4 Hazard Identification and Risk Assessment DRAFT 2-17-23

Note to reviewers: Green highlights: Areas that WSP will address in future versions

Yellow highlights: Areas that require verifications, data gap, or special attention/review of HMPC

44 CFR Requirement 201.6(c)(2):
[The plan shall include] a risk assessment that provides the factual basis for activities proposed in the strategy to reduce the losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

As defined by the Federal Emergency Management Agency (FEMA), risk is a combination of hazard, vulnerability, and exposure. "It is the impact that a hazard would have on people, services, facilities, and structures in a community and refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage."

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. The process allows for a better understanding of a jurisdiction's potential risk to hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

This risk assessment builds upon the methodology described in the 2013 FEMA Local Mitigation Planning Handbook, which recommends a four-step process for conducting a risk assessment:

1. Describe Hazards
2. Identify Community Assets
3. Analyze Risks
4. Summarize Vulnerability

Data collected through this process has been incorporated into the following sections of this chapter:

Section 4.1 Hazard Identification identifies the hazards that threaten the planning area and describes why some hazards have been omitted from further consideration.

Section 4.2 Hazard Profiles discusses the threat to the planning area and describes previous occurrences of hazard events, the likelihood of future occurrences, and the Region's vulnerability to particular hazard events.

Additional County Annexes include a summary of community assets including population, building stock, critical facilities, and historic, cultural, and natural resources. Additional details on vulnerability to specific hazards where they vary from those of the Region are noted in the annexes.

4.1 Hazard Identification

Requirement 201.6(c)(2)(i):
[The risk assessment shall include a] description of the type of all natural hazards that can affect the jurisdiction.

4.1.1 Results and Methodology

Using existing hazards data, plans from participating jurisdictions, and input gained through planning and public meetings, the County and Tribal Planning Teams (CPT/TPTs) agreed upon a list of hazards that could affect the Region.

Hazards data from FEMA, Montana Disaster and Emergency Services (DES), the 2018 State of Montana Multi-Hazard Mitigation Plan, approved county and tribal plans from the participating Eastern Region counties, and many other sources were examined to assess the significance of these hazards to the planning area. The hazards evaluated in this plan include those that have occurred historically or have the potential to cause significant human and/or monetary losses in the future.

The final list of hazards identified and investigated for the 2022/2023 Eastern Region Multi-Hazard Mitigation Plan includes:

- Communicable Disease
- Cyber Attack
- Dam Failure
- Drought
- Earthquake
- Flooding
- Hazardous Materials Incidents
- Landslide
- Severe Summer Weather
- Severe Winter Weather
- Human Conflict
- Tornadoes & Windstorms
- Transportation Accidents
- Volcanic Ash
- Wildland and Rangeland Fire

Members of each CPT and TPT used a hazards worksheet to rate the significance of hazards that could potentially affect the region. Significance was measured in general terms, focusing on key criteria such as the likelihood for future occurrences of the event, frequency of past occurrences, geographical area affected, and damage and casualty potential. Table 4-1 represents the worksheet used to identify and rate the hazards and is a composite that includes input from all the participating jurisdictions. Note that the significance of the hazard may vary from jurisdiction to jurisdiction. The County Annexes include further details on hazard significance by county and municipality.

Table 4-1 Eastern Region Hazard Significance Summary Table

Hazard	Geographic Area	Magnitude/ Severity	Probability	Significance
Communicable Disease	Extensive	Critical	Occasional	Medium
Cyber-Attack	Significant	Critical	Occasional	Medium
Dam Failure	Significant	Limited	Unlikely	Low
Drought	Extensive	Critical	Highly Likely	High
Earthquake	Significant	Limited	Likely	Low
Flooding	Limited	Critical	Likely	High
Hazardous Material Incidents	Limited	Negligible	Highly Likely	Low
Landslide	Limited	Negligible	Occasional	Low
Severe Summer Weather: hail, excessive heat, heat, heavy rain, lightning	Extensive	Critical	Highly Likely	High
Severe Winter Weather: blizzard, cold/wind chill, extreme cold/wind chill, heavy snow, ice storm,	Extensive	Critical	Highly Likely	Medium

Hazard	Geographic Area	Magnitude/ Severity	Probability	Significance
winter storm, winter weather				
Human Conflict (Terrorism, Civil Unrest, etc.)	Significant	Critical	Occasional	Medium
Tornadoes & Windstorms	Extensive	Critical	Highly Likely	High
Transportation Accidents	Significant	Limited	Highly Likely	Medium
Volcanic Ash	Extensive	Limited	Unlikely	Low
Wildland and Rangeland Fire	Extensive	Critical	Highly Likely	High

Geographic Area
Negligible: Less than 10 percent of planning area or isolated single-point occurrences
Limited: 10 to 25 percent of the planning area or limited single-point occurrences
Significant: 25 to 75 percent of planning area or frequent single-point occurrences

Extensive: 75 to 100 percent of planning area or consistent single-point occurrences

Potential Magnitude/Severity

Negligible: Less than 10 percent of property is severely damaged, facilities and services are unavailable for less than 24 hours, injuries and illnesses are treatable with first aid or within the response capability of the jurisdiction.

Limited: 10 to 25 percent of property is severely damaged, facilities and services are unavailable between 1 and 7 days, injuries and illnesses require sophisticated medical support that does not strain the response capability of the jurisdiction, or results in very few permanent disabilities.
Critical: 25 to 50 percent of property is severely damaged, facilities and services are unavailable or severely hindered for 1 to 2 weeks, injuries and illnesses overwhelm medical support for a brief period of time or result in many permanent disabilities and a few deaths. overwhelmed for an extended period of time or many deaths occur.
Catastrophic: More than 50 percent of property is severely damaged, facilities and services are unavailable or hindered for more than 2 weeks, the medical response system is overwhelmed for an extended period of time or many deaths occur.

Probability of Future Occurrences
Unlikely: Less than 1 percent probability of occurrence in the next year or has a recurrence interval of greater than every 100 years.
Occasional: Between a 1 and 10 percent probability of occurrence in the next year or has a recurrence interval of 11 to 100 years.
Likely: Between 10 and 90 percent probability of occurrence in the next year, or has a recurrence interval of 1 to 10 years
Highly Likely: Between 90 and 100 percent probability of occurrence in the next year or has a recurrence interval of less than 1 year.

Overall Significance
Low: Two or more of the criteria fall in the lower classifications or the event has a minimal impact on the planning area. This rating is also sometimes used for hazards with a minimal or unknown record of occurrences/impacts or for hazards with minimal mitigation potential.
Medium: The criteria fall mostly in the middle ranges of classifications and the event's impacts on the planning area are noticeable but not devastating. This rating is also sometimes utilized for hazards with a high impact rating but an extremely low occurrence rating.

High: The criteria consistently fall along the high ranges of the classification and the event exerts significant and frequent impacts on the planning area. This rating is also sometimes utilized for hazards with a high psychological impact or for hazards that the jurisdiction identifies as particularly relevant.

Other Hazards Considered but not Profiled

As part of the hazard identification process, the Regional Steering Committee and CPT/TPTs also noted other hazards that could impact the region but are not further profiled as impacts tend to be more isolated or do not result in local, state or federal disaster declarations. These include wildlife hazards associated with human/wildlife interaction and collisions, and avalanches. Avalanche terrain exists on the far southwestern portion of the Eastern region but typically impacts isolated and undeveloped areas.

Disaster Declaration History

As part of the hazard identification process, the Regional Steering Committee and CPT/TPTs researched past events that triggered federal and/or state emergency or disaster declarations in the planning area.

Federal and/or state disaster declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Should the disaster be so severe that both the local and state governments' capacities are exceeded, a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

The federal government may issue a disaster declaration through FEMA, the U.S. Department of Agriculture (USDA), and/or the Small Business Administration (SBA). FEMA also issues emergency declarations, which are more limited in scope and without the long-term federal recovery programs of major disaster declarations. The quantity and types of damage are the determining factors.

A USDA declaration will result in the implementation of the Emergency Loan Program through the Farm Services Agency. This program enables eligible farmers and ranchers in the affected county as well as contiguous counties to apply for low interest loans. A USDA declaration will automatically follow a major disaster declaration for counties designated major disaster areas and those that are contiguous to declared counties, including those that are across state lines. As part of an agreement with the USDA, the SBA offers low interest loans for eligible businesses that suffer economic losses in declared and contiguous counties that have been declared by the USDA. These loans are referred to as Economic Injury Disaster Loans.

Table 4-2 provides information on federal emergencies and disasters declared in the Eastern Region counties between 1953 and 2022.

Table 4-2 Federal Disaster Declarations in the Eastern Region, 1953-2022

Year	Declaration Title	Disaster Number	Area Impacted
1975	RAINS, SHOWMELT, STORMS & FLOODING	DR-472-MT	Wheatland
1977	DROUGHT	EM-3050-MT	Golden Valley, Musselshell
1978	FLOODING, SEVERE STORMS	DR-558-MT	Big Horn, Carbon, Powder River, Rosebud, Stillwater, Treasure, Yellowstone
1986	HEAVY RAINS, LANDSLIDES & FLOODING	DR-761-MT	Daniels, Dawson, Valley
1986	SEVERE STORMS & FLOODING	DR-777-MT	McCone, Rosebud, Valley
1997	SEVERE STORMS, ICE JAMS, SNOW MELT, FLOODING	DR-1183-MT	All counties in Eastern Region
1999	FISHEL CREEK FIRE COMPLEX	FSA-2266-MT	Musselshell
2000	WILLIE FIRE	FSA-2326-MT	Carbon
2000	WILDFIRES	DR-1340-MT	Most counties in Eastern Region except Daniels, Dawson, McCone, Prairie, Richland, Sheridan, Valley and Wibaux
2000	WINTER STORM	DR-1350-MT	Carter, Fallon, McCone, Richland, Roosevelt, Sheridan, Wibaux
2001	SEVERE STORMS	DR-1377-MT	Big Horn
2003	MISSOURI BREAKS FIRE COMPLEX	FM-2483-MT	Garfield
2005	HURRICANE KATRINA EVACUATION	EM-3253-MT	Statewide
2006	SAUNDERS FIRE	FM-2652-MT	Stillwater
2006	DERBY FIRE	FM-2671-MT	Stillwater
2006	EMERALD HILLS FIRE	FM-2669-MT	Yellowstone

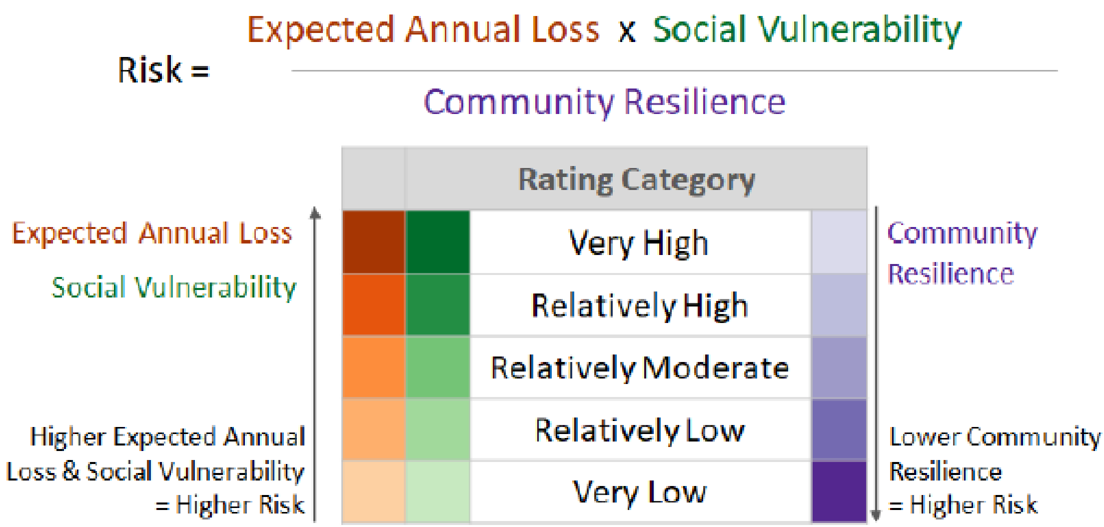
Year	Declaration Title	Disaster Number	Area Impacted
2007	FORD ROAD FIRE	FM-2723-MT	Yellowstone
2008	SEVERE WINTER STORM	DR-1767-MT	Carter, Custer, Fallon, Powder River
2009	EAGLE MOUNT FIRE	FM-2837-MT	Stillwater
2011	SEVERE STORMS AND FLOODING	DR-1996-MT	All counties in Eastern Region
2011	CANYON CREEK FIRE	FM-2950-MT	Yellowstone
2012	DAHL FIRE	FM-2988-MT	Musselshell
2012	ASK CREEK FIRE	FM-2989-MT	Powder River, Rosebud
2012	MONTANA WILDFIRES	DR-4074-MT	Rosebud, Powder River
2013	FLOODING	DR-4127-MT	Musselshell, Rosebud, Custer, Dawson, McCone, Valley, Garfield
2014	ICE JAMS AND FLOODING	DR-4172-MT	Stillwater, Wheatland, Golden Valley, Musselshell, Rosebud, Prairie, Dawson, Richland
2014	SEVERE STORMS, STRAIGHT-LINE WINDS, AND FLOODING	DR-4198-MT	Carter, Musselshell, Valley
2016	TORNADO	DR-4275-MT	Fallen
2017	LODGEPOLE FIRE COMPLEX	FM-5194-MT	Garfield
2018	FLOODING	DR-4388-MT	Valley
2018	FLOODING	DR-4405-MT	Carbon, Custer, Golden Valley, Musselshell, Treasure
2019	FLOODING	DR-4437-MT	Daniels, Valley, McCone, Power River, Treasure, Stillwater
2020	COVID-19	EM-3476-MT	Statewide
2020	COVID-19 PANDEMIC	DR-4508-MT	Statewide
2020	SNIDER/RICE FIRE COMPLEX	FM-5345-MT	Custer, Powder River, Rosebud
2020	HUFF FIRE	FM-5343-MT	Garfield
2020	BOBCAT FIRE	FM-5344-MT	Musselshell, Yellowstone
2020	FALLING STAR FIRE	FM-5324-MT	Stillwater, Yellowstone
2021	POVERTY FLATS FIRE	FM-5403-MT	Big Horn
2021	STRAIGHT-LINE WINDS	4608-DR-MT	Garfield, McCone, Roosevelt, Richland, Dawson
2021	ROBERTSON DRAW FIRE	FM-5392-MT	Carbon
2021	RICHARD SPRING FIRE	FM-5406-MT	Rosebud
2021	RICHARD SPRING FIRE	4623-DR-MT	Rosebud, Big Horn
2021	BUFFALO WILDFIRE	FM-5399-MT	Yellowstone
2022	SEVERE STORMS AND FLOODING	DR-4655-MT	Carbon, Stillwater, Yellowstone

National Risk Index Overview

During the 2022/2023 planning process a relatively new online risk assessment tool became available from FEMA. The National Risk Index (NRI) is a dataset and online tool that helps illustrate the United States communities most at risk for 18 natural hazards. It was designed and built by FEMA in close collaboration with various stakeholders and partners in academia; local, state, and federal government; and private industry. The NRI leverages available source data for natural hazard and community risk factors to develop a baseline relative risk measurement for each United States county and census tract. The NRI's interactive mapping and data-based interface enables users to visually explore individual datasets to better understand what is driving a community's natural hazard risk. Users may also create reports to capture risk details on a community or conduct community-based risk comparisons, as well as export data for analysis using other software. Intended users of the NRI include planners and emergency managers at the local, regional, state, and federal levels, as well as other decision makers and interested members of the general public.

The NRI provides relative Risk Index scores and ratings based on data for Expected Annual Loss (EAL) due to natural hazards, social vulnerability, and community resilience. Separate scores and ratings are also provided for each component: Expected Annual Loss, Social Vulnerability, and Community Resilience. Figure 4-1 illustrates the NRI risk equation and components that define risk based on the expected annual loss times the social vulnerability divided by a community's resilience to that potential hazard.

Figure 4-1 Generalized National Risk Index Risk Equation and Components



Source: FEMA NRI Technical Documentation 2021

For the Risk Index and EAL, scores and ratings can be viewed as a composite score for all hazards or individually for each of the 18 hazard types. These 18 hazard types are listed in Figure 4-2.

Figure 4-2 National Risk Index Hazard Types

NATIONAL RISK INDEX HAZARD TYPES

1. Avalanche	6. Hail	11. Lightning	16. Volcanic Activity
2. Coastal Flooding	7. Heat Wave	12. Riverine Flooding	17. Wildfire
3. Cold Wave	8. Hurricane	13. Strong Wind	18. Winter Weather
4. Drought	9. Ice Storm	14. Tornado	
5. Earthquake	10. Landslide	15. Tsunami	

The NRI was evaluated by the Regional Steering Committee and Montana DES's planning consultant to determine its applicability to the Eastern Region HIRA. An added benefit of leveraging NRI data for the regional plan included standardized methods for assessing risk on a county-by-county scale for most of the natural hazards in the HIRA. This included composite risk indicators for hazards previously lacking necessary data, consisting of subsets of summer and winter storms including cold wave, lightning, wind, and ice storms. The other benefit is that moving forward, FEMA will be periodically updating and improving the NRI, which should provide a valuable and standardized resource for future HIRA updates.

The HIRA sections for Drought, Severe Summer Weather, Severe Winter Weather, and Tornadoes & Windstorms contain the following aggregate risk products, mapped by WSP using NRI data:

- Annualized Frequency
- Composite Risk Index Rating
- Expected Annual Loss

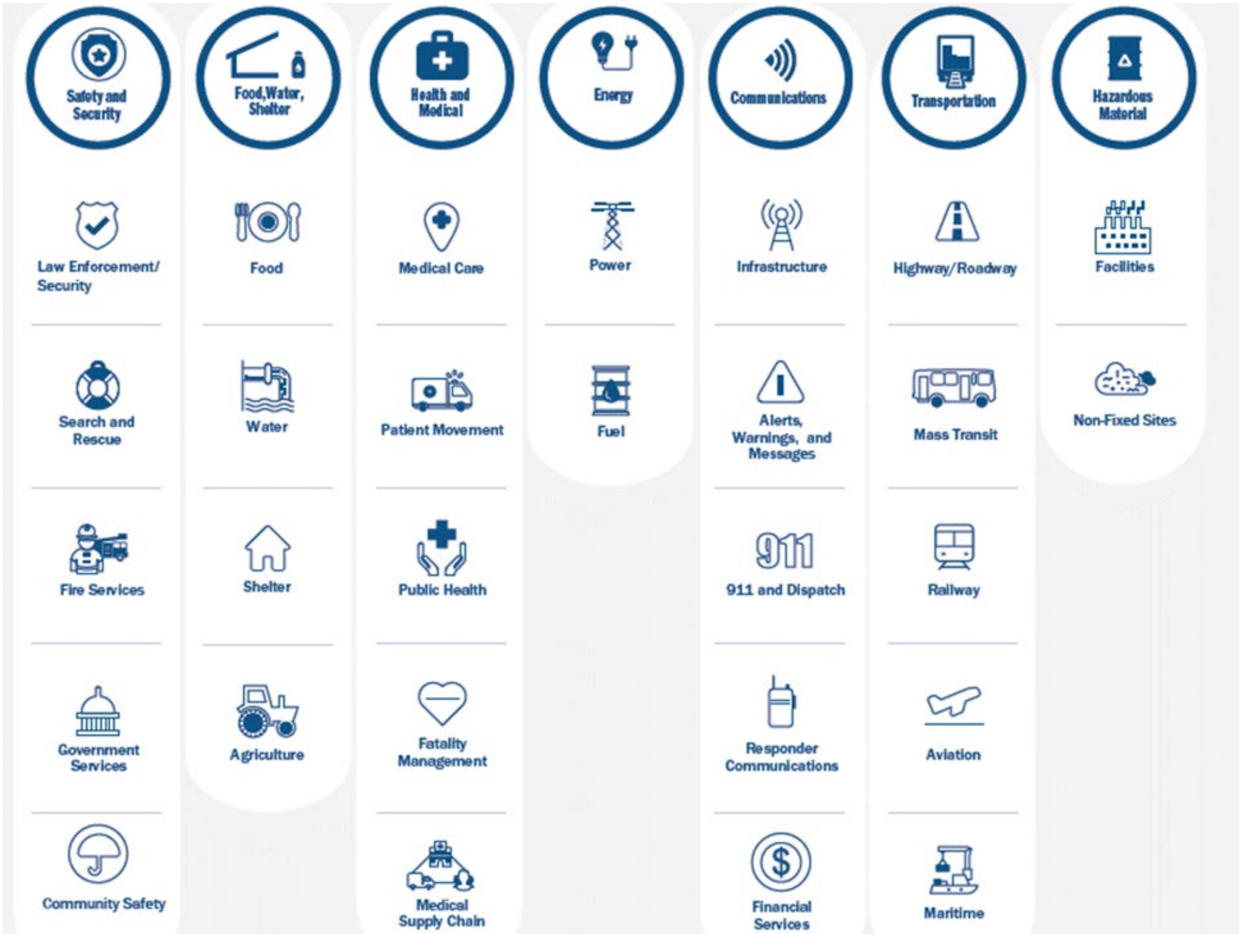
Sources of hazards and exposure data includes SHELDUS, National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), National Weather Service (NWS), and the USDA. Consequences of hazard occurrences are categorized into three different types: buildings, population, and agriculture. Additional details can be referenced in the FEMA NRI Technical documentation 2021, available at https://hazards.fema.gov/nri/.

Assets Summary

Assets inventoried for the purpose of determining vulnerability include people, buildings, critical facilities, and natural, historic, or cultural resources. For the regional planning process two standard databases were utilized for the basis of building and critical facility data. The Montana Spatial Data Infrastructure (MSDI) Cadastral Parcel layer (April 2022) was used for improved parcel and building inventory throughout the region. This information provided the basis for building exposure and property types. Data current as of 2022 was downloaded for all the counties within the Eastern Region, which was then analyzed using Geographic Information Systems (GIS) to create a centroid, or point, representing the center of each parcel polygon, for vulnerability analysis. A critical facility is defined as one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. Much of this data is based on GIS databases associated with the 2022 Homeland Infrastructure Foundation-Level Data (HIFLD). Other critical facility databases were also used, such as the National Bridge Inventory (NBI) and data from Montana DES. Where applicable, this information was used in an overlay analysis for hazards such as flood and wildfire. More detail on assets potentially exposed to hazards can be found in the county annexes.

FEMA organizes critical facilities into seven lifeline categories as shown in Figure 4-3.

Figure 4-3 FEMA Lifeline Categories



These lifeline categories standardize the classification of critical facilities and infrastructure that provide indispensable service, operation, or function to a community. A lifeline is defined as providing indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety, or economic security. These categorizations are particularly useful as they:

- Enable effort consolidations between government and other organizations (e.g., infrastructure owners and operators).
- Enable integration of preparedness efforts among plans; easier identification of unmet critical facility needs.
- Refine sources and products to enhance awareness, capability gaps, and progress towards stabilization.
- Enhance communication amongst critical entities, while enabling complex interdependencies between government assets.
- Highlight lifeline related priority areas regarding general operations as well as response efforts.

A summary of the critical facilities inventory for the Eastern Region can be found in Table 4-3 below.

Table 4-3 Summary of Critical Facilities Exposure Summarized by FEMA Lifelines

County	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Total
Big Horn	41	53	28	6	0	33	137	298
Carbon	38	37	18	3	3	35	86	220
Carter	11	5	1	0	1	11	44	73
Custer	29	25	9	2	4	30	76	175
Daniels	12	14	0	0	0	13	40	79
Dawson	34	14	6	5	2	26	110	197
Fallon	21	41	4	2	0	16	39	123
Garfield	16	1	3	0	1	12	32	65
Golden Valley	2	16	4	0	2	10	20	54
McCone	20	13	4	2	1	10	49	99
Musselshell	1	2	11	0	3	17	1	35
Petroleum	0	0	0	0	0	0	1	1
Phillips	0	0	0	0	0	0	2	2
Powder River	14	3	4	0	1	14	25	61
Prairie	10	12	3	1	2	9	49	86
Richland	32	40	8	14	5	29	104	232
Roosevelt	53	38	9	11	0	40	62	213
Rosebud	52	41	15	2	4	30	119	263
Sheridan	27	24	6	1	2	19	68	147
Stillwater	32	26	7	4	2	35	98	204
Treasure	7	13	2	0	1	7	34	64
Valley	58	40	15	1	2	33	105	254
Wheatland	16	25	3	0	2	15	32	93
Wibaux	5	7	2	0	1	9	29	53
Yellowstone	232	78	63	37	26	157	295	888
Total	763	568	225	91	65	610	1,657	3,979

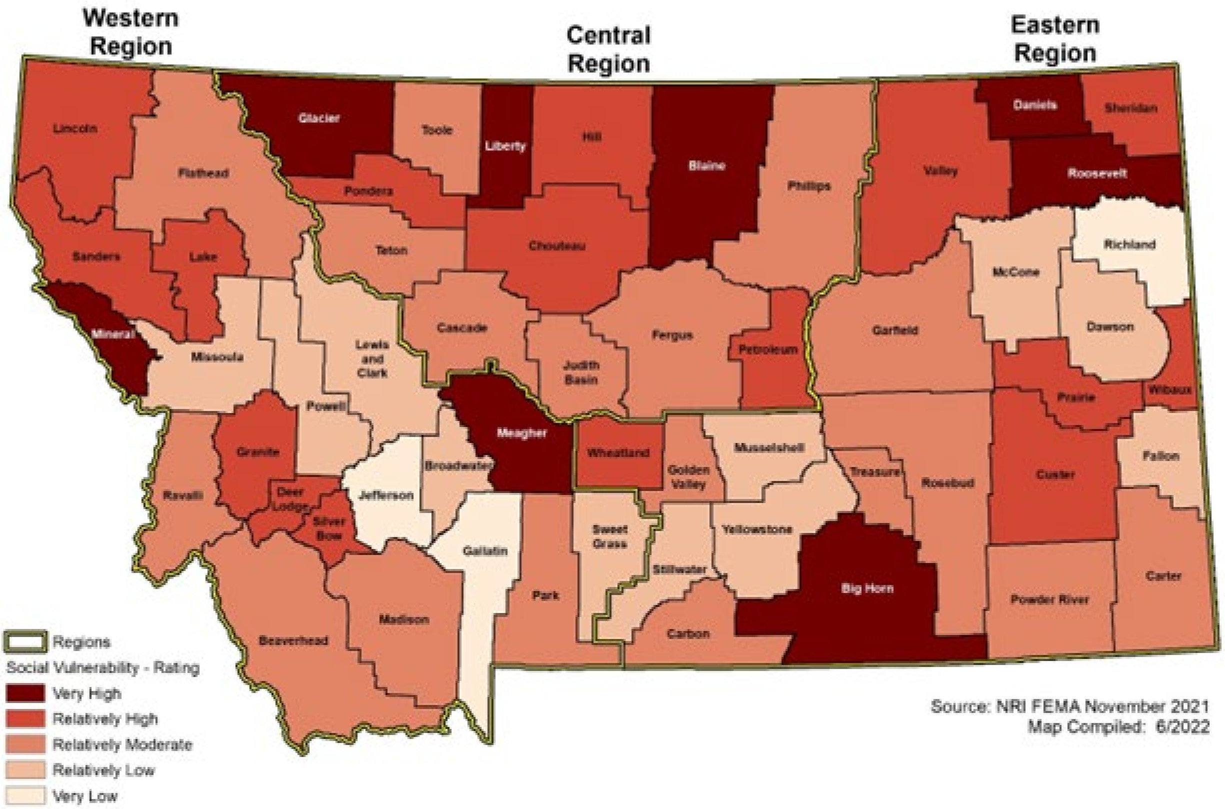
Source: HIFLD 2022, Montana DES, NBI

Social Vulnerability

Social vulnerability is broadly defined as the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood. Social vulnerability considers the social, economic, demographic, and housing characteristics of a community that influence its ability to prepare for, respond to, cope with, recover from, and adapt to environmental hazards.

