2

Hazard Identification and Statewide Risk Assessment

This chapter focuses on the following elements of the FEMA State Mitigation Plan Review Guide (2022)

Does the risk assessment provide an overview of the probabilities of future hazard events?
[44CFR §201.4(c)(2)(i)]

Does the risk assessment address the vulnerability of state assets located in hazard areas and estimate the potential dollar losses to these assets?
[44 CFR §§201.4(c)(2)(ii) and 201.4(c)(2)(iii)]

Does the risk assessment include an overview and analysis of the vulnerability of jurisdictions to the identified hazards and the potential losses?
[44 CFR §§201.4(c)(2)(ii) and 201.4(c)(2)(iii)]

Was the risk assessment revised to reflect changes in development?
[44 CFR §201.4(d)]

To answer these questions, the FEMA State Mitigation Plan Review Guide requires:

- The risk assessment must provide an overview of the probability of future hazard events that includes projected changes in the location, range of anticipated intensities, frequency, and/or duration of each natural hazard.
- Probability must include considerations of changing future conditions, including climate change (e.g., long-term weather patterns, average temperature, and sea levels) on the type, location, and range of anticipated intensities of identified hazards.
- The risk assessment must include an overview and analysis of the vulnerability to state assets from the identified hazards and a summary of the most vulnerable assets. These assets may be located in the identified hazard areas and could be affected by future hazard events. State assets include state-owned or operated critical facilities, buildings, infrastructure, and community lifelines.

» The risk assessment must estimate potential dollar losses to state assets located in identified hazard areas.

» The risk assessment must provide an overview and analysis of vulnerable jurisdictions based on the state and local government risk assessments. Vulnerability must be analyzed in terms of:

  ◊ Jurisdictions most threatened by the identified hazards based on type, location, range of anticipated intensities, and probability. Probability must include the potential impacts of climate change.

  ◊ Jurisdictions most vulnerable to damage and loss from hazard events with respect to potential impacts to:

    - Populations, including socially vulnerable and underserved communities.
    - Structures, including critical facilities.
    - Infrastructure and community lifelines servicing jurisdictions that could affect state resilience, including Safety and Security; Food, Water, Shelter; Health and Medical; Energy; Communications; Transportation; and Hazardous Material lifelines.

» The risk assessment must include an overview and analysis of the potential losses to the identified vulnerable structures based on estimates in the local and state risk assessments.

» If the state is interested in HHPD funding eligibility, the risk assessment must address risks from high hazard potential dams in the risk assessment.

» The plan must provide a summary of recent development and potential or projected development in hazard-prone areas based on state and local government risk assessments including, but not limited to the following:

  ◊ Changes in land use and the built environment and projected future growth or re-development of areas.

  ◊ Changes in population demographics that may affect vulnerability to hazard events, including socially vulnerable and underserved communities.

  ◊ Changes to the vulnerability of state assets.

  ◊ Changes in development that could impact jurisdictions most threatened by the identified hazards based on local risk assessments, including the potential impacts of climate change.

Hazards Summary

This chapter provides details about the natural hazards that Louisiana currently encounters and anticipates encountering in the future. To assess the potential consequences of these natural hazards in 2050, a planning period of 26 years has been chosen.

The following table summarizes the information presented in this section across Louisiana. Greater detail is found in this chapter and the Technical Appendix, including maps showing historic and future hazard probabilities and locations of projected losses. Loss values represent the projected average annual statewide loss in 2050.

Extreme Heat

HISTORY: 1 to 43 days per year(on average) with temperatures exceeding 95°F
PROJECTED CHANGE BY 2050: +20% days over 95°F
PROJECTED HAZARD IN 2050: Up to 52 days per year (on average) with temperatures exceeding 95°F
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$1,000,000***

Drought

HISTORY: 0 to 31% weekly probability
PROJECTED CHANGE BY 2050: +25% probability of occurrence
PROJECTED HAZARD IN 2050: Up to 40% weekly probability of drought
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$54,000,000***

Wildfire

HISTORY: 0% to 11.3% annual burn probability
PROJECTED CHANGE BY 2050: +25% probability of occurrence
PROJECTED HAZARD IN 2050: 0% to 14.1% annual burn probability
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$30,000,000***

Extreme Cold

HISTORY: 1 to 56 days per year (on average) with temperatures less than 32°F
PROJECTED CHANGE BY 2050: -20% days under 32°F
PROJECTED HAZARD IN 2050: 1 to 44 days per year (on average) with temperatures less than 32°F
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$15,000,000***

High Wind

HISTORY: 700-year return period (0.14% annual probability) wind speeds ranging from 105 mph to 170 mph
PROJECTED CHANGE BY 2050: No projected change
PROJECTED HAZARD IN 2050: 700-year return period (0.14% annual probability) wind speeds ranging from 105 mph to 170 mph
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$1,241,000,000***

Hailstorms

HISTORY: 0 to 9 days per year (on average) experiencing hail ≥ 0.75 inches in diameter
PROJECTED CHANGE BY 2050: -10% days with hail
PROJECTED HAZARD IN 2050: 0 to 8 days per year (on average) experiencing hail ≥ 0.75 inches in diameter
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$4,000,000***

Lightning

HISTORY: 9 to 24 lightning flashes per square mile per year
PROJECTED CHANGE BY 2050: +10% increase in flash intensity
PROJECTED HAZARD IN 2050: 10 to 26 lightning flashes per square mile per year
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$54,000,000***

Tornadoes

HISTORY: 0 to 2.1 tornado touchdown days within 25 miles per year
PROJECTED CHANGE BY 2050: +10% probability of occurrence
PROJECTED HAZARD IN 2050: 0 to 2.3 tornado touchdown days within 25 miles per year
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$30,000,000***

Flooding

HISTORY: 65% of Louisiana's land area and 25% of population and structures are in the special flood hazard area (SHFA)
PROJECTED CHANGE BY 2050: No projected change
PROJECTED HAZARD IN 2050: 65% of Louisiana's land area and 25% of population and structures are in the special flood hazard area (SHFA)
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$3,632,000,000***

Dam Failure

HISTORY: One threatened out-of-state dam failure
PROJECTED CHANGE BY 2050: No projected change
PROJECTED HAZARD IN 2050: 0.01% annual probability of failure
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***DUE TO THE LOW PROBABILITY OF DAM FAILURE IN LOUISIANA, LOSSES WERE NOT ESTIMATED***

Levee Failure

HISTORY: Failures during 2005 Hurricane Katrina in New Orleans (0.3% annual probability)
PROJECTED CHANGE BY 2050: No projected change
PROJECTED HAZARD IN 2050: 0.3% annual probability
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***DUE TO THE LOW PROBABILITY OF LEVEE FAILURE IN LOUISIANA, LOSSES WERE NOT ESTIMATED***

Earthquake

HISTORY: 8 minor earthquakes in past 25 years (20% annual probability statewide)
PROJECTED CHANGE BY 2050: No projected change
PROJECTED HAZARD IN 2050: 20% annual probability statewide
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$12,000,000***

Sinkholes

HISTORY: 2 sinkholes in 52 years from 153 terrestrial salt domes (0.025% annual probability)
PROJECTED CHANGE BY 2050: +50% probability of occurrence
PROJECTED HAZARD IN 2050: 0.05% annual probability
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$1,000,000***

Expansive Soil

HISTORY: Soil swelling potential ranging from 3.5% to 58%
PROJECTED CHANGE BY 2050: +15% of soil swelling potential
PROJECTED HAZARD IN 2050: Soil swelling potential ranging from 4% to 66.7%
PROJECTED 2050 AVERAGE ANNUAL STATEWIDE LOSS: ***$96,000,000***

Risk Assessment Summary

The statewide annual average loss for each hazard is shown below and summed up for the state. Parish level loss estimates are provided in the Technical Appendix.

Projected Average Annual Loss in 2050	Building Average Annual Loss	Crop Average Annual Loss	Total Average Annual Loss
Extreme Heat	-	$1,000,000	$1,000,000
Drought	-	$54,000,000	$54,000,000
Wildfire	$30,000,000	-	$30,000,000
Extreme Cold	$13,000,000	$2,000,000	$15,000,000
Wind	$1,241,000,000	-	$1,241,000
Hail	$4,000,000	$200,000	$4,000,000
Lightning	$4,000,000	$5,000	$4,000,000
Tornado	$30,000,000	$400,000	$30,000,000
Flood	$3,632,000,000	-	$3,632,000,000
Earthquake	$12,000,000	-	$12,000,000
Sinkhole	$1,000,000	-	$1,000,000
Expansive Soil	$96,000,000	-	$96,000,000
Total Average Annual Projected Loss	**$5,064,000,000**	**$57,000,000**	

The most vulnerable jurisdictions for each of the hazards are shown visually on maps included in each hazard section. The top five jurisdictions most susceptible to damage and loss from each of the identified hazards are listed in the following table, with "1" being the most susceptible. A complete loss estimate table for each hazard by parish is provided in the Technical Appendix.

	1	2	3	4	5
Extreme Heat	St. James	Caldwell	Franklin	East Carroll	Tensas
Drought	Caddo	Vermilion	Avoyelles	St. Landry	Assumption
Wildfire	St. Tammany	Tangipahoa	Livingston	Calcasieu	East Baton Roughe
Extreme Cold	Caddo	St. Tammany	Livingston	Ascension	Lafayette
Wind	Jefferson	Orleans	St. Tammany	Terrebonne	Lafayette
Hail	Jefferson	Calcasieu	St. Tammany	Bossier	Caddo
Lighning	Livingston	Bossier	East Baton Rouge	Lafayette	St. Martin
Tornado	Bossier	Ouachita	Lincoln	Lafayette	Caddo
Flood	St. Tammany	Terrebonne	Lafayette	St. Mary	Jefferson
Sinkhole	St. Mary	St. Martin	Calcasieu	Acadia	Plaquemines
Expansive Soil	Orleans	Jefferson	East Baton Rouge	St. Tammany	Ascension
Earthquake	Ouachita	East Baton Rouge	Caddo	Bossier	St. Tammany
Total Losses	St. Tammany	Terrebonne	Lafayette	Jefferson	St. Mary

State Asset Risk Assessment Summary

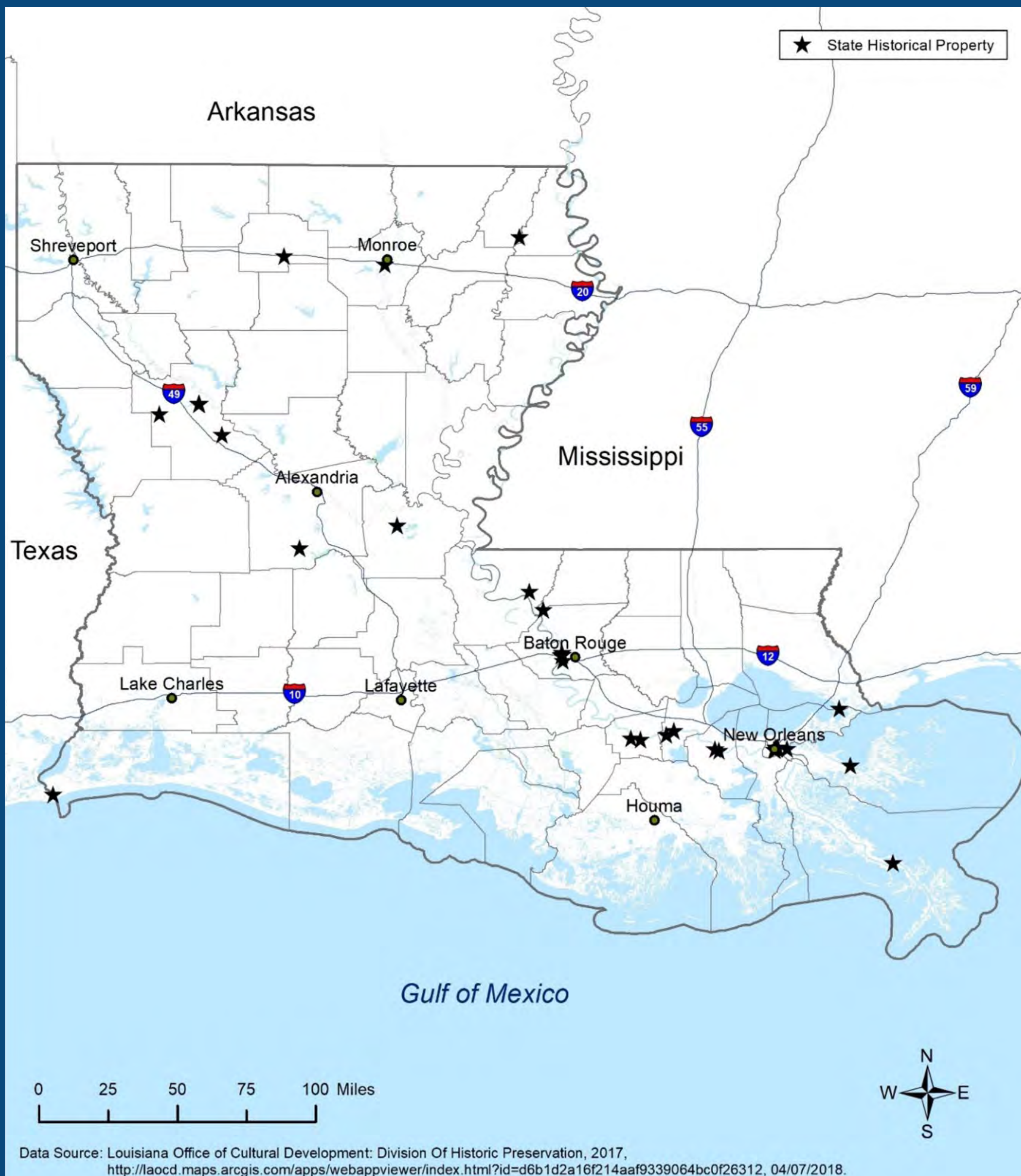
Data from the Louisiana Office of Risk Management show 8,783 state buildings with a total building and contents replacement value of approximately $15.2 billion. In addition to state-owned assets, several historic properties of particular importance are identified. The potential average annual dollar losses for state assets are shown by hazard. A complete loss estimate table for state assets for each hazard by parish is provided in the Technical Appendix. Hazard exposure data are provided for the historic structures in the Technical Appendix.

HAZARD	Projected 2050 Average Annual State Asset Losses
Wildfire Property Loss	$533,438
Extreme Cold Property Loss	$225,656
Wind Property Loss	$15,062,040
Hail Property Loss	$42,060
Lightning Property Loss	$33,865
Tornado Property Loss	$675,481
Flood Property Loss	$51,200,805
Earthquake Property Loss	$249,468
Sinkhole Property Loss	$11,423
Expansive Soil Property Loss	$1,195,379

State Building Locations in Louisiana, 2023

Data Source: Data Source: Louisiana Office of Risk Management, 08/02/2023.

State Historic Preservation Office (SHPO) Properties Location in Louisiana, 2017



CHANGES IN DEVELOPMENT

Parish-level population

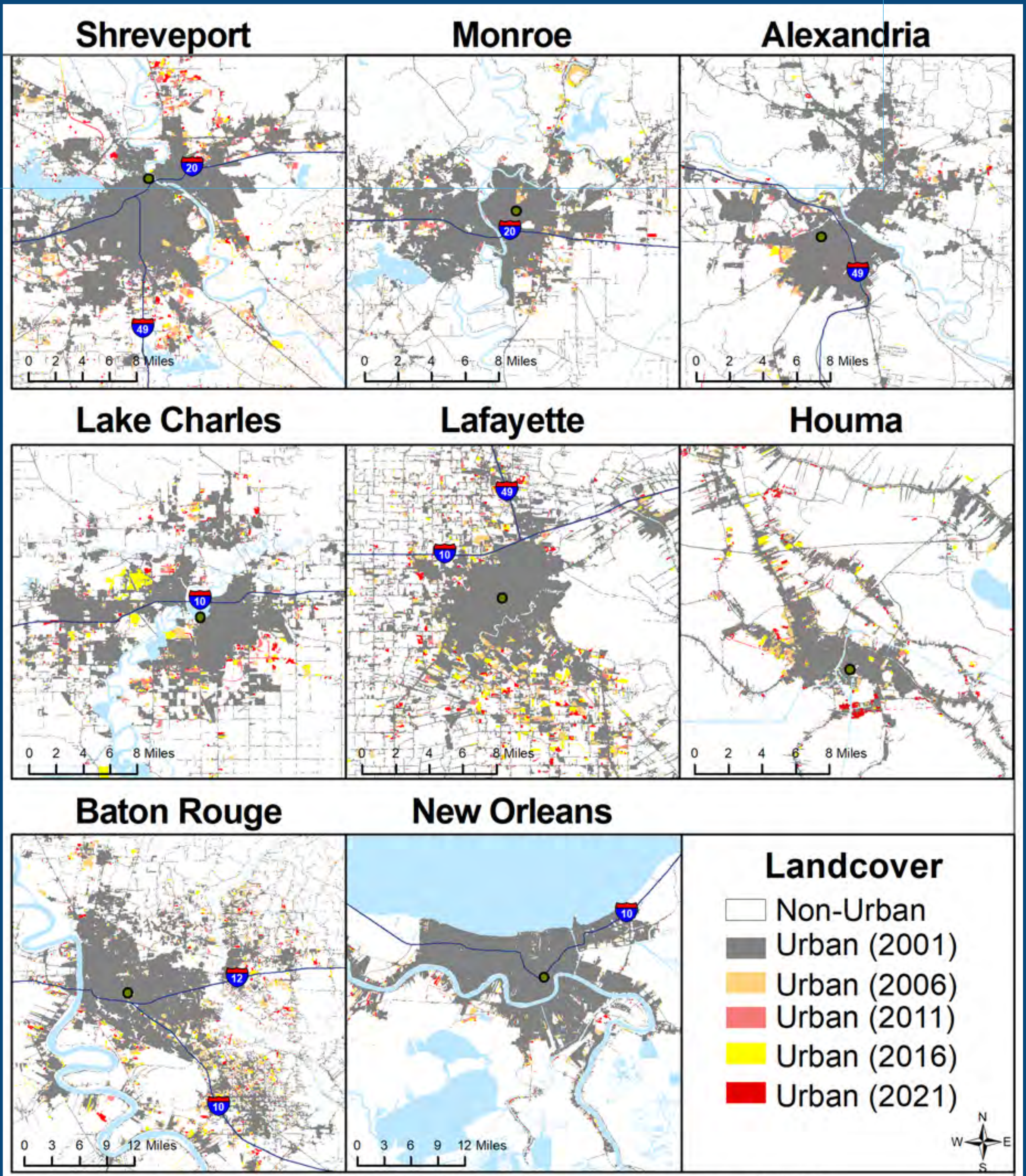
Based on land cover data for the state and major urban areas, recent urban growth in previously rural locations was limited, with most of the urban areas established in Louisiana by 2001. Recent development primarily occurred in outlying metropolitan areas of Shreveport, Monroe, Alexandria, Lake Charles, Lafayette, Houma, Baton Rouge, and New Orleans. The population of Louisiana was 4,657,757 in the 2020 census and is projected to grow by 14.36% to 5,326,484 by 2050. Due to data limitations, loss projections are based on densification of currently populated areas. Additional analysis of development patterns and areas is recommended prior to the next plan update in order to forecast future populations and development more accurately.

Vulnerable populations

The rates of growth of vulnerable populations were determined based on American Community Survey (ACS) 5-year estimates for population age, disability, poverty status, and mobile homes from 2012 to 2021. These demographic variables may not be all-inclusive indicators of vulnerability. For instance, proximity to the coast may enhance (through exposure to the hurricane hazard) or reduce (through economic opportunity) vulnerability. It is assumed here that the demographic variables listed above represent the outcome of whether proximity to the coast is a net vulnerability or an opportunity at the individual level. The parishes with the highest sum of vulnerable population growth rates, indicating a greater likelihood of future increase in demographic vulnerability, are St. Bernard, Plaquemines, Ascension, St. Tammany, West Baton Rouge, and Richland parishes. A full listing of changes in vulnerable populations is provided in the Technical Appendix.

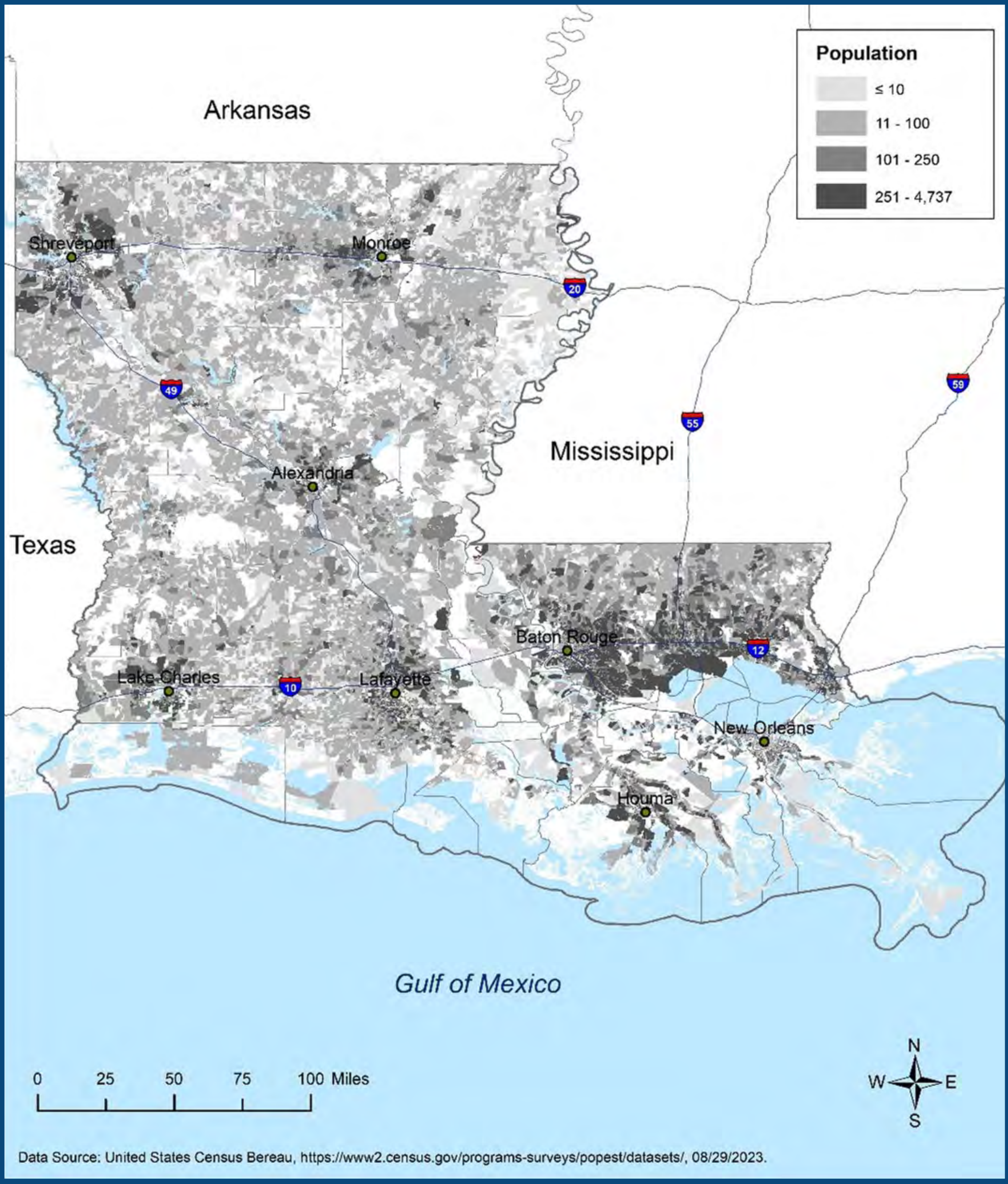
Urban Landcover Change in Louisiana 2001-2021

Urban Landcover Change in Louisiana 2001-2021



Data Source: National Land Cover Database (NLCD) 2001; 2006; 2011; 2016; 2021. https://www.mrlc.gov/index.php,11/19/2023.

Projected Population Distribution by Census Block, 2050

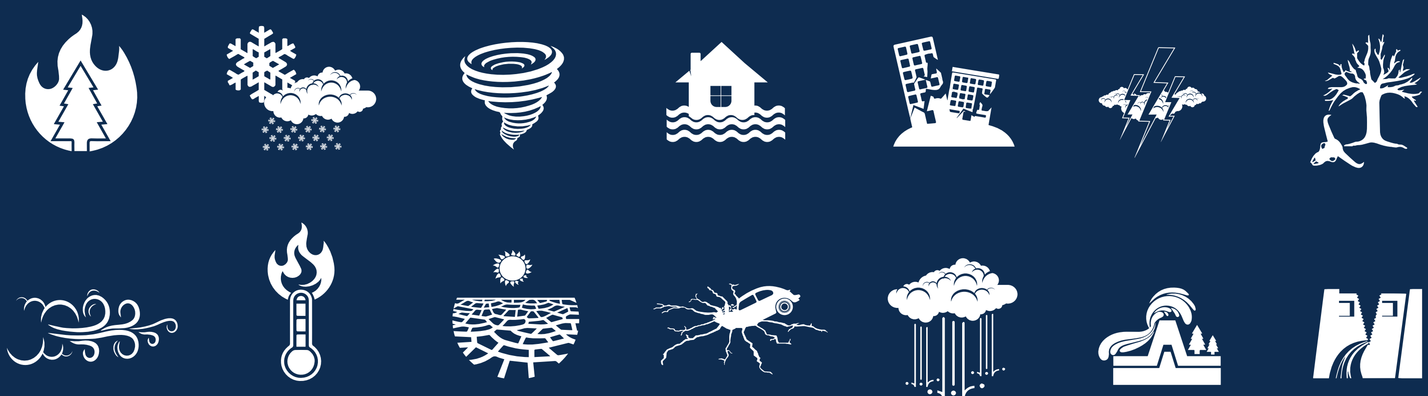


RISK ASSESSMENT ORGANIZATION

The following sections depict the locations of historical hazards using maps created through analysis of previous occurrences. These data and maps were analyzed to determine annual probability of occurrence or number of days per year for each hazard where appropriate. Anticipated hazard maps, reflecting hazard conditions in the year 2050, were developed using the historical data and evaluation of future conditions, which are described in the Technical Appendix for each hazard. The 2050 hazard maps are used in the risk assessment for each hazard to estimate the annual losses expected to occur in Louisiana 26 years from now.

TEMPERATURE HAZARDS

Hazards in Louisiana related to temperature include extreme heat, drought, wildfire, and extreme cold. The following sections contain a discussion of each of these hazards as well as a risk assessment.



EXTREME HEAT

Overview

Although all of Louisiana is vulnerable to extreme heat, summer temperatures can often exceed 100°F in the northern parishes, particularly during dry spells when clear skies allow increased solar radiation to reach the surface. Afternoon highs in the north have occasionally reached 110°F, with an all-time extreme of 114°F recorded in Plain Dealing (Bossier Parish) on August 10, 1936, during the 1936 North American Heat Wave. A more recent occurrence of extreme heat hazards is the August 2007 Heatwave, affecting Lake Charles, Lafayette, New Iberia, and Alexandria, setting new record high temperatures of between 101°F and 103°F.

