2. UNDERSTANDING IOWA

2.1 A Blip or a New Normal?

On June 30 and July 1, 2018, a thunderstorm that was producing localized heavy rainfall stalled over parts of central Iowa. During this storm, parts of the Des Moines metropolitan area received rainfall totals of 5-10 inches. At two National Oceanic and Atmospheric Administration (NOAA) weather stations in Ankeny, weather observers recorded 24-hour precipitation totals of 7.2-8.7 inches. While that amount of rain is already extremely high for a 24-hour period, two factors combined to supercharge the impacts of this event. The first was that this event followed the 10th wettest June in Iowa, which had 50% more rain than average. The second factor was the duration and intensity of rainfall. Nearly 9 inches of rain fell in a matter of hours. In the Fourmile Creek Basin near Ankeny, over the span of 6 hours, the discharge stream flow changed from a flow of 29 cubic feet per second (ft^3/s) and a gauge height of 2.4 feet (ft) to its record peak discharge of 10,000 ft^3/s and a gauge height of 16.2 ft. This peak discharge rate lasted for nearly 2.5 hours.

Figure 2.1: Precipitation for July 1, 2018 and the discharge measured by a streamgage near Ankeny

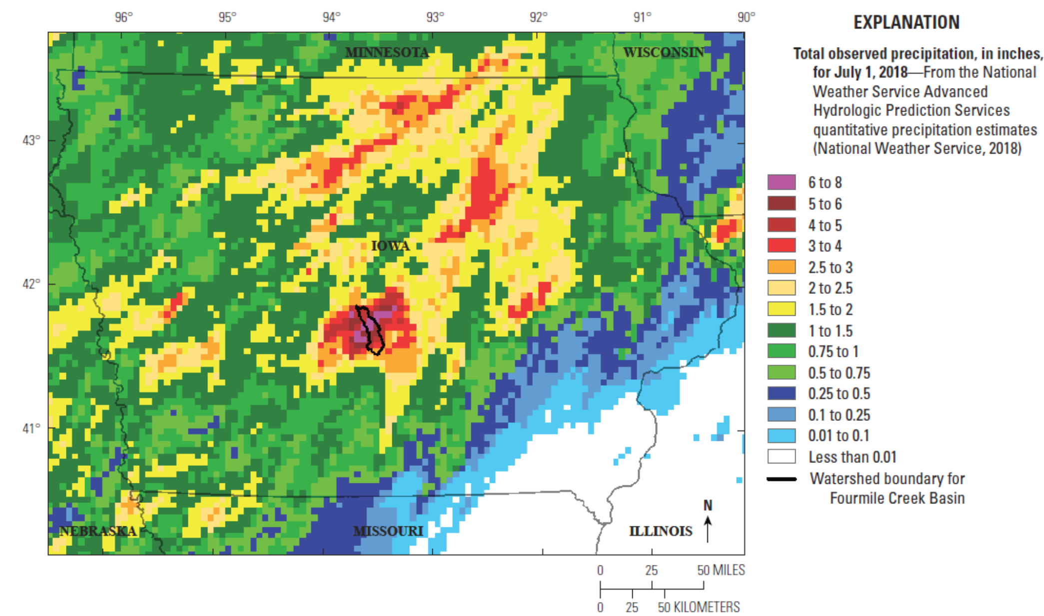
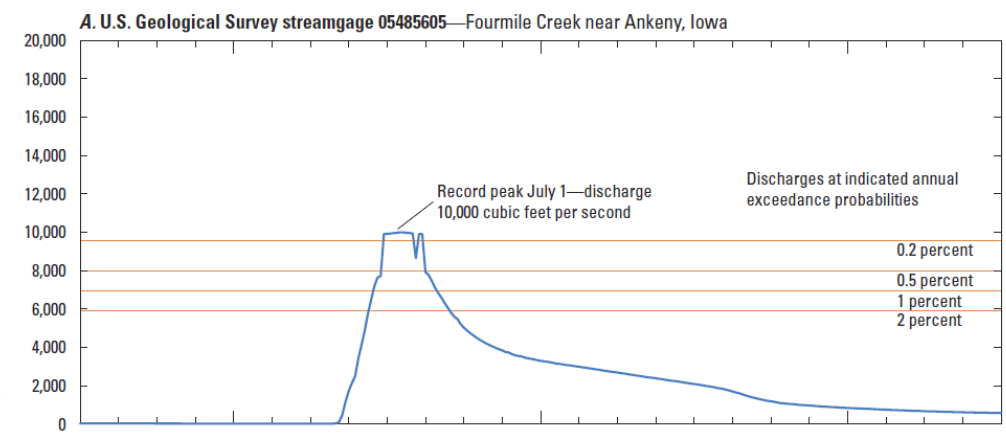


Figure 2. Advanced Hydrologic Prediction Service observed precipitation for Iowa on July 1, 2018, with an inset of the Fourmile Creek Basin watershed boundary (National Weather Service, 2018).



