performed. There were no incidents recorded in the Dams Program.

***Probability of Future Occurrence***

All the Hazard Mitigation Plans within our region reflect little concern over dam failure. There is much public awareness and community involvement on behalf of Ameren Missouri, the current owner of Osage (Bagnell) Dam and safety is a priority.

***Changing Future Conditions Considerations***

Studies have been conducted to investigate the impact of climate change scenarios on dam safety. Dam failure is already tied to flooding and the increased pressure flooding places on dams. The impacts of changing future conditions on dam failure will most likely be those related to changes in precipitation and flood likelihood. Changing future conditions projections suggest that precipitation may increase and occur in more extreme events, which may increase risk of flooding, putting stress on dams and increasing likelihood of dam failure.

The safety of dams for the future climate can be based on an evaluation of changes in design floods and the freeboard available to accommodate an increase in flood levels. The results from the studies indicate that the design of floods with the corresponding outflow floods and flood water levels will increase in the future, and this increase will affect the safety of the dams in the future. Studies concluded that the total hydrological failure probability of a dam will increase in the future climate and that the extent and depth of flood waters will increase by the future dam break scenario.

## Vulnerability

***Vulnerability Overview***

***Potential Losses to Existing Development:***
***(including types and numbers, of buildings, critical facilities, etc.)***

There have been no reported Dam Failures in Morgan. Since we were unable to rely on historical data within our region, we considered the amount of potential water and debris that would flow downstream. The impact of Dam Failure will have a direct correlation to the dam itself and the buildings that lay in the path of the water and debris. In cases of complete Dam Failure there will be a considerable amount of devastation including the destruction of all Existing Structures within the path of water and debris.

***Impact of Previous and Future Development***

Impact on current and future development is low because Dam failure is unlikely in Morgan County.

***Hazard Summary by Jurisdiction***

No significant impact is expected in Morgan County.

## Problem Statement

Unregulated dams could potentially become a problem as they age.

***Mitigation:*** Missouri Department of Natural Resources is the primary resource for state regulated

dams. Their website provides information, templates, and guidance in creating the required Emergency Action Plans for all regulated dams. These plans are to help save lives and reduce property damage concerning dam failures. Planning is an important mitigation tool as it often saves lives, lessens property damage, and shortens recovery time.
http://www.dnr.mo.gov/env/wrc/damsft/eap.htm
Increasing the number of dams that are regulated may become necessary, as these older unregulated dams become more of a hazard.
Missouri State Emergency Management has preparedness tips for before, during, and after a dam failure at http://sema.dps.mo.gov/plan_and_prepare/dam_failure.asp

## 3.4.4 Earthquakes

### Hazard Profile

#### *Hazard Description*

An earthquake is a sudden motion or trembling that is caused by a release of energy accumulated within or along the edge of the earth's tectonic plates. Earthquakes occur primarily along fault zones and tears in the earth's crust. Along with these faults and tears in the crust, stresses can build until one side of the fault slips, generating compressive and shear energy that produces the shaking and damage to the built environment. The heaviest damage generally occurs nearest the earthquake epicenter, which is that point on the earth's surface directly above the point of fault movement. The composition of geologic materials between these points is a major factor in transmitting energy to buildings and other structures on the earth's surface.

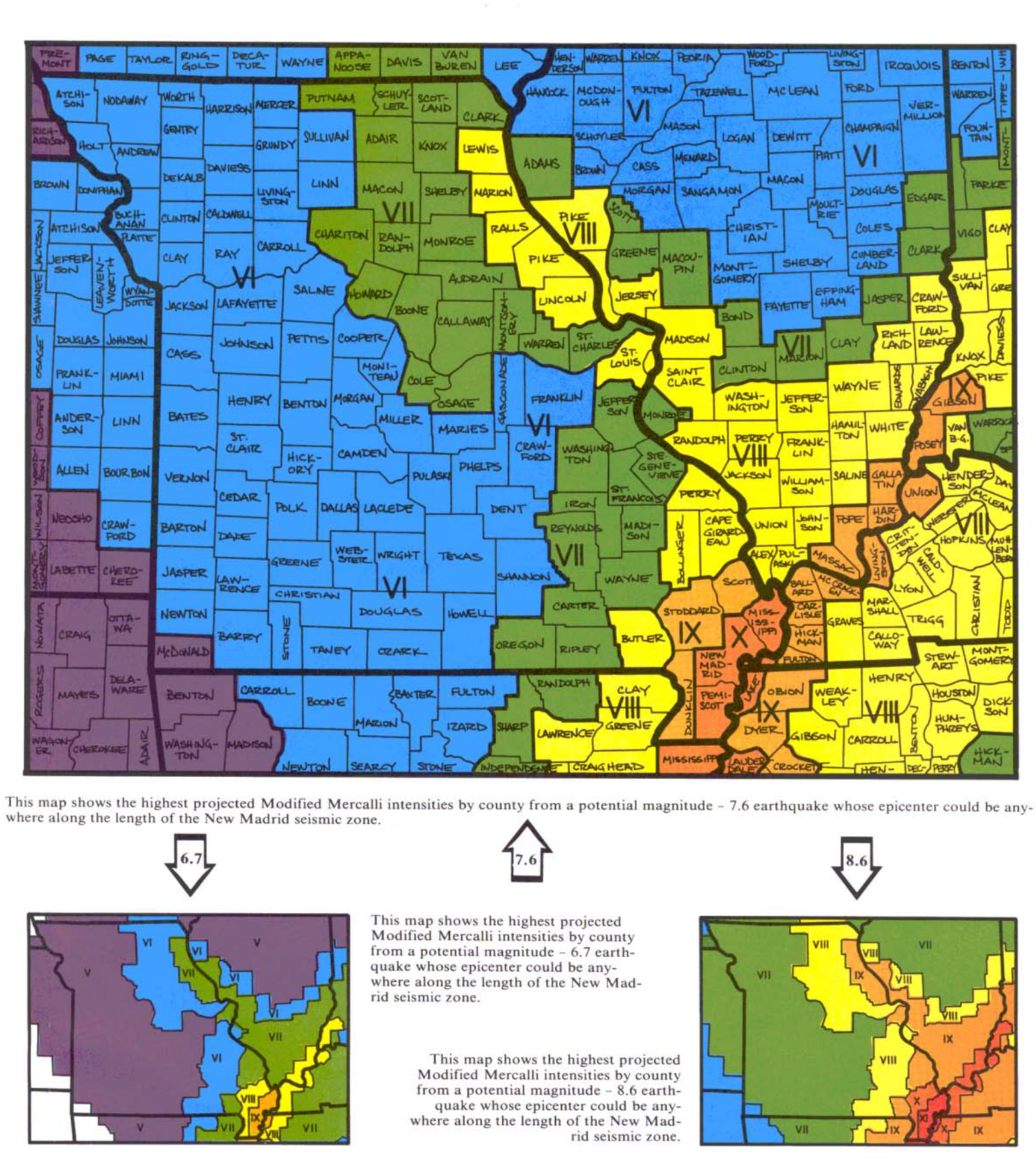
If there were a 7.6 earthquake that could happen at any point on the New Madrid Faultline, all jurisdictions within Morgan County would feel the earth move, poorly built buildings could be slightly damaged, windows, glassware and dishes could be broken, people could have a hard time walking, pictures could fall off shelving and the wall, plaster walls may crack, and some furniture may overturn.

#### *Geographic Location*

The New Madrid Seismic Zone, sometimes called the New Madrid Fault Line, is a major seismic zone and a prolific source of intraplate earthquakes (earthquakes within a tectonic plate) in northern Arkansas through southeast Missouri and western Tennessee and Kentucky to the Illinois side of the Ohio River Valley. This is the most active zone east of the Rocky Mountains. This area is considered equally high risk to the tremors in the seismic zones of California. The New Madrid Fault Line makes earthquakes probable and may have the potential to produce large earthquakes in the future.
Source: SEMA Hazard Mitigation Plan 2018

There has been a lot of research into the New Madrid Seismic Zone and the potential impact it would have on the region, as well as the State of Missouri. Within our region alone, it has been forecasted to have a minimal impact, as the rock structure in our area will shield us from a direct impact. It is also predicted that because of our unique location and many residents from the St. Louis and surrounding areas own second homes at the lake it is possible that we would see an influx of homeowners seeking refuge in a safe and familiar location. There would also be a positive economic impact as we are slated to serve in a supporting role for emergency and recovery assistance to areas that have experienced damage and catastrophic disaster.

## Figure 3.19. Impact Zones for Earthquake Along the New Madrid Fault




Source: https://sema.dps.mo.gov/docs/EQ_Map.pdf

## Figure 3.20. Projected Earthquake Intensities

# MODIFIED MERCALLI INTENSITY SCALE

I People do not feel any Earth movement.

II A few people might notice movement.

III Many people indoors feel movement. Hanging objects swing.

IV Most people indoors feel movement. Dishes, windows, and doors rattle. Walls and frames of structures creak. Liquids in open vessels are slightly disturbed. Parked cars rock.

V Almost everyone feels movement. Most people are awakened. Doors swing open or closed. Dishes are broken. Pictures on the wall move. Windows crack in some cases. Small objects move or are turned over. Liquids might spill out of open containers.

VI Everyone feels movement. Poorly built buildings are damaged slightly. Considerable quantities of dishes and glassware, and some windows are broken. People have trouble walking. Pictures fall off walls. Objects fall from shelves. Plaster in walls might crack. Some furniture is overturned. Small bells in churches, chapels and schools ring.

VII People have difficulty standing. Considerable damage in poorly built or badly designed buildings, adobe houses, old walls, spires and others. Damage is slight to moderate in well-built buildings. Numerous windows are broken. Weak chimneys break at roof lines. Cornices from towers and high buildings fall. Loose bricks fall from buildings. Heavy furniture is overturned and damaged. Some sand and gravel stream banks cave in.

VIII Drivers have trouble steering. Poorly built structures suffer severe damage. Ordinary substantial buildings partially collapse. Damage slight in structures especially built to withstand earthquakes. Tree branches break. Houses not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Temporary or permanent changes in springs and wells. Sand and mud is ejected in small amounts.

IX Most buildings suffer damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks conspicuously. Reservoirs suffer severe damage.

X Well-built wooden structures are severely damaged and some destroyed. Most masonry and frame structures are destroyed, including their foundations. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. Railroad tracks are bent slightly. Cracks are opened in cement pavements and asphalt road surfaces.

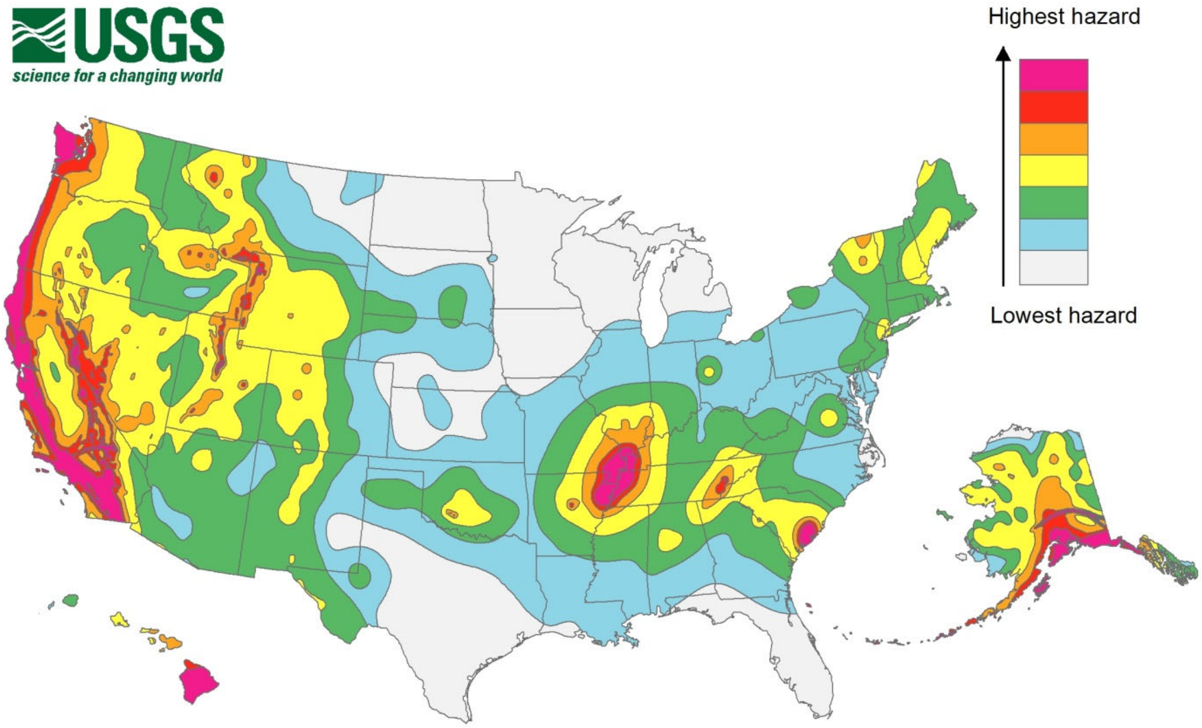
XI Few if any masonry structures remain standing. Large, well-built bridges are destroyed. Wood frame structures are severely damaged, especially near epicenters. Buried pipelines are rendered completely useless. Railroad tracks are badly bent. Water mixed with sand, and mud is ejected in large amounts.

XII Damage is total, and nearly all works of construction are damaged greatly or destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move. Lakes are dammed, waterfalls formed and rivers are deflected.

Intensity is a numerical index describing the effects of an earthquake on the surface of the Earth, on man, and on structures built by man. The intensities shown in these maps are the highest likely under the most adverse geologic conditions. There will actually be a range in intensities within any small area such as a town or county, with the highest intensity generally occurring at only a few sites. Earthquakes of all three magnitudes represented in these maps occurred during the 1811 - 1812 "New Madrid earthquakes." The isoseismal patterns shown here, however, were simulated based on actual patterns of somewhat smaller but damaging earthquakes that occurred in the New Madrid seismic zone in 1843 and 1895.

**Prepared and distributed by**
**THE MISSOURI STATE**
**EMERGENCY MANAGEMENT AGENCY**
**P.O. BOX 116**
**JEFFERSON CITY, MO 65102**
**Telephone: 573-526-9100**

## Figure 3.21. United States Seismic Hazard Map




Source: United States Geological Survey at
https://earthquake.usgs.gov/hazards/hazmaps/conterminous/2014/images/HazardMap2014_lg.jpg

### *Strength/Magnitude/Extent*

The extent or severity of earthquakes is generally measured in two ways: 1) the Richter Magnitude Scale is a measure of earthquake magnitude; and 2) the Modified Mercalli Intensity Scale is a measure of earthquake severity. The two scales are defined as follows.

*Richter Magnitude Scale*

The Richter Magnitude Scale was developed in 1935 as a device to compare the size of earthquakes. The magnitude of an earthquake is measured using a logarithm of the maximum extent of waves recorded by seismographs. Adjustments are made to reflect the variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, comparing a 5.3 and a 6.3 earthquake shows that the 6.3 quake is ten times bigger in magnitude. Each whole number increase in magnitude represents a tenfold increase in measured amplitude because of the logarithm. Each whole number step in the magnitude scale represents a release of approximately 31 times more energy.

*Modified Mercalli Intensity Scale*

The intensity of an earthquake is measured by the effect of the earthquake on the earth's surface. The intensity scale is based on the responses to the quake, such as people awakening, movement of furniture, damage to chimneys, etc. The intensity scale currently used in the United States is the Modified Mercalli (MM) Intensity Scale. It was developed in 1931 and is composed of 12 increasing levels of intensity. They range from imperceptible shaking to catastrophic destruction, and each of the twelve levels is denoted by a Roman numeral. The scale does not have a mathematical basis but is based on observed effects. Its use gives the laymen a more meaningful idea of the severity.

Thes two scales the jurisdictions within Morgan County identify the magnitude of the earth quake and the effect that earthquake will have on their communities.

***Previous Occurrences***

Morgan County experienced a 3.3 mag, 5.0 mi depth (within 30 miles) on 7/31/2005 and another 3.1 mag, 5.0-mile depth on 1/21/1992.

