# Chapter 10: Earth Hazards of the Midwestern US

**Natural hazards** are events that result from natural processes and that have significant impacts on human beings. Extreme **weather** conditions or geologic activity can cause substantial short-term or long-term changes to our environment. These changes can influence crops, homes, infrastructure, and the **atmosphere**. The 4.6-billion-year-old Earth has experienced many of these natural changes, and it has always adjusted accordingly.

Most of the natural hazards in the Midwest are related to weather, geology, or some combination of the two. Examples of weather-related hazards include **tornados** (which cause a narrow path of extreme destruction) and long periods of unseasonably high temperature (which are a threat to crops and human health). Geologic hazards include events such as **earthquakes**, which can cause damage to housing, bridges, and roads. There is often little that can be done to prevent these natural events from occurring, but advanced planning can minimize their impact.

## Weather Hazards

Weather is the measure of short-term conditions of the atmosphere such as temperature, **wind** speed, and humidity. The average weather of a region over decades is its **climate**. Although weather can vary day-to-day or year-to-year, the climate of a region is relatively stable because it represents the average weather over a long period of time. Extra-warm summers and extra-cold winters, when combined with typical seasonal change, result in a moderate average temperature over long periods of decades or centuries. Proximity to a large body of water can also decrease the temperature range of a geographic region. While the Midwest is far from an ocean, it is in close proximity to the **Great Lakes**; nevertheless, states in this area experience a considerable range of temperatures over the course of a year. The greatest temperature ranges are found during the winter: The average winter temperature of northern Minnesota is -13°C (8°F) while that of areas around the Ohio River is 2°C (35°F). Weather hazards can occur fairly frequently, such as several times a year, or relatively infrequently, such as once every century.

### Extreme Temperature

Extreme temperatures can create dangerous conditions for people and may lead to property damage. **Heat waves** are periods of excessively hot weather that may also accompany high humidity. Temperatures of just 3°C (6°F) to 6°C (11°F) above normal are enough to reclassify a warm period as a heat wave. Under these conditions, the mechanism of sweating does little to cool people

Review

***weather*** • *the measure of short-term conditions of the atmosphere such as temperature, wind speed, and humidity.*

***atmosphere*** • *a layer of gases surrounding a planet.*

***wind*** • *the movement of air from areas of high pressure to areas of low pressure.*

***climate*** • *a description of the average temperature, range of temperature, humidity, precipitation, and other atmospheric/hydrospheric conditions a region experiences over a period of many years (usually more than 30).*

***Great Lakes*** • *the largest group of freshwater lakes on Earth (by total surface area and volume), located on the US-Canadian border.*

CHAPTER AUTHOR

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***heat island effect*** • *a phenomenon in which cities experience higher temperatures than do surrounding rural communities.*

***polar vortex*** • *a regularly occurring area of low pressure that circulates in the highest levels of the upper atmosphere.*

***cold front*** • *the boundary between the warm air and the cold air moving into a region.*

***hurricane*** • *a rapidly rotating storm system with heavy winds, a low-pressure center, and a spiral arrangement of thunderstorms.*

down because the humidity prevents sweat from evaporating and cooling off the skin. Heat waves have different impacts on rural and urban settings. In rural settings, agriculture and livestock can be greatly affected. Heat stress recommendations are issued to help farmers protect their animals, particularly pigs and poultry, which, unlike cattle, do not have sweat glands.

The impacts of heat waves on urban settings include a combination of the natural conditions of excessive heat and the social conditions of living in a densely populated space. Cities contain a considerable amount of pavement, which absorbs and gives off more heat than vegetation-covered land does. Air conditioning units that cool down the inside of buildings produce heat that is released outside. Pollution from cars and industrial manufacturing also elevate the outdoor temperatures in cities. This phenomenon, in which cities experience higher temperatures than surrounding rural communities do, is known as the **heat island effect**. Other social conditions can cause an increase in the hazards associated with heat waves in urban areas. People who are in poor health, live in apartment buildings with no air conditioning, or are unable to leave their houses are at greatest risk of death during heat waves. In 1995, a heat wave impacted the Midwest, leading to nearly 740 heat-related deaths in Chicago alone. In addition to causing widespread illness from dehydration and exposure to extreme heat, the high temperatures buckled road pavement and warped train rails.

Recently, a different extreme temperature phenomenon has made the news: the **polar vortex**. As the name implies, a polar vortex is a regularly occurring area of low pressure that circulates in the highest levels of the upper atmosphere. Typically, the polar vortex hovers above Canada. However, a pocket of the counter-clockwise rotating low-pressure center can break off and shift southward at a lower altitude, covering the Midwest with frigid air. The jet stream then shifts to a more southward flow than usual, chilling the Midwest and even the southern states. A polar vortex can lock the jet stream in this new pattern for several days to more than a week. Extreme low temperatures can endanger livestock, and precautions should be taken regarding travel on roadways. Although the cold temperatures of a polar vortex can be uncomfortable and make traveling dangerous in the winter, the Midwest has not yet experienced any major economic or health-related impacts from this extreme weather event.

### Seasonal Severe Storms

Several types of severe storms present challenges to people living in the Midwest. Summer brings severe thunderstorms associated with **cold fronts**. Fall and spring can bring ice storms, and winter brings the challenge of snow and, in some cases, blizzard conditions. Although rare, **hurricanes** moving north from the Gulf of Mexico can impact the weather in the Midwest as well.

Severe thunderstorms are a common occurrence for people living in the Midwest because the conditions over the Great Plains are perfect for the development of severe weather. The flat, open fields are warmed by the summer sun, which sits high in the sky during this time of year. This results in large temperature differences when cold air masses move across the country. The boundary between the warm air and the cold air moving into a region creates a cold front.

At this boundary, denser, colder air moves in, making the less dense, warm air rise. This displaced warm air cools as it rises because air pressure decreases with increasing height in the atmosphere. As the air cools, it becomes saturated with water vapor, and condensation (the shift from a vapor [gas] state to a liquid state) begins to occur. This phase shift takes place because the cooler air contains less thermal energy than warmer air does, and this reduction in energy allows the water molecules to "link" together faster than they are torn apart. At frontal boundaries, warm air quickly rises and condenses, and clouds form. Because liquid water droplets in the clouds must be very small to remain suspended in the air, when there is a significant amount of condensation, the small water droplets come together, eventually becoming too large to remain suspended. This process leads to dramatic rainstorms.