Source: National Weather Service

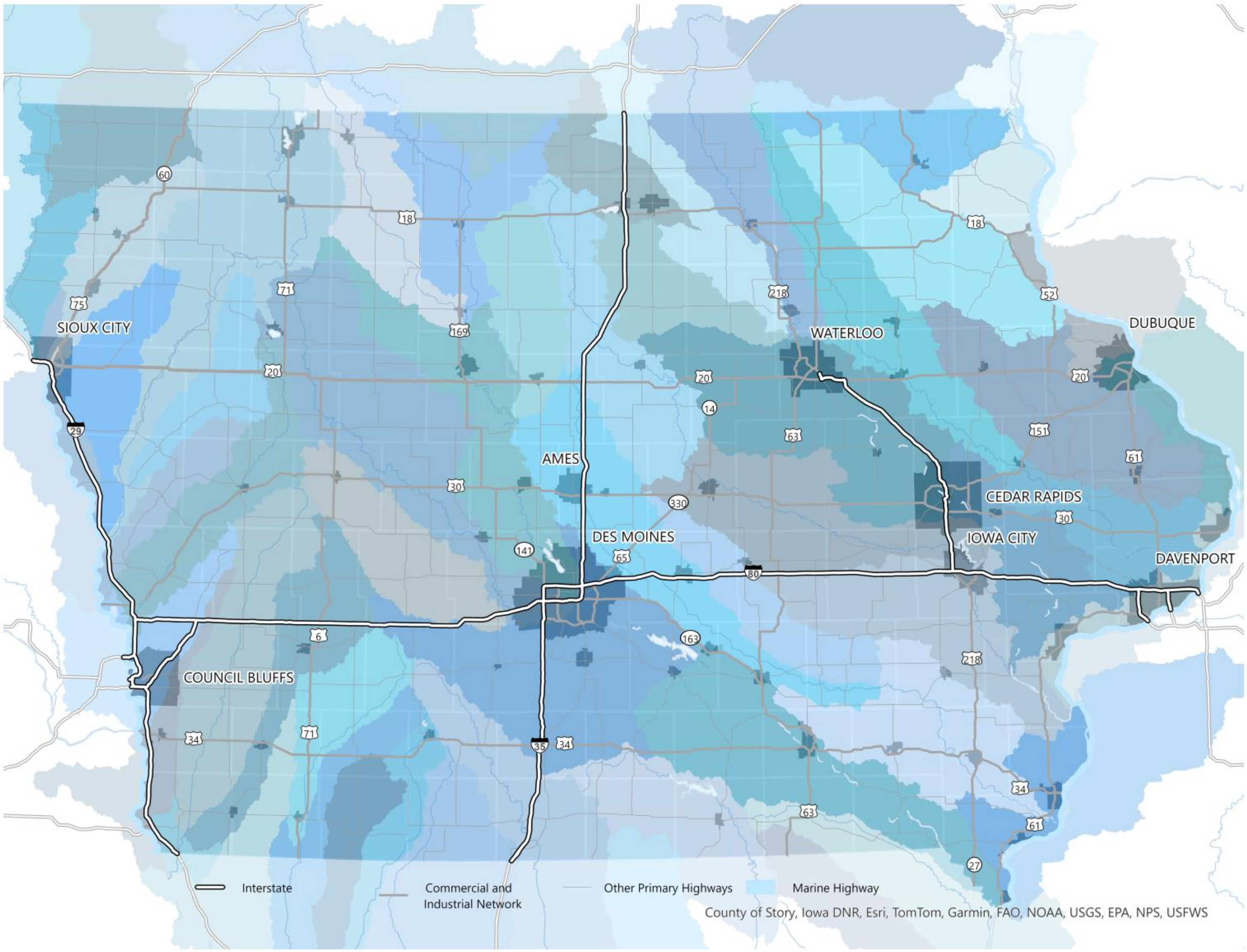
This event surpassed an annual exceedance probability (more commonly known as flood probability) of 0.2 percent, or a flood-recurrence interval of once every 500 years. Although short-lived, the event resulted in a fatality and a major disaster area being declared in Polk County and 30 other counties in Iowa. Damages in Polk County alone were estimated at over $15 million, nearly $1 million of which included damages to roadways and bridges. Extreme weather events like this have been occurring more frequently in the early 21st century. This trend in extreme weather events is not merely anecdotal or a blip, but a noticeable shift in weather, not only in Iowa, but across the globe. This chapter provides an overview of Iowa's geography and environment, the differences between weather and climate, Iowa's climate over time, and previous significant weather events that have occurred in Iowa. The chapter also provides a brief overview of Iowa's transportation system, which provides a foundation for understanding the interactions between hazards and infrastructure.

2.2 Iowa's Geography and Environment

Iowa's weather and climate is experienced through the lens of the state's topography and environment. Located in the north central portion of the country, most land within the state is rural and devoted to agricultural production. The state is bordered by the Mississippi and Missouri rivers, the nation's two longest rivers. The terrain is generally flat with rolling hills with the exception of two areas. The Driftless region in the far northeastern portion of the state is characterized by steep hills, forested ridges, deeply carved river valleys, and spring fed waterfalls and streams. In the western portion of Iowa are the Loess Hills, unique features formed from clay deposits blown eastward from the Missouri River that stretch north and south across the entire state will hilltops reaching nearly 200 feet.

Iowa has nearly 19,000 miles of interior rivers and streams, approximately 209 square miles of lakes and reservoirs, and 79 square miles of wetlands. All interior rivers in the state are part of either the Mississippi or Missouri River systems and can be subject to sudden fluctuations due to the nature of soils, intensive farming, small grain crops, and drainage. Iowa has 56 watersheds that range from 390 to 1,954 square miles in size and include 420 smaller basins. Understanding watersheds and river basins is critical for resiliency planning as infrastructure impacts from flooding are likely to be concentrated in these patterns. Woodlands can be found adjacent to the many rivers and streams and at the edge of agricultural land, as well as areas where the opportunity for agricultural production is limited by topography. There are numerous state, county, and municipal parks devoted to preserving woodland areas; the most prominent are the four major State Forests that consist of 43,917 managed acres.

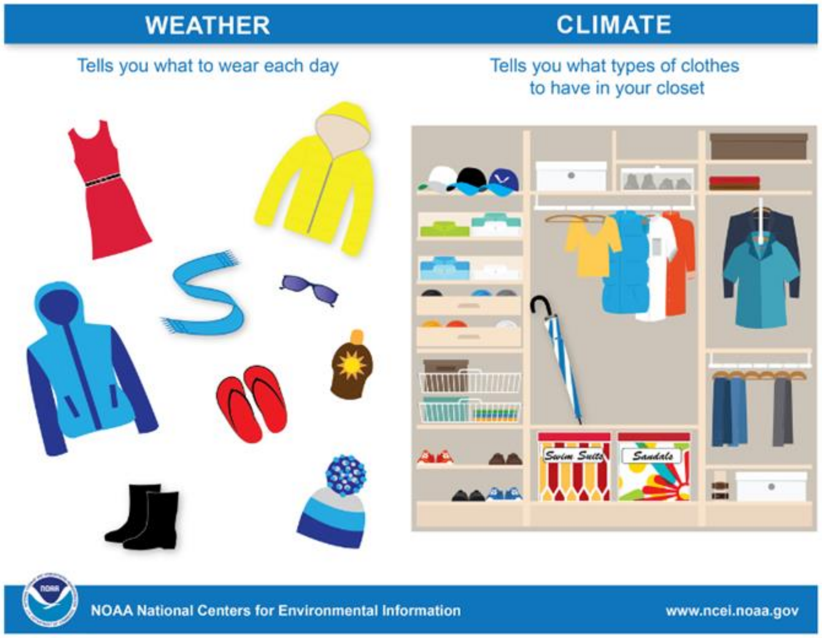
Figure 2.2: Iowa drainage basins



Weather vs. Climate

Although weather and climate are closely related, they are not the same. The U.S National Climate Assessment (NCA4) states that "weather" is a term applied to short-term, daily phenomena, while "climate" describes long-term trends related to averages and the prevalence and intensity of extremes. Weather can be described as a mix of events that happen each day in our atmosphere. These events vary in different parts of the world and can quickly change over time. Climate, on the other hand, describes what weather is like over time in a specific area or region. When describing climate for a particular location it is regularly done using long-term averages of temperature, precipitation, humidity, or wind, and often under the context of a specific season such as summer or winter. When evaluating a particular location, descriptions of an area's climate can provide a sense of what to expect, while weather gives us the short term anticipated conditions on any given day.

