4.9 Landslide and Mine Subsidence

Description

The Ohio Department of Natural Resources (ODNR) defines a landslide as "a variety of downslope movements of earth materials. Some slides are rapid, occurring in seconds, whereas others may take hours, weeks, or even longer to develop." Landslides are commonly triggered by human-induced vibrations, over-steepened slopes, increased weight on a slope, and removal of vegetation on areas with landslide-prone slopes. Landslides can also be caused by heavy precipitation.

Subsidence is the motion of the earth's surface as it shifts downward relative to a benchmark (often sea level) of the surrounding terrain. In Ohio, the two primary causes are abandoned underground mines (AUMs) and karst. Karst is a topographic feature formed when carbonate rock, such as limestone, dolomite, and gypsum, is eroded by water draining or moving from these areas. Karsts are commonly represented as caves.

According to the Ohio Administrative Code 3901-1-48, mine subsidence is loss caused by the collapse or lateral or vertical movement of structures resulting from the caving in of underground mines including coal mines, clay mines, limestone mines, and salt mines. Mine subsidence does not include loss caused by earthquakes, landslides, volcanic eruptions, or collapse of strip mines, storm and sewer drains, or rapid transit tunnels. Several factors determine the potential for mines to collapse including depth, mining technique used, types of rock and/or soils, and the development on the ground surface. Additionally, abandoned underground coal mines in Ohio have the potential to discharge acidic water which, if discharged into creeks or streams, can alter the chemical composition of the water habitat and cause considerable harm to sensitive aquatic life.