The NRI has incorporated a social vulnerability index (SoVI) rating as a "consequence enhancing risk component" using the SoVI compiled by the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina. This SoVI is a location-specific assessment and measures the social vulnerability of U.S. counties to environmental hazards utilizing 29 socioeconomic variables which have been deemed to influence a community's vulnerability. The comparison of SoVI values between counties within the State allows for a more detailed depiction of variances in risk and vulnerability. Figure 4 shows this social vulnerability rating by county in Montana, with those counties shaded in darker red having the highest levels of social vulnerability.

Figure 4-4 Social Vulnerability Rating by County in Montana



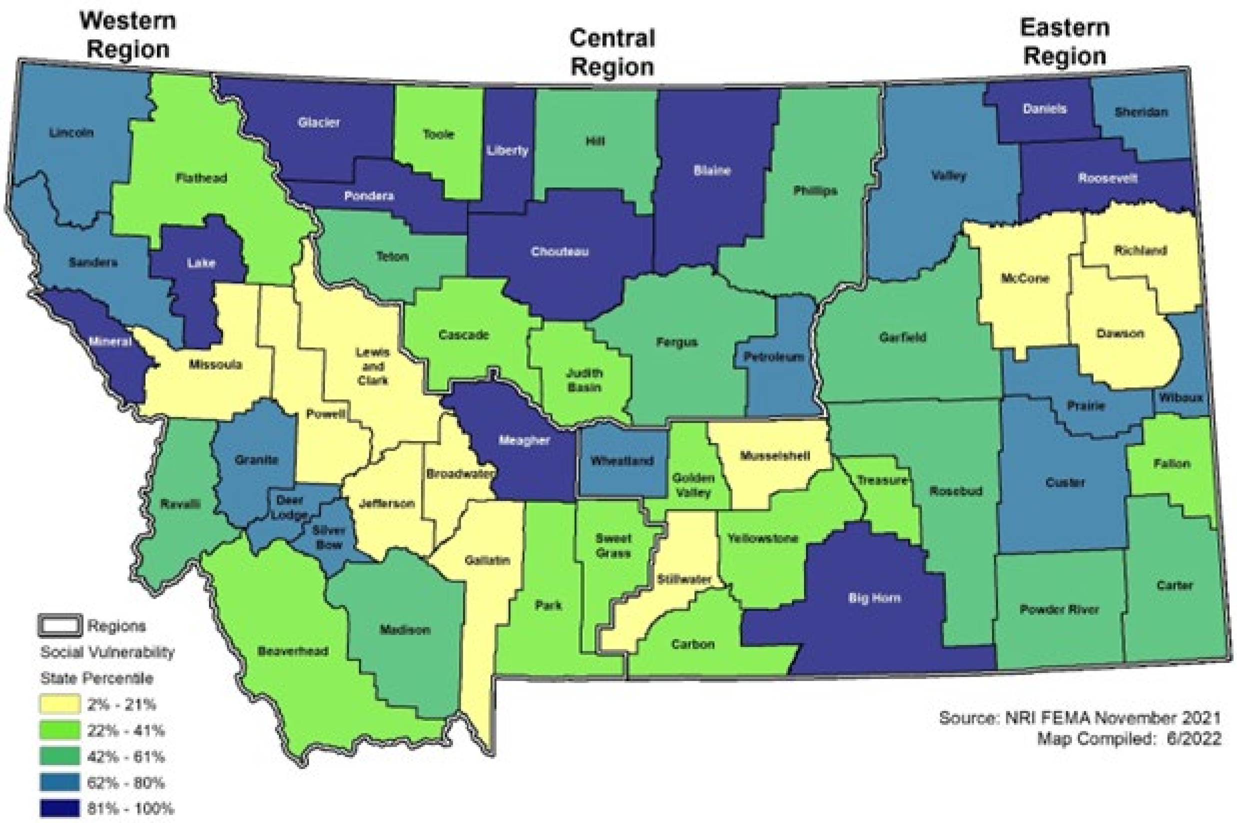
The index can be used by the State to help determine where social vulnerability and exposure to hazards overlaps and how and where mitigation resources might best be used. The SoVI provides a score between 0.01 and 100, with higher scores indicative of higher levels of social vulnerability. According to the index, the following, listed in order, are Montana's ten most socially vulnerable counties:

1. Glacier County (Score 75.72)
2. Roosevelt County (Score 70.60)
3. Big Horn County (Score 70.32)
4. Liberty County (Score 63.07)
5. Meagher County (Score 62.99)
6. Blaine County (Score 61.14)
7. Mineral County (Score 59.05)
8. Lake County (Score 55.77)
9. Chouteau County (Score 54.59)

10. Pondera County (Score 54.24)

Each of the above counties are also in the top 20 percent in the nation in terms of social vulnerability. The average national social vulnerability score is 38.35 and the average for Montana is 43.46. Glacier County for instance has a higher social vulnerability score than 99.2% of U.S. counties. In addition to the ten counties listed above, Wheatland, Valley, Sanders, Granite, Sheridan, Deer Lodge, Silver Bow, Petroleum, and Lincoln also rank in the top 20% most socially vulnerable counties nationwide. Figure 4 below shows the percentile of each county's social vulnerability ranking on a national scale.

Figure 4-5 Social Vulnerability State Percentile

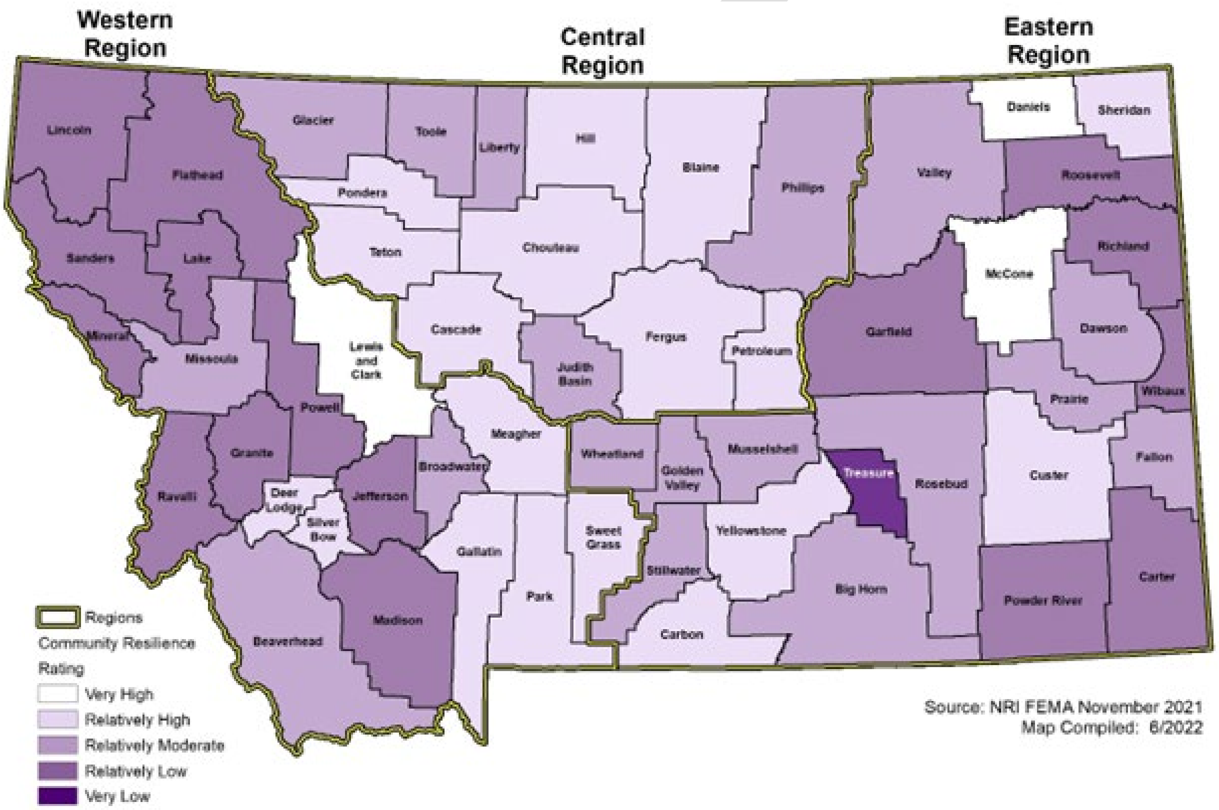


Community Resilience

Related to social vulnerability, the NRI utilizes community resilience as a "consequence reduction component". Community Resilience can essentially be thought of as an inverse to social vulnerability. The NRI defines community resilience as the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. There are multiple, well-established ways to define community resilience at the local level, and key drivers of resilience vary between locations. Because there are no nationally available, bottom-up community resilience indices available, the Social Vulnerability and Community Resilience Working Group chose to utilize a top-down approach. The NRI relies on using broad factors to define resilience at a national level and create a comparative metric to use as a risk factor.

The Community Resilience score is a consequence reduction risk factor and represents the relative level of community resilience in comparison to all other communities at the same level. A higher Community Resilience score results in a lower Risk Index score. Because Community Resilience is unique to a geographic location—specifically, a county—it is a geographic risk factor. Community resilience data are supported by the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI) Baseline Resilience Indicators for Communities (BRIC). HVRI BRIC provides a sound methodology for quantifying community resilience by identifying the ability of a community to prepare and plan for, absorb, recover from, and more successfully adapt to the impacts of natural hazards. The HVRI BRIC dataset includes a set of 49 indicators that represent six types of resilience: social, economic, community capital, institutional capacity, housing/infrastructure, and environmental. It uses a local scale within a nationwide scope, and the national dataset serves as a baseline for measuring relative resilience. The data can be used to compare one place to another and determine specific drivers of resilience, and a higher HVRI BRIC score indicates a stronger and more resilient community. Figure 4 below shows the community resilience rating for each county in Montana.

Figure 4-6 Community Resilience Rating by County in Montana



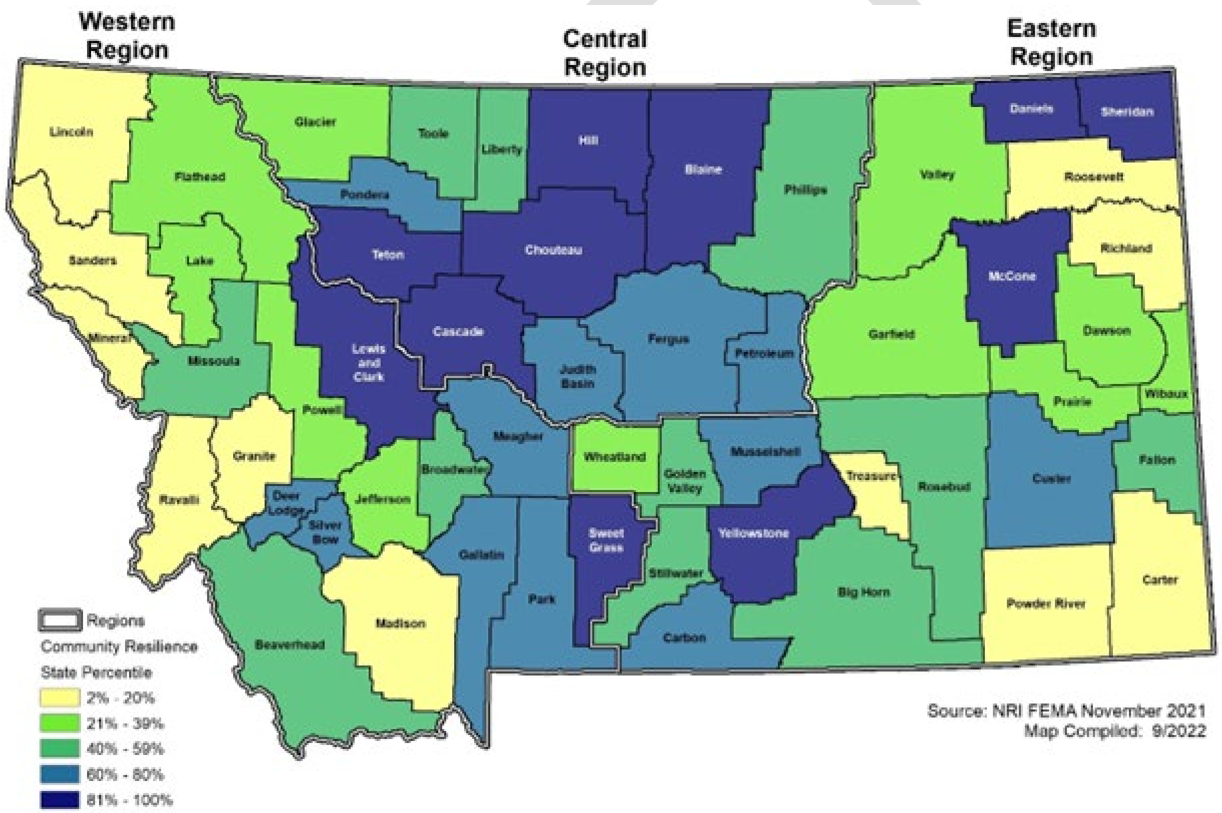
The community resilience rating can be useful in determining counties which have higher levels of ability to cope with hazards and identify success stories for building resilience. According to the index, the following, listed in order, are Montana's ten most resilient counties:

1. Daniels County (58.16)
2. Lewis and Clark County (57.80)
3. Cascade County (57.72)
4. Sheridan County (57.49)
5. Yellowstone County (56.92)
6. Hill County (56.90)

7. Chouteau County (56.79)
8. Teton County (56.71)
9. Sweet Grass County (56.63)
10. Blaine County (56.17)

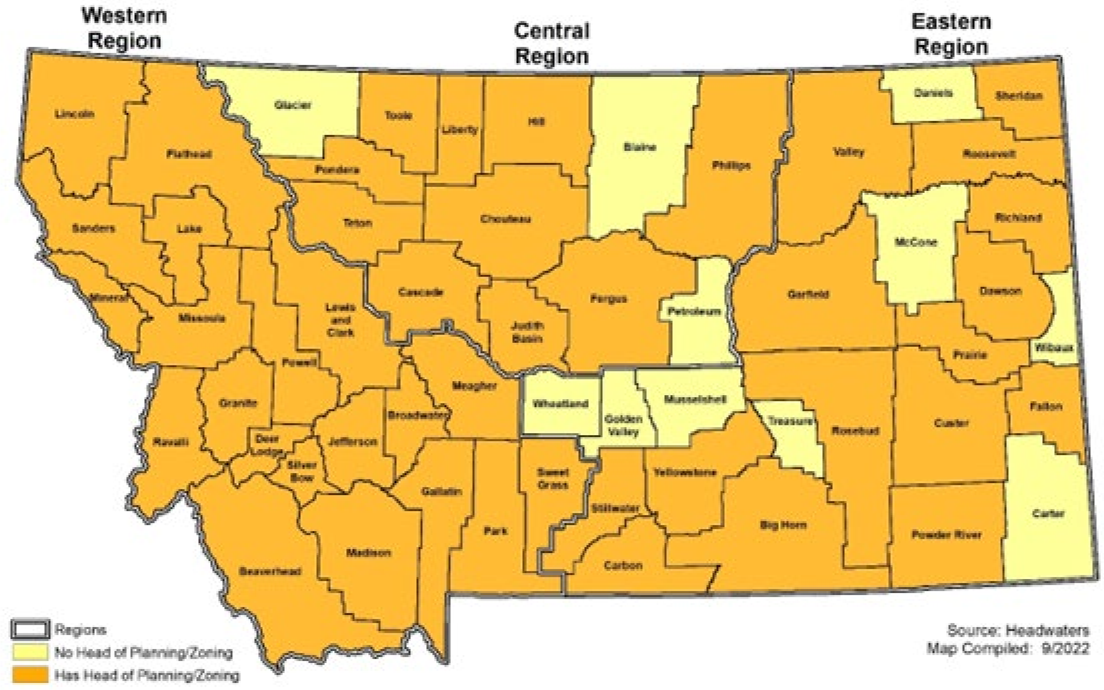
Only a select few of the above counties are in the top 20 percent in the nation in terms of community resilience with those being limited to Daniels, Lewis and Clark, and McCone counties. The average community resilience score for the State of Montana is 54.43, which is slightly lower than the national average score of 54.59. Only 11.1% of counties in the country have a higher level of community resilience than Montana's highest rated county, Daniel County. In addition to the ten counties listed above, Petroleum, Silver Bow, Custer, Pondera, Carbon, Meagher, Gallatin, and Fergus counties each are identified as having relatively high levels of community resilience. Figure 4 below shows the percentile of each county's community resilience ranking on a national scale.

Figure 4-7 Community Resilience State Percentile



Adaptive capacity is the potential for a system to adjust to change and to potential damage and take advantage of opportunities, and cope with consequences. As such, other indicators of community resilience include whether local municipalities have planning departments and administrative and technical staff capabilities to address community needs during hazard events through effective planning processes, community engagement, and planning projects related to resiliency. Data from Headwater Economics was reviewed to map those counties that lack a Planning Department and/or a Zoning Ordinance. Figure 4 shows the counties in Montana that do not have a Planning Department. In other words, these are the counties in the State that lack formal planning resources and have less capability for land use and hazard mitigation planning. These include the counties of Glacier, Blaine, Wheatland, Golden Valley, Musselshell, Treasure, Carter, McCone, and Daniels.

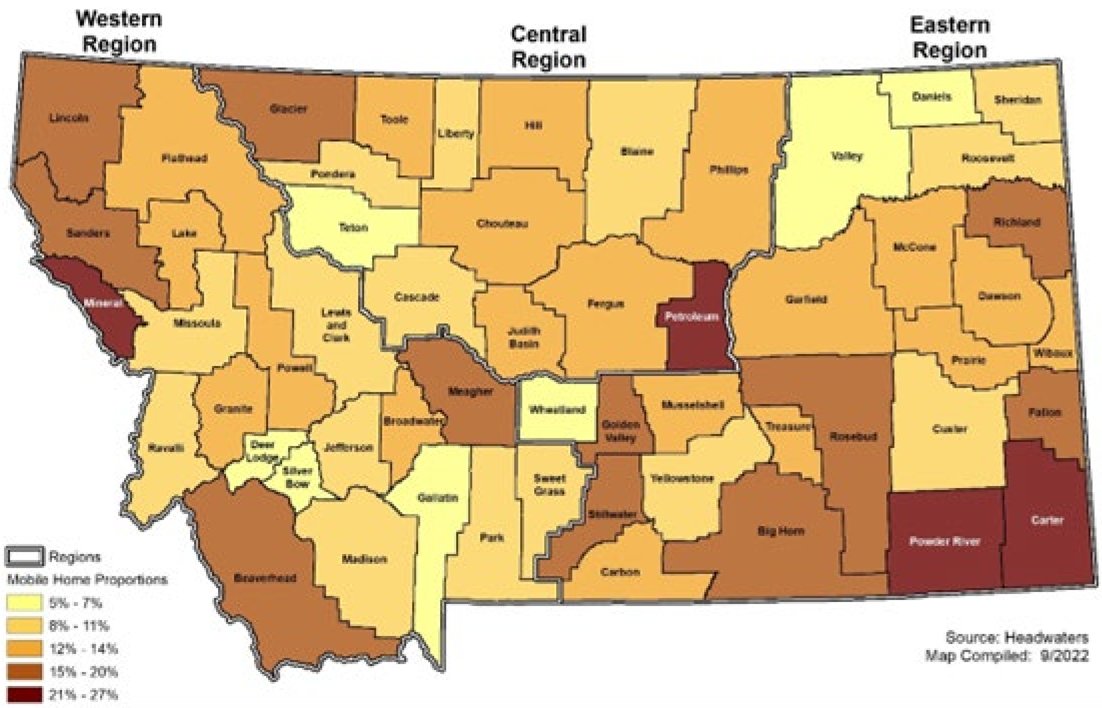
Figure 4-8 Counties in Montana that Lack a Planning Department



Mobile Homes

Mobile and manufactured homes are the most common unsubsidized, affordable housing in the United States. Research shows that these structures face a disproportionately higher risk of flooding and also damage from wind events (Headwater Economics 2022). Approximately 9.2% of the housing types in Montana are mobile homes compared to approximately 5.6% mobile homes in the United States (U.S. Census 2020). Compared to those who live in other types of housing, mobile home residents have higher exposure to natural hazards such as wind, tornadoes, hurricanes, extreme heat, wildfire, and particularly flooding. For example, according to analysis by Headwater Economics, one in seven mobile homes is located in an area with high flood risk, compared to one in 10 for all other housing types (Headwater Economics 2022). Figure 4-9 shows the number of mobile homes as a proportion to the number of households within the County.

Figure 4-9 Mobile Homes in Montana



As shown above, Mineral, Petroleum, Powder River, and Carter counties have the highest number of mobile homes as a proportion to the number of households in that County. Other counties with 15% to 20% mobile home proportions include Lincoln, Sanders, Beaverhead, Glacier, Meagher, Stillwater, Golden Valley, Big Horn, Rosebud, Richland, and Fallon counties.

4.2 Hazard Profiles

Requirement §201.6(c)(2)(i):
[The risk assessment shall include a] description of the…location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

The hazards identified in Section 4.1 are profiled individually in this section. Much of the profile information came from the same sources used to initially identify the hazards.

4.2.1 Profile Methodology

Each hazard is profiled in a similar format that is described below:

Hazard/Problem Description

This subsection gives a description of the hazard and associated problems, followed by details on the hazard specific to the Region.

Geographical Area Affected

This subsection discusses which areas of the Region are most likely to be affected by a hazard event.

Negligible: Less than 10 percent of planning area or isolated single-point occurrences

Limited: 10 to 25 percent of the planning area or limited single-point occurrences

Significant: 25 to 75 percent of planning area or frequent single-point occurrences

Extensive: 75 to 100 percent of planning area or consistent single-point occurrences

Past Occurrences

This subsection contains information on historic incidents, including impacts where known. Information provided by the Regional Steering Committee is included here along with information from other data sources, including NOAA's National Centers for Environmental Information (NCEI) Storm Events Database and other data sources. When available, tables showing county-specific data from the NCEI database may be found in each hazard profile.

Frequency/Likelihood of Occurrence

The frequency of past events is used in this section to gauge the likelihood of future occurrences. Based on historical data, the likelihood of future occurrences is categorized into one of the following classifications:

Highly Likely—90 to 100 percent chance of occurrence in next year or happens every year.

Likely—Between 10 and 90 percent chance of occurrence in next year or has a recurrence interval of 10 years or less.

Occasional—Between 1 and 10 percent chance of occurrence in the next year or has a recurrence interval of 11 to 100 years.

Unlikely—Less than 1 percent chance of occurrence in next 100 years or has a recurrence interval of greater than every 100 years.

The frequency, or chance of occurrence, was calculated where possible based on existing data. Frequency was determined by dividing the number of events observed by the number of years and multiplying by 100. Stated mathematically, the methodology for calculating the probability of future occurrences is:

$$\frac{\text{\# of known events}}{\text{years of historic record}} \times 100$$

This gives the percent chance of the event happening in any given year. An example would be three droughts occurring over a 30-year period which equates to 10 percent chance of that hazard occurring any given year.

Climate Change Considerations

This describes the potential for climate change to affect the frequency and intensity of the hazard in the future.

Potential Magnitude and Severity

This subsection discusses the potential magnitude of impacts, or extent, from a hazard event. Magnitude classifications are as follows:

- **Negligible**: Less than 10 percent of property is severely damaged, facilities and services are unavailable for less than 24 hours, injuries and illnesses are treatable with first aid or within the response capability of the jurisdiction.
- **Limited**: 10 to 25 percent of property is severely damaged, facilities and services are unavailable between 1 and 7 days, injuries and illnesses require sophisticated medical support that does not strain the response capability of the jurisdiction, or results in very few permanent disabilities.
- **Critical**: 25 to 50 percent of property is severely damaged, facilities and services are unavailable or severely hindered for 1 to 2 weeks, injuries and illnesses overwhelm medical support for a brief period of time or result in many permanent disabilities and a few deaths. overwhelmed for an extended period of time or many deaths occur.

- Catastrophic: More than 50 percent of property is severely damaged, facilities and services are unavailable or hindered for more than two weeks, the medical response system is overwhelmed for an extended period of time or many deaths occur.

