer if bay waters become fresher. The enormous volume of freshwater that entered Chesapeake Bay from Tropical Storm Agnes in 1972 killed an estimated 2 million bushels of market-size oysters and eliminated most oyster larvae in the bay.

On the other hand, sea level rise may cause water in the bay to become saltier, encouraging the spread of oyster diseases. Warmer water temperatures, especially in winter, are also linked to oyster diseases. The oyster diseases MSX and Dermo are caused by warm-water parasites.

Chesapeake Bay has very low levels of dissolved oxygen, due in part to the heavy load of nutrients from agricultural runoff and municipal wastewater treatment discharges in the freshwater that flows into the bay. The low oxygen levels make life difficult for fish and other aquatic animals. Global warming may make it even harder for them to survive. For each degree Fahrenheit that the bay's water warms, the capacity of water to dissolve oxygen decreases by about 1.1 percent. Higher water temperatures also raise the metabolic rates—and hence the oxygen requirements—of cold-blooded aquatic animals, such as invertebrates and fish.

Warmer waters could be harmful for Chesapeake Bay species that are at the southern end of their range, such as the soft clam. But warming also could help warm-water species at the northern end of their range survive by reducing the severity of cold snaps during winter.

Higher sea levels would allow storm surges to penetrate farther inland than they do today, placing more structures and people at risk.

Finally, the impacts of climate change will come on top of the many stresses that already affect plants and animals in Chesapeake Bay, such as excess sediment and nutrients, overharvesting, toxic pollutants, and habitat loss from land development by humans.

What Can Be Done?

To address the threat of climate change, first we have to understand the risks. Many scientists are analyzing the potential impacts of climate change in the Chesapeake Bay region. Their findings will help identify the areas of risk to people, animals, and plants in the bay, Assateague Island, and other important ecosystems in the area.

Efforts to restore the bay, such as the federal-state Chesapeake Bay Program, can help reduce current stresses on life in the bay and make natural ecosystems more resilient to some impacts of climate change.

The Maryland and Virginia state governments could help coastal areas adapt to rising sea levels by enacting plans indicating the areas that will be protected and those that will be abandoned to the sea. Some areas may require regulations to prohibit revetments or bulkheads, specify erosion-based setback rules for new construction, or require buildings to be moved landward as the sea rises. Other areas may need structural protection, landfill, or beach nourishment.

Prevention of human-induced climate change also is an important strategy. Some global warming probably will occur no matter what we do, because some of it is natural. But also, humans have become dependent on fossil fuels. The burning of fossil fuels emits greenhouse gases, which may remain in the atmosphere for years, decades, or even centuries, exacerbating the natural warming. But we as individuals can take action now to reduce our own consumption of fossil fuels by improving energy efficiency and using alternative

energy sources. (See "Searching for Solutions" and "What People Can Do" on pages 8 and 9.)

Assateague Island

Assateague Island stretches along the Atlantic coast of the Delmarva Peninsula, between Chesapeake Bay and the ocean. Assateague is one of many barrier islands that rim the eastern coast of the United States. Barriers are narrow islands that run parallel to the continental shoreline, with a protected bay lying between the island and the shore. The bay shores of barrier islands typically are lined with salt marshes.

Like other barrier islands, Assateague is constantly changing shape and geographical position. At one time, it lay far seaward of where it is today.

Large undeveloped barrier islands like Assateague are likely to narrow and "roll" landward during the next century. Sea level rise and storms will cause Assateague Island to erode until it becomes narrow enough for storms to push sand over onto the bay side. Like a rug being rolled up, the island will remain above sea level and roll gradually toward the land.

The bays on the landward side of the island—Sinepuxent and Chincoteague Bays—will expand inland as the sea rises, flooding the coastal plain. The future Assateague Island and its bays may look generally similar to what we see today, but they will be farther inland. The birds and other wildlife that attract so many visitors to Assateague National Seashore and Chincoteague National Wildlife Refuge should still find good habitat conditions as the island migrates landward. However, many of today's popular visitor sites, such as the wildlife loop road that encircles Snow Goose Pond at Chincoteague refuge, eventually will disappear.

Some barrier islands may not be as lucky as Assateague: If the sea level rises too quickly, islands can break up and drown in place. The Isles Dernieres barrier chain along the Louisiana coast was once a single island. Storm erosion and a relative sea level rise of three feet per century broke Isle Dernier into five smaller islands that are expected to be completely submerged by the year 2020. Due to the rapidly subsiding land along Louisiana's coast, the sea level relative to the land level is rising faster than in other parts of the country.

