



***Michigan's  
Natural  
Resources  
and  
Environment:  
A Citizen's  
Guide***

Dear Friend:

Michigan is home to an abundance of high quality natural resources which help support a strong economy and offer a wide range of recreational opportunities to all its citizens. The state's water resources are tremendous, including over 35,000 inland lakes and ponds, more than 49,000 miles of rivers and streams, and over 3,000 miles of coastline on the Great Lakes. Our land resources are also impressive, with fertile soils for agriculture, expansive forest and timberlands, large reserves of oil and gas, and many economically important mineral deposits.

During the state's early years, many of our natural resources were damaged and depleted by reckless exploitation. That trend has been reversed with a series of programs to improve and protect our resources and environment. The Legislature has been particularly active since the 1960s, enacting and supporting many state programs to manage important recreational resources, control pollution, and protect environmental quality.

This *Citizen's Guide* provides general information concerning Michigan's natural resources and the state's efforts to protect the environment. This Guide explores nine natural resource topics and seven environmental topics of interest to the Legislature and Michigan's citizens. Each topic is explored with an introduction, brief explanation of benefits or impacts, statement of current problems (if any), and an outline of how the state manages the resource or protects the environment. Most importantly, each section highlights what citizens can do to enjoy and protect Michigan's natural resources and environment.

To stay informed of activity during the current legislative session, visit the Michigan Legislature's website: <http://www.michiganlegislature.org>.

---

*The information in this publication is available,  
upon request, in an alternative, accessible format.*

---

***Michigan's Natural Resources  
and Environment:  
A Citizen's Guide***

***Prepared by the Michigan Legislature  
Legislative Service Bureau  
Science and Technology Division***

***Revised March 2001***

***This information is provided free to Michigan citizens  
and is not for reproduction for resale or profit.***

# ***Michigan's Natural Resources and Environment: A Citizen's Guide***

## **Introduction**

In many ways, Michigan is defined by its natural resources. Michigan's boundaries, outlined by the Great Lakes, are clearly visible on a road atlas, world globe, or even satellite photographs of North America. Few states can boast such a recognizable "thumb print." Our abundant resources also define our economic base and recreation traditions. Early industrial development in the furniture, steel, iron, and chemical industries relied on abundant supplies of hardwoods, ores, and mineral salts. Farmers thrive on the state's fertile soils and temperate climate. Thanks to the many lakes, streams, forests, dunes, wetlands, and inviting landscapes, Michigan hosts a booming tourism industry.

Michigan legislators have long recognized the value of Michigan's natural resources and environment. The Legislature plays a critical role in directing state policies in these areas by enacting legislation establishing state programs and approving funding. In every 2-year session of the Legislature, legislative committees actively review existing programs to manage, protect, and preserve the state's resources and environment. Sometimes programs enacted years ago through legislation need refinement to work effectively in today's world. Additionally, new problems are investigated and addressed through legislative action. Sometimes the solutions are adopted and new programs are established. Other times, legislators extend the public discussion to gain a deeper understanding of the problem or work through complicated solutions.

This Citizen's Guide has been prepared as an introduction to state programs that protect, preserve, and manage Michigan's natural resources and environment. Sixteen topical areas are discussed in a format that highlights opportunities for citizen action. References to important laws and contacts for further information can be found at the bottom of each two-page section. A list of commonly used acronyms and a subject index are provided in the closing pages to make it easier for citizens to actively pursue a topic of interest or find the information of interest in this document.

## ***Table of Contents***

### ***Introduction***

### ***Natural Resources***

Natural History and Climate / 2

Great Lakes / 4

Inland Lakes and Rivers / 6

Wetlands / 8

Sand Dunes / 10

Agriculture / 12

Forests / 14

Fish and Wildlife / 16

Recreation / 18

### ***Environment***

Air Quality / 20

Water Quality / 22

Waste Management / 24

Waste Management Alternatives / 26

Environmental Cleanup / 28

Land Use / 30

Oil and Gas / 32

### ***Glossary of Acronyms***

### ***Index***

### ***Photo Credits***

***Prepared by the  
Michigan Legislature***

***Revised March 2001***

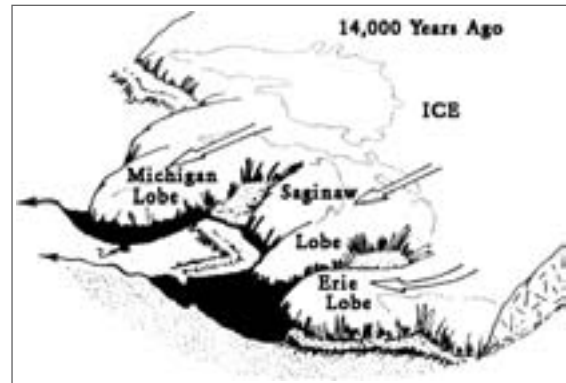
# NATURAL HISTORY AND

Michigan is a geologic basin that began forming over 500 million years ago when large, shallow inland seas covered much of what is now the state of Michigan. Numerous geologic events that occurred over time shaped the state's terrain, deposited mineral resources, and influenced the state's current climate.

## Glaciers Carve Michigan's Terrain

During the Ice Age or Pleistocene Period, continental glaciers repeatedly advanced and retreated over what is now the Great Lakes region. Advancing glaciers scoured the earth's surface, flattening hills and transporting rock material for hundreds of miles like snow before a plow. Linearly shaped mounds of rock material were left behind when the glaciers retreated, creating the rolling hills we see across the state today.

Glaciers also helped build and shape the Great Lakes. Prior to the Ice Age, the sites of the present-day Great Lakes were probably stream valleys. Geologists believe the advancing, massive lobes of glacial ice followed these stream valleys, scraping and scouring deep depressions. When global temperatures rose, causing the ice to melt, the glaciers retreated. Scientists believe that the cyclic pattern of cooling and warming or advancing and retreating glaciers occurred at least four times during Michigan's recent geologic history. Each time, the advancing glaciers carved deeper and wider basins. When the last glacial ice retreated about 10,000 years ago, the lakes were even larger than those we see today. The height and breadth of the ancient lakeshores can be seen in the form of beach ridges and eroded bluffs located high above the present-day Great Lakes shorelines.



### **Michigan Through Geologic Time**

*4.5 Billion - 600 million years ago:* Folding, faulting, and mountain building deformation occur forming the igneous and metamorphic rocks that outcrop in the western Upper Peninsula. Major iron deposits form.

*600 - 280 Million years ago:* Marine seas advance and retreat leaving 14,000 feet of sandstones, limestones, shales, salts, gypsum, and coal. Major oil and gas producing formations are deposited, as well as the thick salt formations below the city of Detroit. Colonial corals grow in the warm shallow seas and become Petoskey stones when fossilized and broken up. When the seas retreated, large continental coal deposits formed.

*280 - 2 Million years ago:* Little is known about this part of Michigan's geologic history because most of these rocks eroded. However, some Jurassic "Red Beds" are found and consist of iron-rich sandstones, shales, and clays.

*2 Million - 500,000 years ago:* Worldwide temperatures drop and glaciers advance and retreat at least four (and possibly six) times over Michigan depositing till and outwash, and carving and shaping the basins of the Great Lakes. During the glaciation, several thousand feet of ice covered Michigan.

*10,000 years ago:* Michigan is free of glacial ice.

## Mineral Riches Left Behind

Michigan's geologic diversity produced a wide variety of mineral resources. Copper was deposited in two forms: metallic or "native" copper ore and nonmetallic copper mineral ore called chalcocite. Michigan's native copper deposits were unsurpassed by any other in the world. More native copper ore was mined in Michigan's Keweenaw Peninsula from 1845 to 1887 than any other place in North America. As native copper ores were depleted, large reserves of chalcocite were mined near White Pine in the Upper Peninsula's Ontonagon County. However, the economics of mining chalcocite resulted in the closure of Michigan's last copper mine in 1995.



# CLIMATE

Michigan's Lake Superior region yielded large amounts of iron ore. As with chalcocite, near-surface deposits of iron ore have been depleted, leaving more costly subsurface mining as the only alternative. Today, only one company extracts iron ore from two subsurface mines in the Upper Peninsula.

Sand and gravel formations are found in varying thicknesses across much of the Michigan Basin. Perhaps the most noteworthy deposits are the large accumulations of windblown sand, or sand dunes, that are found in western Michigan. In addition to its recreational value, sand is also used for construction and industrial purposes (See Sand Dunes, page 10).

One of the world's largest salt accumulations occurs in Michigan. The thickest salt bed, known as the Salina Formation, underlies most of Michigan's Lower Peninsula. At its thickest point, the bed is 3,100 feet from top to bottom. Michigan ranked first or second in the nation in salt production from 1880 to 1926. The mine below the city of Detroit produced rock salt from 1910 to 1983. After a 15-year recess, the Detroit mine reopened in 1998.

Oil and gas are produced from fields scattered across 63 counties in the Lower Peninsula. About 48,390 oil and gas wells were drilled in Michigan between 1925 and 1999. Of these wells, 30% produced oil, 21% produced gas, and the remainder were dry. The state is a net importer of oil and gas. Exploration has boosted our natural gas self-sufficiency from producing 2% of what we consumed in 1970 to 25% in 1999 (See Oil and Gas, page 32).

## Temperate Climate

Michigan owes its temperate climate to the surrounding Great Lakes. Lake water temperatures respond slowly to atmospheric temperature changes, and this slows the onset of winter and summer. Average temperatures in January range from 13°F to 25°F. Average temperatures in July range from 63°F to 73°F. Average annual rainfall and snowfall total 31 inches, but can reach upwards of 180 inches in the Upper Peninsula.

The Great Lakes influence on weather moderates extreme temperatures and adds moisture to the air. These conditions are a boon to farmers, slowing growth until the threat of frost is over and extending the growing season into the fall. Heavy "lake effect" snows are also a boon to winter enthusiasts and the snow-dependent tourism industry around the state.

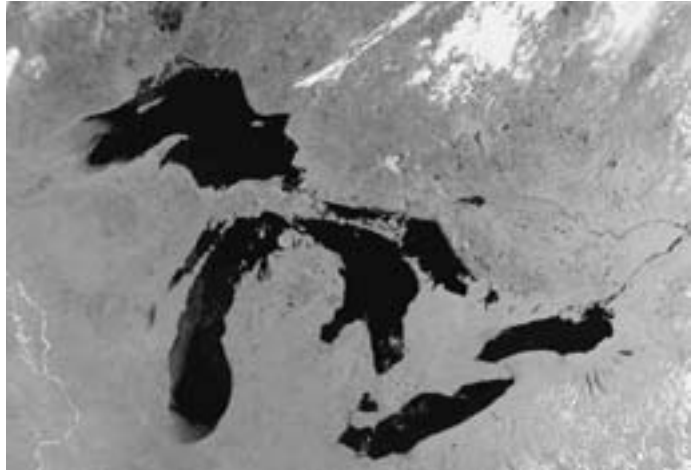
## What Citizens Can Do

In addition to Tahquamenon Falls State Park, Pictured Rocks National Lakeshore, and Sleeping Bear Dunes National Lakeshore, there are many other wonderful places to see Michigan's Geology:

- *Big Springs (KITCH-ITI-KIPI), Manistique*—At Michigan's largest spring, 200 feet across and 40 feet deep, over 10,000 gallons a minute gush from fissures in the underlying limestone. Visitors take a self-operated observation raft to vantage points overlooking underwater features and ever-changing sand shapes.
- *Canyon Falls, L'Anse*—A scenic trail along the Sturgeon River winds past a series of rapids and small waterfalls before you reach Canyon Falls, "Grand Canyon of the U.P."
- *Keweenaw National Historic Park, Calumet*—This park commemorates the heritage of copper mining on the Keweenaw Peninsula: its mines, machinery, and people.
- *The Ledges in Grand Ledge & Fitzgerald Park, Grand Ledge*—These 300 million-year-old majestic rock formations rise 60 feet from the shore of the Grand River and provide a glimpse into how the earth was formed.
- *Arch Rock, Skull Cave and Sugarloaf Stack, Mackinac Island*—These rock outcrops illustrate the wave erosion features along uplifted glacial lakeshores.
- *Gerald E. Eddy Geology Center, Chelsea*—The Eddy Geology Center presents demonstrations, lectures, and workshops on lapidary skills like polishing Petoskey stones and making a gem tree.

# GREAT LAKES

The Great Lakes are the largest surface freshwater system in the world. The five Great Lakes and their connecting waters hold 6 quadrillion gallons of water, enough to cover the entire United States with water over 7 feet deep. This water represents 90% of the United States surface freshwater supply. The Great Lakes basin (the surface area of the Great Lakes and the land draining into the Lakes) covers more than 295,000 square miles and is home to over 33 million people in the United States and Canada.



## Michigan and the Great Lakes

The Great Lakes affect all aspects of life in Michigan. Four of the five Great Lakes border on Michigan. Over 40% of the Great Lakes are under Michigan's jurisdiction, and nearly every drop of water that rains or snows on Michigan's lands eventually flows into the Great Lakes. The Great Lakes keep temperatures moderate and influence rainfall and snowfall throughout the state (See Natural History and Climate, page 3). They provide drinking water for Michigan citizens and water for irrigating Michigan farms. Great Lakes shipping brings in raw products like iron ore and coal that support Michigan's automobile and power industry. Michigan's Great Lakes shoreline, including long expanses of beaches and dunes, provide recreational opportunities for boating, fishing, and vacationing (See Recreation, page 18).