Vulnerability Assessment

Vulnerability is the measurement of exposed structures, critical facilities, or populations relative to the risk of the hazard. For most hazards, vulnerability is a best estimate. Some hazards, such as flood, affect specific areas so that exposure can be quantified, and vulnerability assessments result in a more specific approximation. Other hazards, such as tornadoes, are random and unpredictable in location and duration that only approximate methods can be applied. The assessment was conducted through the study of potential impacts to the following specific assets:

- People
- Property
- Critical Facilities and Infrastructure
- Economy
- Historic and Cultural Resources
- Natural Resources

Development Trends Related to Hazards and Risk

This section describes how future development and growth could impact vulnerability to each hazard. Specific trends can be found in each county or tribal annex.

Risk Summary

This section summarizes risk by county according to the area affected, likelihood, and magnitude of impacts. Overall, Hazard Significance is summarized for the region and by county and tribe. If the hazard has impacts on specific towns or cities in the region that differ from the county, they are noted here, where applicable.

4.2.2 Communicable Disease

Hazard/Problem Description

A communicable disease spreads from one person to another through a variety of ways that include contact with blood and bodily fluids, breathing in an airborne virus, or being bitten by an insect.

The scale of a communicable disease outbreak or biological incident is described by the extent of the spread of disease in the community. An outbreak can be classified as an endemic, an epidemic, or a pandemic depending on the prevalence of the disease locally and around the world.

- An endemic is defined as something natural to or characteristic of a particular place, population, or climate. For example, threadworm infections are endemic in the tropics.
- An epidemic is defined as a disease that spreads rapidly through a demographic segment of the human population, such as everyone in a given geographic area, a similar population unit, or everyone of a certain age or sex, such as the children or women of a region.
- A pandemic is defined as an extensive epidemic with effects felt worldwide.

While many potentially devastating diseases are spread through ingestion or insects, airborne diseases and those spread through physical contact pose higher risks to the community as they are difficult to control. Diseases such as influenza, pertussis, tuberculosis, and meningitis are all spread through these methods and pose a threat to communities. Health agencies closely monitor for diseases with the potential to cause an epidemic and seek to develop and promote immunizations.

A pandemic can be defined as a public health emergency that spans several countries or continents, usually affecting a large number of people. Pandemics are most often caused by new subtypes of viruses or bacteria to which humans have little or no natural immunity. Even when there is a strong healthcare system in place, disease outbreaks can strain and overwhelm community resources.

A pandemic disease could spread easily person-to-person, causing serious illness, and can sweep across the country and around the world in a very short time. Impacts could range from school and business closings to the interruption of basic services such as public transportation, health care, and the delivery of food and essential medicines. An especially severe pandemic could lead to high levels of illness, death, social disruption, and economic loss.

Because of the process utilized to prepare vaccines, it is impossible to have vaccines pre-prepared to combat pandemics. Additionally, for novel viruses, identification of symptoms, mode of transmission, and testing and identification may require development, causing significant delays in response actions. A portion of the human and financial cost of a pandemic is related to the lag time to prepare a vaccine to prevent the future spread of the novel virus. In some cases, current vaccines may have limited activity against novel strains.

Ongoing COVID-19 Pandemic

Since March 2020, the State of Montana, the nation, and the world were dealing with the COVID-19 pandemic. The COVID-19 virus has a much higher rate of transmission than the seasonal flu, primarily by airborne transmission of droplets and bodily fluids. Common symptoms include fever, cough, fatigue, shortness of breath or breathing difficulties, and loss of smell and taste. While most people have mild symptoms, some people develop acute respiratory distress syndrome, with roughly one in five requiring hospitalizations. Recent studies have shown the average area-specific COVID-19 case fatality rate to be 2% - 3% worldwide, higher than previously reported estimates (Cao, Hiyoshi and Montgomery 2020). Case fatality rate, also called case fatality risk or case fatality ratio, in epidemiology, is the proportion of people who die from a specified disease among all individuals diagnosed with the disease over a certain period of time (Harrington 2022). The key challenge in containing the spread has been the fact that it can be transmitted by asymptomatic people.

2022 US Monkeypox Outbreak

According to the Center for Disease Control and Prevention (CDC), monkeypox is a rare disease caused by infection with the monkeypox virus. Monkeypox virus is part of the same family of viruses as smallpox. Monkeypox symptoms are similar to smallpox symptoms but milder, and monkeypox is rarely fatal. Symptoms of monkeypox can include fever, headache, muscle aches, swollen lymph nodes, chills, exhaustion, and a rash that can look like pimples or blisters. The rash goes through different stages before healing completely. Some people get a rash first, followed by other symptoms, while others only experience a rash. The illness typically lasts 2 to 4 weeks and can spread from the time symptoms start until the rash has fully healed and a fresh layer of skin has formed. People who do not have monkeypox symptoms cannot spread the virus to others.

The virus can spread from person to person through:

- Direct contact with the infectious rash, scabs, or bodily fluids
- Touching items (such as clothing or linens) that previously touched the infectious rash or bodily fluids
- Respiratory secretions during prolonged, face-to-face contact, or intimate physical contact
- Touching items (such as clothing or linens) that previously touched the infectious rash or body fluids
- Placenta from pregnant person to fetus

It is also possible for people to get monkeypox from infected animals, either by being scratched or bitten by the animal or by preparing, eating, or using products from an infected animal.

Monkeypox was discovered in 1958 when two outbreaks of a pox-like disease occurred in colonies of monkeys kept for research. Despite being named "monkeypox," the source of the disease remains unknown. However, African rodents and non-human primates (like monkeys) might harbor the virus and infect people. The first human case of monkeypox was recorded in 1970. Before the 2022 outbreak, monkeypox had been reported in people in several central and western African countries. Previously, almost all monkeypox cases in people outside of Africa were linked to international travel to countries where the disease commonly occurs or through imported animals. These cases occurred on multiple continents.

Based on CDC's data, as of December 2, 2022, there are 82,021 cases all over the world in 110 countries. There are 29,630 cases in the US and 7 in the State of Montana. The World Health Organization (WHO) declared Monkeypox Spread a Global Health Emergency on July 23, 2022.

Hantavirus Pulmonary Syndrome (HPS)

According to the State of Montana's Department of Public Health and Human Services (DPHHS), Hantavirus Pulmonary Syndrome (HPS) is another communicable disease of concern to the State of Montana. HPS is an illness caused by a family of viruses called hantaviruses. HPS is a rare but often serious illness of the lungs. In Montana, the deer mouse is the reservoir for the hantavirus. The virus is found in the droppings, urine, and saliva of infected mice. The most common way that a person can get HPS is by breathing in the virus when it is aerosolized (stirred up into the air). People can also become infected after touching mouse droppings or nesting materials that contain the virus and then touching their eyes, nose, or mouth.

Geographical Area Affected

The entirety of the Montana Eastern Region is susceptible to the spread of infectious diseases therefore the geographic area affected is **Extensive**. Disease usually spreads throughout vulnerable populations and in areas where people live and work in close quarters. Depending on the specifics of the illness, these areas can include shelters, senior homes, schools, and places of business. In general, it is likely that the more populated areas may be affected sooner and may experience higher infection rates.

The Montana DPHHS has reported 319,023 cases of COVID-19 statewide and 3,600 deaths as of December 2, 2022. The current COVID-19 pandemic has affected all the counties in the Eastern Region. Table 4-4 shows the total cases and deaths specific to the Eastern Region. Data specific to tribes are included in the nearest counties. The Eastern Region comprises approximately 24% of the statewide total cases and 32% of the statewide total deaths. In general, it is likely that the more-populated areas municipal areas may be affected sooner and may experience higher infection rates.

Table 4-4 COVID-19 Cases and Deaths by County (as of December 09, 2022)

County	Cases	Cases Per Total Pop*.	Deaths	Deaths Per Total Pop.
Big Horn	5,619	42.6%	102	0.8%
Carbon	2,406	22.9%	29	0.3%
Carter	287	21.3%	5	0.4%
Custer	3,463	28.9%	52	0.4%
Daniels	454	26.1%	9	0.5%
Dawson	2,724	30.3%	59	0.7%
Fallon	775	25.2%	11	0.4%
Garfield	250	25.7%	3	0.3%
Golden Valley	166	20.2%	5	0.6%
McCone	436	24.2%	9	0.5%
Musselshell	1,075	22.3%	31	0.6%

County	Cases	Cases Per Total Pop*.	Deaths	Deaths Per Total Pop.
Powder River	412	23.4%	10	0.6%
Prairie	289	23.6%	4	0.3%
Roosevelt	3,786	34.8%	75	0.7%
Rosebud	3,070	36.3%	62	0.7%
Sheridan	882	25.0%	13	0.4%
Stillwater	1,701	19.1%	32	0.4%
Treasure	145	20.9%	1	0.1%
Valley	2,072	27.4%	39	0.5%
Wibaux	243	23.9%	8	0.8%
Wheatland	450	21.6%	14	0.7%
Yellowstone	49,760	29.8%	588	0.4%
Eastern Region	80,465	29.5%	1,161	0.40%

Source: MT DPHHS COVID Dashboard *Population total is based on U.S. Census Bureau ACS 5-Year Estimates

Past Occurrences

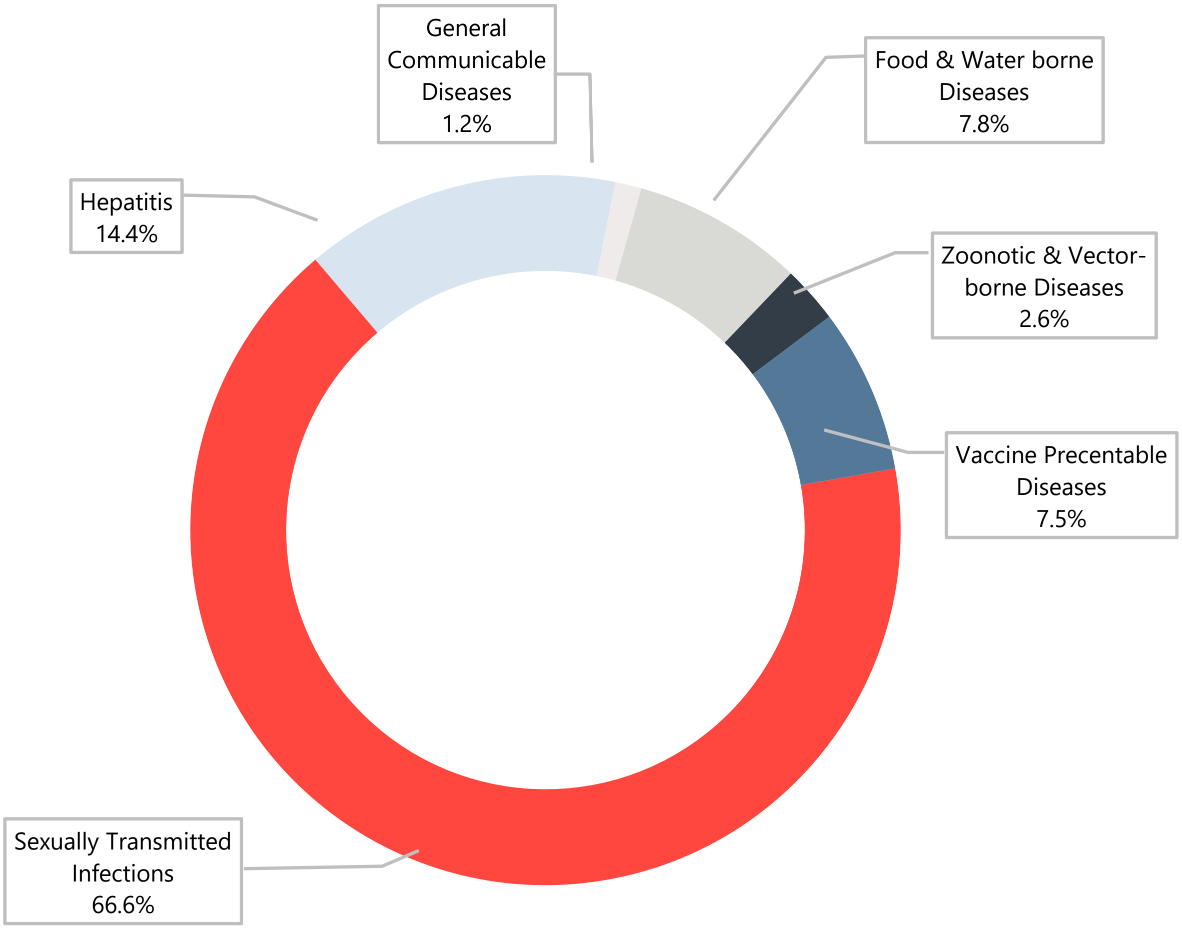
Since the early 1900s, five lethal pandemics have swept the globe:

- **1918-1919 Spanish Flu:** The Spanish Flu was the most severe pandemic in recent history. The number of deaths was estimated to be 50-100 million worldwide and 675,000 in the United States. Its primary victims were mostly young, healthy adults. At one point, more than 10% of the American workforce was bedridden.
- **1957-1958 Asian Flu:** The 1957 Asian Flu pandemic killed 1.1 million people worldwide, including about 70,000 people in the United States, mostly the elderly and chronically ill. Fortunately, the virus was quickly identified, and vaccine production began in May 1957.
- **1968-1969 H3N2 Hong Kong Flu:** The 1968 Hong Kong Flu pandemic killed one million people worldwide and approximately 100,000 people in the United States. Again, the elderly were more severely affected. This pandemic peaked during school holidays in December, limiting student-related infections, which may have kept the number of infections down. Also, people infected by the Asian Flu ten years earlier may have gained some resistance to the new virus.
- **2009-2010 H1N1 Swine Flu:** This influenza pandemic emerged from Mexico in early 2009 and was declared a public health emergency in the US on April 26. By June, approximately 18,000 cases had been reported in the US and the virus had spread to 74 countries. Most cases were fairly mild, with symptoms similar to the seasonal flu, but there were cases of severe disease requiring hospitalization and some deaths. On May 11, 2009, the Montana DPHHS reported the state's first confirmed case of swine flu. As of January 21, 2010, there were 801 confirmed cases and 18 confirmed deaths in Montana.
- **2020-Ongoing COVID-19:** The COVID-19 or novel coronavirus was detected in December 2019 and was declared a pandemic in March 2020. As of December 2, 2022, 643 million cases and 6.6 million deaths have been reported globally, including approximately 98.3 million cases and 1.1 million deaths in the US. Worldwide there have been 13.0 billion vaccine doses administered. The response to the COVID-19 Pandemic included numerous public health orders, including stay-home orders, massive testing infrastructure, the establishment of alternate care sites to support the hospital system, and an unprecedented community-wide vaccination push. Montana’s news leader KTVQ noted on December 2021 that COVID-19 was the leading cause of death among Montana’s Native Americans in 2020. According to a report released by the State’s Department of Public Health and Human Services, COVID-19 was responsible for 251 of the 1,022 total deaths among Montana’s Native Americans in 2020. While

Native Americans only make up around 7% of the state's population, they accounted for 32% of the deaths and 19% of cases in the state from March to October of 2020 (Schubert 2021).

According to the 2019 DPHHS Communicable Disease in Montana Annual Report, the most recent annual report available, sexually transmitted diseases rank the highest among all the reported communicable diseases, followed by hepatitis, food & water borne diseases, and vaccine-preventable diseases, as shown in Figure 4.

Figure 4-10 2019 Montana DPHHS Communicable Disease Rates



The report also noted a sudden increase in the incidence of hepatitis A. While hepatitis A is spread through ingestion of the virus, primarily through close person contact or the sharing of contaminated food or drinks, the 2019 outbreak was predominantly linked to injection drug use and transmission among people experiencing homelessness. Of the cases of hepatitis, A reported in Montana in 2019, almost half were reported in Yellowstone County.

Also noted was the continued increase in the incidence of gonorrhea. However, it is believed that the increase in reported cases is partially due to an increase in screening tests being performed across the state, suggesting that gonorrhea has been underreported for many years.

Frequency/Likelihood of Occurrence

Although it is impossible to predict the next disease outbreak, recent history shows these outbreaks are not uncommon and are likely to reoccur. Based on the five pandemics that have affected the United States in roughly the last 100 years, a pandemic occurs on average roughly every 20 years. In other words, there is a 5% probability that a pandemic that affects the entire United States will occur in any given year. As a result, the likelihood of occurrence for communicable disease is **Occasional.**

For the current COVID-19 pandemic, due to the virus's ability to mutate and rapidly infect those who are not vaccinated, the pandemic may extend for several years, and booster vaccines may be necessary to prevent future outbreaks. In just the last couple of decades, the world has drastically increased points of transmissions through global travel and trade to levels unseen in human history – this may have a drastic impact on the frequency of pandemics and the speed with which they spread in coming years.

Climate Change Considerations

As the Earth's climate continues to warm, researchers predict wild animals will be forced to relocate their habitats — likely to regions with large human populations — dramatically increasing the risk of a viral jump to humans that could lead to the next pandemic. This link between climate change and viral transmission is described by an international research team led by scientists at Georgetown University, published in *Nature* (Georgetown University 2022). The scholars noted that the geographic range shifts due to climate change could cause species that carry viruses to encounter other mammals, sharing associated viruses thousands of times, which may then further be spread to humans. In addition, rising temperatures caused by climate change will impact bats, which account for the majority of novel viral sharing. Bats' ability to fly will allow them to travel long distances and share viruses in geographically dispersed places. Altogether, the study suggests that climate change will become the biggest upstream risk factor for disease emergence — exceeding higher-profile issues like deforestation, wildlife trade, and industrial agriculture. The authors highlight a need to pair wildlife disease surveillance with real-time studies of environmental change (Carlson, C.J., Albery, G.F., Merow, C. *et al*., 2022).

Potential Magnitude and Severity

The magnitude of a disease outbreak or public health emergency will range significantly depending on the aggressiveness of the virus in question, the ease of transmission, and the efficacy of public health and medical responses. Pandemic influenza is easily transmitted from person to person but advances in medical technologies have greatly reduced the number of deaths caused by influenza over time.

Today, a large percentage of the world's population is clustered in cities, making them ideal breeding grounds for epidemics. Additionally, the explosive growth in air travel means a virus could spread around the globe within hours, quickly creating a pandemic. Under such conditions, there may be very little warning time. It is estimated that one to six months will have lapsed between the time that a dangerous new influenza strain is identified and the time that outbreaks begin to occur in the United States. Outbreaks are expected to occur simultaneously throughout much of the nation, preventing shifts in human and material resources that normally occur with other natural disasters. These aspects make influenza pandemic unlike most other public health emergencies or community disasters. Pandemics typically last for several months to years. Taking into account the variations in viruses, the potential magnitude of communicable disease is **Critical.**

As seen with the ongoing COVID-19 pandemic, the rapid spread of a virus combined with the need for increased hospital and coroner resources, testing centers, first responders, and vaccination administration sites causes significant strain on the medical system and public health departments. Additionally, other public health-related triggers or commingled public health hazards (such as an outbreak of another pathogen) or even more contagious strains of COVID such as the recent Omicron, BA.5 and Delta B.1.617.2 variant, can quickly lead to even more outbreaks.

The Pandemic Intervals Framework (PIF) is a six-phased approach to defining the progression of an influenza pandemic. This framework is used to guide influenza pandemic planning and provides recommendations for risk assessment, decision-making, and action. These intervals provide a common method to describe pandemic activities that can inform public health actions. The duration of each pandemic interval might vary depending on the characteristics of the virus and the public health response.

The six-phase approach was designed for the easy incorporation of recommendations into existing national and local preparedness and response plans. Phases 1 through 3 correlates with preparedness in the pre-pandemic interval, including capacity development and response planning activities, while Phases 4 through 6 signal the need for response and mitigation efforts during the pandemic interval.

Pre-Pandemic Interval

Phase 1 is the natural state in which influenza viruses circulate continuously among animals (primarily birds) but do not affect humans.

Phase 2 occurs when an animal influenza virus circulating among domesticated or wild animals is known to have caused infection in humans and is thus considered a potential pandemic threat. Phase 2 involves cases of animal influenza that have circulated among domesticated or wild animals and have caused specific cases of infection among humans.

Phase 3 represents the mutation of the animal influenza virus in humans so that it can be transmitted to other humans under certain circumstances (usually very close contact between individuals). At this point, small clusters of infection have occurred.

Phase 4 is characterized by verified human-to-human transmission of the virus able to cause "community-level outbreaks." The ability to cause sustained disease outbreaks in a community marks a significant upward shift in the risk for a pandemic. Phase 4 involves community-wide outbreaks as the virus continues to mutate and becomes more easily transmitted between people (for example, transmission through the air)

Phase 5 is characterized by verified human-to-human spread of the virus in at least two countries in one WHO region. While most countries will not be affected at this stage, the declaration of Phase 5 is a strong signal that a pandemic is imminent and that the time to finalize the organization, communication, and implementation of the planned mitigation measures is short.

Phase 6, the pandemic phase, is characterized by community-level outbreaks in at least one other country in a different WHO region in addition to the criteria defined in Phase 5. The designation of this phase will indicate that a global pandemic is underway.

Vulnerability Assessment

People

Pandemics can affect large segments of the population for long periods. The number of hospitalizations and deaths will depend on the virulence of the virus. Risk groups cannot be predicted with certainty; the elderly, people with underlying medical conditions, and young children are usually at higher risk, but as discussed above, this is not always the case. People without health coverage or access to good medical care are also likely to be more adversely affected.

According to the 2020 ACS 5-Year Estimates of the Eastern Region, 18.5% of the Region's population is 65 years of age or older, 5.7% of the population is 5 years of age or younger, and 11.7% experienced poverty in the prior 12 months. For comparison, within the State of Montana, those over 65 years of age make up 18.7% of the population, those under five years of age make up 5.8% of the population, and 12.8% of the

State's population had income in the past 12 months below poverty level. This shows that the population at risk to communicable disease in Eastern Montana is similar to the State's population exposure.

However, impacts, mortality rates, speed and type of spread are disease-specific. As seen with the current COVID-19 pandemic statewide, according to the State's DPHHS, the most positive cases occurred in the 30-49 age group. Hospitalizations and deaths, however, happened more within the over 50 age group.

Property

Communicable diseases would not have direct impacts on infrastructure or the built environment. Should infrastructure require human intervention to fulfill vital functions, these functions could be impaired by absenteeism, sick days and isolation, quarantine, and disease prophylaxis measures. As concerns about contamination increase, property may be quarantined or destroyed as a precaution against spreading illness. Additionally, traditional sheltering facilities, including shelters for persons experiencing homelessness or facilities to support displaced persons during an evacuation, cannot be done in a congregate setting. This requires additional planning considerations or the use of facilities that allow for non-congregate shelter settings which may require an approval from FEMA and may have an increased cost.

Critical Facilities and Lifelines

The impacts of a communicable disease on critical infrastructure and lifelines would center on service disruption due to staff missing work and on shortages in essential resources and supplies to perform services, as seen with personal protective equipment during the COVID-19 pandemic within the health and medical sector.

While automated systems and services that allow for the physical distancing of staff from other persons may fare better through a communicable disease incident, all critical infrastructure sectors and lifelines would likely be affected due to the globalization of supply chains, services, and interdependency of most communities.

Economy

A widespread communicable disease outbreak could have devastating impacts on the Eastern Region's economy. The economic impacts fall under two categories – economic losses as a result of the disease, and economic losses to fight the disease. Economic impacts as a result of a disease include those costs associated with lost work and business interruption. Depending on the disease and the type and rate of spread, businesses could see a loss of consumer base as people self-isolate or avoid travel. This could last for a protracted amount of time, compounding economic loss. Economic costs are also associated with incident response. Two of the biggest areas of cost are public information efforts and mass prophylaxis.

In a normal year, lost productivity due to illness costs US employers an estimated $530 billion. During a pandemic, that figure would likely be considerably high and could trigger a recession or even a depression. According to an October 2020 report by The Journal of American Medical Association (JAMA) Network, the estimated cumulative financial costs of the COVID-19 pandemic related to the COVID-19 economic recession and compromised health (premature death, mental health, long-term health impairment) in the US population was almost $16 trillion. As of July 29, 2021, the Montana Coronavirus Relief Fund has awarded over $819 million to businesses and nonprofits across the State to support economic recovery efforts.

Historic and Cultural Resources

As mentioned previously, communicable diseases would not have specific impacts on the built or natural environment, including historic and cultural resources. However, historic and cultural resources are often intertwined with the tourism industry, therefore reduced tourism could lead to impacts such as a loss of revenue needed for resource maintenance.

Natural Resources

Impacts on natural resources can vary. Some ecosystems showed signs of improvement during peak covid-19 lockdown. However, some zoonotic diseases can spread from animals to humans, wreaking havoc on both populations. Examples of zoonotic diseases include avian flu, swine flu, tuberculosis, plague, and rabies.

Development Trends Related to Hazards and Risk

Population growth and development contribute to pandemic exposure. Future development in the Eastern Region has the potential to change how infectious diseases spread through the community and impact human health in both the short and long term. New development may increase the number of people and facilities exposed to public health hazards and greater population concentrations (often found in special needs facilities and businesses) put more people at risk. During a disease outbreak, those in the immediate isolation area would have little to no warning, whereas the population further away in the dispersion path may have some time to prepare and mitigate against disease depending on the hazard, its transmission, and public notification.

Risk Summary

In summary, the Communicable Disease hazard is considered to be overall **Medium** significance for the Region. Variations in risk by jurisdiction are summarized in the table below, along with key issues from the vulnerability assessment.

- Pandemics affecting the U.S. occur roughly once every 20 years, meaning there is a roughly 5% chance a pandemic will happen each year, but they cannot be reliably predicted.
- Effects on people will vary, while the elderly, people with underlying medical conditions, and young children are usually at higher risk.
- Effects on property are typically minimal, although quarantines could result in short-term closures.
- Effects on economy: lost productivity due to illness and potential business closures could potentially have severe economic impacts. Social distancing requirements and fear of public gatherings could significantly reduce in-person commerce.
- Effects on critical facilities and infrastructure: community lifelines, such as healthcare facilities, like hospitals will be impacted and may be overwhelmed and have difficulty maintaining operations due to bed availability, medical staffing shortages, and lack of PPE and other supplies.
- Unique jurisdictional vulnerability: As mentioned above, COVID-19 was the leading cause of death in Montana's Native American tribes, likely due to economic and societal structures.
- Ongoing mitigation activities should focus on disease prevention, especially during flu season. This includes, but is not limited to, pre-season community outreach campaigns to educate the public about risks and available support; establishing convenient vaccination centers; reaching out to vulnerable populations and caregivers; and issuing advisories and warnings.
- Related Hazards: Human Conflict.