Air pressure plays a key role in the formation and severity of these storms. Warm air has a lower pressure relative to cold air, and the movement of air from areas of high pressure to areas of low pressure generates wind. Therefore, when a cold front moves into an area that is very warm, the significant difference in air pressure will generate strong winds. The greater the temperature difference, the greater the air pressure difference and, consequently, the greater the speed at which the air will move. Wind is very common in the Midwest, and the **topography** of the area plays an important role in wind formation, allowing for warm air to heat up over large expanses of flat cropland without hills or mountains to influence the direction of air movement. Therefore, the Midwest has the perfect ingredients for severe weather: flat topography and large temperature differences on a day-to-day basis.

While severe thunderstorms are often a weekly occurrence in much of the Midwest, two less common storm hazards have the potential to cause serious property damage and endanger lives: **derechos** and tornados. Both storm events are associated with **wind shear**, which occurs when the wind speed or direction changes with increasing height in the atmosphere. Wind shear can happen when a cold front moves rapidly into an area with very warm air. There, the condensing water droplets mix with the cooler, drier air in the upper atmosphere to cause a downdraft.

When these downdrafts are very powerful, they can cause a derecho, or a set of powerful straight-line winds that exceed 94 kilometers per hour (kph) (58 miles per hour [mph]) and can often approach 160 kph (100 mph). These powerful windstorms can travel over 400 kilometers (250 miles) and cause substantial wind damage, knocking down trees and causing widespread power outages. The lightning associated with these intense storms can cause both forest fires and house fires. Approximately one derecho every year or two will occur in much of the Midwest (*Figure 10.1*). They are less frequent in the upper Midwest states, which remain cooler throughout the summers.

The differences between tornadoes and derechos are indicated in their names: the word *derecho* is the Spanish word for straight ahead, while the word tornado has its roots in the Spanish word *tonar*, which means to turn. Both types of storm events can be associated with the same major cold front boundary because they require similar ingredients to get started. However, tornado formation is

***topography*** • *the landscape of an area, including the presence or absence of hills and the slopes between high and low areas.*

***derecho*** • *a set of powerful straight-line winds that exceed 94 kph (58 mph) and can often approach 160 kph (100 mph).*

***wind shear*** • *when wind speed and/or direction changes with increasing height in the atmosphere.*

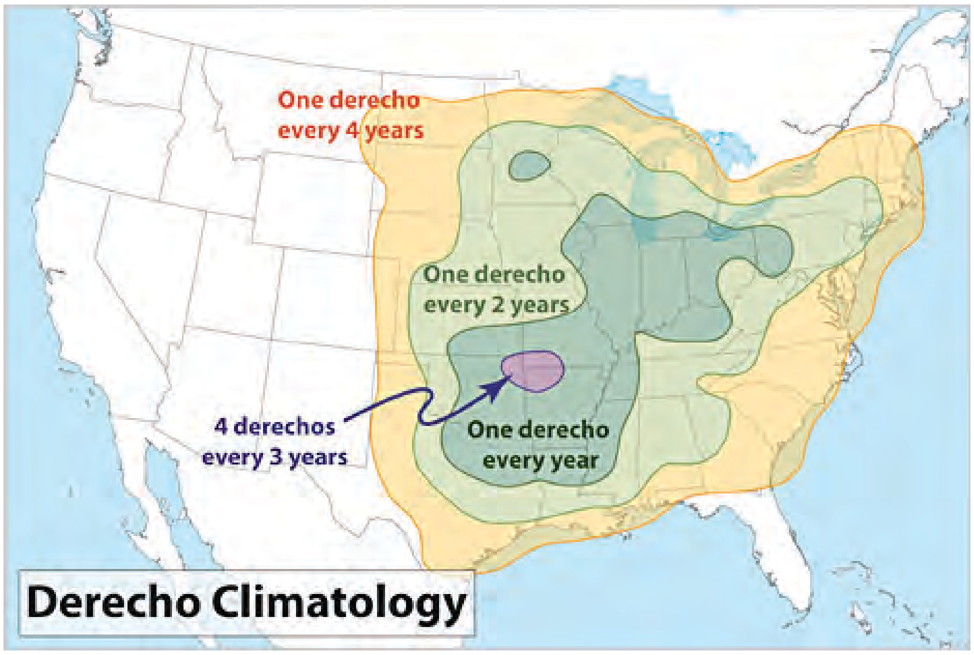


*Figure 10.1: Derecho frequency in the continental US.*

a more complicated process. At the frontal boundary, warm, moist air rapidly rises as cooler, dry air descends. In the meantime, the pressure differences between the warm and cold air masses cause strong winds. As conditions in the atmosphere develop to cause a tornado, clouds with a visible horizontal rotation can appear. The clouds seem to roll like waves crashing on the shore of a beach. This horizontal motion can tilt, lifting the rotating cloud vertically, and the rolling cloud will form a tornado. Most tornados will last a few seconds to several minutes. During that time, many tornado-prone areas will use tornado sirens to alert residents of the danger. A smaller tornado might generate flying debris that can cause injury or damage to buildings, while larger tornados can cause buildings and houses to be completely broken apart. Tornados are classified by their ranking on the Enhanced Fujita scale, or EF scale. The classifications are estimates of the wind speeds based on the type of damage that is observed following the storm.

Although specific tornado paths are not predictable, the conditions that produce them are used to alert people so that they will seek shelter. The National Weather Service issues a *watch,* if the conditions are right for a type of storm event, or a *warning,* if the conditions are occurring or imminent for the storm event. The National Weather Service is part of the National Oceanographic and Atmospheric Administration, which maintains a US map of all current watches and warnings. Since the atmospheric conditions can change very quickly, an important factor in preventing loss of human life is getting the public to act upon the severe weather alerts. One way in which severe weather expert Dr. Greg Forbes has sought to improve public response to warnings is through a tornado alert index that helps people evaluate the risk of a local tornado. The Tor:Con index used by the Weather Channel provides a number from 1 to 10 that represents the probability of a tornado occurring. Meteorologists evaluate the atmospheric conditions associated with a storm and assign a score. For example, a 4 on the Tor:Con index would indicate a 40%, or moderate, chance of a tornado forming in a particular area. The hope is that by representing risk as a number from 1 to 10, people will be more likely to heed warnings and seek shelter.