The northern end of Assateague may be more vulnerable to sea level rise than the rest of the island, as it has been sand-starved for many decades by jetties at Ocean City Inlet that trap the sand. Personnel at Assateague National Seashore are working with the U.S. Army Corps of Engineers and the State of Maryland to create a system that will restore sand transport to northern Assateague.

Condominiums, hotels, shops, and other coastal development on barrier islands will become increasingly at risk of flooding and storm damage as the sea rises. Ocean City, Maryland, is built on the lower end of Fenwick Island, which is just north of Assateague. For the past 10 years, Ocean City has had to bring in sand to replenish its eroding beach. The beach needs replenishing more frequently now than it did only a few years ago because of increased erosion, and

"Assateague Island National Seashore is one of the most dynamic environments administered by the National Park Service."

— Robert Dolan, Bruce Hayden, Jeffrey Heywood,
Atlas of Environmental Dynamics,
Assateague Island National Seashore, October 1977

sea level rise could double the rate of erosion in the next 30 years.

A powerful northeaster that hit the mid-Atlantic coast in early March 1962 caused an estimated $7.5 million in property damage to Ocean City. A similar storm today would cause hundreds of millions of dollars in damage because the island has become densely developed over the past 20 years. Future storms may cause even more harm because storm surges and waves will be superimposed on higher sea levels.

Blackwater National Wildlife Refuge

Blackwater National Wildlife Refuge, on the eastern shore of Chesapeake Bay near Cambridge, Maryland, has the largest concentration of nesting bald eagles on the east coast north of Florida. The wetlands of the wildlife refuge are vital for migratory waterfowl and shorebirds, and also are important for flood control and maintaining water quality.

Blackwater is one of Chesapeake Bay's most popular sites for birders, attracting thousands of visitors annually.

Since 1938, one-third of the marsh at Blackwater has disappeared due to a combination of sea level rise and overgrazing by nutria, large non-native beaver-like rodents that dig canals through the marsh and eat the vegetation. More than 5,000 acres of marsh have been lost, and most of the remaining wetlands are projected to disappear within 30 years.

As the sea rises, inundation by seawater of lowland habitats surrounding the marshes could result in the disappearance of habitat for migratory birds and other species, such as the endangered Delmarva fox squirrel. Similar impacts could occur at Back Bay National Wildlife Refuge, south of Virginia Beach, which contains extensive marshlands.

Waterfowl and Other Birds

Chesapeake Bay is used by nearly 1 million ducks, geese, and swans in the winter months, and by thousands more during migration seasons. The bay also provides important habitat for a variety of other resident and migratory birds, including the osprey, bald eagle, six colonially nesting waders (such as the great blue heron and snowy egret), and dozens of shorebird species. Chesapeake Bay's abundant bird life and its proximity to major urban centers make it a very popular destination for birders. But in the future, global warming could make the bay a much less attractive place for some species of waterfowl and other birds.

Wintering populations of many ducks have declined in recent decades, some quite dramatically. Overwintering Northern pintails, for example, declined from an average of about 40,400 birds from 1950–1959 to only 2,600 birds in 1985–1999. Other species, such as the Canada goose, snow goose, and Brant, have become more abundant.

Researchers believe that the population changes are related to impacts on food resources in and around Chesapeake Bay. In particular, degradation of bay water quality caused by heavy nutrient and sediment runoff has reduced submerged aquatic vegetation, a prime waterfowl food, throughout much of the bay. Geese and swans respond by switching to other foods, such as waste corn in agricultural fields. But species that rely on submerged aquatic vegetation, such as the Northern pintail, redhead, and American widgeon, have practically disappeared from the bay.

Global warming could exacerbate these problems if increases in precipitation lead to greater nutrient and sediment runoff, and if water temperatures become warmer. Sea level rise and coastal development could eliminate many of the marshes and other shallow water habitats that ducks use

in winter—reducing the wildlife that attract many people to the area.

In addition, global warming is expected to affect the prairie pothole region of the north-central United States and south-central Canada, where 50-80 percent of North America's ducks and other waterfowl nest. The shallow prairie wetlands are vulnerable to drought, and computer models indicate that global warming is likely to bring stronger and more frequent droughts to the prairie pothole region.

Many ducks that overwinter in Chesapeake Bay nest in the prairie pothole region, including mallards, Northern pintails, American widgeons, canvasbacks, redheads, lesser scaups, common goldeneyes, ruddy ducks, and buffleheads. Virtually all of the canvasbacks that winter in Chesapeake Bay nest in the prairie pothole region.

Chesapeake and Delaware Bays harbor the largest concentrations of migratory shorebirds in the western hemisphere. The loss of bay islands, marshes, and beaches will eliminate important shorebird habitats and will directly affect shorebird populations.