## Great Lakes Issues

The Great Lakes are a vast resource, but they are not inexhaustible, controllable, or impervious to harm. Proposals to divert or remove large quantities of Great Lakes water for use outside of the Great Lakes region

### ***Water Levels***

Great Lakes water levels rise and fall during the year and over the course of decades under the influence of natural weather events and climate cycles. Water levels may differ by as much as 1.5 feet from summer to winter and as much as 5 feet over the course of decades. The most important factors influencing these fluctuations are rain, snow, and evaporation from the Lakes, not water diversions or water level control structures. Various control structures partially regulate the levels of Lake Superior, Lake Michigan, Lake Huron, and Lake Ontario. Extreme high water levels cause coastal flooding and shoreline erosion. Extreme low water levels make boat launching and navigating difficult in shallow areas, and make commercial shippers carry less cargo to avoid going aground. However, the cycle of high and low water levels is essential for maintaining Great Lakes wetlands and the diversity of wetland plants and animals. To help Michigan citizens, the Michigan Legislature has passed laws to help prevent construction in high risk flood and erosion areas as well as to provide temporary low interest loans to cover dredging costs. More information on Great Lakes water levels may be found on the U.S. Army Corps of Engineers' website at [hur.on.lre.usace.army.mil/levels/hmpglv.html](http://hur.on.lre.usace.army.mil/levels/hmpglv.html).

have been a consistent cause for concern. The dramatic natural changes in water levels from year to year and their impact on Michigan residents are a periodic problem. Pollution has contaminated many areas and limited recreational opportunities. Fish consumption advisories to protect the health of Michigan citizens are in place for certain fish caught in the Great Lakes because of unsafe levels of persistent toxic contaminants like PCBs. Great Lakes fisheries have been decimated over the last 50 years by the



sea lamprey, an exotic species. The continued introduction of exotic species threatens native plants and animals and the stability of the Great Lakes environment.

## Managing the Lakes

Actions at the state and federal levels help address many Great Lakes issues. To limit Great Lakes diversions, a number of agreements and laws require the consultation and approval of all states and Canadian provinces in the Great Lakes region before water can be diverted from the Great Lakes basin. Since the late 1980s, the Michigan Legislature has forbidden the diversion of Michigan's Great Lakes water out of the Great Lakes basin. To help protect the Great Lakes shoreline for residents and other users, state and federal permits are required before shoreline structures like docks and bulkheads (seawalls) can be built in Great Lakes waters. Activities and development on adjacent land areas are restricted in critical sand dunes, environmental areas, coastal wetlands, and high risk erosion and flood areas (See Sand Dunes, page 10). In addition to statewide and nationwide water quality laws, the United States and Canada have specifically agreed to address in a coordinated manner water quality problems in the Great Lakes (See Water Quality, page 22). Areas of Concern (AOCs), including 14 in Michigan, have been identified for immediate cleanup. To help fisheries, the national, state, and provincial governments carry out a sea lamprey control program and stock the Great Lakes and its tributaries with sport fish (See Fish and Wildlife, page 16).

### ***What Citizens Can Do***

#### **Exotic Species - Zebra Mussels:**

- Inspect and remove plants and animals from boats, trailers, trucks, and other equipment before leaving a lake or river.
- Drain water from boat equipment at the ramp or access before leaving a lake or river.
- Wash boats and equipment with hot water and dry for at least three days before launching in another lake or river location.

#### **Water Levels:**

- Apply early for dredging permits during periods of low water levels.
- Install shoreline protection structures to protect homes and businesses from high water levels after obtaining necessary state and federal permits.
- Build shoreline homes, businesses, and structures like docks with extreme high and low water levels in mind.

### ***Exotic Species – Zebra Mussels***

The zebra mussel is a small freshwater animal like a clam that is native to Europe. Zebra mussels were most likely introduced accidentally to the Great Lakes in the mid-1980s in ballast water dumped by ocean-going ships. Since that time, zebra mussels have spread to all of the Great Lakes and at least 119 of Michigan's inland lakes. Zebra mussels grow in large bunches that attach to hard surfaces. They can clog water intake pipes at power plants and drinking water facilities, and may also lead to decreased native fish populations and increased aquatic weed growth. Damage from zebra mussels has been estimated to be as high as \$100 million per year. However, zebra mussels may have helped clean the Great Lakes by filtering pollutants out of the water. The state of Michigan and other organizations are working to educate boaters and other water users on methods to prevent the spread of zebra mussels and other exotic species. In addition, the federal government now has regulations to prevent future introductions of exotic species from ocean-going ships. More information on zebra mussels and exotic species may be found on the Michigan SeaGrant's Zebra Mussel/Aquatic Nuisance Species Office website at [www.msue.msu.edu/seagrant/sgezms.html](http://www.msue.msu.edu/seagrant/sgezms.html) or by calling (517) 353-9748.

# INLAND LAKES AND RIVERS

Michigan has over 35,000 inland lakes and ponds, which collectively have an area of nearly 1,400 square miles. In addition, the state has more than 49,000 miles of rivers and streams. Together with the Great Lakes and groundwater aquifers, Michigan's inland lakes and rivers provide abundant, clean fresh water for agricultural, industrial, recreational, and domestic use. At the same time, they provide habitat for sport and commercial fish, waterfowl, and other wildlife.



## Inland Lake and River Issues

The many uses of inland lakes and rivers can impact each other and, unchecked, can lead to degradation of these valuable water resources. Certain types of structures or developments on inland lakes and rivers, such as boat docks, marinas, dams, and dredged boat channels,

may increase the value of these resources to homeowners, recreational users, industry, and society. However, poorly designed projects or sloppy construction practices can degrade inland lake or river water quality for fish and wildlife. For example, construction projects can dislodge soil and sediments that cloud the water and bury fish breeding habitat.

### ***Watersheds and Watershed Management***

A watershed is the land area that drains into a specific lake, river, or other surface water body. Watersheds come in many sizes. For example, the Grand River watershed may be broken up into smaller watersheds associated with its tributaries like the Red Cedar and Rogue River. In turn, the Grand River watershed is part of the much larger Lake Michigan watershed. Activities throughout the watershed can affect the water quality of a lake or river (See Water Quality, page 22). Therefore, watersheds are the preferred regional area for planning and coordinating efforts to improve water quality. Government agencies, businesses, citizens and other groups consider the watershed impacting a lake or river and prioritize pollution control efforts based on this watershed. Efforts begin with the development of a watershed management plan that identifies problems and solutions for a watershed and its major lake or river. The plan is the blueprint for future actions to protect and rehabilitate lakes and rivers. Federal and state grants to develop watershed management plans and implement provisions of the plan are available. In addition, the Michigan Legislature has authorized the formation of watershed councils to promote cooperation among local governments in a watershed. More information on watersheds and watershed management can be found on the DEQ's Michigan Watershed homepage at [www.deq.state.mi.us/swq/watershd/](http://www.deq.state.mi.us/swq/watershd/) or the U.S. EPA's website at [www.epa.gov/owow/watershed/](http://www.epa.gov/owow/watershed/).

Water quality may be degraded when pollutants flow into inland lakes and rivers from pipes, rain, snow, and surface runoff. Toxic mercury can accumulate in wildlife and lead to official warnings on eating too much fish. Excess plant nutrients like phosphorus can contribute to the growth of nuisance aquatic plants and algae that make the water unpleasant for swimming and clog boat propellers. Often these nuisance plants are exotic, non-native species like the Eurasian watermilfoil. Exotic plants and animals in general can harm native fish and wildlife and decrease their populations.

## Protecting Inland Lakes and Rivers

The Michigan Legislature has addressed many of these issues over the years. To prevent damage caused by careless construction, the Michigan Legislature established a permitting program. Anyone who wishes to dredge, fill, divert water, or build a structure in the floodplain of a river or the bottom land of an inland lake or river must first obtain a state permit.

The bottomland includes all lands below the ordinary high water mark of the water body. Since the water's edge may be below the ordinary high water mark at certain times as during a drought, what could appear to be dry land may actually be regulated under the law. Permits are also required before applying pesticides for aquatic weed control.

Inland lake and river water quality is protected under numerous state and federal laws (See Water Quality, page 22). In addition, the state of Michigan promotes the development of watershed management plans to coordinate federal, state, and local water quality efforts. The state may also designate outstanding river and river segments as natural river areas and provide them with special protection to preserve and enhance their recreational and environmental value.

To protect natural resources and property values, the Michigan Legislature allows local groups to help themselves. Lakeshore residents can form lake boards to oversee and raise funds for inland lake improvements like dredging and aquatic weed control. Lakeshore residents may also petition for counties to maintain lake water at normal levels. To support these efforts to protect inland lakes and rivers, the state of Michigan has monitored water quality in large public lakes and helps coordinate a volunteer monitoring program for other lakes. Monitoring occurs periodically and measures the plant nutrient levels in these lakes. In addition, toxic contaminants are measured in fish from eight Michigan lakes. In recent years, the Michigan Legislature has required the development of a more comprehensive monitoring plan.

### ***What Citizens Can Do***

- Check with the DEQ to determine if a permit is necessary before planning and constructing structures adjacent to a lake or river, or undertaking chemical control of aquatic weeds.
- Be aware of fish consumption advisories for Michigan's inland lakes and rivers. Check for advisories on the DCH website at [www.mdch.state.mi.us/pha/fish](http://www.mdch.state.mi.us/pha/fish).
- Get involved with local lake, river, or watershed groups that help preserve these water resources.
- Avoid dumping aquarium water or live fish bait in inland lakes or rivers to help limit the spread of exotic species.

### ***Groundwater***

Groundwater is water that flows very slowly underground to and from lakes, rivers, springs, and wells. About 95% of the freshwater supply in the United States is groundwater. Groundwater originates when rain and snow falls on the land and soaks into the ground. This water moves downward through spaces between soil particles and porous rock. Beginning at a certain depth known as the water table, these spaces become filled entirely with groundwater. Abundant groundwater capable of supporting wells for drinking water and other uses is found in geologic formations called aquifers. Over 40% of Michigan citizens use groundwater as their main source of drinking water. Nearly 40% of Michigan farmers use it for crop irrigation and livestock. Many industries use groundwater for food processing, manufacturing, and other industrial purposes. When groundwater is depleted, wells can stop producing water and run dry. Chemical pollutants also can be washed down wells or seep down with rain, and contaminate groundwater. The Michigan Legislature has passed a number of laws to protect groundwater from activities that have the potential to degrade its quality, such as the use of unlined municipal sewage lagoons or the application of fertilizers and pesticides to farmland (See Agriculture, page 13). More information on groundwater can be found at the Groundwater Foundation website at [www.groundwater.org](http://www.groundwater.org).

# WETLANDS

Wetlands are areas where soil is wet or saturated with water for at least part of the year. These wet conditions create soils typical of wetlands and support specialized plants that thrive in water or wet conditions. All wetlands share these characteristics but may appear very different. Historically, wetlands were filled or drained to provide land for farming and development and to eliminate mosquito-breeding areas. Government incentives were common for these actions. Today, wetlands have been recognized to provide important public services such as flood control and water purification. Throughout the 1990s, the national policy goal has been “no net loss” in wetland acreage throughout the nation.

## Wetland Values

Wetlands are valuable resources that may perform a number of functions that benefit individuals and society. Wetlands may:

- Filter soil particles and other pollutants from the waters that flow through them and help maintain water quality for swimming, fishing, and drinking.
- Protect shorelines and lakeshore homes and businesses from erosion caused by storms and waves.
- Prevent flash flooding by acting like sponges and temporarily absorbing water during rainstorms before it reaches lakes and rivers.
- Support recreational activities and game species like fish, deer, ducks, and geese as well as other types of wildlife, including rare and endangered plants and animals.



Not all wetlands provide these benefits and not all wetlands provide these benefits at the same level but all wetlands perform some valuable role. However, wetlands may also provide homes for mosquitoes and other pests that may spread malaria, encephalitis, and other diseases.

### ***Michigan Wetlands***

*Bogs and Fens* are wetlands found in northern areas that accumulate peat, a spongy soil made up primarily of partially decomposed plants. Carnivorous plants like pitcher plants and sundews are found in bogs and fens.

*Marshes* are wetlands where the ground is covered with water for large portions of the year and populated by soft-stemmed plants that rise above the water surface, such as cattails. Floating plants, such as water lilies, and completely submerged plants are also found in marshes.

*Swamps* are wetlands that are covered by trees or shrubs. Red maple, northern white cedar, and black willow are commonly found in Michigan swamps.

## Impacts on Wetlands

The most serious threat to wetlands continues to be draining and filling to create dry areas for agriculture and urban development. About 50% of the wetlands that were present when the first European settlers arrived in Michigan are now farm fields, shopping malls, and other types of development. In addition to development, wetlands may be harmed by less obvious threats. Too much pollution flowing into wetlands from nearby activities may overload their capacity to filter pollutants. Wildlife habitat in particular may be impacted by the heavy flow of pollutants into a wetland. Exotic (non-native) plants or animals can crowd out native plants and harm animals dependent on those plants. Finally, wetland management to enhance one wetland value may have adverse impacts on other values. For example, wetlands may be managed to create more open water for ducks at the expense of fish habitat.



## Managing Activities in Wetlands

Draining and filling of wetlands is regulated at the federal and state levels. In 1979, the Michigan Legislature established requirements that a person planning to drain, fill, or carry out any use or development activity in wetlands must first obtain a state permit. For wetlands on the Great Lakes coastline and along portions of certain large rivers, a person must also obtain a federal permit. Finally, local communities are authorized to adopt wetland ordinances that may or may not include local permitting requirements.