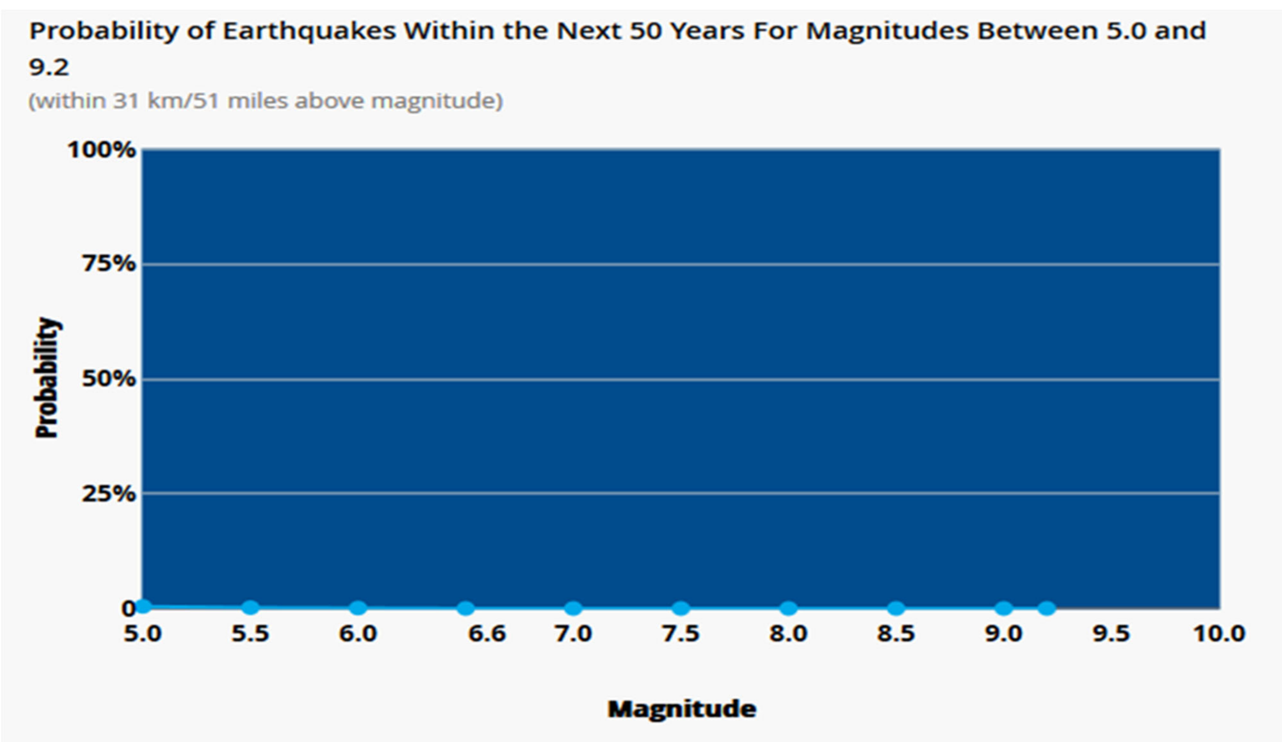
Source: www.homefacts.com

***Probability of Future Occurrence***

Probability of magnitude 5.0 or greater within 100 years is .46%, according to the United States Geological Survey.

This probability decreases over the next 50 years as the magnitude rises. Homes built prior to 1939 are especially vulnerable to earthquakes. See the figure and the table below.

**Figure 3.22. Probability of Earthquakes within the next 50 Years**



Source: https://www.homefacts.com

**Table 3.26. Homes Built 1939 & Earlier**

| Morgan County | Barnett | Gravois Mills | Laurie | Stover | Syracuse | Versailles |
|---|---|---|---|---|---|---|
| Estimate | Estimate | Estimate | Estimate | Estimate | Estimate | Estimate |
| 1,024 | 39 | 0 | 0 | 161 | 41 | 226 |

Source: https://factfin1,024der.census.gov

**Table 3.27. Projected Earthquake Hazards**

| Projected Earthquake Hazard for LOCLG Region | | | | | |
|---|---|---|---|---|---|
| Magnitude at NMSZ (Richter) | Probability (2003 – 2053) | Intensity in Region (MM Scale) | | MM Scale Descriptor | Expected Experience and Damage |
| 6.7 | 25 – 40% | Camden | V | Rather Strong | Felt by most; damage minimal to none. |
| | | Laclede | V | | |
| | | Miller | V | | |
| | | Morgan | V | | |
| 7.6 | 25 – 40% | Camden | VI | Strong | Felt by all; damage slight. |
| | | Laclede | VI | | |
| | | Miller | VI | | |
| | | Morgan | VI | | |
| 8.6 | 7 – 10% | Camden | VII | Very Strong | Difficult to stand; damage negligible in building of good design and construction; considerable damage in poorly built or badly designed structures. |
| | | Laclede | VII | | |
| | | Miller | VII | | |
| | | Morgan | VII | | |

Source:http://sema.dps.mo.gov/docs/programs/Planning,%20Disaster%20&%20Recovery/State%20of%20Missouri%20Hazard%20Analysis/2011%20State%20Hazard%20Analysis/Annex_F_Earthquakes.pdf

### *Changing Future Conditions Considerations*

## Vulnerability

### *Vulnerability Overview*

***Measure of Vulnerability:*** Low

Damages from earthquakes could cause many types of ground failures including landslides and rockslides. Ground failures also include lateral spreading and ground subsidence by soil liquefaction along rivers and lakes. Roadways in Arkansas and Missouri areas such as Highway 54 could become impassable because of fissuring road surfaces. Liquefaction of large quantities of water, sand, and mud could flood fields and roads disrupting agriculture for weeks or months. Flooding areas where farm contaminates are stored could contaminate rivers and streams.
Source: U.S. Geological Survey https://pubs.usgs.gov/fs/2009/3071/pdf/FS09-3071.pdf

***Potential Losses to Existing Development***

Potential loss within Morgan County due to an earthquake is limited as a rural county and most of the structures are a single story the impact will be minimal. Residences built prior to 1939 are likely to experience more damage.

***Impact of Previous and Future Development***

Future development is not expected to increase the risk other than contributing to the overall exposure of what could become damaged because of an event.

***Hazard Summary by Jurisdiction***

The risk is not likely to vary greatly throughout the planning area. However, damages could differ if there are structural variations in the planning area-built environment. The risks are the same throughout the county.
Source http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

## Problem Statement

The impact of an earthquake in the Morgan County area would be an increase in population that move to the lake area to stay in their second home if their primary home in the St. Louis areas was impacted.

***Mitigation:*** Missouri has designated February as Earthquake Awareness Month. The Emergency Management Director of Morgan County participates in an exercise to replicate a severe earthquake called the Great Central U.S. Shakeout Earthquake Drill.

## 3.4.5 Land Subsidence/Sinkholes

### Hazard Profile

***Hazard Description***

The 2023 Morgan County Hazard Mitigation Plan reflects low concern for Land Subsidence and/or Sinkholes, however, the 2018 Missouri State Hazard Mitigation Plan considered land subsidence/Sinkholes as a potential risk. After further research to define what and where sinkholes are most prevalent, the planning team decided to include the research, but not to continue with further risk assessment of this natural hazard.

Land subsidence occurs slowly and continuously over time, as a rule. On occasion, it can occur abruptly, as in the sudden formation of sinkholes. Sinkhole formation can be aggravated by flooding.

In the case of sinkholes, the rock below the surface is rock that has been dissolving by circulating groundwater. As the rock dissolves, spaces and caverns form, and ultimately the land above the space's collapses. In Missouri, sinkhole problems are usually a result of surface materials above openings into bedrock caves eroding and collapsing into the cave opening. These collapses are called "cover collapses" and geologic information can be applied to predict the general regions where collapse will occur. Sinkholes range in size from several square yards to hundreds of acres and may be quite shallow or hundreds of feet deep.

According to the U.S. Geological Survey (USGS), the most damage from sinkholes tends to occur in Florida, Texas, Alabama, Missouri, Kentucky, Tennessee, and Pennsylvania. Fifty-nine percent of Missouri is underlain by thick, carbonate rock that makes Missouri vulnerable to sinkholes. Sinkholes occur in Missouri on a frequent basis. Most of Missouri 's sinkholes occur naturally in the state 's karst regions (areas with soluble bedrock). They are a common geologic hazard in southern Missouri, but also occur in the central and northeastern parts of the state. Missouri sinkholes have varied from a few feet to hundreds of acres and from less than one to more than 100 feet deep. The largest known sinkhole in Missouri encompasses about 700 acres in western Boone County southeast of where Interstate 70 crosses the Missouri River. Sinkholes can also vary is shape like shallow bowls or saucers whereas other have vertical walls. Some hold water and form natural ponds.

***Geographic Location***

**Figure 3.23. Morgan County Sinkholes**

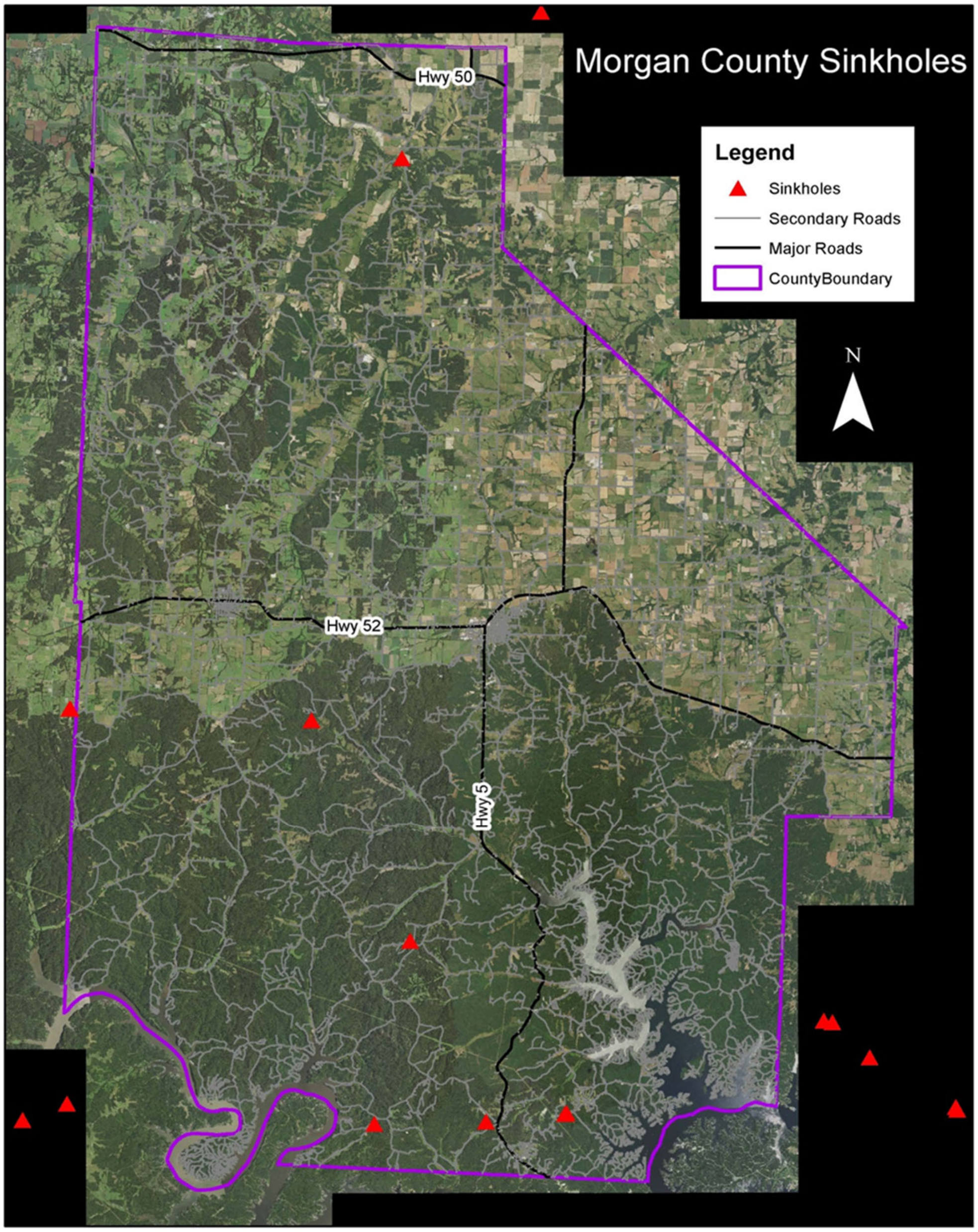
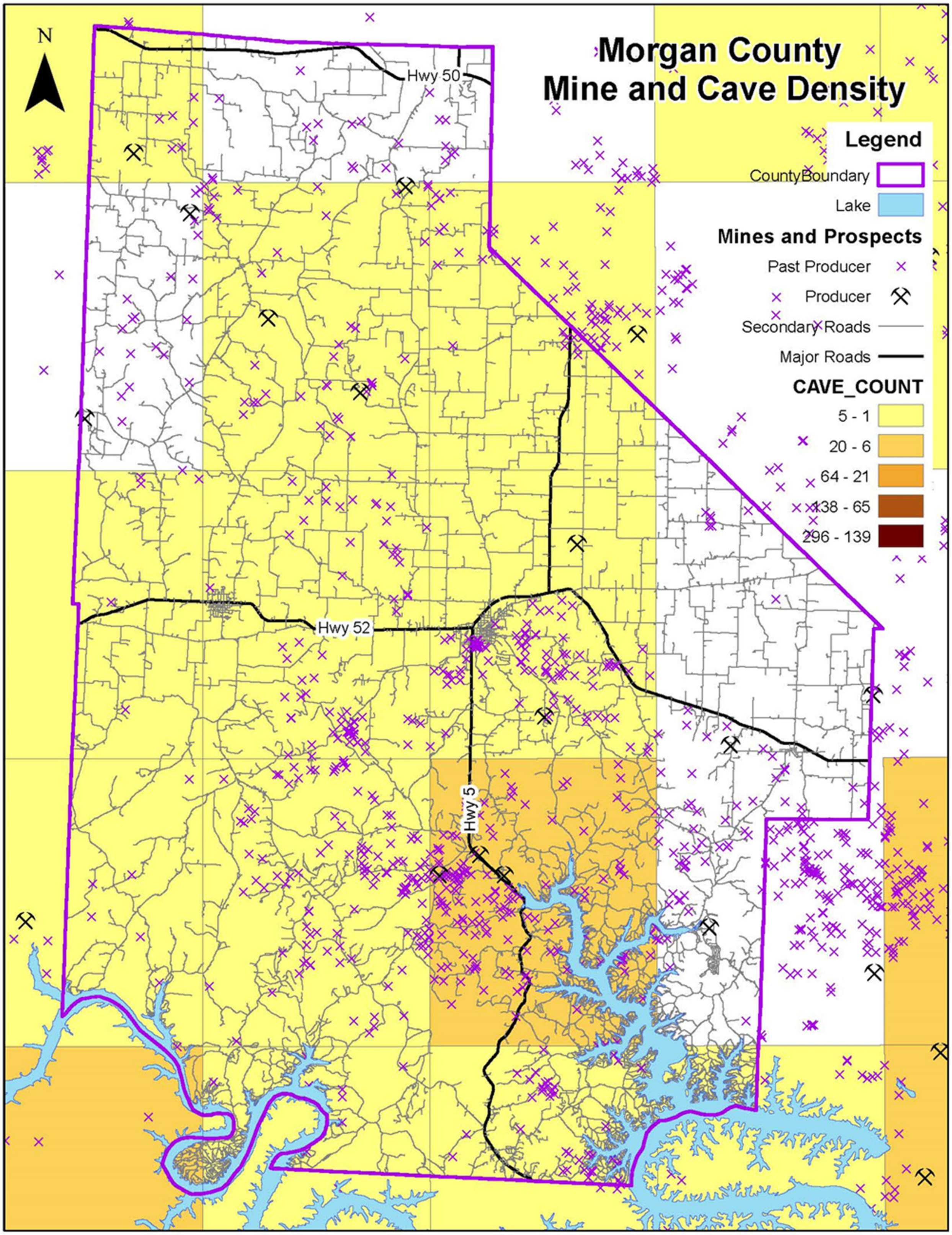


**Figure 3.24. Morgan County Mine and Cave Density Map**



### *Strength/Magnitude/Extent*

Sinkholes vary in size and location, and these variances will determine the impact of the hazard. A sinkhole could result in the loss of a personal vehicle, a building collapse, or damage to infrastructure such as roads, water, or sewer lines. Groundwater contamination is also possible from a sinkhole. Because of the relationship of sinkholes to groundwater, pollutants captured or dumped in sinkholes could affect a community 's groundwater system. The Sinkhole collapse could be triggered by large earthquakes. Sinkholes located in floodplains can absorb floodwaters but make detailed flood hazard studies difficult to model.

The 2018 State Plan included only seven documented sinkhole "notable events". The plan stated that sinkholes are common to Missouri and the probability is high that they will occur in the future. To date, Missouri sinkholes have historically not had major impacts on development nor have they caused serious damage. Thus, the severity of future events is likely to be low.

Source: http://www.foundation-repair-guide.com/expansive-soil.html, http://www.ehow.com/list_6880295_properties-expansive-soils.html

### *Previous Occurrences*

Morgan County has not had any notable sinkholes issues. As discussed in the 2018 State Plan sinkholes are a regular occurrence in Missouri, but they are rarely events of any significance. Research was conducted and no information on previous events was found.

### *Probability of Future Occurrence*

Probability: Low

Due to lack of previous occurrences, there no data to calculate future probability.

### *Changing Future Conditions Considerations*

Direct effects from changing climate conditions such as an increase in droughts which could contribute to an increase in sinkholes. These changes raise the likelihood of extreme weather, meaning the torrential rain and flooding conditions which often lead to the exposure of sinkholes are likely to become increasingly common. Certain events such as heavy precipitation following a period of drought can trigger a sinkhole due to low levels of groundwater combined with a heavy influx of rain.
Source: https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

## Vulnerability

### *Vulnerability Overview*

There are too few sink holes recorded in Morgan County to calculate vulnerability.

### *Potential Losses to Existing Development*

The risk is uniform throughout the planning area. Data limitations prevent an analysis specific enough to indicate risk to the school or special district assets. To date sinkholes have not historically had major impacts on the jurisdictions in Morgan County.

### *Impact of Previous and Future Development*

With growing population and increased development, this is some potential for increased losses as a result of the increase in exposure, but it is considered a low risk at this time.
Source: https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

### *Hazard Summary by Jurisdiction*

The risk is uniform throughout the planning area. Data limitations prevent an analysis specific enough to indicate risk to the school and special district assets. To date sinkholes have not historically had major impacts on the jurisdictions in Morgan County. This could change as the county increases in growth.

## Problem Statement

Sinkholes in Missouri are a common feature where limestone and dolomite outcrop. Dolomite is a rock similar to limestone with magnesium as an additional element. Calcium is normally present. in the minerals that form the rocks. While some sinkholes may be considered a slow changing nuisance; other more sudden, catastrophic collapses can destroy property, delay construction projects, and contaminate ground water resources.