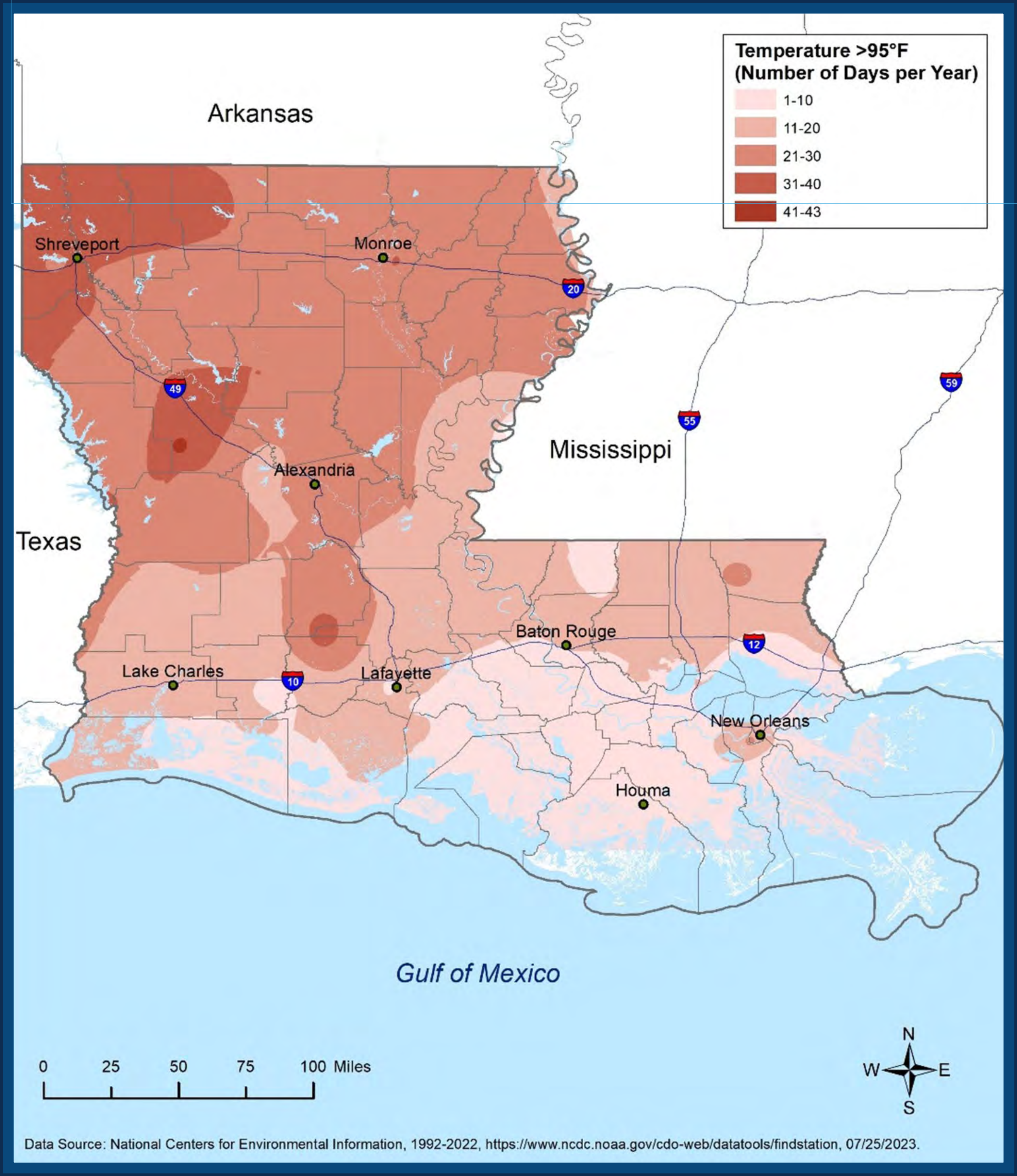
Northwest Louisiana, which includes Shreveport, experienced more than 25 days of maximum temperatures over 95°F in each of several months (June, July, and August) in 2011. Likewise, July 2016 had 25 days of these extreme temperatures, and 25 and 23 such extreme temperature days occurred in 2018 (July and August, respectively). According to the Louisiana Department of Health, 25 people died due to heat-related illness during the summer of 2023, with New Orleans experiencing its hottest summer on record.

The following map shows the historic number of days with temperatures exceeding 95°F. Most studies on the topic focus on the number of days with temperatures exceeding 95°F. The 2050 temperature map showing the number of days with temperatures exceeding 95°F considers the projected increases in the intensity of extreme heat hazards we could expect to see in the year 2050. This probability map is used in the extreme heat risk assessment.

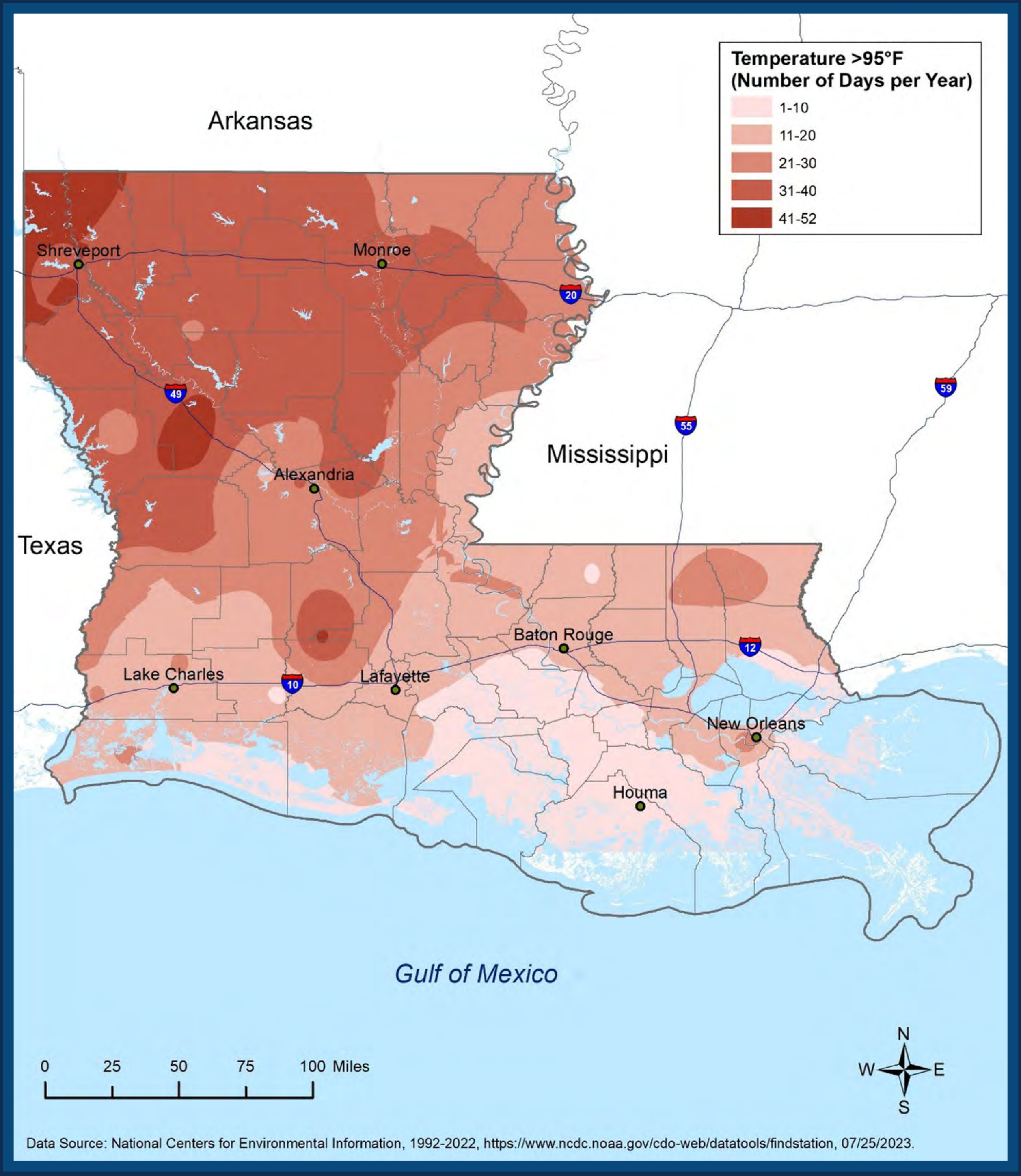
RISK ASSESSMENT

The projected crop loss map shows anticipated annual average losses due to extreme heat hazards by census block. Extreme heat has not historically caused direct property losses.

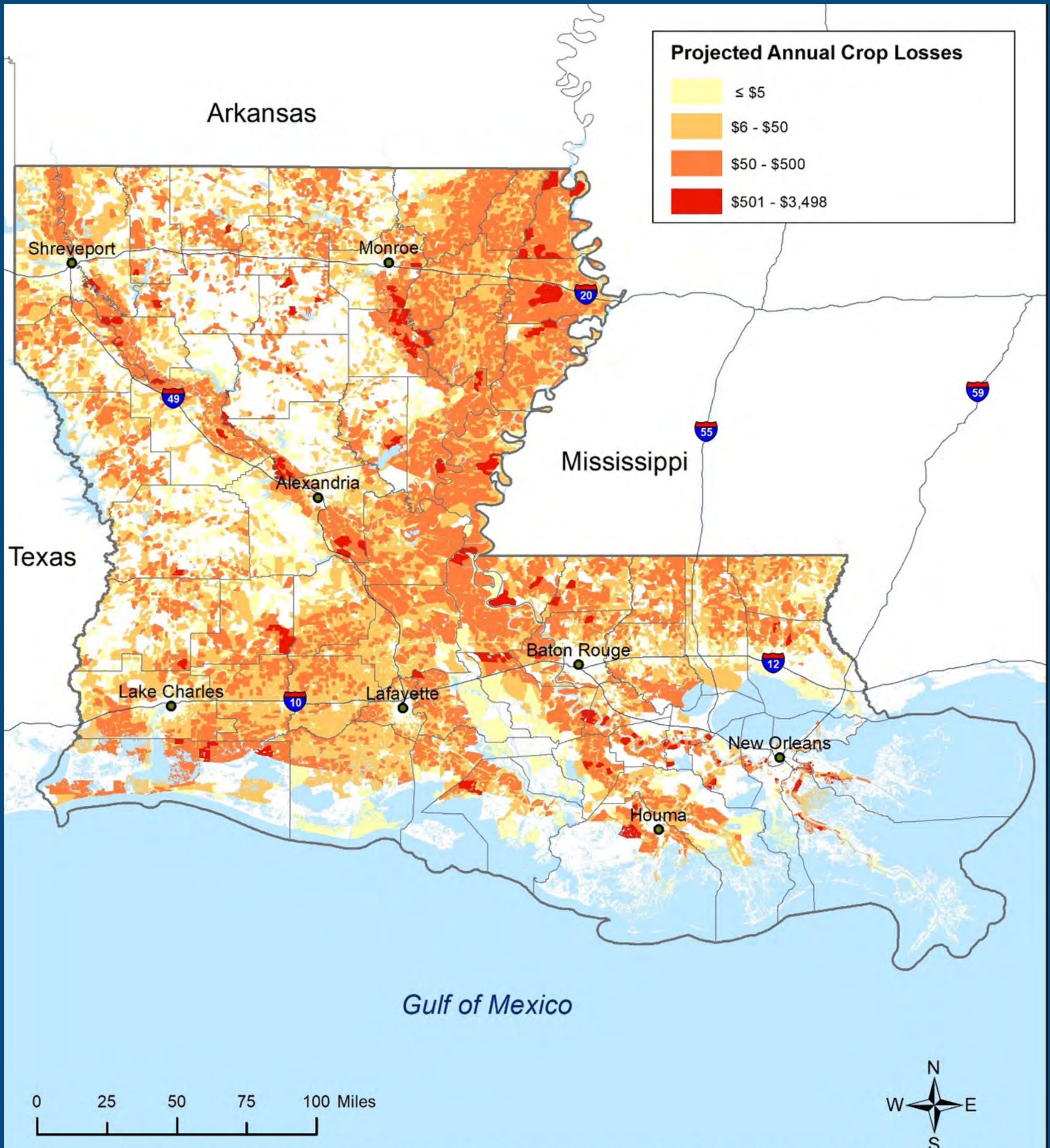
Number of Days per Year with Temperature Above 95F, 1992-2022



Projected Number of Days per Year with Temperature Above 95F, 2050



Projected Annual Crop Losses from Extreme Heat by Census Block, 2050



Data Sources: Spatial Hazard Events and Losses Database for the United States (SHELDUS), 1960-2021, https://cemhs.asu.edu/sheldus, 08/26/2023.
National Centers for Environmental Information, 1992-2022, https://www.ncdc.noaa.gov/cdo-web/datatools/findstation, 07/25/2023.
National Land Cover Database (NLCD), 2001-2021, https://www.mrlc.gov/index.php, 08/26/2023.

DROUGHT

Overview

A drought is a deficiency in water availability over an extended period of time, caused by precipitation totals and soil water storages that do not satisfy the environmental demand for water, either by evaporation or transpiration through plant leaves. It is important to note that the lack of precipitation alone does not constitute drought; the season during which the precipitation is lacking has a major impact on whether drought occurs. For example, a week of no precipitation in July, when the solar energy to evaporate water and vegetation's need for water to carry on photosynthesis are both high, may trigger a drought, while a week of no precipitation in January may not initiate a drought. The driest year on record in Louisiana occurred in 1963. The second driest year on record was 2011, with parts of southeast Louisiana in extreme drought status.

Although Louisiana features several large bodies of water, thousands of miles of rivers, streams, and bayous, and is home to thousands of acres of wetlands, the state has experienced occasional drought conditions. Significant periods of drier-than-average conditions include the mid-1890s through the mid-1900s, the 1950s, the 1960s through the early 1970s, the early 2000s and early 2010s, and late 2022.

Louisiana experienced a severe drought in 2023, with 99.9% of the state in moderate (D1) drought or worse, and 90% of the state in extreme (D3) drought or worse.
This drought impacted the agricultural sector significantly, with record heat and exceptional drought affecting every major crop in the state. The U.S. Drought Monitor also reported that Louisiana faced its most widespread drought in 23 years.

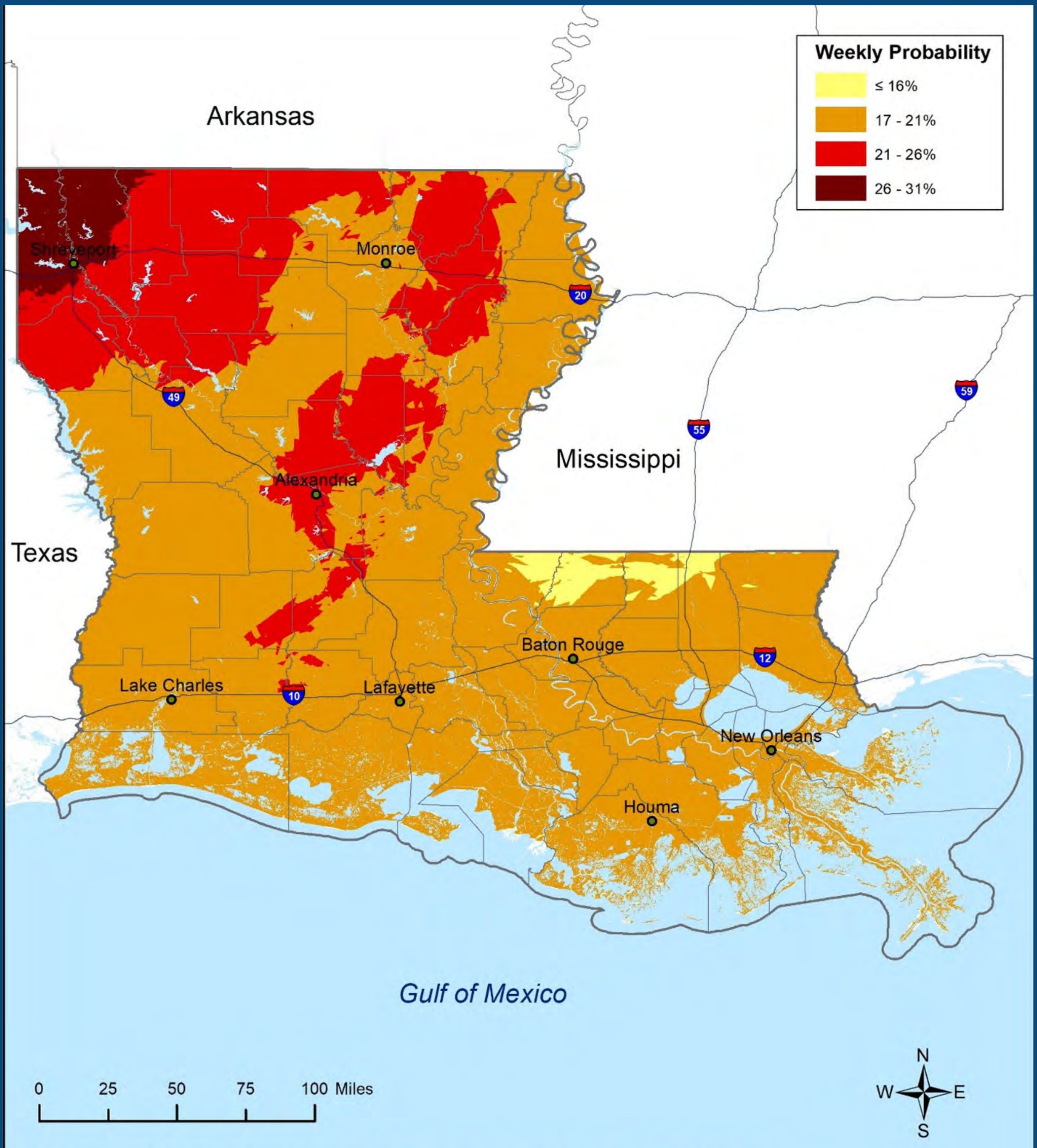
Drought is a unique and insidious hazard. Unlike other natural hazards, no specific, standard threshold of "dryness" exists for declaring a drought. In addition, the definition of drought depends on stakeholder needs. For instance, the onset (and demise) of agricultural drought is quick, as crops need water every few days; once they get rainfall, they improve. But hydrologic drought sets in (and is alleviated) only over longer time periods. A few dry days will not drain a reservoir, but a few rain showers cannot replenish it, either. Moreover, different geographical regions define drought differently based on the deviation from local, normal precipitation. And drought can occur anywhere, triggered by changes in the local-to-regional-scale atmospheric circulation over an area or by broader-scale circulation variations such as the expansion of semi-permanent oceanic high-pressure systems or the stalling of an upper-level atmospheric ridge in place over a region. The severity of a drought depends upon the degree and duration of moisture deficiency, and the size of the affected area. Periods of drought tend to be associated with other hazards such as wildfires and/or heat waves as well. Drought is a slow onset event, causing less direct—but tremendous indirect—damage. Depletion of aquifers, crop loss, and livestock and wildlife mortality rates are examples of direct impacts.

The 2000-2022 weekly drought probability map shows areas that have historically been affected by drought, while the 2050 probability map considers projected increases in the probability of drought that we could expect to see in the year 2050. This probability map is used in the drought risk assessment. A discussion of potential factors that contribute to the increased probability appears in the Technical Appendix (Future Conditions: Drought and Wildfire).

RISK ASSESSMENT

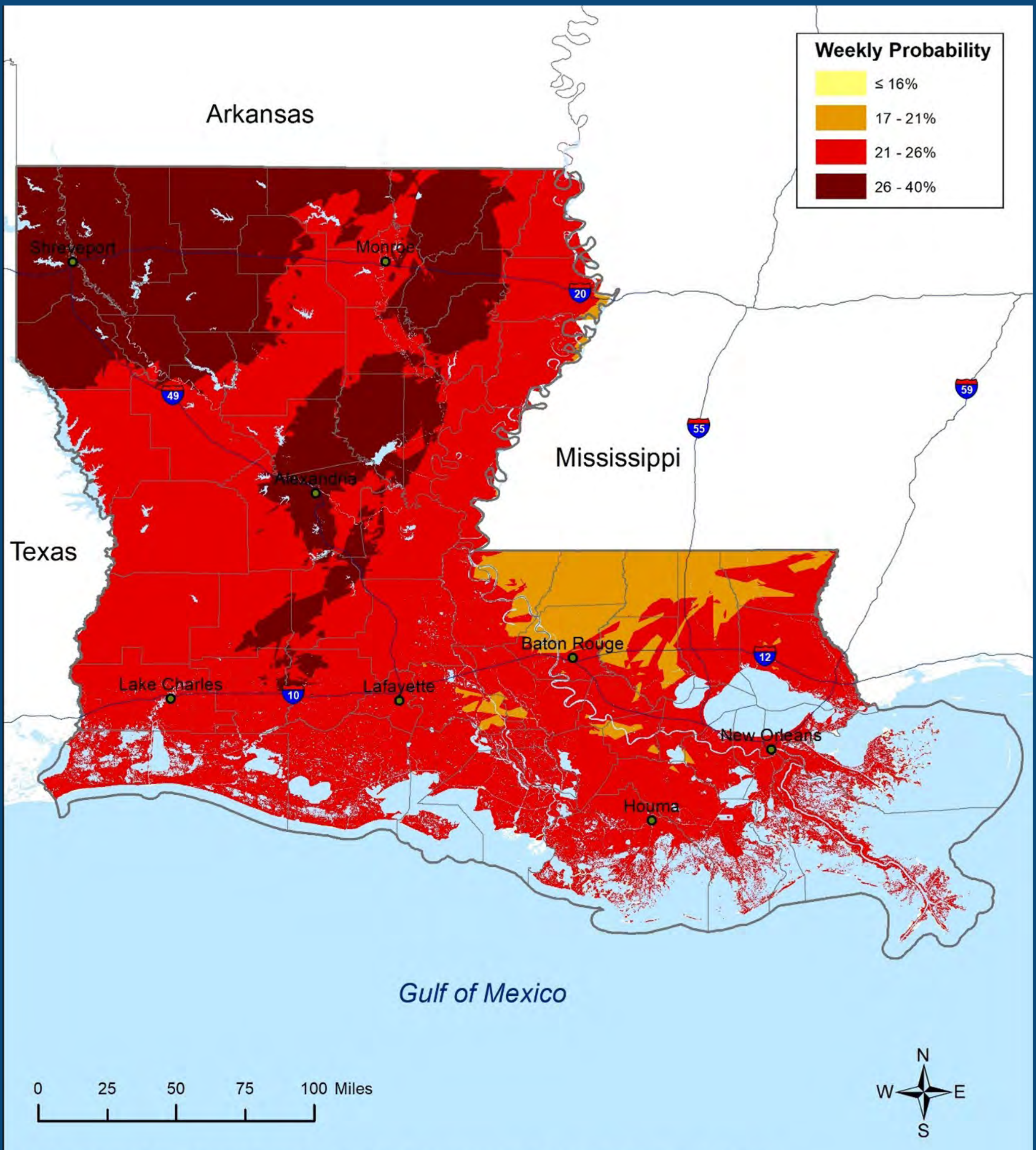
The projected crop loss map shows anticipated annual average loss due to drought hazards by census block.

Weekly Probability of Drought in Louisiana, 2000-2022



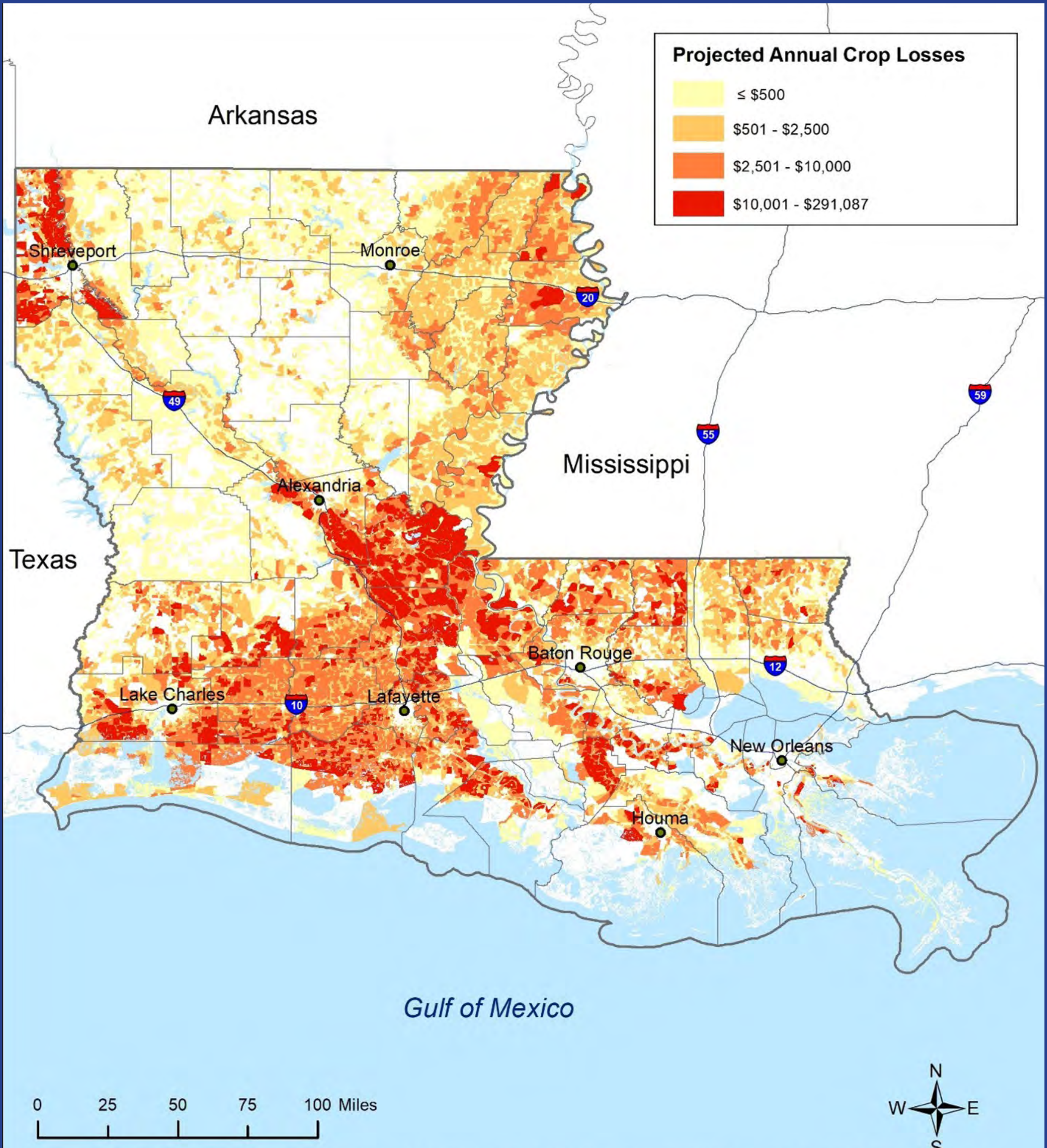
Data Source: United States Drought Monitor, 2000-2022, http://droughtmonitor.unl.edu/Data/GISData.aspx, 07/25/2023.