Figure 2.3: Weather vs. climate



Source: NOAA National Centers for Environmental Information (NCEI)

Iowa's Climate

All parts of the U.S. are experiencing subtle changes in in their climate, but the magnitude and impact of these changes vary from one region to the next. Iowa is located in the interior of North America and is largely exposed to incursions of bitterly cold air masses from the Arctic and warm humid air masses from the Gulf of Mexico. The state has a continental climate with hot, moist summers and cold, generally dry winters. Weather can be highly variable from season to season and year to year. With this variability comes extremes in weather events. These extreme events may become more frequent for Iowa as observational data collected over several decades show trends of increasing temperature and precipitation.

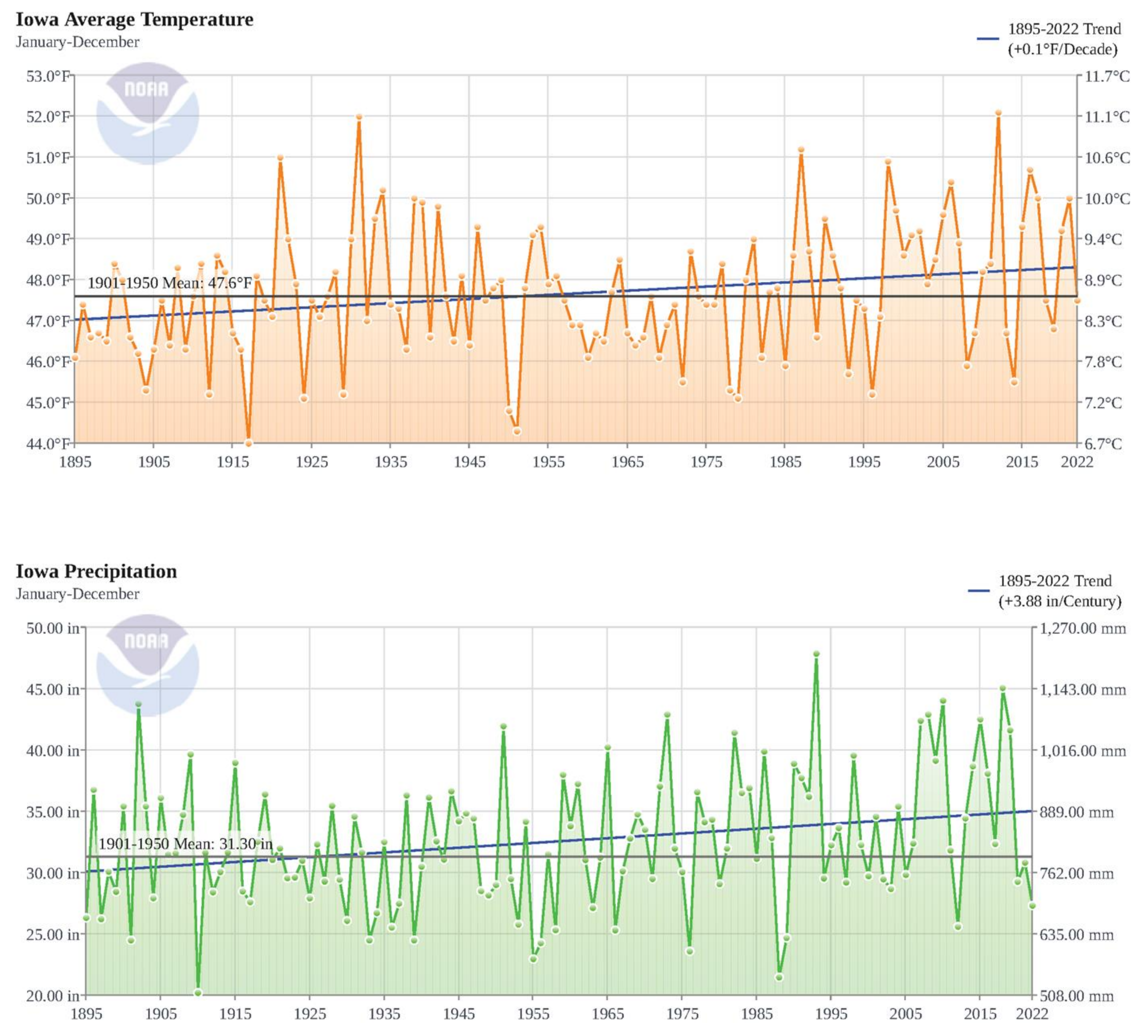
Temperature

Average temperatures in Iowa have risen more than 1 degree Fahrenheit (° F) since the beginning of the 20th century to 47.7° F. The hottest year on record was 2012, with an average of 52.1° F. Averages only portray part of the story, as the nuance to temperature trends is when specifically these increases are occurring throughout the day and year. The increasing trend is mostly attributed to increases in nighttime minimum temperatures. From a seasonal perspective, warming temperatures have been more concentrated during Iowa's fall and winter seasons.

Precipitation

Precipitation in Iowa can be highly variable, with southeastern portions of the state generally receiving more than northwestern portions. Most precipitation that falls in Iowa does so in the summer, which averages about 14 inches of rain per year for the central part of the state. In general, average precipitation has been increasing, with springtime precipitation being above average since 1990 and annual and summertime precipitation being above average since 2005. One notable trend has been the seasonality of precipitation, as much of it occurs in the first half of the year, leading to wetter springs and drier autumns. Similarly, Iowa has been experiencing more intense rainfall, with the frequency of 2-inch extreme precipitation events increasing over the last few decades.