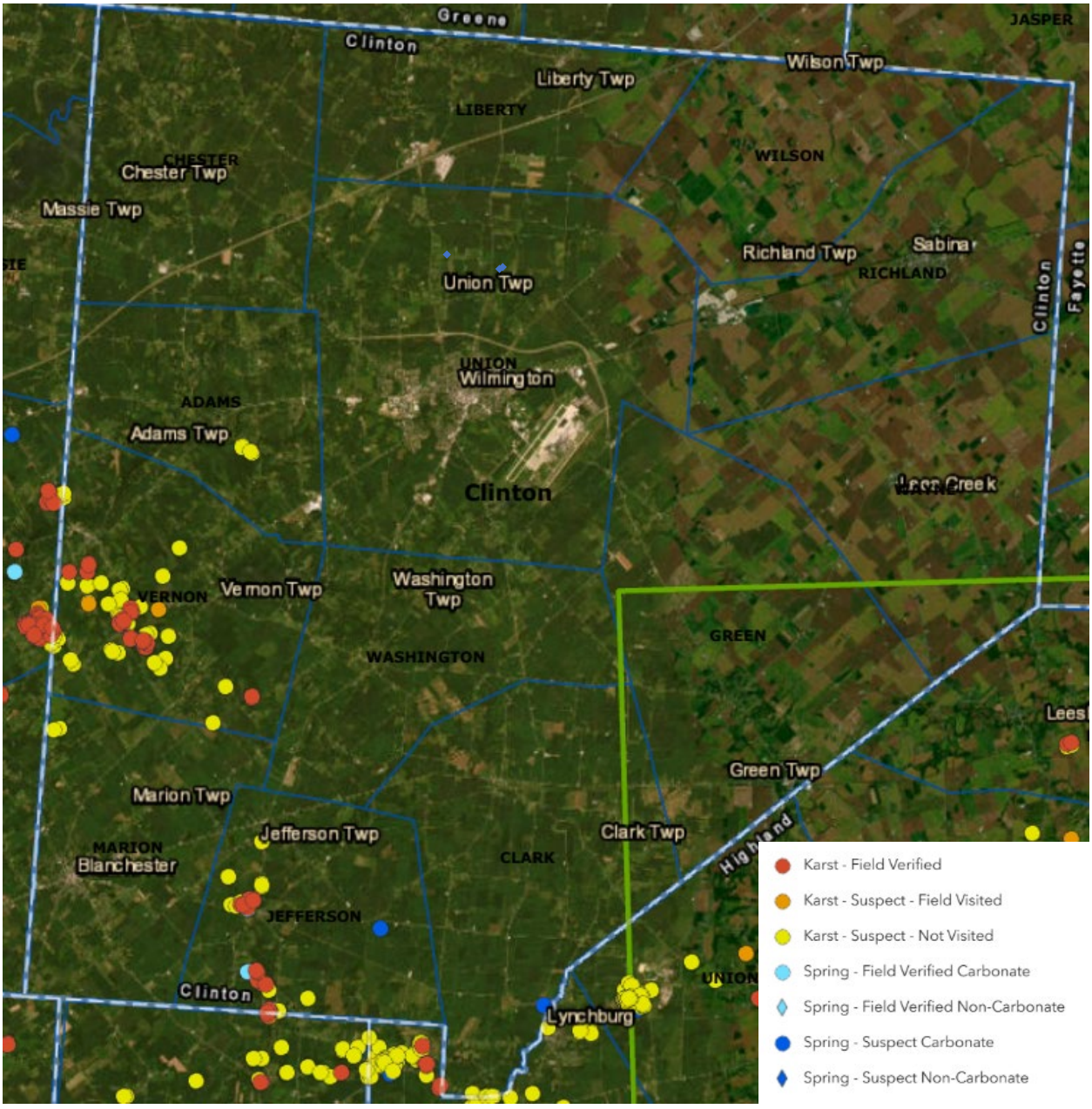
Location

Figure 4.9.1 is a snapshot of the ODNR Karst Interactive Map for Clinton County. The map shows areas of verified Karst fields, suspect karst fields (visited and not visited), and springs (suspect and verified). Several sink holes have been located in Vernon and Jefferson Townships. **Figure 4.9.2** shows the location of areas impacted by bedrock and glacial drift overlay.

Figure 4.9.3 shows the location of abandoned underground mines (UAMs) in Ohio and which counties have the option or are required to obtain mine subsidence insurance. The majority of abandoned underground mines can be found in region three or in nearby counties. All but six counties in region three require land subsidence insurance. Clinton County is located in region two where nine counties have the option to obtain insurance. Clinton County does not have any unabandoned underground mines.