Table 4-5 Risk Summary Table: Communicable Disease

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	Medium		
Big Horn	High	Hardin, Lodge Grass	Big Horn has the lowest rate of insurance, and the highest rate of COVID-19 infections in the Eastern region, which suggest vulnerability to communicable disease.

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Carbon	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	None
Carter	Medium	Ekalaka	None
Custer	Medium	Ismay, Miles City	None
Crow Tribe	Medium		NA
Daniels	Medium	Scobey, Flaxville	None
Dawson	Low	Richey, Glendive	None
Fallon	Medium	Plevna, Baker	Societal and economic structures have increased poor outcomes from communicable diseases in Native communities.
Fort Peck Tribes	High	Jordan	None
Garfield	Medium	Ryegate, Lavina	Garfield has the lowest population density of all counties in Montana which lowers the risk of communicable disease spread.
Golden Valley	Medium	Circle	None
McCone	Low	Roundup	Dawson has a low population density and a high rate of health insurance, lowering the risk of spread and increasing the probability of medical intervention.
Musselshell	Medium		None
Northern Cheyenne	High	Broadus	Societal and economic structures have increased poor outcomes from communicable diseases in Native communities.
Powder River	Medium	Terry	None
Prairie	Medium	Fairview, Sidney	A significant portion of Prairie County's population is over the age of 65 and is therefore more susceptible to communicable diseases.
Richland	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	None
Roosevelt	High	Colstrip, Forsyth	Roosevelt has the highest rate of poverty in the Eastern Region which would impact its ability to adapt to a communicable disease event.
Rosebud	Medium	Outlook, Westby, Plentywood, Medicine Lake	None
Sheridan	Medium	Columbus	None
Stillwater	Medium	Hysham	None
Treasure	Medium	Fort Peck, Glasgow, Nashua, Opheim	None
Valley	Medium	Harlowton, Judith Gap	None
Wheatland	Medium	Wibaux	None
Wibaux	Medium	Billing, Laurel, Broadview	None
Yellowstone	High		Yellowstone has the largest population per square mile of all counties in Montana, which increases the likelihood of disease spread.

4.2.3 Cyber-Attack

Hazard/Problem Description

The Merriam-Webster dictionary defines cyber-attacks as "an attempt to gain illegal access to a computer or computer system to cause damage or harm." Cyber-attacks use malicious code to alter computer operations or data. The vulnerability of computer systems to attacks is a growing concern as people and institutions become more dependent upon networked technologies. The Federal Bureau of Investigation (FBI) reports that "cyber intrusions are becoming more commonplace, more dangerous, and more sophisticated," with implications for private- and public-sector networks. Cyber threats can take many forms, including:

- **Phishing attacks:** Phishing attacks are fraudulent communications that appear to come from legitimate sources. Phishing attacks typically come through email but may come through text messages as well. Phishing may also be considered a type of social engineering meant to exploit employees into paying fake invoices, providing passwords, or sending sensitive information.
- **Malware attacks:** Malware is malicious code that may infect a computer system. Malware typically gains a foothold when a user visits an unsafe site, downloads untrusted software, or may be downloaded in conjunction with a phishing attack. Malware can remain undetected for years and spread across an entire network.
- **Ransomware:** Ransomware typically blocks access to a jurisdiction's/agency's/ business' data by encrypting it. Perpetrators will ask for a ransom to provide the security key and decrypt the data, although many ransomware victims never get their data back even after paying the ransom.
- **Distributed Denial of Service (DDoS) attack**: Perhaps the most common type of cyber attack, a DDoS attack seeks to overwhelm a network and causes it to either be inaccessible or shut down. A DDoS typically uses other infected systems and internet-connected devices to "request" information from a specific network or server that is not configured or powerful enough to handle the traffic.
- **Data breach**: Hackers gaining access to large amounts of personal, sensitive, or confidential information has become increasingly common in recent years. In addition to networked systems, data breaches can occur due to the mishandling of external drives.
- **Critical Infrastructure/SCADA System attack:** There have been recent critical infrastructure Supervisory Control and Data Acquisition (SCADA) system attacks aimed at taking down lifelines such as power plants and wastewater facilities. These attacks typically combine a form of phishing, malware, or other social engineering mechanisms to gain access to the system.

Cyber-attacks are rapidly increasing in the United States. The FBI Internet Crime Complaint Center (IC3) was developed to provide the public with a direct way to report cyber crimes to the FBI. In 2021, the FBI Internet Crime Report reported a record number of cyber-attacks, with a 7% increase from 2020. The events reported to the FBI are used to track the trends and threats from cyber criminals to combat cyber threats and protect U.S. citizens, businesses, and government from future attacks.

Geographical Area Affected

Cyber-attacks can and have occurred in every location regardless of geography, demographics, and security posture. Anyone with information online is vulnerable to a cyber-attack. Incidents may involve a single location or multiple geographic areas. A disruption can have far-reaching effects beyond the location of the targeted system; disruptions that occur far outside the State can still impact people, businesses, and institutions within Eastern Region. All servers in the Eastern Region are potentially vulnerable to cyber-attacks. Businesses, industry, and even individuals are also susceptible to cyber-attacks. Therefore, the geographic extent of cyber-attack is **Significant**.

Past Occurrences

According to the FBI's 2021 Internet Crime Report, the FBI received 2.76 million complaints with $18.7 billion in losses over the last five years due to cyber-attacks. The Crime Report also noted a trend of increasing cybercrime complaints and losses each year. Nationwide losses in 2021 alone exceeded $6.9 billion, a 392% increase since 2017. According to the 2021 Report, Montana ranked 48/57 among U.S. territories in the total number of victims, with 1,188 victims of cyber-crime, and 49th in total victim losses, with $10,107,283 in total losses,

Data on past cyber-attacks impacting Montana was gathered from The Privacy Rights Clearinghouse. The Privacy Rights Clearinghouse, a non-profit organization based in San Diego, maintains a timeline of 9,741 data breaches resulting from computer hacking incidents in the United States from 2005-2021. The database lists 35 data breaches against systems located in Montana totaling almost 1.5 million impacted records; it is difficult to know how many of those affected residents in the Montana Eastern Region. Attacks happening outside of the State can also impact local businesses, personal identifiable information, and credit card information. Table 4-6 shows several of the most significant cyber-attacks in Montana in recent years. The data aims to provide a general understanding of the impacts of cyber-attacks by compiling an up-to-date list of incidents but is limited by the availability of data: "This is an incomplete look at the true scope of the problem due in part to varying state laws."

Table 4-6 Major Cyber Attacks Impacting Montana (10,000+ Records), 2005-2021

Date Reported	Target	City	Organization Type	Total Records	Type of Attack
7/7/2014	Montana Department of Public Health & Human Services	-	Healthcare	1,062,509	Hacked by an Outside Party or Infected by Malware
1/30/2008	Davidson Companies	Great Falls	Business	226,000	Hacked by an Outside Party or Infected by Malware
3/11/2011	OrthoMontana	Billings	Healthcare	37,000	Portable Device (lost, discarded or stolen laptop, PDA, smartphone, memory stick, CDs, hard drive, data tape, etc.)
1/15/2016	New West Health Services dba New West Medicare	Kalispell	Healthcare	28,209	Portable Device (lost, discarded or stolen laptop, PDA, smartphone, memory stick, CDs, hard drive, data tape, etc.)
4/14/2017	Eastern Health Screening	-	Healthcare	15,326	PHYS

Source: The Privacy Rights Clearinghouse

In total, the Privacy Rights Clearinghouse has reported 35 attacks in Montana since 2005 with a total of 1,471,889 records. Of these records lost in Montana, a majority were from healthcare organizations. It is difficult to know how many of these incidents affected residents in the Montana Eastern Region.

The Montana Department of Agriculture temporarily took the USAHERDS web-based software offline in the year 2021 to allow the application's developer to beef up security following a suspected Chinese state-sponsored cyberattack. USAHERDS is used to track livestock by at least 18 US states. The suspected attacker – APT41, had carried out a hacking campaign that comprised the networks of at least six US state governments (Power 2022).

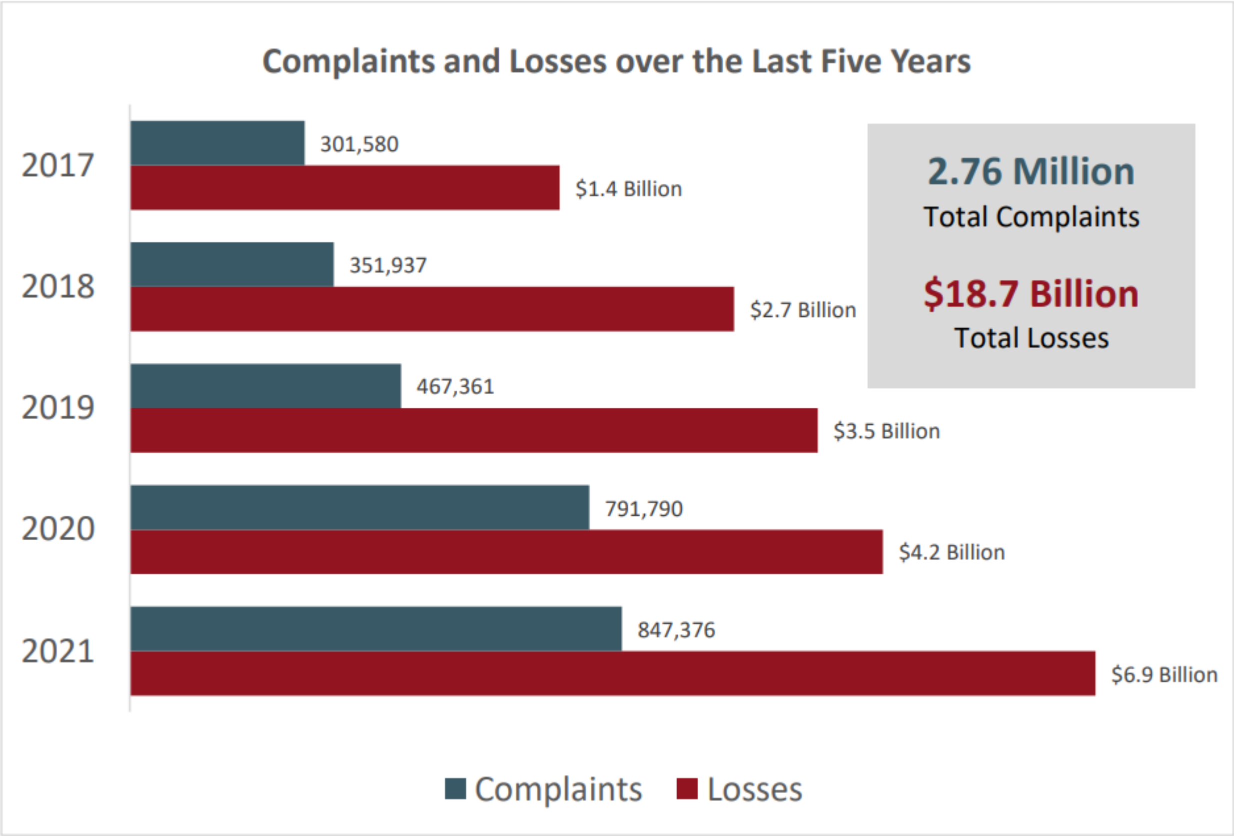
In February 2020, it is reported that Ryuk ransomware hacked the computer system of the Havre Public Schools. Despite the major scare, it was eventually concluded that the hackers did not gain access to student and employee information (Dragu 2020).

On April 3, 2015, Eastern Montana Clinic notified almost 7,000 patients of a payment data hack. The hacker bypassed the Clinic website's security measures and obtained access to the demographic and credit card information of 6,994 patients who paid their bill(s) via the link on the Clinic's website. The information available to the hacker included patient names, addresses, telephone numbers, email addresses, dates and amounts of credit card transactions, and the last four digits of patients' credit card numbers. In addition, approximately 44 patients' full credit card information was compromised. The Clinic took steps to mitigate any further harm to patients from this security incident ("Eastern Montana Clinic Notifies Almost 7,000 Patients Of Payment Data Hack" 2015).

Frequency/Likelihood of Occurrence

Small-scale cyber-attacks such as DDoS attacks occur daily, but most have negligible impacts at the local or regional level. Data breaches are also extremely common, but again most have only minor impacts on government services. Additionally, the FBI Internet Crime Report 2021 found that there is a trend of increasing cyber-attacks over the past 5 years. These trends are shown in Figure 4.

Figure 4-11 Trends of the Frequency of Cyber-attacks, 2017-2021



Source: The FBI Internet Crime Report 2021

Perhaps of greatest concern to the Eastern Region are ransomware attacks, which are becoming increasingly common. It is difficult to calculate the odds of the Eastern Region or one of its jurisdictions being hit with a successful ransomware attack in any given year, but it is likely to be attacked in the coming years.

The possibility of a larger disruption affecting systems within the Region is a constant threat, but it is difficult to quantify the exact probability due to such highly variable factors as the type of attack and intent of the attacker. Major attacks specifically targeting systems or infrastructure in the Eastern Region cannot be ruled out. Therefore, the probability of future cyber-attack is **Occasional**.

Climate Change Considerations

Changes in development have no impact on the threat, vulnerability, and consequences of a cyber-attack.

Potential Magnitude and Severity

There is no universally accepted scale to explain the severity of cyber-attacks. The strength of a DDoS attack is often explained in terms of a data transmission rate. One of the largest DDoS disruptions ever, known as the Dyn Attack which occurred on October 21, 2016, peaked at 1.2 terabytes per second and impacted some of the internet's most popular sites, including Amazon, Netflix, PayPal, Twitter, and several news organizations.

Data breaches are often described in terms of the number of records or identities exposed. The largest data breach ever reported occurred in August 2013, when hackers gained access to all three billion Yahoo accounts. The hacking incidents associated with Montana in the Privacy Rights Clearinghouse database are of a smaller scale, ranging from 201 records to approximately 1.06 million, along with several cases in which an indeterminate number of records may have been stolen.

Ransomware attacks are typically described in terms of the amount of ransom requested, or the amount of time and money spent to recover from the attack. One report from cybersecurity firm Emsisoft estimates the average successful ransomware attack costs $81 million and can take 287 days to recover from. Therefore, the potential magnitude and severity of cyber-attack is **Critical**.

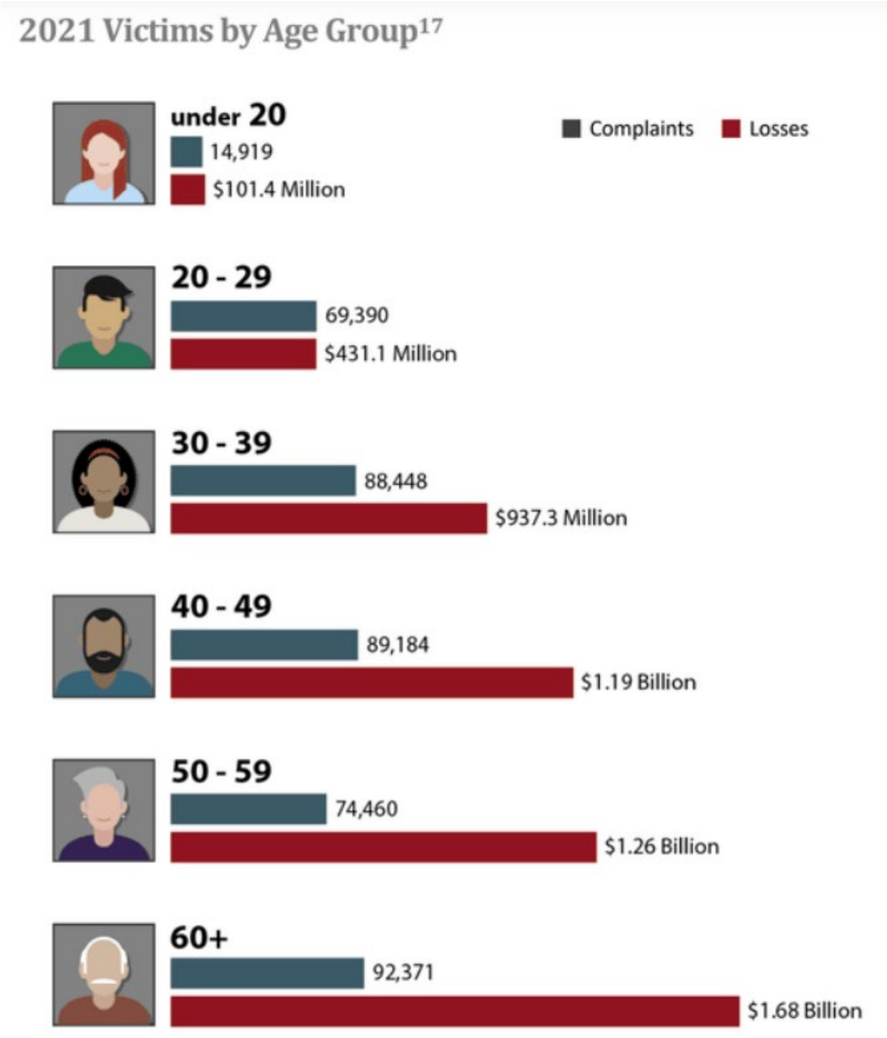
Vulnerability Assessment

People

Injuries or fatalities from cyber-attacks would generally only be possible from a major cyber-terrorist attack against critical infrastructure. More likely impacts on the public are financial losses and an inability to access systems such as public websites and permitting sites. Indirect impacts could include interruptions to traffic control systems or other infrastructure.

The FBI Internet Crime Reports on the victims of cyber-attack by age group. While the number of cyber-attack complaints is comparable across age groups, the losses increase significantly as age group increases, with individuals 60 years and older experiencing the greatest losses. This is likely due to seniors being less aware of cyberthreats, lack of the tools to identify cyberthreats, and "Grandparent Scams", which is a cyberattack where criminals impersonate a loved one in need, such as a grandchild, and ask for money. Figure 4 displays the breakdown of victims by age group in 2021.

Figure 4-12 Victims by Age Group in 2021



Source: The FBI Internet Crime Report 2021

Property

Most cyber-attacks affect only data and computer systems and have minimal impact on the general property. However, sophisticated attacks have occurred against the SCADA systems of critical infrastructure, which could potentially result in system failures on a scale equal to natural disasters. Facilities and infrastructure such as the electrical grid could become unusable. A cyber-attack took down the power grid in Ukraine in 2015, leaving over 230,000 people without power. A ransomware attack on the Colonia Pipeline in 2021 caused temporary gas shortages on the East Coast. The 2003 Northeast Blackout, while not the result of a cyber-attack, caused 11 deaths and an estimated $6 billion in economic loss.

Critical Facilities and Lifelines

An article posted on July 31, 2022, by government technology mentions that despite the lack of major headline-grabbing cyber-attacks against U.S. critical infrastructure so far in 2022, our global cyber battles continue to increase. Worldwide cyber actions are becoming less covert. Besides, according to IBM's 2022 annual Cost of a Data Breach Report, almost 80 percent of critical infrastructure organizations studied don't adopt zero-trust strategies, seeing average breach costs rise to $5.4 million – a $1.17 million increase compared to those that do. All while 28 percent of breaches amongst these organizations were ransomware or destructive attacks (Lohrmann 2022).

Cyber-attacks can interfere with emergency response communications, access to mobile data terminals, and access to critical pre-plans and response documents. According to the Cyber & Infrastructure Security Agency (CISA), cyber risks to 9-1-1 systems can have "severe impacts, including loss of life or property; job disruption for affected network users; and financial costs for the misuse of data and subsequent resolution." CISA also compiled a recent list of attacks on 9-1-1 systems including a DDoS in Arizona, unauthorized access with stolen credentials in Canada, a network outage in New York, and a ransomware attack in Baltimore.

Moreover, the delivery of services can be impacted since governments rely to a great extent on the electronic delivery of services. Most agencies rely on server backups, electronic backups, and remote options for Continuity of Operations and Continuity of Government. Access to documents on the network, OneDrive access, and other operations that require collaboration across the Eastern Region will be significantly impacted.

In addition, public confidence in the government will likely suffer if systems such as permitting, DMV, voting, or public websites are down for a prolonged amount of time. An attack could raise questions regarding the security of using electronic systems for government services.

Economy

Data breaches and subsequent identity thefts can have huge impacts on the public. The FBI Internet Crime Report 2021 reported losses in Montana due to cyber-attacks totaled $10,107,283 in 2021 alone.

Economic impacts from a cyber-attack can be debilitating. The cyber-attack in 2018 that took down the City of Atlanta cost at least $2.5 million in contractor costs and an estimated $9.5 million additional funds to bring everything back online. The attack in Atlanta took more than a third of the 424 software programs offline and recovery lasted more than 6 months. The 2018 cyber-attack on the Colorado Department of Transportation cost an estimated $1.5 million. None of these statistics consider the economic losses to businesses and ongoing IT configuration to mitigate a future cyber-attack.

Additionally, a 2016 study by Kaspersky Lab found that roughly one in five ransomware victims who pay their attackers never recover their data. A 2017 study found ransomware payments over a two-year period totaled more than $16 million. Even if a victim is perfectly prepared with full offline data backups, recovery from a sophisticated ransomware attack typically costs far more than the demanded ransom.

Historic and Cultural Resources

Most cyber incidents have little to no impact on historic, cultural, or natural resources. A major cyber terrorism attack could potentially impact the environment by triggering a release of hazardous materials, or by causing an accident involving hazardous materials by disrupting traffic control devices.

Natural Resources

Most cyber-attacks would have a limited impact on natural resources. There are cases, such as a cyber-attack on a hydroelectric dam, that could result in catastrophic consequences to natural and human-built environments in the case of a flood. If a cyber-attack occurred on several upstream dams and released significant amounts of water downstream, the additional pressure put on downstream dams could fail, resulting in massive flood events. This would not only jeopardize the energy system that relies on these dams but also cause significant damage to the natural environment.

Development Trends Related to Hazards and Risk

Changes in development have no impact on the threat, vulnerability, and consequences of a cyber-attack. Cyber-attacks can and have targeted small and large jurisdictions, multi-billion-dollar companies, small mom-and-pop shops, and individual citizens. The decentralized nature of the internet and data centers means that the cyber threat is shared by all, regardless of new construction and changes in development.

Risk Summary

- Overall, cyber-attacks are rated as a **Medium** significance in the planning area
- Cyber-attacks can occur anywhere and on any computer network, therefore, this hazard is rated as **Significant** location
- There is an increasing trend in the number of cyber-attacks in the U.S. each year, therefore, the frequency of cyber-attack is rated as **Likely**
- Cyber-attacks can result in significant economic losses, interruptions of critical facilities and services, and confidential data leaks; therefore, magnitude is ranked as **Critical**
- People ages 60+ are the most likely age group to experience the greatest monetary losses, although anyone of any age can be a victim to a cyber-attack
- Small businesses worth less than $10 million and local governments are increasingly becoming targets for cyber-attack, with criminals assuming these smaller organizations will lack the resources to prevent an attack
- Critical infrastructure, such as the energy grid and first responder communication, is vulnerable to cyber-attack and disruption
- Significant economic losses can result from cyber-attacks if the attackers ask for ransom
- Jurisdictions with a significantly large population and advanced infrastructure are most likely to experience cyber-attacks

Table 4-7 Risk Summary Table: Cyber Attack

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	Medium		None
Big Horn	Medium	Hardin, Lodge Grass	None
Carbon	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	None
Carter	Medium	Ekalaka	None
Crow Tribe	Medium		None
Custer	Medium	Ismay, Miles City	None
Daniels	Medium	Scobey, Flaxville	None
Dawson	Medium	Richey, Glendive	None
Fallon	Medium	Plevna, Baker	None
Garfield	Medium	Jordan	None
Golden Valley	Medium	Ryegate, Lavina	None
McCone	Medium	Circle	None
Musselshell	Medium	Roundup	None
North Cheyenne Tribe	Medium		None
Powder River	Medium	Broadus	None
Prairie	Medium	Terry	None
Richland	Medium	Fairview, Sidney	None
Roosevelt	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	None
Rosebud	Medium	Colstrip, Forsyth	None
Sheridan	Medium	Outlook, Westby, Plentywood, Medicine Lake	None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Stillwater	Medium	Columbus	None
Treasure	Medium	Hysham	None
Valley	Medium	Fort Peck, Glasgow, Nashua, Opheim	None
Wheatland	Medium	Harlowton, Judith Gap	None
Wibaux	Medium	Wibaux	None
Yellowstone	Medium	Billing, Laurel, Broadview	None

4.2.4 Dam Failure

Hazard/Problem Description

A dam is a barrier constructed across a watercourse that stores, controls, or diverts water. Dams are constructed for a variety of uses, including flood protection, power, agriculture/irrigation, water supply, and recreation. The water impounded behind a dam is referred to as the reservoir and is usually measured in acre-feet, with one acre-foot being the volume of water that covers one acre of land to a depth of one foot. Depending on local topography, even a small dam may have a reservoir containing many acre-feet of water. Dams serve many purposes, including irrigation control, providing recreation areas, electrical power generation, maintaining water levels, and flood control.

Dam failures and releases from dams during heavy rain events can result in downstream flooding. Water released by a failed dam generates tremendous energy and can cause a flood that is catastrophic to life and property. Two factors that influence the potential severity of a full or partial dam failure are the amount of water impounded and the density, type, and value of downstream development and infrastructure. The speed of onset depends on the type of failure. If the dam is inspected regularly then small leaks allow for adequate warning time. Once a dam is breached, however, failure and resulting flooding occurs rapidly. Dams can fail at any time of year, but the results are most catastrophic when the dams fill or overtop during winter or spring rain/snowmelt events.

A catastrophic dam failure could challenge local response capabilities and require evacuations to save lives. Impacts to life safety would depend on the warning time and the resources available to notify and evacuate the public and could include major loss of life and potentially catastrophic damage to roads, bridges, and homes. Associated water quality and health concerns could also be an issue.