Projected Weekly Drought Probability in Louisiana, 2050



Data Source: United States Drought Monitor, 2000-2022, http://droughtmonitor.unl.edu/Data/GISData.aspx, 07/25/2023.

Projected Annual Crop Losses from Drought by Census Block, 2050



Data Sources: Spatial Hazard Events and Losses Database for the United States (SHELDUS), 1960-2021, https://cemhs.asu.edu/sheldus, 08/26/2023.
United States Drought Monitor, 2000-2022, http://droughtmonitor.unl.edu/Data/GISData.aspx, 07/25/2023.
National Land Cover Database (NLCD), 2001-2021, https://www.mrlc.gov/index.php, 08/26/2023.

WILDFIRE

Overview

Wildfire is combustion in a natural setting, marked by flames or intense heat. According to the State of Louisiana Forestry Division, most forest fires in Louisiana are caused by intentional acts (arson) or carelessness and negligence committed by people, exacerbated by human confrontation with nature. The wildland–urban interface (WUI) is the area in which development meets wildland vegetation, where both vegetation and the built environment provide fuel for fires. As development near wildland settings continues, more people and property are exposed to wildfire danger.

Wildfires are common in Louisiana. In contrast with much of the U.S., Louisiana wildfires tend to be small, averaging 10 acres in size. Data from the Louisiana Department of Agriculture and Forestry show that between 2007-2017, there have been more than 15,000 wildfires, burning nearly 160,000 acres. On average, 3% of residences threatened by fires are damaged while 97% are protected. The year 2011 was the most active fire year between 2007-2017, with 2,888 fire events and 76 damaged structures. This same year, 2,764 residences were threatened by fire but protected from damage. Without the effort and dedication of Office of Forestry personnel, the loss from wildfire could be catastrophic.

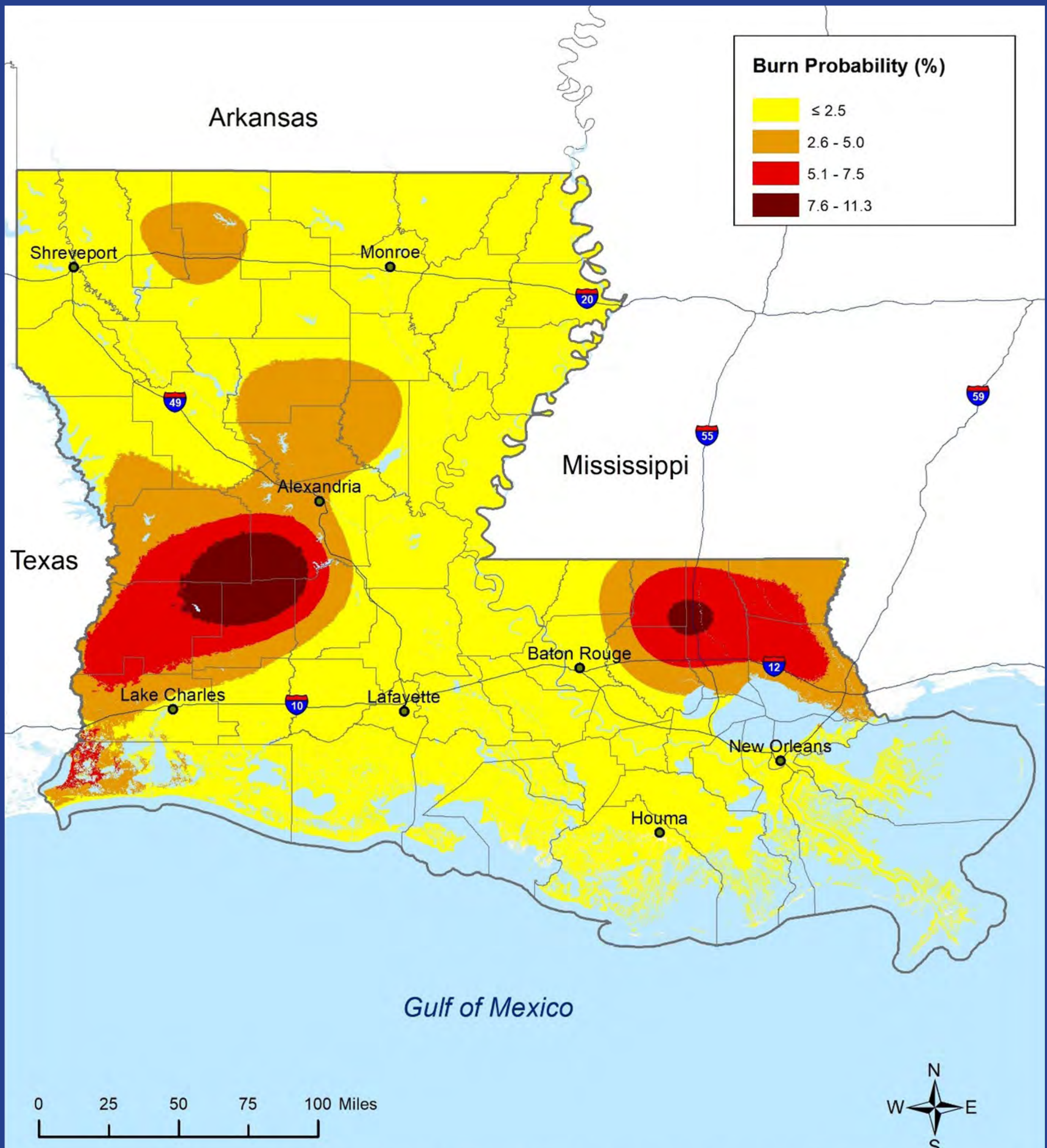
Between August and October 2023, wildfires in Louisiana ravaged over 60,000 acres (94 square miles), leading to evacuations in various towns, including Merryville and Singer. Starting on August 22, a total of 441 wildfires were active in 17 parishes, resulting in the destruction of at least 21 buildings. In response, the Federal Emergency Management Agency (FEMA) approved an assistance grant for Beauregard Parish, Louisiana. Approximately 100 Louisiana National Guard troops were placed on standby, and significant efforts were made to contain multiple wildfires. The Tiger Island fire in Beauregard Parish stands as the largest recorded wildfire in the state, consuming over 50,000 acres (about twice the area of Manhattan).

For the current plan, the 1992-2022 annual wildfire probability map was derived from previous wildfire occurrences, while the 2050 probability map considers projected increases in the probability of wildfire hazards we could expect to see in the year 2050. This probability map is used in the wildfire risk assessment. Of course, some of these wildfire-vulnerable lands are private and others are under the jurisdiction of the U.S. Forest Service.

RISK ASSESSMENT

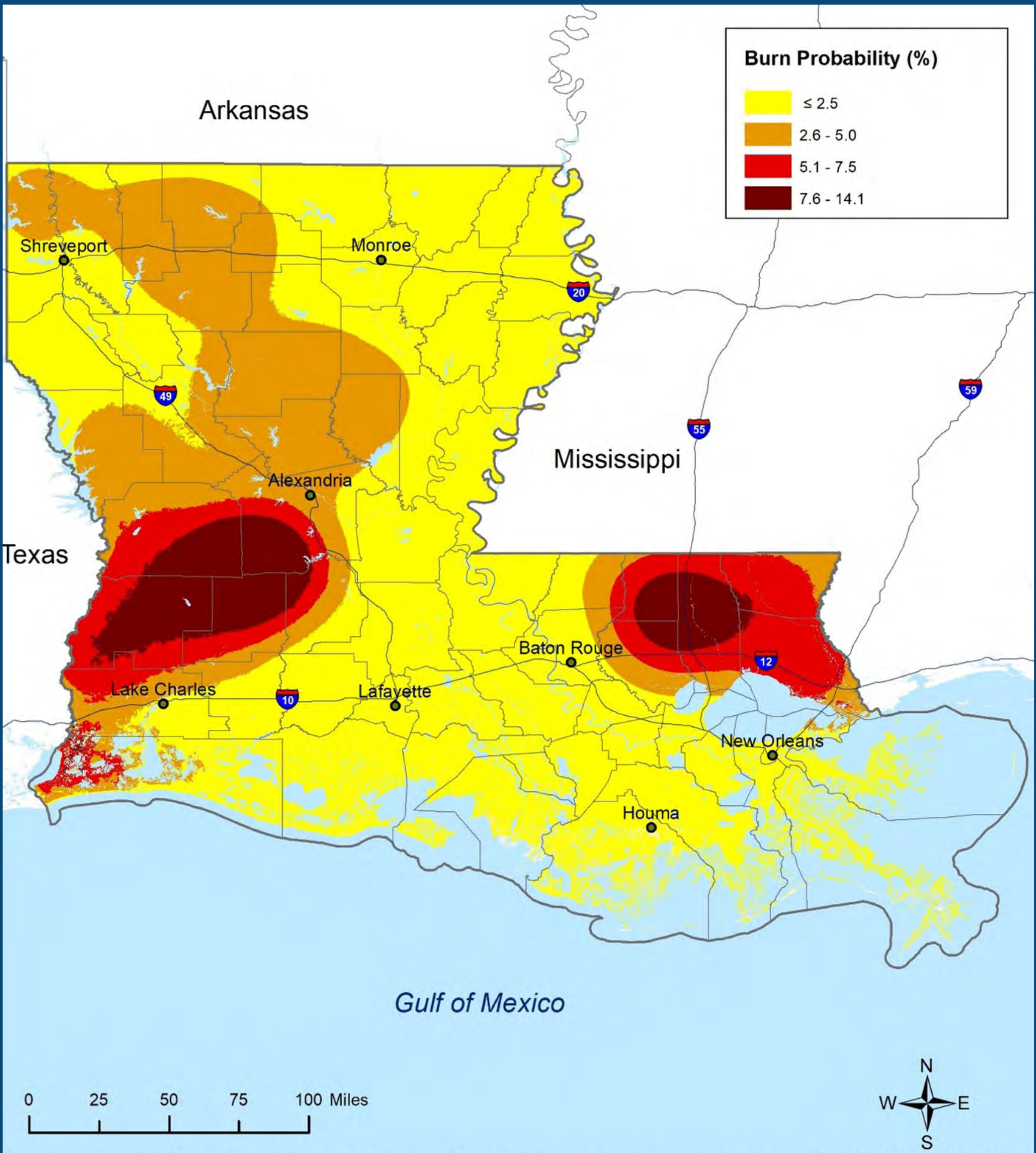
Projected property and crop loss maps show anticipated annual average losses due to wildfire hazards by census block.

Annual Probability of Wildfire in Louisiana, 1992-2020



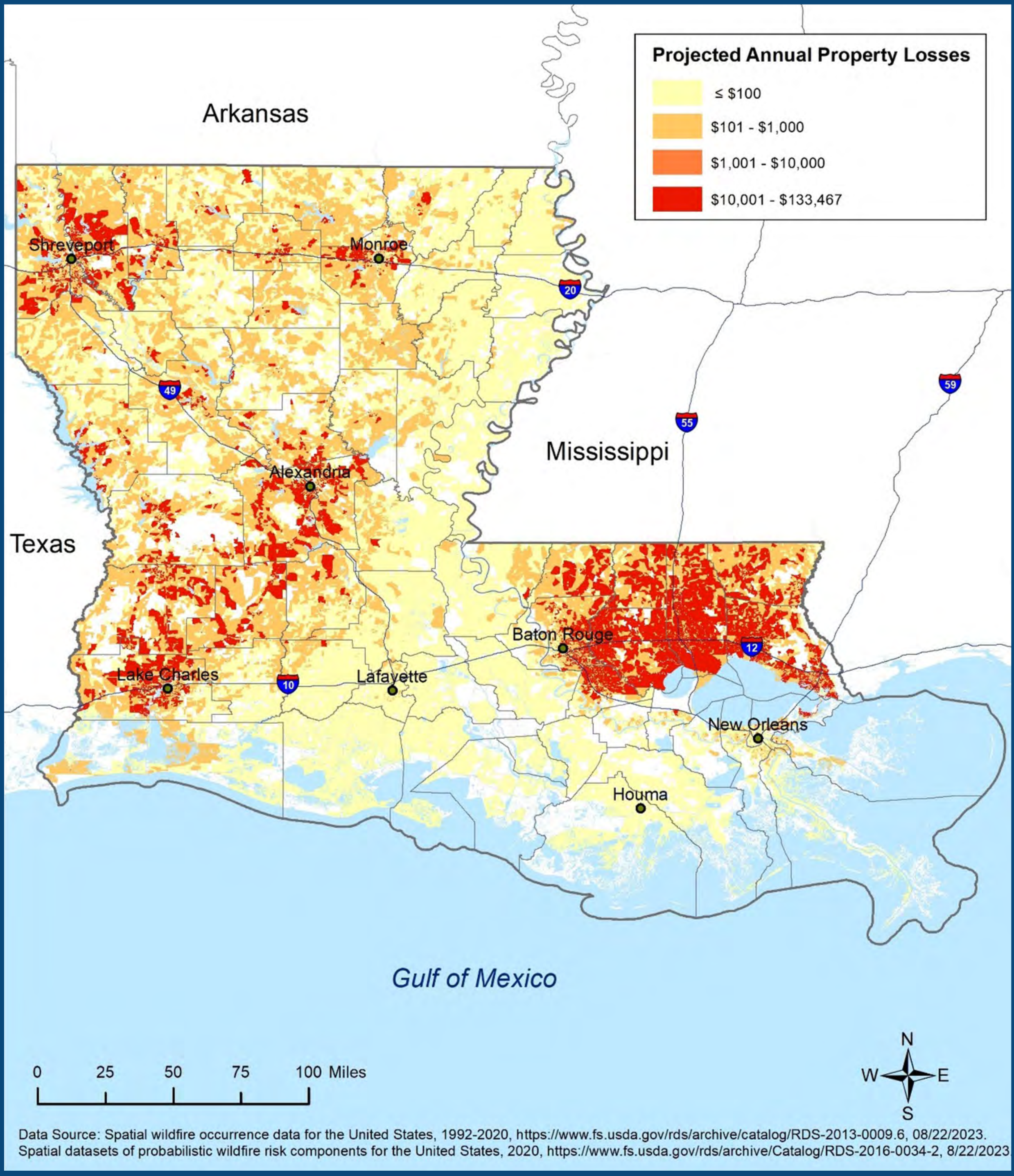
Data Source: Spatial wildfire occurrence data for the United States, 1992-2020, https://www.fs.usda.gov/rds/archive/catalog/RDS-2013-0009.6, 08/22/2023.
Spatial datasets of probabilistic wildfire risk components for the United States, 2020, https://www.fs.usda.gov/rds/archive/Catalog/RDS-2016-0034-2, 8/22/2023.

Projected Annual Probability of Wildfire in Louisiana, 2050



Data Source: Spatial wildfire occurrence data for the United States, 1992-2020, https://www.fs.usda.gov/rds/archive/catalog/RDS-2013-0009.6, 08/22/2023. Spatial datasets of probabilistic wildfire risk components for the United States, 2020, https://www.fs.usda.gov/rds/archive/Catalog/RDS-2016-0034-2, 8/22/2023.

Projected Annual Property Losses from Wildfire by Census Block, 2050



EXTREME COLD

Overview

Extreme cold temperatures occur in Louisiana when the normal quasi-west-to-east upper-level steering circulation patterns undulate with an unusually strong north-to-south component of motion directed toward Louisiana. A cold front generally forms on the southwestern flank of the southward-moving air mass, trailing from a surface cyclone (i.e., low-pressure center). An anticyclone (high-pressure, clear-sky area) northwest of the cold front's associated low-pressure center then follows. Once the cold front passes, temperatures fall suddenly. After the cloudiness associated with the cold front and low-pressure areas passes through the area and higher-pressure approaches, the clearing skies allow for rapid loss of radiant energy from the surface, especially at night, resulting in an even more abrupt drop in temperature. If air of Arctic origin traverses over snow-covered land on its trek southward, it can become even more bitterly cold by the time it reaches Louisiana. This scenario of cold temperatures, or "Arctic outbreaks," represents a formidable hazard in subtropical climates like Louisiana, where natural and human systems are ill-equipped to adapt, but yet are exposed to the hazard occasionally. Property (especially in the form of uninsulated pipes) and crops are particularly vulnerable. Recent extreme cold events include January 18, 2018, when temperatures at the New Orleans International Airport and Baton Rouge Metro Airport (20°F and 14°F, respectively) broke the previous record lows at those locations, which had been set in 1977.

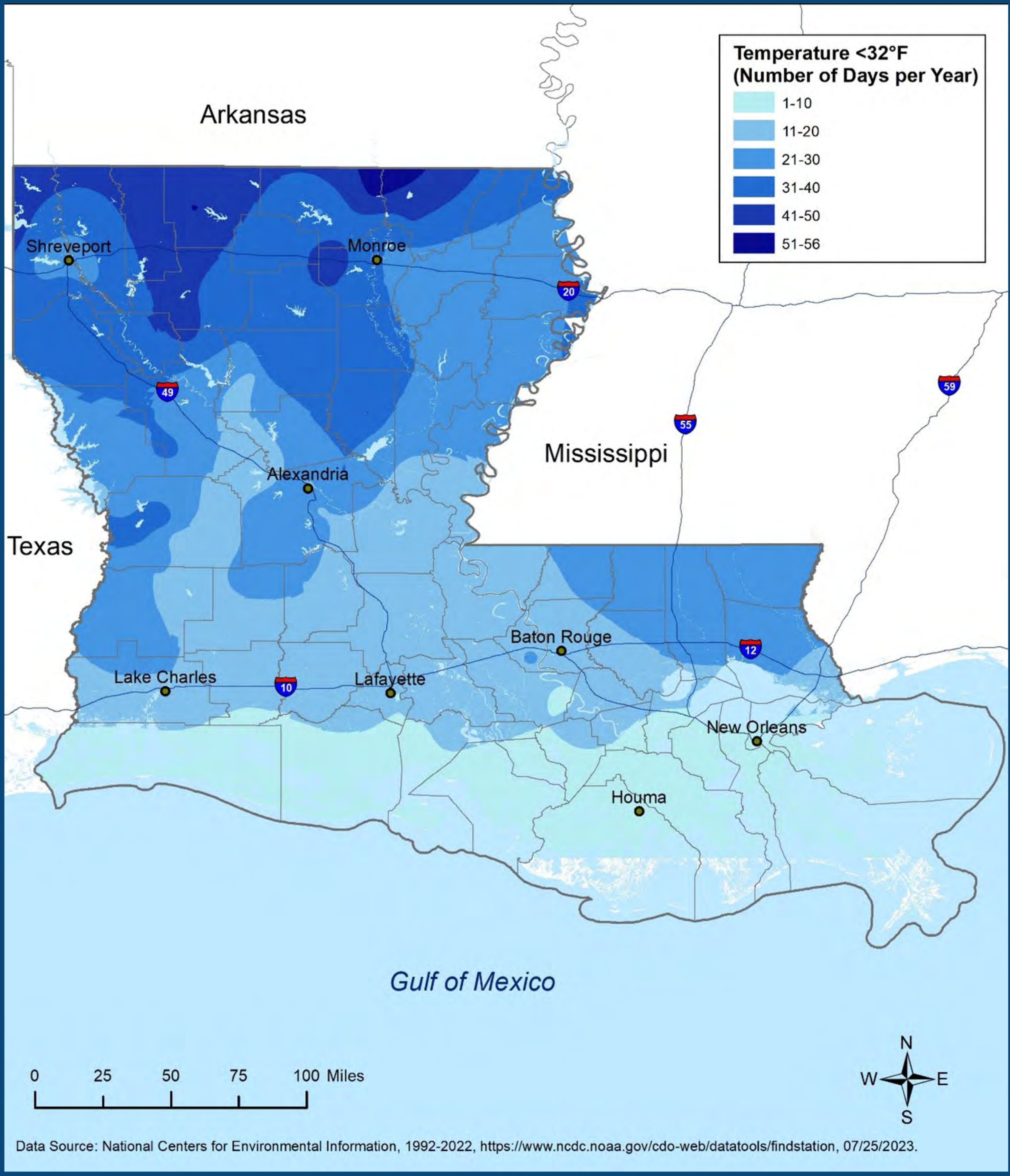
Louisiana Severe Winter Storms (DR-4590): Severe winter storms struck the state of Louisiana between February 11 and February 19. On March 9, President Biden declared a major disaster, making federal funding available to individuals and business owners affected.

The following map shows the historic number of days with temperatures below 32°F. Most studies on the topic focus on the number of days with temperatures below 32°F. The 2050 map shows the expected number of days with temperatures below 32°F considering projected decreases in the intensity of extreme cold hazards and is used in the risk assessment.

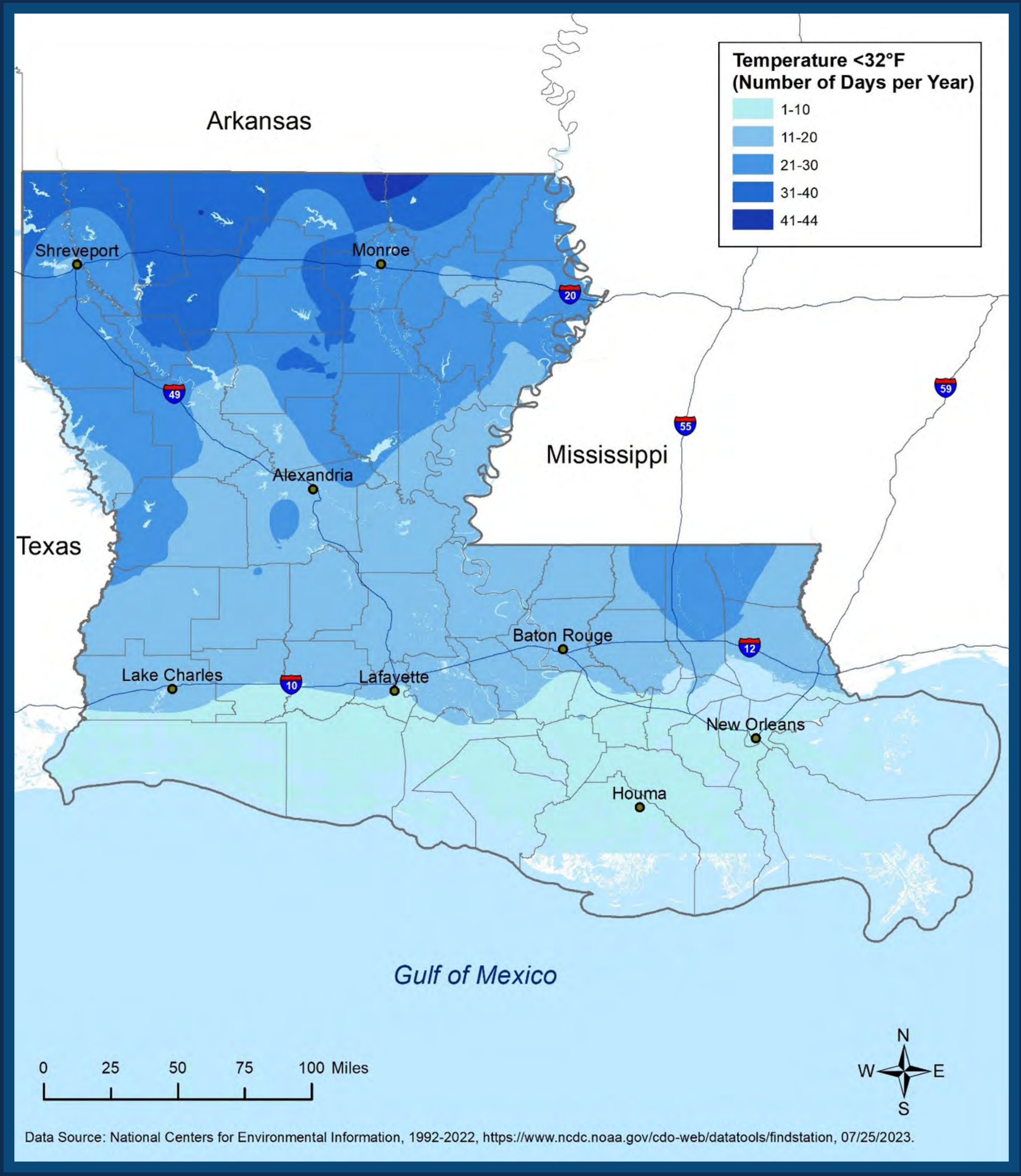
RISK ASSESSMENT

Projected property and crop loss maps show anticipated annual average losses due to extreme cold hazards by census block.