Other severe weather events are more loosely associated with seasonal weather. Hurricanes occur when a warm and moist tropical low-pressure air mass forms over portions of the Atlantic Ocean south and east of Florida. These storms gather strength because the warm summer ocean water evaporates, causing very humid, low-pressure air. The air rises and condenses into water droplets that form clouds and release latent heat. The latent heat provides energy for even greater evaporation of warm ocean water, and thus the cycle continues until the low-pressure center moves over land. These storms are considered **tropical depressions** when wind speeds are below 63 kph (39 mph). As the storm develops a more organized structure, however, with more concentrated rising warm air in the center and bands of rain, it will officially become a tropical storm when its wind speeds reach the 63 to 117 kph (39 to 73 mph) range. Once winds have reached 119 kph (74 mph), the storm is classified as a hurricane.

***tropical depression*** • *an organized, rotating system of clouds and thunderstorms.*

***global warming*** • *the current increase in the average temperature worldwide, caused by the buildup of greenhouse gases in the atmosphere.*

Hurricanes are not common in the Midwest. However, if a hurricane is particularly strong, it can move far enough northward and inland to cause a significant rain event for areas in the Midwest. The impact on the Midwest is usually less serious than the property damage experienced along the southern and eastern seaboards of the United States. Natural hazards experienced during a hurricane are similar to those experienced during a severe thunderstorm that is accompanied by flooding.

## Climate Change

With the earlier definitions of weather and climate in mind, it is important to understand that most of the extreme climate change in Earth's history occurred before humans existed. That being said, the rapid release of carbon dioxide into the atmosphere from human activity is causing a **global warming** event. The seemingly slight increase in the average annual temperatures in the Midwest has been accompanied by more frequent heat waves and shorter winters. In addition to the previously mentioned risks associated with heat waves, increasing temperatures allow for certain bugs, such as ticks and mosquitoes, to live longer, thereby increasing the risk of contracting the diseases they carry. Heat waves can also be associated with droughts that hurt crop production. In contrast, scientists are predicting more severe rainfall events in the Midwest in the coming years. This has recently resulted in an increase in severe flooding, damage to infrastructure, and even death. While the coexistence of these two types of events may seem contradictory, it is indicative of an increase in extreme events overall. Ultimately, the Midwest,

**See Chapter 9: Climate for more about the impacts of climate change.**

## Climate Change

unlike the coastal US states, should be able to more easily endure the effects of climate change because of its considerable distance from an ocean that would be subjected to rising sea levels.

Humans have designed and built air conditioning and heating *systems* for protection from extreme weather. The crops, fish, and livestock, upon which humans depend for food, however, live without these climate control systems, and will therefore experience the impacts of environmental changes more directly. Increasing temperatures and changes in rainfall patterns will alter the type of crops that can be successfully grown and harvested across the Midwest (*Figure 10.2*). Models have predicted that the climate of Midwestern states, such as Michigan and Illinois, will be more similar to the current climate of Texas by the end of the 21st century (*Figure 10.3*).

Another concern regarding hazards exacerbated by climate change in the Midwest is whether or not there has been or will be an increase in the number or the severity of storms, such as hurricanes and tornadoes. According to NASA, the present data is inconclusive in terms of whether the Atlantic Ocean

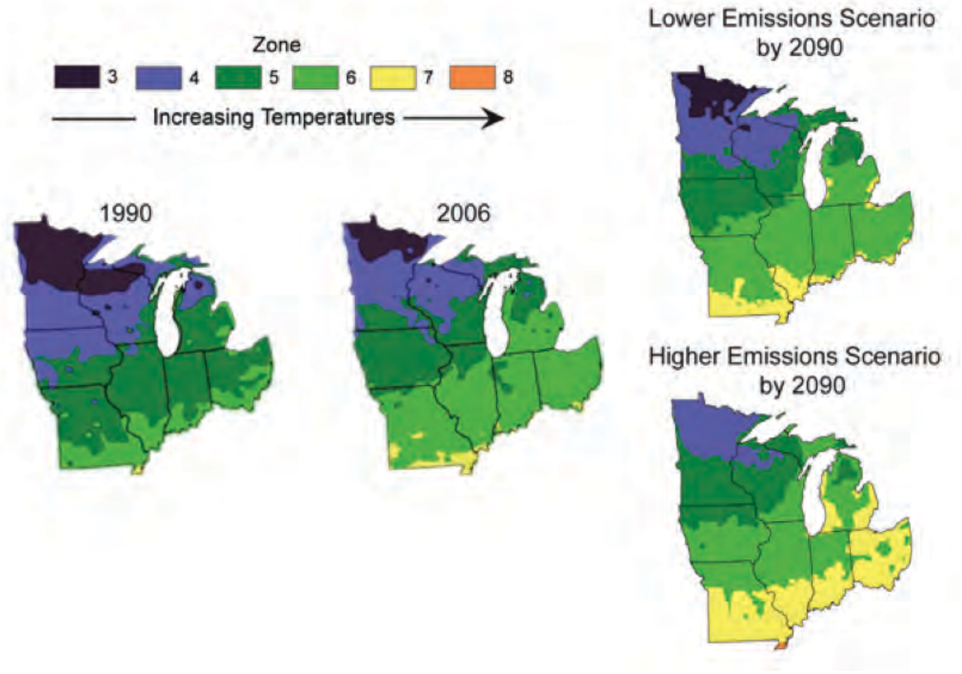


*Figure 10.2: Shifts in USDA Hardiness Zones as a result of climate change.*

hurricanes are already more severe, but there is a greater than 66% chance that global warming will cause more intense hurricanes in the 21st century. Since tornados are hard to predict, involve a complex mix of atmospheric conditions, and occur on a much smaller geographic scale than hurricanes do, it is difficult to determine if global warming is currently influencing the frequency or severity of tornado activity. Since climate is weather averaged over decades, it might take many years to determine that a change has occurred with respect to these