Dam failures are often the result of prolonged rainfall and overtopping, but can happen in any conditions due to erosion, piping, structural deficiencies, lack of maintenance and repair, or the gradual weakening of the dam over time. Other factors that can lead to dam failure include earthquakes, landslides, improper operation, rodent activity, vandalism, or terrorism.

According to FEMA, dams are classified in three categories that identify the potential hazard to life and property:

- **High hazard** - Dams where failure/mis-operation will probably cause loss of human life.
- **Significant hazard** - Dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
- **Low hazard** - Dams where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

Dam inundation can also occur from non-failure events or incidents such as when outlet releases increase during periods of heavy rains or high inflows. Controlled releases to allow water to escape when a reservoir is overfilling can help prevent future overtopping or failure. When outlet releases are not enough, spillways are designed to allow excess water to exit the reservoir and prevent overtopping. This can protect the dam but result in flooding downstream. Dam safety incidents are defined as situations at dams that require an immediate response by dam safety engineers. Detailed below in Figure 4 are the high, significant, and low hazard dams organized by county in the Eastern region. The Eastern region has the lowest number of high hazard dams of the three regions in the State, and 100% of the high hazard dams have Emergency Action Plans (EAPs) on file.

Table 4-8 Eastern Region Dam Summary Table

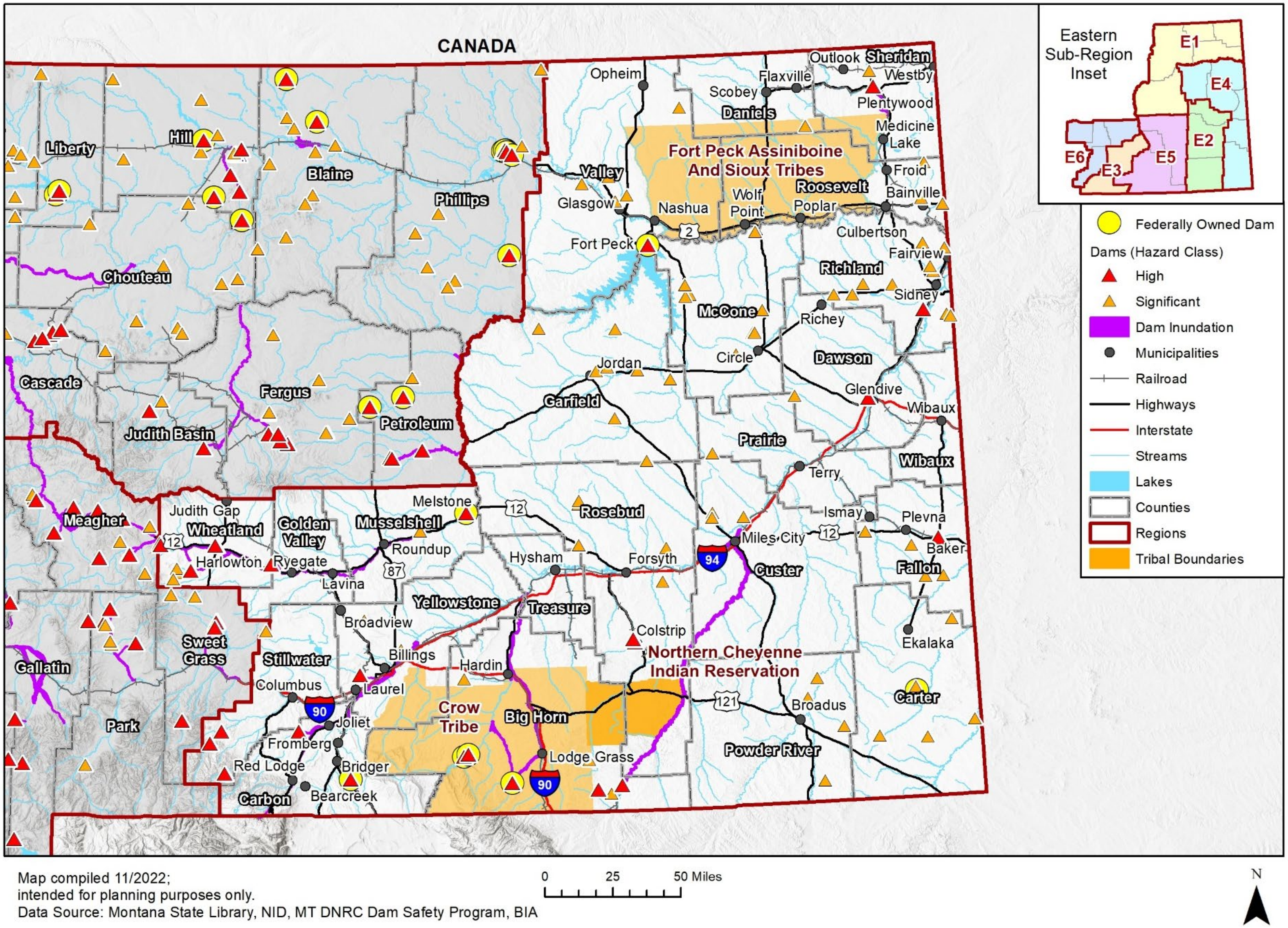
County	# High Hazard	# Significant	# Low	Total	Percentage of High hazard Dam with EAP
Big Horn	5	3	64	72	100%
Carbon	2	-	11	13	100%
Carter	-	7	104	111	-
Custer	-	3	173	176	-
Daniels	-	1	19	20	-
Dawson	1	1	62	64	100%
Fallon	2	4	30	36	100%
Garfield	-	8	236	244	-
Golden Valley	-	-	8	8	-
McCone	1	8	111	120	100%
Musselshell	1	1	28	30	100%
Powder River	-	4	43	47	-
Prairie	-	1	48	49	-
Richland	1	10	67	78	100%
Roosevelt	-	4	35	39	-
Rosebud	4	5	261	270	100%
Sheridan	1	1	22	24	100%
Stillwater	4	-	7	11	100%
Treasure	-	-	16	16	-
Valley	-	5	140	145	-
Wheatland	8	5	23	36	100%
Wibaux	-	-	13	13	-
Yellowstone	1	2	22	25	100%
Total	31	73	1,543	1,647	

Source: Montana Department of Natural Resources and Conservation (DNRC) Dam Safety Program, Montana State Library, NID, HIFLD 2022, Montana DES, NBI

Geographical Area Affected

The geographical area affected by dam failure is potentially **Significant**. According to the National Inventory of Dams (NID), there are a total of 1,647 dams throughout the counties of the Eastern Region. Thirty-one (31) of these dams are high hazard, and 73 are significant hazard dams, with the remainder being low hazard dams. 100% of the high hazard dams in the Eastern Region have EAPs on file. High and significant hazard dams located in and adjacent to the region are also shown on the map below, as some of these dam facilities, if impacted, can impact the Eastern Region. In some cases, there is inundation mapping, limited to privately owned high hazard dams, based on data from the MT DNRC. Additionally, there are limited inundation zones for dams owned by the Bureau of Indian Affairs (BIA), used with permission. Other federally owned dams are highlighted in yellow and do not have publicly available inundation mapping.

Figure 4-13 Eastern Region Dams



Past Occurrences

Dam failure floods in Montana have primarily been associated with riverine and flash flooding. According to the 2018 Montana State Hazard Mitigation Plan (SHMP) and the Montana Department of Natural Resources and Conservation (Montana DNRC), aging infrastructure is largely to blame for a number of failed dams in Montana. There have been numerous small failures primarily related to deterioration of corrugated metal pipe outlet works, which causes slow release of reservoir contents along the outside of the outlet pipe, with minimal downstream property damage but serious damage to the structure. Dams with potential for loss of life downstream are subject to stringent permitting, inspection, operation, and maintenance requirements. Deficiencies and problems are identified in advance and actions taken to mitigate the chance that the deficiency leads to failure. If a deficiency cannot be immediately addressed due to lack of data or lack of dam owner resources, risk reduction measures are put in place.

According to the 2018 State of Montana Hazard Mitigation Plan, there have been three past dam failures or incidents in the Eastern Region. The following information concerning these events is excerpted from the 2018 SHMP:

- March 1937 – The Midway Dam, located 40 miles northwest of Nashua in Valley County, suffered a breach during a flood on the Porcupine Creek. The spillway was undermined by floating ice, leading to a failure and subsequent four-foot wall of water which swept through the valley and caused extensive damage.
- July 1946 – The Carrol Dam, in Sheridan County eight miles northwest of Plentywood, failed after several inches of rainfall in the area over a short period of time. There were no fatalities in this incident, but there was extensive damage and destruction of homes and farm buildings throughout the valley beneath the dam.
- June 23, 2002 – Ross Dam in Garfield County failed, prompting downstream evacuations, but with limited damage downstream. Once house was flooded and several downstream stock dams broke, and gravel roads were washed out.

Frequency/Likelihood of Occurrence

Dam failures in the United States typically occur in one of four ways:

- Overtopping of the primary dam structure, which accounts for 34% of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30% of all dam failures.
- Failure due to piping and seepage accounts for 20% of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10% of all failures.

The remaining 6% of U.S. dam failures are due to miscellaneous causes. Many dam failures in the United States have been secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage.

Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable by a program of regular inspections. Terrorism and vandalism are serious concerns that all operators of public facilities must plan for; these threats are under continuous review by public safety agencies.

All of these factors considered, and taking into consideration the record of past events, the likelihood of a catastrophic dam failure is unlikely, but still possible. This gives a probability rating for dam failure of **Unlikely**. Compared to the other regions in the state, the relative lack of high and significant hazard dams in the Eastern Region means a generally lower risk of future severe consequences or casualties from this hazard. However, low hazard dams could still potentially fail and cause issues downstream, though not enough data is available to determine the magnitude or detail how impactful a low hazard dam could be on their surrounding communities.

Climate Change Considerations

According to the 2018 SHMP population and property exposure to dam failure is not likely to change significantly due to climate change. With a potential for more extreme precipitation events as a result of climate change, this could result in large inflows to reservoirs. However, this could be offset by generally lower reservoir levels if storage water resources become more limited or stretched in the future due to increasing droughts, and/or population growth. Owners and operators of dams may need to alter current maintenance and operational procedures in order to account for changes in the hydrograph as well as increased sedimentation.

Potential Magnitude and Severity

As noted above, dams are classified as High Hazard Potential if failure is likely to result in loss of life, or Significant Hazard Potential if failure is likely to cause property damage, economic loss, environmental damage, or disruption of lifeline facilities. These dam hazard designations can be used as an indicator of the potential magnitude and severity that is possible on a site-by-site basis. Based on the record of past events in the region and the hazard rankings of the regions dams, the impacts of dam failure or incident is **Limited**.

The potential magnitude of a dam failure in the planning area could change in the future; the hazard significance of certain dams could increase if development occurs in inundation areas

Vulnerability Assessment

While dam failures are unlikely, a major failure could have severe consequences. Structures, aboveground infrastructure, critical facilities, and natural environments are all vulnerable to dam failure. Roads closed due to dam failure floods could result in serious transportation disruptions due to the limited number of roads in the Eastern Region of the State. Information for the exposure analysis provided in the sections below is based off dam inundation data provided by the state.

The most significant issue associated with dam failure involves the properties and populations in the inundation areas. Flooding as a result of a dam failure would significantly impact these areas. There is often limited warning time for dam failure. These events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard.

People

Vulnerable populations are all populations downstream from dam facilities that are incapable of escaping the area within the allowable timeframe. This population includes the elderly and young who may be unable to get themselves out of the inundation area. The vulnerable population also includes those who would not have adequate warning from a television or radio emergency warning system.

According to GIS analysis conducted for this vulnerability assessment, there are an estimated 22,746 people residing in dam inundation zones throughout the Eastern Region. This estimate was derived by taking the number of residential parcels within the inundation zone and multiplying them by the average household size for each county per the U.S. Census Bureau American Community Survey estimates. The breakdown of these exposed populations per county and jurisdiction are shown in Table 4-9 below.

Property

Vulnerable properties are those within and close to the dam inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect.

Communities located below a high or significant hazard dam and along a waterway are potentially exposed to the impacts of a dam failure. High hazard dams threaten lives and property, while significant hazard dams threaten property only. Inundation maps that identify anticipated flooded areas (which may not coincide with known floodplains) are produced for many high hazard dams. Table 4-9 summarizes the estimated number of improved parcels, building values, and people within inundation zones (private dams only) for each county in the Eastern Region. Counties with the highest exposure of people and property include Yellowstone, Custer, and Carbon Counties. Table 4-10 summarizes the estimated number of parcels, building values, and people within inundation zones for each Tribe in the Eastern Region.

Table 4-9 Eastern Region Parcels at Risk to Overall Dam Inundation by County and Jurisdiction

County	Jurisdiction	Improved Parcels	Improved Value	Content Value	Total Value	Population
Big Horn	Crow Tribe	314	$27,051,775	$19,085,857	$46,137,632	1,007
	Big Horn County	22	$2,507,695	$1,965,058	$4,472,753	29
	Total	336	$29,559,470	$21,050,915	$50,610,385	1,036
Carbon	Joliet	268	$34,910,122	$19,545,855	$54,455,977	585
	Red Lodge	418	$81,783,960	$42,929,156	$124,713,116	952
	Carbon County	540	$139,084,832	$82,742,566	$221,827,398	1,023
	Total	1,226	$255,778,914	$145,217,577	$400,996,491	2,560
Custer	Miles City	3,275	$457,747,587	$255,949,474	$713,697,061	7,353
	Custer County	584	$74,246,037	$47,024,649	$121,270,686	1,233
	Total	3,859	$531,993,624	$302,974,122	$834,967,746	8,586
Fallon	Baker	180	$22,765,807	$12,321,269	$35,087,076	377
	Fallon County	5	$405,041	$251,441	$656,482	7
	Total	185	$23,170,848	$12,572,709	$35,743,557	384
Garfield	Garfield County	7	$279,990	$139,995	$419,985	17
	Total	7	$279,990	$139,995	$419,985	17
Golden Valley	Lavina	106	$9,412,853	$6,177,639	$15,590,492	207
	Ryegate	124	$9,347,421	$5,986,023	$15,333,444	250
	Golden Valley County	33	$3,223,648	$2,755,364	$5,979,012	29
	Total	263	$21,983,922	$14,919,026	$36,902,948	486
Musselshell	Roundup	134	$7,925,167	$4,025,413	$11,950,580	273

County	Jurisdiction	Improved Parcels	Improved Value	Content Value	Total Value	Population
	Musselshell County	106	$5,923,568	$4,165,939	$10,089,507	185
	Total	240	$13,848,735	$8,191,352	$22,040,087	458
Rosebud	Northern Cheyenne Indian Reservation	57	$3,089,925	$1,756,822	$4,846,747	214
	Rosebud County	131	$10,719,734	$7,884,477	$18,604,211	249
	Richland County	5	$734,424	$509,317	$1,243,741	8
	Total	193	$14,544,083	$10,150,616	$24,694,699	471
Sheridan	Plentywood	940	$121,121,067	$72,008,009	$193,129,076	1,939
	Sheridan County	38	$12,707,566	$16,106,768	$28,814,334	60
	Total	978	$133,828,633	$88,114,776	$221,943,409	1,999
Treasure	Treasure County	1	$366,520	$366,520	$733,040	-
	Total	1	$366,520	$366,520	$733,040	0
Wheatland	Harlowton	214	$14,033,469	$7,521,986	$21,555,455	491
	Wheatland County	170	$21,505,215	$19,038,660	$40,543,875	287
	Total	384	$35,538,684	$26,560,646	$62,099,330	778
Yellowstone	Billings	1,373	$331,662,987	$225,615,257	$557,278,244	3,017
	Yellowstone County	1,366	$415,127,399	$403,266,080	$818,393,479	2,954
	Total	2,739	$746,790,386	$628,881,337	$1,375,671,723	5,971
	Grand Total	**10,411**	**$1,807,683,809**	**$1,259,139,589**	**$3,066,823,398**	**22,746**

Source: County Assessor data, NID, MT DNRC, WSP GIS Analysis

Table 4-10 Eastern Region Parcels at Risk to Dan Inundation by Tribe

Tribe	Improved Parcels	Improved Value	Content Value	Total Value	Population
Crow Tribe	314	$27,051,775	$19,085,857	$46,137,632	1,007
Fort Peck Assiniboine and Sioux Tribe	-	-	-	-	-
Northern Cheyenne Indian Reservation	57	$3,089,925	$1,756,822	$4,846,747	214
Total	**371**	**$30,141,700**	**$20,842,679**	**$50,984,379**	**1,221**

Source: County Assessor data, NID, MT DNRC, WSP GIS Analysis

Critical Facilities and Lifelines

A total dam failure can cause catastrophic impacts to areas downstream of the water body, including critical infrastructure. Any critical asset located under the dam in an inundation area would be susceptible to the impacts of a dam failure. Transportation routes are vulnerable to dam inundation and have the potential to be washed out in flooding following dam failure incidents, creating isolation and emergency response issues. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

Based on the critical facility inventory considered in the updating of this plan there are 352 critical facilities throughout the Eastern Region which lie within mapped dam inundation areas. These at-risk facilities are listed in the table below by critical facility classification as based on the FEMA Lifeline categories (FEMA Community Lifelines 2019).

Table 4-10 Eastern Region Critical Facilities at Risk to Dam Inundation by Jurisdiction and FEMA Lifeline

County	Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Total
Big Horn	Lodge Grass	-	-	2	-	-	1	-	3
	Big Horn County	3	4	6	-	-	3	36	52
	Total	3	4	8	0	0	4	36	55
Carbon	Joliet	-	-	3	-	1	2	1	7
	Red Lodge	-	2	-	-	-	1	2	5
	Carbon County	1	1	2	-	-	-	24	28
	Total	1	3	5	0	1	3	27	40
Custer County	Miles City	3	4	6	-	3	22	2	40
	Custer County	1	4	1	1	-	4	13	24
	Total	4	8	7	1	3	26	15	64
Fallon	Baker	-	-	-	-	-	1	2	3
	Fallon County	-	-	1	-	-	-	3	4
	Total	0	0	1	0	0	1	5	7
Golden Valley	Lavina	-	3	1	-	1	4	1	10
	Ryegate	-	-	2	-	1	6	1	10
	Golden Valley County	-	-	1	-	-	-	6	7
	Total	0	3	4	0	2	10	8	27
Musselshell	Roundup	-	-	-	-	-	-	1	1
	Musselshell	-	-	1	-	-	-	9	10
	Total	0	0	1	0	0	0	10	11
Petroleum	Petroleum County	-	-	-	-	-	-	1	1
	Total	0	0	0	0	0	0	1	1
Richland	Richland County	-	-	-	-	-	-	1	1
	Total	0	0	0	0	0	0	1	1
Rosebud	Rosebud County	1	3	2	-	1	7	11	25
	Total	1	3	2	0	1	7	11	25
Sheridan	Plentywood	4	2	1	-	1	-	8	16
	Sheridan County	-	2	1	-	-	-	5	8

County	Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Total
	Total	4	4	2	0	1	0	13	24
Treasure	Treasure County	-	-	-	-	-	-	3	3
	Total	0	0	0	0	0	0	3	3
Wheatland	Harlowtown	-	-	-	-	-	1	-	1
	Wheatland County	1	2	2	-	-	2	11	18
	Total	1	2	2	0	0	3	11	19
Yellowstone	Billings	7	2	1	4	-	7	10	31
	Yellowstone County	5	9	3	7	2	1	17	44
	Total	12	11	4	11	2	8	27	75
	Grand Total	26	38	36	12	10	62	168	352

Sources: Montana DNRC Dam Safety Program, Montana State Library, NID, HIFLD 2022, Montana DES, NBI

Economy

Extensive and long-lasting economic impacts could result from a major dam failure or inundation event, including the long-term loss of water in a reservoir, which may be critical for potable water needs. A major dam failure and loss of water from a key structure could bring about direct business and industry damages and potential indirect disruption of the local economy. A dam failure can have long lasting economic impacts and could deter visitors from the region for an extended period of time.

Historic and Cultural Resources

Reservoirs held behind dams are often significant cultural and economic resources for tourism and recreation. The loss of these resources in the event of dam failure which empties the reservoir would be substantial. Dam breaches and incidents could also result in substantial downstream inundation that could impact historic buildings and cultural resources.

Natural Resources

Reservoirs held behind dams affect many ecological aspects of a river. River topography and dynamics depend on a wide range of flows, but rivers below dams often experience long periods of very stable flow conditions or saw-tooth flow patterns caused by releases followed by no releases. Water releases from dams usually contain very little suspended sediment; this can lead to scouring of riverbeds and banks.

Dam failure can cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary hazards of dam failure are landslides around the reservoir perimeter, bank erosion on the rivers. The inundation could introduce many foreign elements into local waterways, potentially causing the destruction of downstream habitats. Loss of the water resource from dam failure could cause water shortages and result in downstream curtailment.

Development Trends Related to Hazards and Risk

Several areas experiencing growth and development in Montana are within dam inundation areas. Future development below dams can have significant financial impact on dam owners. When new development occurs in the inundation area below an existing dam that previously lacked downstream hazards, the dam could be reclassified as "high hazard". High hazard dams are required to meet stringent requirements for design, construction, inspection, and maintenance. Bringing a dam up to high hazard design standards can be costly for a dam owner. Even for dams already classified as high hazard, additional downstream development can still have a financial impact. Spillway design standards are based on potential for loss of life downstream. As the population at risk increases, the spillway design standard increases. A dam that is currently in compliance with state design standards can suddenly be out of compliance after a subdivision is built downstream.

Risk Summary

Dam failure is a hazard that presents an unlikely chance of occurrence, but a potentially significant negative impact should a dam failure occur. Major impacts to downstream populations, property, infrastructure, and natural and cultural resources could occur.

- The overall significance rating of dam failure for the eastern region is **Low** in part due to low probability of occurrence.
- Dam failures, especially those of high hazard dams, could potentially result in people downstream caught in inundation area flooding with little to no warning;
- Property and buildings located within the inundation area are vulnerable to damage or destruction in the event of a dam failure; counties with the highest exposure of people and property include Yellowstone, Custer, Carbon Counties.
- Direct economic losses in terms of property damage, as well as indirect losses in terms of impeded tourism and loss of cultural or recreational resources like reservoirs, could result from dam failures. There is an estimated $3,066,823,398 in total property value located within inundation areas in the Eastern Region exclusive to privately owned high hazard dams;
- Critical facilities and infrastructure, most notably roads and bridges, located in the inundation zones are also vulnerable to damage or complete loss in the event of a dam failure;
- Related hazards: Flooding, earthquake, landslide

Table 4-11 Risk Summary Table: Dam Failure

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	Low		
Big Horn	Low	Hardin, Lodge Grass	Most areas at risk are on the Crow Tribe reservation
Carbon	Medium	Bear creek, Bridger, Joliet, Fromberg, Red Lodge	Carbon County has the third highest total value of exposed property within mapped inundation areas.
Carter	Low	Ekalaka	There are no high hazard dams in Carter County.
Custer	Medium	Ismay, Miles City	There are no high hazard dams in Custer County. There are high hazard dams upstream which do pose a threat to Custer County. The county has the second highest total value of exposed property within mapped inundation areas, with most of this in Miles City.
Crow Tribe	Low		N/A
Daniels	Low	Scobey, Flaxville	There are no high hazard dams in Daniels County
Dawson	Low	Richey, Glendive	None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Fallon	Low	Plevna, Baker	Baker has more parcels at risk than the unincorporated areas
Fort Peck Tribes	Low		None
Garfield	Low	Jordan	There are no high hazard dams in Garfield County
Golden Valley	Low	Ryegate, Lavina	There are no high hazard dams in Golden Valley County
McCone	Medium	Circle	None
Musselshell	Low	Roundup	None
Northern Cheyenne	Low		NA
Powder River	Low	Broadus	There are no high hazard dams in Powder River County
Prairie	Low	Terry	There are no high hazard dams in Prairie County
Richland	Medium	Fairview, Sidney	
Roosevelt	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	There are no high hazard dams in Roosevelt County
Rosebud	Low	Colstrip, Forsyth	None
Sheridan	Medium	Outlook, Westby, Plentywood, Medicine Lake	Plentywood has higher exposure than the rest of the County
Stillwater	Medium	Columbus	
Treasure	Low	Hysham	There are no high hazard dams in Treasure County but the Town of Hysham would be impacted by dam incidents (overtopping) at the Yellowtail Dam and AfterBay Dam. There are also several critical facilities (including bridges) exposed to dam failure hazards in Treasure County in the towns of Hysham, Meyers, and Sanders.
Valley	Medium	Fort Peck, Glasgow, Nashua, Opheim	There are no high hazard dams in Valley County
Wheatland	Low	Harlowton, Judith Gap	Harlowton has more exposure
Wibaux	Low	Wibaux	There are no high hazard dams in Wibaux County
Yellowstone	Medium	Billing, Laurel, Broadview	Yellowstone county has the highest total value of exposed property within mapped dam inundation zones but roughly equal amounts in Billings and the unincorporated areas

4.2.5 Drought

Hazard/Problem Description

Drought is a condition of climatic dryness that is severe enough to reduce soil moisture and water below the minimum necessary for sustaining plant, animal, and human life systems. Influencing factors include temperature patterns, precipitation patterns, agricultural and domestic water supply needs, and growth. Lack of annual precipitation and poor water conservation practices can result in drought conditions.

Drought is a gradual phenomenon. Although droughts are sometimes characterized as emergencies, they differ from typical emergency events. Most natural disasters, such as floods or wildland fires, occur relatively rapidly and afford little time for preparing for disaster response. Droughts occur slowly, over a multi-year period, and can take years before the consequences are realized. It is often not obvious or easy to quantify when a drought begins and ends. Droughts can be a short-term event over several months or a long-term event that lasts for years or even decades.

Drought is a complex issue involving many factors—it occurs when a normal amount of moisture is not available to satisfy an area's usual water-consuming activities. Drought can often be defined regionally based on its effects:

- **Meteorological drought** is usually defined by a period of below average water supply.
- **Agricultural drought** occurs when there is an inadequate water supply to meet the needs of the state's crops and other agricultural operations such as livestock.
- **Hydrological drought** is defined as deficiencies in surface and subsurface water supplies. It is generally measured as streamflow, snowpack, and as lake, reservoir, and groundwater levels.
- **Socioeconomic drought** occurs when a drought impacts health, well-being, and quality of life, or when a drought starts to have an adverse economic impact on a region.