Permits ensure review of proposed activities in wetlands, not necessarily the prohibition of these activities. Activities may still be carried out in a wetland if approved by the permit, but the approval may require changes to the proposed project to limit impacts on the wetland or to compensate for any impacts. Furthermore, certain activities including recreation, construction of a farm or forestry road, or activities in smaller wetlands may not need a state permit. However, failure to obtain a necessary permit is a violation of state and federal wetland laws and is punishable by fines. Local governments also enforce their wetland ordinances.

## ***Exotic Species - Purple Loosestrife***

Purple loosestrife is an exotic wetland plant native to Europe and Asia. It was most likely introduced to the United States in ships' ballast water over 150 years ago. Purple loosestrife's colorful flowers, hardy nature, and abundant nectar have made it popular with some gardeners and beekeepers. However, it is a serious problem in wetlands where it grows densely and crowds out native plants. Wetlands that have been invaded by purple loosestrife may lack the high quality food, breeding, and nesting sites provided by native plants and required by fish and wildlife. In 1997, the Michigan Legislature banned the sale of certain varieties of purple loosestrife. In addition, the DNR attempts to control its spread in game and wildlife areas. Citizens can also help control the spread of this harmful plant by learning to recognize it and removing it where it grows. More information on purple loosestrife may be found at the Purple Loosestrife Project website at [www.msue.msu.edu/seagrant/pp/](http://www.msue.msu.edu/seagrant/pp/) or by calling (517) 353-9568.

## ***What Citizens Can Do***

- Contact the DEQ before planning any construction in a suspected wetland.
- Establish and maintain a buffer of natural vegetation around a wetland.
- Avoid activities that may disturb a wetland, for example, mowing.
- Install fencing to prevent trampling by people and livestock.
- Restore wetlands on old farm fields.
- Sell or donate the development portion of your property rights for a wetland to a conservation organization.
- Control exotic or nuisance species like purple loosestrife.

A number of state, federal, and private programs exist to provide financial assistance for these efforts.

# SAND DUNES

---

Sand dunes are ridges or hills of loose sand piled up by the wind. Dunes are among the youngest natural land formations in Michigan. Most Michigan dunes are located along the shores of Lake Michigan and are only 3,000 to 4,000 years old. However, much of the sand that created the dunes was deposited hundreds of thousands of years ago when glaciers covered the state. The last of these great “ice sheets” covering the Midwest began to melt and retreat about 14,000 years ago. As the glacier melted, millions of tons of rock debris (including boulders, cobbles, sand, silt, and mud) were left behind. Gradually, wind and wave action sorted the debris, and piled up the sand grains along the shorelines, creating the dunes we see today along Lake Michigan.



Although there are dunes along the Lake Superior shoreline, Lake Michigan houses the largest concentration of freshwater sand dunes in the world. Michigan’s largest dunes reach 250 feet in height and up to 1 mile in width. Michigan designated 200,000 acres of sand dune areas along the Great Lakes shorelines for regulation and protection.

## Habitat, Housing, and Recreation

The dunes support plant and animal life that cannot be found elsewhere. The Piping Plover, a federally endangered bird nests along Michigan’s sand dune shorelines. In addition, a number of threatened plant species can be found in the dunes, including: Houghton’s Goldenrod, Pitcher’s Thistle, and the Dwarf Lake Iris (Michigan’s state wildflower). Dunes also moderate winds and weather from the lakes, protecting coastal marshes and their inhabitants.

Lakeside sand dunes are popular sites for residential developments. Many people have built year-round and vacation homes along much of the Lake Michigan shore. However, residential development has not been without costs. Sand dunes readily change shape as the wind and waves shift loose sand grains, creating potentially unstable dune areas. Homes and other structures have been damaged or destroyed by fluctuating lake levels and shifting sands. The problem is made worse during home construction or remodeling when vegetation that grows on and stabilizes the dunes is removed. Removing the dune vegetation exposes the sand to the forces of the wind and rain.

Sand dunes also provide a unique recreational environment. People of all ages visit Michigan dunes to soak up sun, enjoy swimming or wading, ride ORVs, or simply walk across the miles of sand bordering the shoreline. The popularity of sand dunes is evident from the large number of visitors to Michigan’s coastal treasures, such as Sleeping Bear Dunes. Of Michigan’s 99 state parks, 18 contain sand dunes, including P. J. Hoffmaster State Park which boasts 2½ miles of sandy shoreline with towering sand dunes and a stairway leading to the top of a high dune overlook. The Gillette Sand Dune Visitor Center, located at the park, offers programs, exhibits, and hands-on displays that tell the story of Michigan’s sand dunes. Silver Lake State Park is the only state park with sand dunes open to ORVs. The 450-acre vehicle scramble area is separate from the pedestrian area, allowing foot traffic on the dunes as well.

## Sand Dune Mining

Sand from dunes has unique characteristics which makes it economically valuable. Coastal dune sand is noted for its purity, uniform grain size, and ease of extraction. Thus, mining dune sand is a profitable business in Michigan. Dune sand is used by the foundry industry for producing molds and cores and the construction industry for fill. Glass is manufactured from high quality dune sand, as is certain types of sandpaper.



Sand dune mining has been regulated in Michigan since 1976. Sand from *Designated Sand Dune Areas* (created in rules) can be mined if an operator obtains a permit from the DEQ. To obtain a permit, the sand dune mining operator must submit an environmental impact statement, a 15-year mining plan, a reclamation plan, and a bond of \$2,000 per acre of disturbance. The operator must also forecast the future mining locations, acreage of sand dune areas, and amount of sand proposed for future mining efforts. A sand dune mine operator is limited to a total of 30 acres of disturbance at any one time.

Even though sand from dunes has unique economic characteristics and is easily extracted, sand dune mining has steadily decreased over the last few years due to industrial reuse of sands, competition from inland sources, and the development of more heat-resistant materials, such as ceramics. In 1976, about 3.6 million tons of sand were mined from dunes. By comparison, just over 2.5 million tons of sand were mined from dunes in 1998.

## Critical Dune Areas

*Critical dune areas* are dunes that have been determined to be unique, irreplaceable, and fragile resources. They encompass both open, unvegetated dunes as well as highly vegetated and wooded dune regions. The Michigan Legislature required that all critical dunes areas be mapped by the DEQ. A total of 71,189 acres have been designated as critical dune areas and are protected under statute due to their significant recreational, economic, scientific, geological, scenic, and other benefits to the people of this state. When a person wishes to alter the physical characteristics or contour of a critical dune area due to silviculture, recreation, or construction, he or she must obtain a use permit from the DEQ or the local unit of government if a local zoning ordinance has been adopted. However, certain activities are prohibited in critical dune areas, including hydrocarbon and brine surface drilling operations or production facilities. In general, sand dune mining is prohibited in critical dune areas unless the mine operator is renewing or amending an existing mine permit issued before July 5, 1989.

### What Citizens Can Do

- Understand permit requirements for building in dune areas. Know where to obtain permit information if an application becomes necessary.
- Educate local governments to the public, recreational, and environmental benefits of sand dunes.
- Follow the “no impact” theory when recreating on the dunes. Protect dune grasses and avoid areas where birds may nest.
- Enjoy the Michigan sand dunes. Check out the DNR website for state parks featuring sand dunes.

### Inland Sand and Gravel Mining

As glaciers melted, sand and gravel was deposited all across Michigan. Inland sand and gravel deposits are not as well sorted as dune sand, but are also a good source of construction, foundry, and landscaping materials. Michigan boasts inland sand and gravel mining in almost every county of the state.

Michigan does not specifically regulate sand and gravel mining except *when the sand is mined from a sand dune*. However, certain inland sand and gravel mining practices or mine locations may impact other natural resources which are regulated under state statute and rule. A mine owner or operator may be required to obtain a permit from the DEQ if the inland mining operation: creates a water; impacts a wetland; discharges waste to groundwater or surface water, or generates large amounts of fugitive dust.

Thus, the state may regulate certain activities that are associated with inland sand and gravel mining, even though *there is no requirement for a state permit to mine sand or gravel outside of regulated dune areas*.

## Contacts

For a mining permit: DEQ, Geological Survey Division, (517) 334-6907, [www.deq.state.mi.us/gsd](http://www.deq.state.mi.us/gsd)  
For information on critical dunes: DEQ, Land and Water Management Division, (517) 335-3458, [www.deq.state.mi.us/lwm](http://www.deq.state.mi.us/lwm)  
For state parks information: DNR, Parks and Recreation Division, (517) 373-9900, [www.dnr.state.mi.us](http://www.dnr.state.mi.us)

# AGRICULTURE

Agricultural land remains one of Michigan's most valuable natural resources. Agriculture is Michigan's second leading industry, contributing about \$35 billion to the state's economy annually. Cash receipts from the sale of crops and livestock were \$3.5 billion in 1998, 22nd in the nation. Michigan's 52,000 farms encompass approximately 10.4 million acres or almost 30% of Michigan's land area. Crops were harvested from almost 7 million acres of this land.



## Agricultural Production

More than 100 commercial crops are produced in Michigan which is second only to California in crop variety. Nationwide, Michigan ranked among the top producers of more than a dozen different types of crops in 1998. These crops include dry beans, blueberries, tart cherries, Niagara grapes, potted geraniums, and hanging flower baskets. However, Michigan's most valuable crops are corn and soybeans. They accounted for 34% of Michigan's crop values or about \$730 million.

The livestock industry is essential to Michigan agriculture, accounting for almost 40% of the total 1998 cash receipts from farming. Milk production is Michigan's single largest agricultural product based on cash receipts. In 1998, Michigan's 300,000 dairy cows produced 5.4 billion pounds of milk with sales of \$815 million.

## Farmland Preservation

Despite the importance of agriculture to Michigan's economy, the number of farms and the amount of farmland in the state is declining. Farmland in Michigan and nationwide is slowly being converted to other land uses. Between 1982 and 1992, 854,000 acres of Michigan farmland were converted, primarily to residential development. Once a farm is developed with homes or businesses, that land is lost for any future food production and wildlife habitat. The reason for these farmland losses is a complicated combination of economic, political, and social forces that have resulted in poor farm profitability (See Land Use, page 30).

### **The Drain Code**

The Michigan Drain Code regulates the construction, maintenance, and improvement of drains. These regulations include agricultural drains that make farming possible in many wet regions of Michigan. However, drains may destroy valuable wildlife habitats and deliver farm pollutants to lakes and rivers. Activities under the Drain Code are carried out by an elected county Drain Commissioner and charged to landowners benefiting from drainage. Many groups are concerned over the limited public input and lack of environmental protections in the Drain Code. In recent years, the Michigan Legislature has debated major amendments to the Drain Code that would strengthen the responsibility of Drain Commissioners to protect the environment, increase public input, and streamline the process for drain construction, maintenance, and improvements.

Over the years, the Michigan Legislature has instituted programs to help lighten the financial burden on farmers. The Legislature protected farmers from certain lawsuits filed by neighbors concerning noise and odor, and provided tax relief and payments if a farmer agree to keep his land in agriculture or its natural state. In 1999, the Michigan Senate Agricultural Preservation Task Force concluded an investigation into the forces threatening agriculture in Michigan and recommended solutions. The Legislature

passed a number of laws incorporating these solutions, including additional tax relief, incentives for the establishment of businesses that process farm production into marketable products, increased funding for the purchase of development rights (PDRs), and increased protection from local government regulations. The Legislature also continues to promote promising new markets like organic farming.

## Environmental Issues

The production of plants and livestock for human use often results in unintended impacts on surrounding people and the environment. Pesticides and fertilizers that may be necessary for large-scale crop production can be a danger to farm workers and neighbors. Soil erosion from farms decreases the long-term productivity of farmland. Manure from livestock operations can emit unpleasant, noxious odors. Pesticides, fertilizers, soils, and manure can all pollute nearby lakes and rivers if they are not managed properly. The Michigan Legislature has established programs to address many of these problems. Michigan and the federal government regulate the manufacture, sale, and application of pesticides and fertilizers through licensing and registration. A variety of state and federal programs encourage farmers through education and grants to implement practices that limit soil erosion and the amount of pollutants that washes off their land. With the cooperation of farmers, these programs and many others help to maintain Michigan's agricultural industry and protect Michigan's environment.

### What Citizens Can Do

- Purchase Michigan grown and manufactured products by looking for the "Select Michigan" label.
- Examine killed deer for pea-sized tan or yellow lumps or lesions on the lungs or inner rib cage that might indicate bovine TB infection.
- Turn in deer heads to a DNR office or check stations for free bovine TB testing when deer are killed in the northern Lower Peninsula.



### Bovine Tuberculosis

Bovine Tuberculosis (TB) is a disease that infects a wide range of animals including cattle, deer, and humans. It is spread among livestock and wild animals when animals are in close contact ("nose-to-nose") as well as by the consumption of raw contaminated food. In the early 20th century, bovine TB killed more livestock in the United States than all other livestock diseases combined. Since that time, the federal and state governments have carried out an aggressive and successful campaign to eradicate the disease from livestock. After 20 years of successful suppression, bovine TB has reemerged as a problem in Michigan. It has apparently spread in the wild deer population, and cattle and captive cervid (elk and deer) herds are being infected. In response, the Michigan Legislature has supported an extensive testing program for these herds and restricted the movement of cattle and captive cervids from high-risk areas. Infected herds are destroyed, and farmers compensated for the value of the livestock. In addition, surveillance of wild deer is being conducted. Restrictions have also been instituted on practices that promote the gathering of large numbers of deer nose-to-nose like feeding and baiting. In the meantime, federal and other states' laws restrict the ability of Michigan farmers to sell their livestock out of state. For more information on bovine TB, visit a joint agency website at [www.bovinetb.com](http://www.bovinetb.com) or call the DNR's Wildlife Division at (517) 373-9358 or the MDA's Animal Industry Division at (517) 373-1077.