Number of Days per Year with Temperature Below 32F, 1992-2022



Projected Number of Days per Year with Temperature Below 32F, 2050



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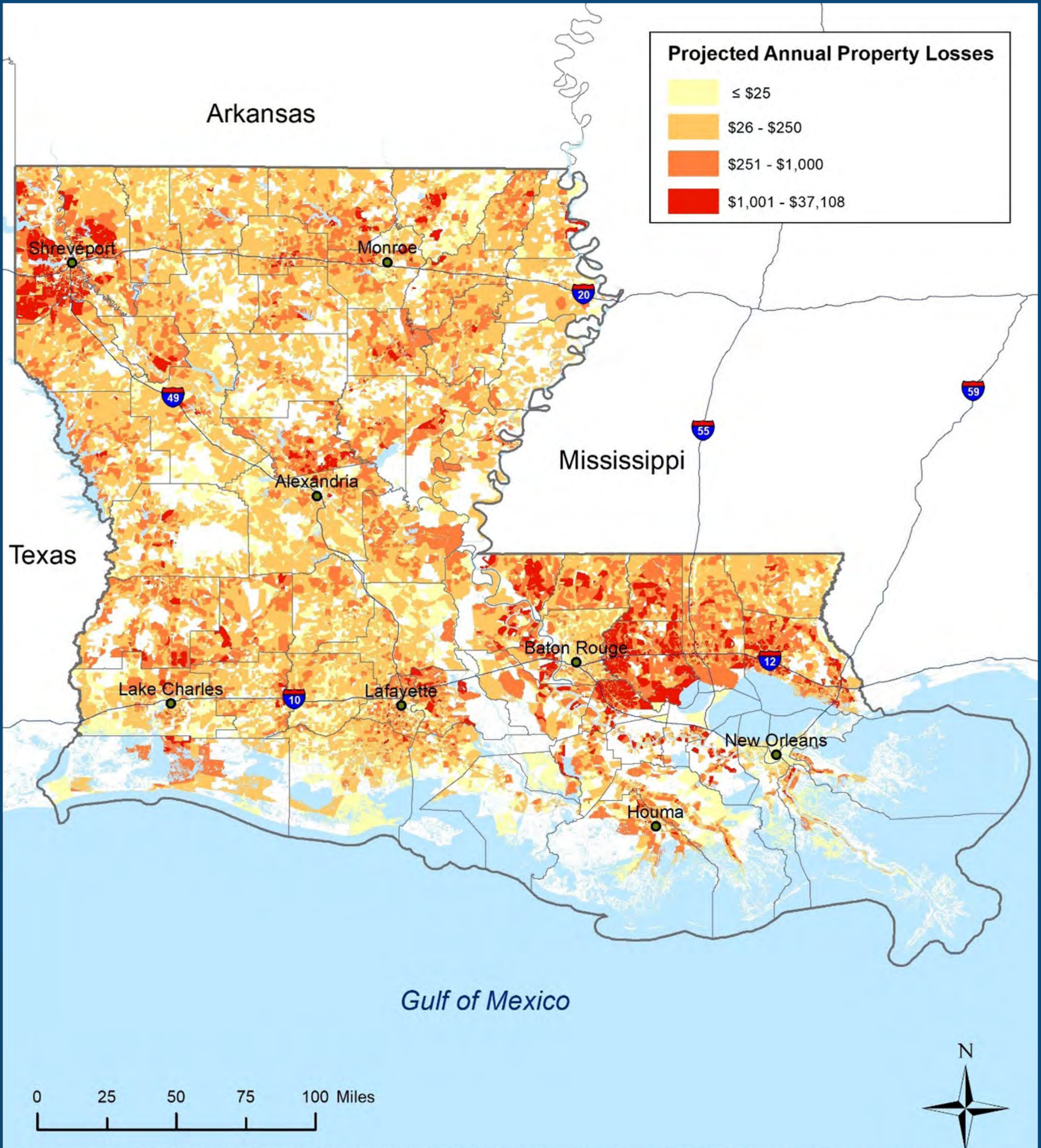
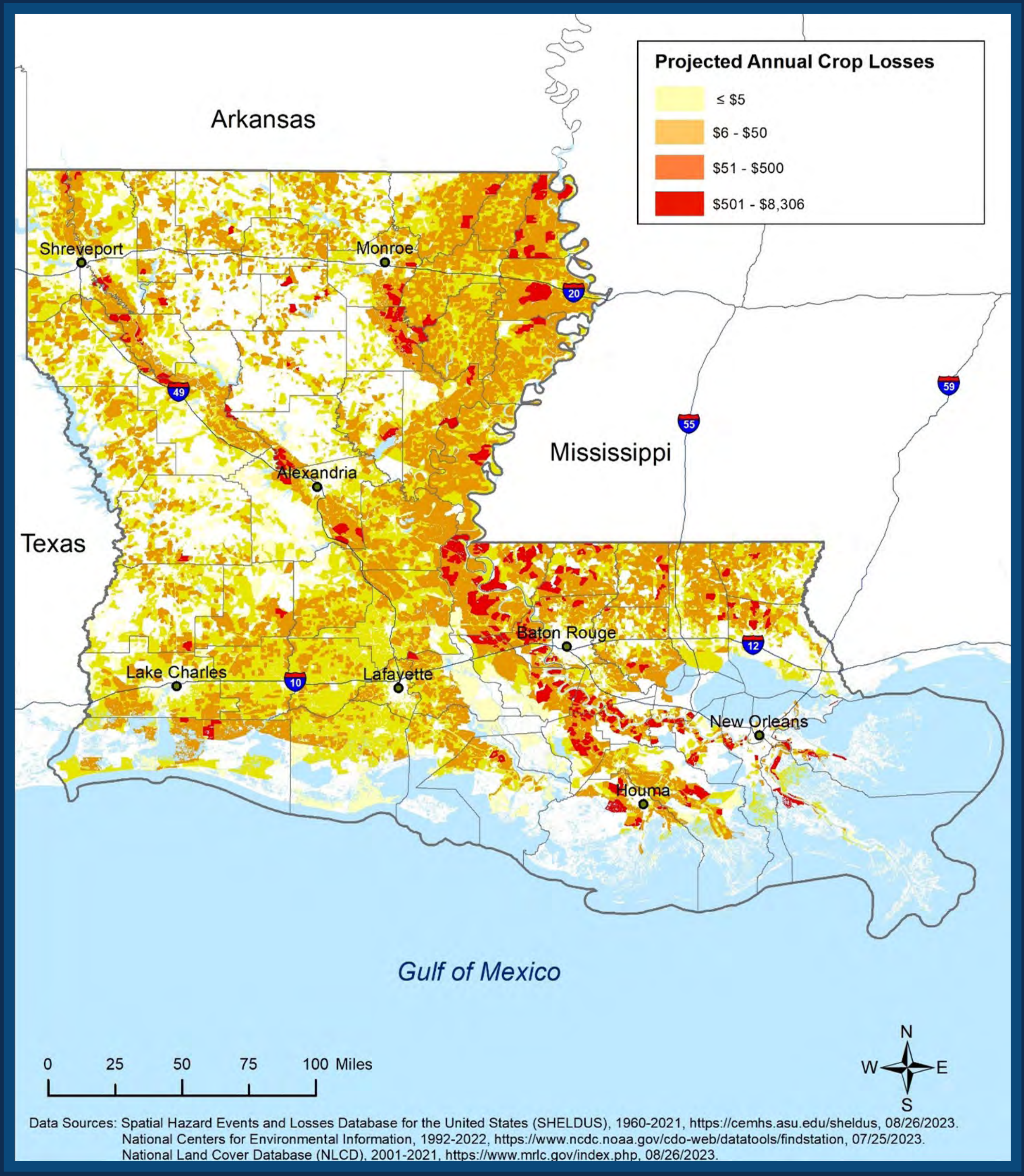
Projected Annual Property Losses from Extreme Cold by Census Block, 2050



Data Source:Spatial Hazard Events and Losses Database for the United States (SHELDUS), 1960-2021, https://cemhs.asu.edu/sheldus, 08/18/2023. National Centers for Environmental Information, 1992-2022, https://www.ncdc.noaa.gov/cdo-web/datatools/findstation, 07/25/2023.

Projected Annual Crop Losses from Extreme Cold by Census Block, 2050



WIND AND FLOOD HAZARDS

Hazards in Louisiana related to wind and flood include tropical cyclones, high wind, hailstorms, lightning, tornadoes, flooding (coastal and riverine), dam failure, and levee failure. There have been eight major disaster declarations since the 2019 State Hazard Mitigation Plan Update – all for wind and flood hazards.

Declaration Number	Description	Incident Period
DR-4611	Louisiana Hurricae Ida	August 26, 2021 - September 3, 2021
DR-4606	Louisiana Severe Storms, Tornadoes, and Flooding	May 17, 2021 - May 21, 2021
DR-4577	Louisiana Hurricane Zeta	October 26, 2020 - October 29, 2020
DR-4570	Louisiana Hurricane Delta	October 6, 2020 - October 19, 2020
DR-4559	Louisiana Hurricane Laura	August 22, 2020 - August 27, 2020
DR-4458	Louisiana Hurricane Barry	July 10, 2019 - July 15, 2019
DR-4462	Louisiana Flooding	May 10, 2019 - July 24, 2019
DR-4439	Louisiana Severe Storms and Tornadoes	April 24, 2019 - June 25, 2019
DR-4345	Louisiana Tropical Storm Harvey	August 28, 2017 - September 10, 2017
DR-4300	Louisiana Severe Storms, Tornadoes, and Straight-line Winds	February 7, 2017
DR - 4277	Louisiana Severe Storms and Flooding	August 11, 2016 - August 31, 2016
DR - 4263	Louisiana Severe Storms and Flooding	March 8, 2016 - April 8, 2016
DR - 4228	Louisiana Severe Storms and Flooding	May 18, 2015 - June 20, 2015

An overview of tropical cyclones (which includes all storms of tropical origin, from weak easterly waves to the most intense hurricanes) is provided in the following section. However, many associated hazards can occur during a hurricane, including flooding, high winds, and tornadoes. Because these hazards are discussed individually in this chapter, a risk assessment is not performed for hurricane hazards themselves. The probabilities of occurrence and annualized losses for flooding, winds, and tornadoes are inclusive of hurricane-related incidents.

The wind and flood hazards are discussed in the following sections, and a risk assessment is provided, except in the case of levee failure. Due to the low probability of levee failure, the losses have not been estimated.

TROPICAL CYCLONES

Overview

Tropical cyclones are spinning, low-pressure storms that draw surface low-latitude air into their centers and attain strength, ranging from weak tropical waves to the most intense hurricanes. Often, these storms begin as clusters of oceanic thunderstorms off the western coast of Africa, moving westward in the trade wind flow. These thunderstorms acquire a rotational component when a small “buckle” forms in the east-to-west trade wind, caused by the Earth’s spin. This west-moving, counterclockwise-spinning collection of storms—now called a tropical disturbance—may then gather strength as it draws humid air toward its low-pressure center, forming a tropical depression (defined when the circulation is completely developed but maximum sustained surface wind speed is 38 mph or less), then a tropical storm (when the maximum sustained surface wind speed ranges from 39 mph to 73 mph), and finally a hurricane (when the maximum sustained surface wind speeds exceed 73 mph). Major hurricanes are classified as Category 3 to 5 based on the Saffir-Simpson Hurricane Wind Scale.

Data from 1900 to 2021 show that the entire state has been impacted by tropical cyclones, often significantly. As an example, Hurricane Katrina in 2005 remains the costliest tropical cyclone in U.S. history. However, the probabilities of occurrence and historical losses for high winds, tornadoes, lightning, and flooding that constitute the tropical cyclone hazard are best represented within each hazard. Therefore, a risk assessment is not provided for tropical cyclones as a standalone hazard.

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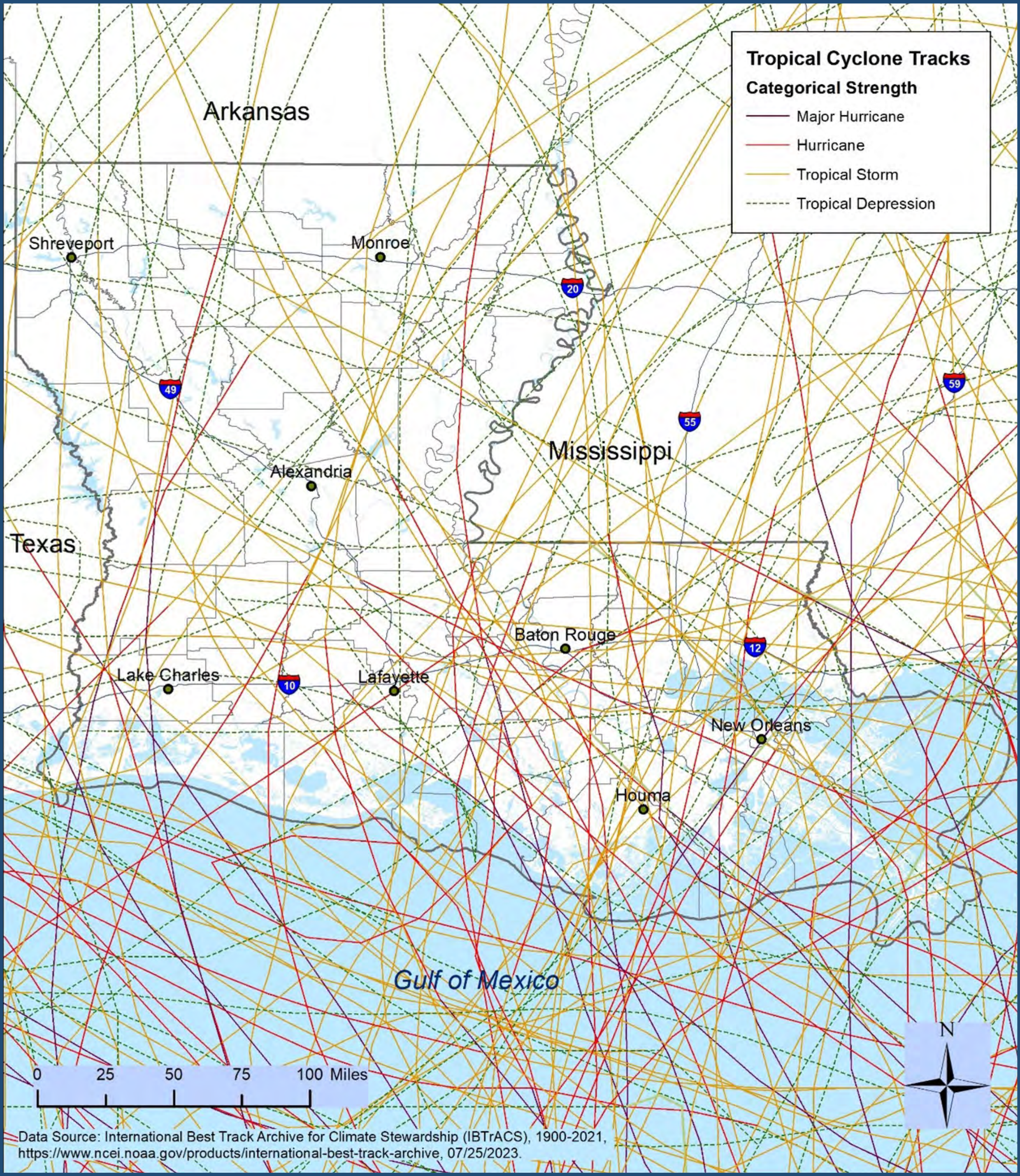
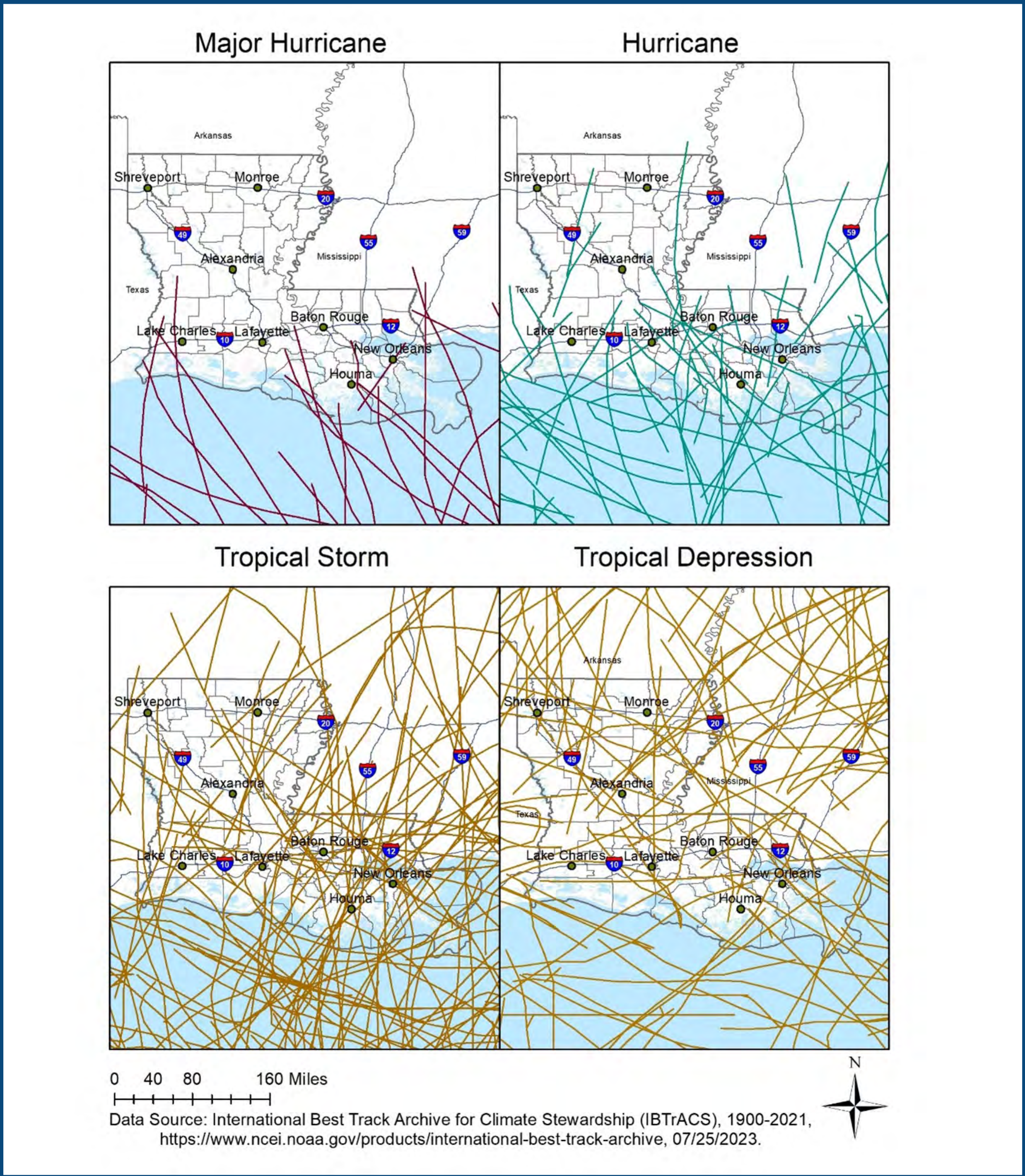
Tropical Cyclone Tracks Across Louisiana, 1900-2021



Tropical Cyclone Tracks Across Louisiana, 1900-2021



HIGH WIND

Overview

High winds considered in this section are caused by thunderstorms, downbursts, straight-line winds, and tropical cyclones, with their scope defined in the table below. Source, frequency, and duration of high winds (source: Making Critical Facilities Safe from High Wind, FEMA).

High Wind Type	Description	Relative Maximum Duration in Louisiana
Thurderstorm Winds	Wind blowing due to thunderstorms, and thus associated with temperature and pressure gradients	Few Minutes - Several Hours
Downbursts	Sudden wind blowing down due to downdraft in a thunderstorm; spreads out horizontally at the ground, possibly forming horizontal vortex rings around the downdraft	15-20 Minutes
Straight-line Winds	Wind blowing in straight line; usually associated with intense low-pressure area	Few minutes - 1 day
Hurricane Winds	Wind blowing in spirals, converging with increasing speed toward eye; associated with temperature and pressure gradients between the Atlantic and Gulf and land	Several days

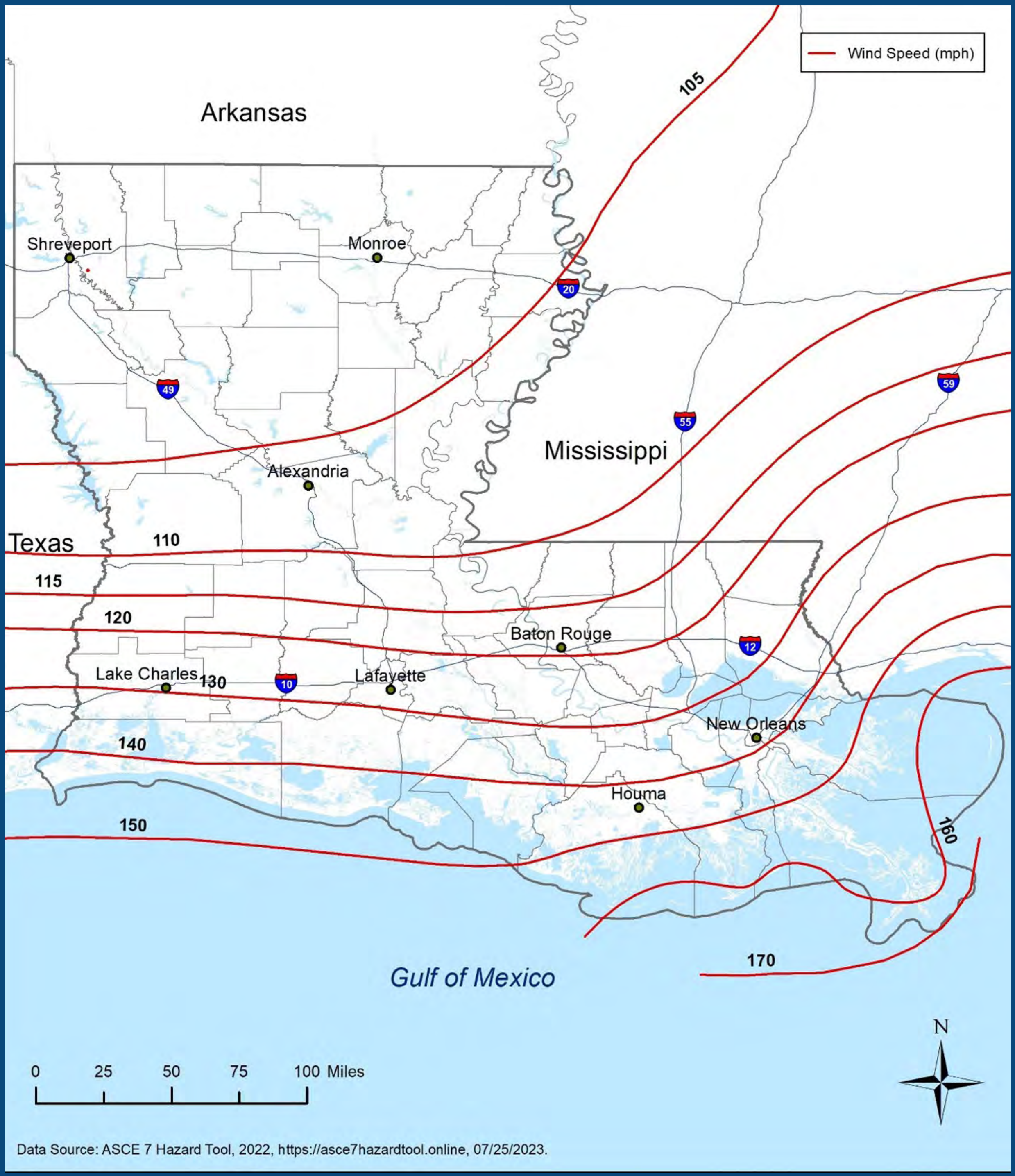
Recent high wind events (excluding tornadoes, which are discussed separately) include the severe storms and straight-line winds from May 17-21, 2021 (DR-4606) in Ascension, Calcasieu, East Baton Rouge, Iberville, and Lafayette parishes, and the winds associated with Tropical Storm Ida in 2021 (DR-4611).

The wind contour map depicts historic wind speeds by location, representing the 700-year return period wind speeds for Louisiana, corresponding to approximately a 7% probability of exceedance in 50 years (annual exceedance probability = 0.14%). Wind speeds for other return periods (e.g., 300-year, 1700-year return period) defined by the American Society of Civil Engineers are used to more fully describe the probability of hazard occurrence used in the risk assessment. Higher wind speeds near the coast reflect the intensity of tropical cyclone winds. These wind speeds are the basis for the design of smaller buildings, including homes. No increase in wind speed is projected in 2050; therefore, only one hazard map is provided, which is used in the risk assessment.

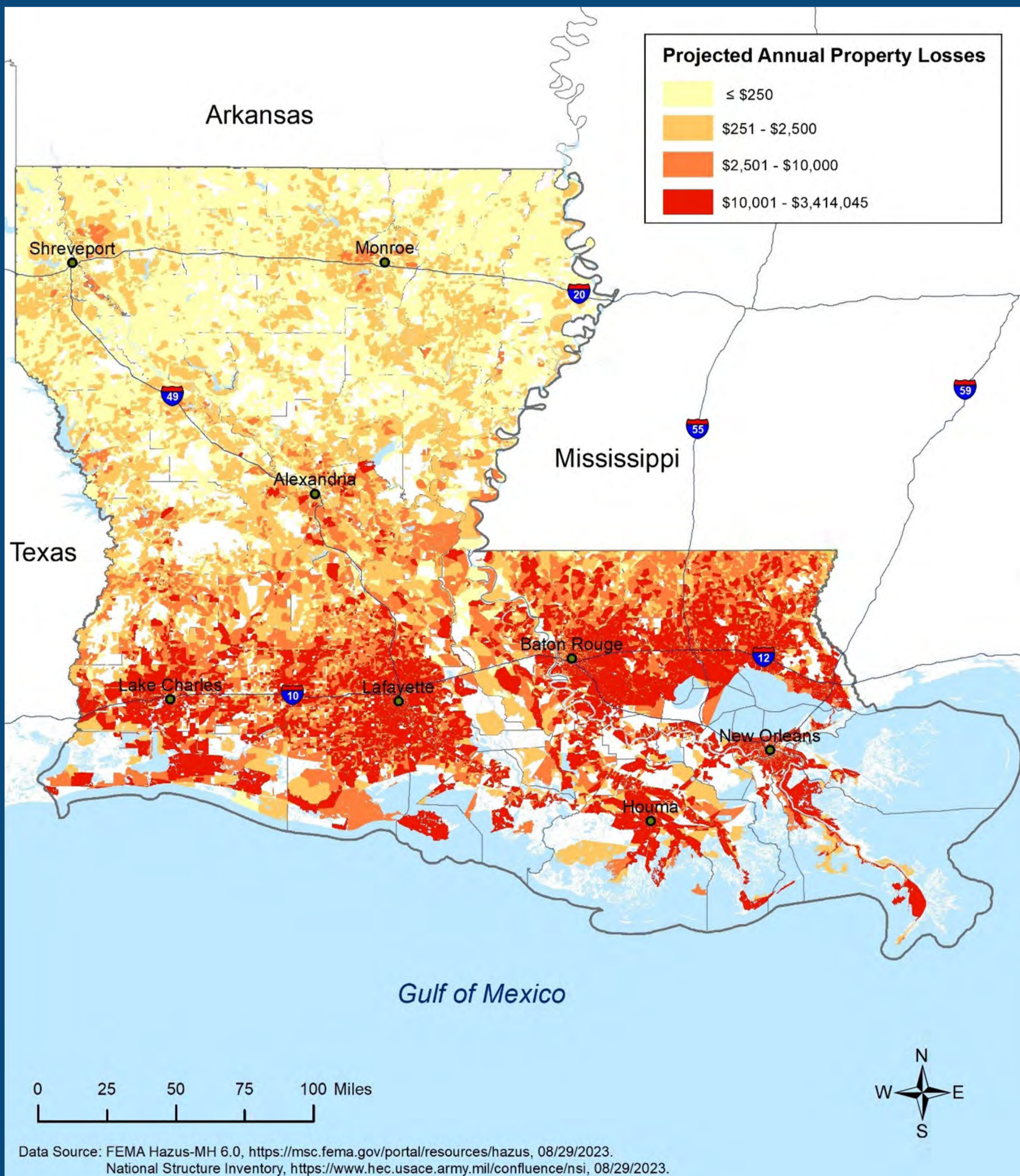
RISK ASSESSMENT

The projected property loss map shows anticipated annual average losses due to wind hazards by census block.