Drought impacts are wide-reaching and may be economic, environmental, and/or societal. The most significant impacts associated with drought in Montana are those related to water intensive activities such as agriculture, wildland fire protection, municipal usage, commerce, tourism, recreation, and wildlife preservation. An ongoing drought may leave an area more prone to beetle kill and associated wildland fires. Previous drought events in Montana have led to grasshopper infestations. Drought conditions can also cause soil to compact, increasing an area's susceptibility to flooding, and reduce vegetation cover, which exposes soil to wind and erosion. A reduction of electric power generation and water quality deterioration are also potential problems. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline.

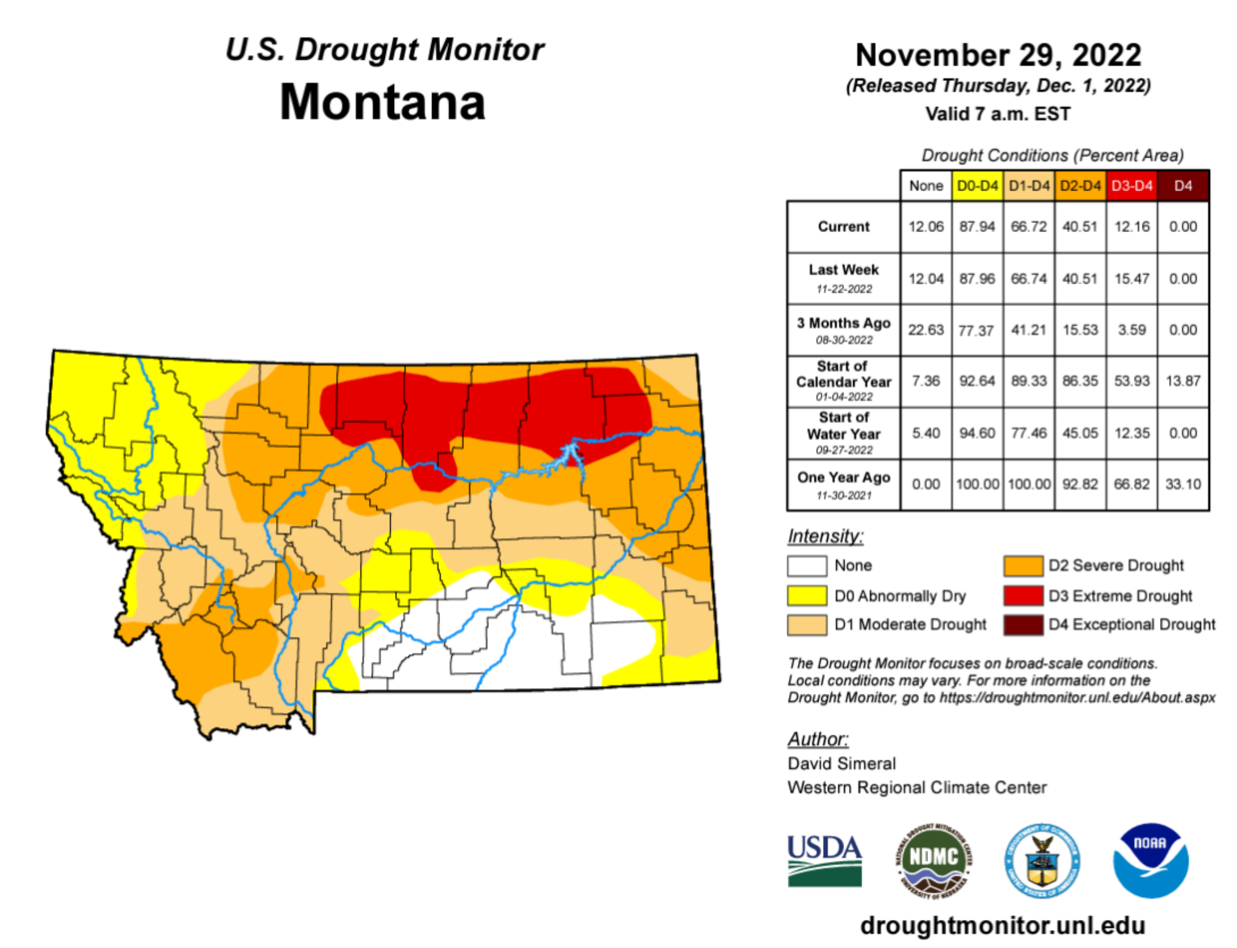
Much of the State was in a drought during the late 1980's. In response to this, and to assist with increasing awareness of and planning for drought in the future, the Governor's Drought Advisory Committee was formed in 1991. This committee, comprised of state and federal water supply and moisture condition experts, meets monthly to evaluate conditions for each county in the State and supports watershed groups and county drought committees by providing planning support and information. Water supply and moisture status maps are produced monthly from February to October by the Committee unless above average moisture conditions are prevalent.

Geographical Area Affected

Droughts are often regional events, impacting multiple counties and states simultaneously. Therefore, as the climate of the planning area is contiguous, it is reasonable to assume that a drought will impact the entire planning region. Based on this information, the geographic extent rating for drought is **Extensive.**

Drought in the United States is monitored by the National Integrated Drought Information System (NIDIS). A major component of this portal is the U.S. Drought Monitor. The Drought Monitor concept was developed jointly by the NOAA's Climate Prediction Center, the National Drought Mitigation Center, and the USDA's Joint Agricultural Weather Facility in the late 1990s as a process that synthesizes multiple indices, outlooks, and local impacts into an assessment that best represents current drought conditions. The outcome of each Drought Monitor is a consensus of federal, state, and academic scientists who are intimately familiar with the conditions in their respective regions. A snapshot of the most current drought conditions in Montana can be found in Figure 4.

Figure 4-14 Drought Status September 2022 in the State of Montana



Source: U.S. Drought Monitor *Montana | U.S. Drought Monitor (unl.edu)*

Past Occurrences

Between 2012 and 2021, there were 79 USDA disaster declarations due to drought in the Eastern Region. Table 4-12 provides a list of these events with impacted counties.

Table 4-12 USDA Drought Disaster Declarations (2012-2021)

2012	S3317	Carter
	S3319	Carter, Powder River
	S3350	Big Horn, Carbon, Powder River
	S3365	Big Horn, Carbon, Carter, Custer, Fallon, Garfield, Golden Valley, Musselshell, Powder River, Prairie, Rosebud, Stillwater, Treasure, Yellowstone

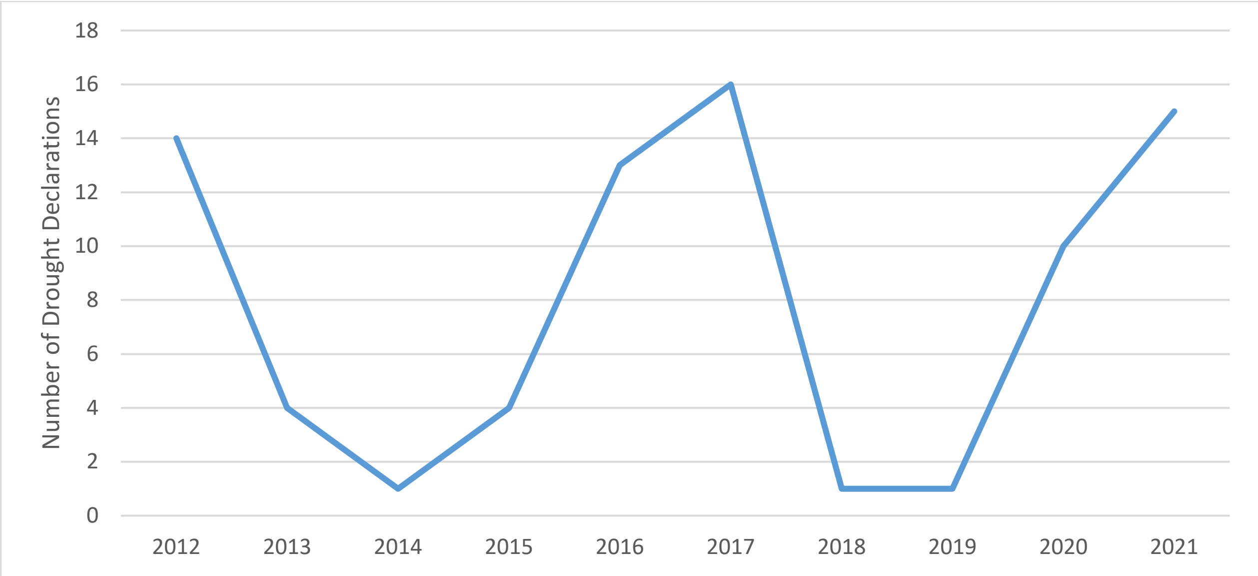
	S3374	Carter, Fallon
	S3391	Big Horn, Carbon, Carter, Custer, Fallon, Golden Valley, Musselshell, Powder River, Rosebud, Stillwater, Treasure, Wheatland Yellowstone
	S3416	Big Horn, Carter, Custer, Fallon, Garfield, Musselshell, Powder River, Prairie, Rosebud, Treasure, Wibaux, Wheatland, Yellowstone
	S3432	Custer, Garfield, Golden Valley, McCone, Musselshell, Prairie, Rosebud, Valley, Wheatland
	S3436	Sheridan
	S3437	Custer, Dawson, Fallon, Garfield, McCone, Prairie, Richland, Roosevelt, Rosebud, Valley, Wibaux
	S3467	Richland, Roosevelt, Wibaux
2013	S3508	Big Horn, Carbon, Carter, Powder River
	S3521	Big Horn, Carbon, Golden Valley, Musselshell, Powder River, Rosebud, Stillwater, Treasure, Yellowstone
	S3522	Carter, Fallon
	S3620	Sheridan
2014	S3804	Fallon, Richland, Sheridan, Wibaux
2015	S3959	Sheridan
	S3960	Fallon, Richland, Roosevelt, Sheridan, Wibaux
	S3961	Fallon, Wibaux
	S3972	Carter, Custer, Fallon, Garfield, Powder River, Prairie, Rosebud
2016	S3982	Big Horn, Carbon, Powder River
	S3988	Carter, Powder River
	S3999	Carter, Custer, Fallon, Powder River
	S4000	Carter, Fallon
	S4002	Powder River
	S4035	Big Horn, Carter, Custer, Fallon, Powder River, Prairie, Rosebud, Wibaux
	S4036	Fallon
	S4061	Golden Valley, Wheatland
	S4066	Big Horn, Carbon, Golden Valley, Powder River, Rosebud, Stillwater, Treasure, Wheatland, Yellowstone
	S4070	Carbon
	S4138	Fallon Wibaux
2017	S4185	Custer, Daniels, Dawson, Garfield, McCone, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Valley
	S4186	Fallon, Richland, Roosevelt, Sheridan, Wibaux
	S4190	Carter, Custer, Dawson, Fallon, McCone, Prairie, Richland, Wibaux
	S4191	Richland, Roosevelt, Wibaux
	S4193	Big Horn, Custer, Dawson, Garfield, Golden Valley, McCone, Musselshell, Powder River, Richland, Roosevelt, Rosebud, Treasure, Valley, Wheatland, Wibaux, Yellowstone
	S4195	Carter, Custer, Dawson, Fallon, Garfield, McCone, Powder River, Prairie, Rosebud, Wibaux
	S4198	Carter, Fallon
	S4210	Big Horn, Carbon, Golden Valley, Musselshell, Rosebud, Stillwater, Treasure, Yellowstone
	S4211	Carter
	S4214	Big Horn, Carter, Custer, Fallon, Powder River, Rosebud
	S4217	Big Horn, Carbon, Golden Valley, Musselshell, Powder River, Rosebud, Stillwater, Treasure, Wheatland, Yellowstone
	S4219	Carter, Powder River
	S4221	Wheatland
	S4330	Fallon, Richland, Roosevelt, Sheridan, Wibaux
2018	S4432	Daniels, McCone, Richland, Roosevelt, Sheridan, Valley
2019	S4640	Sheridan
2020	S4746	Big Horn, Carbon, Powder River

	S4777	Big Horn, Carter, Custer, Powder River, Rosebud
	S4785	Powder River
	S4864	Daniels, McCone, Richland, Roosevelt, Sheridan, Valley
	S4871	Big Horn, Carbon, Carter, Custer, Fallon, Powder River, Rosebud, Treasure, Yellowstone
	S4889	Custer, Rosebud, Big Horn, Carter, Fallon, Garfield, Musselshell, Powder River, Prairie, Treasure, Yellowstone
	S4891	Carter, Powder River
	S4948	Fallon, Richland, Roosevelt, Sheridan, Wibaux
	S4949	Sheridan
	S4950	Fallon
2021	S4926	Big Horn, Carbon, Powder River
	S4931	Carbon, Carter, Powder River
	S4939	Fallon, Richland, Roosevelt, Sheridan, Wheatland, Wibaux
	S4960	Carter, Custer, Daniels, Dawson, Fallon, McCone, Prairie, Richland, Roosevelt, Sheridan, Valley, Wibaux, Garfield, Powder River, Rosebud
	S4964	Carter, Fallon
	S4970	Garfield, Custer, McCone, Prairie, Rosebud, Valley
	S4993	Golden Valley, Musselshell, Powder River, Rosebud, Big Horn, Carter, Custer, Garfield, Stillwater, Treasure, Yellowstone
	S5001	Golden Valley, Wheatland,
	S5007	Carbon, Stillwater, Treasure, Yellowstone, Big Horn, Golden Valley, Musselshell, Rosebud, Wheatland
	S5016	Wheatland
	S5022	Big Horn, Carbon, Powder River, Rosebud, Treasure, Yellowstone
	S5203	Fallon, Richland, Roosevelt, Sheridan, Wibaux

Source: USDA

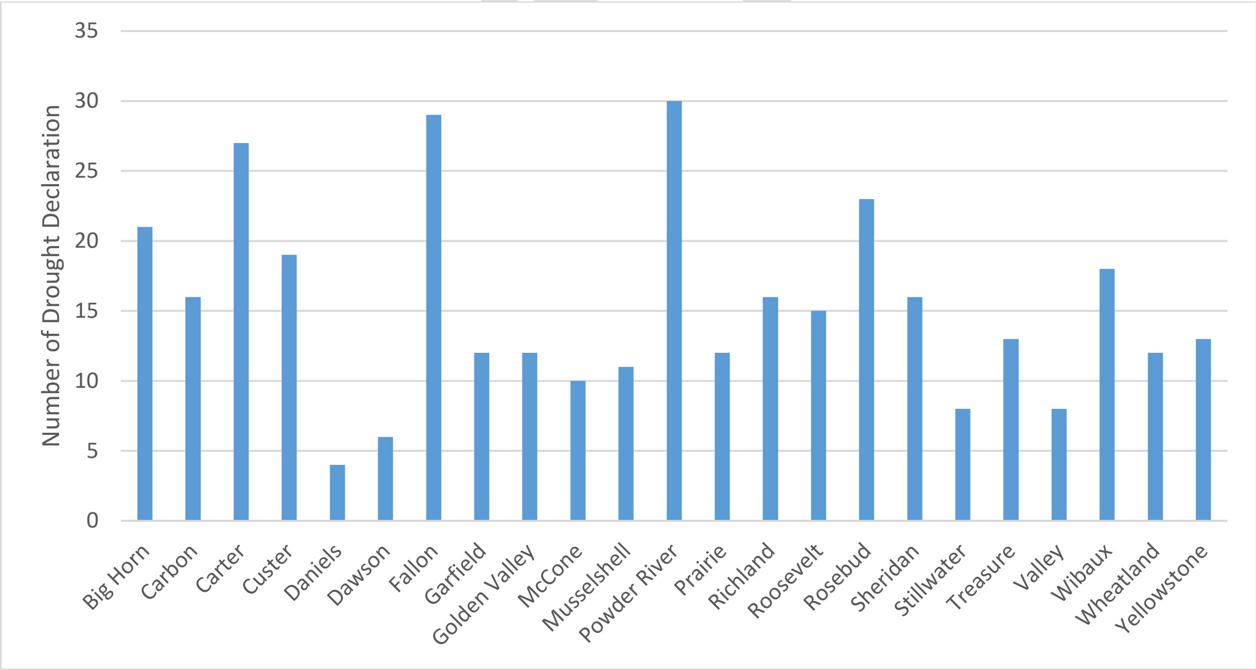
Figure 4-15 displays the temporal trend in USDA disaster declarations from drought by year in the Eastern Region. While there is evident variability in the number of declarations from year to year, there has been a gradual increase in the number of declarations due to drought in the Eastern Region, with the greatest number of declarations occurring in 2017. Figure 4-16 displays the breakdown of declarations by county. In the Eastern Region, Powder River County has experienced the greatest number of USDA disaster declarations, followed by Fallon and Carter Counites.

Figure 4-15 USDA Drought Disaster Declarations by Year (2012-2021)



Source: USDA

Figure 4-16 USDA Drought Disaster Declarations by County (2012-2021)



Source: USDA

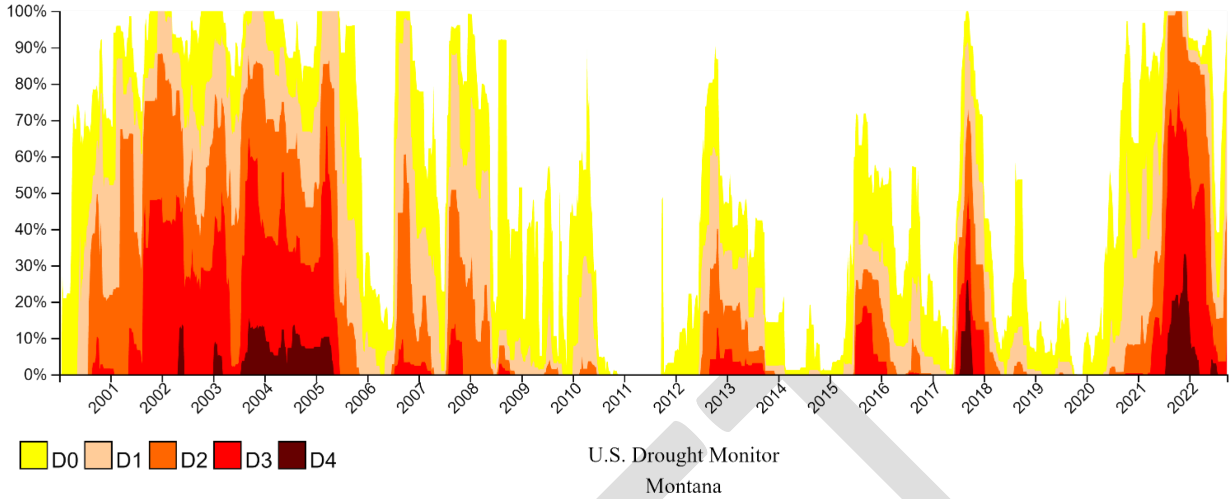
The 2021 Teton County Hazard Mitigation Plan and 2018 State of Montana Hazard Mitigation Plan provide details of drought history in the State of Montana:

- **1917-1923:** Rising wheat prices encouraged farmers to transform grasslands into farmland for wheat, corn, and row crops. This resulted in significant losses of soil and overconsumption of water for crops.

- **1928-1939:** The driest period in the historic record, the Palmer Hydrologic Drought Index (PHDI) showed the entire state was in a hydrologic deficit for over 10 years. Better conservation practices, such as strip cropping, helped to lessen the impacts of the worst water shortages.
- **Mid-1950's**: Montana faced a period of reduced rainfall in eastern and central portions of the state. By November of 1956, a total of 20 Montana counties had applied for federal drought assistance.
- **1961:** By August of 1961, 24 counties had applied for federal drought disaster aid. Montana's State Crop and Livestock Reporting Service called it the worst drought since the 1930's.
- **1966:** The entire state was experiencing yet another episode of drought. Although water shortages were not as great as in 1961, a study of ten weather recording stations across Montana showed all had recorded below normal precipitation amounts for a ten-month period.
- **1977:** In June, officials from Montana were working with others from Idaho, Washington, and Oregon on the Northwest Utility Coordination Committee to moderate potential hydroelectricity shortages. On June 23, Governor Judge issued an energy supply alert and ordered a mandatory ten percent reduction in electricity use by state and local governments.
- **1979-1981:** By October of 1980, estimates of 1980 federal disaster payments were five times those paid in 1979. Total drought related economic losses from Montana in 1980 were estimated to be $380 million (equivalent to $1.26 billion in 2021). Large May storms in 1981 brought flooding to formerly parched areas.
- **1984:** By July, Montana was again experiencing water shortages and rationing schedules were put into effect. Crop losses were estimated at $12-15 million. Numerous forest and range fires burned out of control across the state in August.
- **1985:** All 56 counties received disaster declarations for drought. Cattle herds were reduced by approximately one-third. The state's agriculture industry lost nearly $3 billion in equity.
- **1999-2008:** This period of dryness and hydrologic deficits mimicked the Dust Bowl years in every measurable factor besides duration. Area aquifers as well as municipal water supplies suffered severe water losses.
- **2017:** Northeastern Montana had record dry conditions for much of 2017, especially through August.
- **2021-2022:** By December of 2021, every county in Montana was identified as experiencing some level of drought. A third of the state was classified as "D4" or "exceptional" drought, a designation the U.S. Department of Agriculture expects to occur in any one location just once every 50 to 100 years.

Figure 4-17 displays data from the U.S. Drought Monitor for the State of Montana from 2000-2022. "D0" represents least severe drought conditions and "D4" is most severe. The chart shows peak drought conditions in the years 2002-2005, 2017, and 2021-2022 across the State.

Figure 4-17 US Drought Monitor: State of Montana Drought Conditions (2000-2022)



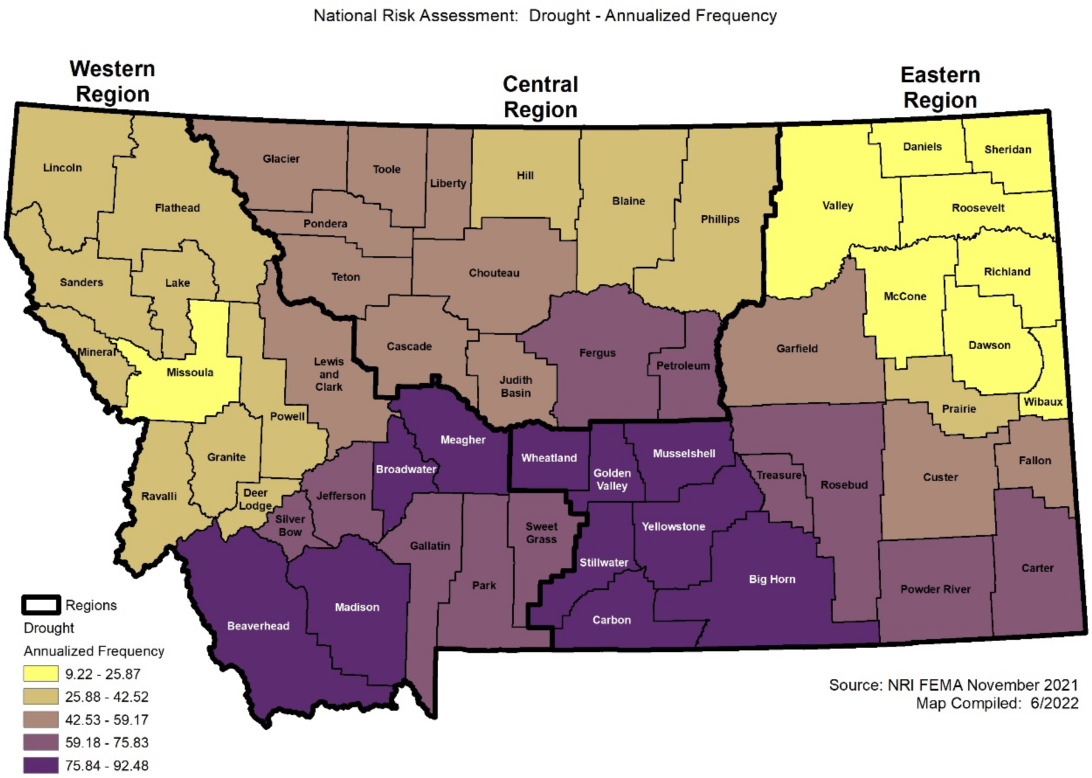
Source: U.S. Drought Monitor

Frequency/Likelihood of Occurrence

The likelihood of drought somewhere in the Eastern Region is **Highly Likely** based on the US Drought Monitor. The 2018 State of Montana Hazard Mitigation Plan also reported that, despite variation in drought severity, drought losses are incurred every year in Montana.

The figure below depicts annualized frequency of drought at a county level based on the NRI. The mapping shows a trend towards increased likelihood in the south-central portion of the Eastern Region, particularly in Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Wheatland, and Yellowstone Counties.