# FORESTS

---

Michigan has over 19.3 million acres of forests covering more than half the land area of the state, mainly in the Upper Peninsula and northern Lower Peninsula. Michigan has the fifth largest amount of timberland (forestland that can produce commercial timber) in the United States. Hardwoods such as maple, aspen, and oak make up 75% of the trees in the state, while softwoods, including pine, spruce, and cedar comprise the remaining 25%. More than 75 different types of trees grow in the state. Michigan's forests are home to an abundance of plants and animals, including moose, bear, wolves, deer, and one of the rarest birds in the world, the Kirtland's warbler. Michigan's forests provide many social, environmental, and economic benefits.



## Social Value

Michigan's State Forest system covers over 3.8 million acres. It is the largest State Forest system in the United States. There are three national forests in Michigan covering about 2.7 million acres of land, the Ottawa, Hiawatha, and Huron-Manistee National Forests. Many people visit Michigan forests to participate in recreational opportunities such as camping, hiking, hunting, and wildlife viewing (See Fish & Wildlife and Recreation, pages 16 and 18). Many kinds of wildlife depend on the cover, food, and environment that trees provide.

## Environmental Value

Michigan's forests play a key role in maintaining air and water quality. Trees are an important part of the natural carbon cycle. Human activities have increased the amount of carbon dioxide (CO<sub>2</sub>) in the atmosphere and this increase affects global warming (See Air Quality, page 20). Trees help to reduce atmospheric CO<sub>2</sub> levels by taking CO<sub>2</sub> from the atmosphere and trapping the carbon as wood. Trees improve surface water quality by reducing the amount of chemicals that enter our waterways and by reducing soil erosion.

## Economic Value

Most of the forestland in Michigan is in the hands of private owners. Approximately 11 million acres are owned by individuals or small groups and 1.5 million acres are owned by industrial wood products companies. Private ownership accounts for two-thirds of the forestland in the state, while public forests make up the remainder. Each year about 322 million cubic feet of timber are harvested from Michigan's public and private forests to manufacture products ranging from paper to lumber to furniture. The state is also a leader in plantation-grown Christmas trees. One fifth of all Christmas trees in the U.S. come from Michigan. About 150,000 Michigan citizens work in forest-related industries that contribute about \$9 billion to Michigan's economy. Forest-based recreation and tourism bring in around \$3 billion and provide jobs to 50,000 people in the state.

## Forest Issues

Michigan's forest health is threatened by many issues including fragmentation, disease, and exotic species. Human development fragments forestland into smaller and smaller parcels. Fragmented forestland causes problems for many animals such as the cougar and lynx because they need large areas in which to roam.

The cougar and lynx are on the Michigan endangered species list. Diseases, such as oakwilt and beechbark disease, can seriously damage trees and in many cases bring about tree mortality. Perhaps the most serious threat is the introduction and spread of exotic (non-native) species, such as the gypsy moth and the Asian longhorned beetle, which can harm native wildlife and plantlife and cause property damage and other nuisances, requiring costly control efforts.

## Sustainable Forestry Management

An important challenge for forest managers is to balance the environmental and social value of forests with their economic value and society's need for forest products. The current federal and state forest management philosophy to balance these needs is called sustainable forestry. Under sustainable forestry, social and environmental needs are evaluated alongside society's need for forest products. The number of trees harvested in a forest is designed to meet the needs of the present generation without compromising the needs of future generations. Federal and state laws mandate that federal- and state-owned forests be managed sustainably.

In addition, there are governmental laws which provide for programs to encourage sustainable management practices on privately owned forestland. Michigan's Commercial Forest Program operated by the DNR gives tax incentives to private forestland owners under certain conditions. First, their forestland must meet the statutory definition of timberland, and second the owner must develop a forest management plan. A number of federally-funded programs operated under the USDA Forest Service, State and Private Forestry Division, also promote sustainable forestry. One example is the Forestry Incentive Program which provides financial, technical, and educational assistance to non-industrial private forest landowners to protect, maintain, conserve, and improve forestland to increase the nation's supply of timber products.

### **What Citizens Can Do**

- Plant a tree ([www.msue.msu.edu](http://www.msue.msu.edu))
- Reduce paper use and re-cycle.
- Volunteer in urban and community forest projects. In the Detroit Area call (313) 237-8733.
- Manage your land for forest sustainability.
- Buy wood products bearing the ecolabel.

### **Exotic Species - Gypsy Moth**

The gypsy moth was introduced to North America in 1868. It is an exotic insect pest of various hardwood and some softwood trees in many parts of North America, including Michigan. The caterpillar eats tree leaves before it spins a cocoon and develops into a moth. The moths do not damage trees. The favorite trees of the caterpillar are oak, alder, aspen, willow, apple, basswood, hawthorn, and birch. The damage caused by gypsy moth caterpillars has many consequences. Trees that are repeatedly defoliated (leaves removed) are weakened, they grow more slowly, become vulnerable to diseases, and may die. Wildlife may suffer by the loss of tree cover, and the loss of acorns and other tree seeds that many animals eat. In addition, landowners can lose valuable timber acreage. In 1999, 176,626 acres of forests in lower Michigan were defoliated by the gypsy moth. State officials at the DNR and the MDA address the gypsy moth problem in four ways: (1) by monitoring the extent of the gypsy moth infestation, (2) educating the public on gypsy moth control, (3) using natural control measures such as predators and parasites, and (4) providing money to local governments to help pay for pesticides in problem areas. For more information see: [www.mda.state.mi.us/hot/gypsy moth/](http://www.mda.state.mi.us/hot/gypsy%20moth/) or call the MDA at (517) 335-0730.

## Contacts

USDA, Forest Service, [www.fs.fed.us](http://www.fs.fed.us)  
DNR, Forest Management Division, (517) 373-1275, [www.dnr.state.mi.us](http://www.dnr.state.mi.us)  
Michigan Forest Resource Alliance, (800) 474-1718, [www.mfra.org](http://www.mfra.org)  
Sustainable Forestry Initiative, [www.michiganforestry.com](http://www.michiganforestry.com)



# FISH AND WILDLIFE

Michigan's extensive water resources and vast forestlands provide many recreational opportunities including hunting and fishing. Hunting and fishing have been part of life in Michigan since before the territory became a state in 1837. Early in the state's history, a number of game animals were overhunted, many to the point of extinction. Sportsmen became alarmed at the decline of game and called for controls on hunting. In 1859, the first of many hunting and conservation laws was enacted by the Michigan Legislature, setting a closed season on deer, turkey, woodcock, and partridge. Other laws followed and Michigan began rebuilding its game populations through conservation practices and wildlife management. Today, hunting is a multi-million-dollar sport.



## Hunting and Fishing

An estimated 1 million citizens participate in hunting activities throughout the year. An additional 16,000 citizens possess fur harvester's licenses. The DNR manages game areas throughout the state for use by hunters. Popular game animals and birds include deer, bear, wild turkey, elk, waterfowl, pheasant, quail, woodcock, grouse, and fox.

### ***Lifetime Licenses***

Lifetime licenses were made available in March of 1989 as an alternative means to addressing budget shortfalls in the Game and Fish Protection Fund. A game and fish lifetime license trust fund in the state treasury was created to receive the money raised from the sale of lifetime licenses. Each year, funds are transferred from the Lifetime License Trust Fund to the Game and Fish Protection Fund in the amount the DNR would have received had individuals purchased regular licenses each year. The intent of the Lifetime License Trust Fund is to provide a steady stream of income to the Game and Fish Protection Fund. Lifetime licenses were sold from March 1, 1989 through February 28, 1990. Prices for the licenses ranged from \$220 for a restricted fishing license (trout stamp not included) to \$285 for a firearm deer license to \$1,025 for a comprehensive sportsperson license. A total of 3,135 lifetime licenses were sold including 856 comprehensive sportsperson licenses, 621 firearm deer licenses, and 883 restricted fishing licenses. More than \$1.5 million was raised by the lifetime license sale.

Michigan's Great Lakes, 35,000 inland lakes and ponds, and over 49,000 miles of rivers and streams make our state a fisher's paradise. An estimated 1.4 million residents purchase fishing licenses each year. Another 129,000 out-of-state residents also purchase licenses to fish in Michigan waters. The value of recreational fishing to Michigan's economy is about \$2.0 billion. About one-quarter of this value is derived from hatchery-reared fish, including most recreationally-caught Great Lakes trout and salmon. In 1996, Michigan's Great Lakes commercial fisheries netted more than 16.6 million pounds of whitefish, chubs, perch, lake trout, and other species with a dockside value of \$10.5 million. Michigan's lakes and rivers support a variety of fish including perch, pike, bluegill, salmon, lake trout, brown trout, bass, and walleye.

Sportfishing is a billion-dollar industry in Michigan. However, fisheries have had upswings and downswings. Many fish populations, mainly in the Great Lakes, have been threatened by habitat destruction, pollution, overfishing, disease, and exotic (non-native) species such as the sea lamprey. The DNR, responsible for managing and enforcing fishing laws in the state, has used restocking programs and fish hatcheries to maintain fish populations around the state. Even with the fluctuations in fish population, sportfishing remains an economically important use of our natural resources in Michigan.



## Licensing

Licensing hunters and fishers in Michigan is done by computer. Electronic licensing provides the DNR with immediate access to license buyers' names and addresses, and sportspeople whose licenses have been revoked can be easily tracked. The DNR can track the number of licenses sold by each agent and the amount of money due the Game and Fish Fund. The electronic system has been in place since March 1994.

Beginning December 2000, sportspeople are also able to purchase their licenses online, through the DNR's Internet site using a personal computer. The online licensing site allows users to purchase licenses 24 hours a day, 7 days a week, during the appropriate season. To purchase a license online, users need a valid Michigan driver's license, Michigan ID card, or sportsman ID card. Many of the licenses available online, including small game and fishing licenses, can be printed at home.

## Nongame and Endangered Species

Although hunting and fishing are very popular in Michigan, more than 80% of the wildlife in the state are nongame species. Examples of nongame animals include wolves, loons, eagles, bats, and flying squirrels. The Legislature established the Nongame Wildlife Fund in 1985 to protect nongame and endangered wildlife and plants and their habitats. More than \$6 million has been contributed to the fund by Michigan citizens since 1985.

### **What Citizens Can Do**

- Review the Hunting and Trapping and Fishing Guides to learn about rules and guidelines for hunting and fishing.
- Know the season start and end dates.
- Take a hunter's safety course.
- Conserve our natural resources and protect the habitat of both game, nongame, and endangered species.
- Report illegal taking of game or fish to the proper authorities by calling (800) 292-7800.
- Enjoy Michigan's natural resources!

## **Funding**

Funding of fish and game management activities traditionally comes from the Game and Fish Protection Fund. The Game Fund was established by the Legislature in 1913. In 1923 the Game Fund was merged with the Anglers Fund. The Anglers Fund consisted of fees collected from the sale of nonresident fishing licenses.

The Game and Fish Protection Fund is a dedicated fund established for the "purpose of funding the propagation and liberation of game, fur-bearing animals, birds or fish . . . for the purchase, lease, and management of lands . . . for establishing and maintaining game refuges, wildlife sanctuaries, and public shooting and fishing grounds...and other purposes established in law." The Fund, supported by both fishing and hunting license revenue, continues to exist today.

*A Selection of Activities Funded by the Game and Fish Protection Fund:*

- Refurbishing public use facilities at State Game Areas
- Expanding access to State Game and Wildlife Areas
- Monitoring wildlife populations and relocating wildlife
- Improving wildlife habitat
- Promoting hunter safety and education
- Maintaining state hatcheries and restocking programs
- Managing fish ecosystems and fish losses
- Studying and managing exotic species
- Enforcing game and fish laws
- Purchasing land

Michigan is also home to a number of endangered species: plants and animals that are in danger of extinction throughout all or a significant part of their range. The gray wolf, cougar, lynx, and prairie vole are examples of endangered animals that can be found in Michigan.

# RECREATION

Michigan's natural resources offer unique and ample recreational opportunities. Michigan borders four of the five Great Lakes and has 3,288 miles of coastline, which is more coastline than any state except Alaska. Over 40% (about 40,000 square miles) of the state's surface area is water. Michigan has over 35,000 inland lakes and ponds and more than 49,000 miles of rivers and streams. In addition to our water resources, Michigan's vast forestlands provide many recreational opportunities. The state manages its natural resources with recreational opportunities in mind. Access to lakes and streams is maintained for fishing and boating; trails are groomed for off-road vehicles (ORVs), hiking, cross-country skiing, and biking; and state parks offer camping and other outdoor opportunities.

## Boating

The 40,000 square miles of Great Lakes waters and thousands of inland lakes provide an important recreational opportunity for Michigan residents: boating. With almost 946,000 registered boats in Michigan, our state residents own more watercraft than any other state. Over 50% of these boats are used primarily for fishing. To accommodate these boats, over 30,000 slips have been constructed with access to the Great Lakes. Another 10,000 can be found on inland lakes. Many cities located on the Great Lakes cater to boaters by providing full service marinas.