700-Year 3-Second Peak Gust Wind Speeds in Louisiana, 2022



Projected Annual Property Losses from Wind by Census Block, 2050



HAILSTORMS

Overview

Hailstorms are severe thunderstorms in which balls or chunks of ice fall along with rain. Hail develops in the upper atmosphere as ice crystals that are bounced about by high-velocity updraft winds. The ice crystals grow through deposition of water vapor onto their surface, fall partially to a level in the cloud where the temperature exceeds the freezing point, melt partially, get caught in another updraft whereupon re-freezing and deposition grows another concentric layer of ice, and fall after developing enough weight, sometimes after several trips up and down the cloud. The size of hailstones varies depending on the severity and height of the thunderstorm.

Because of this cycle, hailstorms generally occur more frequently during the late spring and early summer—a period of extreme variation between ground surface temperatures and upper atmospheric temperatures, which contributes to vigorous updrafts of air. Hailstorms can cause widespread damage to homes and other structures, automobiles, and crops. While the damage to individual structures or vehicles is often minor, the cumulative cost to communities, especially across large metropolitan areas, can be quite significant. Hailstorms can also be devastating to crops. Thus, the severity of hailstorms depends on the size of the hailstones, the length of time the storm lasts, and where it occurs. An example of a recent significant hail event is the January 21, 2017, severe weather event, where several reports of large hail, up to 2 inches in diameter, were documented in Northwest Louisiana.

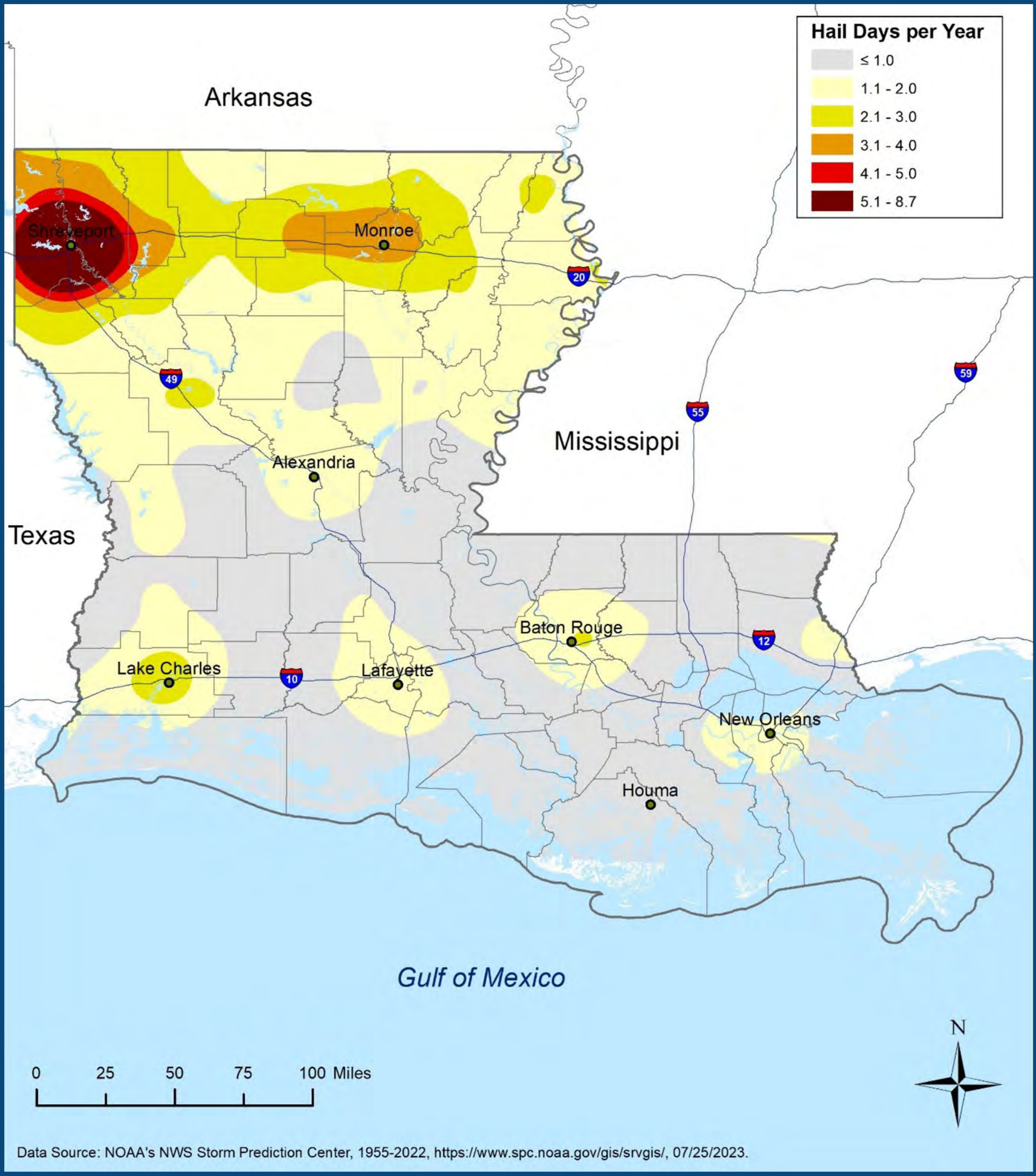
The largest hail recorded in Louisiana, with a 4.5-inch diameter, was spotted in four different parishes. A total of 69 hailstorms occurred in the state from 2009 to 2018. The worst by far was the storm of 2012 in Avoyelles Parish, which inflicted $1 million in property damage.

Historic hail occurrences are represented through the 1955-2022 annualized map showing the number of days per year experiencing events with hailstones ¾" diameter or larger within 25 miles. The 2050 annual projected occurrence map considers projected increases in the probability of tornado hazards we could expect to see in the year 2050. This projected occurrence is used in the risk assessment.

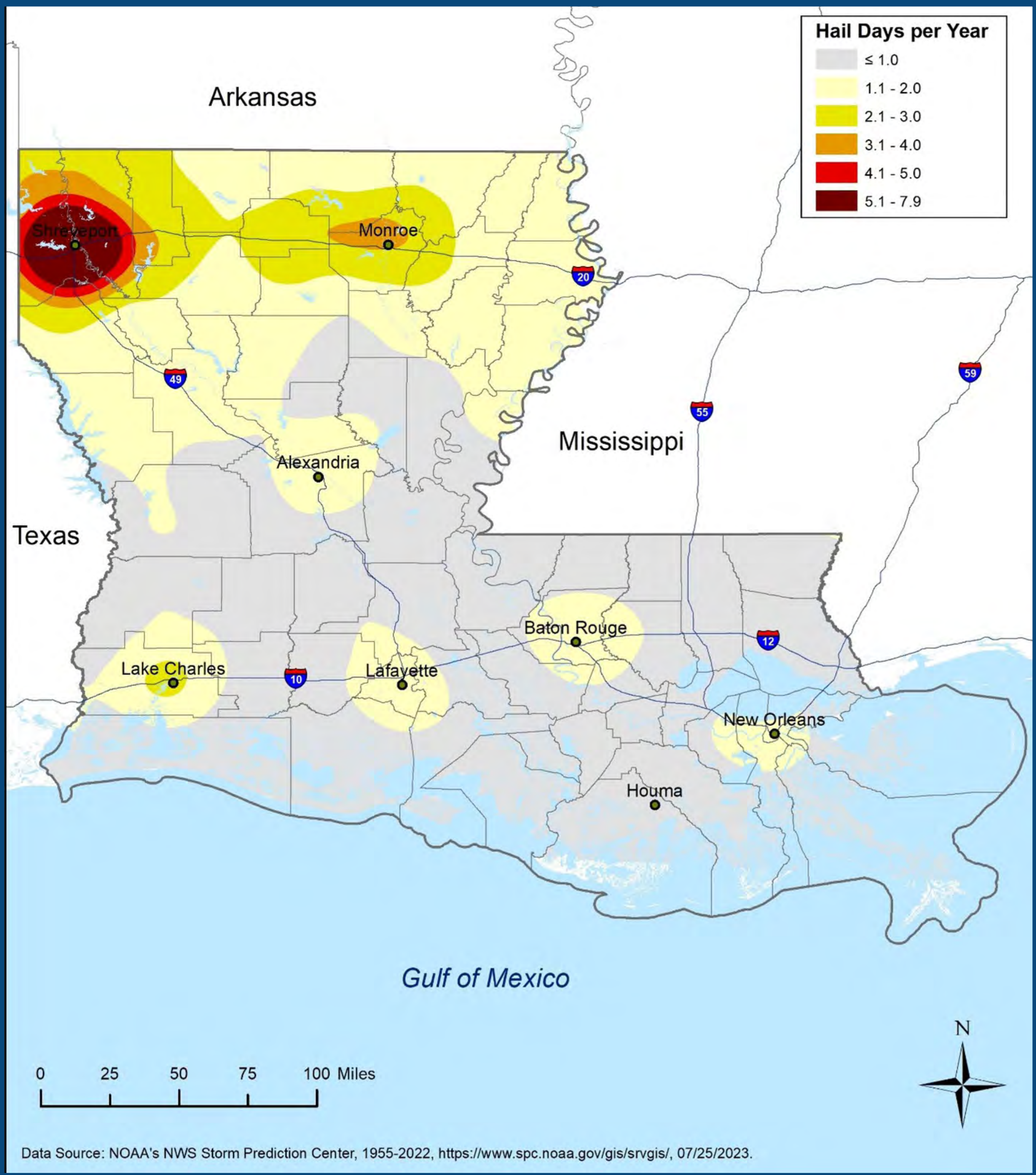
RISK ASSESSMENT

The projected property and crop loss maps show the anticipated annual average losses due to hail hazards by census block.

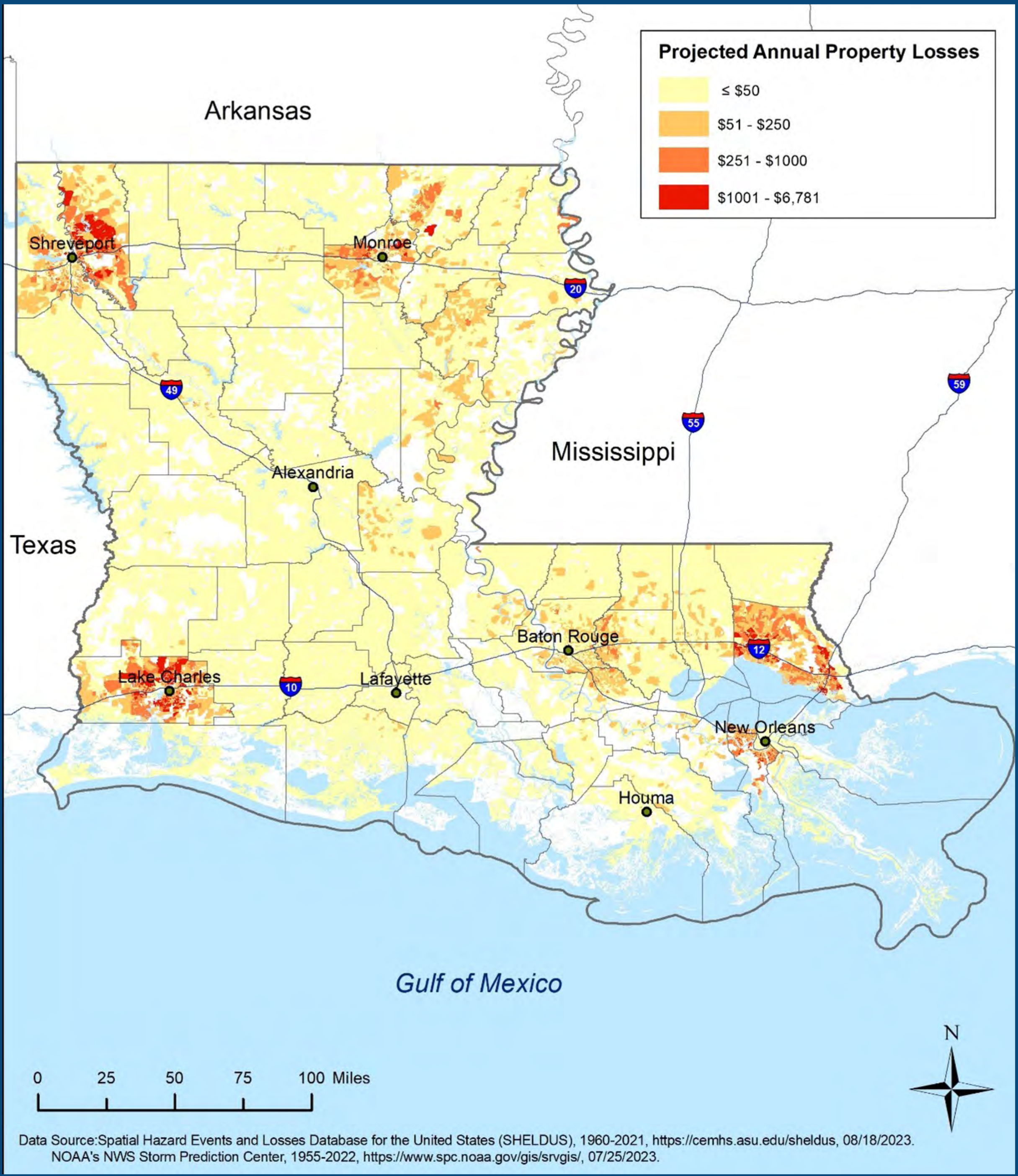
Number of Days per Year Experiencing Hail > 0.75" within 25 Miles, 1955-2022



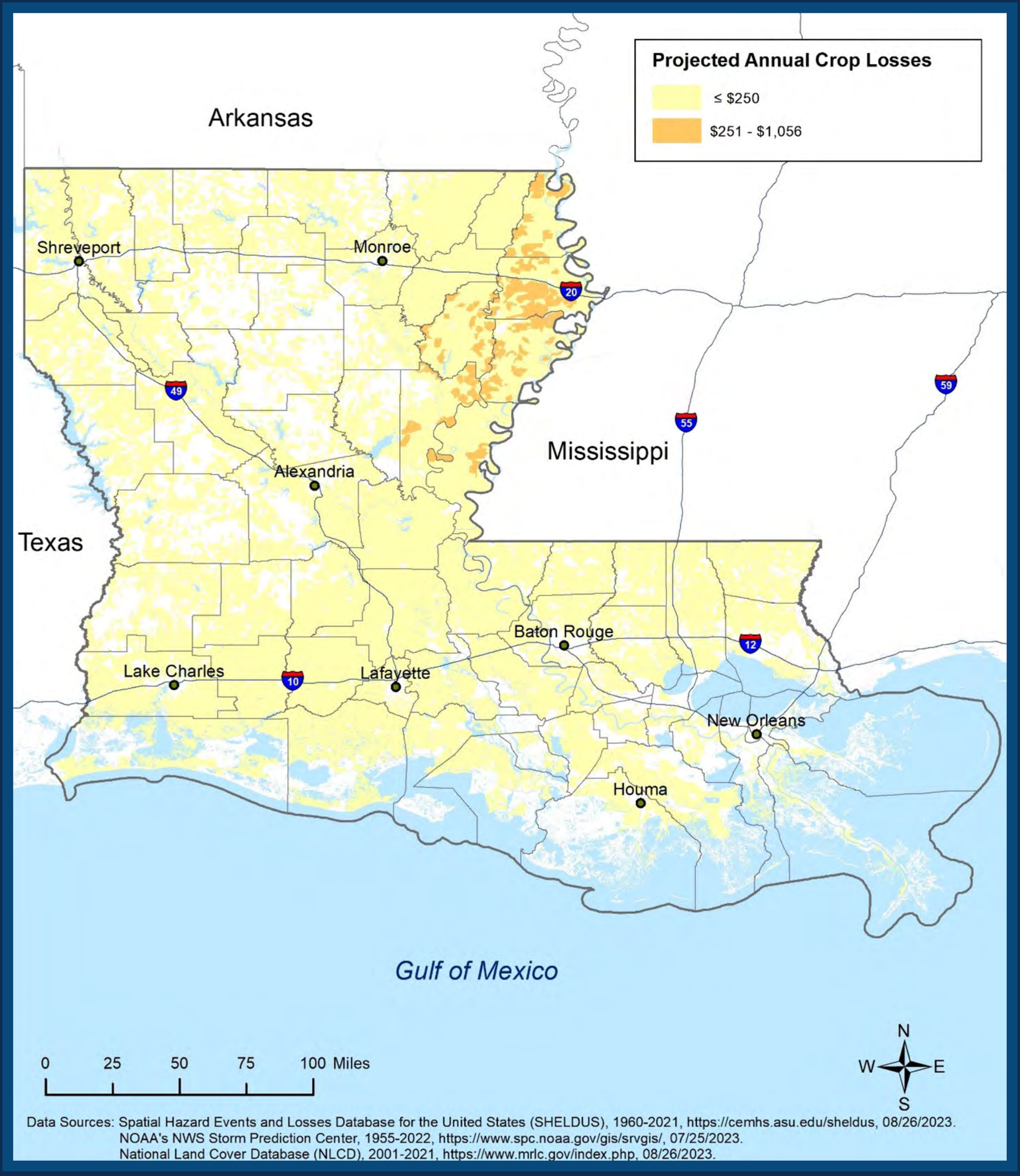
Projected Number of Days per Year Experiencing Hail > 0.75” within 25 Miles, 2050



Projected Annual Property Losses from Hail by Census Bock, 2050



Projected Annual Crop Losses from Hail by Census Block, 2050



LIGHTNING

Overview

The warning signs for possible cloud-to-ground lightning strikes are high winds, rainfall, and darkening cloud cover. While many lightning casualties happen at the beginning of an approaching storm, more than half of lightning deaths occur after a thunderstorm has passed. The lightning threat diminishes after the last sound of thunder, but still may persist for more than 30 minutes. When thunderstorms are in the area but not overhead, the lightning threat can exist even when overhead skies are clear. Lightning can even strike more than ten miles from the storm in an area with clear skies.

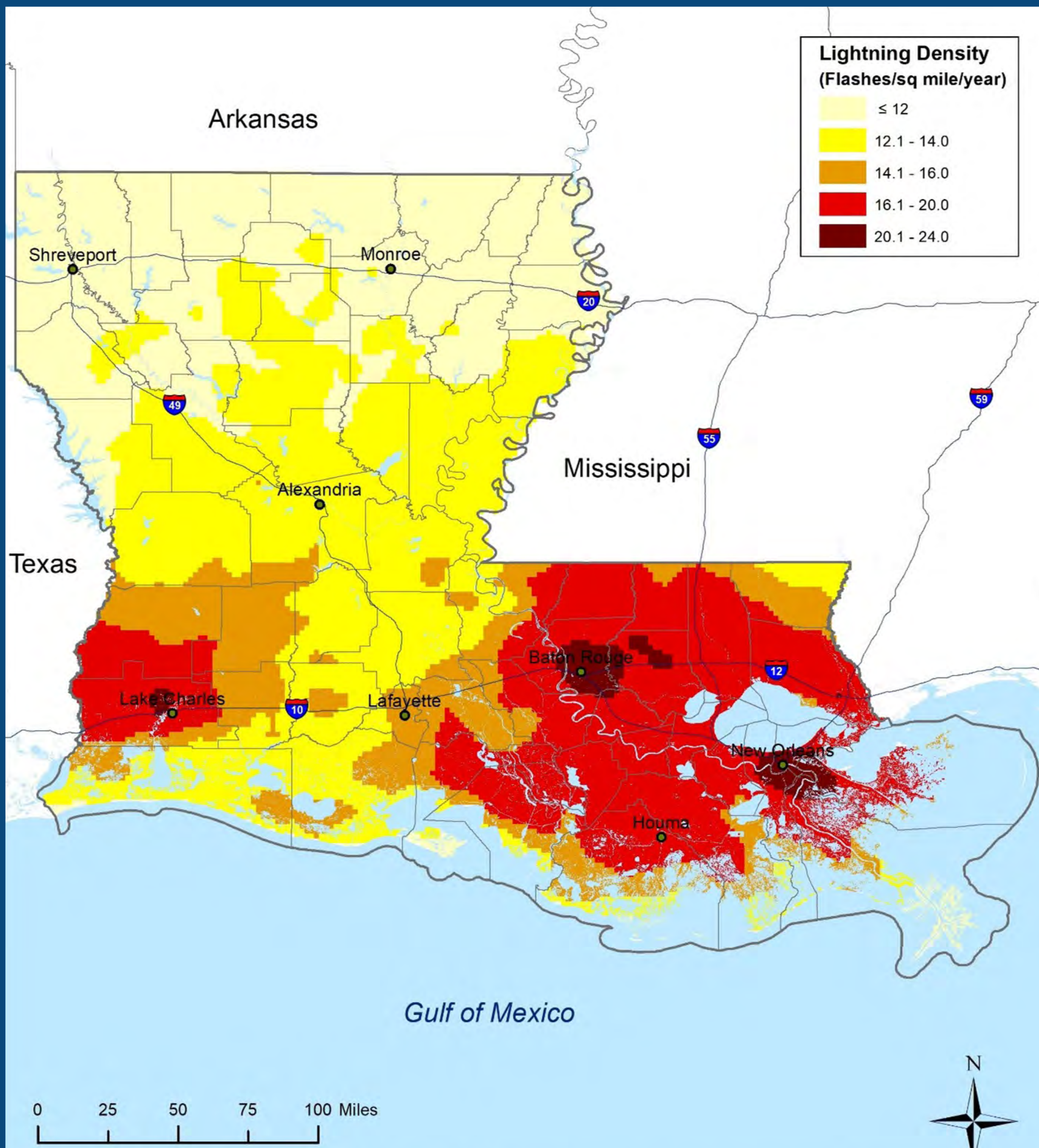
According to NOAA, Louisiana is the second-most lightning-prone state, with around 825,000 lightning strikes per year, following Florida. The year 2016 was one of the worst years nationally for lightning deaths, with 38 fatalities around the country. Louisiana recorded 4 lightning-related deaths that year. In 2022, Louisiana recorded approximately 11.6 million lightning strikes, reinforces its ranking as one of the top states for lightning activity. The state's high humidity and frequent storminess contribute to the relatively high frequency of lightning strikes.

The 1987 to 2022 average annual lightning density is based on historic lightning observations, while the 2050 lightning density map considers projected increases in the probability of lightning hazards we could expect to see in the year 2050. The probability of lightning hazards in 2050 is used in the risk assessment.

RISK ASSESSMENT

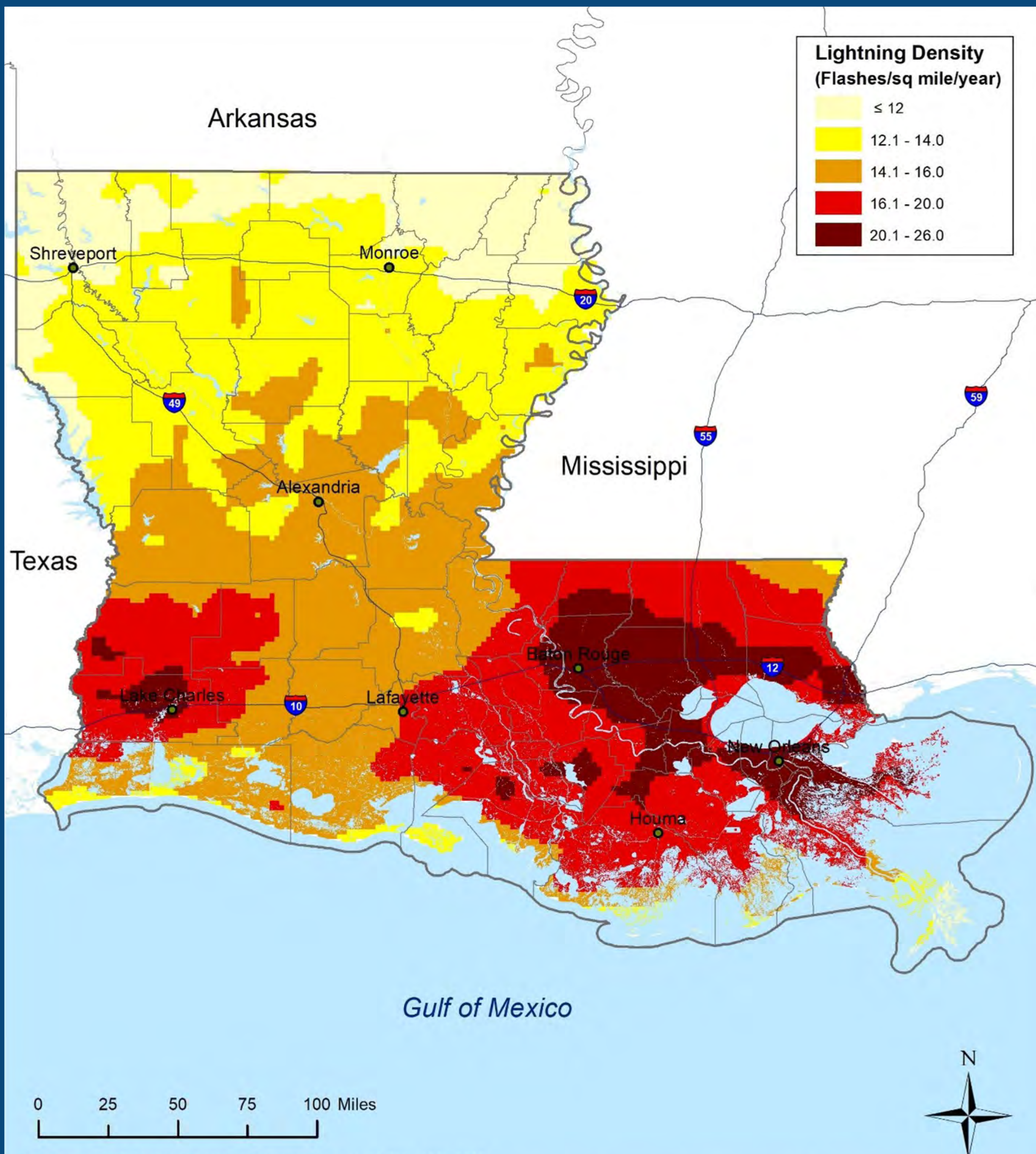
The projected property and crop loss maps show the anticipated annual average losses due to lightning hazards by census block.