There are not any statistics on the number of voids present in the subsurface, which will collapse in the future. To form new surface sinkholes, however, areas have been identified that have the greatest potential for future sinkholes and land subsidence.
Source: Missouri State Hazard Mitigation Plan 2018

***Mitigation:*** The U.S. Geological Survey (USGS) recommends identification, prediction, and mitigation of sinkhole hazards in evaporates karst areas. Identification techniques include field surveys and geomorphologic mapping combined with accounts from local people and historical sources. Detailed sinkhole maps can be constructed from sequential historical maps, recent topographical maps, and digital elevation models (DEMs) complemented with building-damage surveying, remote sensing, and high-resolution geodetic surveys. Sinkhole distribution can be investigated by spatial distribution analysis techniques including studies of preferential elongation, alignment, and nearest neighbor analysis.
Source USGS https://pubs.er.usgs.gov/publication/70033261

## 3.4.6 Drought

### Hazard Profile

#### *Hazard Description*

Drought is generally defined as a condition of moisture levels significantly below normal for an extended period over a large area that adversely affects plants, animal life, and humans. A drought period can last for months, years, or even decades. There are four types of drought conditions relevant to Missouri, according to the State Plan, which are as follows.

- Meteorological drought is defined in terms of the basis of the degree of dryness (in comparison to some "normal" or average amount) and the duration of the dry period. A meteorological drought must be considered region-specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region.

- Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (e.g., streamflow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, streamflow, and ground water and reservoir levels. As a result, these impacts also are out of phase with impacts in other economic sectors.

- Agricultural drought focuses on soil moisture deficiencies, differences between actual and potential evaporation, reduced ground water or reservoir levels, etc. Plant demand for water depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil.

- Socioeconomic drought refers to when physical water shortage begins to affect people.

Sources: http://www.drought.unl.edu/

Missouri faced an extremely severe drought in 2012. The drought impacted every aspect of Missouri 's agriculture and related industries. The economic impact to the drought was felt by all Missourians.

> ***Missouri currently faces its worst drought in 30 years with all 114 counties declared primary natural disaster areas by Secretary of Agriculture Tom Vilsack on July 17, 2012. Numerous portions of the state are experiencing severe to extreme drought resulting in poor site conditions for the establishment and installation of conservation practices.***

On July 21, 2022, the Missouri Governor Mike Parsons issued an Executive Order declaring a drought alert for 53 counties that lasted until March 1, 2023.. Due to the lack of precipitation, Missouri faced a water deficit that affected agriculture, livestock, and navigable waterways.

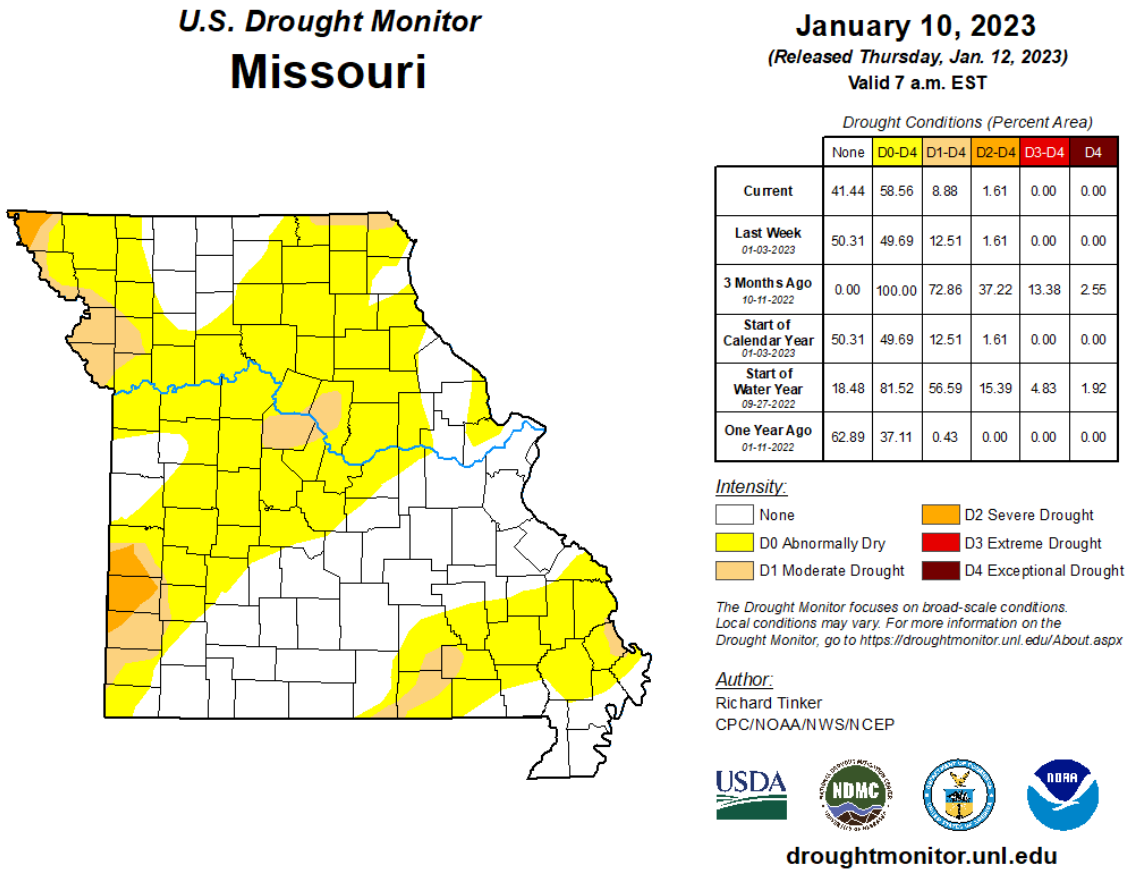
In response to the Governor's Executive Order, the Department of Natural Resources activated the Drought Assessment Committee, a workgroup set up to assess drought levels and work with impact teams on response and recovery recommendations. An Agriculture Impact Team was assembled in August to coordinate response actions for the state's agricultural community that has been impacted throughout the drought. In addition, a Navigational Impact Team was convened to address the low flow levels of the Missouri and Mississippi rivers which impacted commercial navigators such as barges to maneuver through the rivers.

The Drought Monitor Map on page 3.67 indicates the percentage of the state that experienced drought and the level of severity over the last year. The jurisdictions within Morgan County experience abnormally dry conditions compared to previous years.

### *Geographic Location*

The history of drought for Morgan County has not been frequent, but excessive heat combined with lack of precipitation has created much havoc in this agricultural county. The most recent being in January, 2013. Morgan County was named by the USDA as one of the 31 Missouri counties that would receive assistance due to extreme or exceptional drought by Governor Nixon. Also, in July, 2012, Morgan County was named as a disaster county by the Missouri State Farm Service Agency (FSA) after drought conditions began in April. Prior to 2012, federally and state recognized drought conditions have occurred in Moran County in 2001, 2000, 1979, 1964, 1957, and 1956.
Source: http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Missouri/ and http://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Missouri/ provide information on agriculture at the county level.

**Figure 3.25. U.S. Drought Monitor Map of Missouri on Date**




Source: U.S. Drought Monitor, https://droughtmonitor.unl.edu/Maps/MapArchive.aspx

### ***Strength/Magnitude/Extent***

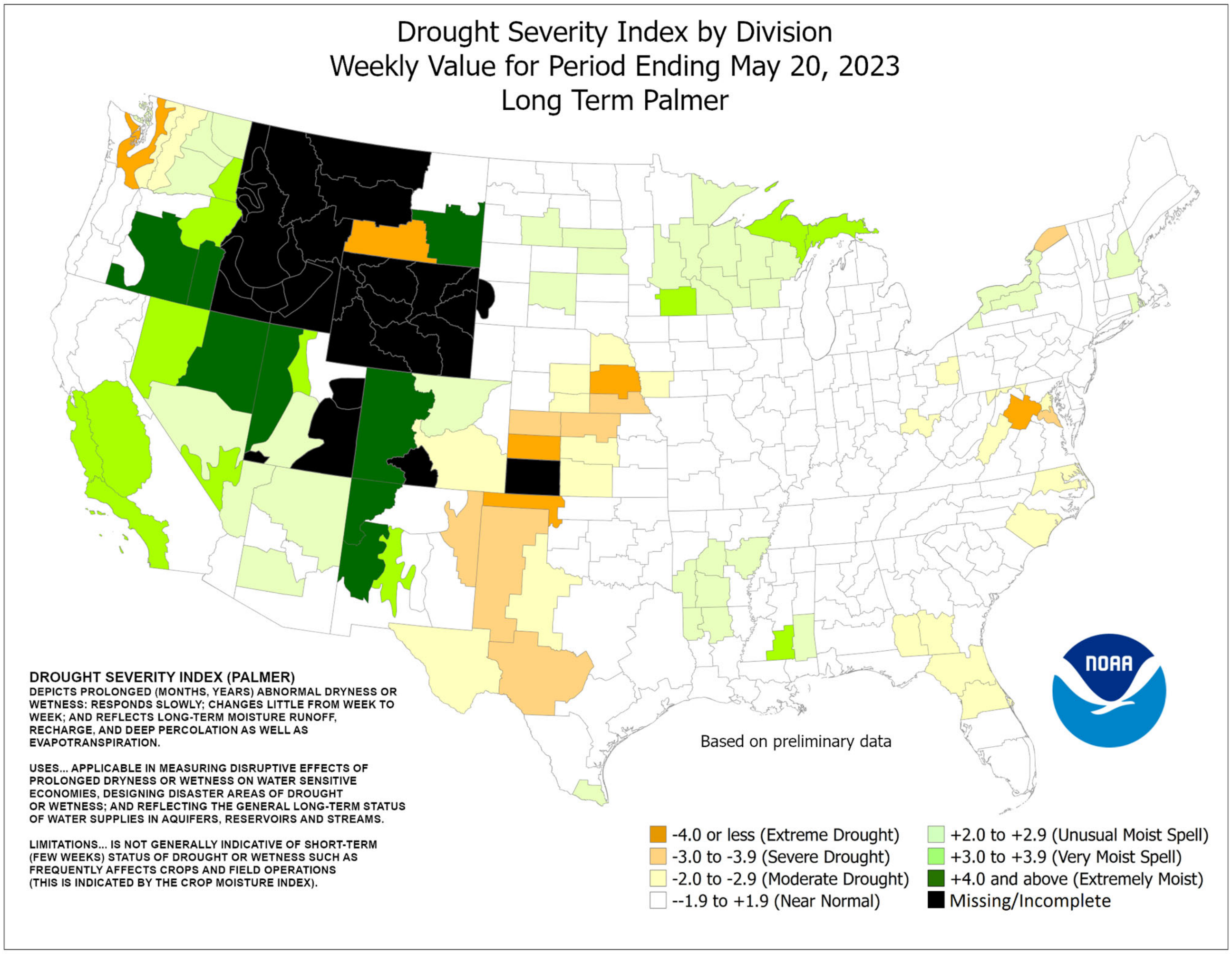
The Palmer Drought Indices measure dryness based on recent precipitation and temperature. The indices are based on a “supply-and-demand model” of soil moisture. Calculation of supply is relatively straightforward, using temperature and the amount of moisture in the soil. However, demand is more complicated as it depends on a variety of factors, such as evapotranspiration and recharge rates. These rates are harder to calculate. Palmer tried to overcome these difficulties by developing an algorithm that approximated these rates and based the algorithm on the most readily available data — precipitation and temperature.

The Palmer Index has proven most effective in identifying long-term drought of more than several months. However, the Palmer Index has been less effective in determining conditions over a matter of weeks. It uses a “0” as normal, and drought is shown in terms of negative numbers; for example, negative 2 is moderate drought, negative 3 is severe drought, and negative 4 is extreme drought. Palmer's algorithm also is used to describe wet spells, using corresponding positive numbers.

Palmer also developed a formula for standardizing drought calculations for each individual location based on the variability of precipitation and temperature at that location. The Palmer index can therefore be applied to any site for which sufficient precipitation and temperature data is available.

The Drought Severity Index can be used by the jurisdictions within Morgan county to help measure the disruptive effects drought may have on their communities.

**Figure 3.26. Drought Severity Index**




The National Drought Monitor Center at the University of Nebraska at Lincoln summarized the potential severity of drought as follows. Drought can create economic impacts on agriculture and related sectors, including forestry and fisheries, because of the reliance of these sectors on surface and subsurface water supplies. In addition to losses in yields in crop and livestock production, drought is associated with increases in insect infestations, plant disease, and wind erosion. Droughts also bring increased problems with insects and disease to forests and reduce growth. The incidence of forest and range fires increases substantially during extended droughts, which in turn place both human and wildlife populations at higher levels of risk. Income loss is another indicator used in assessing the impacts of drought because so many sectors are affected. Finally, while drought is rarely a direct cause of death, the associated heat, dust, and stress can all contribute to increased mortality.

The impact of drought is often categorized in three terms: economical, environmental, and social. All types of impacts specifically affect Morgan County. Economic impact is incurred through loss of vegetation for both human and livestock consumption, loss of revenue, hardship on farmers, etc. Environmental impact is lack of water supply, loss of wildlife, erosion of land, poor soil quality, etc. In addition, the social impact creates health problems, loss of life, reduced incomes, threat to public safety, and loss in recreational activities. The average value of crops per acre for Morgan County is $80.47. A farmer is said to lose over 50% of that value during a severe drought.

***Previous Occurrences***

| Commodity Year | State Code | State | County Code | County Name | Commodity Name | Insurance Plan Code | Insurance Plan Abbreviation | Stage Code | Damage Cause Code | Damage Cause Description | Determined Acres | Indemnity Amount |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2022 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 729.8 | $32,511.00 |
| 2022 | 29 | MO | 141 | Morgan | Corn | 2 | RP | UH | 11 | Drought | 36.9 | $19,719.80 |
| 2022 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 1237.1 | $375,114.00 |
| 2022 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 488 | $145,682 |
| 2022 | 29 | MO | 141 | Morgan | Corn | 2 | RP | UH | 11 | Drought | 200 | $86,007.00 |
| 2022 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 242.6 | $63,259.00 |
| 2022 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 329 | $57,079.00 |
| 2022 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 24.1 | $1,778.00 |
| 2021 | 29 | MO | 141 | Morgan | Corn | 2 | RP | UH | 11 | Drought | 37.7 | ($7,678) |
| 2021 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 144.7 | $22,298.00 |
| 2021 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 614.5 | $68,897.50 |
| 2021 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | R | 11 | Drought | 4.9 | $177.00 |
| 2021 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 255.1 | $29,353.00 |
| 2021 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 791.5 | $72,924.00 |
| 2021 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | UH | 11 | Drought | 2.4 | $1,055.50 |
| 2020 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 68.9 | $4,586.00 |
| 2020 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 10.6 | $340.00 |
| 2020 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 24 | $165.00 |
| 2020 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 37.9 | $3,302.00 |
| 2020 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 238.1 | $44,496.00 |
| 2020 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 29.4 | $1,607.00 |
| 2020 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 22.1 | $2,271.00 |
| 2020 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | UH | 11 | Drought | 15.9 | $5,033.00 |
| 2018 | 29 | Mo | 141 | Morgan | Wheat | 2 | RP | H | 11 | Drought | 20.4 | $1,441.50 |
| 2018 | 29 | Mo | 141 | Morgan | Wheat | 2 | RP | UH | 11 | Drought | 35.35 | $4,065.50 |
| 2018 | 29 | Mo | 141 | Morgan | Wheat | 2 | RP | H | 11 | Drought | 55.6 | $3,035.50 |
| 2018 | 29 | Mo | 141 | Morgan | Wheat | 2 | RP | H | 11 | Drought | 76 | $4,447.00 |
| 2018 | 29 | Mo | 141 | Morgan | Wheat | 2 | RP | UH | 11 | Drought | 35.35 | $4,065.50 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018 | 29 | Mo | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 37.3 | $2,865.00 |
| 2018 | 29 | Mo | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 31 | $541.00 |
| 2018 | 29 | Mo | 141 | Morgan | Corn | 2 | RP | UH | 11 | Drought | 111.8 | $19,069 |
| 2018 | 29 | Mo | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 209.6 | $31,026.00 |
| 2018 | 29 | Mo | 141 | Morgan | Corn | 2 | RP | UH | 11 | Drought | 626 | $114,229.42 |
| 2018 | 29 | Mo | 141 | Morgan | Corn | 2 | RP | UH | 11 | Drought | 29 | $2,566.00 |
| 2018 | 29 | Mo | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 604.8 | $57,676.00 |
| 2018 | 29 | Mo | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 110.5 | 9013 |
| 2018 | 29 | Mo | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 42.5 | 2145 |
| 2018 | 29 | Mo | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 182.3 | 22266 |
| 2018 | 29 | Mo | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 2723 | 320467 |
| 2018 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 589.3 | 90961.3 |
| 2017 | 29 | Mo | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 39.3 | $2,362.00 |
| 2017 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 11.2 | $579.00 |
| 2016 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | R | 11 | Drought | 63.9 | $1,696.00 |
| 2014 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 11.5 | $3,059.50 |
| 2013 | 29 | MO | 141 | Morgan | Corn | 2 | RP | H | 11 | Drought | 375.7 | $38,151.00 |
| 2013 | 29 | MO | 141 | Morgan | Soybeans | 1 | YP | H | 11 | Drought | 118.8 | $5,642.00 |
| 2013 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | UH | 11 | Drought | 32.21 | $8,570.00 |
| 2013 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 890.04 | $64,929.00 |
| 2013 | 29 | MO | 141 | Morgan | Soybeans | 1 | YP | UH | 11 | Drought | 31.55 | $8,366.00 |
| 2012 | 29 | MO | 141 | Morgan | Grain | 2 | RP | H | 11 | Drought | 16.6 | $5,936.00 |
| 2012 | 29 | MO | 141 | Morgan | Grain | 1 | YP | H | 11 | Drought | 23.6 | $920.00 |
| 2012 | 29 | MO | 141 | Morgan | Grain | 2 | RP | UH | 11 | Drought | 37.6 | $17,191.00 |
| 2012 | 29 | MO | 141 | Morgan | Soybeans | 1 | YP | H | 11 | Drought | 300.56 | $53,552.00 |
| 2012 | 29 | MO | 141 | Morgan | Soybeans | 1 | YP | UH | 11 | Drought | 40.2 | $1,514.00 |
| 2012 | 29 | MO | 141 | Morgan | Soybeans | 1 | YP | UH | 11 | Drought | 180.87 | $55,912.00 |
| 2012 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | R | 11 | Drought | 556.8 | $20,963.00 |
| 2012 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | H | 11 | Drought | 7355.91 | $1,613,651.00 |
| 2012 | 29 | MO | 141 | Morgan | Soybeans | 2 | RP | UH | 11 | Drought | 194.7 | $78,645.00 |
| **Total** | | | | | | | | | | | | **$3,701,495.02** |

***Probability of Future Occurrence***

Calculations from 2006-2022 predict a 25% probability of future occurrences of moderate to severe drought. Although drought is not predictable, long-range outlooks and predicted impacts of climate change could indicate an increased chance of drought.