Figure 2.4: Iowa annual average temperature and precipitation, 1895-2022



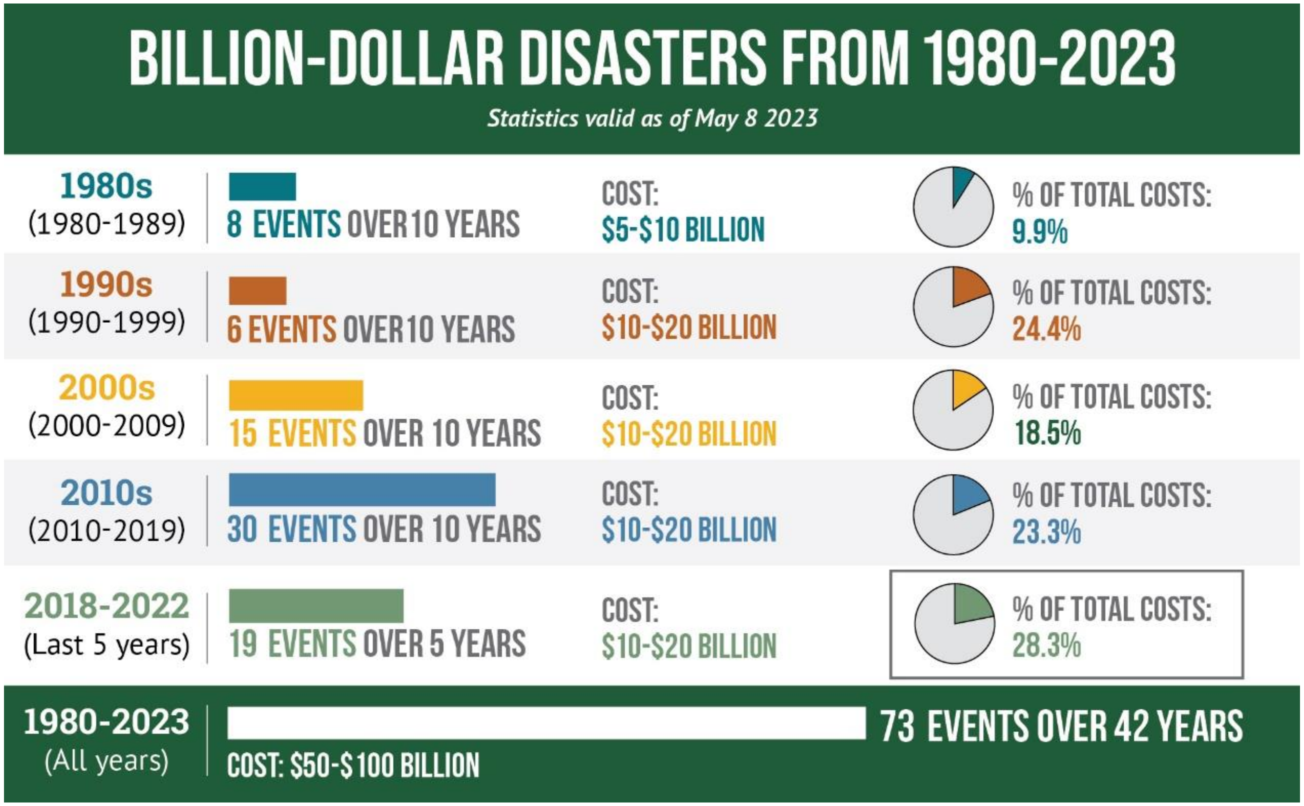
Source: National Oceanic and Atmospheric Administration (NOAA)

Significant Weather Events

With the increasing trends in warmer temperatures and precipitation in Iowa, there has also been an increase in the frequency, severity, and cost of weather events. The National Centers for Environmental Information (NCEI) tracks the nation's severe weather and climate events. As part of this responsibility, NCEI evaluates weather events that have great economic and societal impacts, including those that exceed $1 billion in cost. Figures 2.5 and 2.6 provide a comparison of the billion-dollar events that have occurred in Iowa by each decade since 1980 (the earliest year available).

Since 1980 Iowa has had 73 events with an estimated Consumer Price Index (CPI) adjusted cost exceeding $1 billion. From 1980 to 2023, Iowa has averaged just under two of these events per year. However, the frequency has increased as Iowa has averaged over three billion-dollar events per year since 2010. Over 28% of the total costs of natural disaster events since 1980 have occurred within the last 5 years.

Figure 2.5: Major disasters in Iowa since 1980 by time period



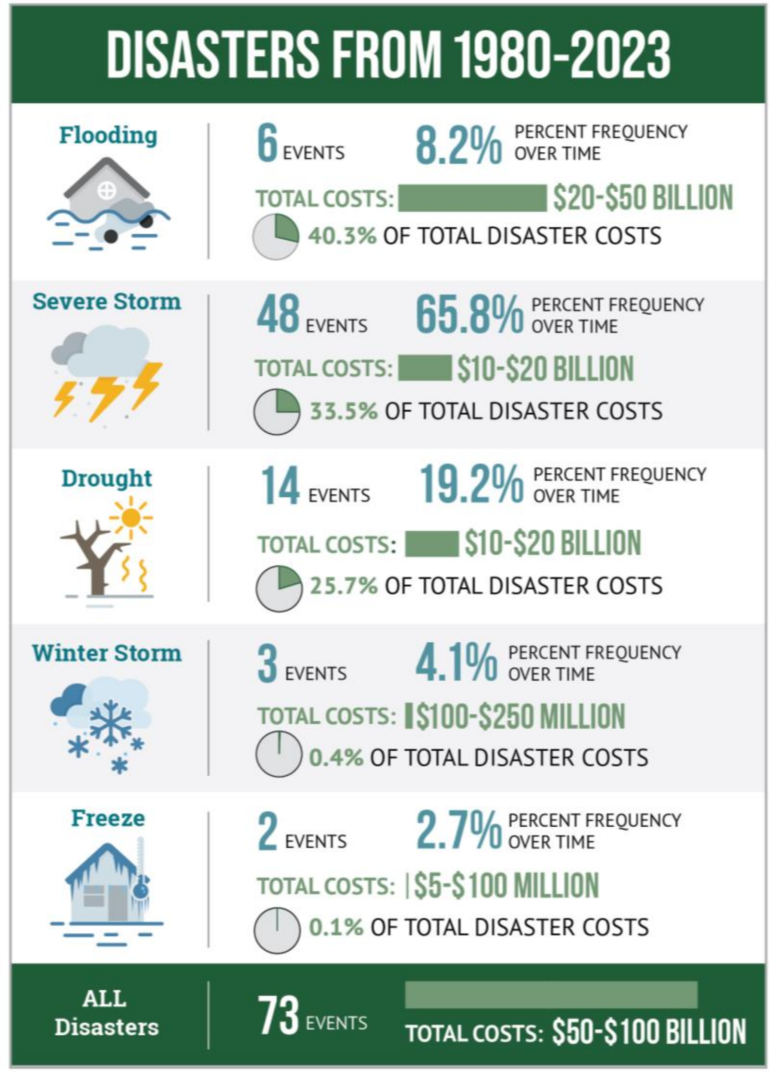
Source: NOAA NCEI

Escalating frequency and costs

The last five years have seen over 26% of the occurrences and over 28% of the costs of natural disaster events that have happened since 1980.

The most frequent types of disasters impacting Iowa since 1980 are severe storms, which occurred 48 times. Although flooding events occur quite frequently in Iowa, only six have exceeded the billion-dollar threshold. Despite the low count, flooding has still been the costliest of these disasters, representing just over 40% of the total cost of all billion-dollar events in the state during this timeframe.

Figure 2.6: Major disasters in Iowa since 1980 by type



Source: NOAA NCEI

Some recent significant weather events are all too familiar to residents in Iowa, and are often referred to in shorthand with names like “The Great Flood of 1993”. What makes a particular event memorable or significant comes from a combination of factors, including cost to the state and its residents, duration of the event, and the geographic extent. The following significant weather events are some of the more well-known and costly in Iowa’s recent history.