Average Lightning Density per Year in Louisiana, 1987-2022



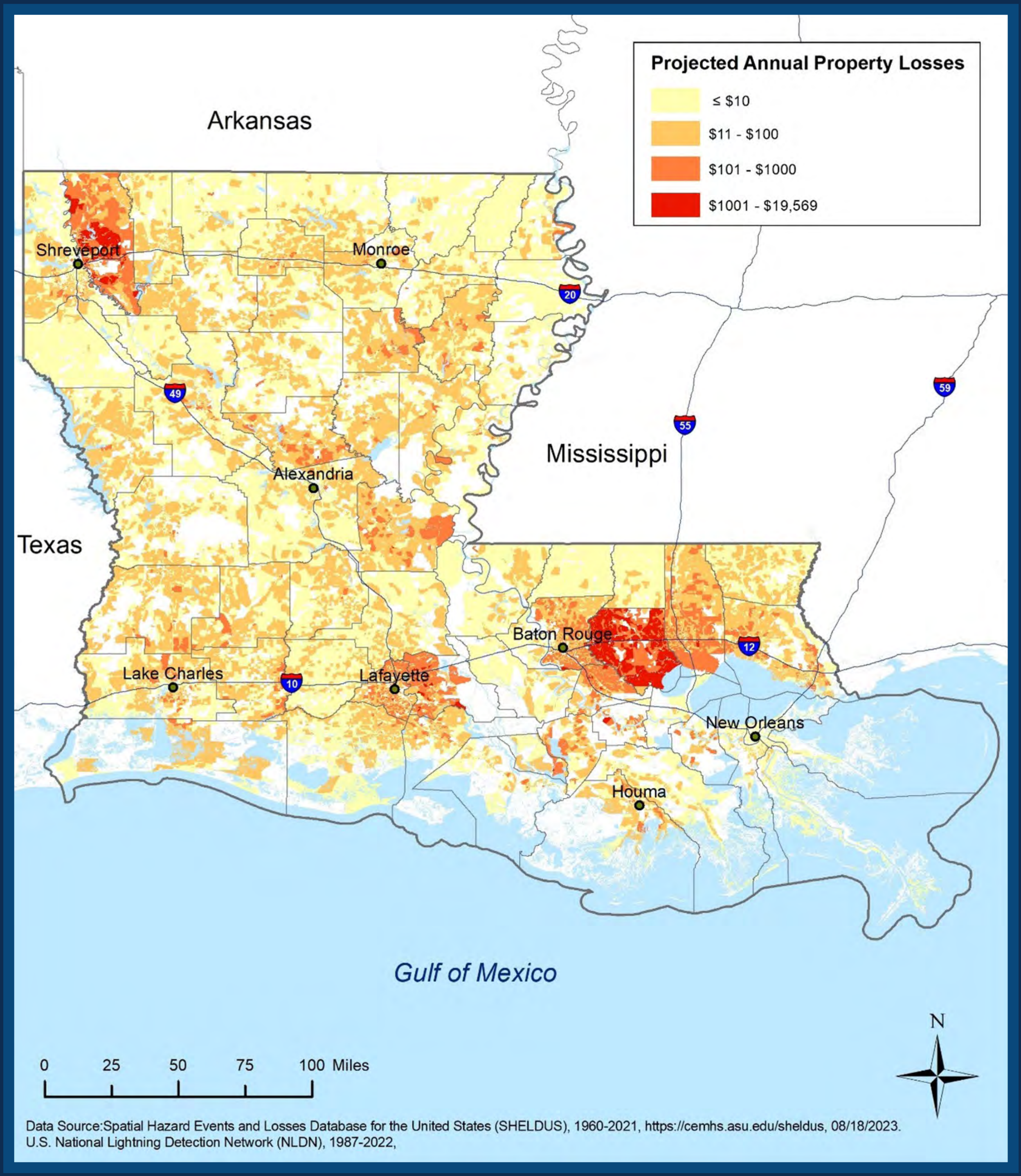
Data Source: U.S. National Lightning Detection Network (NLDN), 1987-2022, https://www1.ncdc.noaa.gov/pub/data/swdi/database-csv/v2/?fbclid=IwAR2WrtQsAplwWBPRu1UAzNaegJkY3lPXX5RGOjDFMUb_RcZSbT18A7DCA1A, 07/25/2023.

Projected Lightning Density per Year in Louisiana, 2050



Data Source: U.S. National Lightning Detection Network (NLDN), 1987-2022, https://www1.ncdc.noaa.gov/pub/data/swdi/database-csv/v2/?fbclid=IwAR2WrtQsAplwWBPRu1UAzNaegJkY3lPXX5RGOjDFMUb_RcZSbT18A7DCA1A, 07/25/2023.

Projected Annual Property Losses from Lightning by Census Block, 2050



Projected Annual Crop Losses from Lightning by Census Block, 2050

Data Sources: Spatial Hazard Events and Losses Database for the United States (SHELDUS), 1960-2021, https://cemhs.asu.edu/sheldus, 08/26/2023.
U.S. National Lightning Detection Network (NLDN), 1987-2022, 07/25/2023.
National Land Cover Database (NLCD), 2001-2021, https://www.mrlc.gov/index.php, 08/26/2023.

TORNADOES

Overview

Tornadoes are rapidly rotating funnels of wind extending between storm clouds and the ground. For their size, tornadoes are the most severe storms. Approximately 70 percent of the world's reported tornadoes occur within the continental U.S., making them one of the most significant hazards Americans face. When tornadoes exist over water, they are considered waterspouts. Tornadoes and waterspouts form during severe weather events, such as thunderstorms, when cold air overrides a layer of warm air, causing the warm air to rise rapidly, which usually occurs in a counterclockwise direction in the northern hemisphere. Tornadoes can also occur in association with hurricanes but are more likely to be weaker in intensity than land-based tornadoes that occur shortly before a cold frontal passage.

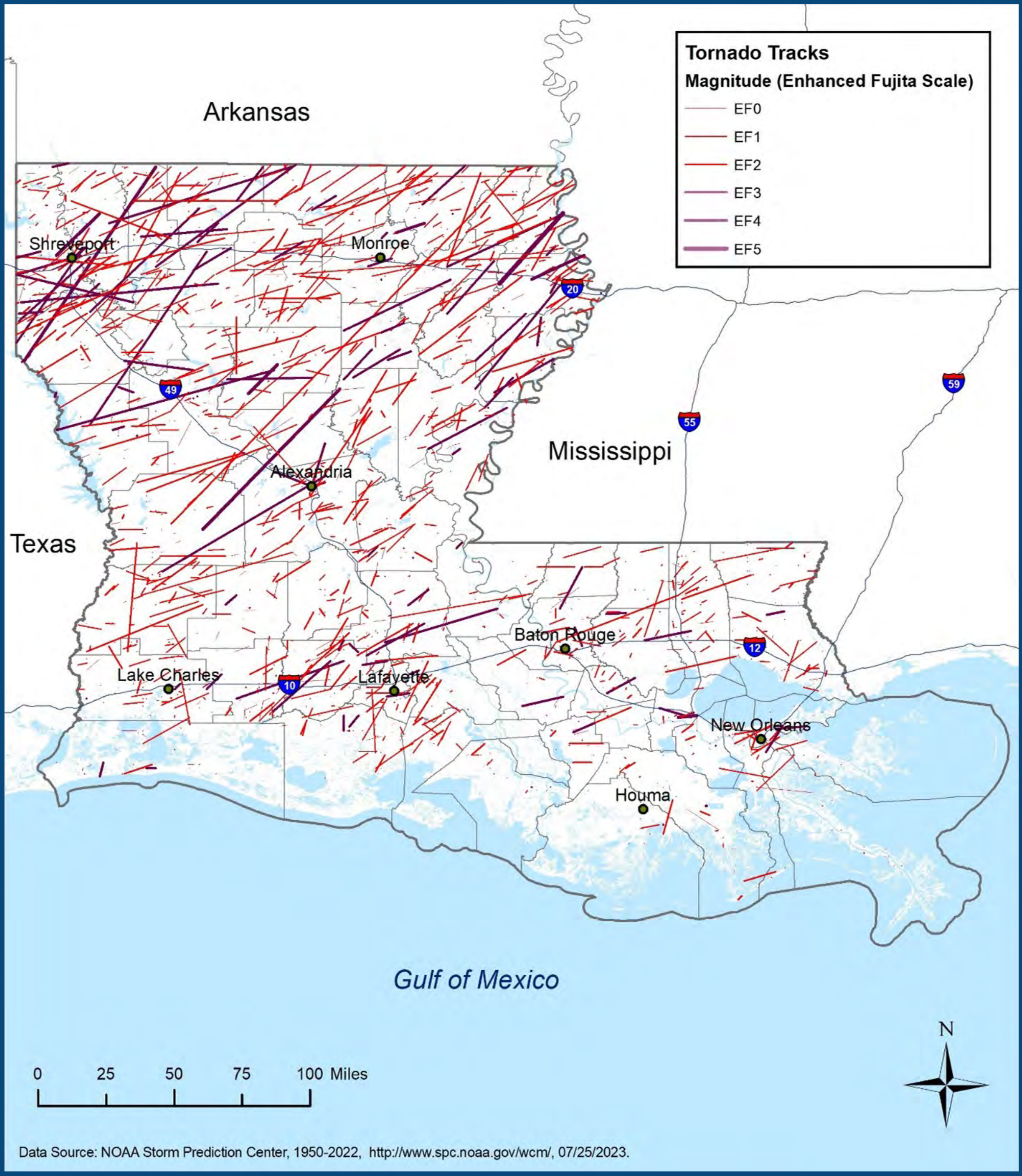
Peak tornado activity in Louisiana occurs during the spring, as it does in the rest of the United States. Nearly one-third of observed tornadoes in the U.S. occur during April and May. About half of the tornadoes in Louisiana, including many of the strongest, occur between March and June. Fall and winter tornadoes are less frequent, but the distribution of tornadoes throughout the year is more uniform in Louisiana than in locations farther north. Recent tornado outbreaks in Louisiana include those on May 17-21, 2021 (DR-4606), in Ascension, Calcasieu, East Baton Rouge, Iberville, and Lafayette parishes, as well as the Morehouse, Union, and Lincoln Parish tornadoes on April 24-June 2019 (DR-4439).

Historic tornado occurrence is shown by Enhanced Fujita (EF) classification (from the weakest tornadoes starting at EF0 to the most powerful category of EF5) of tornado tracks, as well as through an annualized map depicting the number of days per year with a tornado touchdown within 25 miles. The 2050 annual projected occurrence map considers projected increases in the probability of tornado hazards we could expect to see in the year 2050. These projected increases are used in the risk assessment.

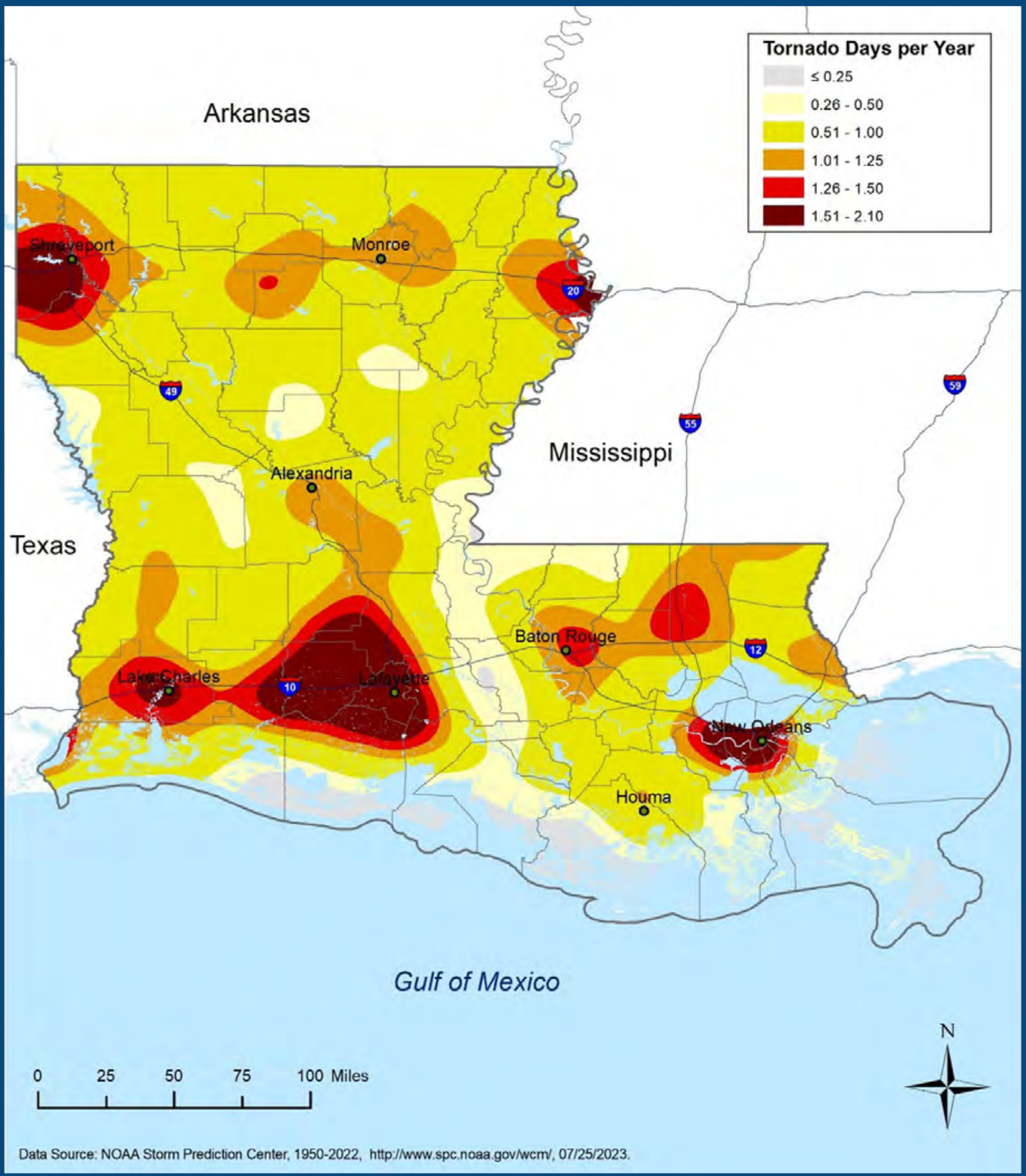
Risk Assessment

The projected property and crop loss maps show the anticipated annual average losses due to tornado hazards by census block.

Tornado Tracks in Louisiana, 1950-2022



Number of Days per Year Having a Tornado Touchdown within 25 Miles, 1950-2022



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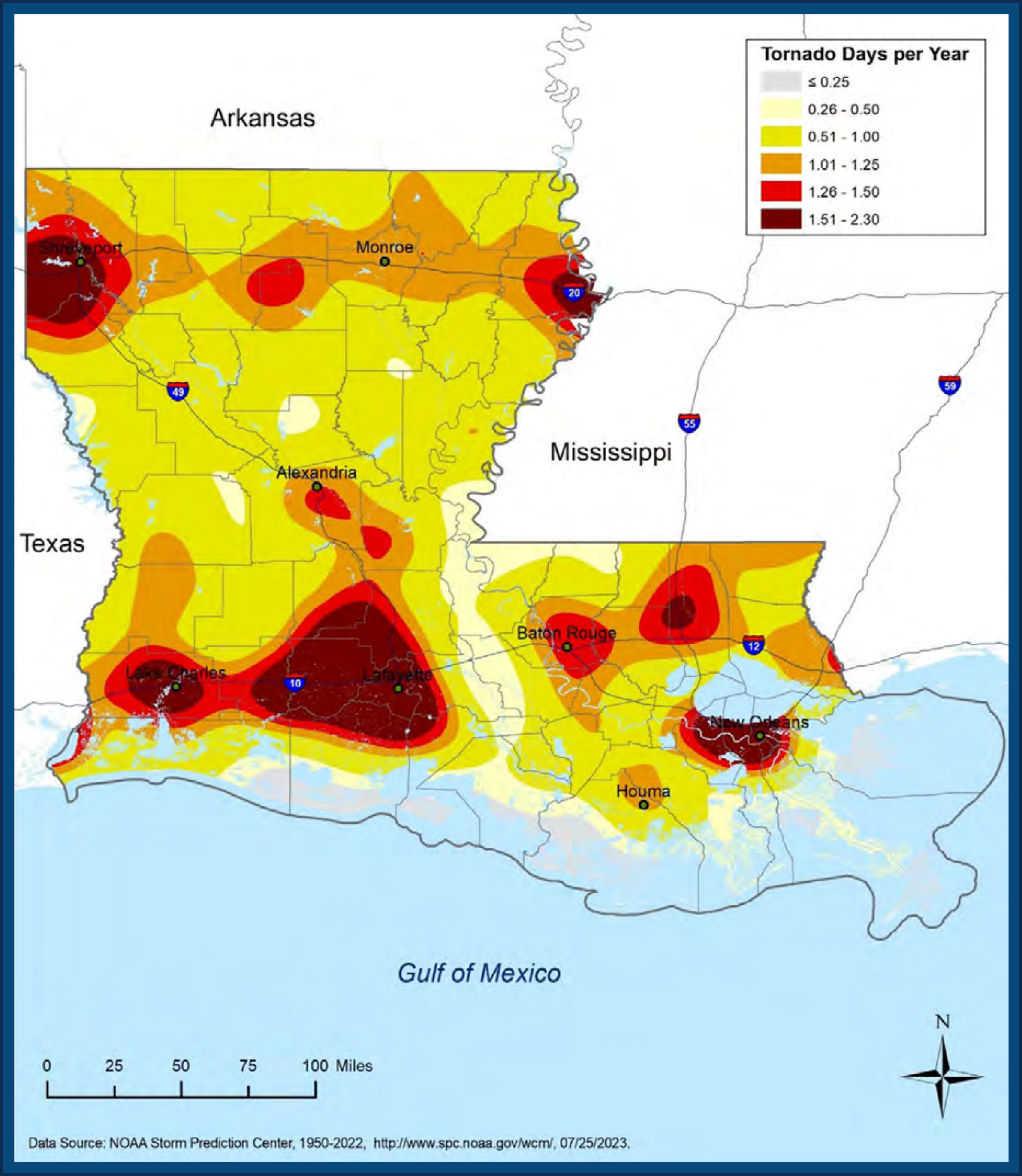
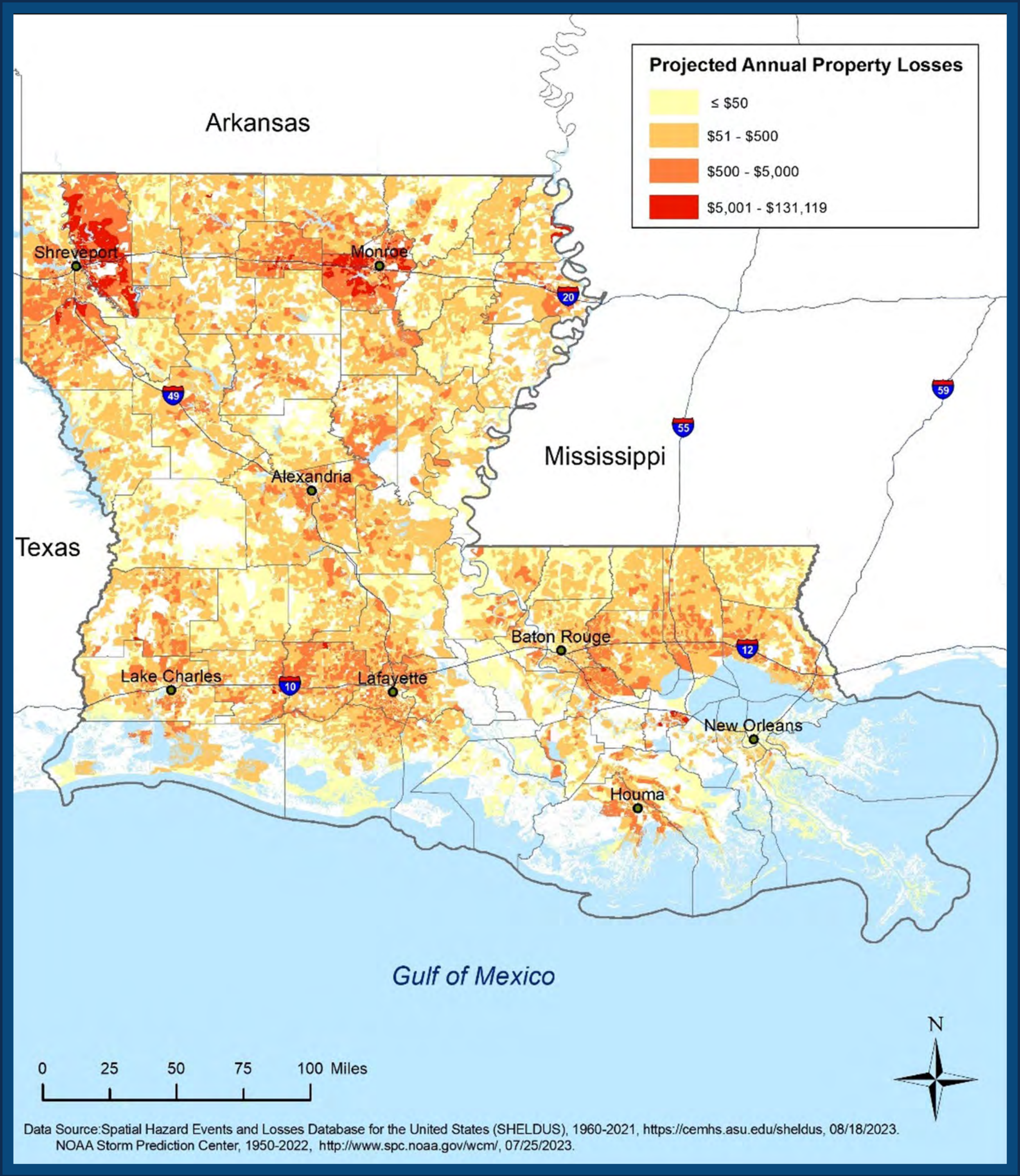
Projected Number of Days per Year Having a Tornado Touchdown within 25 Miles, 2050



Projected Annual Property Losses from Tornado by Census Block, 2050



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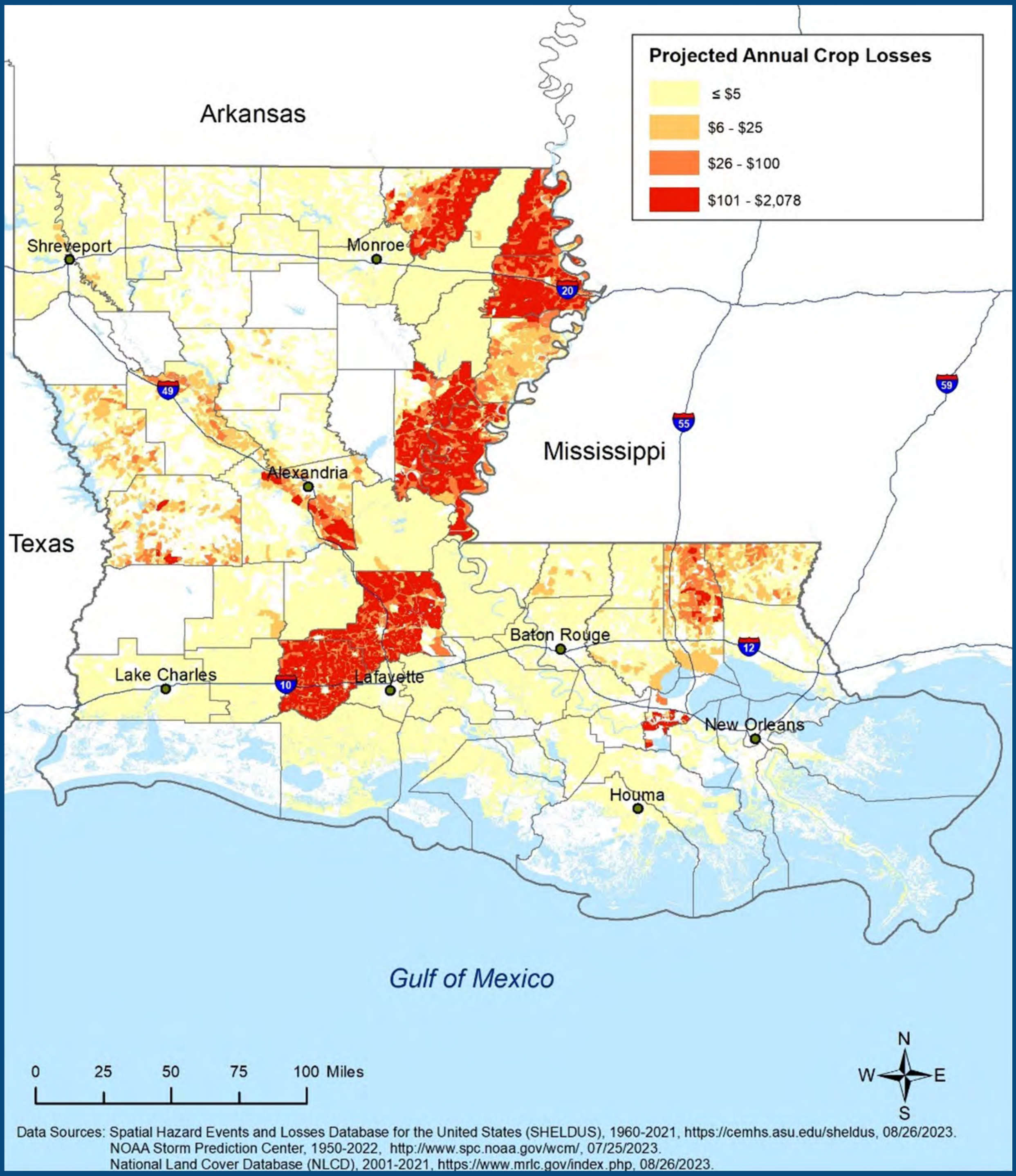
Projected Annual Crop Losses from Tornado by Census Block, 2050



FLOODING

Overview

A flood is the overflow of water onto land that is typically not inundated. Excess precipitation, produced from thunderstorms or hurricanes, is often the major initiating condition for flooding, and Louisiana can have high rainfall totals at any time of the day or year. In Louisiana, five specific types of floods are of main concern: riverine, flash, ponding, backwater, and urban. The 1% annual exceedance probability flood (often called the 100-year flood, corresponding to a mean recurrence interval of 100 years) is of particular significance, because it is used as the basis for regulatory standards, such as building codes and flood insurance requirements.

Over the period 1959 to 2005, Louisiana ranked 18th among the states in flood fatalities (excluding those related to Katrina), but third in flood-related injuries and in total flood casualties. Recent significant floods include the 11-31 August 2016 flood affecting southeast Louisiana (DR-4277), the 8 March - 8 April 2016 flood affecting northern Louisiana (DR-4263), and the 18 May - 20 June 2015 flood along the Red River in northwestern Louisiana (DR-4228).

The special flood hazard area (SHFA) is defined by FEMA, as the land area that has a 1% or greater chance of flooding per year (map on the following page). However, this is not a complete picture of flood risk, as the flood inundation boundaries corresponding with other likelihoods have not yet been defined systematically. While no changes are projected for riverine flooding due to lack of data, the Louisiana Coastal Protection and Restoration Agency (CPRA) has predicted increases in coastal flooding. The risk assessment merges predicted (increased) 100-year coastal inundation under a high environmental scenario with plan implementation scenario in 2055 (elapsed 32 years) with the FEMA's 100-year flood maps.