In addition to recreational boating, Michigan's water resources provide many opportunities for competitive events such as the yearly sailboat races from Port Huron and Chicago to Mackinac and power boat racing on the



Detroit River. Tour boats are also popular. Visitors to CrossRoads Village in Genesee County can ride the *Genesee Belle*, a paddle-wheel boat on Mott Lake. Educational and sightseeing tours on tall ships are available on the *Manitou* and *Malabar* docked in Traverse City, Michigan.

## Trails

The state of Michigan, working with local communities, has established an extensive network of trails for hiking, biking, horseback riding, and cross-country skiing. The trail system follows inactive railroad lines, shorelines, and other corridors. These trails provide scenic travel along broad, smooth-surface trails through Michigan countryside, connecting small as well as urban communities. Five linear trail state parks currently open include the Hart-Montague Trail State Park, Kal-Haven Trail State Park, Lakelands Trail State Park, Van Buren Trail State Park and White Pine Trail State Park. The "Networking Michigan with Trails" brochure lists additional trails outside of the state park system. The brochure is available from the DNR.

## State Parks and Forests

Michigan has 96 state parks and 6 state forests located in both the Upper and Lower Peninsulas. Michigan state parks offer residents a multitude of recreational opportunities from canoeing, hiking, and crosscountry skiing to wildlife viewing and fishing. Camping facilities are available at state parks and forests and accommodate both RVs and tent campers. Several parks also have rustic cabins for rent. Our state parks and forests encompass inland waterways, waterfalls, sand dunes, old growth forests, and Great Lakes shoreline. State parks and forests preserve Michigan's natural resources for all residents to enjoy.

## Off-Road Vehicles (ORVs)

ORVs are popular recreational vehicles and include motorcycles, dune buggies, trucks, and three- or four-wheeled all-terrain vehicles. The state has designated a public ORV trail system that provides four types of trail riding opportunities: motorcycle trails, all terrain vehicle (ATV) trails, ORV routes which are open to all Secretary of State licensed vehicles, and scramble areas. The five scramble areas include St. Helen's Motorsport Area, Black Lake Scramble Area, Silver Lake State Park, Bull Gap in the Huron National Forest, and The Mounds, a Genesee County Park. The ORV trail/route system covers 3,107 miles with 73% in state forests.

In the Upper Peninsula, it is legal for ORVs to operate on state forest roads as well as the designated trail system unless a specific state forest road is posted closed to ORV use. In the Lower Peninsula, ORVs may operate only on those roads posted open to ORV use.

## Funding

The Michigan Legislature has recognized the importance of the many recreational opportunities in our state and over the years enacted legislation to provide funds for the management of these resources. The Recreation Improvement Fund was established in 1987 to provide funds for recreational projects including those related to trails used by ORVs, cross-country skiers, horseback riders, and hikers; to waterways projects; and to snowmobile trail improvement. Two percent of the gasoline tax in the state is credited to the Recreation Improvement Fund. In addition, the trailways system in Michigan is partly funded by fees paid by users of the trails on state forestlands. These fees are deposited into the Trailways Fund and used to acquire, develop, and maintain the trailways system in Michigan.

The Recreational Snowmobile Trail Improvement Fund is used to cover the annual cost of trail grooming, as well as acquisition and construction of trails.

In November 1998, Michigan voters approved the Clean Michigan Initiative (CMI), a bond initiative to provide funds for a number of environmental activities in the state. CMI included \$50 million allocated to local recreational projects and \$50 million allocated to state parks for construction and maintenance of recreational facilities.

## What Citizens Can Do

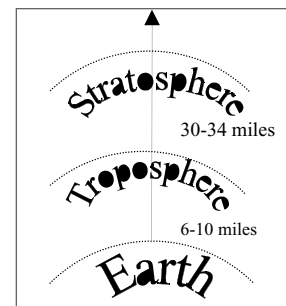
- Learn what permits or licenses are required for motor vehicles, ORVs, snowmobiles, and boats before entering state parks or using the trail system.
- Visit a local DNR office or the DNR website for lists of parks, maps of trails, and information on operating hours of recreational facilities.
- Volunteer as a campground host.
- Work with an organization that voluntarily grooms trails for snowmobile use.
- Work with an organization that maintains part of the Michigan trailway system or work to establish additional trails along the system.
- Enjoy Michigan's natural resources!

## Snowmobiles

Over 5,900 miles of designated snowmobile trails are located in Michigan on state and private lands. The interconnected trail system is maintained by the DNR and over 60 volunteer organizations. Before operating a snowmobile in Michigan, a registration decal must be purchased from the Secretary of State. Decals are good for 3 years. To ride a snowmobile on public land or the trail system, a trail permit is also required. These permits are available at retail stores throughout the state. Registration fees and snowmobile permit fees help cover the annual cost of trail grooming.

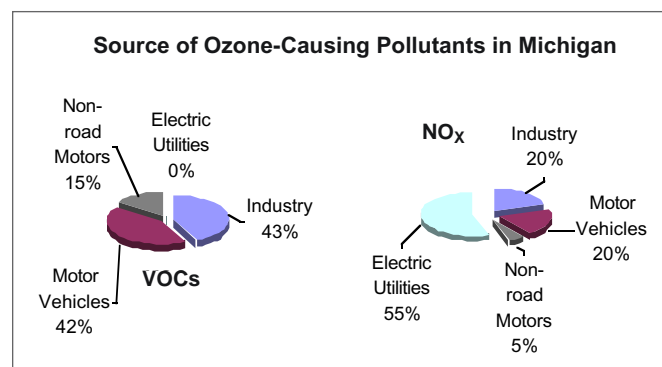
# AIR QUALITY

Preserving and improving the quality of outdoor or *ambient air* has long been the focus of all levels of government. Two compartments of the earth's atmosphere, troposphere and stratosphere, affect the quality of life on earth differently. The troposphere, which begins at the earth's surface and extends for 6-10 miles, directly affects the health of the people, animals, and plants living on the earth. The stratosphere, which extends to 30-34 miles above the earth's surface, preserves the earth's climate and protects the earth from the sun's radiation. Different pollutants impact the quality of each sphere.



## Pollutants in the Troposphere

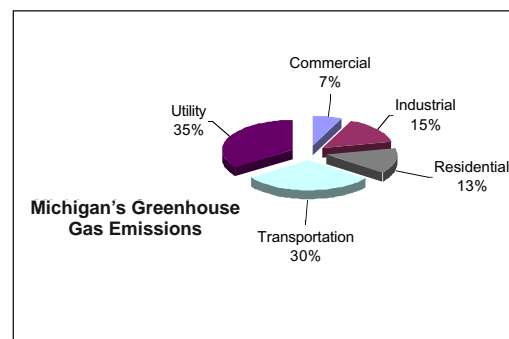
Summertime ozone pollution in the troposphere can affect the quality of daily life by making it difficult to breathe for those who have impaired lungs or who work or play strenuously outdoors. Ozone is formed in the troposphere by chemical reactions between volatile organic compounds (VOCs) and nitrogen oxides (NO<sub>x</sub>) on hot, sunny, summer days. Industrial facilities, motor vehicles, gas-powered yard tools, boats, and coal-fired power plants emit VOCs and NO<sub>x</sub>.



Recent research has linked high levels of microscopic particulate pollution to altered heartbeats and possibly premature death. Microscopic particles are emitted by the combustion of fossil fuels, such as gasoline and coal. Tropospheric air pollution also impacts the quality of lakes and rivers when pollutants such as acid rain and mercury "fall" from the skies and pollute lakes and rivers.

## Pollutants in the Stratosphere

Chlorofluorocarbon (CFC) pollution in the stratosphere depletes the protective ozone layer, which allows more of the sun's harmful radiation to penetrate to the earth's surface. A wide variety of industrial processes and consumer products have used CFCs as aerosol propellants and refrigerants. Carbon dioxide (CO<sub>2</sub>) and other pollutants form a "heat shield" in the stratosphere that reflects heat back toward the earth's surface thereby causing a gradual increase in the earth's temperature. CO<sub>2</sub> is released by the burning of coal, natural gas, gasoline, and wood.



## Current Issues

Numerous air quality issues continue to challenge state and federal policymakers.

- Are standards that limit concentrations of ozone and particulates in outdoor air sufficient to protect public health?
- What level of NO<sub>x</sub> emission controls should be required of "upwind" sources to benefit metropolitan areas that are hundreds of miles "downwind?"
- What actions, if any, should governments, industry, and citizens take to address climate change?

---

## Protecting Air Quality

Government, industry, and individuals all share some responsibility for implementing air pollution control laws and improving air quality. These responsibilities are outlined in the federal Clean Air Act and Michigan's Natural Resources and Environmental Protection Act.

Michigan's DEQ monitors air quality, develops plans to control air pollution, and issues permits setting legal limits on air pollutants emitted by industrial and commercial sources. Air quality in Michigan meets the current federal standard for ozone of 0.12 parts per million. However, Michigan will not meet a more stringent federal standard of 0.08 parts per million that is under review by the U.S. Supreme Court. Michigan is among 22 states that are being asked to reduce NO<sub>x</sub> emissions to help "downwind" cities control ozone pollution. Industrial facilities and coal-fired power plants in Michigan will likely be asked to reduce NO<sub>x</sub> emissions to meet this federal requirement.

Manufacturers of new cars are required, by federal law, to reduce emissions of VOCs and NO<sub>x</sub> from new model-year cars and trucks. Since 1996, manufacturers have been required to install onboard diagnostic systems on new cars that alert drivers to poor performance and the need for service.

Residents of Wayne, Oakland, Macomb, Monroe, Washtenaw, St. Clair, and Livingston counties are asked to voluntarily reduce their use of cars, trucks, lawn mowers, barbecues, motorboats, and other small engines on ozone action days in the summer. Owners of motor vehicles with onboard diagnostic systems are expected to voluntarily seek vehicle repairs when the system alerts the driver to vehicle performance problems.

Congress expanded the scope of the federal Clean Air Act beyond tropospheric pollutants to control the use and production of CFCs, a stratospheric pollutant, in 1990. The federal government is banning the production and phasing out the use of CFC-containing products as substitutes come onto the market.

### **What Citizens Can Do**

Reduce the use of products that pollute the air:

- Stop using products with CFCs when alternatives are available.
- Limit the use of equipment powered by high-polluting small motors (e.g., lawn mowers, weed whackers, boat motors).
- Buy equipment powered by less-polluting small motors.
- Carpool or use alternate transportation.
- Heed the call to reduce polluting activities on Ozone Action Days.
- Reduce CO<sub>2</sub> emissions by driving less, buying fuel-efficient vehicles, using less electricity, and choosing renewable energy fuels.

Monitor enforcement of air pollution laws:

- File complaints when you believe air pollution laws are being violated.
- Watchdog federal, state, and local government agency enforcement of air pollution laws.

### **Funding**

Historically, Michigan's air pollution control programs were funded by the state's general fund, which is largely supported by the collection of various taxes. The funding burden shifted to "user fees" under federal law in 1990. Applicants for federally mandated operating permits are required to pay the state a permit fee that covers the cost of administering the permit program. Most of the state's air pollution control activities relate to the permit program. Some general fund support remains to cover air pollution control activities that are not related to the operating permit program.

---

### **Contacts**

DEQ, Air Quality Division, (517) 373-7023, [www.deq.state.mi.us/aq](http://www.deq.state.mi.us/aq)  
U.S. EPA, Office of Air and Radiation, [www.epa.gov/oar/oarhome.html](http://www.epa.gov/oar/oarhome.html)  
Climate Change Resource, [www.pewclimate.com](http://www.pewclimate.com)



# WATER QUALITY

Michigan's Great Lakes, inland lakes, rivers, and groundwater have good to excellent water quality in general. Since the 1970s, major efforts by government, industry, and citizens have improved water quality to the present point. However, pollutants from many sources still degrade water quality in some lakes, rivers, and groundwater.

## Pollutants and Sources

Pollutants that degrade water quality originate from numerous sources. These sources are split into two major categories: point sources and nonpoint sources. Point sources discharge waste to lakes and rivers from a specific, easily identified point like a pipe outlet. Sewage treatment plants and industry are common examples of point sources. Point source waste may contain pollutants such as toxic contaminants, plant nutrients like phosphorus and nitrogen, and pathogens (disease-causing microorganisms). Nonpoint



sources are pollutant discharges that are carried to lakes and rivers by natural processes like rain, snow, and water draining off the land. This pollution originates from numerous activities carried out by farmers, businesses, and average citizens. Nonpoint source pollutants include toxic contaminants like PCBs and mercury washed from the air; nutrients from lawns, golf courses, and farms; pathogens from livestock operations, septic systems, and pet wastes; and sediments (waterborne soil and dirt) from farms and construction sites.

### *Drinking Water*

Michigan's drinking water is tapped nearly equally from surface waters and groundwater (See Inland Lakes and Rivers, page 6). These waters may contain contaminants like nitrates and pathogens at levels that are not safe to drink. To protect public health, Michigan and federal laws require the treatment of drinking water. Filtration and chlorination are common methods of water treatment. After treatment, drinking water must not exceed maximum contaminant levels set by government regulations. Water suppliers must test treated water on a regular basis to determine if they are in compliance. In recent years, over 99% of Michigan citizens using community water were served by a public water supplier meeting all health standards. The remaining 1% were served by a supplier that had at least one violation during the year. In addition to these treatment standards, Michigan and federal programs support efforts to prevent the contamination of the surface water and groundwater used for drinking water. For more information on drinking water, contact the DEQ's Drinking Water and Radiological Protection Division at (517) 335-9218, [www.deq.state.mi.us/dwr/](http://www.deq.state.mi.us/dwr/) or call EPA's Safe Drinking Water hotline at (800) 426-4791.