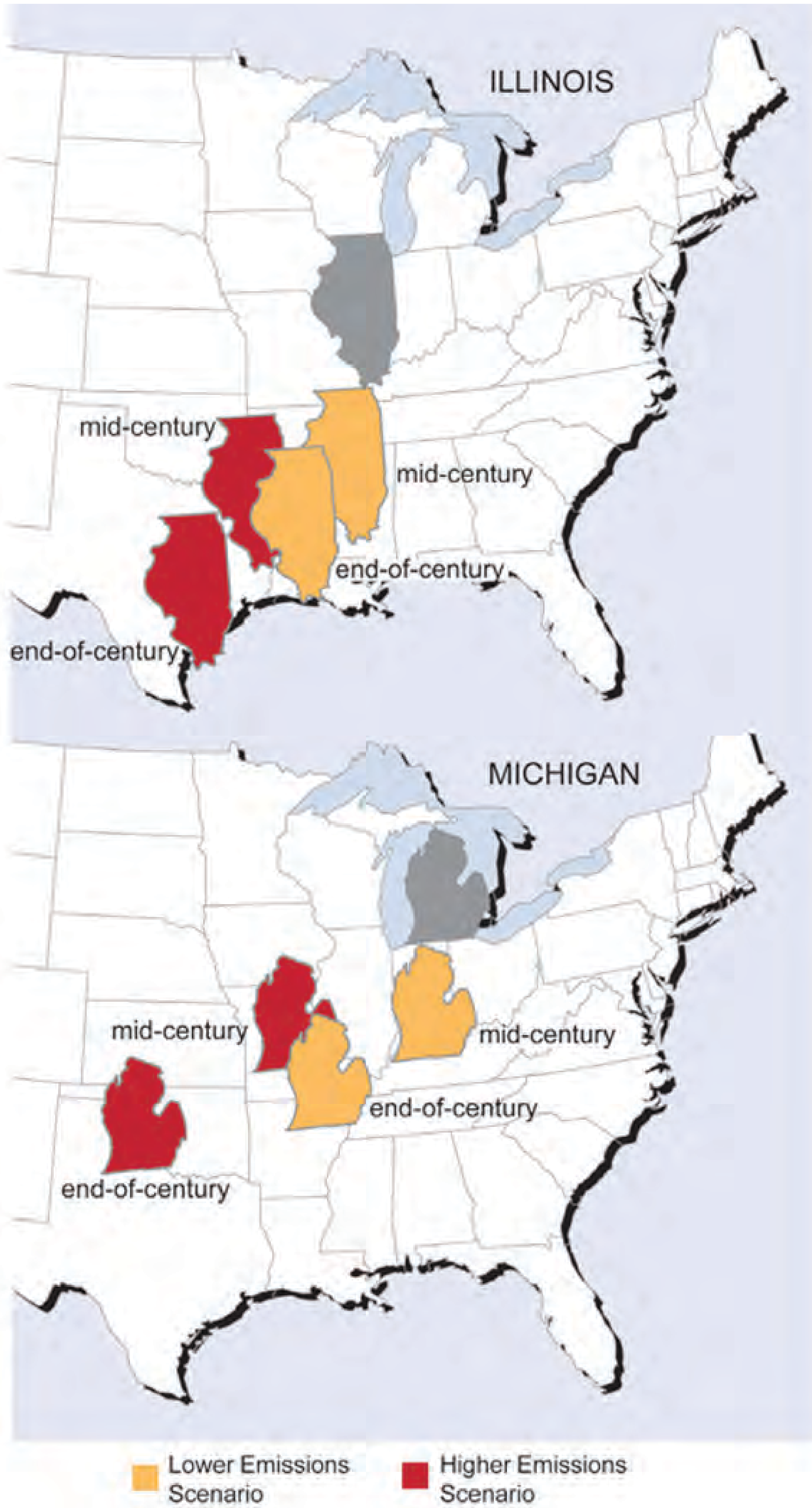


*Figure 10.3: Prediction of the relative climates for Illinois and Michigan's Lower Peninsula due to climate change.*

***radon*** • *a naturally occurring radioactive, colorless, odorless gas.*

***plates*** • *large, rigid pieces of the Earth's crust and upper mantle, which move and interact with one another at their boundaries.*

***fault*** • *a fracture in the Earth's crust in which the rock on one side of the fracture moves measurably in relation to the rock on the other side.*

***limestone*** • *a sedimentary rock composed of calcium carbonate ($CaCO_3$).*

***dolostone*** • *a rock primarily composed of dolomite, a carbonate mineral.*

***radioactive*** • *when an unstable atom loses energy by emitting radiation.*

***seismic zone*** • *a regional zone that encompasses areas prone to seismic hazards, such as earthquakes or landslides.*

two types of storms. Scientists are certain that the conditions necessary to form such storms are becoming more favorable due to global warming.

The Union of Concerned Scientists has created an infographic that demonstrates the relative strength of the evidence that various hazards are increasing as a result of climate change (*Figure 10.4*).

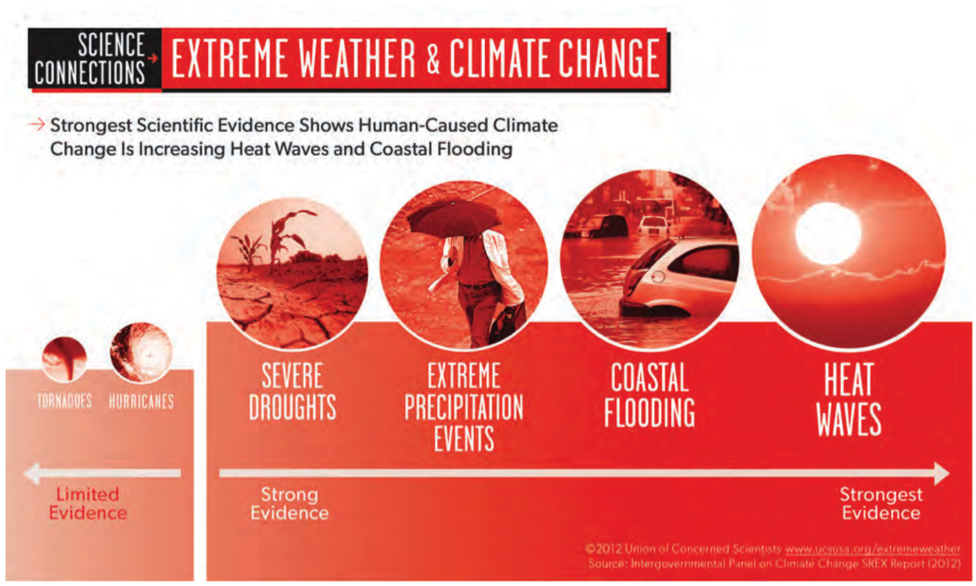


*Figure 10.4: The strength of evidence supporting an increase in different types of extreme weather events caused by climate change.*

## Geologic Hazards

Several natural hazards are the result of the geologic conditions beneath the surface of the Midwest. Three hazards that are common in the Midwest are earthquakes, sinkholes, and **radon**. Although the Midwest does not lie on a **plate** boundary, the New Madrid **fault** is currently active and capable of generating earthquakes. Sinkholes are caused by the dissolving of **limestone** and **dolostone** rocks beneath the surface of some regions in the Midwest. Radon is a gas that is released from the natural breakdown of **radioactive** elements found in bedrock. Although these three hazards are not unique to the Midwest, they do pose some challenges for people living in this area.