The Great Flood of 1993

From April through October, Iowa and much of the Midwest was devastated by flooding of both the Mississippi and Missouri rivers and their respective tributaries. There were numerous factors that contributed to the flooding, including above normal soil moisture, persistent precipitation, and snowfall. The flood resulted in over 50 deaths (in Iowa and other states) and damages approached $15 billon ($44.4B CPI adjusted). Over the course of this event, flood waters receded and returned as many as five times in some locations before the disaster was officially over.

Parkersburg Tornado, 2008

On May 25th, a strong supercell developed in northeast Iowa and resulted in one of the strongest tornados in the state’s history. After touching down just south of Aplington, the tornado eventually traveled east towards Parkersburg and became extremely violent, intensifying to EF5 strength. As the tornado continued, it leveled much of the town of Parkersburg and the neighboring town of New Hartford. Nine individuals lost their lives and over 70 were injured. The tornado resulted in an estimated $75 million in damages.

Iowa Flood of 2008

In June, a major flood event impacted most of the rivers and tributaries in eastern Iowa. The most significant flooding occurred in the Cedar Rapids and Iowa City areas. Flooding records in many locations were greatly surpassed, including in Cedar Rapids where the flood waters crested at 31.1 feet on June 13th. This flood event is one of the costliest flooding events in Iowa’s history with estimated damages of over $6 billion.

Blizzard of 2009

On December 8th and 9th, a long-lived storm system brought heavy amounts of snow and blizzard conditions to Iowa. Snow totals measured between 8-15 inches and all 99 counties were under a blizzard warning. Drifting snow caused many roadways to be impassable and residents across the state were unable to access vehicles and homes. This was the first of many storms that impacted the state during the winter of 2009-2010.

Missouri River Flood, 2011

Record snowfall in the Rocky Mountains of Montana and Wyoming and near-record spring rainfall contributed to trigger significant flooding along the Missouri River.

Drought of 2012

Much of the Great Plains, including Iowa, suffered through an intense but relatively short-lived drought characterized by both a lack of precipitation and excessive heat, particularly in the month of July. Some locations in Northwest Iowa recorded the second driest summer on record.

The Great Flood of 2019

In March, a major flood impacted the Missouri River and its tributaries in Nebraska, Missouri, South Dakota, Iowa, and Kansas. The duration lasted well into the fall as multiple rounds of flooding damaged areas repeatedly. At least one million acres of farmland in nine states were flooded. The event resulted in an estimated $1.6 billion in property damage in Iowa alone.

Midwest Derecho, 2020

On August 11th, a powerful derecho (a widespread, long-lived, straight-line windstorm) impacted large swaths of the Midwest, primarily in Nebraska, Iowa, Illinois, Wisconsin, and Indiana. The highest winds were measured in Iowa at nearly 126 mph. The derecho caused over $11 billion in damages.

Winterset Tornado, 2022

A significant early spring tornado outbreak occurred during the afternoon and evening hours of March 5th. One of the largest of these was an EF 4 tornado that caused damage near the towns of Winterset and Norwalk, resulting in six fatalities.

What Do These Trends Mean?

The observational trends of increasing temperature and precipitation along with the increasing number of costly and significant weather events establish a pattern of changes in Iowa's weather and climate. Assuming these trends continue, conditions in Iowa will gradually evolve over time to include more extreme weather events and highly variable weather patterns. In projecting these changes, scientists often refer to trajectory models of greenhouse gas (GHG) emissions called representative concentration pathways (RCP). The NCA4 analyzes the effects of two scenarios: one in which GHG concentrations continue to rise and temperatures rise by 5.8 to 9.7°F by the end of the century (known as RCP 8.5), and one in which GHG concentrations are significantly reduced by midcentury and warming is limited to 3.1 to 5.8°F at the end of the century (known as RCP4.5). NCA4 suggests that a lower GHG concentration scenario (e.g., RCP 1.9 or 2.6) would require significant and immediate reductions in carbon and methane concentrations. The lower end of this range still carries with it the effects already seen, but likely more severe. The higher end of this range could lead to a series of catastrophes. We will not likely see either extreme, but rather somewhere in the middle – an intermediate or mid-high GHG concentration scenario, such as RCP 4.5 or 6.0, respectively. Still, a mid-range temperature increase would result in a very different world than what existed in the 20th century, including more frequent and intense natural disasters and fragile, fluctuating ecosystems and agriculture.

The shifts in Iowa's climate and weather will occur gradually and compound over time. Some years may see variability and extremes in the weather, while other years may seem more average or mild. Over time, these changes will have wide-ranging impacts to the various sectors within Iowa, including transportation. The most direct impact to transportation will be in the form of hazards to the system. The trends in Iowa's weather and climate point to increased variability and more significant impacts from these hazards.

2000 vs. 2100

A mid-range temperature increase by the end of the 21st century would result in a very different world than what existed in the 20th century, including more frequent and intense natural disasters and fragile, fluctuating ecosystems and agriculture.

Table 2.2: Projected changes in Iowa's weather and climate

Near-term: Next 20-30 years	Long-term: By 2100
Annual average temperatures at least 2.4F higher compared to the first half of the 20th century, according to NOAA.	Trend continues.
Increased heat waves. • Most of Iowa is projected to see about one extra month per year of daily high temperatures above 90° F than was observed from 1961 to 1990, according to the U.S. Climate Resilience Toolkit.	More extreme heat waves. • Most of Iowa is projected to see about six weeks more per year above 90° F than was observed from 1961 to 1990, according to the U.S. Climate Resilience Toolkit. In some areas, there may be nearly four months of these hot days. • Iowa is projected to see at least a tenfold increase in days per year above 100° F than was observed from 1961 to 1990. With higher GHG concentrations, the increase in some counties may be closer to a hundredfold, with some seeing several weeks over 100° F per year. • Decreased yields due to heat stress despite higher CO_2, according to NCA4.
Increased humidity. • Leads to increased spring rainfall, soil erosion, and fewer days suitable for fieldwork during planting season.	Trend continues.
Lower air quality. • Warmer temperatures lead to higher surface-level ozone. NCA4 notes that higher ozone levels could lead to 200 to 550 more premature deaths annually across the Midwest by 2050. Livestock are also vulnerable to higher ozone levels.	Trend continues.
Frost-free seasons increasing by up to 10 days by 2045 and 20 days by 2065 compared to the period of 1976-2005, according to NCA4 (these numbers are projections under the RCP 8.5 scenario).	Frost-free seasons increasing by 30 days compared to the period of 1976-2005, according to NCA4.
Increased heavy precipitation and flooding events.	Increases in precipitation are projected for Iowa, most likely during the winter and spring.
Increased drought. • With warmer air, the atmosphere pulls more moisture from plants, leading to increased tree mortality and stressed crops. • Decreased corn yields due to heat stress, despite longer growing season and higher CO_2. • Decreased snowpack and early spring melts may lead to lower stream flows at times (combined with high heat will drive demand for water).	Trend continues.