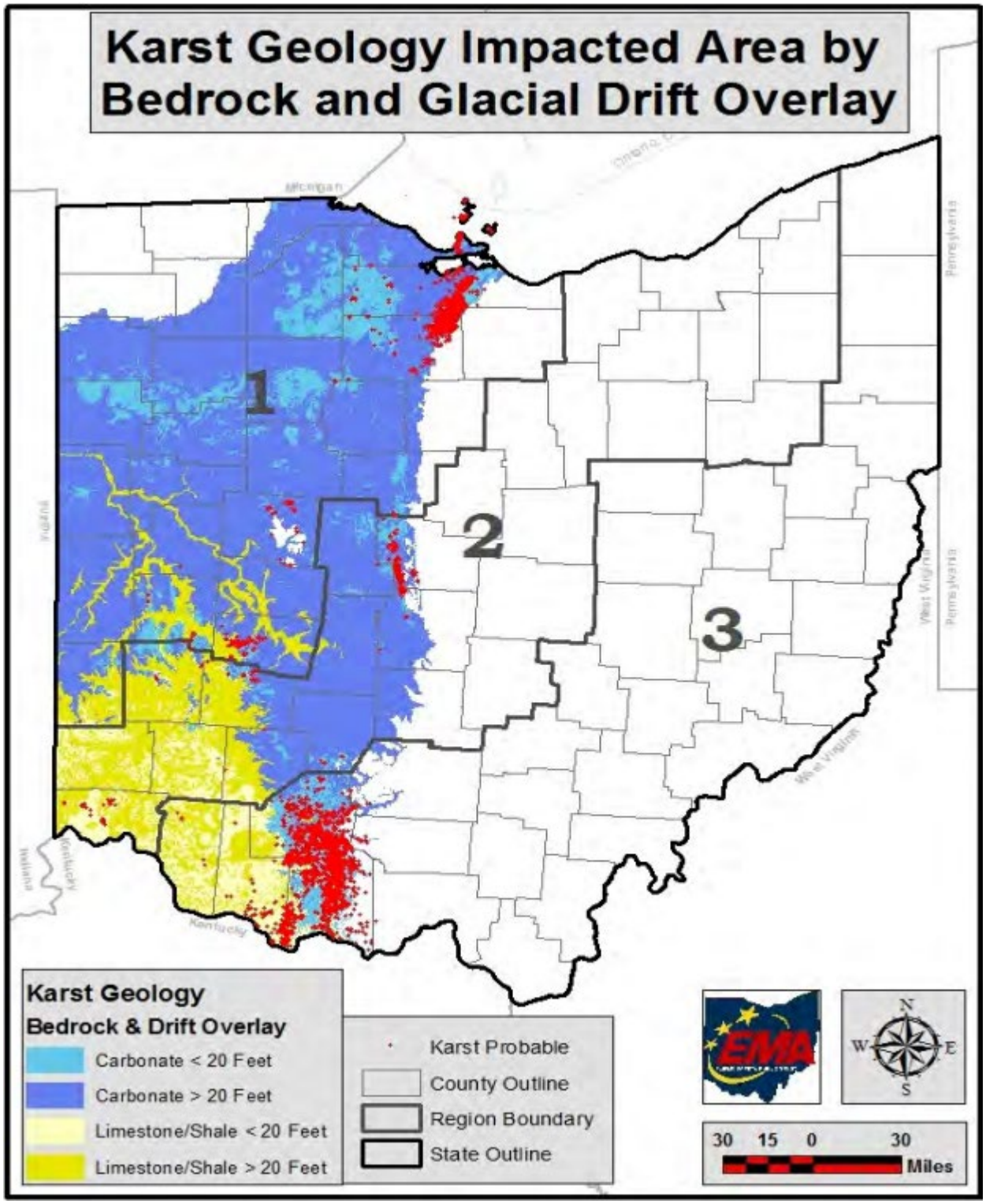
Figure 4.9.4 shows the location of areas at risk for landslides. Clinton County is in region two and has low incidence of landslides. The map displays both the incidence of landslides and susceptibility of the land surface to landslides. Briefly, the map was constructed by evaluating geologic units shown on the geologic map of the United States (King and Beikman, 1974) and classifying them as having high, medium, or low landslide incidence based on number of known landslides, and as having the high, medium, or low susceptibility to landslide. High incidence was assigned to map units (indicated in red on the map) having more than 15 percent of their area involved in landslide; moderate incidence (in tan) to those having between 15 and 1.5 percent; and low incidence (in yellow) to those having less than 1.5 percent.