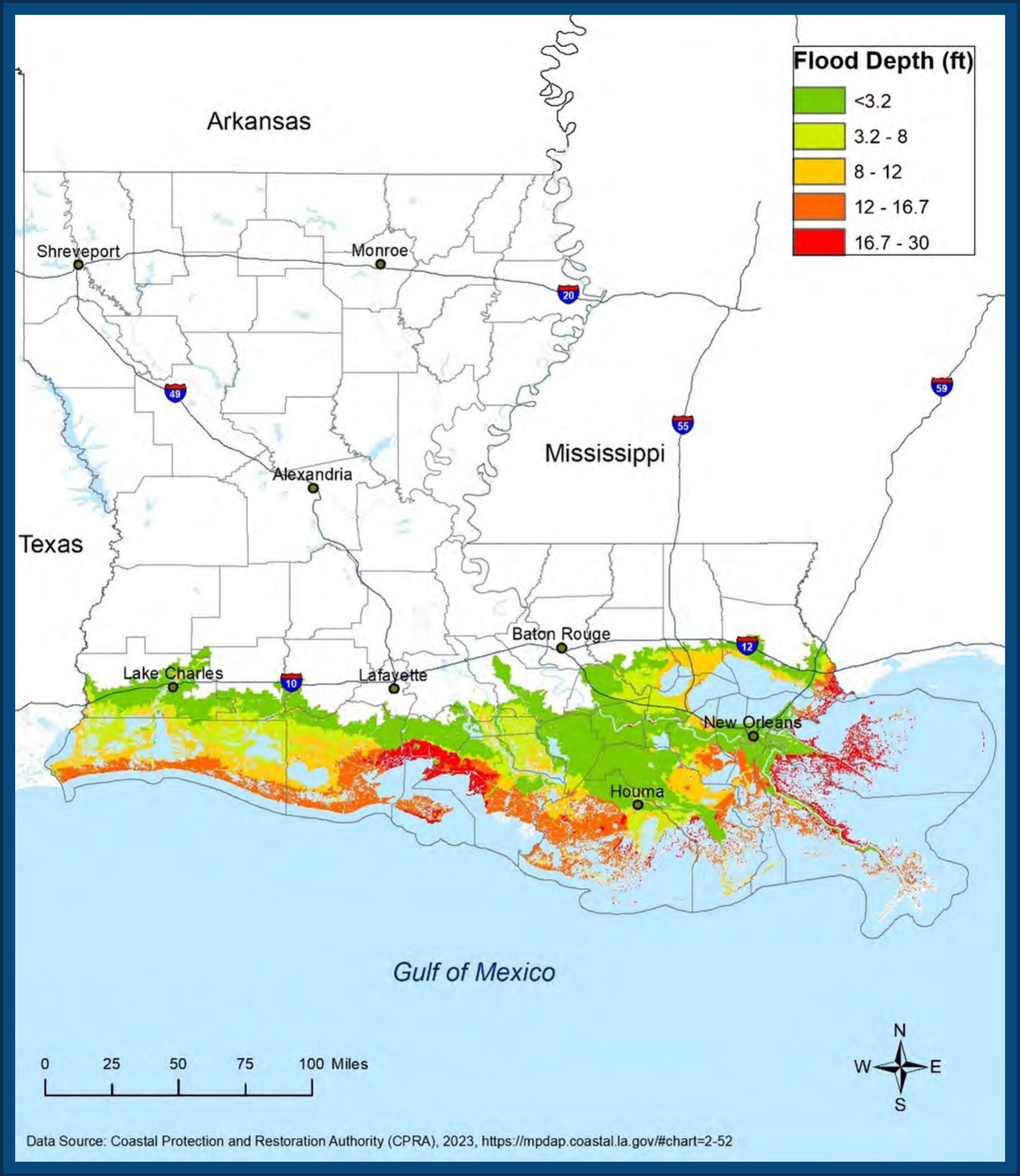
Risk Assessment

The projected property loss map shows the anticipated annual average losses due to flood hazards by census block.

100-Year Flood Inundation Area in Louisiana, 2023

Data Source: Jurisdictional Hazard Mitigation Plans, Various Dates, https://msc.fema.gov/portal,12/18/2023.

Predicted 100-Year Flood Coastal Inundation High Environmental Scenario with plan implementation, 2055



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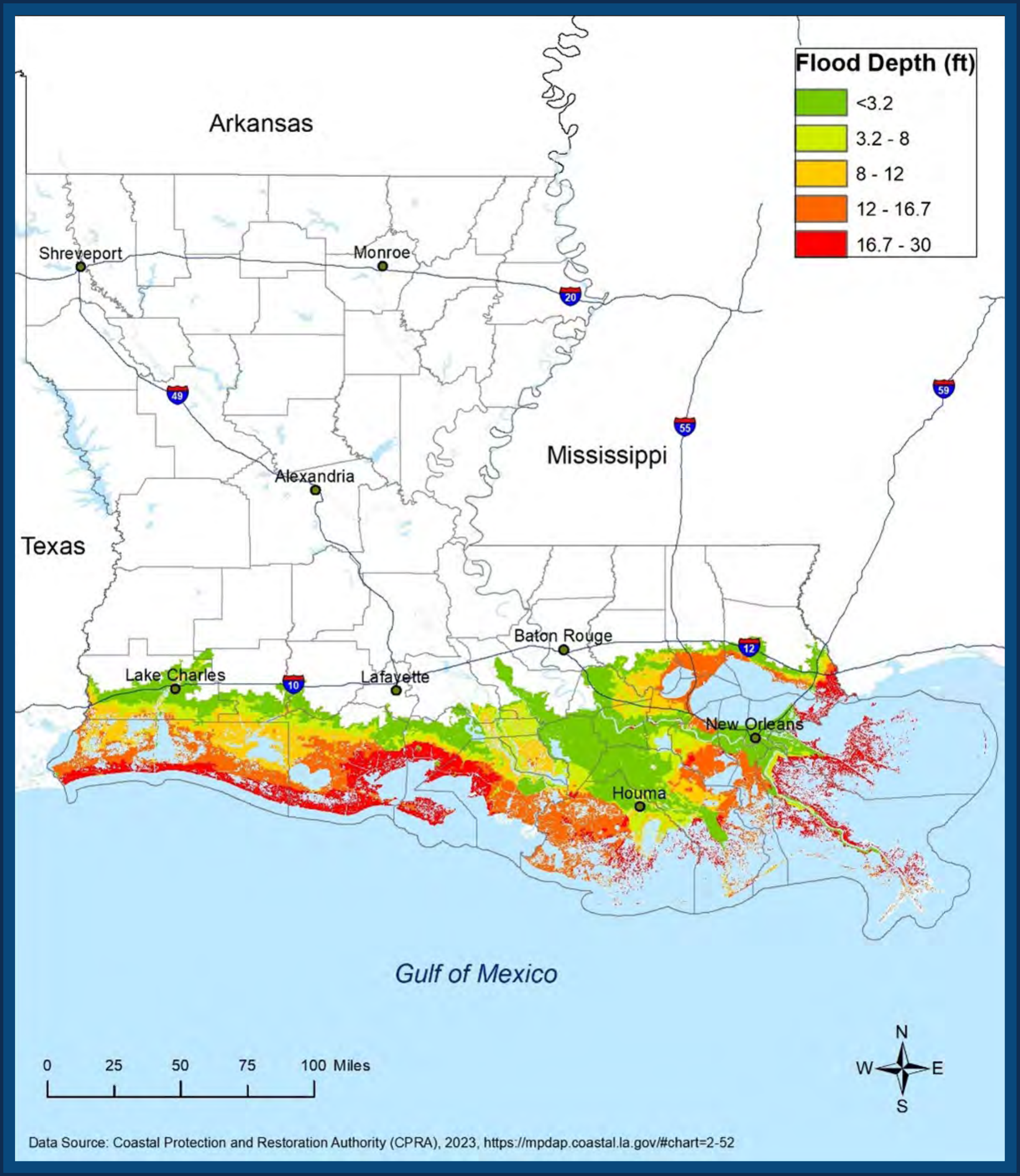
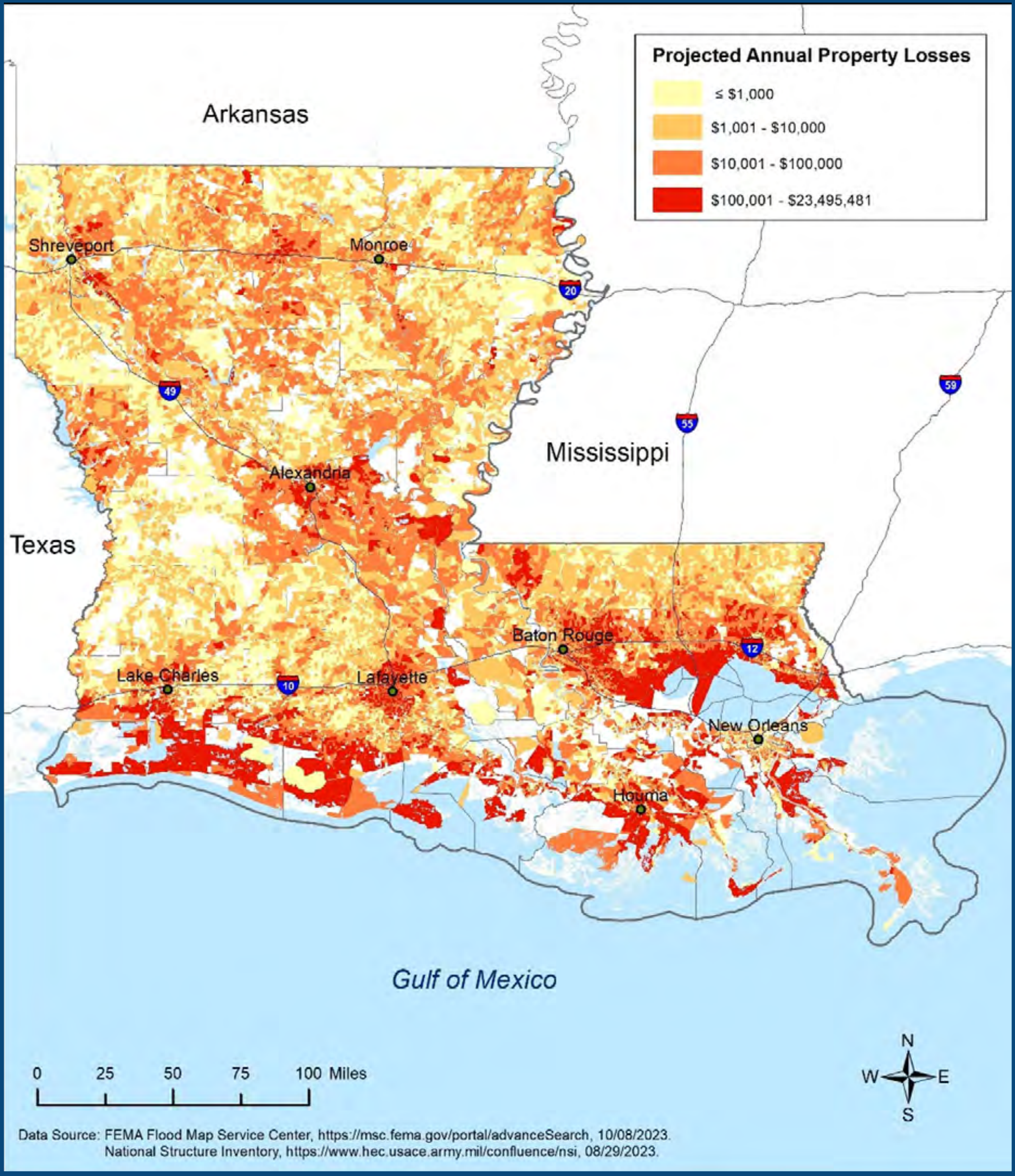
Predicted 500-Year Flood Coastal Inundation High Environmental Scenario with plan implementation, 2055



Projected Annual Property Losses from Flood by Census Block, 2050



DAM FAILURE

Overview

Dams are water storage, control, or diversion barriers that impound water upstream in reservoirs. Dams are a vital part of our nation's infrastructure, providing drinking water, flood protection, renewable hydroelectric power, navigation, irrigation, and recreation. These critical daily benefits are also inextricably linked to the potential harmful consequences of a dam failure.

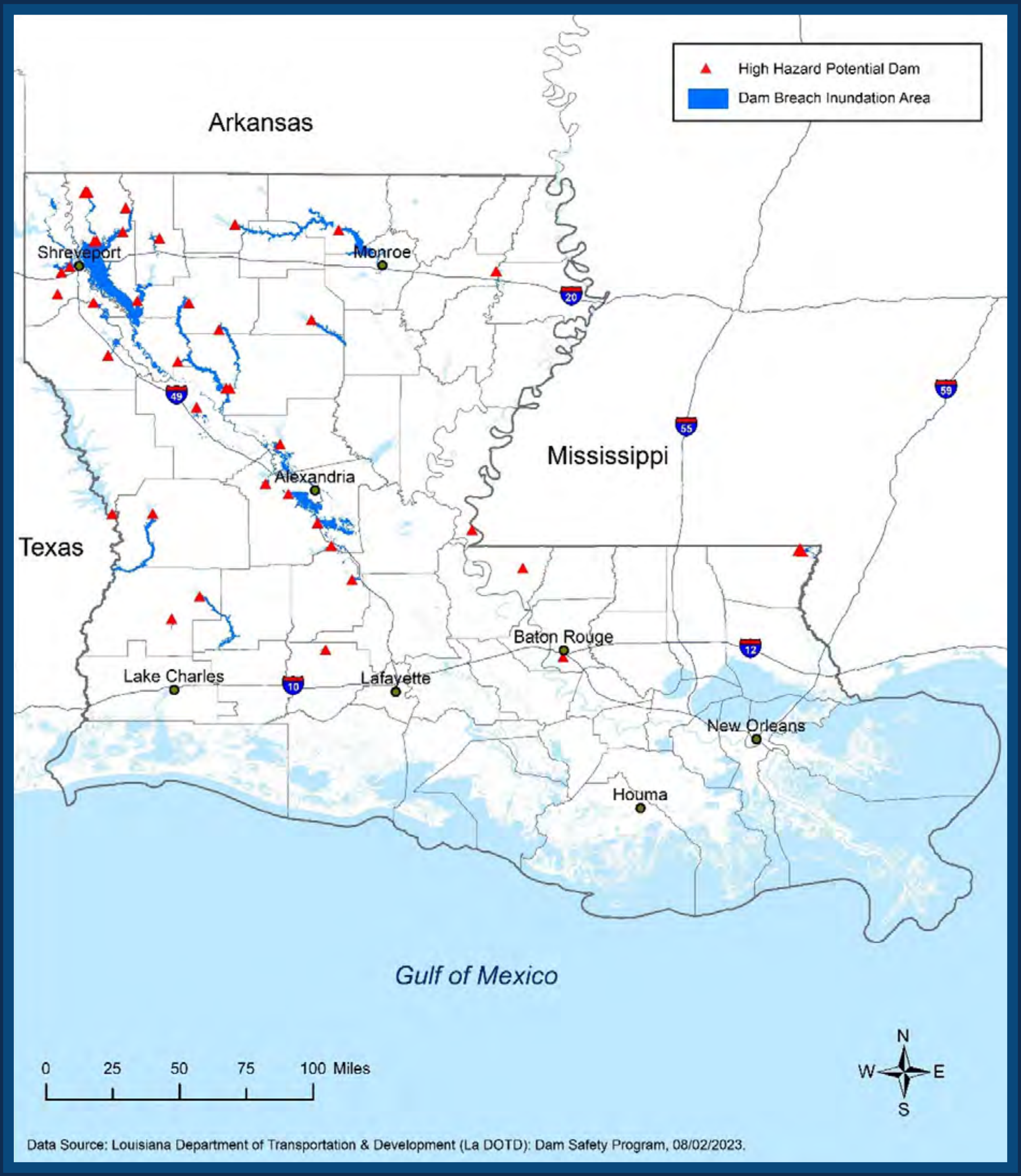
Dam failure is a collapse or breach in the structure that can result in severe loss of life, economic disaster, and extensive environmental damage. While most dams have storage volumes small enough that failures have few repercussions, dams with large storage volumes can cause significant flooding downstream. Dam failures often have a rapid rate of onset, leaving little time for evacuation. The first signs of failure may go unnoticed upon visual inspection of the dam structure. However, appropriate design and continual maintenance and inspection of dams often provide the opportunity to identify possible deficiencies in their early stages and can prevent a possible catastrophic failure event.

High hazard potential dams are dams where failure or improper operation will most likely cause loss of human life. According to the Dam Safety Program of DOTD Public Works & Water Resources, Louisiana has 42 high hazard potential dams. There have been zero high hazard dam failures in the state of Louisiana, although a threatened failure of the Percy Quin Dam in Mississippi following 2012 Hurricane Isaac resulted in a mandatory evacuation for Tangipahoa Parish. In 2021, an aqua-dam failure in Iberville Parish forced hundreds to evacuate. Because Louisiana does not have a history of high hazard dam failures, this section assumes a future probability of 0.0001 (0.01% annual probability) for dam failure in 2050.

Risk Assessment

A risk assessment was not performed due to the low probability of dam failure in Louisiana.

High Hazard Potential Dams in Louisiana, 2023



LEVEE FAILURE

Overview

Levees and floodwalls are flood control barriers constructed of earth, concrete, or other materials. For the purposes of this plan, levees are distinguished from smaller flood barriers (such as berms) by their size and extent. Berms are barriers that only protect a small number of structures, or in some cases, only a single structure. Levees and floodwalls are barriers that protect significant areas of residential, commercial, or industrial development; at a minimum, they protect a neighborhood or small community.

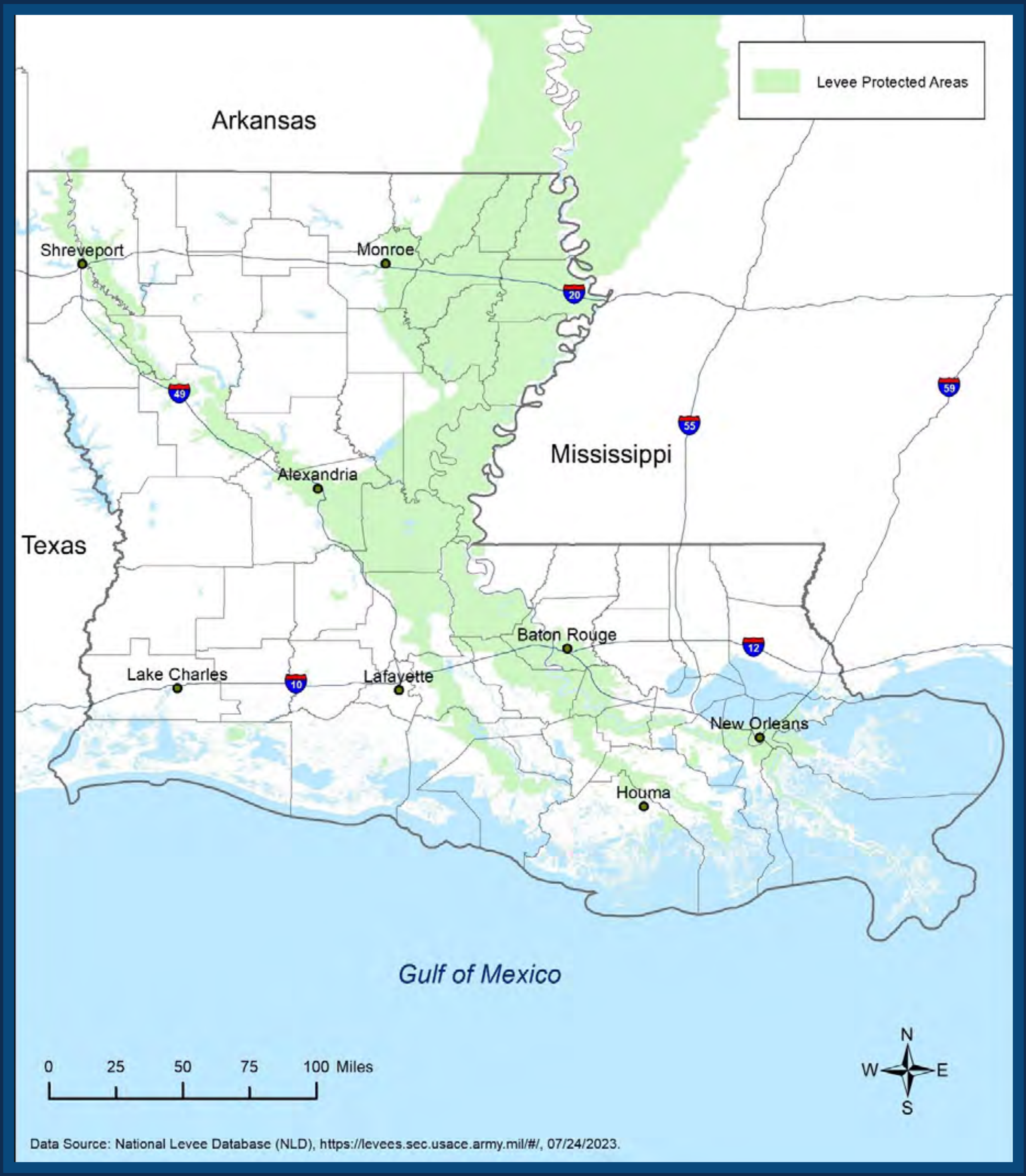
Levees are commonplace throughout Louisiana. Northern Louisiana is protected by levees on the Ouachita River, under the authority of the Vicksburg District of the U.S. Army Corps of Engineers (USACE). The Vicksburg District encompasses 68,000 mi2 in Arkansas, Mississippi, and Louisiana, and manages seven drainage basins, including the Yazoo, Pearl, Big Black, Red, Ouachita, and Mississippi Rivers; 12 locks and dams on the Pearl, Red, and Ouachita rivers; 1,808 miles of levees, including 468 along the Mississippi River; and multiple lakes with 1,709 mi. of shoreline. The New Orleans East Bank Levee System, comprising approximately 176 miles of Mississippi River Levees (MRL) and the Hurricane and Storm Damage Risk Reduction System (HSDRRS), is classified as Moderate to High risk, with ongoing armoring efforts to enhance resilience and reduce the potential consequences of overtopping or breach in St. Charles, Orleans, Jefferson, and St. Bernard parishes. The New Orleans West Bank Levee System, covering 115 miles with MRL and HSDRRS, is classified as Moderate to High risk, featuring locally operated MRL with USACE major maintenance, locally operated HSDRRS, ongoing armoring efforts, and completed 100-year risk reduction features, aiming to protect commercial and residential areas in St. Charles, Jefferson, Orleans, and Plaquemines parishes with an estimated population of 246,048 and assets valued at $41.1 billion. The following map illustrates the leveed areas in the Vicksburg and New Orleans Districts.

Levee failure involves the overtopping, breach, or collapse of the levee and can be especially destructive to nearby development during flood and hurricane events. The most well-known levee breaches in Louisiana occurred in association with Hurricane Katrina in 2005, when several sections along Lake Pontchartrain and along both navigation and drainage canals failed in New Orleans. The extent and depth of these levee failures resulting from Hurricane Katrina caused extreme flooding in New Orleans. However, given the quantity of levees in Louisiana, the annual probability of levee failure is 0.3%. The state has faced concerns about the potential breach of levees in cities such as Baton Rouge and New Orleans, prompting emergency measures to prevent failure and mitigate flooding.

Risk Assessment

Due to the low probability of occurrence and insufficient failure model data, a risk assessment was not performed.

Levee Protected Areas in Louisiana, 2023



GEOLOGIC HAZARDS

EARTHQUAKE

Overview

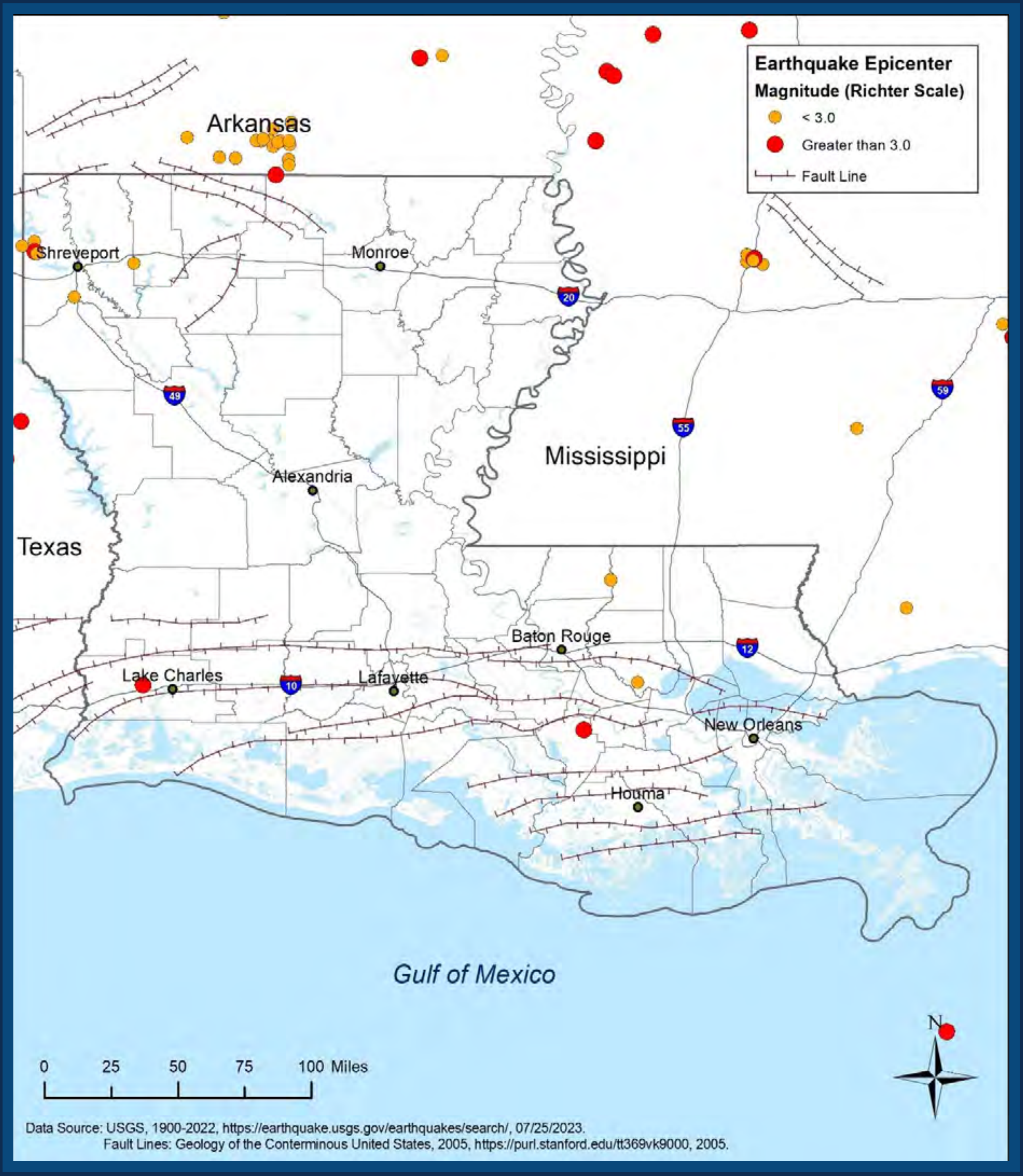
An earthquake is a sudden motion or trembling of the Earth caused by an abrupt release of stored energy in the rocks beneath the Earth's surface. The energy released results in vibrations known as seismic waves. Ground motion from seismic waves is expressed as peak ground acceleration (PGA), the fastest measured change in speed for a particle at ground level that is moving because of an earthquake. PGA is commonly measured as a percentage of acceleration due to Earth's gravity (%g). This measurement is considered in seismic load engineering design and construction requirements.