### Earthquakes

While earthquakes usually bring California to mind, the New Madrid and Wabash **seismic zones** are responsible for earthquakes throughout the southern Midwest (*Figure 10.5*). The New Madrid seismic zone is in the Mississippi Valley, at the boundaries of Arkansas, Tennessee, Kentucky, Illinois, and Missouri. The Wabash Valley seismic zone extends northward along the boundary between Illinois and Indiana. These seismic zones are poorly understood because, unlike other seismic zones, there is nothing on the surface to help scientists understand the faults responsible for the seismic activity. For example, there is a thick layer of river-deposited sediments (called **alluvium**) that covers what is thought to be a strike slip fault. Microseismic earthquakes that are too small to be felt by humans happen every other day, but larger earthquakes are fairly rare. The bedrock that makes up most of the central US is colder, drier, and less fractured than rocks on the East or West Coast. As a result, the earthquakes here can release the same amount of energy as other earthquakes, but the shaking affects a much larger area because the **seismic waves** travel through denser, more solid bedrock.

***seismic wave*** *• a regional zone that encompasses areas prone to seismic hazards, such as earthquakes or landslides.*

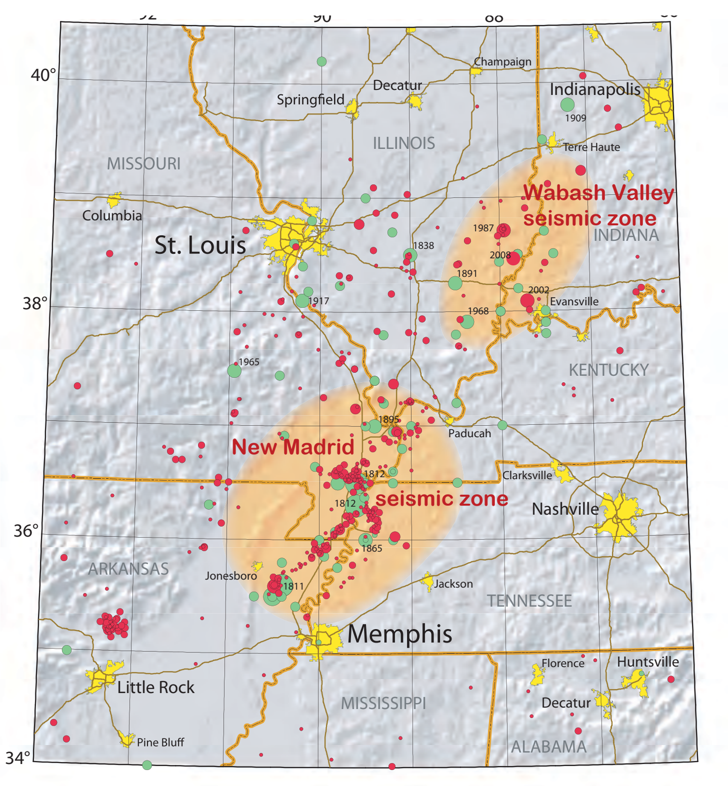


*Figure 10.5: Earthquake events in the New Madrid and Wabash Valley seismic zones.*

Earthquake prediction is very difficult because most of the mechanisms that cause earthquakes are beneath the Earth's surface. Scientists typically make use of historical records as well as limited surface monitoring to understand the probability of a seismic event occurring. Historical reports of earthquakes from 1811 to 1812 indicate a two-month period that included several major earthquakes thought to be greater than 7.0 in magnitude. Based on these historical reports, and the absence of a large magnitude earthquake in the past century, scientists expect that the New Madrid seismic zone is overdue for a large magnitude earthquake.

# Earth Hazards

## Geologic

***karst topography*** • *a kind of landscape defined by bedrock that has been weathered by dissolution in water, forming features like sinkholes, caves, and cliffs.*