Figure 4.9.1: ODNR Karst Interactive Map



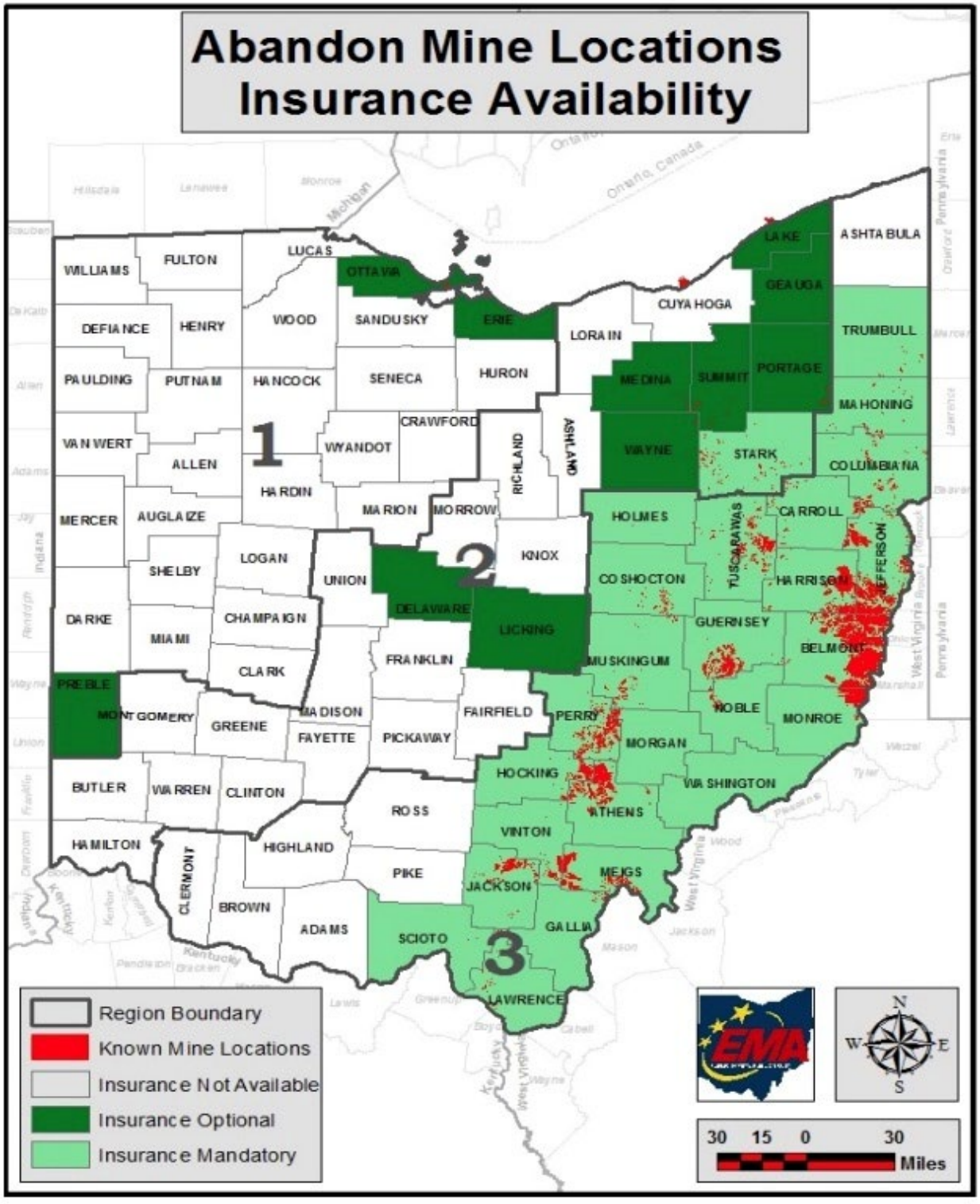
Source: Ohio Department of Ohio Natural Resources