Figure 4-18 Annualized Frequency of Drought Events by County



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

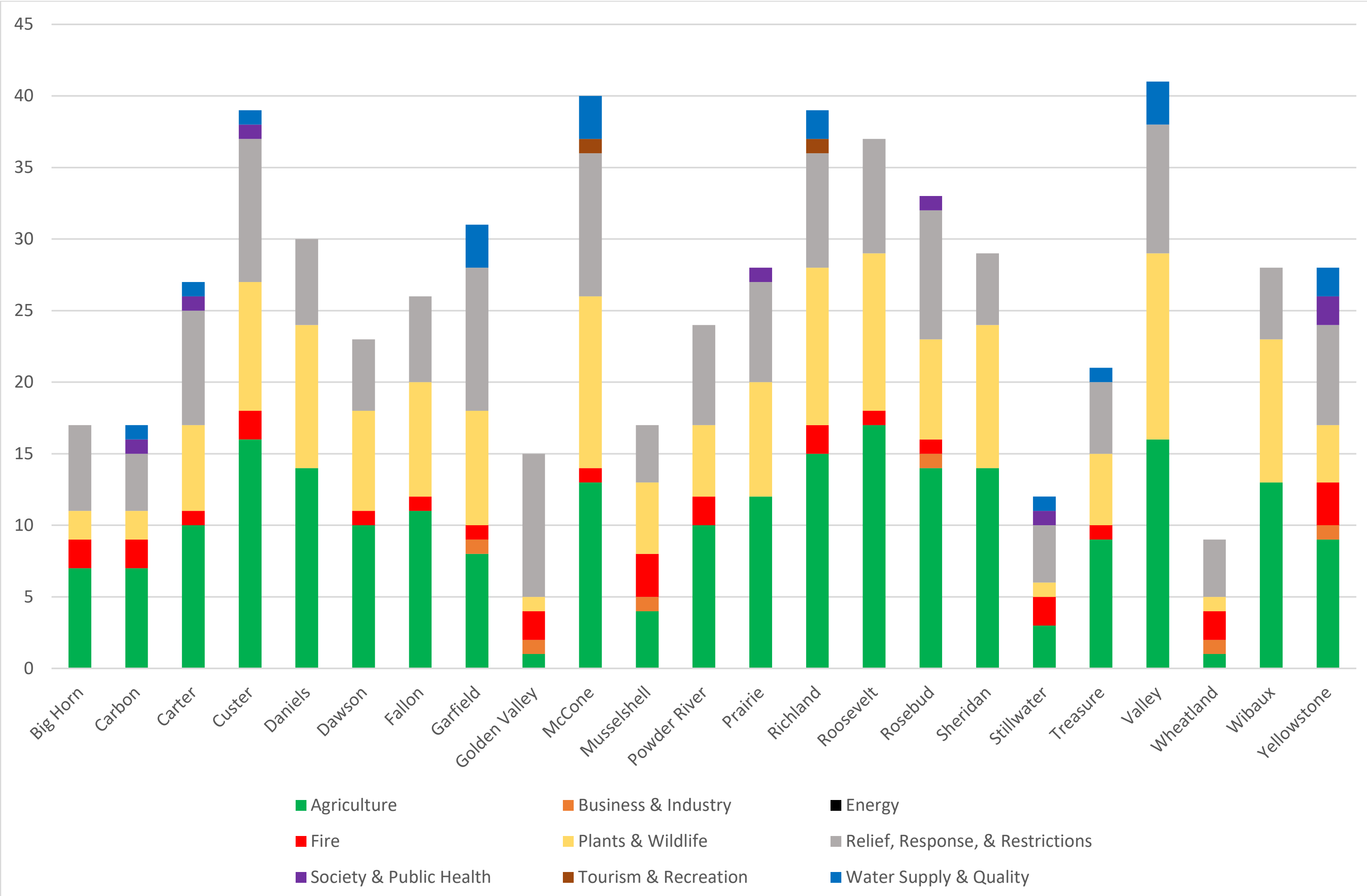
Climate Change Considerations

The USGS reports that climate change has already altered the natural pattern of droughts. Climate change has made droughts longer, more frequent, and more severe. Montana is likely to experience drier summers and less precipitation falling as snow in the winter. The 2018 State of Montana Hazard Mitigation Plan noted that Montana has been steadily warming for decades, with a 3-degree F average increase in temperatures since 1950. All projections indicate that this trend is likely to continue, which will exacerbate future drought conditions. The area impacted by drought is not likely to be altered by climate change, but severity, duration, and frequency will increase with climate change conditions.

Potential Magnitude and Severity

Drought impacts are wide-reaching and may be economic, environmental and/or societal; therefore, the potential magnitude and severity is ranked as **Critical**. The most significant impacts associated with drought in the Eastern Region are those related to water intensive activities such as agriculture, wildfire protection, municipal usage, and wildlife preservation. A reduction of electric power generation and water quality deterioration are also potential problems, as seen in the history of droughts in Montana. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding. Indirect effects include those impacts that ripple out from the direct effect and include reduced business and income for local retailers, increased credit risk for financial institutions, capital shortfalls, loss of tax revenues and reduction in government services, unemployment, and outmigration. Figure 4 displays the number of impacts from drought in the Eastern Region by impact type and county based on the Drought Impact Reporter.

Figure 4-19 Drought Impacts by County and Impact Type (2000-2021)

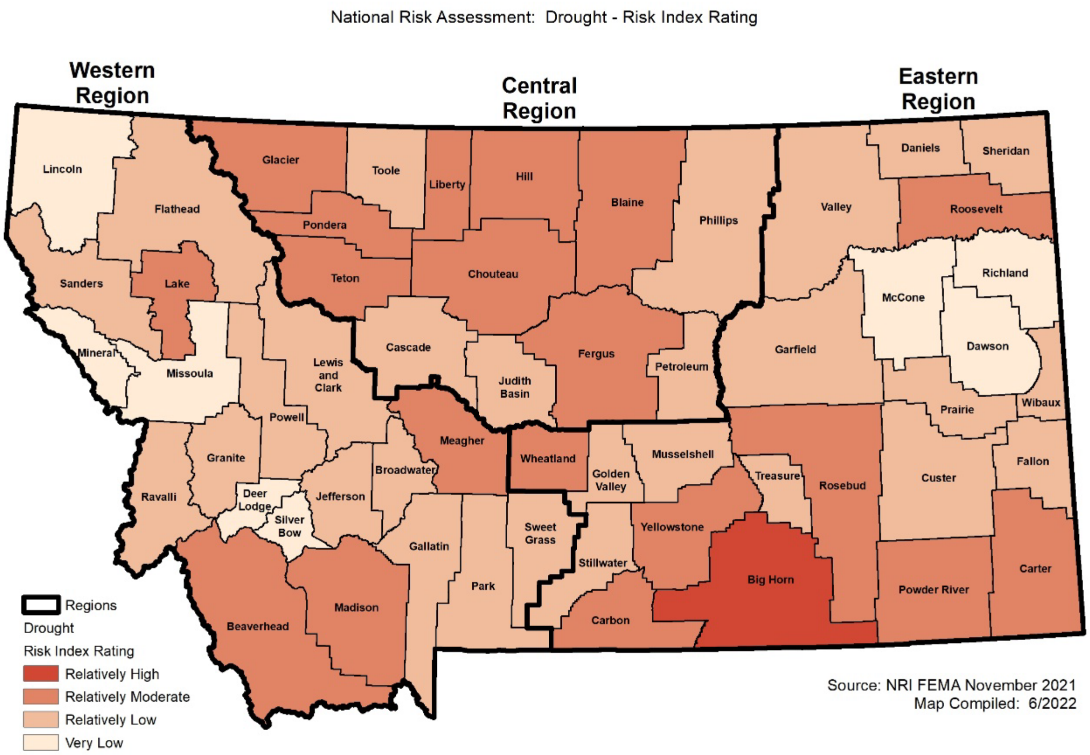


Source: The Drought Impact Reporter, Chart by WSP

Vulnerability Assessment

The figure below illustrates the relative Risk Index (RI) rating to drought for Montana counties based on data in the NRI. The RI calculation takes into account various factors, including the expected annual losses from drought, social vulnerability, and community resilience in each county across Montana. Most counties in the Eastern Region have a relatively low to moderate rating; only Big Horn has a relatively high rating.

Figure 4-20 NRI Risk Index Rating for Drought



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

People

The historical and potential impacts of drought on populations include agricultural sector job loss, secondary economic losses to local businesses and public recreational resources, increased cost to local and state government for large-scale water acquisition and delivery, and water rationing and water wells running dry for individuals and families. As drought is often accompanied by prolonged periods of extreme heat, negative health impacts such as dehydration can also occur, where children and elderly are most susceptible. Other public health issues can include impaired drinking water quality, increased incidence of mosquito-borne illness, increased wildlife-human confrontations, and respiratory complications due to declined air quality in times of drought.

Farmers are likely to experience economic losses due to drought. The Montana Governor's Drought Report of May 2004 referenced the economic and societal effects of drought: "The state's biggest drought story remains the deepening socio-economic drought. The drought threatens to change the very fabric of Montana's rural communities and landscape. It is the final straw that can bankrupt 4th and 5th generation farmers and ranchers, placing the birthright of descendants of pioneer families on the auction block. And like the changing vistas, many of the well-established County agri-businesses are disappearing forever, along with other main street institutions."

Property

Direct structural damage from drought is rare, though it can happen. Drought can affect soil shrinking and swelling cycles and can result in cracked foundations and infrastructure damage. Droughts can also have significant impacts on landscapes, which could cause a financial burden to property owners. There is a greater threat of structure damage in a drought-affected area due to the secondary impacts of drought. For example, drought increases the risk of wildfire and may create water shortages that inhibit adequate fire response. Additionally, heavy rains after prolonged drought conditions can result in significant flooding, which can damage property.

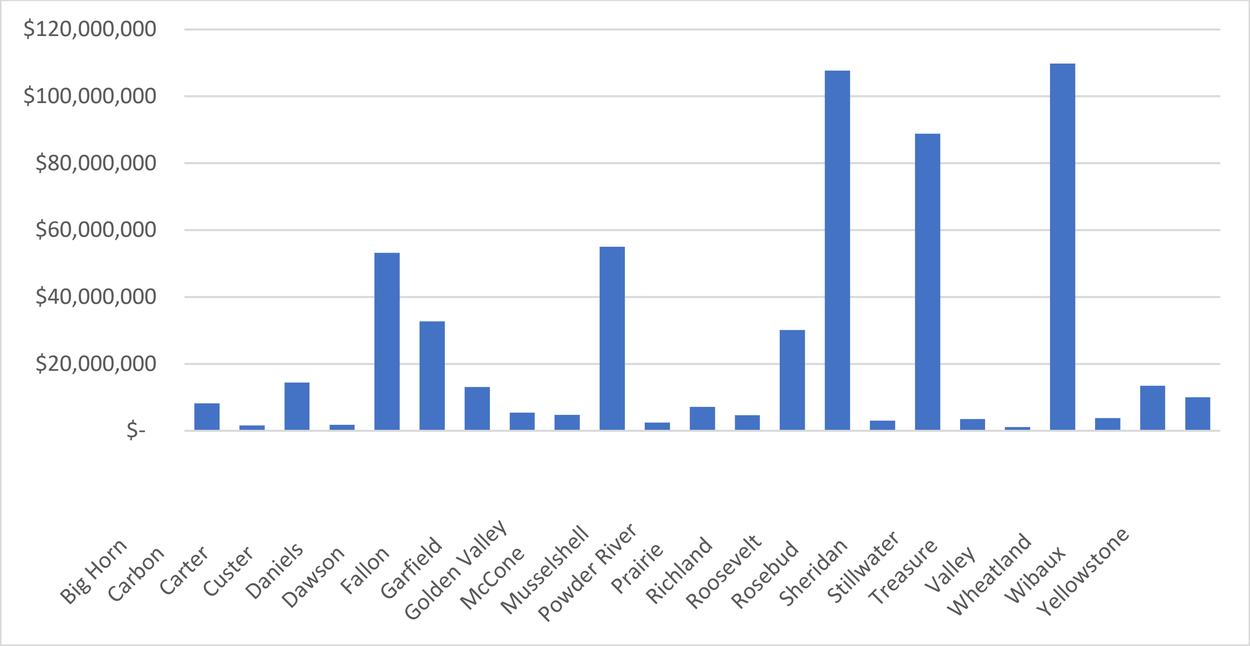
Critical Facilities and Lifelines

Water systems are the most likely critical infrastructure to be impacted by drought. As shown in Figure 4 above, nearly half the counties in the Eastern Region have experienced impacts to water supply and quality due to drought. Additionally, hydroelectric power is reduced during periods of drought, as well as the reduction of biofuel seedstock, which can cause energy conservation mandates. Like general property, most critical facility infrastructure is more likely to experience losses due to the secondary hazards caused by drought, such as wildfire and flooding.

Economy

Economic impact will be largely associated with industries that use water or depend on water for their business. For example, landscaping businesses were affected in the droughts of the past as the demand for service significantly declined because landscaping was not watered. Additionally, drought can exacerbate the risk of wildfires and flooding, increase the cost of municipal water usage, and deplete water resources used for recreation, all of which may impact the local economy. Agricultural industries will be impacted if water usage is restricted for irrigation. The Risk Management Agency (RMA) reported that from 2007-2021 $575,895,266.30 was lost as indemnity payments to farmers due to lost crops from drought in the Eastern Region, primarily in Daniels, McCone, Roosevelt, Sheridan, and Valley counties. Figure 4 displays indemnity payments by county from 2007-2021.

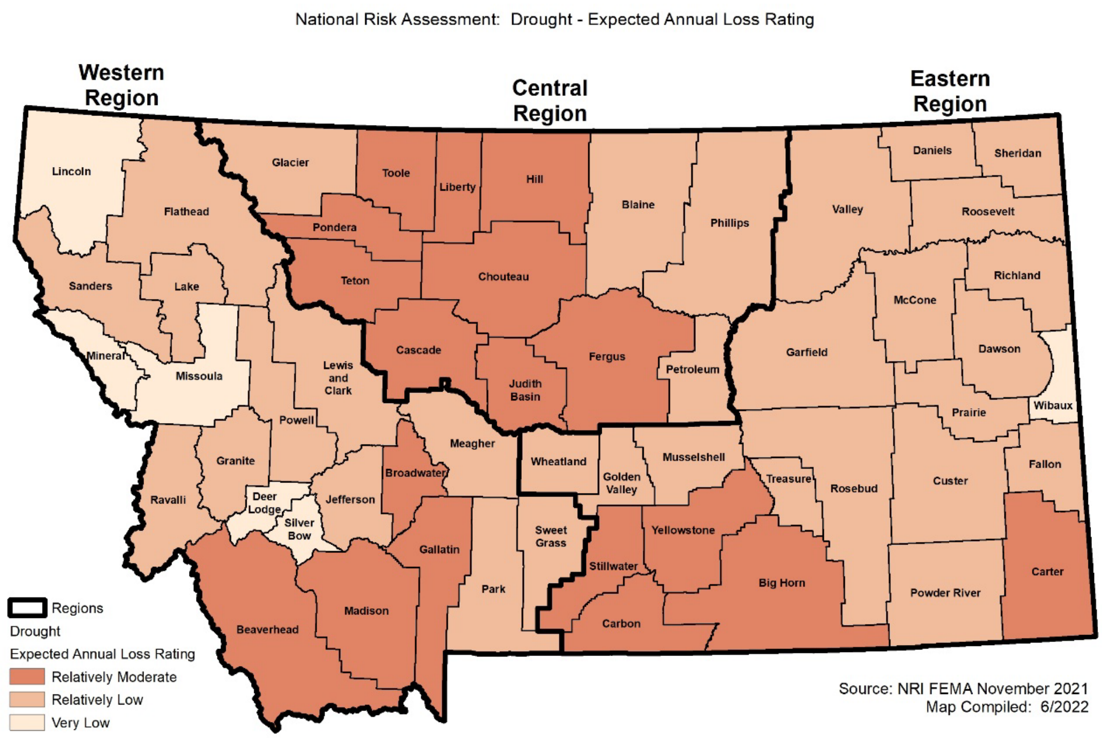
Figure 4-21 Crop Indemnity Losses due to Drought by County 2007-2021



Source: Risk Management Agency (RMA), Chart by WSP

The figure below illustrates the relative risk of Expected Annual Loss (EAL) rating due to drought for Montana counties based on data in the NRI. Most counties in the Region have a relatively moderate to relatively low rating; none have a high or very high-risk EAL rating. The EAL calculation takes into account agriculture value exposed to drought, annualized frequency for drought, and historical loss for drought. The EAL rating is thus heavily based on agricultural impacts.

Figure 4-22 NRI Drought Expected Annual Loss Rating



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Historic and Cultural Resources

The biggest threat to historic and cultural resources due to drought is to the long-standing farms existing in the Eastern Region. Past droughts have threatened to bankrupt farmers and ranchers and alter the farming tradition in the State.

Natural Resources

Environmental losses from drought are associated with decreases in air and water quality, forest and range fires, degradation of landscape quality, loss of biodiversity, soil erosion, and damage to plants, animals, and wildlife habitat. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes, and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

Development Trends Related to Hazards and Risk

An increasing population would put greater demand on water supply. However, the impact of future development with respect to drought is considered low by the Montana Department of Environmental Quality (DEQ), which carefully monitors and regulates public water systems. Additionally, the Governor's Drought Advisory Committee was established by an act of the Montana State Legislature in 1991 following the drought years of the late 1980s, including the highly publicized Yellowstone National Park wildfire year of 1988. The rationale behind the initiative to create a state drought advisory committee was that if state, local, and federal officials who monitor water supply and moisture conditions can be brought together on a regular basis, and ahead of the seasons when impacts are most likely to occur to Montana's economy and natural resources, advance measures could be taken to lessen the degree of those impacts.

Risk Summary

In summary, drought is considered to be overall **High** significance for the Region. Variations in risk by jurisdiction are summarized in the table below, as well as key issues from the vulnerability assessment.

- Frequency of drought is rated as **Highly likely** because the Eastern Region experiences agricultural losses from drought every year and the US Drought Monitor indicates a high frequency of drought conditions.
- Due to historic economic losses from drought in the Eastern Region, magnitude of drought is ranked as **Critical.**
- Drought, like other climate hazards, occurs on a regional scale and can impact every county in the Eastern Region; therefore, geographic extent is rated as **Extensive.**
- Drought impacts to people include public health issues such as impaired drinking water quality, increased incidence of mosquito-borne illness, increased wildlife-human confrontations, and respiratory complications because of declined air quality in times of drought.
- Most common impacts to property from drought are damage from secondary hazards such as flooding and wildfire. However, direct impacts from drought such as structural damage resulting from lack of moisture in the soil, do occur.
- Significant economic impacts are likely to result from drought from direct damages to crops and livestock, as well as indirect economic losses from business disruptions.
- Water systems are at significant risk to drought, as are energy systems that depend on biofuels or hydropower.

Related Hazards: Wildfire, Flooding, Severe Summer WeatherTable 4-13 Risk Summary Table: Drought

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	High		
Big Horn	High	Hardin, Lodge Grass	High annualized frequency of drought
Carbon	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	High annualized frequency of drought
Carter	High	Ekalaka	Large amount of USDA drought declarations
Custer	Medium	Ismay, Miles City	Many drought impact reports on agriculture
Crow Tribe	High		None
Daniels	Medium	Scobey, Flaxville	Higher crop indemnity losses due to drop
Dawson	Medium	Richey, Glendive	None
Fallon	High	Plevna, Baker	Large amount of USDA drought declarations
Fort Peck	High		None
Garfield	Medium	Jordan	None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Golden Valley	Medium	Ryegate, Lavina	High annualized frequency of drought
McCone	High	Circle	Higher crop indemnity losses due to drop
Musselshell	Medium	Roundup	High annualized frequency of drought
Northern Cheyenne	High		None
Powder River	High	Broadus	Has had the most USDA drought declarations in the Eastern Region
Prairie	Medium	Terry	None
Richland	High	Fairview, Sidney	None
Roosevelt	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	Higher crop indemnity losses due to drop
Rosebud	Medium	Colstrip, Forsyth	None
Sheridan	High	Outlook, Westby, Plentywood, Medicine Lake	Higher crop indemnity losses due to drop
Stillwater	Medium	Columbus	High annualized frequency of drought
Treasure	Medium	Hysham	None
Valley	Medium	Fort Peck, Glasgow, Nashua, Opheim	Higher crop indemnity losses due to drop
Wheatland	High	Harlowton, Judith Gap	High annualized frequency of drought
Wibaux	Medium	Wibaux	None
Yellowstone	High	Billing, Laurel, Broadview	High annualized frequency of drought

4.2.6 Earthquake

Hazard/Problem Description

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a volcanic eruption or by the sudden dislocation of the crust, which is the cause of most destructive earthquakes. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Earthquakes can last from a few seconds to over five minutes; they may also occur as a series of tremors over several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties generally result from falling objects and debris, because the shocks shake, damage, or demolish buildings and other structures. Disruption of communications, electrical power supplies and gas, sewer, and water lines should be expected. Earthquakes may trigger fires, dam failures, landslides, or releases of hazardous material, compounding their disastrous effects.

Earthquakes east of the Rocky Mountains are generally less frequent than in the western United States and are typically felt over a much broader region. Most of North America east of the Rocky Mountains has infrequent earthquakes, and the region from the Rockies to the Atlantic Ocean can go years without an earthquake large enough to be felt. The earthquakes that do occur in this region are typically small and occur at irregular intervals.

Earthquakes tend to reoccur along faults, which are zones of weakness in the crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur. Thousands of faults have been mapped in Montana, but scientists think only about 95 of these faults have been active in the past 1.6 million years (the Quaternary Period). Although it has been over six decades since the last destructive earthquake in Montana, small earthquakes are common in the Eastern Region, occurring at an average rate of 4-5 earthquakes per day. Scientists continue to study faults in Montana to determine future earthquake potential.

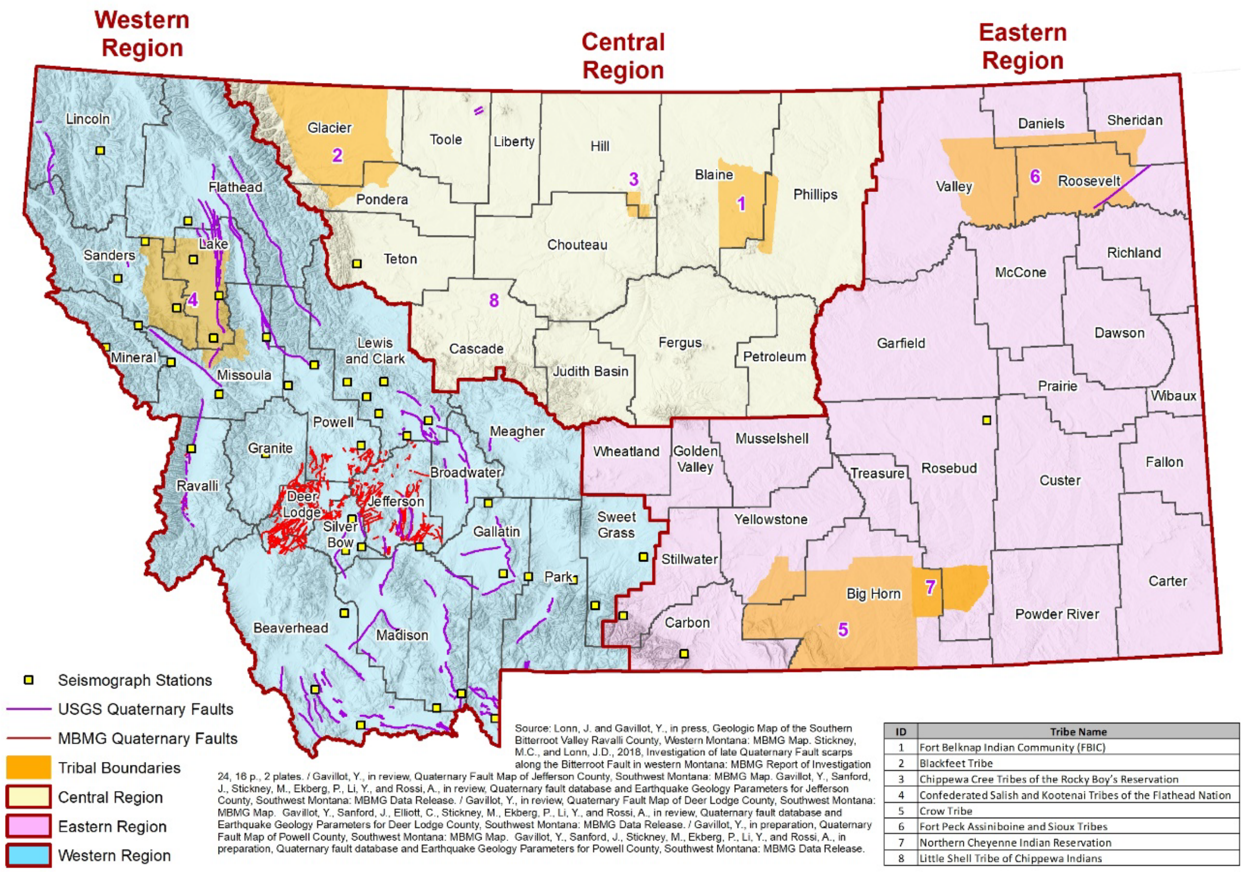
A “great” earthquake is defined as any earthquake classified as a magnitude 8 or larger on the Richter Scale. Montana has not experienced a great earthquake in recorded history. A great earthquake is not likely in Montana, but a major earthquake (magnitude 7.0-7.9) occurred near Hebgen Lake in 1959 and dozens of active faults have generated magnitude 6.5-7.5 earthquakes during recent geologic time.

Geographical Area Affected

The geographic extent of earthquakes in the planning area is **Significant**. All of the Eastern Region could be impacted by earthquakes, but the greatest potential for damaging quakes is in the very southwestern portion of the Region.

Montana is one of the most seismically active states in the United States according to the USGS. There is a belt of seismicity known as the Intermountain Seismic Belt which extends through western Montana. This Intermountain Seismic Belt ranges from the Flathead Lake region in the northwest corner of the state to the Yellowstone National Park region. Since 1925, the state has experienced five shocks that reached intensity VIII or greater (Modified Mercalli Scale). During the same interval, hundreds of less severe tremors were felt within the state. Montana's earthquake activity is concentrated mostly in the mountainous western third of the state, which lies within the Intermountain Seismic Belt and is relatively farther from the Eastern Region when compared to the Central and especially the Western Region. However, large seismic events centered in other parts of the state – Central and Western Regions, may still cause impacts in the Eastern Region. Seismic events may lead to landslides, uneven ground settling, flooding, and damage to homes, dams, levees, buildings, power and telephone lines, roads, tunnels, and railways. Broken natural gas lines may also ignite fires as a cascading hazard.