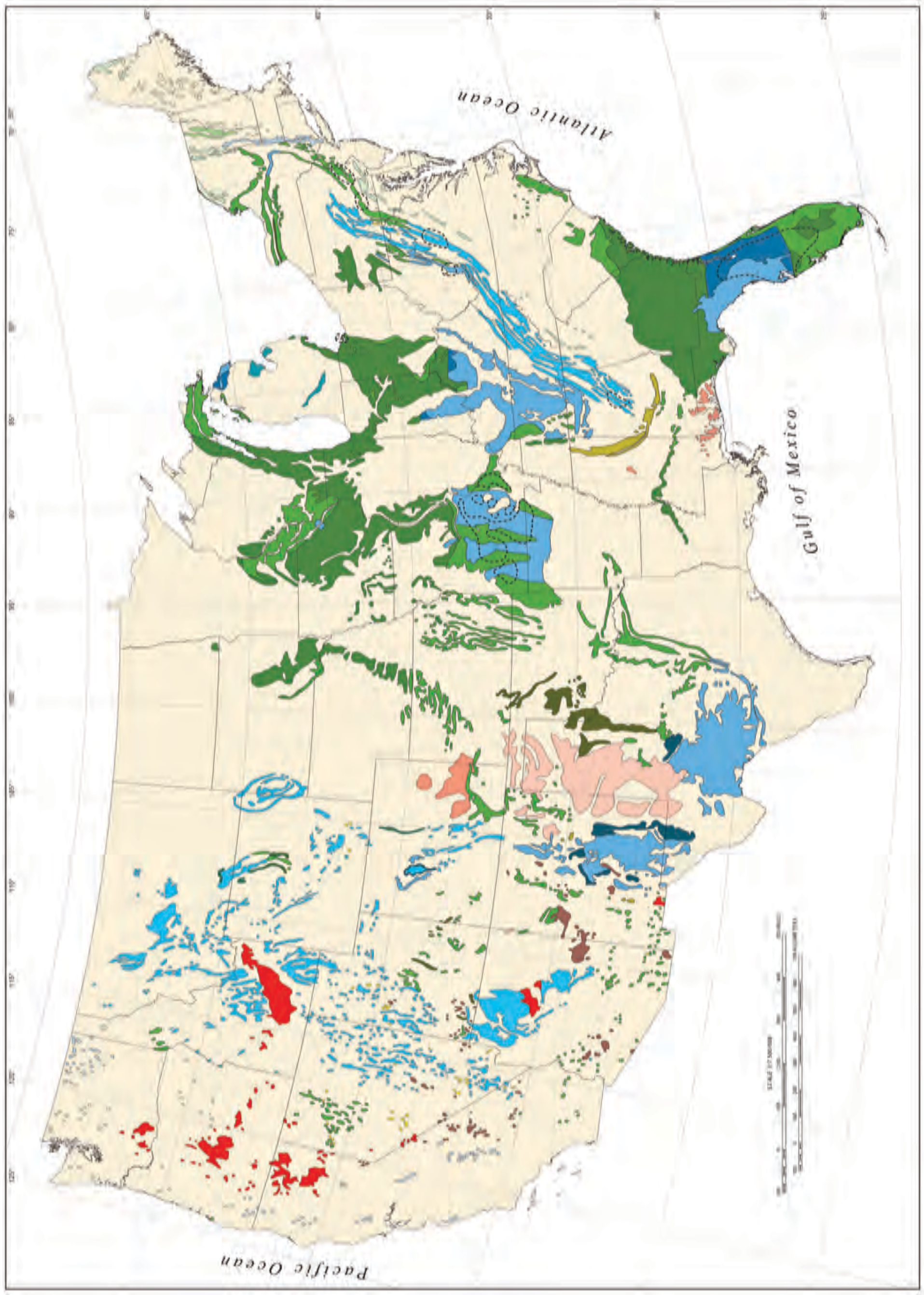


*Figure 10.6: Karst topography in the continental US.*
*See Key on facing page.*


FISSURES, TUBES, AND CAVES OVER 1,000 FT (300 M) LONG; 50 FT (15 M) TO OVER 250 FT (75 M) VERTICAL EXTENT
In metamorphosed limestone, dolostone, and marble
In moderately to steeply dipping beds of carbonate rock
In gently dipping to flat-lying beds of carbonate rock
In gently dipping to flat-lying beds of carbonate rock beneath an overburden of noncarbonate material 10 ft (3 m) to 200 ft (60 m) thick
In moderately to steeply dipping beds of gypsum
In gently dipping to flat-lying beds of gypsum
FISSURES, TUBES, AND CAVES GENERALLY LESS THAN 1,000 FT (300 M) LONG; 50 FT (15 M) OR LESS VERTICAL EXTENT
In metamorphosed limestone, dolostone, and marble
In crystalline, highly siliceous intensely folded cabonate rock
In moderately to steeply dipping carbonate rock
In gently dipping to flat-lying carbonate rock
In gently dipping to flat-lying beds of carbonate rock beneath an overburden of noncarbonate material 10 ft (3 m) to 200 ft (60 m) thick
In moderately to steeply dipping beds of gypsum
In gently dipping to flat-lying beds of gypsum
In gently dipping to flat-lying beds of gypsum beneath and overburden of nongypsiferous material 10 ft (3 m) to 200 ft (60 m) thick
In carbonate zones in highly calcic granite (Alaska only)
In moderately to steeply dipping beds of carbonate rock with a thin cover of glacial till and frost-derived residual soil (Alaska only)
FISSURES, TUBES, AND CAVES GENERALLY ABSENT; WHERE PRESENT IN SMALL ISOLATED AREAS, LESS THAN 50 FT (15 M) LONG; LESS THAN 10 FT (3 M) VERTICAL EXTENT
In crystalline, highly siliceous intensely folded carbonate rock
In moderately to steeply dipping beds of carbonate rock
In gently dipping to flat-lying beds of carbonate rock
FEATURES ANALOGOUS TO KARST
Fissures and voids present to a depth of 250 ft (75 m) or more in areas of subsidence from piping in thick unconsolidated material
Fissures and voids present to a depth of 50 ft (15 m) in a of subsidence from piping in thick, unconsolidated mate
Fissures, tubes, and tunnels present to a depth of 250 ft (75 m) or more in lava
Fissures, tubes, and tunnels present to a depth of 50 ft (15 m) in lava
Areas in which extensive historical susidence has occurred

# 10 Earth Hazards

## Geologic

A new research study is likely to better explain the seismic activity of the Midwest. EarthScope is a large-scale project funded by the National Science Foundation to gather data about the lithosphere beneath the Earth's surface. There are three large investigations of the seismic activity of this area. A network of 400 temporary **seismometers** has been installed, with a distance of approximately 70 kilometers (40 miles) between each seismometer. The volume of data collected by these seismometers will help geophysicists create three-dimensional models of the lithosphere. With these models, we will have a virtual picture of the seismic zones, and, hopefully, we will come to better understand the seismic hazards of the Midwest.

### Sinkholes

Sinkholes are usually caused by a geologic feature known as **karst topography**. Karst can form where the underlying bedrock is composed of material that can be slowly dissolved by water. Much of the Midwest has **carbonate** bedrock consisting of limestone, dolostone, and **marble**. These particular types of **sedimentary rock** contain significant amounts of carbonate (carbon atoms combined with multiple oxygen atoms). Water that mixes with carbon dioxide in the air and **soil** reacts to produce carbonic acid ($H_2CO_3$). This acid and the carbonate react, dissolving the rock. Although this takes a long time to occur, much of the bedrock in the Midwest is **Paleozoic** in age (between 541 million years and 252 million years old) (*Figure 10.6*). Eventually, caves and caverns form in the rock, and sinkholes form when caves near the surface collapse. The karst topography is noticeable in areas that contain many sinkholes and where the land surface is scattered with large, round depressions.

There are a few conditions that increase the hazards associated with sinkholes. The previously mentioned underground caves are often filled with groundwater. In regions where there is a rapidly growing population, a greater amount of water is extracted from the ground. Likewise, during periods of drought, the **water table** can drop considerably, leaving these caves filled with air instead of the water that would normally help to support the weight of the ground above. Without the support of the ground water, the surface can collapse. In some cases, increasing the weight on the surface by rapidly building large structures can also lead to sinkhole collapse. There are a few steps that can be taken to mitigate these issues. Geologists and environmental engineers can use ground-penetrating radar to identify the location of sinkholes. In some areas where sinkholes are very prevalent, engineers can fill the sinkholes with gravel, which will allow for water drainage while still supporting the surface.