Figure 4.9.2: Karst Geology Impacted Area by Bedrock and Glacial Drift Overlay



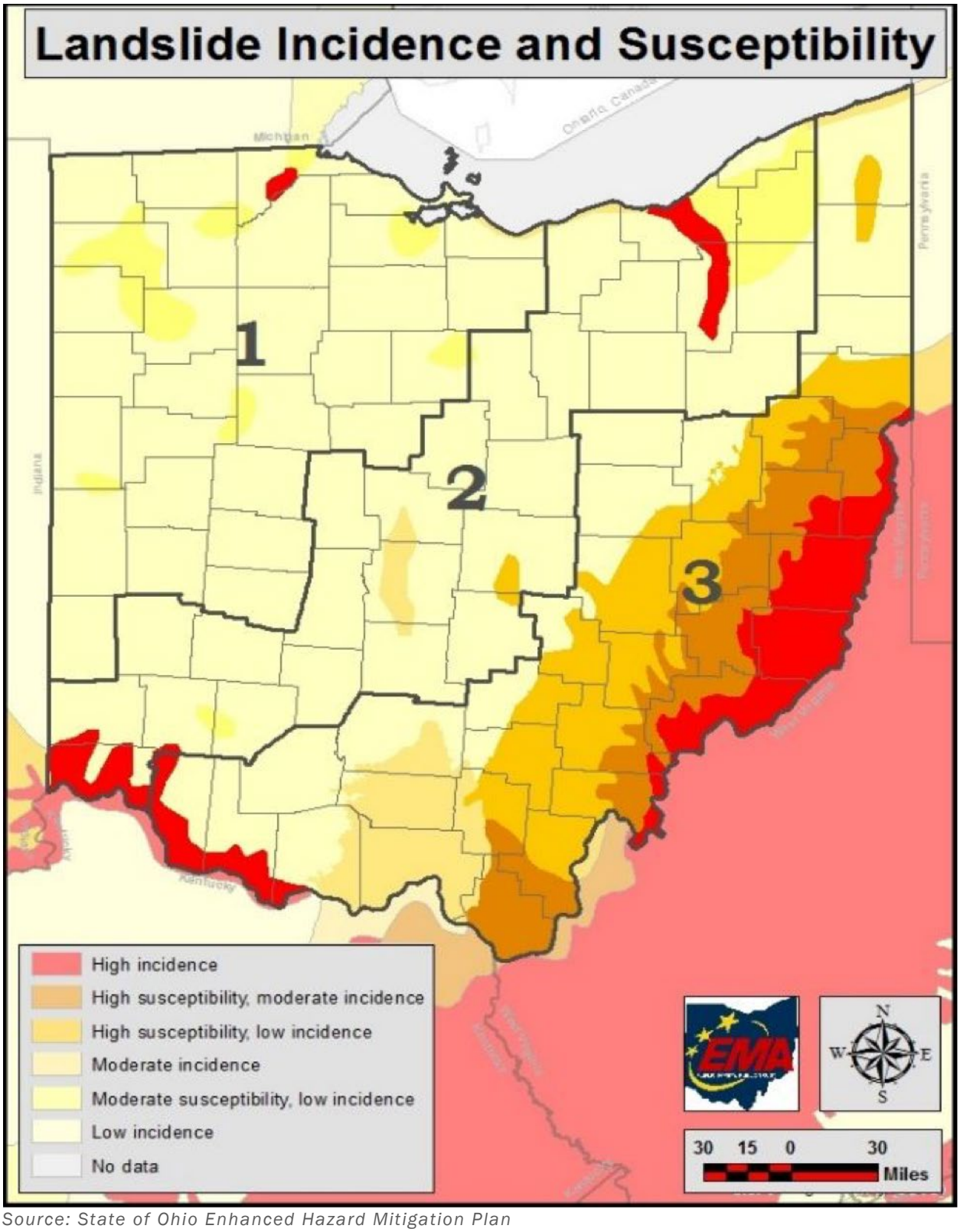
Source: State of Ohio Enhanced Hazard Mitigation Plan

Figure. 4.9.3: Abandon Mine Locations and Insurance Availability



Source: State of Ohio Enhanced Hazard Mitigation Plan

Figure 4.9.4: Landslide Incidence and Susceptibility Map



Source: State of Ohio Enhanced Hazard Mitigation Plan

Extent

According to ODNR Division of Geologic Survey, Clinton County is home to 11 bedrock formations: Drakes formation, Whitewater formation, and Liberty formation undivided; Drakes formation and Waynesville formation undivided; Grant Lake formation; Cedarville dolomite, Springfield dolomite, Euphemia dolomite, Massie shale, Laurel dolomite undivided; Estill shale; Dayton limestone, Noland formation and Brassfield undivided; Massie shale, Laurel dolomite, Osgood shale, Dayton limestone, and Brassfield limestone undivided; Drakes formation and Waynesville formation undivided; Cedarville dolomite, Springfield dolomite, Euphemia dolomite undivided; Arnheim formation; and Ordovician undivided. These formations include a mix of shale, limestone, and shale with interbedded dolomite.

There are three major types of landslides:

1. Rotational slump, or a mass of weak rock or sediment moving as a block unit along a slope. These are the largest types of landslides found in Ohio.
2. Earthflow, or a mass of rock or sediment flowing downslope. These are the most common landslides in Ohio.
3. Rock fall, or a rapid downslope movement of large blocks of bedrock. Most rockfalls in Ohio involve sandstone or limestone that have been weakened by surface water.

According to the Ohio Mine Subsidence Insurance Underwriting Association, mine subsidence is caused by the collapse of underground mines causing damage or movement to a property and/or structure located above. Mine Subsidence insurance is required in 26 counties and optional for 11 counties in Ohio. Insurance for the mandatory counties has an annual premium of $1.00, while optional counties have a premium of $5.00.

History

According to the Ohio Department of Transportation (ODOT), Clinton County has not had any rock slopes or landslides.