***Changing Future Conditions Considerations***

Severe drought, a natural part of Missouri's climate, is a risk to this agriculture-dependent state. Future increases in evaporation rates due to higher temperatures may increase the intensity of naturally occurring droughts. Although springtime in Missouri is likely to be wetter, summer droughts are likely to be more severe. Higher evaporation and lower summer rainfall are likely to reduce river flows. The drought of 2012 narrowed navigation channels, forced lock closures, and caused dozens of barges to run aground on the Mississippi River along the Missouri shoreline. The resulting impact on navigation cost the region more than $275 million. The drought of 2012–2013 also threatened municipal and industrial water users along the Missouri River. The number of heavy rainfall events is predicted to increase, yet researchers currently expect little change in total rainfall amounts, indicating that the periods between heavy rainfalls will be marked by an increasing number of dry days. Higher temperatures and increased evapotranspiration increase the likelihood of drought. This could lead to agricultural drought and suppressed crop yields.

## Vulnerability

### *Vulnerability Overview*

### *Potential Losses to Existing Development*

The National Drought Monitor Center at the University of Nebraska at Lincoln summarized the potential impacts of drought as follows: Drought can create economic impacts on agriculture and related sectors, including forestry and fisheries, because of the reliance of these sectors on surface and subsurface water supplies. In addition to losses in yields in crop and livestock production, drought is associated with increases in insect infestations, plant disease, and wind erosion. Droughts also bring increased problems with insects and disease to forests and reduce growth. The incidence of forest and range fires increases substantially during extended droughts, which in turn place both human and wildlife populations at higher levels of risk. Income loss is another indicator used in assessing the impacts of drought because so many sectors are affected. Finally, while drought is rarely a direct cause of death, the associated heat, dust and stress can all contribute to increased mortality.

### *Impact of Previous and Future Development*

At this time there is no anticipated future development in the county that could affect the risk of damage from this hazard in the planning area.

### *Changing Future Conditions Considerations*

A new analysis, performed for the Natural Resources Defense Council, examined the effects of climate change on water supply and demand in the contiguous United States. The study found that more than 1,100 counties will face higher risks of water shortages by mid-century because of climate change. Two of the principal reasons for the projected water constraints are shifts in precipitation and potential evapotranspiration (PET).
Climate models project decreases in precipitation in many regions of the U.S., including areas that may currently be described as experiencing water shortages of some degree.

The NRDC has assisted in promoting renewable energy portfolios in Missouri. This will help in the transformation of energy sectors in the area by promoting wind, solar, and other clean energy technologies. Missouri along with other states are embracing the concepts of clean energy.
Source:
Natural Resources Defense Council
https://www.nrdc.org/search?search=water%20sustainability&f[0]=field_place_term%3A71&f[1]=field_place_term%3A10419

### *Hazard Summary by Jurisdiction*

The potential impact on previous and future development in Morgan County by drought is not significant.

## Problem Statement

The largest impact will be on the agriculture industry within the region and that would be in regard to crops and the economy of the region based on crop loss if impacted by severe drought.

### *Mitigation:*

*Crop Insurance:* Crop insurance protects farmers from losses due to natural disasters, including drought. Crop insurance can be purchased through private insurance companies or agents.

*Drought Tolerant Crops:* With the increase of genetically engineered crops such as corn and soybean, there are many droughts tolerant hybrids on the market today. Educating farmers on the new products and advantages of these hybrid seeds can increase resiliency of our farming communities.

# 3.4.7 Extreme Temperatures

## Hazard Profile

### *Hazard Description*

Extreme temperature events, both hot and cold, can impact human health and mortality, natural ecosystems, agriculture and other economic sectors. According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Ambient air temperature is one component of heat conditions, with relative humidity being the other. The relationship of these factors creates what is known as the apparent temperature. The Heat Index chart shown in **Figure 3.27** uses both factors to produce a guide for the apparent temperature or relative intensity of heat conditions.

Extreme cold often accompanies severe winter storms and can lead to hypothermia and frostbite in people without adequate clothing protection. Cold can cause fuel to congeal in storage tanks and supply lines, stopping electric generators. Cold temperatures can also overpower a building’s heating system and cause water and sewer pipes to freeze and rupture. Extreme cold also increases the likelihood of ice jams on flat rivers or streams. When combined with high winds from winter storms, extreme cold becomes extreme wind chill, which is hazardous to health and safety.

The National Institute on Aging estimates that more than 2.5 million Americans are elderly and especially vulnerable to hypothermia, with the isolated elders being most at risk. About 10 percent of people over the age of 65 have some kind of bodily temperature-regulating defect, and 3-4 percent of all hospital patients over 65 are hypothermic.

Also, at risk are those without shelter, those who are stranded, or who live in a home that is poorly insulated or without heat. Other impacts of extreme cold include asphyxiation (unconsciousness or death from a lack of oxygen) from toxic fumes from emergency heaters; household fires, which can be caused by fireplaces and emergency heaters; and frozen/burst pipes.

### *Geographic Location*

Extreme heat is an area-wide hazard event, and the risk of extreme heat does not vary across the planning area.

### *Strength/Magnitude/Extent*

The National Weather Service (NWS) has an alert system in place (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for issuing excessive heat alerts is when for two or more consecutive days: (1) when the maximum daytime Heat Index is expected to equal or exceed 105 degrees Fahrenheit (°F); and the nighttime minimum Heat Index is 80°F or above. A heat advisory is issued when temperatures reach 105 degrees, and a warning is issued at 115 degrees. The Heat Index Chart in figure 3.27 helps jurisdictions within the county to forecast severe heat conditions and send out advisories to the residents, potentially reducing the number of heat related injuries.

**Figure 3.27. Heat Index (HI) Chart**

NWS Heat Index

Temperature (°F)

| Relative Humidity (%) | 80 | 82 | 84 | 86 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 108 | 110 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 80 | 81 | 83 | 85 | 88 | 91 | 94 | 97 | 101 | 105 | 109 | 114 | 119 | 124 | 130 | 136 |
| 45 | 80 | 82 | 84 | 87 | 89 | 93 | 96 | 100 | 104 | 109 | 114 | 119 | 124 | 130 | 137 | |
| 50 | 81 | 83 | 85 | 88 | 91 | 95 | 99 | 103 | 108 | 113 | 118 | 124 | 131 | 137 | | |
| 55 | 81 | 84 | 86 | 89 | 93 | 97 | 101 | 106 | 112 | 117 | 124 | 130 | 137 | | | |
| 60 | 82 | 84 | 88 | 91 | 95 | 100 | 105 | 110 | 116 | 123 | 129 | 137 | | | | |
| 65 | 82 | 85 | 89 | 93 | 98 | 103 | 108 | 114 | 121 | 128 | 136 | | | | | |
| 70 | 83 | 86 | 90 | 95 | 100 | 105 | 112 | 119 | 126 | 134 | | | | | | |
| 75 | 84 | 88 | 92 | 97 | 103 | 109 | 116 | 124 | 132 | | | | | | | |
| 80 | 84 | 89 | 94 | 100 | 106 | 113 | 121 | 129 | | | | | | | | |
| 85 | 85 | 90 | 96 | 102 | 110 | 117 | 126 | 135 | | | | | | | | |
| 90 | 86 | 91 | 98 | 105 | 113 | 122 | 131 | | | | | | | | | |
| 95 | 86 | 93 | 100 | 108 | 117 | 127 | | | | | | | | | | |
| 100 | 87 | 95 | 103 | 112 | 121 | 132 | | | | | | | | | | |

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: National Weather Service (NWS); https://www.weather.gov/safety/heat-index
Note: Exposure to direct sun can increase Heat Index values by as much as 15°F. The shaded zone above 105°F corresponds to a HI that may cause increasingly severe heat disorders with continued exposure and/or physical activity.

The NWS Wind Chill Temperature (WCT) index uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from winter winds and freezing temperatures. The figure below presents wind chill temperatures which are based on the rate of heat loss from exposed skin caused by wind and cold.

As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature. The Heat Index Chart in figure 3.28 helps jurisdictions within the county to forecast severe cold resulting from a combination of wind chill and low temperature. Using and understanding the wind chill chart will potentially reduce the number of cold related injuries.

**Figure 3.28. Wind Chill Chart**

**Wind Chill Chart**

Temperature (°F)

| Wind (mph) / Calm | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 | -10 | -15 | -20 | -25 | -30 | -35 | -40 | -45 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 36 | 31 | 25 | 19 | 13 | 7 | 1 | -5 | -11 | -16 | -22 | -28 | -34 | -40 | -46 | -52 | -57 | -63 |
| 10 | 34 | 27 | 21 | 15 | 9 | 3 | -4 | -10 | -16 | -22 | -28 | -35 | -41 | -47 | -53 | -59 | -66 | -72 |
| 15 | 32 | 25 | 19 | 13 | 6 | 0 | -7 | -13 | -19 | -26 | -32 | -39 | -45 | -51 | -58 | -64 | -71 | -77 |
| 20 | 30 | 24 | 17 | 11 | 4 | -2 | -9 | -15 | -22 | -29 | -35 | -42 | -48 | -55 | -61 | -68 | -74 | -81 |
| 25 | 29 | 23 | 16 | 9 | 3 | -4 | -11 | -17 | -24 | -31 | -37 | -44 | -51 | -58 | -64 | -71 | -78 | -84 |
| 30 | 28 | 22 | 15 | 8 | 1 | -5 | -12 | -19 | -26 | -33 | -39 | -46 | -53 | -60 | -67 | -73 | -80 | -87 |
| 35 | 28 | 21 | 14 | 7 | 0 | -7 | -14 | -21 | -27 | -34 | -41 | -48 | -55 | -62 | -69 | -76 | -82 | -89 |
| 40 | 27 | 20 | 13 | 6 | -1 | -8 | -15 | -22 | -29 | -36 | -43 | -50 | -57 | -64 | -71 | -78 | -84 | -91 |
| 45 | 26 | 19 | 12 | 5 | -2 | -9 | -16 | -23 | -30 | -37 | -44 | -51 | -58 | -65 | -72 | -79 | -86 | -93 |
| 50 | 26 | 19 | 12 | 4 | -3 | -10 | -17 | -24 | -31 | -38 | -45 | -52 | -60 | -67 | -74 | -81 | -88 | -95 |
| 55 | 25 | 18 | 11 | 4 | -3 | -11 | -18 | -25 | -32 | -39 | -46 | -54 | -61 | -68 | -75 | -82 | -89 | -97 |
| 60 | 25 | 17 | 10 | 3 | -4 | -11 | -19 | -26 | -33 | -40 | -48 | -55 | -62 | -69 | -76 | -84 | -91 | -98 |

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T = Air Temperature (°F) V = Wind Speed (mph)

*Effective 11/01/01*

Source: https://www.weather.gov/safety/cold-wind-chill-chart

### *Previous Occurrences*

**Table 3.28. Insurance Indemnity Payments Years 2006-2022**

| Commodity Year | Location State Code | Location State Abbreviation Code | Location County Code | Location County Name | Commodity Code | Commodity Name | Insurance Plan Code | Insurance Plan Abbreviation | Stage Code | Damage Cause Code | Damage Cause Description | Determined Acres | Indemnity Amount |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2022 | 29 | MO | 141 | Morgan | 41 | Corn | 2 | RP | H | 12 | Heat | 40.1 | $2,057 |
| 2021 | 29 | MO | 141 | Morgan | 41 | Corn | 2 | RP | UH | 12 | Heat | 31 | $6,731.00 |
| 2021 | 29 | MO | 141 | Morgan | 41 | Corn | 2 | RP | H | 12 | Heat | 448.1 | $179,986.00 |
| 2021 | 29 | MO | 141 | Morgan | 41 | Corn | 2 | RP | H | 12 | Heat | 287.4 | $66,883.00 |
| 2018 | 29 | MO | 141 | Morgan | 11 | Wheat | 2 | RP | UH | 12 | Heat | 251.9 | $6,271.50 |
| 2013 | 29 | MO | 141 | Morgan | 81 | Soybeans | 1 | YP | UH | 12 | Heat | 18 | $4,429.00 |
| 2013 | 29 | MO | 141 | Morgan | 81 | Soybeans | 1 | YP | H | 12 | Heat | 33.80 | $4,316.00 |
| 2012 | 29 | MO | 141 | Morgan | 41 | Corn | 1 | YP | H | 12 | Heat | 28.50 | $8,493.00 |
| 2012 | 29 | MO | 141 | Morgan | 41 | Corn | 1 | YP | H | 12 | Heat | 26.60 | $8,918.00 |
| 2012 | 29 | MO | 141 | Morgan | 41 | Corn | 2 | RP | UH | 12 | Heat | 11.95 | $7,844.00 |
| 2012 | 29 | MO | 141 | Morgan | 81 | Soybeans | 1 | YP | H | 12 | Heat | 100.38 | $12,661.00 |
| 2012 | 29 | MO | 141 | Morgan | 81 | Soybeans | 1 | YP | UH | 12 | Heat | 74.11 | $21,903.00 |
| 2012 | 29 | MO | 141 | Morgan | 81 | Soybeans | 2 | RP | H | 12 | Heat | 280.33 | $64,975.00 |
| 2011 | 29 | MO | 141 | Morgan | 41 | Corn | 2 | RP | UH | 12 | Heat | 320.59 | $127,383.00 |
| 2011 | 29 | MO | 141 | Morgan | 41 | Corn | 2 | RP | H | 12 | Heat | 2,683.94 | $347,861.00 |
| 2011 | 29 | MO | 141 | Morgan | 81 | Soybeans | 2 | RP | H | 12 | Heat | 404.63 | $26,931.00 |
| 2007 | 29 | Mo | 141 | Morgan | 51 | Grains | 44 | CRC | H | 12 | Heat | 24.53 | $2,410.00 |
| 2007 | 29 | MO | 141 | Morgan | 81 | Soybeans | 25 | RA | H | 12 | Heat | 239.47 | $2,634.00 |
| 2007 | 29 | MO | 141 | Morgan | 81 | Soybeans | 44 | CRC | H | 12 | Heat | 15.40 | $857.00 |
| 2006 | 29 | MO | 141 | Morgan | 81 | Soybeans | 90 | APH | H | 12 | Heat | 50.50 | $1,98.00 |
| **Total** | | | | | | | | | | | | **5,371.23** | **$903,543.50** |

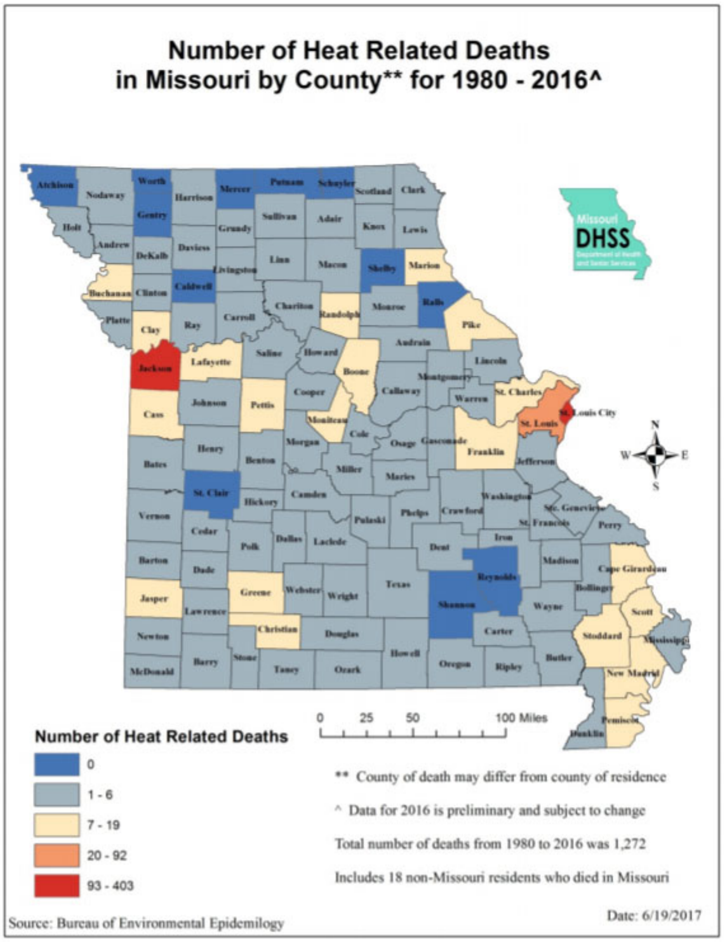
Agency, losses to insurable crops during the 10-year time period from 2006 to 2022 were $903,543.50. Extreme heat can also strain electricity delivery infrastructure overloaded during peak use of air conditioning during extreme heat events. Another type of infrastructure damage from extreme heat is road damage. When asphalt is exposed to prolonged extreme heat, it can cause buckling of asphalt-paved roads, driveways, and parking lots.