### Radon

Radon is a naturally occurring radioactive, colorless, odorless gas. It is the leading cause of lung cancer in non-smokers and the second leading cause of lung cancer overall. It can collect in homes, buildings, and even in the water supply. The bedrock geology and glacial history of the Midwest provides ideal conditions for radon hazards.

Radon is one of the products of decay from the breakdown of radioactive elements in soil, rock, and water. Uranium-238 undergoes radioactive decay, producing energy and several radioactive products, such as Radon-222 and

***seismometer*** • *an instrument that measures seismic waves (movements) within the ground.*

***carbonate rocks*** • *rocks formed by accumulation of calcium carbonate, often made of the skeletons of aquatic organisms.*

***marble*** • *a metamorphic rock composed of recrystallized carbonate minerals, most commonly calcite or dolomite.*

***sedimentary rock*** • *formed through the accumulation and consolidation of grains of broken rock, crystals, skeletal fragments, and organic matter.*

***Paleozoic*** • *a geologic time period that extends from 541 to 252 million years ago.*

***water table*** • *the upper surface of groundwater.*

***granite*** • *a common and widely occurring type of igneous rock.*

***sandstone*** • *sedimentary rock formed by cementing together grains of sand.*

Thorium-232, the latter of which decays to emit energy and Radon-220. Uranium and Thorium are naturally occurring radioactive elements found in bedrock such as **granite**, **shale**, and limestone. Most of the Midwest has bedrock consisting of shale, **sandstone**, limestone, and dolostone, all of which can contain radon (*Figure 10.7*). Most of the northern Midwest has been substantially **eroded** from the **glaciers** of the **Pleistocene**. These glaciers left behind large deposits of gravel, **sand**, and **clay** as they receded and melted. The gravel, sand, and clay are often the eroded remnants of radon-containing bedrock, and the moist temperate climate of the Midwest provides an excellent environment for **weathering** of both the bedrock and the glacial sediments. As they weather, more rock is exposed, which, in turn, allows more radon to be released.

Radon gas finds its way through cracks in the basement foundation, sump pump wells, dirt floor crawlspaces in the basement, and basement floor drains. Radon can be found in water from wells and municipal water. Since radon is more easily released from warm water than from cold water, one of the greatest forms of exposure likely occurs while showering in water with high radon levels. Fortunately, with proper monitoring and mitigation (reduction) techniques, radon gas can be easily reduced to low levels. One technique that is often used in homes involves sealing cracks in the basement floor, covering drains,

***glacier*** • *a body of dense ice on land that does not melt away annually and has sufficient mass to move under its own weight.*

***Pleistocene*** • *a subset of the Quaternary, lasting from 2.5 million to about 11,700 years ago.*

***erosion*** • *the transport of weathered materials.*

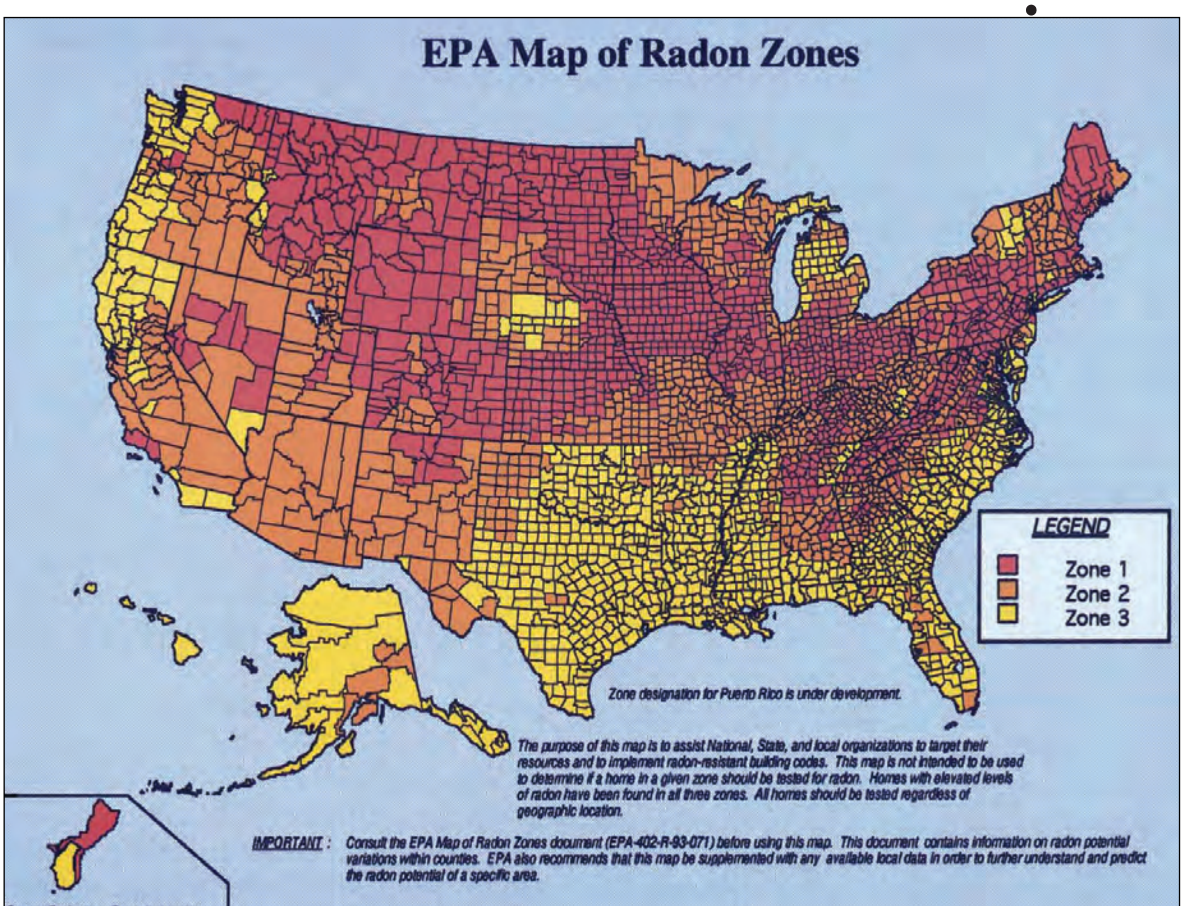


*Figure 10.7: Radon zone map of the US. (Note: Zone 1 contains the highest radon levels.)*

and installing ventilation systems. A well ventilated space will prevent the radon from accumulating and will reduce the risk of exposure. Most states have licensed radon mitigation specialists who are trained in the proper testing and mitigation of radon levels in buildings. The EPA has published a homebuyer's guide designed to help citizens make informed decisions about radon gas. For radon in water, filtration systems can be installed to mitigate exposure in the home.