Probability

According to the ODNR, Clinton County falls within an area of low risk for slope failure and landslides and rock slopes should not be considered a likely event. The 1870 Ohio Mine Law required a mine be registered if it had more than ten employees and mined more than 200,000 tons of coal. This leaves an undocumented number of smaller mines that closed prior to 1870. There are a known 6,000 underground mines in Ohio. On February 08, 2022, the federal government granted the State of Ohio $46.4 million to reclaim abandoned coal mines. There haven't been any reports of UAMs in Clinton County.

Vulnerability Risk Assessment

Infrastructure Impact

Landslides can block or damage roadways, and damage existing utility infrastructure. Mine subsidence can occur under existing roadways or utility infrastructure causing anything from minor damage to complete destruction.

Population Impact

Landslides and mine subsidence can cause injury or death if a person is struck by or trapped under falling earthen material. Mine subsidence can cause sinkholes under occupied structures which could lead to injuries.

For social vulnerability, mine subsidence is not listed in the National Risk Index, but landslide is listed with a score of 25.7 (relatively low). The index indicates an expected annual loss of $22,000 due to landslides with zero events occurring per year.

Property Damage

Properties caught in the path of a landslide can be destroyed or severely damaged. Properties, including their structures, can be destroyed by mine subsidence.

Table 4.9.5 below shows the census tracts in Clinton County, ranked highest total EAL (expected annual loss) to lowest EAL from landslides, and is broken down by expected losses for buildings, population ($11.6 million for each fatality or 10 injuries), and agriculture. EAL rates, calculated by FEMA, identify the total value of loss expected each year for a particular community, in this case the census tracts for Clinton County.

Table 4.9.5: Structure and Population Vulnerability from Landslides

Census Tract	Expected Annual Loss (Building)	Expected Annual Loss (Population Equivalence)	Expected Annual Loss (Agriculture)	Expected Annual Loss (Total)
39027964800	$1,838	$9,831	$0	$11,669
39027964400	$1,363	$5,367	$0	$6,730
39027964700	$1,027	$824	$0	$1,851
39027965000	$205	$1,035	$0	$1,240
39027964501	$33	$175	$0	$208
39027965100	$32	$145	$0	$177
39027964300	$3	$22	$0	$25
39027964502	$0	$0	$0	$0
39027964900	$0	$0	$0	$0
39027964600	$0	$0	$0	$0
Grand Total	**$4,501**	**$17,399**	**$0**	**$21,900**

Source: FEMA National Risk Index

Loss of Life

Loss of life is possible during sudden mine subsidence or landslides. However, there are no known fatalities in Clinton County due to mine subsidence or landslides.

Economic Losses

Landslides and mine subsidence can block or destroy sections of roadways vital to shipping. Stores, storage facilities, and other structures that are important to economic activity can also be severely damaged or destroyed. It can also be quite expensive to repair sinkholes when they occur.

Future Trends

Land Use and Development Trends

Uses that serve vulnerable populations, such as schools and hospitals, should not be placed in areas that are in high-risk zones for landslides. Development should be limited to areas with minimal slope to reduce potential losses during landslides. Development should also consider low-impact techniques to reduce the likelihood of runoff from precipitation and therefore reduce the risk of landslides. If new residential construction units are within areas with steep slopes, it would increase property and population vulnerabilities in those areas.

Using the United States Geological Survey Landslide Inventory and Susceptibility map as a resource for mapping, future land use changes can reduce the potential of property damage. The map depicts areas that have increasing susceptibility to landslides.

Shifting Weather Patterns and Environmental Trends

Due to shifts in weather patterns, the likelihood of precipitation has increased five to 15 percent, and the amount of rain falling during heavy precipitation events has increased by 45 percent on average between 1958 to 2021. Extreme precipitation could increase the likelihood of landslides in areas with steep slopes. Flooding caused by heavy precipitation could also increase the rate of runoff for acid mine drainage along rivers and streams. More frequent and intense rain events can also increase erosion rates and lead to greater amounts of sediment runoff into rivers, lakes, and streams (U.S. Environmental Protection Agency 2023).