2.3 Iowa's Transportation System, Resources, and People

To understand how the weather and climate trends are likely to impact transportation in Iowa, it is important to provide some context for the transportation system, important facilities and resources, and Iowa's population.

Transportation System

Iowa has an extensive highway system complemented by a vast secondary (county) and municipal (city) roadway network. Among the 50 states, Iowa ranks fifth in rural roadway miles. In addition to this expansive roadway system, other transportation options include the following. Full inventories of these modes are available in the SLRTP.

- A variety of **bicycle and pedestrian accommodations** such as multiuse trails, side paths, sidewalks, and on-road bicycle accommodations
- **Public transit** service availability in all 99 counties
- **Passenger transportation options** such as intercity bus service, paid rideshare, and other shared transportation options
- **Freight and passenger rail** service
- Commercial, general, and freight **aviation** service
- Mississippi and Missouri **waterway systems**

The state's roadway system is the predominant mode of transportation for both passenger and freight traffic. A little over 60% of total Vehicle Miles Traveled (VMT) and over 90% of large truck VMT occurs on the Primary Highway System, owned by the Iowa DOT. Most Primary Highway System traffic occurs on the National Highway System (NHS), which includes Interstates, Iowa's Commercial and Industrial Network, and other key highways for traveling across the state.

The state's highway system provides the backbone for the overall transportation system. It is a mature and extremely accessible network that provides a high level of mobility throughout the state. While there are locations that can experience bottlenecks or congestion, the vast majority of the highway system operates smoothly. Highways are typically the focus for resiliency planning given their critical role in facilitating most transportation throughout the state. However, the other modes of transportation are also key considerations, both in terms of their resiliency to hazards and the role they play in helping to move people and goods in times of crisis. Access to Iowa's diverse range of modal options is critical during times of disruptions.

Getting from A to B

Almost the entirety of the state's land area is **within ten miles** of an Iowa DOT highway. The system's criticality in traveling throughout the state reinforces the importance of increasing its resilience.

Figure 2.7: Iowa DOT highways

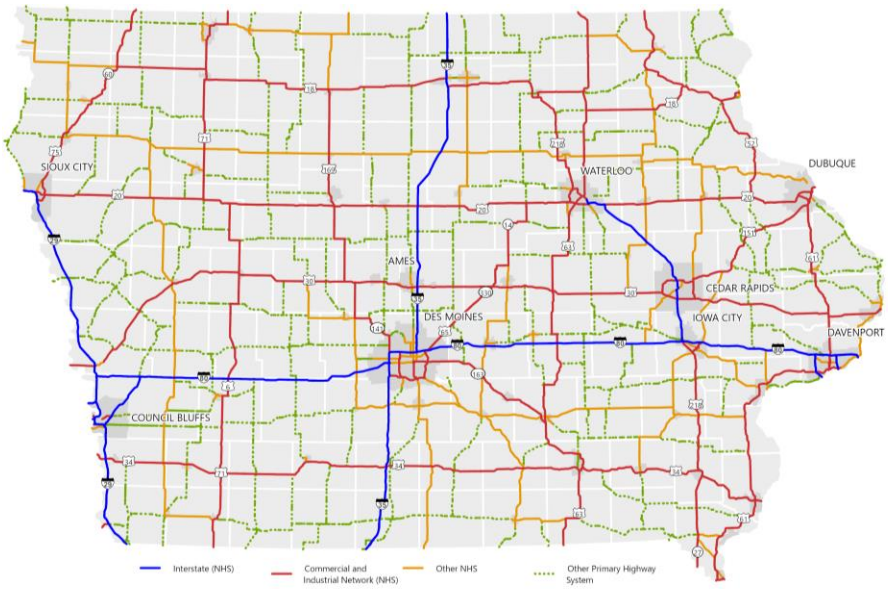
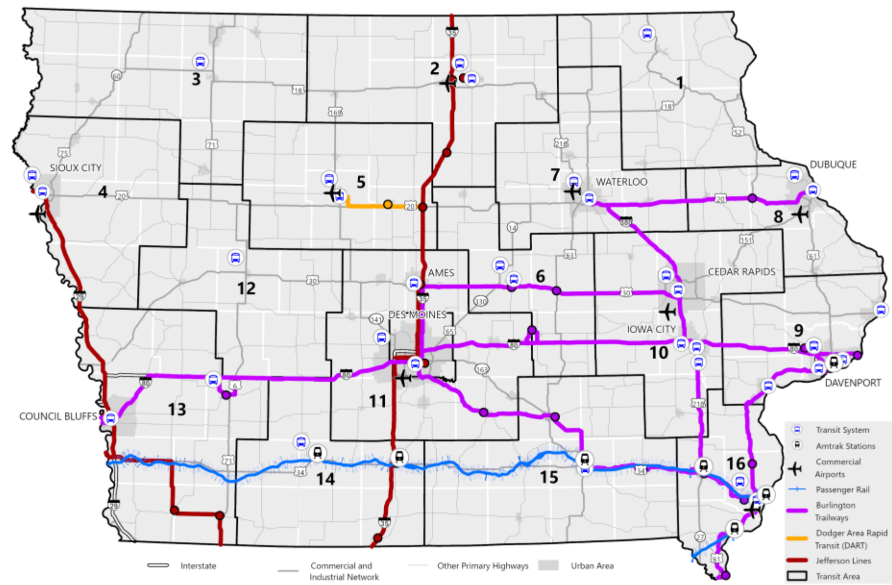