From 1988-2011, there were 3,496 fatalities in the U.S. attributed to summer heat. This translates to an annual national average of 146 deaths. During the same period, zero deaths were recorded in the planning area, according to NCEI data. The National Weather Service stated that among natural hazards, no other natural disaster—not lightning, hurricanes, tornadoes, floods, or earthquakes—causes more deaths.

Those at greatest risk for heat-related illness include infants and children up to five years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications.

However, even young and healthy individuals are susceptible if they participate in strenuous physical activities during hot weather. In agricultural areas, the exposure of farm workers, as well as livestock, to extreme temperatures is a major concern.

**Figure 3.29. Heat Related Deaths in Missouri 1980 - 2016**




*Source: https://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/stat-report.pdf*

### *Probability of Future Occurrence*

Summer comes every year and high heat is expected so the probability of some extreme heat during the summer months is expected.

### *Changing Future Conditions Considerations*

Under a higher emissions pathway, historically unprecedented warming is projected by the end of the century. Even under a pathway of lower greenhouse gas emissions, average annual temperatures are projected to most likely exceed historical record levels by the middle of the 21st century. For example, in southern Missouri, the annual maximum number of consecutive days with temperatures exceeding 95 degrees F is projected to increase by up to 20 days. Temperature increases will cause future heat waves to be more intense, a concern for this region which already experiences hot and humid conditions. Extreme heat is a concern for urban areas such as St. Louis and Kansas City, where the urban heat island effect raises summer temperatures. If the warming trend conditions, future heat waves are likely to be more intense, and cold wave intensity is projected to decrease.

The impacts of extreme heat events are experienced most acutely by the elderly and other vulnerable populations. High temperatures are exacerbated in urban environments, a phenomenon known as the urban heat island effect, which in turn tends to have higher concentrations of vulnerable populations. Higher demand for electricity as people try to keep cool amplifies stress on power systems and may lead to an increase in the number of power outages. Atmospheric concentrations of ozone occur at higher air temperatures, resulting in poorer air quality, while harmful algal blooms flourish in warmer water temperatures, resulting in poorer water quality.

Mitigation against the impacts of future temperature increase may include increasing education on heat stress prevention, organizing cooling centers, allocating additional funding to repair and maintain roads damaged by buckling and potholes, and reducing nutrient runoff that contributes to algal blooms. Local governments should also prepare for increased demand on public recreational facilities, utility systems, and healthcare centers. Improving energy efficiency in public buildings will also present an increasingly valuable savings potential.

## Vulnerability

### *Vulnerability Overview*

Those at greatest risk for heat-related illness include infants and children up to five years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. However, even young and healthy individuals are susceptible if they participate in strenuous physical activities during hot weather. In agricultural areas, the exposure of farm workers, as well as livestock, to extreme temperatures is a major concern.

**Table 3.29** lists typical symptoms and health impacts due to exposure to extreme heat.

**Table 3.29. Typical Health Impacts of Extreme Heat**

| Heat Index (HI) | Disorder |
|---|---|
| 80-90° F (HI) | Fatigue possible with prolonged exposure and/or physical activity |
| 90-105° F (HI) | Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and/or physical activity |
| 105-130° F (HI) | Heatstroke/sunstroke highly likely with continued exposure |

Source: National Weather Service Heat Index Program, www.weather.gov/os/heat/index.shtml

### *Potential Losses to Existing Development*

No expected losses to existing development anticipated.

### *Impact of Previous and Future Development*

Population growth can result in increases in the age groups that are most vulnerable to extreme heat. Population growth also increases the strain on electricity infrastructure, as more electricity is needed to accommodate the growing population.

*Hazard Summary by Jurisdiction*

Those at greatest risk for heat-related illness and deaths include children up to five years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. To determine jurisdictions within the planning area with populations more vulnerable to extreme heat, demographic data was obtained from the 2010 census on population percentages in each jurisdiction comprised of those under age 5 and over age 65. Data was not available for overweight individuals and those on medications vulnerable to extreme heat. **Table 3.30** below summarizes vulnerable populations in the participating jurisdictions. Note that school and special districts are not included in the table because students and those working for the special districts are not customarily in these age groups.

**Table 3.30. Morgan County Population Under Age 5 and Over Age 65, 2020 Census Data**

| Jurisdiction | Population Under 5 yrs | Population 65 yrs and over |
|---|---|---|
| Morgan County | 1,366 | 4,788 |
| City of Barnett | 12 | 47 |
| City of Laurie | 32 | 436 |
| City of Stover | 24 | 215 |
| City of Syracuse | 13 | 22 |
| City of Versailles | 191 | 550 |
| Village of Gravois Mills | NA | NA |

Source: U.S. Census Bureau, (2020 ACS 5-Year Estimate) includes entire population of each city or county

## Problem Statement

Morgan County has a growing population of residents over 65 years, who are at a greater risk for extreme-temperature related illnesses, injuries, and death. Possible solutions include organizing outreach to the vulnerable elderly populations, including establishing and promoting accessible heating or cooling centers in the community and creating a database in coordination with the Health Department to track those individuals at high risk.

# 3.4.8 Severe Thunderstorms Including High Winds, Hail, and Lightning

## Hazard Profile

*Hazard Description*

*Thunderstorms*

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. When cold upper air sinks and warm moist air rises, storm clouds or 'thunderheads' develop resulting in thunderstorms. This can occur singularly, as well as in clusters or lines. The National Weather Service defines a thunderstorm as "severe" if it includes hail that is one inch or more, or wind gusts that are at 58 miles per hour or higher. At any given moment across the world, there are about 1,800 thunderstorms occurring. Severe thunderstorms most often occur in Missouri in the spring and summer, during the afternoon and evenings, but can occur at any time. Other hazards associated with thunderstorms are heavy rains resulting in flooding (discussed separately in **Section 3.4.1**) and tornadoes (discussed separately in **Section 3.4.10**).

***High Winds***

A severe thunderstorm can produce winds causing as much damage as a weak tornado. The damaging winds of thunderstorms include downbursts, microbursts, and straight-line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less than 2.5 miles across. They include a strong wind shear (a rapid change in the direction of wind over a short distance) near the surface. Microbursts may or may not include precipitation and can produce winds at speeds of more than 150 miles per hour. Damaging straight-line winds are high winds across a wide area that can reach speeds of 140 miles per hour.

***Lightning***

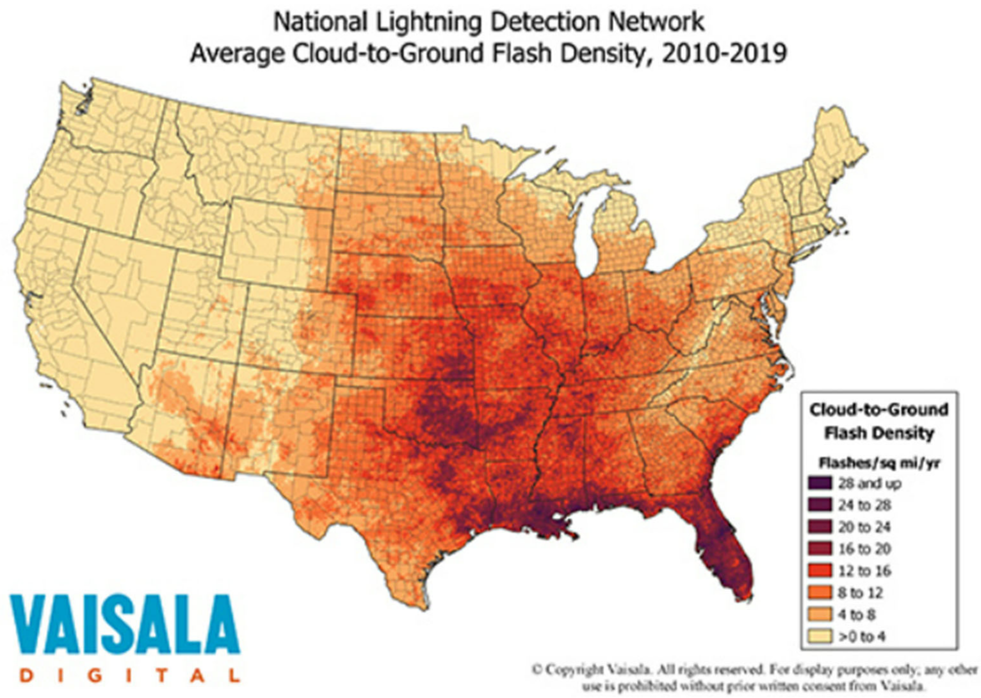
All thunderstorms produce lightning which can strike outside of the area where it is raining and has been known to strike more than 10 miles away from the rainfall area. Thunder is simply the sound that lightning makes. Lightning is a huge discharge of electricity that shoots through the air causing vibrations and creating the sound of thunder.

***Hail***

According to the National Oceanic and Atmospheric Administration (NOAA), hail is precipitation that is formed when thunderstorm updrafts carry raindrops upward into extremely cold atmosphere causing them to freeze. The raindrops form into small frozen droplets. They continue to grow as they encounter super-cooled water which will freeze on contact with the frozen rain droplet. This frozen droplet can continue to grow and form hail. As long as the updraft forces can support or suspend the weight of the hailstone, hail can continue to grow before it hits the earth.

At the time when the updraft can no longer support the hailstone, it will fall to the earth. For example, a ¼" diameter or pea sized hail requires updrafts of 24 miles per hour, while a 2 ¾" diameter or baseball sized hail requires an updraft of 81 miles per hour. According to the NOAA, the largest hailstone in diameter recorded in the United States was found in Vivian, South Dakota on July 23, 2010. It was eight inches in diameter, almost the size of a soccer ball. Soccer-ball-sized hail is the exception, but even small pea-sized hail can do damage.

**Figure 3.30. Location and Frequency of Lightning in Missouri**

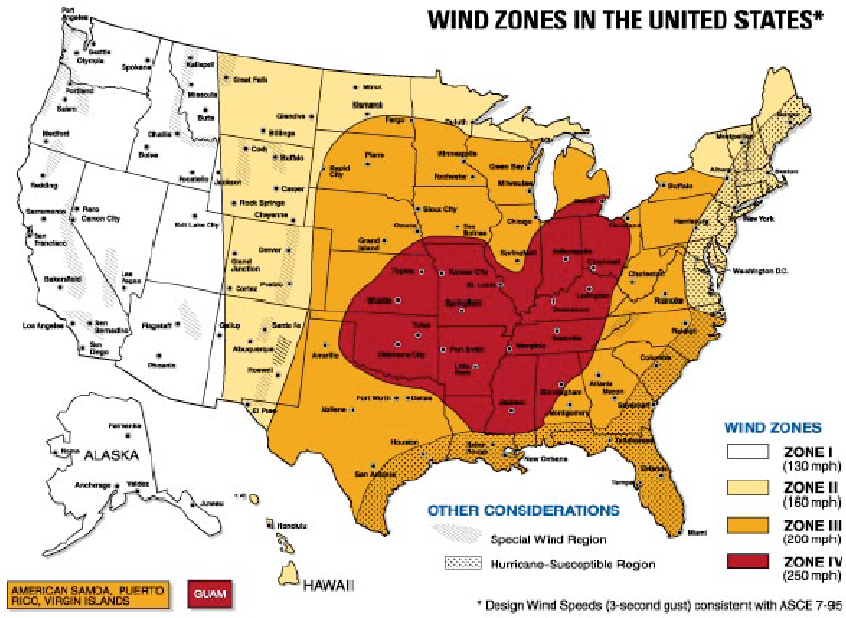



Source: National Weather Service, http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx . Note: indicate location of planning area with a colored square or arrow.

The chart in figure 3.30 displays the location and frequency of lightning strikes in the U.S. It is important to know where lightning historically strikes so that jurisdictions can prepare themselves for lightning related events such as wildfires, personnel injury, property damage, etc.

Wind Zones within the United States as depicted below in figure 3.31 are important to Morgan County jurisdictions because it predicts the potential of where the winds will be the strongest. High winds can impact buildings and crops. They can also have an impact on the direction and strength of storms. Using and understanding wind zone charts will better prepare jurisdictions for adverse weather.

## Figure 3.31. Wind Zones in the United States




Source: FEMA 320, Taking Shelter from the Storm, 3rd edition, https://www.fema.gov/pdf/library/ism2_s1.pdf

### *Strength/Magnitude/Extent*

Based on information provided by the Tornado and Storm Research Organization (TORRO), **Table 3.31** below describes typical damage impacts of the various sizes of hail.

## Table 3.31. Tornado and Storm Research Organization Hailstorm Intensity Scale

| Intensity Category | Diameter (mm) | Diameter (inches) | Size Description | Typical Damage Impacts |
|---|---|---|---|---|
| Hard Hail | 5-9 | 0.2-0.4 | Pea | No damage |
| Potentially Damaging | 10-15 | 0.4-0.6 | Mothball | Slight general damage to plants, crops |
| Significant | 16-20 | 0.6-0.8 | Marble, grape | Significant damage to fruit, crops, vegetation |
| Severe | 21-30 | 0.8-1.2 | Walnut | Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored |
| Severe | 31-40 | 1.2-1.6 | Pigeon's egg > squash ball | Widespread glass damage, vehicle bodywork damage |
| Destructive | 41-50 | 1.6-2.0 | Golf ball > Pullet's egg | Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries |
| Destructive | 51-60 | 2.0-2.4 | Hen's egg | Bodywork of grounded aircraft dented; brick walls pitted |
| Destructive | 61-75 | 2.4-3.0 | Tennis ball > cricket ball | Severe roof damage, risk of serious injuries |
| Destructive | 76-90 | 3.0-3.5 | Large orange > Soft ball | Severe damage to aircraft bodywork |
| Super Hailstorms | 91-100 | 3.6-3.9 | Grapefruit | Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open |
| Super Hailstorms | >100 | 4.0+ | Melon | Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open |

Source: Tornado and Storm Research Organization (TORRO), Department of Geography, Oxford Brookes University

Notes: In addition to hail diameter, factors including number and density of hailstones, hail fall speed and surface wind speeds affect severity. http://www.torro.org.uk/site/hscale.php

Straight-line winds are defined as any thunderstorm wind that is not associated with rotation (i.e., is not a tornado). It is these winds, which can exceed 100 miles per hour, which represent the most common type of severe weather. They are responsible for most wind damage related to thunderstorms. Since thunderstorms do not have narrow tracks like tornadoes, the associated wind damage can be extensive and affect entire (and multiple) counties. Objects like trees, barns, outbuildings, high-profile vehicles, and power lines/poles can be toppled or destroyed, and roofs, windows, and homes can be damaged as wind speeds increase.

The onset of thunderstorms with lightning, high wind, and hail is generally rapid. Duration is less than six hours and warning time is generally six to twelve hours. Nationwide, lightning kills 75 to 100 people each year. Lightning strikes can also start structural and wildland fires, as well as damage electrical systems and equipment.

### *Previous Occurrences*

"Limitations to the use of NCEI reported lightning events include the fact that only lightning events that result in fatality, injury and/or property and crop damage are in the NCEI.

The tables below (**Table 3.32 through Table 3.35**) summarize past crop damages as indicated by crop insurance claims. The tables illustrate the magnitude of the impact on the planning area's agricultural economy.