## Hazards Where Geology and Weather Interact

Flooding is a natural hazard resulting from the combination of geology and weather. The flat-lying bedrock of the Midwest and the large storm events create an ideal setting for flooding. Much of the southern and western boundaries of Midwestern states border the Mississippi and Ohio Rivers. Additionally, most of the waterways of the Midwestern states drain through the Upper Mississippi and Ohio River Basins (*Figure 10.8*). Areas near rivers, tributaries, creeks, and streams are likely to experience flooding during periods of heavy rainfall. The **floodplain** of a river is the land around the river that is prone to flooding. This area can be grassy, but the sediments under the surface are usually deposits from previous floods. For those living near a river, it is important to know both the location of the floodplain boundaries and the likelihood and extent of flooding in that area.

Scientist assess the hazard risk of flooding based on historical data, and they then establish a probability of an extreme flood event taking place over a particular time interval. **Recurrence interval** is the time between major flood events. The physical extent of the flooding during that interval is the floodplain itself. For example, a 100-year flood would be the most extreme flood event to happen over 100 years and would identify a zone of land in the 100-year floodplain with a 1% chance of recurrence each year. Since this value represents only the probability of flooding, it is possible for multiple 100-year floods to occur within a few years. Most people who live within the 100-year floodplain must carry flood insurance on homes, businesses, and personal property. It is not a matter of if a flood will occur in these floodplains, but rather when.

Flooding has some direct impacts that can themselves be hazards. For example, the increased volume of water flowing through a river channel travels at an increased velocity. This allows for the transport of large amounts of sediment, which can erode supports for roadways, bridges, and buildings. Water traveling at high velocity can also carry large objects like cars and buildings. The water itself can enter buildings (causing permanent damage to homes and businesses) and flood farmland (damaging crops and killing livestock). There are also secondary impacts of major flooding events: Floods can cause transportation problems, loss of electricity for long periods of time, and contaminated drinking water supplies. This can cause long-term economic strain on the towns and industries impacted by flooding.


*Figure 10.8: Major river basins of the continental US.*

In addition to the direct hazards associated with large flooding events, human land use can greatly impact the type and severity of the natural hazards associated with flooding. Because water cannot infiltrate impermeable pavement, there is much more concentrated runoff during rainstorms as the water flows off roads into drains and directly into rivers. To accommodate this, humans have built extensive storm drain systems to prevent the flooding of roads. Unfortunately, these storm drains empty into already swelling rivers. Although these efforts are helpful in preventing flooding in one area, they amplify the flooding event in the river. Heavily developed areas with extensive buildings and bridges can also put increased weight on the ground surface, causing compaction of underlying sediments. This can decrease infiltration rates and the storage capacity of the ground.

While there is no way to completely avoid these human impacts on the natural system, good community planning and informed decision-making can greatly reduce the safety concerns and economic impacts of these events. The Federal Emergency Management Agency (FEMA) provides guidelines for communities that are planning mitigation strategies designed to minimize the impacts of natural hazards such as flooding.

# Resources

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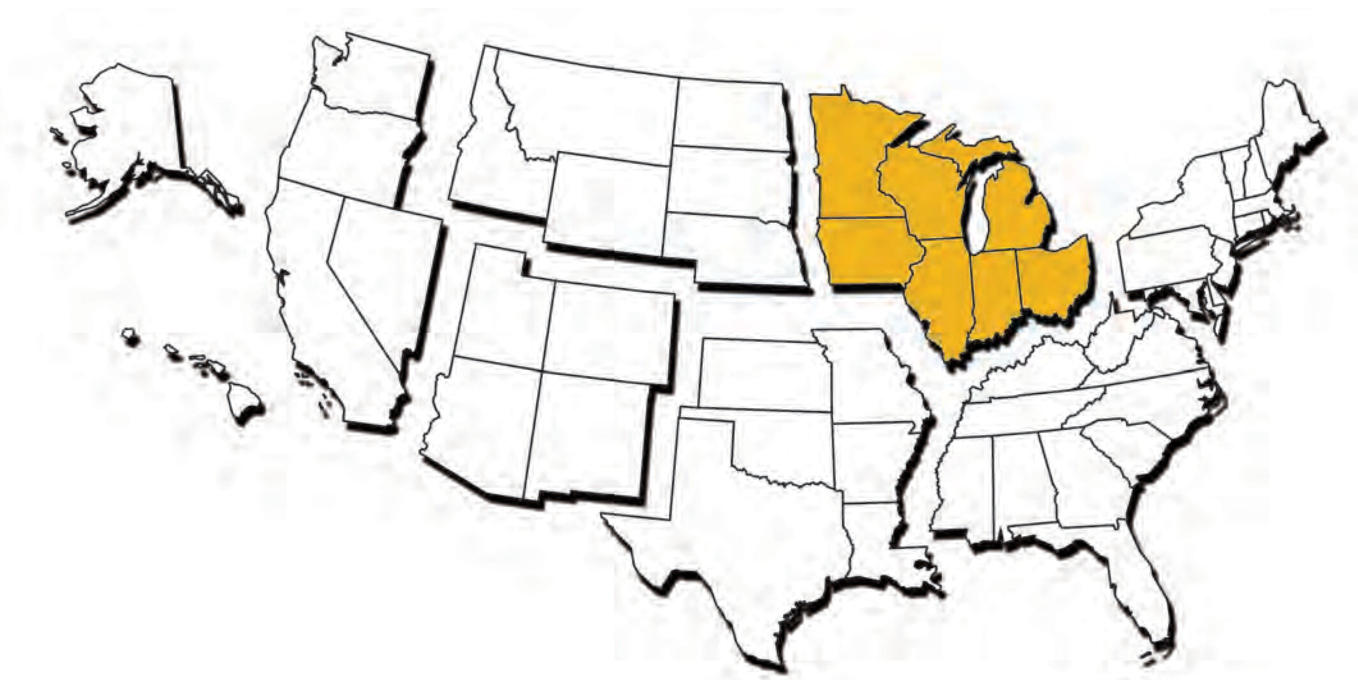
# The *Teacher-Friendly* Guide™

# to the Earth Science of the Midwestern US



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