Based on historic events, the most severe earthquakes in the state are likely to occur to the very north (near the Arkansas–Mississippi border), originating from the New Madrid seismic zone, and to the south (near the coast) from the subsidence fault system. Nevertheless, the USGS has recorded only eight minor earthquakes in Louisiana in the past 25 years. Historically, earthquakes have caused minimal damage in Louisiana.

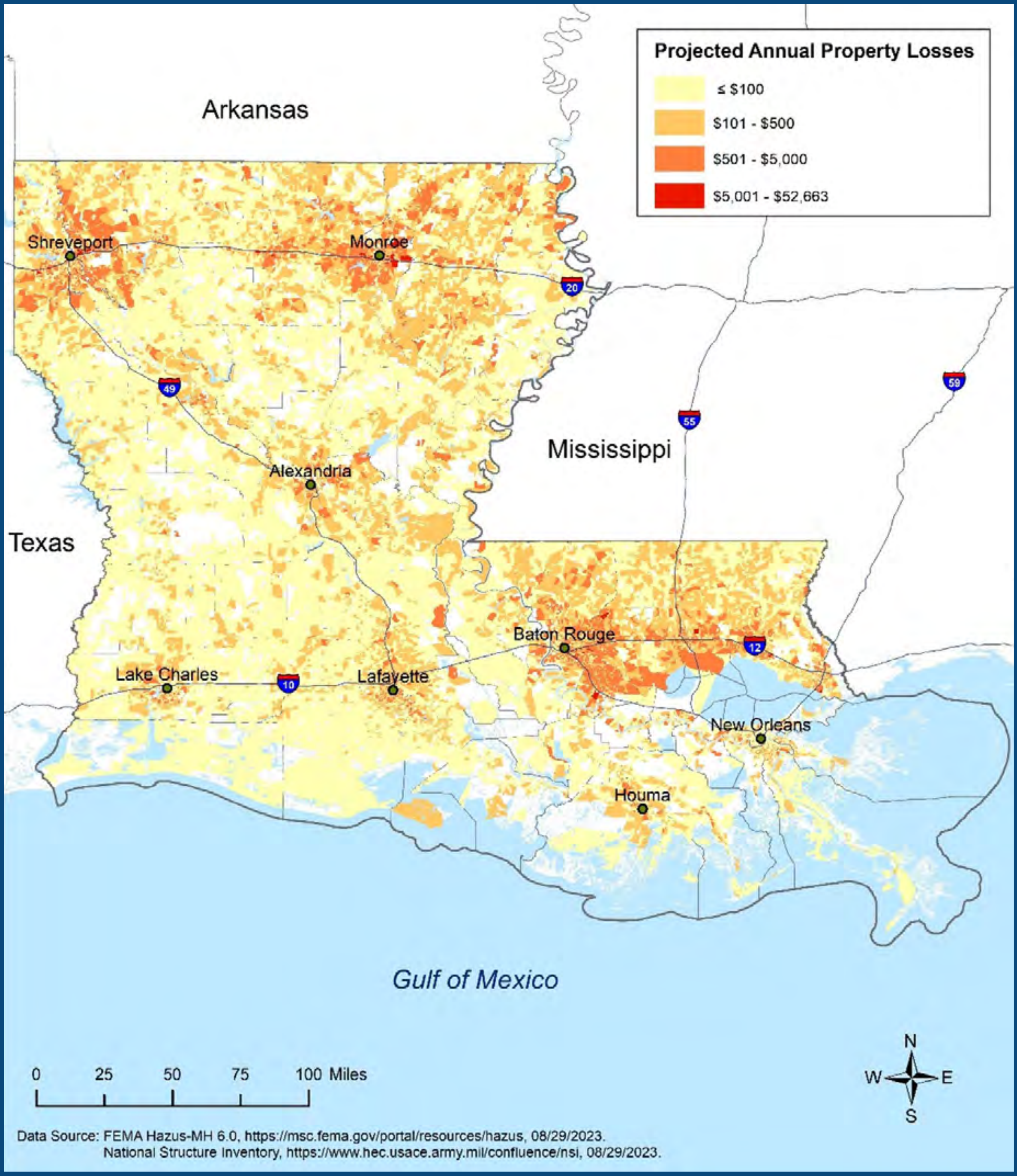
Risk Assessment

The projected property loss map shows the anticipated annual average losses due to earthquake hazards by census block using Hazus-MH.

Earthquake Events and Fault Lines in and near Louisiana, 1900-2022



Projected Annual Propety Losses from Earthquake by Census Block, 2050



SINKHOLES

Overview

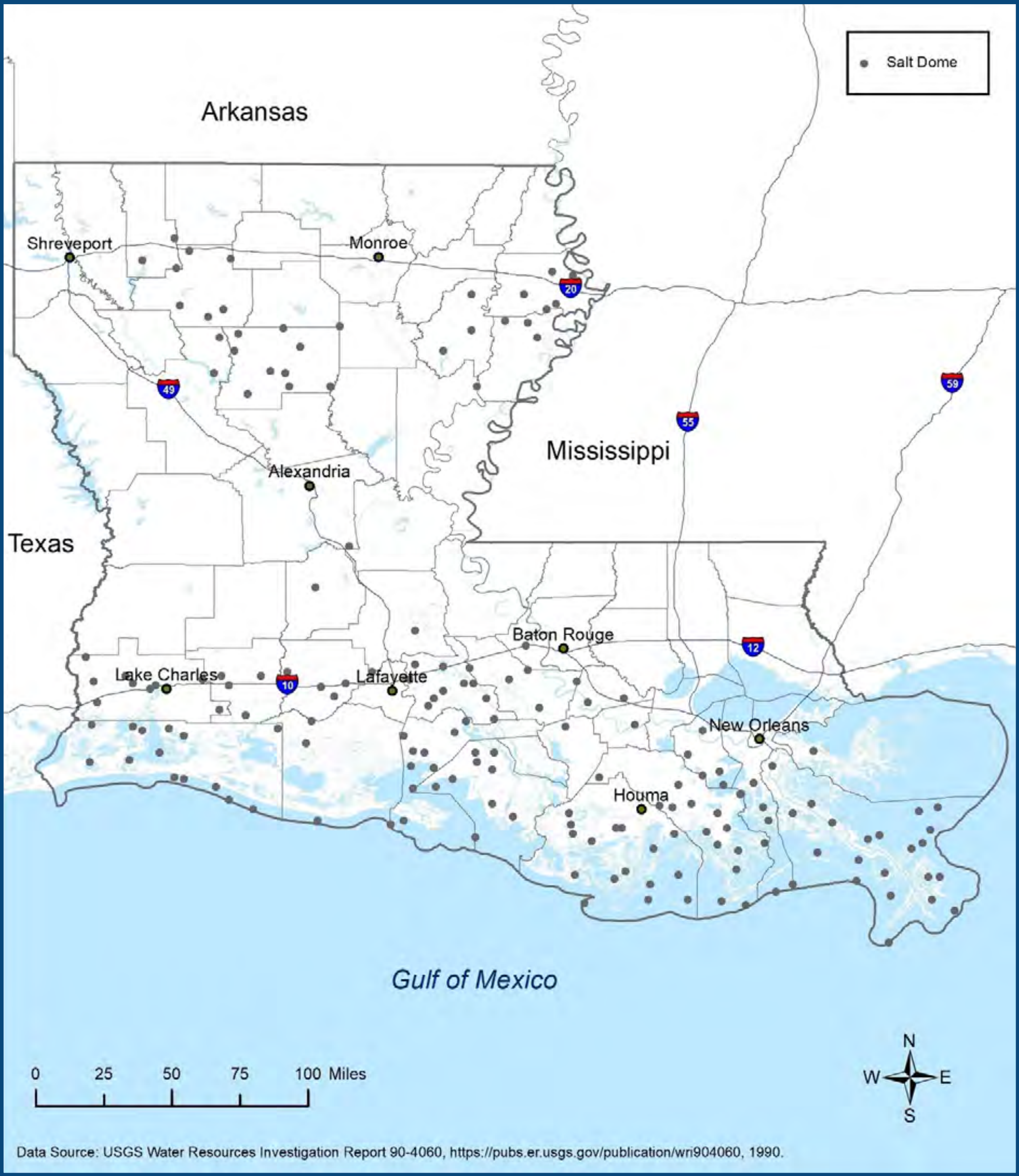
Sinkholes are areas of ground with no natural external surface drainage where the Earth's surface has collapsed. They vary in size from a few square feet to hundreds of acres and reach in depth from 1 to more than 100 feet. In Louisiana, sinkholes are typically formed when a natural salt dome is perforated, fills with water, and the salt dissolves, leading to failure of the surface.

Two recent Louisiana sinkhole events occurred at Lake Peigneur (Iberia Parish), which began to form in 1980, and at Bayou Corne (Assumption Parish), which formed in 2012. Both sinkholes were caused by the human-influenced collapse of salt dome caverns. Thus, future sinkholes are more likely to occur in locations that contain salt domes. Based on historic sinkhole formation, the future annual probability of sinkholes in 2050 is 0.01%.

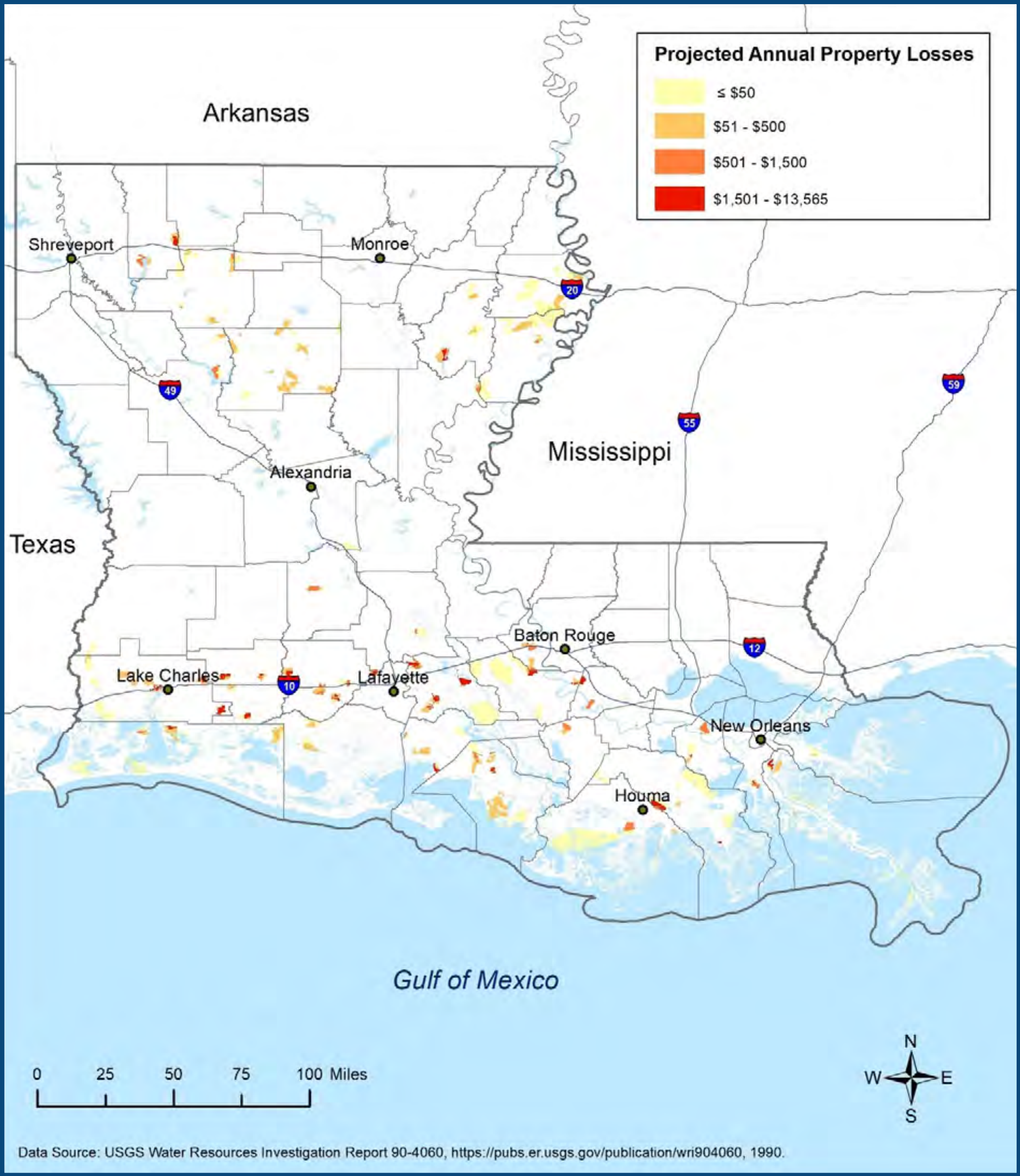
Risk Assessment

The projected property loss map shows the anticipated annual average losses due to sinkholes by census block.

Location of Salt Domes in Louisiana, 1990



Projected Annual Property Losses from Sinkhole by Census Block, 2050



EXPANSIVE SOIL

Overview

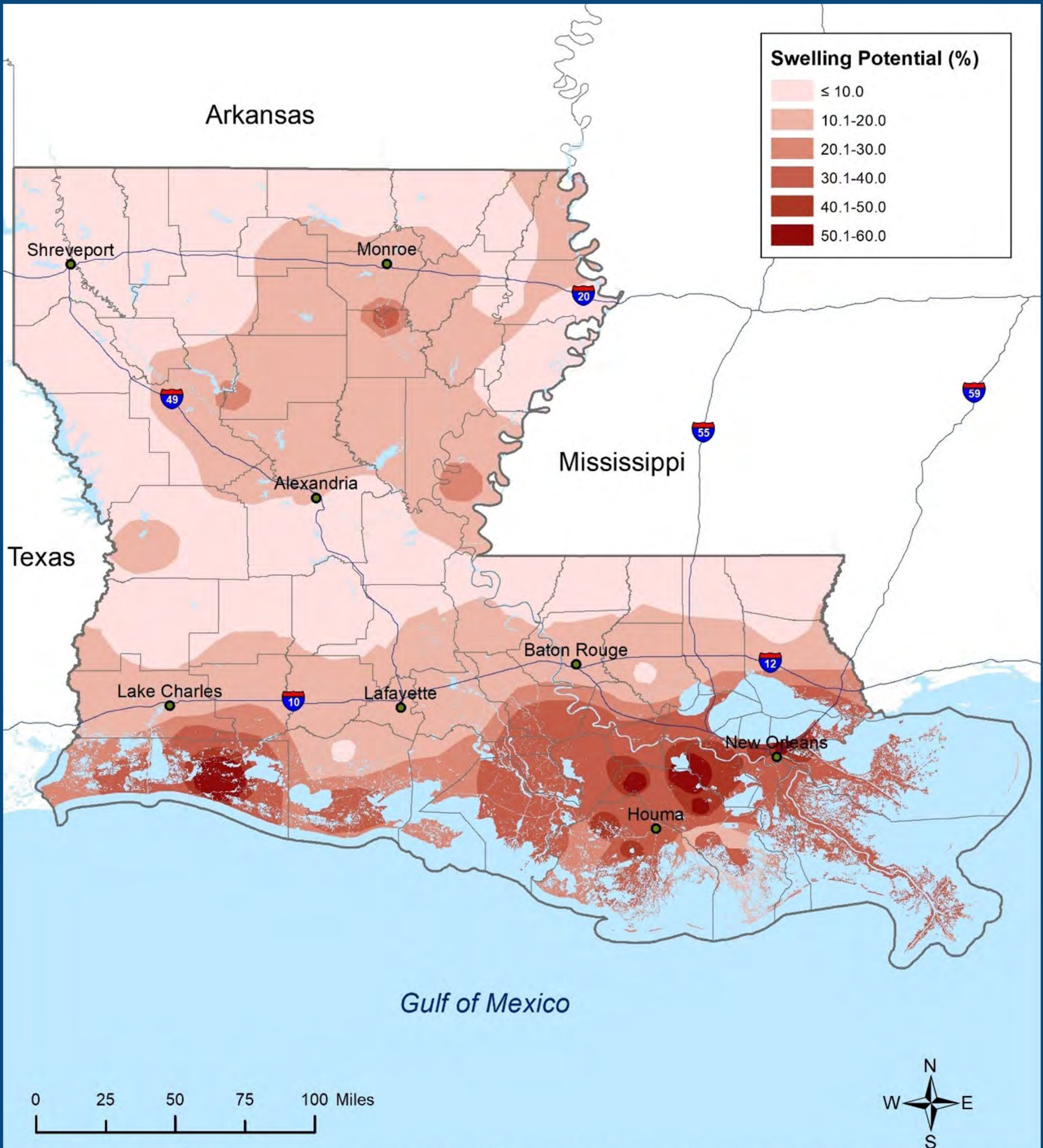
Soil and soft rock that tend to swell or shrink due to changes in moisture content are commonly known as expansive soil. Changes in soil volume present a hazard to lightweight structures built on expansive soil. Differential settlement of structures may occur, causing uneven shifting and settlement, cracks in the foundation and walls, and windows and doors that do not open properly. The American Society of Civil Engineers estimates that one-quarter of all homes in the U.S. are affected by expansive soil. Unlike the other hazards considered in this plan update, the effects of expansive soil are not manifested in a single event but rather become evident over time. Therefore, no significant past events exist for discussion.

Researchers at Louisiana Tech University previously predicted the swelling potential of Louisiana soil. The following map indicates the existing severity of potential soil expansion. No increase in swelling potential is projected for 2050; therefore, the current hazard map is used in the risk assessment.

Risk Assessment

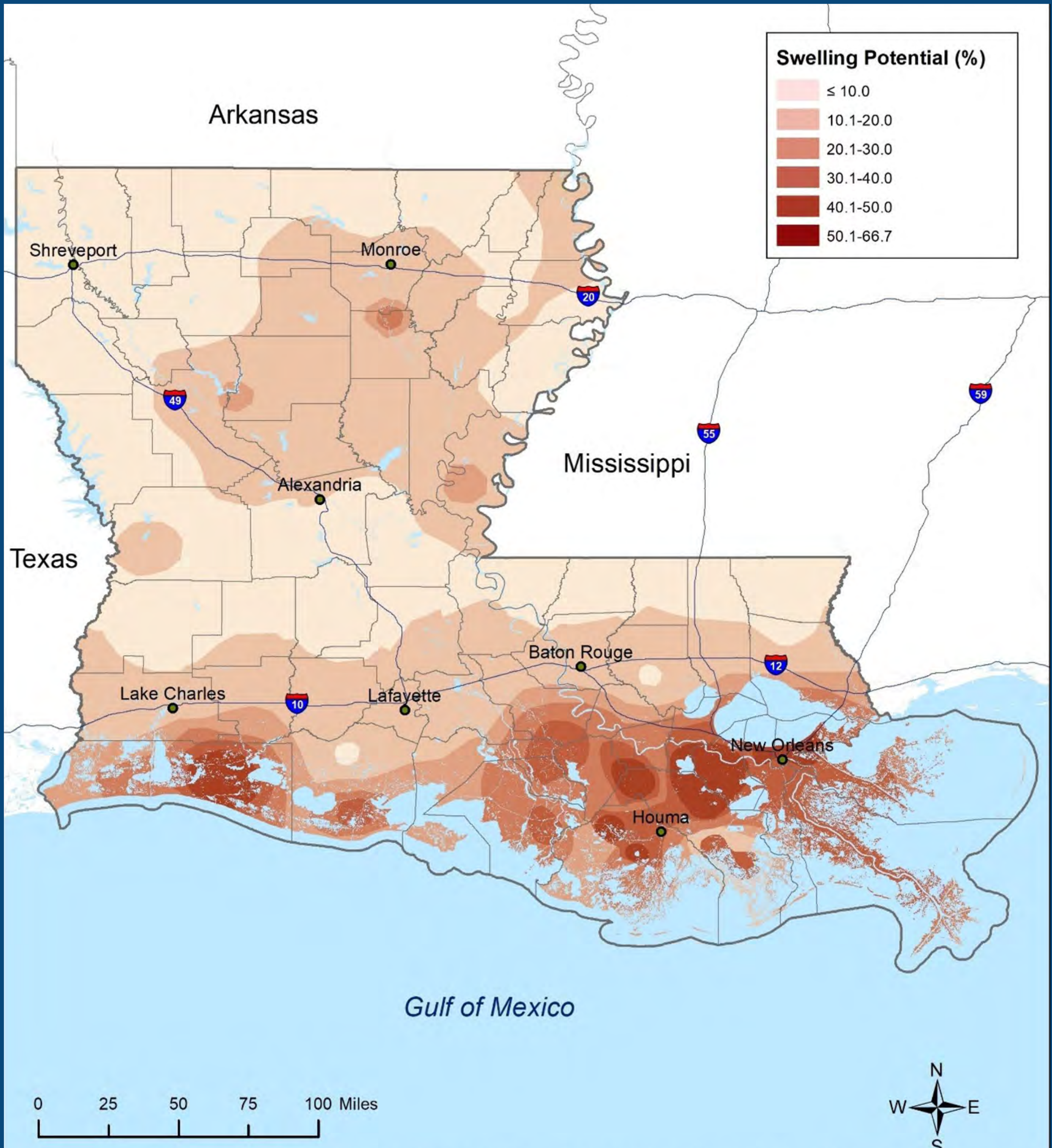
The projected property loss map shows anticipated annual average losses due to expansive soil by census block.

Expansive Soil in Louisiana: Swelling Potential Distribution, 2016



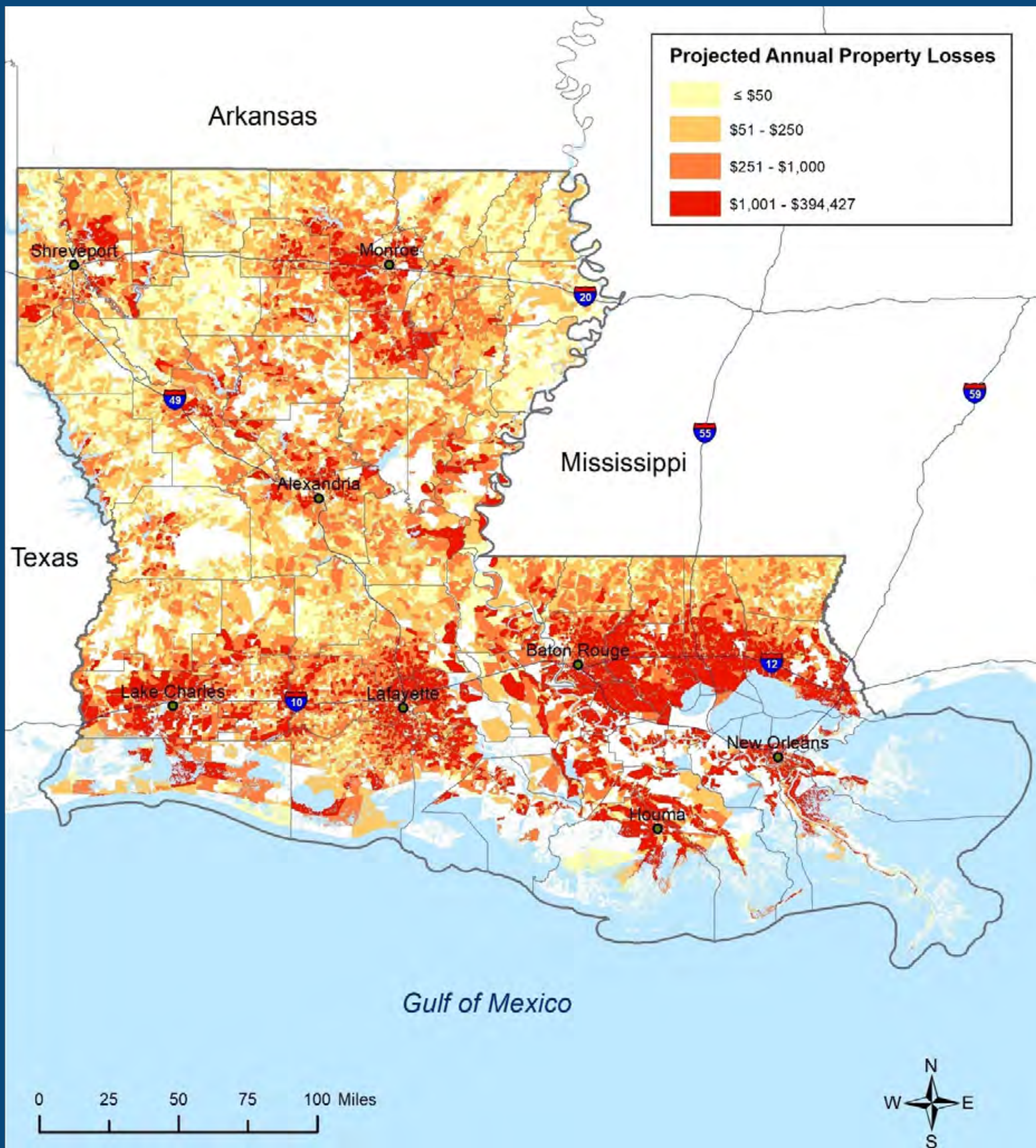
Data Source: Expansive Soils and Practice in Foundation Engineering, 2016, http://www.ltrc.lsu.edu/ltc_16/pdf/presentations/10-University%20Transportation%20Centers%20(Part%201)-Characterization%20of%20Expansive%20Soils%20in%20Northern%20Louisiana.pdf, 03/07/2016.

Projected Expansive Soil in Louisiana: Swelling Potential Distribution, 2050



Data Source: Expansive Soils and Practice in Foundation Engineering, 2016, http://www.ltrc.lsu.edu/ltc_16/pdf/presentations/10-University%20Transportation%20Centers%20(Part%201)-Characterization%20of%20Expansive%20Soils%20in%20Northern%20Louisiana.pdf, 03/07/2016.

Projected Annual Property Losses from Expansive Soil by Census Block, 2050



Data Source: Expansive Soils and Practice in Foundation Engineering, 2016, http://www.ltrc.lsu.edu/ltc_16/pdf/presentations/10-University%20Transportation%20Centers%20(Part%201)-Characterization%20of%20Expansive%20Soils%20in%20Northern%20Louisiana.pdf, 03/07/2016.