**Table 3.32. Crop Insurance Claims Paid in Morgan County from Thunderstorms, [2006-2022].**

| Crop Year | Crop Name | Cause of Loss Description | Insurance Paid |
|---|---|---|---|
| 2006 | Corn | Excess Precipitation | 808.00 |
| 2007 | Grain | Excess Precipitation | 938.00 |
| 2008 | Corn | Excess Precipitation | 650,746.00 |
| 2008 | Soybeans | Excess Precipitation | 381,957.00 |
| 2009 | Corn | Excess Precipitation | 250201.00 |
| 2009 | Soybeans | Excess Precipitation | 13,522.00 |
| 2010 | Wheat | Excess Precipitation | 35,554.00 |
| 2010 | Corn | Excess Precipitation | 66,393.00 |
| 2011 | Wheat | Excess Precipitation | 1,901.00 |
| 2011 | Corn | Excess Precipitation | 51,030.00 |
| 2011 | Grain | Excess Precipitation | 411.00 |
| 2011 | Soybeans | Excess Precipitation | 2,506.00 |
| 2012 | Corn | Excess Precipitation | 727.00 |
| 2012 | Soybeans | Excess Precipitation | 3,389.00 |
| 2013 | Wheat | Excess Precipitation | 1,984.00 |
| 2013 | Corn | Excess Precipitation | 214,698.00 |
| 2013 | Soybeans | Excess Precipitation | 9,437.00 |
| 2014 | Soybeans | Excess Precipitation | 3,981.00 |
| 2015 | Wheat | Excess Precipitation | 33,759.00 |
| 2015 | Corn | Excess Precipitation | 289,863.00 |
| 2015 | Grain | Excess Precipitation | 5,032.00 |
| 2015 | Soybeans | Excess Precipitation | 985,688.00 |
| 2016 | Wheat | Excess Precipitation | 13,173.00 |
| 2016 | Corn | Excess Precipitation | 2,570.20 |
| 2016 | Grain | Excess Precipitation | 2,255.00 |

| | | | |
|---|---|---|---|
| 2016 | Soybeans | Excess Precipitation | 10,411.00 |
| 2017 | Corn | Excess Precipitation | 4473 |
| 2017 | Corn | Excess Precipitation | 7885 |
| 2017 | Corn | Excess Precipitation | 11207 |
| 2018 | Corn | Excess Precipitation | 974.55 |
| 2018 | Soybean | Excess Precipitation | 1448 |
| 2018 | Soybean | Excess Precipitation | 2844 |
| 2019 | Wheat | Excess Precipitation | 24915 |
| 2019 | Wheat | Excess Precipitation | 48869 |
| 2019 | Wheat | Excess Precipitation | 3776 |
| 2019 | Wheat | Excess Precipitation | 4615 |
| 2019 | Corn | Excess Precipitation | 3914 |
| 2019 | Corn | Excess Precipitation | 24616 |
| 2019 | Corn | Excess Precipitation | 4376 |
| 2019 | Corn | Excess Precipitation | 8363 |
| 2019 | Corn | Excess Precipitation | 70530 |
| 2019 | Corn | Excess Precipitation | 280 |
| 2019 | Corn | Excess Precipitation | 9120 |
| 2019 | Corn | Excess Precipitation | 1163 |
| 2019 | Corn | Excess Precipitation | 23511 |
| 2019 | Soybean | Excess Precipitation | 4506 |
| 2019 | Soybean | Excess Precipitation | 1314 |
| 2019 | Soybean | Excess Precipitation | 21593 |
| 2019 | Soybean | Excess Precipitation | 3001 |
| 2019 | Soybean | Excess Precipitation | 4309 |
| 2019 | Soybean | Excess Precipitation | 1487 |
| 2019 | Soybean | Excess Precipitation | 11210.40 |
| 2019 | Soybean | Excess Precipitation | 83843 |
| 2019 | Soybean | Excess Precipitation | 8210 |
| 2019 | Soybean | Excess Precipitation | 4542 |
| 2020 | Corn | Excess Precipitation | 1217 |
| 2020 | Corn | Excess Precipitation | 13512 |
| 2020 | Corn | Excess Precipitation | 6053 |
| 2020 | Corn | Excess Precipitation | 1418 |
| 2020 | Soybean | Excess Precipitation | 13763 |
| 2020 | Soybean | Excess Precipitation | 2503 |
| 2020 | Soybean | Excess Precipitation | 8891 |
| 2021 | Corn | Excess Precipitation | 6634 |
| 2021 | Corn | Excess Precipitation | 20161 |
| 2021 | Corn | Excess Precipitation | 92175.50 |
| 2021 | Corn | Excess Precipitation | 1932 |
| 2021 | Corn | Excess Precipitation | 2503 |
| 2021 | Corn | Excess Precipitation | 48741.40 |
| 2021 | Corn | Excess Precipitation | 37617.50 |
| 2021 | Corn | Excess Precipitation | 16275 |
| 2021 | Corn | Excess Precipitation | 10408 |
| 2021 | Soybean | Excess Precipitation | 44962 |
| 2021 | Soybean | Excess Precipitation | 397 |
| 2021 | Soybean | Excess Precipitation | 13779 |
| 2021 | Soybean | Excess Precipitation | 13875 |
| 2021 | Soybean | Excess Precipitation | 3818 |
| 2021 | Soybean | Excess Precipitation | 68392 |
| 2022 | Corn | Excess Precipitation | 2708.20 |
| 2022 | Corn | Excess Precipitation | 25704.80 |
| 2022 | Corn | Excess Precipitation | 6022 |

| | | | |
|---|---|---|---|
| 2022 | Corn | Excess Precipitation | 39782 |
| 2022 | Corn | Excess Precipitation | 10203 |
| 2022 | Soybean | Excess Precipitation | 1861 |
| 2022 | Soybean | Excess Precipitation | 6018 |
| 2022 | Soybean | Excess Precipitation | 15027 |
| **TOTAL** | | | **$3,970,183** |

Source: USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/cause

**Table 3.33. Crop Insurance Claims Paid in Morgan County from High Winds, [2006-2022]**

| Crop Year | Crop Name | Cause of Loss Description | Insurance Paid |
|---|---|---|---|
| | | | |
| | No Data Provided | | |
| | | | |
| | | | |
| Total | | | |

Source: USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/cause

**Table 3.34. Crop Insurance Claims Paid in Morgan County from Lightning, [2006-2022].**

| Crop Year | Crop Name | Cause of Loss Description | Insurance Paid |
|---|---|---|---|
| | | | |
| | No Data Provided | | |
| | | | |
| | | | |
| **Total** | | | |

USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/cause

**Table 3.35. Crop Insurance Claims Paid in Morgan County from Hail, [2006-2022].**

| Crop Year | Crop Name | Cause of Loss Description | Insurance Paid |
|---|---|---|---|
| | | | |
| | No Data Provided | | |
| | | | |
| | | | |
| **Total** | | | |

USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/cause

### *Probability of Future Occurrence*

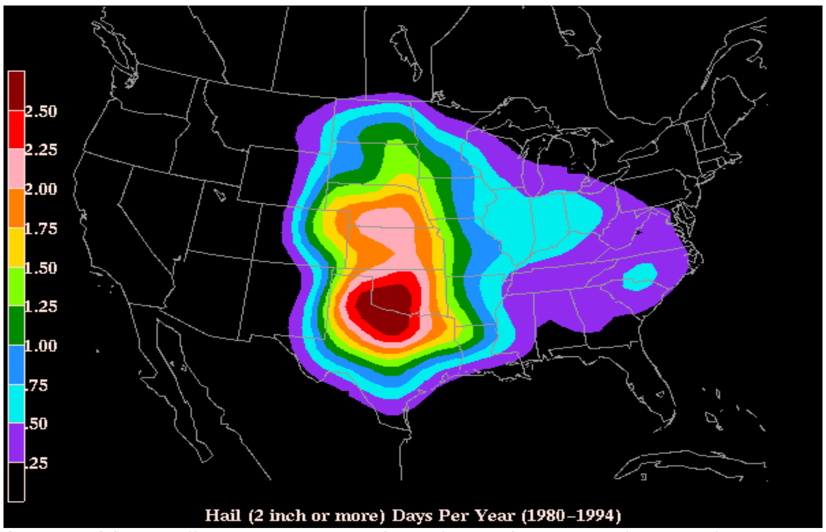
The below probability figures are supported by the recorded events in the last 20 years, tracked by the National Oceanic and Atmospheric Administration (NOAA) formally the National Climatic Data Center (NCEI).

**Thunderstorms-** 100%
**Lightening-** 100%

**High Wind**- 100%
**Hail**- 100%

The hailstorm data below is from 1980-1994. It shows the probability of hailstorm occurrence (2" diameter or larger) based on number of days per year. Morgan County is in the .75 blue zones. The highest recorded hail size has been 1.75 inches in Barnett on 5/25/2001, in Gravois Mill on 3/12/2006 and 4/15/2012, in Stover on 4/15/2012 and 4/10/2016, and in Versailles on 5/26/2016. There is an average of 8 events per year for lightening, high winds, and hail since they are usually part of most thunderstorms in Morgan County, Missouri. The below Annual Hailstorm Probability Chart in Figure 3.32 helps with planning within Morgan Counties jurisdictions by helping identify potential areas that are more likely to incur damages from hail. This damage could be to crops, homes, government buildings and vehcles.

**Figure 3.32. Annual Hailstorm Probability (2" diameter or larger), U 1980- 1994**




Source: NSSL, http://www.nssl.noaa.gov/users/brooks/public_html/bighail.gif Note:

***Changing Future Conditions Considerations***

NASA's Earth Observatory provides an analysis on how climate change could, theoretically, increase potential storm energy by warming the surface and putting more moisture in the air through evaporation. The presence of warm, moist air near the surface is a key ingredient for summer storms that meteorologists have termed "convective available potential energy," or CAPE. With an increase in CAPE, there is greater potential for cumulus clouds to form. The study also counters this theory with the theory that warming in the Arctic could lead to less wind shear in the mid-latitude areas prone to summer storms, making the storms less likely.

Predicted increases in temperature could help create atmospheric conditions that are fertile breeding grounds for severe thunderstorms and tornadoes in Missouri. Possible impacts include an increased risk to life and property in both the public and private sectors. Public utilities and manufactured housing developments will be especially prone to damage. Jurisdictions already affected should be prepared for more of these events and should thus prioritize mitigation actions such as construction of safe rooms for vulnerable populations, retrofitting and/or hardening existing structures, improving warning systems and public education, and reinforcing utilities and additional critical infrastructure.

## Vulnerability

### *Vulnerability Overview*

Severe thunderstorm losses are usually attributed to the associated hazards of hail, downburst winds, lightning, and heavy rains. Losses due to hail and high wind are typically insured losses that are localized and do not result in presidential disaster declarations. However, in some cases, impacts are severe and widespread and assistance outside state capabilities is necessary. Hail and wind also can have devastating impacts on crops. Severe thunderstorms/heavy rains that lead to flooding are discussed in the flooding hazard profile. Hailstorms cause damage to property, crops, and the environment, and can injure and even kill livestock. In the United States, hail causes more than $1 billion in damage to property and crops each year. Even relatively small hail can shred plants to ribbons in a matter of minutes. Vehicles, roofs of buildings and homes, and landscaping are also commonly damaged by hail. Hail has been known to cause injury to humans, occasionally fatal injury.

In general, assets in the County vulnerable to thunderstorms with lightning, high winds, and hail include people, crops, vehicles, and built structures. Although this hazard results in high annual losses, private property insurance and crop insurance usually cover most losses. Considering insurance coverage as a recovery capability, the overall impact on jurisdictions is reduced.

Most lightning damage occurs to electronic equipment located inside buildings. But structural damage can also occur when a lightning strike causes a building fire. In addition, lightning strikes can cause damage to crops, if fields or forested lands are set on fire. Communications equipment and warning transmitters and receivers can also be knocked out by lightning strikes. http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx and http://www.lightningsafety.noaa.gov/

### *Potential Losses to Existing Development*

Morgan County can expect hail to damage structures throughout the entire planning area. There is inconsistent data concerning the costs associated with the historical information available. It is difficult to estimate the potential impact on both the number of structures and the cost of any given natural hazard, as they are completely unpredictable.

### *Previous and Future Development*

Hail is frozen precipitation created by thunderstorms that contain large amounts of moisture, strong upward winds and freezing temperatures. The moisture freezes in irregular sizes and shapes. Within the planning area, the sizes range from 0.75 inches to 2.75 inches. Falling hailstones can cause damage to:

- Homes (Roofs, Siding, Glass Windows and Doors)
- Automobiles
- Airplanes
- Crop Damage
- Livestock
- Humans

### *Hazard Summary by Jurisdiction*

According to the census information there are 372 estimated homes built before 1939 in Morgan County.

**Table 3.36. Homes Built 1939 & Earlier (2022 Estimates)**

| Morgan County | Barnett | Gravois Mills | Laurie | Stover | Syracuse | Versailles |
|---|---|---|---|---|---|---|
| Estimate | Estimate | Estimate | Estimate | Estimate | Estimate | Estimate |
| 372 | 43 | 2 | 0 | 124 | 23 | 170 |

## Problem Statement

Mitigation: Early-warning systems and public information increase the safety and lessen the loss of life in the event of Severe Thunderstorms, Tornadoes, Windstorms, and Hailstorms. Increased public awareness and education in conjunction with the early -warning systems have helped mitigate disasters from these severe weather threats.

# 3.4.9 Severe Winter Weather

## Hazard Profile

### *Hazard Description*

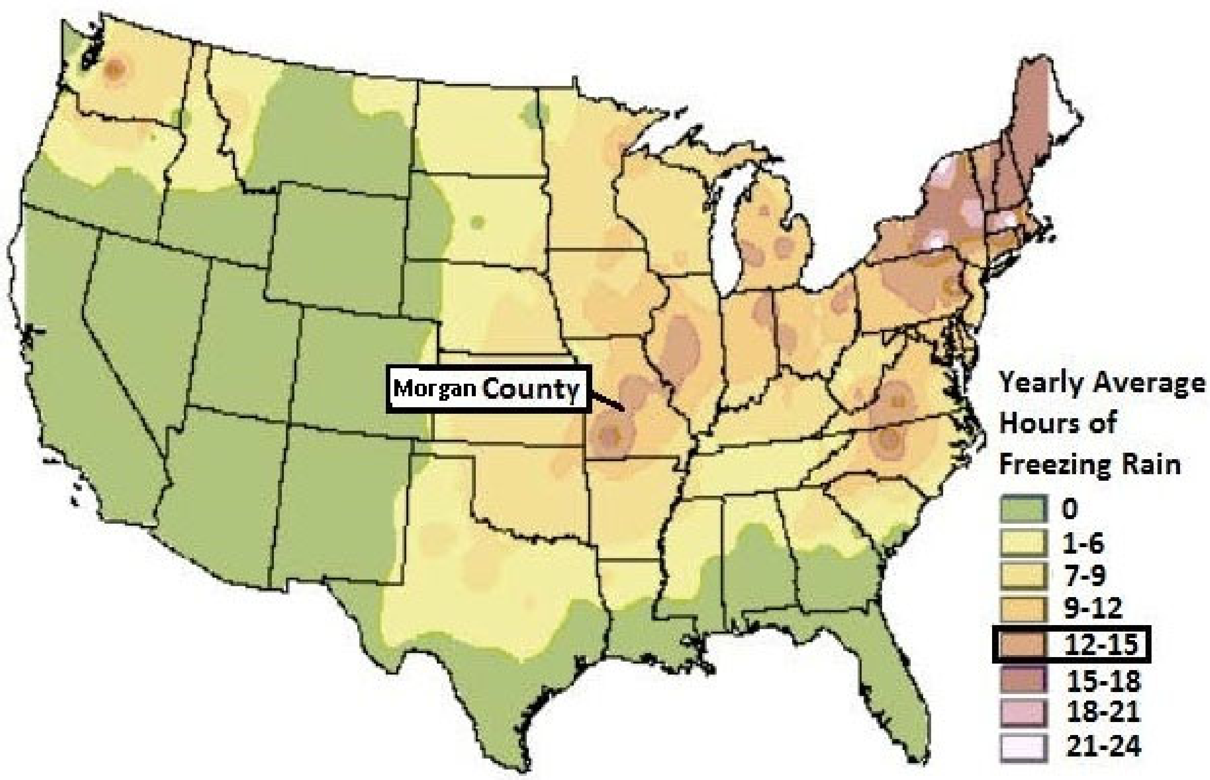
A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service describes different types of winter storm events as follows.

- **Blizzard**—Winds of 35 miles per hour or more with snow and blowing snow reducing visibility to less than ¼ mile for at least three hours.
- **Blowing Snow**—Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.
- **Snow Squalls**—Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant.
- **Snow Showers**—Snow falling at varying intensities for brief periods of time. Some accumulation is possible.
- **Freezing Rain**—Measurable rain that falls onto a surface with a temperature below freezing. This causes it to freeze to surfaces, such as trees, cars, and roads, forming a coating or glaze of ice. Most freezing-rain events are short lived and occur near sunrise between the months of December and March.
- **Sleet**—Rain drops that freeze into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and does not stick to objects.

Figure 3.33 depicts the average number of hours per year with freezing rain. This information is important to jurisdictions so that they can properly plan for this type of adverse weather. Freezing rain can affect transportation, crops, homes, powerlines etc. some of the damages could be mitigated with enough planning.

***Geographic Location***

**Figure 3.33. NWS Statewide Average Number of Hours per Year with Freezing Rain**




Source: American Meteorological Society. “Freezing Rain Events in the United States.” http://ams.confex.com/ams/pdfpapers/71872.pdf

***Strength/Magnitude/Extent***

Severe winter storms include heavy snowfall, ice, and strong winds which can push the wind chill well below zero degrees in the planning area.

For severe weather conditions, the National Weather Service issues some or all of the following alerts as conditions warrant across the State of Missouri. NWS local offices in Missouri may collaborate with local partners to determine when an alert should be issued for a local area.

- Winter Weather Advisory — Winter weather conditions are expected to cause significant inconveniences and may be hazardous. If caution is exercised, these situations should not become life threatening. Often the greatest hazard is to motorists.
- Winter Storm Watch — Severe winter conditions, such as heavy snow and/or ice are possible within the next day or two.
- Winter Storm Warning — Severe winter conditions have begun or are about to begin.
- Blizzard Warning — Snow and strong winds will combine to produce a blinding snow (near

zero visibility), deep drifts, and life-threatening wind chill.

- Ice Storm Warning -- Dangerous accumulations of ice are expected with generally over one quarter inch of ice on exposed surfaces. Travel is impacted, and widespread downed trees and power lines often result.
- Wind Chill Advisory -- Combination of low temperatures and strong winds will result in wind chill readings of -20 degrees F or lower.
- Wind Chill Warning -- Wind chill temperatures of -35 degrees F or lower are expected. This is a life-threatening situation.