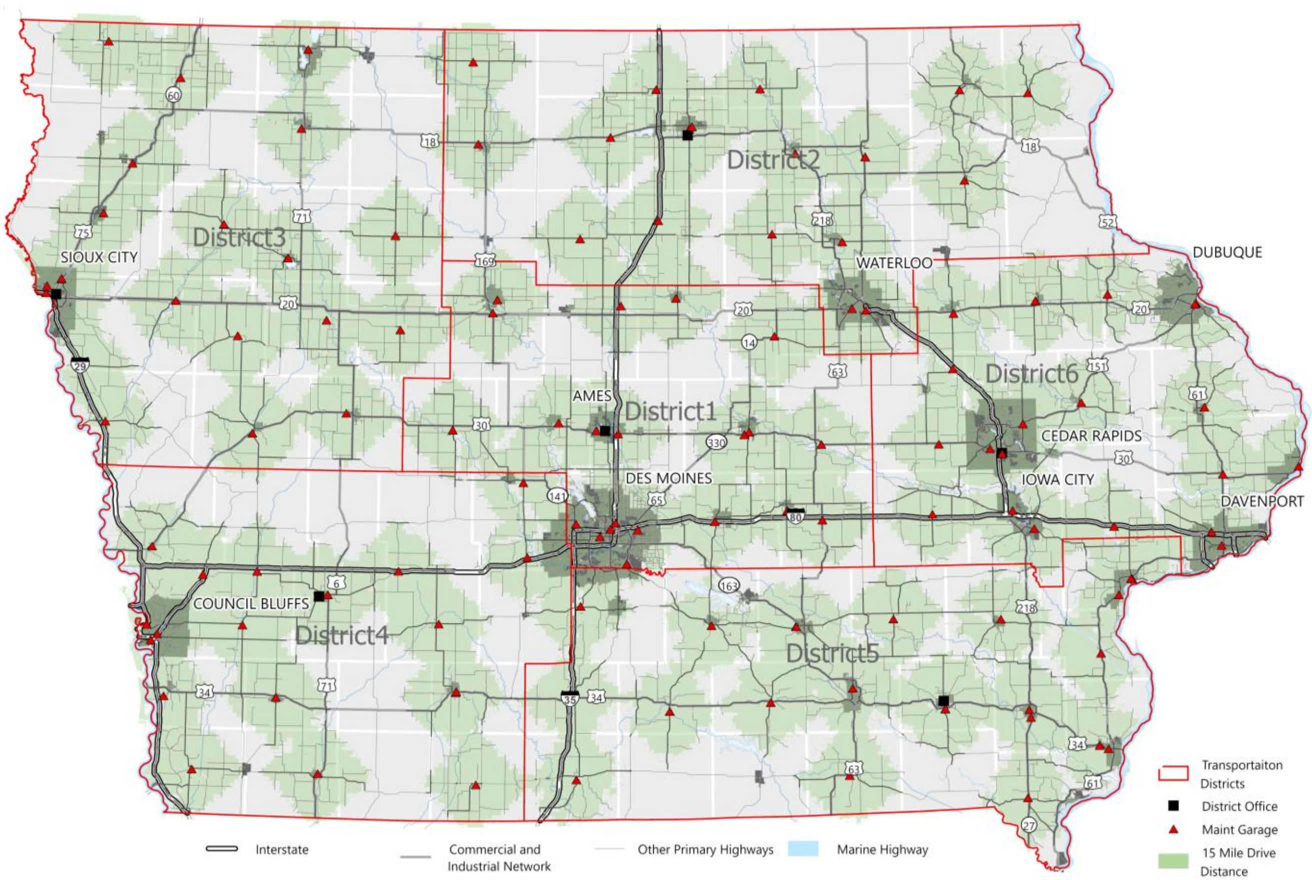
Figure 2.8: Iowa's passenger transportation connections



Iowa DOT Facilities and Resources

With such a vast transportation system, an equally vast system of facilities and resources are needed to support and maintain that system. The Iowa DOT provides statewide oversight with its central office located in Ames and six district offices throughout the state. Within each district a network of offices and garages provide stewardship of the transportation system within their region. Figure 2.9 shows how much of Iowa's primary network is within 15 miles from these facilities. When a disruption to Iowa's transportation system occurs, the Iowa DOT has significant resources that can be leveraged to address the situation. This includes physical equipment such as snow removal trucks, motor graders, endloaders, and tow plows. Or this could include materials like rock salt, liquid salt brine, or sand. The Iowa DOT also has significant staff resources with over 2,800 permanent full-time staff within the department.

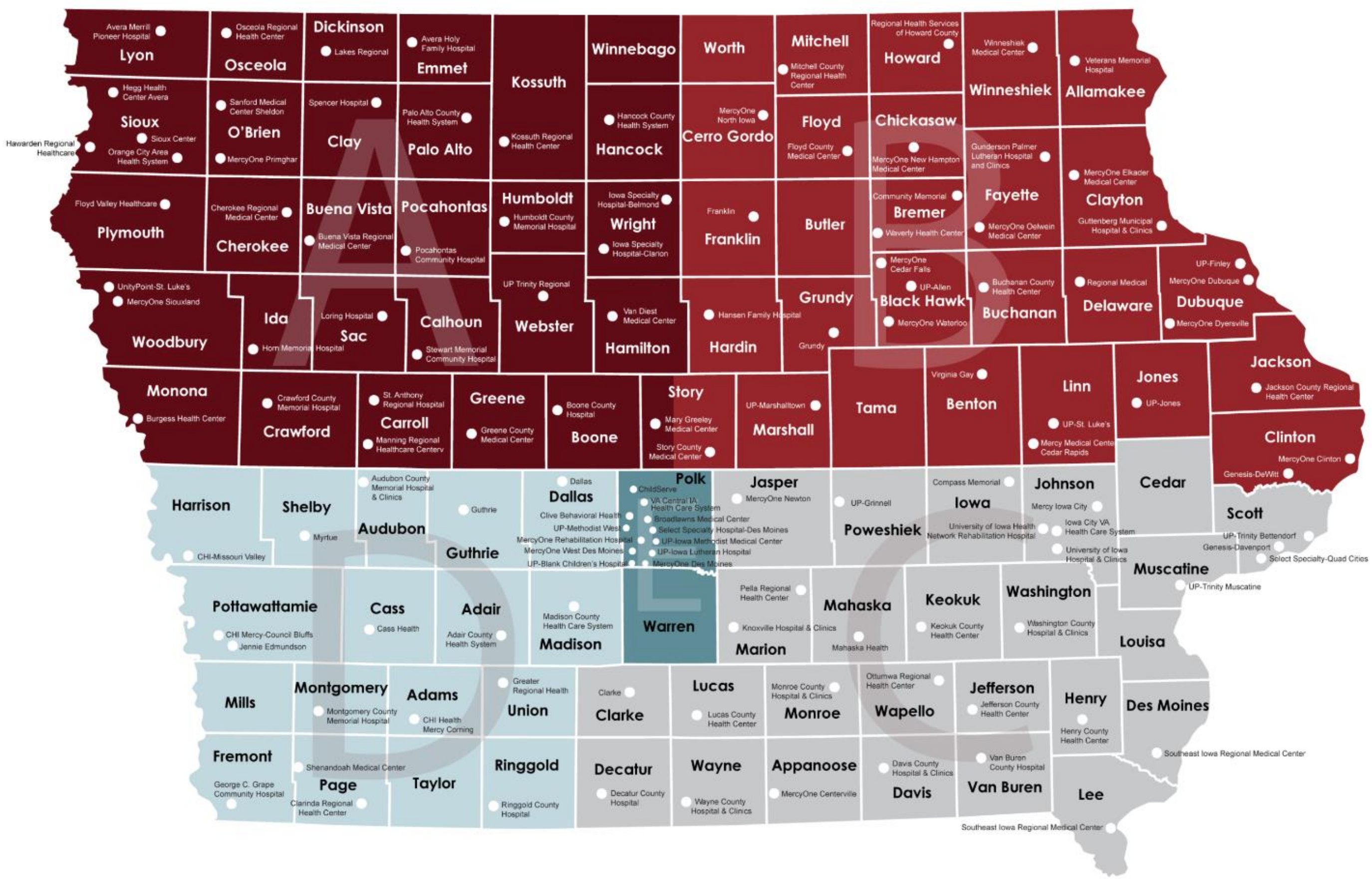
Figure 2.9: Areas within 15 miles of Iowa DOT maintenance garages