Changes in climate may affect inland birds as well. According to one research study, global warming could cause the Baltimore oriole to shift its range northward out of Maryland. There might be no more Baltimore orioles in Baltimore by the year 2100.

Searching for Solutions

To address the threat of global warming, Maryland, Virginia, and the other mid-Atlantic states could improve the health and resiliency of natural ecosystems, prepare for a changing climate and rising sea level, and/or work to limit future global warming by reducing greenhouse gas emissions.

The Chesapeake Bay Program, a federal-state effort launched in 1983, responds to the problems of nutrient enrichment, population growth, coastal development, habitat loss and degradation, and toxic substances. In addition, the program's Scientific and Technical Advisory Committee launched Chesapeake Futures, a team of experts looking at issues related to the bay of 2030. By working to improve the health of the ecosystem, the Chesapeake Bay Program may help make the bay and its wildlife more resilient to the future impacts of climate change.

In addition, the Federal Agencies Chesapeake Ecosystem Unified Plan (FACEUP) was established in 1998 to help protect the Chesapeake Bay region. FACEUP added 50 new commitments, such as increased support to the states for research on *Pfiesteria*.

Island and beach restoration programs also can help mitigate the effects of climate change and sea level rise. The Poplar Island restoration project, led by the U.S. Army Corps of Engineers, is designed to reconstruct the island to its approximate size in 1847 (1,100 acres) using uncontaminated dredged material from Baltimore Harbor and the Channels Federal Navigation project. The restoration will create new habitat for wildlife, including

marshes, uplands, small ponds, and wooded areas. The first phase of the 20-year project, which included constructing 640 acres of dikes and a breakwater, was completed in 1999.

Slowing Climate Change

Today, action is occurring at every level to reduce, avoid, and better understand the risks associated with global warming. Many cities and states across the country have prepared greenhouse gas inventories, and many are pursuing programs and policies that will result in reductions of greenhouse gas emissions.

At the national level, the federal government is working in partnership with businesses, states, and localities to address global warming while also strengthening the economy. In addition, the U.S. Global Change Research Program coordinates the world's most extensive research effort on climate change.

What People Can Do

We all add greenhouse gases to the atmosphere whenever we use energy from fossil fuels. Residential energy use accounted for 19 percent of overall CO_2 emissions from the combustion of fossil fuels in 1997, and motor vehicle use accounted for approximately 20 percent. Here are a few actions that people can take to reduce their emissions.

- **Use mass transit, carpool with friends, or ride a bike whenever possible.**
- **When it's time to replace the family vehicle, consider one that gets more miles per gallon than your present vehicle.**
- **If you have a small boat for fishing and recreation, run it with "human power" when possible.**
- **When it's time to replace an appliance, look for the ENERGY STAR® label identifying energy-efficient models.**
- **When buying or building a new house, an ENERGY STAR model gives greater quality and comfort as well as lower monthly costs. For more information, go to the ENERGY STAR Homes web site, www.epa.gov/homes.**
- **Buy products that feature reusable, recyclable, or reduced packaging to save the energy required to manufacture new containers and reduce greenhouse gas emissions from landfills.**
- **Encourage your company to join EPA programs such as ENERGY STAR Buildings℠ and Waste Wi$e recycling programs, and to buy office equipment with the ENERGY STAR label.**
- **Plant trees, which absorb carbon dioxide from the air.**
- **Educate others. Let friends and family know about these practical, energy-saving steps they can take to save money while protecting the environment.**
- **Encourage scientific research and public discussion on global warming and solutions such as energy efficiency and alternative energy.**

For More Information

- The U.S. Environmental Protection Agency's global warming site includes detailed information on climate change, impacts, and actions.

  www.epa.gov/globalwarming/

- A 50-page handbook, *Vanishing Lands: Sea Level, Society, and Chesapeake Bay*, is available free of charge from the U.S. Fish and Wildlife Service. Call 410-573-4562 to order a copy. A videocassette of the award-winning *Vanishing Lands* documentary film is available from the University of Maryland's Laboratory for Coastal Research. For prices and information on ordering, visit the laboratory's web site.

  www.geog.umd.edu/coastal/index.html

- The Chesapeake Bay Program's web site offers a wealth of information on the current and future status of Chesapeake Bay.

  www.chesapeakebay.net/

- The Poplar Island Restoration Project web site provides an overview and updates on progress in restoring the island.

  www.fws.gov/r9dhcbfa/success.htm

- EPA's state-specific climate change fact sheets include information on potential impacts in the mid-Atlantic states.

  www.epa.gov/globalwarming/impacts/stateimp/

- The latest U.S. *National Assessment of Climate Variability and Change* gives a detailed report on the potential effects of global warming in the United States.

  www.nacc.usgcrp.gov/