***Previous Occurrences***

**Table 3.37. NCEI Morgan County Winter Weather Events Summary, [2007-2023]**

| Type of Event | Inclusive Dates | Magnitude | # of Injuries | Property Damages | Crop Damages |
|---|---|---|---|---|---|
| Winter Storm | 12/20-22/2013 | Freezing rain accumulations one quarter to one-half of an inch. Downed limbs in localized areas. | | | |
| Winter Storm | 03-24-2013 | Heavy snow accumulations of 4 to 8 inches | 0 | 0 | 0 |
| Winter Storm | 02/25-26/2013 | Snow accumulations of 6 to 11 inches | 0 | 0 | 0 |
| Winter Storm | 02/21/2013 | Snow and Sleet accompanied by thunder, 1-2 inches with snow accumulations ranging 1-2 inches. | 0 | 0 | 0 |
| Blizzard | 02/01/2011 | Heavy wintry precipitations, and blizzard conditions at times, sleet accumulations of one half to 2 inches, freezing rain accumulations. | 0. | 0 | 0 |
| Winter Storm | 03/20-21/2010 | Snow accumulations of 3 to 6 inches along with sleet accumulations up to one quarter of an inch and minor ice accumulations made trave dangerous. | 0 | 0 | 0 |
| Winter Storm | 02/28/2009 | Heavy snow with accumulations of 4-7 inches | 0 | 0 | 0 |
| Winter Storm | 1/26-27/2009 | Freezing rain, sleet, accumulations on roofs of several buildings and a boat dock to collapse. Accumulations of 1-3 inches, 2-4 inches of snow on top of sleet. | 0 | 0 | 0 |
| Winter Storm | 02/28/2009 | Heavy snow with accumulations of 4-7 inches | 0 | 0 | 0 |
| Ice Storm | 02/21/2008 | Sleet accumulations of 1-2 inches | 0 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| Ice Storm | 12/9-10/2007 | Ice accumulations ranging from three quarters of an inch to one inch. | 0 | 26K | 0 |
| Ice Storm | 1/12-14/2007 | Power outages, catastrophic tree damage, several indirect fatalities, carbon monoxide poisoning occurred, generators were being used in garages. | 0 | 12K | 0 |
| Winter Storm | 2/5/2020 | Heavy snow which form into rin an freezing rain. 2-5 inches of snow fell, with some locally higher amounts of 6 inches. | 0 | 0 | 0 |
| Ice Storm | 2/6/2019 | Heaviest freezing rain and ice accumulation occurred during the late evening. ¼ inch of ice accumulation was recorded. | 0 | 0 | 0 |
| Winter Storm | 1/11/2019 | Winter storm where heavy snow fell across central Missouri with accumulations of 6-12 inches of snow. | 0 | 0 | 0 |
| Winter Storm | 1/1/2021 | Freezing rain that accumulated between .30 and .50 inches across the county. | 0 | 25K | 0 |
| Winter Storm | 2/1-3/2022 | There were 2 rounds of wintry precipitation that fell across the county. Rain changed into a mix of sleet and snow. Accumulations of 10inches of snow. | 0 | 0 | 0 |
| Winter Storm | 2/17/2022 | A mixture of freezing rain sleet and snow changed over to all snow during the early morning hours. There was 2-5 inches of accumulations. | 0 | 0 | 0 |

Source: NCEI, data accessed [insert date]

### Table 3.38. Crop Insurance Claims Paid in Morgan County as a Result of Cold Conditions and Snow [2006-2022]

| Crop Year | Crop Name | Cause of Loss Description | Insurance Paid ($) |
|---|---|---|---|
| 2007 | Wheat | Freeze | 8,742.00 |
| 2007 | Wheat | Freeze | 136.00 |
| 2007 | Corn | Cold Wet Weather | 901.00 |
| 2008 | Soybeans | Freeze | 9,620.00 |

| | | | |
|---|---|---|---|
| 2009 | Corn | Cold Wet Weather | 2,564.00 |
| 2010 | Wheat | Cold Wet Weather | 43,949.00 |
| 2011 | Corn | Cold Wet Weather | 12,154.00 |
| 2011 | Soybeans | Cold Wet Weather | 2,104.00 |
| 2012 | Corn | Cold Wet Weather | 727.00 |
| 2013 | Wheat | Cold Wet Weather | 1,984.00 |
| 2013 | Soybeans | Freeze | 1,969.00 |
| 2014 | Wheat | Cold Winter Weather | 11,458.00 |
| 2014 | Corn | Cold Wet Weather | 1,366.20 |
| 2014 | Soybeans | Cold Wet Weather | 166.00 |
| 2015 | Wheat | Cold Wet Weather | 2,000.00 |
| 2017 | Corn | Cold Wet Weather | 668 |
| 2017 | Corn | Cold Wet Weather | 266 |
| 2019 | Wheat | Cold Wet Weather | 2324 |
| 2019 | Wheat | Cold Wet Weather | 2324 |
| 2019 | Wheat | Cold Wet Weather | 8486 |
| 2019 | Wheat | Cold Wet Weather | 8486 |
| 2019 | Soybeans | Cold Wet Weather | 11337 |
| 2020 | Wheat | Freeze | 816 |
| 2020 | Corn | Cold Wet Weather | 1965 |
| 2021 | Corn | Cold Wet Weather | 20187 |
| 2021 | Corn | Cold Wet Weather | 1078 |
| 2021 | Corn | Cold Wet Weather | 3938 |
| 2021 | Soybeans | Cold Wet Weather | 856 |
| 2021 | Soybeans | Cold Wet Weather | 3184 |
| 2022 | Corn | Cold Wet Weather | 4058 |
| **TOTAL** | | | $169,813.20 |

Source: USDA Risk Management Agency, https://www.rma.usda.gov/data/cause

### *Probability of Future Occurrence*

Based on the data in table 3.37 the probability of winter weather is High with a 100 percent probability of future occurrences.

### *Changing Future Conditions Considerations*

A shorter overall winter season and fewer days of extreme cold may have both positive and negative indirect impacts. Warmer winter temperatures may result in changing distributions of native plant and animal species and/or an increase in pests and non-native species. Warmer winter temperatures will result in a reduction of lake ice cover. Reduced lake ice cover impacts aquatic ecosystems by raising water temperatures. Water temperature is linked to dissolved oxygen levels and many other environmental parameters that affect fish, plants, and other animal populations. A lack of ice cover also leaves lakes exposed to wind and evaporation during a time of year when they are normally protected. As both temperature and precipitation increase during the winter months, freezing rain will be more likely. Additional wintertime precipitation in any form will contribute to saturation and increase the risk and/or severity of spring flooding. A greater proportion of wintertime precipitation may fall as rain rather than snow.

## Vulnerability

### *Vulnerability Overview*

Heavy snow can bring a community to a standstill by inhibiting transportation (in whiteout conditions), weighing down utility lines, and by causing structural collapse in buildings not designed to withstand the weight of the snow. Repair and snow removal costs can be significant. Ice buildup can collapse utility lines and communication towers, as well as make transportation difficult and hazardous. Ice can also become a problem on roadways if the air temperature is high enough that precipitation falls as freezing rain rather than snow.

Buildings with overhanging tree limbs are more vulnerable to damage during winter storms when limbs fall. Businesses experience loss of income as a result of closure during power outages. In general, heavy winter storms increase wear and tear on roadways though the cost of such damages is difficult to determine. Businesses can experience loss of income as a result of closure during winter storms.

Overhead power lines and infrastructure are also vulnerable to damage from winter storms. Ice accumulation during winter storm events damage to power lines due to the ice weight on the lines and equipment. Damage also occurs to lines and equipment from falling trees and tree limbs weighted down by ice. Potential losses could include the cost of repair or replacement of damaged facilities and lost economic opportunities for businesses.

Secondary effects from loss of power could include burst water pipes in homes without electricity during winter storms. Public safety hazards include the risk of electrocution from downed power lines. Specific amounts of estimated losses are not available due to the complexity and multiple variables associated with this hazard. Standard values for loss of service for utilities reported in FEMA's 2009 BCA Reference Guide, the economic impact as a result of loss of power is $126 per person per day of lost service.

Severe Winter Storms have taken a significant toll on Morgan County, its residents and resources. Most recently, in early 2011, the county was identified with two separate Presidential Disasters Declarations due to Severe Winter Weather and Ice/Snowstorms. In addition, Morgan County was identified in a Presidential Disaster Declaration in 2009 and 2007, as well as a separate Emergency Declaration in 2007, all for Winter Weather Storms, including Ice and Snowstorms.

### *Potential Losses to Existing Development*

Morgan County has experienced a considerable amount of Severe Winter Weather and the damages are high for both structural damages and infrastructure damages to utility lines and roads. Lake front properties have experienced extensive damage to boats and boat docks. Estimating the overall costs is difficult as many of these items are personal property and claims are filed individually with each insurance company and that data is not collectively shared.

### *Previous and Future Development*

At this time there is no anticipated future development in the county that could affect the risk of damage from this hazard in the planning area.

### *Hazard Summary by Jurisdiction*

No reports of damage caused to education facilities.

## Problem Statement

***Mitigation:*** Preservation of critical power sources is essential in rural areas to ensure that people are not stranded in homes with no heat and no access to the main roads. Many of the local power companies spend considerable time during the summer months trimming trees along the power lines to help minimize the impact closest to those power lines. The cost of burying the utility lines has often been discussed but the cost factor has limited many projects from being feasible and therefore left undone. A Multi-Jurisdictional Hazard Mitigation Plan for Missouri's Electric Cooperatives was developed and submitted to FEMA and approved in 2012. Within the LOCLG region, all the Rural Electric Cooperatives serving our area participated in the planning process; this will enable the electric cooperatives to be eligible for FEMA mitigation funds, which could be used to help offset the cost of some of these improvements.

The Springfield Office of the National Weather Service covers the planning area. It has established an early-warning system to help the public prepare for pending severe weather.

## 3.4.10 Tornado

### Hazard Profile

#### *Hazard Description*

Essentially, tornadoes are a vortex storm with two components of winds. The first is the rotational winds that can measure up to 500 miles per hour, and the second is an uplifting current of great strength. The dynamic strength of both these currents can cause vacuums that can overpressure structures from the inside.

Although tornadoes have been documented in all 50 states, most of them occur in the central United States. The unique geography of the central United States allows for the development of thunderstorms that spawn tornadoes. The jet stream, which is a high-velocity stream of air, determines which area of the central United States will be prone to tornado development. The jet stream normally separates the cold air of the north from the warm air of the south. During the winter, the jet stream flows west to east from Texas to the Carolina coast. As the sun "moves" north, so does the jet stream, which at summer solstice flows from Canada across Lake Superior to Maine. During its move northward in the spring and its recession south during the fall, the jet stream crosses Missouri, causing large thunderstorms that breed tornadoes.

Tornadoes spawn from the largest thunderstorms. The associated cumulonimbus clouds can reach heights of up to 55,000 feet above ground level and are commonly formed when Gulf air is warmed by solar heating. The moist, warm air is overridden by the dry cool air provided by the jet stream. This cold air presses down on the warm air, preventing it from rising, but only temporarily. Soon, the warm air forces its way through the cool air and the cool air moves downward past the rising warm air. This air movement, along with the deflection of the earth's surface, can cause the air masses to start rotating. This rotational movement around the location of the breakthrough forms a vortex, or funnel. If the newly created funnel stays in the sky, it is referred to as a funnel cloud. However, if it touches the ground, the funnel officially becomes a tornado.

A typical tornado can be described as a funnel-shaped cloud that is "anchored" to a cloud, usually a cumulonimbus that is also in contact with the earth's surface. This contact on average lasts 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. The National Weather Service, in reviewing tornadoes occurring in Missouri between 1950 and 1996, calculated the mean path length at 2.27 miles and the mean path area at 0.14 square mile.

The average forward speed of a tornado is 30 miles per hour but may vary from nearly stationary to 70 miles per hour. The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. Tornadoes are most likely to occur in the afternoon and evening but have been known to occur at all hours of the day and night.

### *Geographic Location*

Tornadoes can occur anywhere in Morgan County and the planning area.

### *Strength/Magnitude/Extent*

Tornadoes are the most violent of all atmospheric storms and are capable of tremendous destruction. Wind speeds can exceed 250 miles per hour and damage paths can be more than one mile wide and 50 miles long. Tornadoes have been known to lift and move objects weighing more than 300 tons a distance of 30 feet, toss homes more than 300 feet from their foundations, and siphon millions of tons of water from water bodies. Tornadoes also can generate a tremendous amount of flying debris or "missiles," which often become airborne shrapnel that causes additional damage. If wind speeds are high enough, missiles can be thrown at a building with enough force to penetrate windows, roofs, and walls. However, the less spectacular damage is much more common.

Tornado magnitude is classified according to the EF- Scale (or the Enhance Fujita Scale, based on the original Fujita Scale developed by Dr. Theodore Fujita, a renowned severe storm researcher). The EF-Scale (see **Table 3.39**) attempts to rank tornadoes according to wind speed based on the damage caused. This update to the original F Scale was implemented in the U.S. on February 1, 2007.

**Table 3.39. Enhanced F Scale for Tornado Damage**

| FUJITA SCALE | | | DERIVED EF SCALE | | OPERATIONAL EF SCALE | |
|---|---|---|---|---|---|---|
| F Number | Fastest ¼-mile (mph) | 3 Second Gust (mph) | EF Nu | 3 Second Gust (mph) | EF Number | 3 Second Gust (mph) |
| 0 | 40-72 | 45-78 | 0 | 65-85 | 0 | 65-85 |
| 1 | 73-112 | 79-117 | 1 | 86-109 | 1 | 86-110 |
| 2 | 113-157 | 118-161 | 2 | 110-137 | 2 | 111-135 |
| 3 | 158-207 | 162-209 | 3 | 138-167 | 3 | 136-165 |
| 4 | 208-260 | 210-261 | 4 | 168-199 | 4 | 166-200 |
| 5 | 261-318 | 262-317 | 5 | 200-234 | 5 | Over 200 |

Source: The National Weather Service, www.spc.noaa.gov/faq/tornado/ef-scale.html

The wind speeds for the EF scale and damage descriptions are based on information on the NOAA Storm Prediction Center as listed in **Table 3.40**. The damage descriptions are summaries. For the actual EF scale it is necessary to look up the damage indicator (type of structure damaged) and refer to the degrees of damage associated with that indicator. Information on the Enhanced Fujita Scale's damage indicators and degrees or damage is located online at www.spc.noaa.gov/efscale/ef-scale.html .

**Table 3.40. Enhanced Fujita Scale with Potential Damage**

| Enhanced Fujita Scale | | | |
|---|---|---|---|
| Scale | Wind Speed (mph) | Relative Frequency | Potential Damage |
| EF0 | 65-85 | 53.5% | Light. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e. those that remain in open fields) are always rated EF0). |

| | | | |
|---|---|---|---|
| EF1 | 86-110 | 31.6% | Moderate. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken. |
| EF2 | 111-135 | 10.7% | Considerable. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes complete destroyed; large trees snapped or uprooted; light object missiles generated; cars lifted off ground. |
| EF3 | 136-165 | 3.4% | Severe. Entire stores of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some |
| EF4 | 166-200 | 0.7% | Devastating. Well-constructed houses and whole frame houses completely levelled; cars thrown and small missiles generated. |
| EF5 | >200 | <0.1% | Explosive. Strong frame houses levelled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300 ft.; steel reinforced concrete structure badly damaged; high rise buildings have significant structural deformation; incredible phenomena will occur. |

Source: NOAA Storm Prediction Center, http://www.spc.noaa.gov/efscale/ef-scale.html

Enhanced weather forecasting has provided the ability to predict severe weather likely to produce tornadoes days in advance. Tornado watches can be delivered to those in the path of these storms several hours in advance. The lead time for actual tornado warnings is about 30 minutes. Tornadoes have been known to change paths very rapidly, thus limiting the time in which to take shelter. Tornadoes may not be visible on the ground if they occur after sundown or due to blowing dust or driving rain and hail.

### *Previous Occurrences*

There are limitations to the use of NCEI tornado data that must be noted. For example, one tornado may contain multiple segments as it moves geographically. A tornado that crosses a county line or state line is considered a separate segment for the purposes of reporting to the NCEI. Also, a tornado that lifts off the ground for less than 5 minutes or 2.5 miles is considered a separate segment. If the tornado lifts off the ground for greater than 5 minutes or 2.5 miles, it is considered a separate tornado. Tornadoes reported in Storm Data and the Storm Events Database are in segments.