Hospitals and Emergency Medical Services (EMS)

Health care and emergency services are critical during disasters. Iowa has 117 hospitals, including two veteran hospitals and two state psychiatric facilities. There are 54 hospitals providing some level of EMS services to their community, with 75% of Iowa's EMS services being entirely volunteer based. In addition to the many hospitals, there are numerous other regulated medical and health care facilities, including long-term care facilities, hospices, end stage renal disease units, rural health clinics, and child-placing agencies.

Figure 2.10: Iowa's hospitals



Source: Iowa Hospital Association

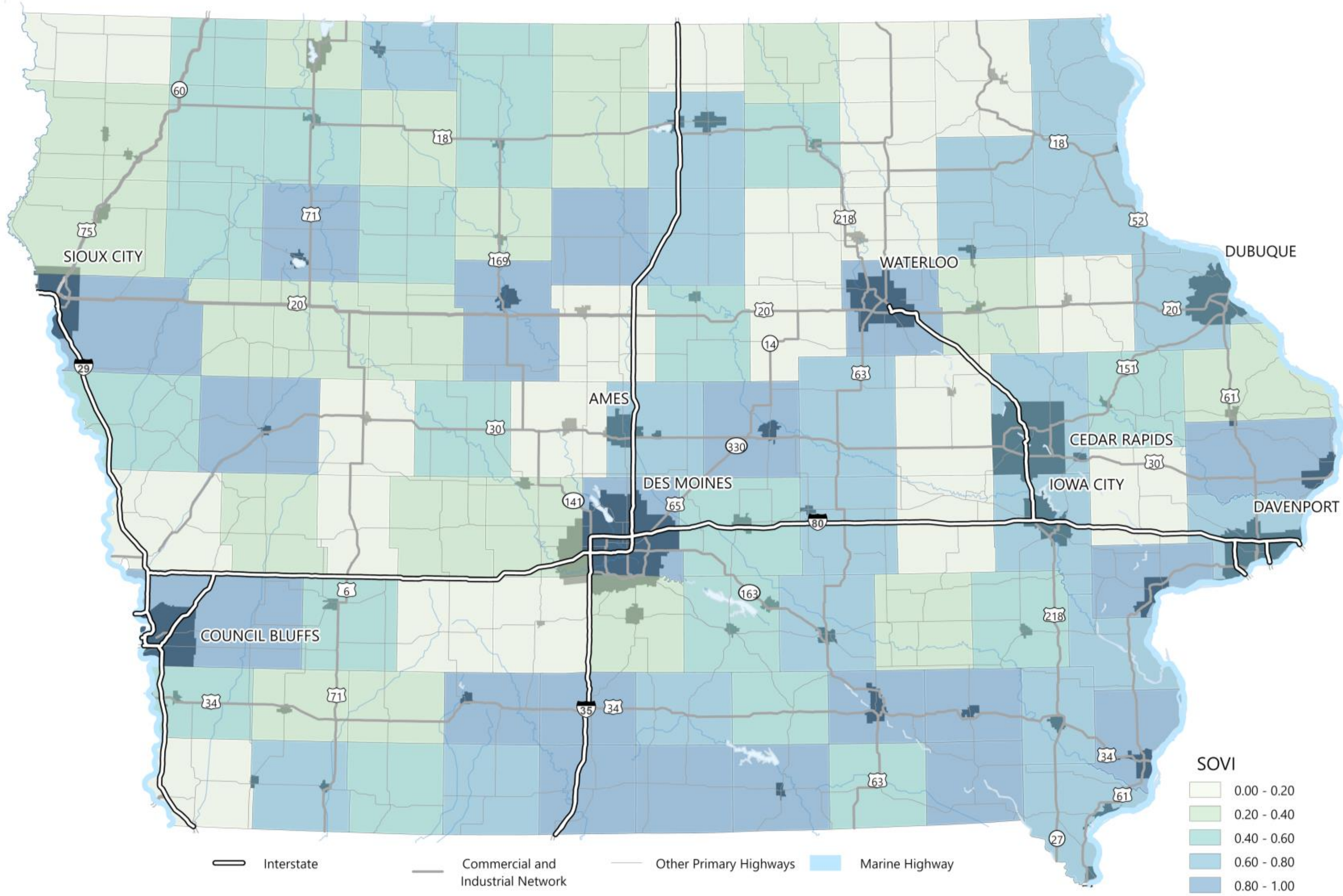
Iowa Demographics and Social Vulnerability

The criticality of the transportation systems and facilities discussed in the prior section comes into focus when considering Iowa's demographics and vulnerable populations.

- Iowa's 2020 population was 3,190,369 with much of this population concentrated in relatively few counties. Iowa's population has become increasingly urbanized and population growth has primarily been in the state's nine metropolitan areas. The percent of the population living in incorporated cities and communities that would be defined as urban or urbanized areas has increased steadily over time, from 58% in 1930 to 81% in 2020.
- The percent of Iowa's population that is 65 and older continues to increase. Iowa's median age has increased steadily over time to 38.2 in 2020. Rural areas of the state tend to be older and metropolitan areas are trending younger.
- Iowa's employment has grown steadily over time, however, most employment increases have been concentrated around the state's nine metropolitan areas.
- Among Iowa's households, the median income is currently $60,523, slightly less than the national median income of $62,843. While the statewide median household income has been increasing over time, it varies considerably for different areas of the state and for different racial and ethnic groups.

As Iowa's population continues to change over time, it is important for decision makers to routinely evaluate which communities would most likely need support before, during, and after hazardous events or natural disasters. The Centers for Disease Control and Prevention (CDC) has developed the Social Vulnerability Index (SV) to provide a high-level assessment of a community's need during a disruption. The index ranks counties based on 14 social factors including poverty, lack of vehicle access, crowded housing, and others, and groups them into four related themes.

Figure 2.11: Social Vulnerability Index for Iowa Counties



Source: Centers for Disease Control and Prevention