## Water Quality Impacts

Both point and nonpoint source pollution have a detrimental impact on Michigan's waters that affect public health, the environment, and the economy. Specific impacts depend on the pollutant, but they may limit the use of these waters for fishing, swimming, or drinking. Toxic contaminants can be a problem even in dilute amounts because they concentrate in the flesh of fish and wildlife that may be eaten by people. The potential presence of pathogens associated with sewage and manure is a threat to public health that often forces beach closings during summer months. Excess nutrients stimulate the growth of algae and aquatic plants that cloud the water, make swimming unappealing, and clog boat propellers. When the abundant plants and algae die, their decay depletes oxygen from the water necessary for the health and survival of fish and other



aquatic life. Sediments cover breeding areas used by sport and commercial fish as well as other aquatic organisms that live on the bottom. All of these impacts may have serious economic consequences from the commercial and recreational revenue lost as well as the cost of compensating for the impacts. The national economic impact of sediment pollution alone has been estimated to be between \$6 billion and \$17 billion per year.

## Managing Michigan's Water Quality

Since the 1970s, the Michigan Legislature and the U.S. Congress have passed many laws that protect Michigan's water quality. The most important laws require that point sources have a joint federal and state permit to discharge pollutants into lakes and rivers. The permit limits how much of a pollutant may be discharged into a lake or river based on the best available treatment technology for that point source as well as the water quality of the lake or river. To help communities upgrade sewage treatment plants to meet these levels, federal and state funds are used to provide low interest loans. In recent years, the Michigan Legislature and the U.S. Congress have started to address more specific problems, including sewage overflows during heavy rains, the treatment of stormwater collected in sewers, and heavily contaminated sediments at the bottom of lakes and rivers. It has also been recognized that the major remaining water quality problems are due to nonpoint sources of pollution.

### What Citizens Can Do

- Dispose of household fertilizers, pesticides, paints, used motor oil, and other hazardous materials properly, NOT in the garbage or down the sink (See Waste Management, page 24).
- Choose nontoxic household products.
- Clean up your pet's waste from grass and sidewalks.
- Use only the amount of fertilizer needed on lawns and agricultural fields.
- Avoid using pesticides, fertilizers, and other pollutants near a well.

### Clean Michigan Initiative (CMI)

The CMI, a \$675 million bond approved by the Michigan Legislature and Michigan citizens in 1998, provides for a number of activities that will help clean up Michigan's environment and enhance recreational opportunities. Many activities benefit water quality (indicated by italics).



For more information, visit the DEQ's website at: [www.deq.state.mi.us/exec/cmi/cmiimp.html](http://www.deq.state.mi.us/exec/cmi/cmiimp.html).

The state and federal government have taken some steps to regulate nonpoint sources of pollution. The Michigan Legislature passed laws to limit sediment pollution from construction activities by requiring permits to control soil erosion. However, most government efforts encourage voluntary action rather than mandate controls. Voluntary actions are supported by public education and government grants that encourage farmers, land developers, and others to adopt management practices that keep soil and other potentially polluting materials out of the water (See Agriculture, page 13).

## Contacts

DEQ, Surface Water Quality Division, (517) 373-1949, [www.deq.state.mi.us/swq/](http://www.deq.state.mi.us/swq/)  
 DEQ, Waste Management Division, Groundwater Programs, (517) 373-2730, [www.deq.state.mi.us/wmd/gwp/](http://www.deq.state.mi.us/wmd/gwp/)  
 U.S. EPA, Office of Water, [www.epa.gov/ow/](http://www.epa.gov/ow/)  
 Institute of Water Research, MSU, [www.gem.msu.edu](http://www.gem.msu.edu)

# WASTE MANAGEMENT

Many activities of citizens and businesses generate wastes that must be disposed of or managed. These wastes are generally classified as either “solid” or “hazardous.” To protect the public health and welfare and the environment, programs have been established to manage the collection and disposal of these wastes. Efforts to reduce waste generation are covered in “Waste Management Alternatives” on page 26.

## Solid Waste

Solid waste is a term defined in law to describe household garbage and trash (everything from used cans and bottles to wrappers and plastics), together with many types of non-hazardous commercial wastes such as packaging and waste paper. The disposal of solid waste has been a problem for society throughout most of our history and solid waste generation continues to increase.

Federal and state laws regulate the collection and management of solid waste. However, the Michigan DEQ administers the management of solid waste under Part 115 of NREPA in lieu of the federal program as long as our regulations are as stringent as the federal regulations. Construction permits and operating licenses are required for each facility that treats, stores, or disposes of solid waste. Using county plans as a guide, the state issues permits and licenses to waste facility owners. Public participation is provided in the licensing procedure through the public hearing process. The DEQ also regulates landfill closure and post-closure monitoring.

Michigan uses county solid waste management plans to assure sufficient capacity for disposal and direct the movement or “flow” of solid waste from the point of generation to the point of disposal. The plan must detail the county’s solid waste disposal methods for a 10-year period, estimate the minimum amount of waste that will be generated, and identify disposal facilities. Additionally, the plan should evaluate management options such as resource recovery and recycling.

While Part 115 requires counties to find the means to manage wastes generated within their borders, it also gives them the authority to restrict the import or export of solid waste into and beyond their borders. Private landfill operators challenged these laws in federal court claiming they violate the commerce clause of the U.S. Constitution. With few exceptions, the U.S. Supreme Court has overturned state “flow control” laws ruling that solid waste is a commercial commodity whose transport across state borders cannot be restricted. However, the U.S. Supreme Court refrained from ruling on flow control laws between counties. In 1999, the Michigan State Supreme Court refused to hear an appeal of a lower court decision upholding flow control restrictions between Michigan counties. Thus, waste from out-of-state may be disposed of in Michigan without county approval,

but cannot move between counties without express consent in the county solid waste management plan.

### ***Methods of Solid Waste Disposal***

Michigan’s solid waste is handled in primarily four ways: landfilling, incineration, recycling, and composting.

- Landfilling solid waste refers to the burial of waste in the ground.
- Incineration refers to the burning of waste to reduce its volume.
- Recycling refers to practices and technologies that recover materials from the waste stream for reuse.
- Composting refers to the breakdown or decomposition of leaves, yard clippings, and garden debris (e.g., organic materials) into high nutrient soil or humus.

## Hazardous Waste

When we think about hazardous wastes, images of industrial sludges, chemicals, commercial solvents, or cleansers often come to mind. In fact, Michigan industries and businesses generate many different kinds of hazardous waste while producing everyday consumer goods.

A hazardous waste is a solid, liquid, or semi-solid material that poses a significant risk to human health or the environment.

Hazardous waste management and disposal is regulated by the federal government under the Resource Conservation and Recovery Act (RCRA). The federal government classifies wastes as hazardous either because of the industrial process that generates the waste or because it has been tested and characterized as being corrosive, ignitable, reactive, or leaching hazardous constituents out of the waste.

Michigan has EPA authorization to be the sole regulatory authority of hazardous waste management and disposal in the state as long as the state's laws are no less stringent than the federal laws. The DEQ administers the hazardous waste program under Part 111 of NREPA. The act and rules define hazardous waste; regulate hazardous waste treatment, storage, and disposal; and establish requirements for obtaining waste facility construction permits and operating licenses. In addition, Part 111 sets up a "cradle to grave" tracking system for transporting hazardous waste from its points of generation to disposal.

Siting a hazardous waste treatment, storage, or disposal facility is a two-part process. The DEQ reviews the proposal for compliance with regulations and human health and environmental safety standards. A Site Review Board is appointed by the governor and consists of representatives of academia, industry, the public, and the municipality in which the facility is being sited. The Board reviews the proposal and addresses concerns about how the hazardous waste facility will impact the local community and other public policy issues.

### **Handling Hazardous Wastes**

*Treatment facilities* use chemical or biological processes to make the waste less hazardous or non-hazardous.

*Incineration* destroys waste by burning in a specially-designed high temperature furnace.

*Landfilling* buries hazardous waste in highly engineered vaults.

*Injecting* waste down wells into deep rock formations isolates the waste from the land surface and minimizes exposure to toxic chemicals in the liquid wastes.

Hazardous wastes can also be recycled and reused for other industrial or commercial purposes.

### **What Citizens Can Do**

- Purchase environmentally-friendly products, use all the product purchased, and participate in household hazardous waste collection days.
- Evaluate your own waste-producing activities and make changes as appropriate (See Waste Management Alternatives, page 26).
- Participate in or be informed of the public hearing process for the county solid waste management plan.
- Understand the siting process for hazardous waste facilities and the authority of the Site Review Board.

### **Household Hazardous Wastes**

In addition to industrial wastes, common household items can also be defined as hazardous wastes. Residentially-generated hazardous wastes can be disposed of in a solid waste landfill, except lead acid automotive batteries. However, studies have shown that disposal of these materials in solid waste landfills may cause groundwater contamination and other concerns. Many communities have responded to these concerns by organizing household hazardous waste collection days allowing residents to bring their hazardous waste to a central collection point for proper disposal.

# WASTE MANAGEMENT A

Many of our everyday activities generate wastes that need to be managed or disposed of. In “Waste Management” (page 24), programs that manage the collection and disposal of solid and hazardous waste were described. Every person and business that generates waste can choose to “reduce,” “reuse,” and “recycle” waste to decrease the amount of waste sent to landfills and incinerators.

## Reduce

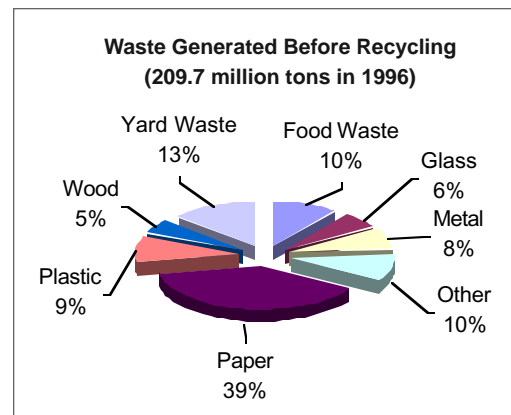
Reducing waste is at the top of the list because it actually prevents the generation of waste in the first place. Also referred to as source reduction or waste prevention, reducing waste places emphasis on purchasing durable, long-lasting products so that there are fewer items to be disposed of. Also, consumers are encouraged to purchase items with less packaging or select products and packaging containing fewer toxic chemicals to reduce the amount of toxics going into our landfills. Businesses are encouraged to redesign production processes to reduce the use of toxic materials and the amount of raw materials or to manufacture more durable products.

## Reuse

“Reuse” means to use a product more than once for the same or a different purpose. Reuse avoids the more costly reprocessing required to “recycle” a product for another use. Repairing a product and donating or selling a product to another user are examples of reuse.

## Recycle

Recycling refers to practices and technologies that recover materials from the waste stream for reuse. Such material recovery and reuse could be as simple as collecting, sterilizing, and reusing beverage containers, or as complex as separating, grinding, and re-smelting metal cans. In general, recycling consists of three basic steps: 1) the separation or recovery of recyclable materials from a waste stream; 2) the processing of recyclable material for reuse in the same product or for incorporation into feedstocks for the manufacture of new products; and 3) the purchase of products made from recycled material by consumers. A number of everyday items can be recycled, including paper and paperboard, magazines, glass, aluminum, many plastics, and tin cans. These items make up over 50% of the solid waste by weight generated by most communities.



### **Disposal Bans**

In the past several years, a greater emphasis has been placed on managing our solid wastes through composting and recycling. To encourage the recycling or composting of waste materials and to save space in landfills, the Michigan Legislature has banned disposal of lead-acid batteries, used oil, and yard clippings in landfills. Each of these products is “valuable” and can be reused rather than disposed of. The lead in lead-acid batteries can be reclaimed and reused. Used motor oil can be refined and reused in motor vehicles. And, finally, composted yard clippings can add nutrients back into the soil.

products; and 3) the purchase of products made from recycled material by consumers. A number of everyday items can be recycled, including paper and paperboard, magazines, glass, aluminum, many plastics, and tin cans. These items make up over 50% of the solid waste by weight generated by most communities.

### **Obstacles**

Recycling may be limited by unstable markets and prices, irregular supply of materials, and contaminated materials. Market prices have been known to fluctuate causing problems for recycling programs when prices for certain materials fall below levels needed to support the program. Irregular supplies disrupt the supply of materials, leaving equipment and personnel idle, which poses a serious financial

# ALTERNATIVES

strain on community-based recycling programs. This may be a particularly serious problem where the level of public participation varies from week to week or month to month. Contaminated materials, such as plastic mixed in with paper waste, will force a whole container of paper waste to be rejected by the recycling center. To prevent contamination, community programs and recycling centers may spend unnecessary hours sorting waste and removing unwanted items.

## What Citizens Can Do

- Reduce the amount of unnecessary packaging.
- Consider reusable products.
- Maintain and repair durable products.
- Reuse bags, containers, and other items.
- Borrow, rent, or share items used infrequently.
- Consider large or economy size items for products that are used frequently.
- Sell or donate goods instead of throwing them out.
- Select products made from recycled materials.
- Compost yard trimmings and some food scraps.
- Commercial drain cleaner can be replaced with 1/2 cup each of baking soda and vinegar.
- Baking soda and water can be used for cleaning ovens.
- Baking soda or 1/4 cup of liquid bleach can be used as toilet cleaner.
- Lemon juice, club soda, or cold water can be used as a spot remover.
- Equal parts of mineral oil with lemon oil or Carnauba wax can be used as a furniture polish.
- To clean silver, soak in 1 quart of water mixed with 2 tablespoons baking soda, 1 tablespoon salt, and a small piece of aluminum foil.