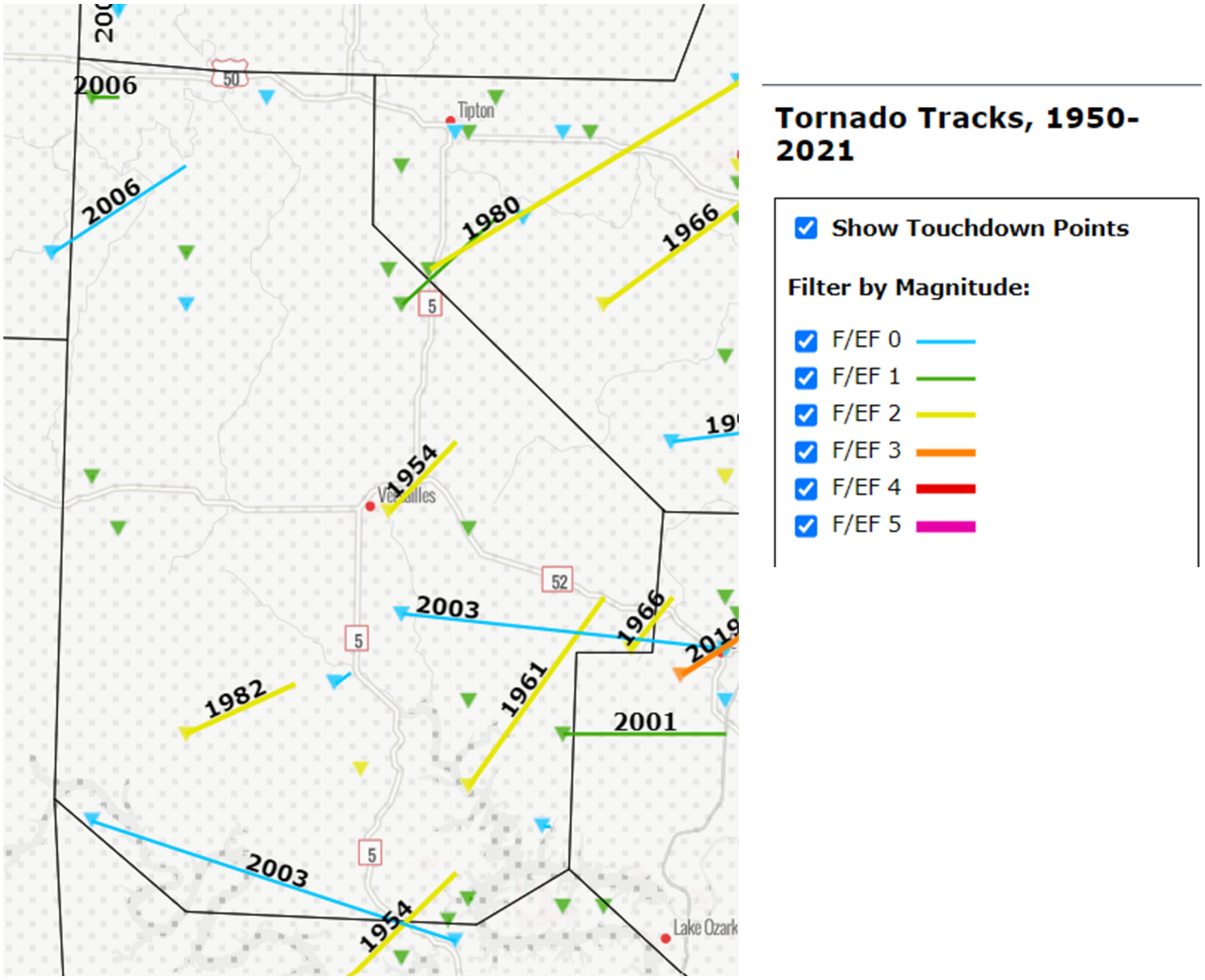
**Table 3.41. Recorded Tornadoes in Morgan County, 1993 – 2022**

| Date | Beginning Location | Ending Location | Length (miles) | Width (yards) | F/EF Rating | Death | Injury | Property Damage | Crop Damages |
|---|---|---|---|---|---|---|---|---|---|
| 5/27/2017 | 6SSEGravois Mills ARPT | 6SSE Gravois Mills ARPT | 0.06 | 300 | EF1 | 0 | 0 | 25K | 0 |
| 5/27/2017 | 5SSE GravoisMillsARPT | 5 SSE Gravois Mills ARPT | 0.13 | 50 | EF1 | 0 | 0 | 50K | 0 |
| 3/6/2017 | 4SSW Rocky Mount | Rocky Mount | 0.33 | 50 | EF0 | 0 | 0 | 100K | 0 |
| 5/20/2013 | 3WNW Gravois Mills | 2WNW Gravois Mills | .74 | 100 | EF0 | 0 | 0 | 50K | 0 |
| 3/12/2006 | 3 SW Gravois Mills | 3 SW Gravois Mills | 6 | 100 | EF2 | 0 | 5 | 850 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3/12/2006 | 9W Syracuse | 8 W Syracuse | 1 | 250 | EF1 | 0 | 0 | 10K | 0 |
| 5/6/2003 | 11SW Gravois Mills | 10SW Gravois Mills | 1 | 100 | EF0 | 0 | 0 | 0 | 0 |
| 5/6/2003 | 3 N Gravois Mills | 3 SE Barnett | 10 | 100 | EF0 | 0 | 0 | 0 | 0 |
| 4/16/1995 | 2E Gravois Mills | 2 E Gravois Mills | .5 | 100 | EF1 | 0 | 0 | 175K | 0 |
| | **Total** | | | | | | | | |

Source: National Centers for Environmental Information, http://www.NCEI.noaa.gov/stormevents/

**Figure 3.34. Morgan County Map of Historic Tornado Events**




Source: Missouri Tornado History Project, http://www.tornadohistoryproject.com/tornado/Missouri

### *Probability of Future Occurrence*

Morgan County is no stranger to the likeliness of tornadoes either. There have been three (3) F0 category tornadoes reported since 1993 and two (2) F1. There has only been one (1) F2 reported for the county. There have not been any F3 to F5 tornadoes reported for the county. Because of the terrain, tornadoes are not as probable in the county as flooding. There is a 25% probability of future occurrence of tornadoes based on the NCEI statistics.

### *Changing Future Conditions Considerations*

Scientists do not know how the frequency and severity of tornadoes will change. Research published in 2015 suggests that changes in heat and moisture content in the atmosphere, brought on by a warming world, could be playing a role in making tornado outbreaks more common and severe in the U.S. The research concluded that the number of days with large outbreaks has been increasing since the 1950s and that densely concentrated tornado outbreaks are on the rise. It is notable that the research shows that the area of tornado activity is not expanding, but rather the areas already subject to tornado activity are seeing the more densely packed tornadoes. Because Missouri experiences on average around 39.6 tornadoes a year, such research is closely followed by meteorologists in the state.

## Vulnerability

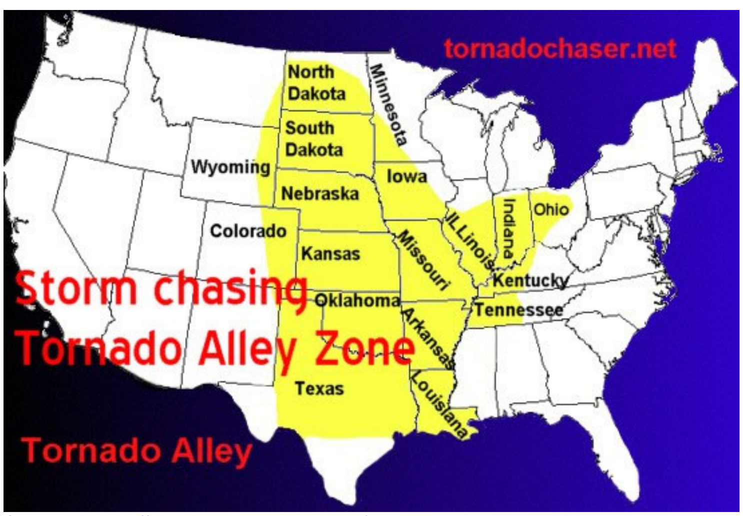
### *Vulnerability Overview*

Morgan County is located on the Ozark Plateau along the eastern edge of tornado alley. Due to its location, Morgan County is subject to severe thunderstorms, heavy rainfall, and tornadoes. Historical data reflects that Morgan County from 1950 to 2017 has experienced 25 tornado events. Morgan County has experienced two (2) F4 tornadoes, 1943 and 1880, one (1) F3, 1916, and the remaining have been an F0 to F2 within the Fujita scale.

Tornado events that occurred in 1954, 1982, 2003, and 2006 had several tornadoes touchdown within the county in a one to three day period. Morgan County was included in a Presidential Disaster Declaration in connection with the May 6, 2003, tornadoes.

Currently, there is no data showing that one jurisdiction was more vulnerable to a tornado event than another was. All the data collected only reflected that the county experienced a reported tornado.

**Figure 3.35. Tornado Alley in the U.S.**




Source: http://www.tornadochaser.net/tornalley.html

### *Potential Losses to Existing Development*

Potential loss of development remains high in Morgan County as tornadoes have the potential to demolish any type of structure in their path.

*Previous and Future Development*

With growing population and increased development, there is potential for increased losses because of the increase in exposure. But this will be dependent on where the severe thunderstorms occur which is a variable that cannot be predicted due to the random nature of this hazard.

***Hazard Summary by Jurisdiction***

Tornadoes can occur anywhere within Morgan County and have devastating impacts on personal property, agriculture, homes, and government buildings.

## Problem Statement

Morgan County can expect Tornadoes to damage structures throughout the entire planning area. There is inconsistent data concerning the costs associated with the historical information available. It is difficult to estimate the potential impact on both the number of structures and the cost of any given natural hazard, as they are completely unpredictable.

Tornado safe rooms have become a priority for many of our local school districts in the wake of the Joplin, Missouri tornadoes. While many of these projects are still in the design phase, both FEMA and SEMA have been instrumental in the funding of these projects. All the school districts have expressed an interest in building safety-related infrastructure, including safe rooms. All the communities have expressed interest in upgrading or installing additional early-warning equipment to cover more of the planning area.

The Springfield Office of the National Weather Service covers our planning area. Early-warning systems are established to help the public prepare for pending severe weather.

# 3.4.11 Wildfire

## Hazard Profile

***Hazard Description***

The incident types considered for urban/structural fire include all fires in the following categories: 1) general fires, 2) structure fire, 3) fire in mobile property used as a fixed structure, and 4) mobile property (vehicle) fire. The fire incident types for wildfires include: 1) natural vegetation fire, 2) outside rubbish fire, 3) special outside fire, and 4) cultivated vegetation, crop fire.

The Missouri Division of Fire Safety (MDFS) indicates that approximately 80 percent of the fire departments in Missouri are staffed with volunteers. Whether paid or volunteer, these departments are often limited by lack of resources and financial assistance. The impact of a fire to a single-story building in a small community may be as great as that of a larger fire to a multi-story building in a large city.

The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from wildfires. To accomplish this task, eight forestry regions have been established in Missouri for fire suppression. The Forestry Division works closely with volunteer fire departments and federal partners to assist with fire suppression activities. Currently, more than 900 rural fire departments in Missouri have mutual aid agreements with the Forestry Division to obtain assistance in wildfire protection if needed.

Most Missouri fires occur during the spring season between February and May. The length and severity of both structural and wildland fires depend largely on weather conditions. Spring in Missouri is usually characterized by low humidity and high winds. These conditions result in higher fire danger. In addition, due to the recent lack of moisture throughout many areas of the state, conditions are likely to increase the risk of wildfires. Drought conditions can also hamper firefighting efforts, as decreasing water supplies may not prove adequate for firefighting. It is common for rural residents to burn their garden spots, brush piles, and other areas in the spring. Some landowners also believe it is necessary to burn their forests in the spring to promote grass growth, kill ticks, and reduce brush. Therefore, spring months are the most dangerous for wildfires. The second most critical period of the year is fall. Depending on the weather conditions, a sizeable number of fires may occur between mid-October and late November.

MDC reported 1,203 fires from 2002 to 2017 with 53.53 percent of all these fires caused by humans. There were 43 arson fires (3.6 percent), six campfires (.5 percent), four fires started by children (.33 percent), 30 from discarding a cigarette, and 561 fires started by burning debris, which also includes trash. There were 53 fires that were started by equipment (4.5 percent) miscellaneous or unreported fires total 503 (41.8 percent). Only three fires (.25 percent) were caused by a natural cause, lightning. There were some 15,486.87 acres burned during this time period.

In 2012, Missouri wildfires were fueled by record high temperatures and drought persistent conditions, burning a significant number of acres. The leading causes of wildfires are mostly human caused. Carelessness and intent represent most of the fires that are started in Missouri. Escaping embers from campfires, uncontrolled private land burning, and inappropriately discarding cigarette butts are all contributing factors to Missouri's wildfires. Industrialized hazards, including equipment, trains, and power lines account for a small percentage of all fires.

***Geographic Location***

Absent demographic information indicating otherwise, the risk of structural fire probably does not vary widely across the planning area. However, damages due to wildfires would be higher in communities with more wildland–urban interface (WUI) areas. The term refers to the zone of transition between unoccupied land and human development and needs to be defined in the plan. Within the WUI, there are two specific areas identified: 1) Interface and 2) Intermix. The interface areas are those areas that abut wildland vegetation and the Intermix areas are those areas that intermingle with wildland areas. According to the University of Wisconsin Slivis Lab Map it does not appear that there is a community at high risk.

***Strength/Magnitude/Extent***

Structural and urban fires are a daily occurrence throughout the state. Statewide, approximately 100 fatalities occur annually, as well as numerous injuries affecting the lives of the victims, their families, and many others—especially those involved in fire and medical services. Unlike other disasters, structural fires can be caused by human criminal activity: arson. All citizens pay the costs of arson whether through increased insurance rates, higher costs to maintain fire and medical services, or the costs of supporting the criminal justice system.

Wildfires damage the environment, killing some plants and occasionally animals. Firefighters have been injured or killed, and structures can be damaged or destroyed. The loss of plants can heighten the risk of soil erosion and landslides. Although Missouri wildfires are not the size and intensity of those in the Western United States, they could affect recreation and tourism in and near the fires.

Wildland fires in Missouri have been mostly a result of human activity rather than lightning or some other natural event. Wildfires in Missouri are usually surface fires, burning the dead leaves on the ground or dried grasses. They do sometimes “torch” or “crown” out in certain dense evergreen stands like eastern red cedar and shortleaf pine. However, Missouri does not have the extensive stands of evergreens found in the western US that fuel the large firestorms seen on television news stories.

While very unusual, crown fires can and do occur in Missouri native hardwood forests during prolonged periods of drought combined with extreme heat, low relative humidity, and high wind. Tornadoes, high winds, wet snow, and ice storms in recent years have placed a large amount of woody material on the forest floor that causes wildfires to burn hotter and longer. These conditions also make it more difficult for fire fighters suppress fires safely.See ***http://www.firewisemissouri.org/wildfire-in-missouri.html***

Often wildfires in Missouri go unnoticed by the general public because the sensational fire behavior that captures the attention of television viewers is rare in the state. Yet, from the standpoint of destroying homes and other property, Missouri wildfires can be quite destructive.

### *Previous Occurrences*

### *Previous Occurrences Wildfires 2012-2022*

| **Damages from Wildfires in Morgan County 2003 – 2022** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Threatened** | | | **Damaged** | | | **Destroyed** | | |
| **County** | **Acres Burnt** | **R** | **O** | **C** | **R** | **O** | **C** | **R** | **O** | **C** |
| Morgan | 15,298.36 | 15 | 20 | 2 | 235 | 131 | 13 | 15 | 30 | 0 |
| **Key: R = Residential Buildings, O = Outbuildings, C = Commercial Buildings** | | | | | | | | | | |
| Source: http://mdc4.mdc.mo.gov/applications/FireReporting/Report.aspx | | | | | | | | | | |

### *Probability of Future Occurrence*

Based on the probability, severity, and vulnerability, fire has the probability of happening by 100 percent. Prevention is possible and education of the community is a real need in Morgan County, During the planning process two jurisdictions identified the need to communicate and be able to notify the community of the fire hazards based on the current weather conditions. 53.53 percent of all reported fires that were classified showed that humans were the main contributor to fires. The unclassified fires could also be human related but that is unknown at this time.

### *Changing Future Conditions Considerations*

Higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Missouri, although the composition of trees in the forests may change. More droughts would reduce forest productivity, and changing future conditions are also likely to increase the damage from insects and diseases. But longer growing seasons and increased carbon dioxide concentrations could more than offset the losses from those factors. Forests cover about one-third of the state, dominated by oak and hickory trees. As the climate changes, the abundance of pines in Missouri’s forests is likely to increase, while the population of hickory trees is likely to decrease 0.

Higher temperatures will also reduce the number of days prescribed burning can be performed. Reduction of prescribed burning will allow for growth of understory vegetation – providing fuel for destructive wildfires. Drought is also anticipated to increase in frequency and intensity during summer months under projected future scenarios. Drought can lead to dead or dying vegetation and landscaping material close to structures which creates fodder for wildfires within both the urban and rural settings.

## Vulnerability

### *Vulnerability Overview*

Areas that are heavily timbered and areas with dry crops have the highest potential for wildfires. Drought also plays a major role in wildfires as there is little to no moisture to stifle the fires.

### *Potential Losses to Existing Development*

Wildfires can have an enormous impact on existing structures that may be in the path of the wildfire. Little can be done to protect a structure that is made of flammable materials. There is limited data available on the costs associated with wildfires in Morgan County; therefore, it is hard to determine the potential impact on existing structures other than it can have a devastating impact about property damage that is unsalvageable.

### *Impact of Previous and Future Development*

The impact is mostly felt by the farmers and landowners, with only a total of five buildings being impacted. There is no indication of future development that would be at risk due to wildfires.

### *Hazard Summary by Jurisdiction*

The only differences in Jurisdictions would be the amount of agriculture an forested areas compared to the more urbanized areas that are less likely to be affected by wildfire.

## Problem Statement

***Mitigation:*** Operation Forest Arson is a toll-free hotline that allows concerned citizens to call in anonymously and report arson related fires and any information that may be available on any suspected arson. (800) 392-1111

Morgan County collaborates with local fire departments, fire protection districts, and community groups to conduct special public education events, such as Fire Safety and Awareness Day.

Public awareness of burn bans is particularly important when unsafe burn conditions exist. Morgan County works with local fire departments, fire protection districts, and local media to create public service announcements that reflect burn ban restrictions. Ozarks First.Com also provides and updated listing on all Burn Bans in the Ozarks.
Source http://www.ozarksfirst.com/news/updated-list-burn-bans-in-the-ozarks/66982600