## Benefits of Recycling

- Conserves resources for the future.
- Prevents emissions of many greenhouse gases and water pollutants.
- Saves energy.
- Supplies valuable raw materials to industry.
- Creates jobs.
- Reduces the need for new landfills and incinerators.

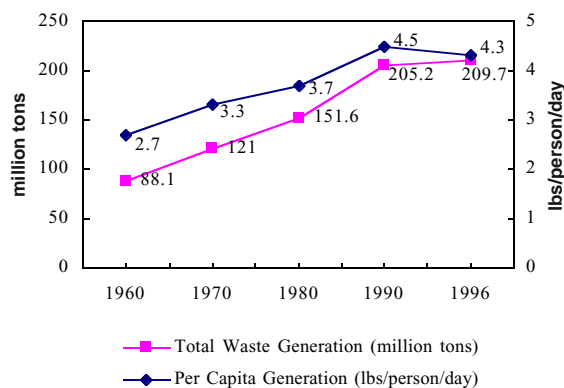
## Composting

Composting of leaves and garden refuse is a form of recycling used to return plant material to the soil. Grass clippings, leaves, and other organic material are often placed in open piles to decompose. The pile is kept at a constant temperature through frequent turning and kept moist by watering. The final compost product is usually used as a mulch or conditioner to enrich and fertilize soils.

## Household Hazardous Wastes

A number of household products, such as cleaning fluids, paints, and paint thinners, may be classified as hazardous waste. Reducing the generation of household hazardous waste reduces the disposal of these items in landfills, potentially protecting our water and air resources. Safer alternatives can be substituted for many hazardous household products.

Trends in MSW Generation 1960-1996





# ENVIRONMENTAL CLEAN

For years, industrial development proceeded in Michigan and the nation without recognizing the “environmental costs” of that development. Pollution below the earth’s surface could not be seen. It went undiscovered until a site was excavated or contaminated groundwater was pumped from a well. Such sites could not be used or groundwater drunk until it was “cleaned up.”

## Impacts of Past Practices

Subsurface contamination was caused by past industrial practices and leaks in underground tanks storing chemicals. Chemical storage tanks were often buried underground to reduce fire and explosion hazards. Leaking tanks were the source of millions of gallons of chemicals and gasoline “spilled” beneath the surface. Industrial facilities did not manage their chemical wastes or feedstocks as carefully in the past as they do today. Haphazard management and disposal caused chemical releases, which then contaminated soil and groundwater resources.

Michigan was one of the first states to react to the problem of environmental contamination. The state, industry, and citizens have been identifying and working to clean up contaminated sites for twenty years. The early years of state programs were spent identifying and listing “known” sites of environmental contamination. As of September 2000, the state had registered more than 84,415 underground storage tanks in Michigan. Contaminant releases had been confirmed at nearly 18,950 sites. Cleanup of environmental contamination had been completed at slightly less than half of these sites.

It is more difficult to “count” the number of industrial sites where contamination is attributable to industrial practices, though that number probably exceeds 2,000 sites. A complicated process of identifying the parties responsible for the contamination and, therefore, the cleanup ensues once a site is identified. It is often difficult to assign responsibility for environmental contamination when a series of landowners have owned the property or when some parties are bankrupt or businesses no longer exist. Limited state resources and practical limits on the recovery of cleanup costs from recalcitrant, bankrupt, or nonexistent private parties has forced the state and public to answer tough questions concerning the extent of cleanup required at individual sites.

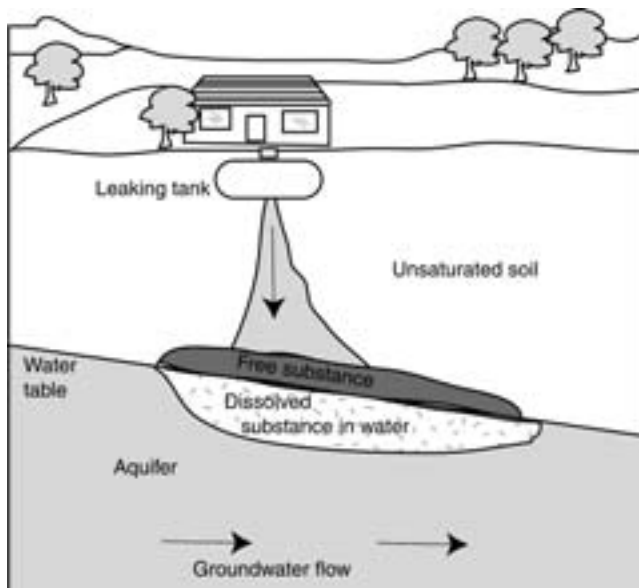
## Facing Cleanup Issues in This Century

Answers to some tough questions are still being sought.

- What groundwater resources should be preserved and protected for future use?
- How do we restore “brownfields” to productive use when resources are limited?
- How clean is clean?

## Assigning Responsibility for Cleanup

Responsibility for environmental cleanup is assigned differently for underground storage tanks and other sites of environmental contamination. Under federal law, if you are the current owner of the land where a leaking underground storage tank is located, you are responsible for cleanup. The current landowner may not have installed the tank, used the tank, or in some cases known of its presence. In many of these cases, responsibility for cleanup has created personal financial hardships for the landowner.



Under state law, responsibility for cleanup at other sites of environmental contamination falls on the party or parties “responsible for contamination.” This standard for liability gives a reprieve to the current landowner who may not be the party responsible for contamination. It also creates an opportunity for a party interested in purchasing a property to do so without assuming full responsibility for past contamination. In these cases, the current or future landowner is responsible for practicing due care and cleaning up the property to a level that makes it safe for the intended use.

## Setting and Meeting Cleanup Standards

Cleanup standards prevent people from being exposed to unacceptable risks. Risk is assessed using a combination of factors including the toxicity of the contaminant(s), the frequency of exposure, the method of exposure (inhaling, skin contact, or ingestion), and whether the potential exposure is to a child or adult. Properties intended to be used for residences must meet the most stringent cleanup standards.

Cleanup standards can be met through a combination of activities ranging from the removal of contaminants to the construction of barriers to exposure. Contaminated soils can be excavated and hauled away for disposal. Contaminated groundwater can be pumped, cleaned up, and returned to the ground. Fencing, paving, or constructing other appropriate barriers can also prevent exposure to harmful contaminants.

Matching the cleanup to the intended use of the contaminated property is one approach to restoring and redeveloping these sites. A former industrial site need not be cleaned up to make the property pristine for residential housing if in fact it is going to be used for an industrial or commercial enterprise. Additional information on the redevelopment of contaminated land can be found in the Land Use section, page 30.

### ***Landowners and “Due Care”***

A contaminated property may be currently owned by an innocent party who did not cause the contamination. As mentioned above, state law restricts the responsibility of cleaning up the contaminated site to the party or parties who caused the contamination regardless of whether they own the property now. However, Michigan's cleanup laws require all landowners to prevent exposure to hazardous substances or the spread of contamination. These requirements are called Due Care provisions and ensure that owners of contaminated properties:

- Prevent the exacerbation of the problem caused by existing contamination,
- Take reasonable precautions to prevent trespass,
- Mitigate unacceptable exposures, and
- Clean up what is necessary to allow for safe use of property.

### ***What Citizens Can Do***

- Report a suspected release or chemical spill to the Storage Tank Division or the Environmental Response Division district offices. In case of emergency call PEAS: The Pollution Emergency Alerting System at 800-292-4706.
- Follow due care provisions to prevent access and limit exposure if you own a contaminated site.
- Register regulated underground storage tanks.
- Keep out of fenced properties.

# LAND USE

Historical accounts of Michigan's early years as a territory and state emphasize the two peninsulas' unique characteristics, their abundance of resources, and the increasingly aggressive harvesting of those resources. Since the 1780s, Michiganders have exploited the state's wildlife for furs, its waters for fish, its forest for lumber, and its mineral resources for copper, iron, salt, and sand. As Michigan's industries and population grew, the state's landscape changed radically by land clearing, agriculture, mining, urban and suburban expansion, and road construction.

These changes to Michigan's landscape have posed many challenges to state land use. For example, agricultural production contributes nearly \$35 billion to Michigan's economy each year, yet the amount of farmland in the state has steeply declined in recent years (See Agriculture section, page 12). Corresponding changes have occurred in Michigan's big cities. Urban populations continue to fall while the overall state population increases. The result is the conversion of agricultural land and open spaces to residential and commercial properties to meet the suburban expansion.

## ***Tools for Managing Growth***

A wide array of tools and techniques are available to encourage urban redevelopment and limit the conversion of rural or natural resource lands. The extent to which some of these techniques can be used in Michigan at the local and state levels may be limited under existing statutes.

- **Purchase of Development Rights (PDR):** Compensates the landowner for the value of lost development rights in exchange for maintaining the property at a desired use and density. Michigan's local governments can currently use PDR programs for farmland preservation.
- **Transfer of Development Rights (TDR):** Similar to the PDR tool, TDRs address rights between a developer and a landowner, not a local government and a landowner. TDRs could be initiated under Michigan's zoning enabling acts.
- **Concurrency:** "Pay as you grow" concept requiring public infrastructure and services to be available concurrent with the impacts of development. New growth is only permitted when adequate public services are in place to support the growth.
- **Urban Growth Boundaries:** A fixed boundary identified in a community's land use plan to discourage premature development of rural land while encouraging development within and adjacent to existing development. Growth boundaries usually limit growth beyond the boundary during a 20- to 30-year timeframe.

## **Urban Sprawl**

Between 1990 and 2020, Michigan's population is expected to grow by 1.1 million people. This 12% population increase represents between 63% to 87% more developed land than in 1990, potentially causing nearly 2 million acres of farmland to be permanently lost to urban sprawl.

Urban sprawl refers to the change in land use patterns from high density urban centers to low density suburban growth and it is the most common form of growth in Michigan today. Sprawl occurs when rural lands are replaced with large malls and megastores on urban fringes or residential subdivisions comprised of houses on large plots of land. This type of low density development is distinctly different from the layout of traditional urban communities with compact patterns of integrated residential, commercial, and educational areas and a separation between the urban and the surrounding rural community.

## **Managing Growth**

The expansion of our communities is inevitable. Many of today's land use planners are trying to balance the need for adequate community growth with the need for agricultural and natural resource land. Unchecked sprawl can compound community problems by increasing traffic in rural and suburban areas, increasing storm runoff, and overtaxing the existing infrastructure. To manage growth more effectively, land use planners have created a variety of tools some of which are outlined in the gray box on this page.

## Brownfield Redevelopment

One option for limiting sprawl is “recycling” brownfields. Brownfields are abandoned, idled, or under-used industrial and commercial facilities found in our cities, towns, and villages. Decades of industrial and manufacturing practices may have left these brownfield areas contaminated. Derelict buildings, broken machinery, and other debris add to a brownfield’s image of urban decay. However, even when environmental contamination and debris are not present, these abandoned properties tend to be avoided by developers due to the perception of environmental contamination.

Brownfield sites are an urban resource as they are usually well-situated and possess existing infrastructure. Redeveloping brownfields can provide opportunities for communities to rebuild their tax base, upgrade their infrastructure, and improve economically-depressed neighborhoods. However, the real or perceived environmental contamination associated with brownfield sites is also a liability. Developers are reticent to invest in brownfield sites when the cost of meeting state environmental cleanup standards may exceed the value of the property. The cleanup costs as well as the availability of relatively pristine suburban and rural open spaces, draw industry, manufacturing, and commercial businesses away from our cities.

Recent efforts by the Legislature encourage state and local government to promote and fund brownfield redevelopment and contamination site cleanup to limit urban sprawl. Prior to 1995, owners of contaminated land were responsible for the cleanup. Changes to state law made liability for environmental cleanups dependent on being responsible for the contamination. Baseline environmental assessments (BEAs) were instituted to protect new owners from liability for existing contamination. Other statutory amendments promoted redevelopment by focusing on the future use of the property. Finally, changes in state law enabled redevelopers to limit exposure to toxic substances by using institutional controls and physical barriers to meet the cleanup standards rather than removing all the contamination from the site.

### ***What Citizens Can Do***

- Determine if your community has a land use management plan.
- Participate in discussions about growth management with government officials.
- Consider using brownfields when making decisions about expanding your business.
- Conduct a BEA prior to purchasing previously developed properties.

### ***State Funding to Encourage Brownfield Redevelopment***

To encourage the reuse of abandoned or contaminated land, the Legislature established programs to subsidize redevelopment to minimize or eliminate the cost difference.

- The 1988 Environmental Protection Bond generated \$425 million for state-funded environmental cleanup and redevelopment.
- The Cleanup and Redevelopment Fund provides state funding for response activities or to facilitate brownfield redevelopment.
- A revitalization revolving loan program provides loans to local governments for eligible cleanup activities to promote economic growth and redevelopment.
- Municipality-created Brownfield Redevelopment Authorities develop and implement redevelopment financing plans for remediation at specific properties. Taxes are captured to finance environmental assessments, due care provisions, and other cleanup activities facilitating redevelopment.
- The 1998 Clean Michigan Initiative bond generated \$335 million for state-conducted cleanup projects and redevelopment grants and loans to local governments and \$50 million for Waterfront Redevelopment grants.
- Single Business Tax Credits (up to \$30 million) are direct incentives to qualified taxpayers for certain activities to remediate brownfields and encourage redevelopment.

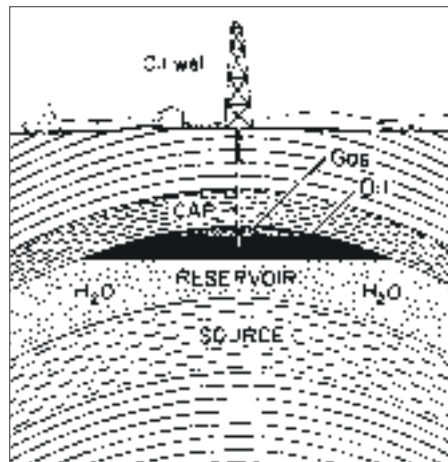
## Contacts

DEQ, Environmental Response Division, Michigan Brownfields Program, (517) 373-9540, [www.deq.state.mi.us/erd/brownfields/index.html](http://www.deq.state.mi.us/erd/brownfields/index.html); DEQ, Environmental Assistance Division, Community/Site Redevelopment Program, (517) 335-2109, [www.deq.state.mi.us/ead/eosect/comredev.html](http://www.deq.state.mi.us/ead/eosect/comredev.html); MDA, Farmland and Open Space Preservation Program, (517) 373-3328, [www.mda.state.mi.us/prodag/farmland/index.html](http://www.mda.state.mi.us/prodag/farmland/index.html)

# OIL AND GAS

Oil and gas deposits formed when animals and plants died and settled to the bottom of ancient, shallow saltwater seas. Over time, the animal and plant matter was buried deep within the earth where heat, pressure, and the lack of oxygen promoted their breakdown into hydrocarbons, or crude oil and natural gas. Michigan was covered with shallow saltwater seas for hundreds of millions of years, creating oil and gas fields across the Lower Peninsula.

Drilling for oil and gas began in Michigan during 1886. The state had an oil and gas drilling “boom” in the late 1920s and began to regulate oil and gas development and issue drilling permits in 1927. During 1999, over 7.6 million barrels of oil and over 270 billion cubic feet of gas were pumped from the ground. Since 1925, over 1.2 billion barrels of oil and more than 5.3 trillion cubic feet of natural gas have been withdrawn from Michigan’s rock formations.



## Management

Michigan’s policy is to conserve oil and gas through proper drilling and production and by preventing waste. Before a person can drill an oil or gas well in Michigan, he or she must own or lease the subsurface oil and gas mineral rights. State-owned minerals are leased from the DNR-Real Estate Division. Additionally, he or she must obtain a drilling permit from the DEQ’s Geological Survey Division. Before the DEQ can issue the permit, the driller must file a bond with the state to ensure proper closure of the well if the well is abandoned or improperly plugged. The bond amount varies depending on the depth of the well.

When a well is no longer used for oil or gas production, state law requires that it be “plugged” within one year. Improperly plugged or unplugged abandoned wells cause environmental problems, including damage to groundwater and drinking water sources.

Environmental contamination concerns led the Legislature to establish the Orphan Well Fund in 1994. The fund receives a minimum of \$1 million each year from taxes collected on oil and gas production. Money in the fund may be used for plugging abandoned or improperly closed oil or gas wells and conducting cleanup activities and site restoration at oil and gas wells where the owner is unknown or financially insolvent. The abandoned wells are plugged based on a priority list developed by the DEQ.

## Severed Mineral Issues

Land rights can be divided into surface rights and mineral rights. Surface property owners do not always own the rights to the minerals below their land, nor are they always aware that another party may own or acquire the rights to minerals below their property. A mineral rights owner can be a private citizen, corporation, or the state and the owner can lease the rights for development. Conflicts often arise when mineral development is proposed and different parties own the surface and mineral rights. The state does not intervene to settle these disputes, rather the parties must settle them privately. While each party has rights that are protected under the law, mineral owners cannot be prevented from accessing their minerals if the state’s oil and gas drilling requirements are met. Thus, the inability of the private parties to settle a dispute is not a reason for the state to deny a drilling permit.

Michigan acquires much of its rights in surface property and minerals when land reverts to the state through a citizen’s or company’s failure to pay property taxes. The state currently holds 5.9 million acres of mineral rights, 2.1 million acres of which are severed from the surface rights.

Until recently, the state had a policy of stripping the mineral rights from the other rights in real property when it acquired land. Thus, the state could sell the surface rights and retain the mineral rights for leasing at a



later date. However, conflicts often develop because the DNR can lease the mineral rights without consulting the surface property owner. This conflict was addressed by the Legislature in 1998 when it enacted a law requiring the DNR to offer state-held severed oil and gas mineral rights back to the surface property owner for fair market prices under certain circumstances. Severed oil and gas mineral rights that are transferred back to the surface property owner are subject to a deed restriction that prevents the future severance of the mineral rights from the surface property rights. Should a landowner sever the mineral rights from the surface rights in property which have been the subject of mineral rights reunification, the subsurface oil and gas rights would revert to the state.

## Bottomlands Leasing

The DNR's Real Estate Division occasionally issues leases for minerals located beneath the bottomlands of the Great Lakes. Bottomlands are the land areas that lie below the ordinary high water mark and may or may not be covered with water. The state owns all the bottomlands located within Michigan's boundaries. Michigan has leased the Great Lakes bottomlands since 1945. To date, the DNR has issued 70 nondevelopment oil and gas leases for bottomlands minerals. Thirty leases are currently active.

Permits to drill below the Great Lakes bottomlands are obtained from the DEQ. A total of 13 wells have been drilled below the bottomlands. Of this total, eight wells have produced oil or gas. Currently, seven bottomlands wells are producing; six are gas wells and one is an oil well. All oil or gas reserves below Great Lakes bottomlands are tapped using directional or slant drilling because the state prohibits drill rigs or platforms to be physically located on the Great Lakes.

### ***Natural Resources Trust Fund***

In 1984, Michigan voters passed a ballot proposal to amend the State Constitution establishing the Michigan Natural Resources Trust Fund (MNRTF) for purchasing recreational and scenic lands for public use. The MNRTF's revenues consist of rents and royalties from private oil, gas, and mineral exploration on state-owned lands, together with bonuses resulting from bids for access to such state lands.

In 1994, Michigan voters overwhelmingly approved constitutional amendments to prohibit the Legislature from appropriating MNRTF monies for any use other than those specified. In addition, new caps and spending guidelines were established allowing the interest and earnings of the MNRTF and a maximum of one-third of the mineral revenues deposited in the MNRTF to be used to acquire public recreational lands, protect land due to its environmental importance or its scenic beauty, and develop recreational lands and facilities. However, only 25% of the MNRTF revenues can be used for recreational facility development annually.

The 1994 constitutional amendments also established the State Parks Endowment Fund to provide a stable long-term source of funding state parks operations, maintenance, and capital improvements. The Endowment Fund receives \$10 million each year from mineral revenues.

### ***What Citizens Can Do***

- Determine if you own the mineral rights below your surface property.
- Report any abandoned wells you find to the appropriate DEQ District Office.

## Contacts

For drilling permits: DEQ, Geological Survey Division, (517) 334-6907, [www.deq.state.mi.us/gsd](http://www.deq.state.mi.us/gsd)  
For mineral leases: DNR, Land and Mineral Services Division, (517) 373-7663, [www.dnr.state.mi.us](http://www.dnr.state.mi.us)  
For MNRTF grants: DNR, Grants Management, (517) 373-2724, [www.dnr.state.mi.us/pdfs/dnr/grants/mnrftgrant.pdf](http://www.dnr.state.mi.us/pdfs/dnr/grants/mnrftgrant.pdf)

# GLOSSARY OF ACRONYMS

---

AOC	Great Lakes Areas of Concern
BEA	Baseline Environmental Assessment
CMI	Clean Michigan Initiative
DCH	Michigan Department of Community Health
DEQ	Michigan Department of Environmental Quality
DNR	Michigan Department of Natural Resources
EPA	U.S. Environmental Protection Agency
MCL	Michigan Compiled Law
MDA	Michigan Department of Agriculture
MNRTF	Michigan Natural Resources Trust Fund
MSU	Michigan State University
NREPA	Natural Resources and Environmental Protection Act
ORV	Off-road Vehicle
PCB	Polychlorinated biphenyl
PDR	Purchase of Development Rights
PEAS	Pollution Emergency Alerting System
TB	Tuberculosis
TDR	Transfer of Development Rights
USDA	U.S. Department of Agriculture

---

## A

Abandoned Wells, 32  
 Agriculture, 12, 30  
 Air Pollution Laws, 20

---

## B

Baseline Environmental Assessments (BEA), 31  
 Boating, 18  
 Bottomlands, 33  
 Bovine Tuberculosis (TB), 13  
 Brownfield Redevelopment, 31

---

## C

Chlorofluorocarbons (CFCs), 20  
 Clean Michigan Initiative (CMI), 19, 22  
 Climate, 3, 20  
 Commercial Forest Program, 15  
 Composting, 24, 26  
 Concurrency, 30

---

## D

Directional Drilling, 33  
 Drains, 12  
 Drilling Permits, 32  
 Drinking Water, 22

---

## E

Endangered Species, 14, 16  
 Environmental Cleanup, 28, 31  
 Environmental Contamination, 28, 31, 32  
 Exotic Species, 5, 9, 15

---

## F

Farmland Preservation, 12  
 Farms, 12  
 Fertilizers, 12  
 Fish Consumption Advisories, 7  
 Fishing, 16  
 Forest Products, 14  
 Forestry Incentive Program, 15  
 Forests, 14

---

## G

Glaciers, 2  
 Great Lakes, 4  
 Great Lakes Bottomlands, 33  
 Groundwater, 7, 28  
 Growth Management, 30  
 Gypsy Moth, 15

## H

Hazardous Waste, 24  
 Household Hazardous Waste, 24, 26  
 Hunting, 16  
 Hydrocarbons, 32

---

## I

Incineration, 24  
 Inland Lakes, 6

---

## L

Landfills, 24  
 Land Use, 30  
 Lifetime Licenses, 16  
 Livestock, 12

---

## M

Michigan Natural Resources Trust Fund  
 (MNRTF), 33  
 Mineral Rights, 32  
 Mining, 2, 10, 30

---

## N

National Ambient Air Quality Standards, 20  
 Nongame Species, 15, 16  
 Non-native Species, 5, 9, 15  
 Nonpoint Source Pollution, 22

---

## O

Off-road Vehicles (ORVs), 10, 18  
 Oil and Gas, 3, 32  
 Oil and Gas Drilling, 32  
 Orphan Well, 32  
 Ozone, 20

---

## P

Pesticides, 12  
 Plugging Wells, 32  
 Purchase of Development Rights, 30  
 Purple Loosestrife, 9

---

## R

Recreation, 18  
 Recycling, 24, 26  
 Redevelopment, 31  
 Reuse, 26  
 Rivers, 6

# INDEX *(continued)*

---

## **S**

Sand Dune Mining, 10  
Sand Dunes, 10  
Severed Mineral Rights, 32  
Snowmobiles, 19  
Solid Waste, 24  
Source Reduction, 26  
State Forests, 14  
State Parks, 3, 10, 18  
Sustainable Forestry, 15

---

---

## **T**

Timberland, 14  
Transfer of Development Rights, 30  
Tuberculosis (TB), 13

---

---

## **U**

Underground Storage Tanks, 28  
Urban Growth Boundaries, 30  
Urban Sprawl, 30

---

---

## **W**

Waste Management, 24  
Waste Minimization, 26  
Waste Reduction, 26  
Water Levels, 4  
Water Pollution, 4, 6, 22  
Watersheds, 6  
Wetlands, 8

---

---

## **Z**

Zebra Mussels, 5

## PHOTO CREDITS

---

Satellite Image of Great Lakes, *U.S. Army Corps of Engineers - Detroit District*, page 4

Lake of the Clouds, Porcupine Mountains State Park, *Grand Hotel*, Balthazar Korab, page 6

Lotus plants, Indiana Dunes National Lakeshore, *National Park Service*, provided by Great Lakes National Program Office ([www.epa.gov/glnpo/image](http://www.epa.gov/glnpo/image)), page 8

Sleeping Bear Dunes, Lake Michigan Empire, *Michigan Travel Bureau*, Robert De Jonge, provided by Great Lakes National Program Office ([www.epa.gov/glnpo/image](http://www.epa.gov/glnpo/image)), page 10

Michigan Farm, *Michigan Travel Bureau*, Randall McCune, provided by Great Lakes National Program Office ([www.epa.gov/glnpo/image](http://www.epa.gov/glnpo/image)), page 12

Michigan Forests, *Michigan Department of Natural Resources*, David Kenyon, page 14

White-tailed Buck Deer, *Michigan Travel Bureau*, Randall McCune, provided by Great Lakes National Program Office ([www.epa.gov/glnpo/image](http://www.epa.gov/glnpo/image)), page 16

Port Huron to Mackinac Race, Port Huron, Michigan, *Michigan Travel Bureau*, provided by Great Lakes National Program Office ([www.epa.gov/glnpo/image](http://www.epa.gov/glnpo/image)), page 18

Lake Huron, Tawas Point State Park, *Michigan Sea Grant Extension*, Carol Y. Swinehart, provided by Great Lakes National Program Office ([www.epa.gov/glnpo/image](http://www.epa.gov/glnpo/image)), page 22

---

---