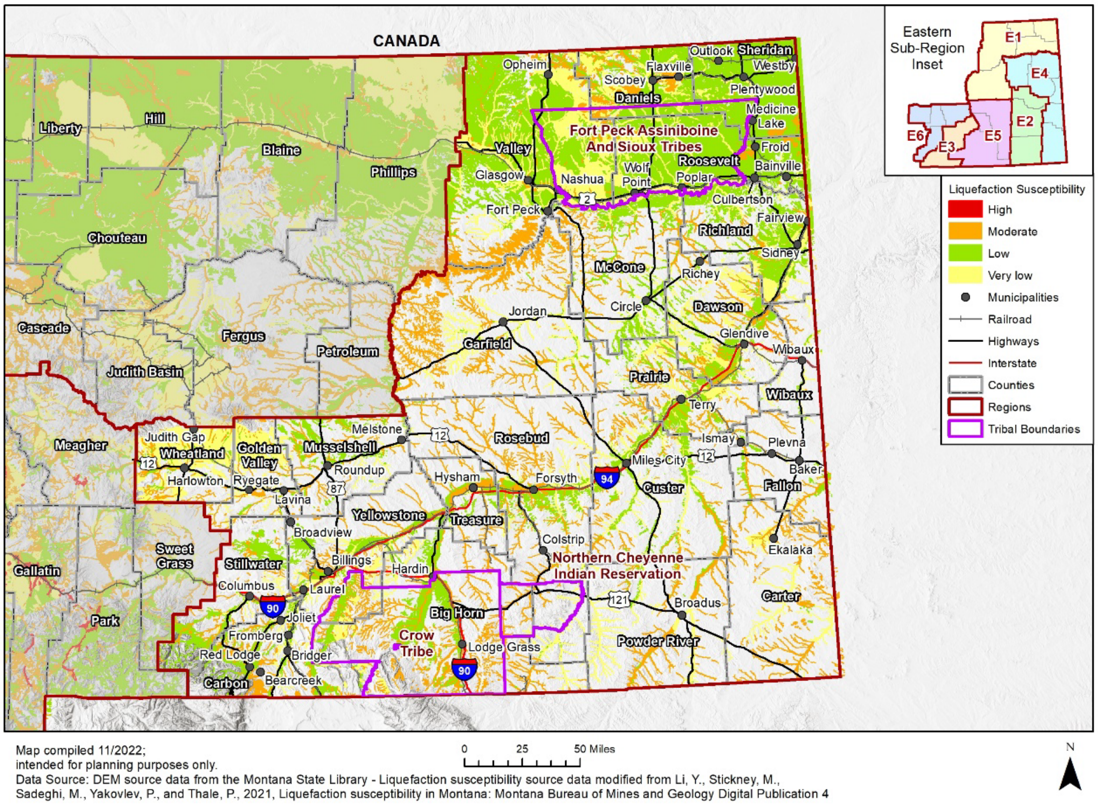
Figure 4-23 Fault Map of Montana



Liquefaction is the process by which water-saturated sediment temporarily loses strength due to strong ground shaking and acts as a fluid. Buildings and road foundations may lose load-bearing strength and cause major damage if liquefaction occurs beneath them. The increased water pressure that accompanies liquefaction can also cause landslides and dam failure.

As shown in Figure 4 below, the Eastern Region has a low to moderate liquefaction susceptibility in general. No area in the Eastern Region has a high liquefaction susceptibility.

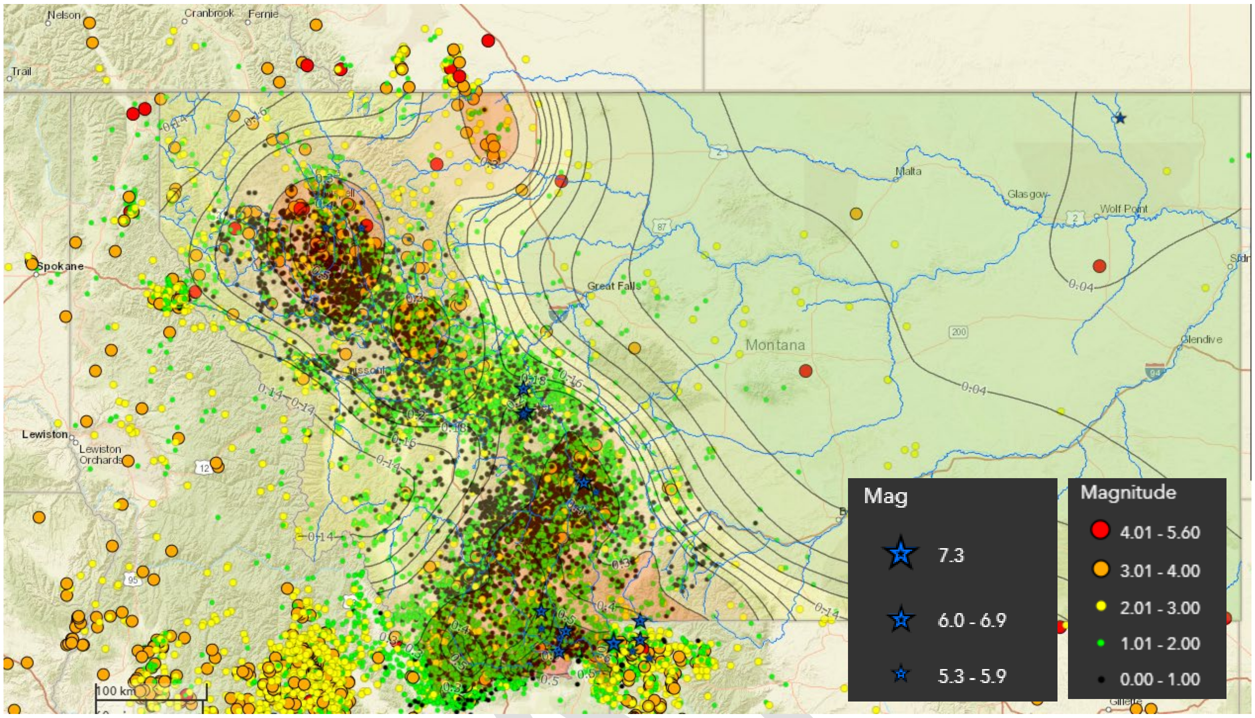
Figure 4-24 Liquefaction Map of the Eastern Region



Past Occurrences

As mentioned previously, Montana's earthquake activity occurs primarily in the western third of the state. In the Eastern Region, although earthquake events happen less frequently, there have been a few recorded earthquakes that are relatively bigger, in the 4-5.6 magnitude range. As mentioned in the 2018 Montana SHMP, one significant earthquake occurred in Northeast Montana on May 16, 1909, with a magnitude of 5.5. Most of the rest of the recorded earthquakes are relatively smaller, in the magnitude 1 to 3 range. These types of earthquakes very rarely cause any structural damage or injuries. As mentioned above, earthquake events tend to occur in the western part of the state more frequently, and numerous earthquakes in the western part of the state have been felt in the Eastern Region. A map of recorded earthquakes is presented below based an online mapping tool developed by the Montana Bureau of Mines and Geology (https://mbmg.mtech.edu/mapper/mapper.asp?view=Quakes&).

Figure 4-25 Statewide Map of Earthquake Epicenters



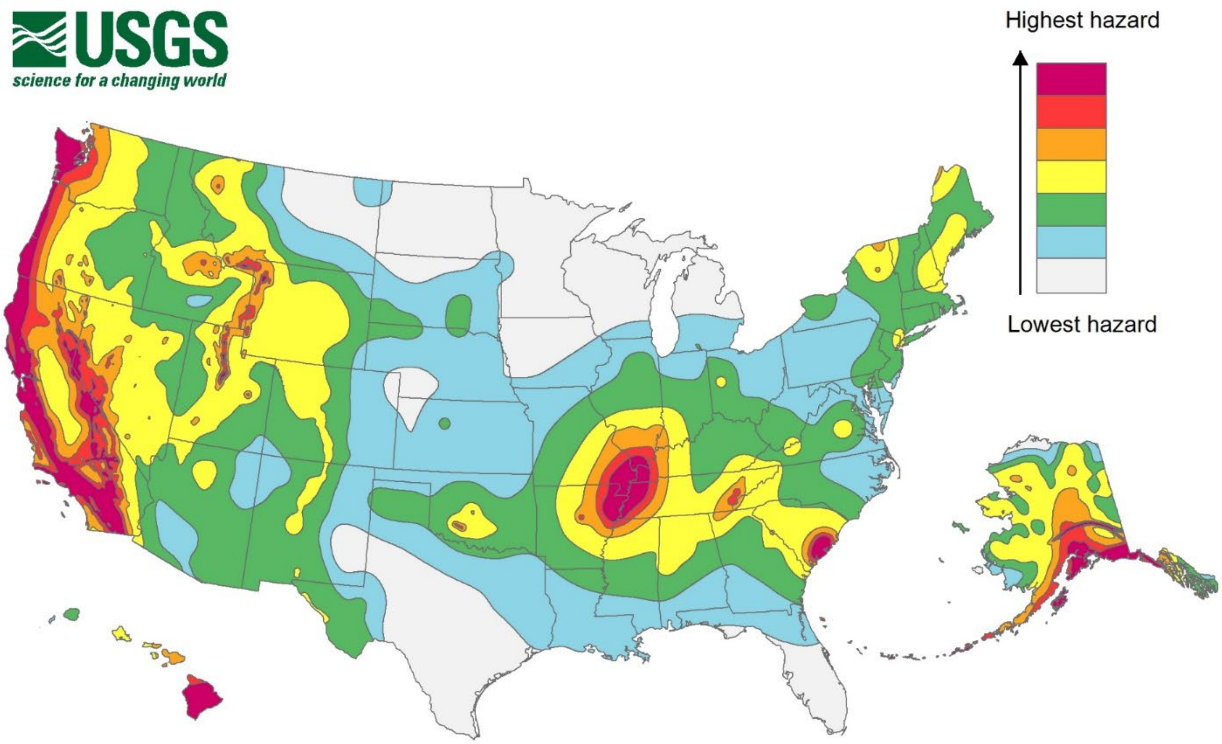
Source: Montana Bureau of Mines and Geology(https://mbmg.mtech.edu/mapper/mapper.asp?view=Quakes&).

Frequency/Likelihood of Occurrence

The frequency of earthquakes in the Eastern Region is ranked as **Likely,** but damaging events are more **Occasional** (between 1 and 10 percent chance of occurrence in the next year or has a recurrence interval of 11 to 100 years). Earthquakes will continue to occur in Montana; however, the precise time, location, and magnitude of future events cannot be predicted. As discussed above, earthquake hazard areas in Montana are concentrated in the western portion of the state, which is part of the Intermountain Seismic Belt.

The USGS issues National Seismic Hazard Maps with updates approximately every five years. These maps provide various acceleration and probabilities for time periods. Figure 4 below is from the most recent USGS models for the contiguous U.S., showing peak ground accelerations having a 2 percent probability of being exceeded in 50 years, for a firm rock site. The models are based on seismicity and fault-slip rates and take into account the frequency of earthquakes of various magnitudes. Until recently, the 500-year map was often used for planning purposes for average structures and was the basis of the most current Uniform Building Code. The new International Building Code, however, uses a 2,500-year map as the basis for building design.

Figure 4-26 USGS Long-Term National Seismic Hazard Map



Source: USGS

Climate Change Considerations

The impacts of global climate change on earthquake intensity and probability are largely unknown, but there is not expected to be a direct correlation.

Potential Magnitude and Severity

The expected magnitude of earthquakes in the Eastern Region is **Limited**. Earthquakes can cause structural damage, injury, and loss of life, as well as damage to infrastructure networks, such as water, power, communication, and transportation lines. Damage and loss of life can be particularly devastating in communities where buildings were not designed to withstand seismic forces (e.g., historic structures). Other damage-causing effects of earthquakes include surface rupture, fissuring, settlement, and permanent horizontal and vertical shifting of the ground. Secondary impacts can include landslides, rock falls, liquefaction, fires, dam failure, and hazardous materials (HAZMAT) incidents.

In simplistic terms, the severity of an earthquake event can be measured in the following terms:

- How hard did the ground shake?
- How did the ground move (horizontally or vertically)?
- How stable was the soil?
- What is the fragility of the built environment in the area of impact?

Earthquakes are typically classified in one of two ways: By the amount of energy released, measured as magnitude; or by the impact on people and structures, measured as intensity. A comparison of magnitude and intensity is shown in the table below.

Table 4-14 Magnitude and Modified Mercalli Scales for Measuring Earthquakes

Magnitude	Modified Mercalli Intensity
1.0 – 3.0	I
3.0 – 3.9	II, III
4.0 – 4.9	IV – V
5.0 – 5.9	VI – VII
6.0 – 6.0	VII – IX
7.0 and higher	VIII or higher

Source: USGS Earthquake Hazards Program

Magnitude

Magnitude measures the energy released at the source of the earthquake and is measured by a seismograph. Currently the most used magnitude scale is the moment magnitude (Mw) scale, with the follow classifications of magnitude:

- Great—Mw > 8.
- Major—Mw = 7.0 – 7.9.
- Strong—Mw = 6.0 – 6.9.
- Moderate—Mw = 5.0 – 5.9.
- Light—Mw = 4.0 – 4.9.
- Minor—Mw = 3.0 – 3.9.
- Micro—Mw < 3.

Estimates of Mw scale roughly match the local magnitude scale (ML), commonly called the Richter scale. One advantage of the Mw scale is that, unlike other magnitude scales, it does not saturate at the upper end. That is, there is no value beyond which all large earthquakes have about the same magnitude. For this reason, Mw scale is now the most often used estimate of large magnitude earthquakes.

Intensity

Intensity is a measure of the shaking produced by an earthquake at a certain location and is based on felt affects. Currently the most used intensity scale is the modified Mercalli intensity scale, with ratings defined as follows (USGS 1989):

Table 4-15 Modified Mercalli Intensity (MMI) Scale

Magnitude	Mercalli Intensity	Effects	Frequency
Less than 2.0	I	Micro-earthquakes, not felt or rarely felt; recorded by seismographs.	Continual
2.0-2.9	I to II	Felt slightly by some people; damages to buildings.	Over 1M per year
3.0-3.9	II to IV	Often felt by people; rarely causes damage; shaking of indoor objects noticeable.	Over 100,000 per year
4.0-4.9	IV to VI	Noticeable shaking of indoor objects and rattling noises; felt by most people in the affected area; slightly felt outside; generally, no to minimal damage.	10K to 15K per year
5.0-5.9	VI to VIII	Can cause damage of varying severity to poorly constructed buildings; at most, none to slight damage to all other buildings. Felt by everyone.	1K to 1,500 per year
6.0-6.9	VII to X	Damage to a moderate number of well-built structures in populated areas; earthquake-resistant structures survive	100 to 150 per year

Magnitude	Mercalli Intensity	Effects	Frequency
		with slight to moderate damage; poorly designed structures receive moderate to severe damage; felt in wider areas; up to hundreds of miles/kilometers from the epicenter; strong to violent shaking in epicenter area.	
7.0-7.9	VIII<	Causes damage to most buildings, some to partially or completely collapse or receive severe damage; well-designed structures are likely to receive damage; felt across great distances with major damage mostly limited to 250 km from epicenter.	10 to 20 per year
8.0-8.9	VIII<	Major damage to buildings, structures likely to be destroyed; will cause moderate to heavy damage to sturdy or earthquake-resistant buildings; damaging in large areas; felt in extremely large regions.	One per year
9.0 and Greater	VIII<	At or near total destruction - severe damage or collapse to all buildings; heavy damage and shaking extends to distant locations; permanent changes in ground topography.	One per 10-50 years

Source: USGS Earthquake Hazards Program

Vulnerability Assessment

Numerous factors contribute to determining areas of vulnerability such as historical earthquake occurrence, proximity to faults, soil characteristics, building construction, and population density. Earthquake vulnerability data was generated during the 2022 planning process using a Level 1 Hazus-MH analysis for the Eastern Region. Hazus-MH estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and clean up. Details specific to the HAZUS analysis for each county are provided in each county's respective annex.

People

The entire population of the Eastern Region is potentially exposed to direct and indirect impacts from earthquakes, but more so in the southwestern counties. The degree of exposure is dependent on many factors, including the age and construction type of the structures people live in, the soil type their homes are constructed on, their proximity to fault location and earthquake epicenter. Whether impacted directly or indirectly, the entire population will have to deal with the consequences of an earthquake to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

Impacts on persons and households in the planning area were estimated for the entire region for a 2,500-Year probabilistic earthquake scenario (2% chance of occurrence in 50 years) resulted in low potential impacts. Table 4-16 summarizes the results of displaced households. It is estimated in a 2 p.m. time of occurrence scenario that there would be a total of 37 injuries across the region, four of which would require hospitalization. There would not be any fatalities. Additionally, there could be increased risk of damage or injury from rock fall or landslides to travelers, hikers, and others recreating outdoors at the time of the earthquake. More detailed descriptions of the numbers of estimated casualties in the Eastern Region under the various time of occurrence scenarios are available in the county annexes.

Table 4-16 Estimated Earthquake Impacts on Persons and Households

	Number of Displaced Households	Number of Persons Requiring Short-Term Shelter
2,500-Year Earthquake	27	15

Source: HAZUS-MH Global Summary Report, WSP Analysis

Property

The HAZUS analysis estimates that there are 119,000 buildings in the planning area for the Eastern Region, with a total replacement value of $27.91 billion. Because all structures in the planning area are susceptible to earthquake impacts to varying degrees, this total represents the regionwide property exposure to seismic events. Most of the buildings and most of the associated building value are residential. According to the model and shown in Table 4-17, about 1,783 buildings will be at least moderately damaged, with 3 buildings completely destroyed.

Table 4-17 Estimated Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	1024.20	0.92	47.59	0.87	21.63	1.31	3.45	2.69	0.13	3.87
Commercial	5914.34	5.29	376.94	6.85	178.71	10.82	30.67	23.94	1.34	40.67
Education	284.41	0.25	14.25	0.26	6.35	0.38	0.95	0.74	0.04	1.36
Government	312.01	0.28	16.17	0.29	6.85	0.41	0.92	0.72	0.04	1.35
Industrial	1521.82	1.36	104.86	1.91	53.69	3.25	9.34	7.29	0.29	8.80
Other Residential	16626.78	14.88	1820.01	33.09	917.10	55.51	54.94	42.90	1.17	35.42
Religion	625.43	0.56	32.66	0.59	13.89	0.84	1.92	1.50	0.10	3.04
Single Family	85442.42	76.46	3087.57	56.14	453.93	27.48	25.89	20.22	0.18	5.51
Total	111,751		5,500		1,652		128		3	

Source: HAZUS-MH Global Summary Report, WSP Analysis

The HAZUS model provides estimates of building related losses in the earthquake scenario, broken out into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

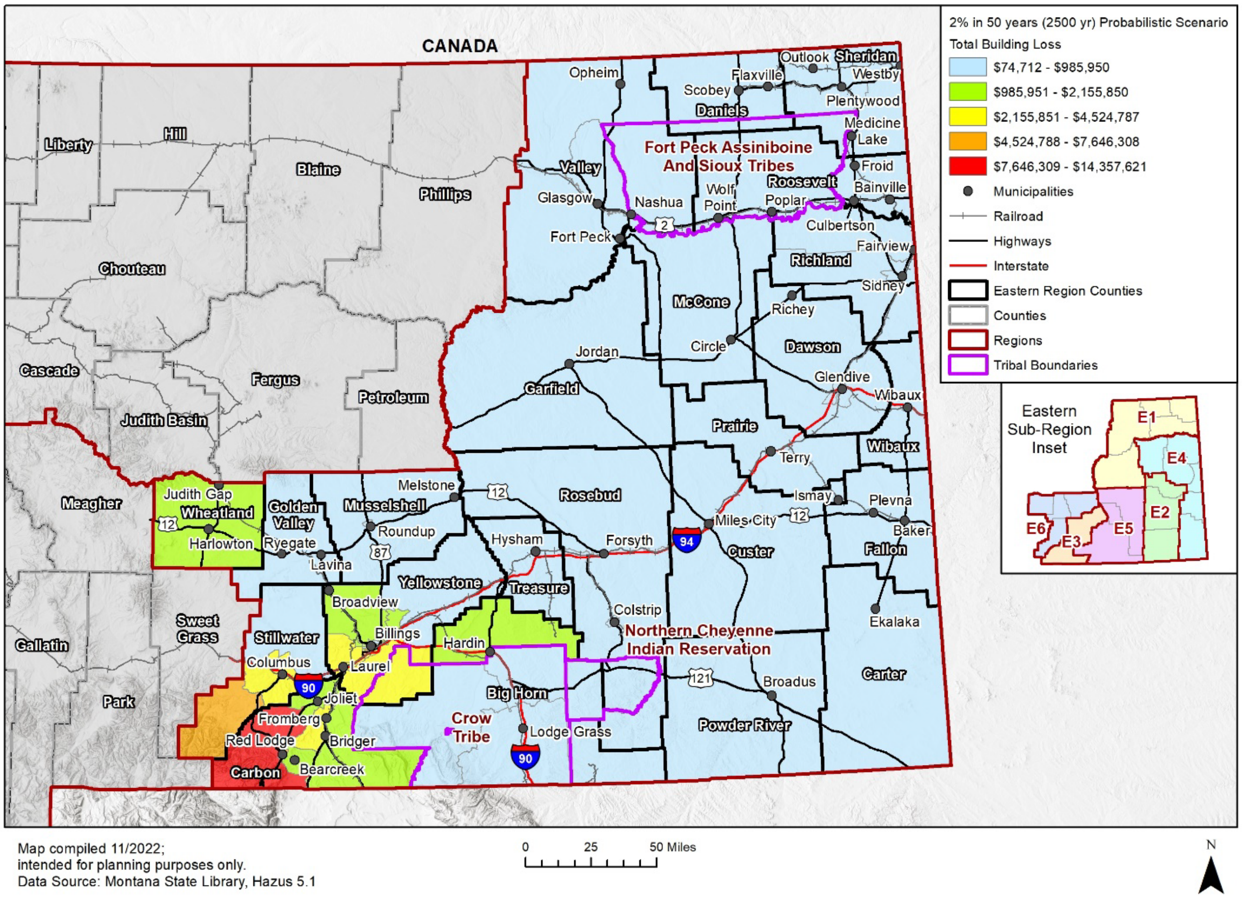
For the 2,500-year probabilistic earthquake scenario, the total building related losses for the entire planning area is an estimated $133.27 million, as shown in Table 4-18. Of this total, direct building losses are estimated at $104.6 million and $28.68 million in income related losses. A map of these losses per county is shown in Figure 4-27 below.

Table 4-18 HAZUS Building Related Economic Loss Estimates for 2,500-Year Scenario (Millions of Dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.7135	5.3439	0.1375	0.5015	6.6964
	Capital-Related	0.0000	0.3038	4.8199	0.0905	0.0870	5.3012
	Rental	0.8998	1.3440	3.1215	0.0603	0.1638	5.5894
	Relocation	2.8937	1.8012	4.6889	0.4261	1.2810	11.0909
	Subtotal	**3.7935**	**4.1625**	**17.9742**	**0.7144**	**2.0333**	**28.6779**
Capital Stock Losses							
	Structural	5.6987	3.3790	6.2527	0.9743	1.9266	18.2313
	Non_Structural	31.8007	10.4014	12.6666	2.8401	3.8091	61.5179
	Content	11.2479	2.1543	6.7518	1.8043	2.2430	24.2013
	Inventory	0.0000	0.0000	0.2475	0.3195	0.0749	0.6419
	Subtotal	**48.7473**	**15.9347**	**25.9186**	**5.9382**	**8.0536**	**104.5924**
	Total	**52.54**	**20.10**	**43.89**	**6.65**	**10.09**	**133.27**

Source: HAZUS-MH Global Summary Report, WSP Analysis

Figure 4-27 Eastern Region HAZUS 2,500-Year Probabilistic Scenario Direct Economic Loss



The HAZUS analysis also estimated the amount of earthquake-caused debris in the planning area for the 2,500-Year probabilistic earthquake scenario event, which is estimated to be 29,000 tons.

Critical Facilities and Lifelines

Many critical facilities and infrastructure in the planning area are exposed to earthquakes. HAZMAT releases can occur during an earthquake from fixed facilities or transportation-related incidents. Transportation corridors can be disrupted during an earthquake, leading to the release of materials to the surrounding environment. Facilities holding HAZMAT are of particular concern because of possible isolation of neighborhoods surrounding them. During an earthquake, structures storing these materials could rupture and leak into the surrounding area or an adjacent waterway, having a disastrous effect on the environment.

HAZUS-MH classifies the vulnerability of essential facilities to earthquake damage in two categories: at least moderate damage or complete damage. The analysis did not indicate any damages in these categories to specific facilities. The model also anticipates pipeline breaks and leaks in the Eastern Region's potable water, wastewater, and natural gas lines. Across these linear networks, the earthquake is expected to cause 625 pipeline leaks and 156 complete fractures in the potable water, wastewater and natural gas systems. The model also estimates lifeline damages to linear networks such as transportation and utilities. Damage to the transportation system is estimated at $7.8 million and utility lifelines at $239 million. The steep terrain in the southwestern counties of the Eastern Region would likely experience multiple rockslides that could damage roadways and disrupt traffic along the rail, highway, and road corridors.

Economy

Economic impacts of an earthquake could be staggering in the impacted areas. Not only the costs of direct damages to property, infrastructure, and inventory, but the losses incurred from businesses forced to close temporarily or permanently. As mentioned above, the total income-related economic losses are estimated by the model to be $28.68 million in the 2,500-year scenario. HAZUS-MH models many other estimated impacts, which are summarized in Table 4-19 and Table 4-20 below. Yellowstone and Carbon counties have the highest potential losses; Stillwater, Wheatland and Big Horn counties also have higher loss ratios.

Table 4-19 HAZUS-MH Earthquake Loss Estimation 2,500-Year Scenario Results

Type of Impact	Impacts to Region
Total Buildings Damaged	Slight: 5,500 Moderate: 1,652 Extensive: 128 Complete: 3
Building and Income Related Losses	$133.27 million 55% of damage related to residential structures 22% of loss due to business interruption
Total Economic Losses (includes building, income, and lifeline losses)	$380.16 Million - Total Building: $133.27 Million Income: $28.68 Million Transportation/Utility: $246.89 Million
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 14 Requiring hospitalization: 1 Life threatening: 0 Fatalities: 0
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 33 Requiring hospitalization: 4 Life threatening: 0 Fatalities: 0

Type of Impact	Impacts to Region
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 23 Requiring hospitalization: 3 Life threatening: 0 Fatalities: 0
Fire Following Earthquake	0 Ignitions
Debris Generation	29,000 tons of debris generated 1,160 estimated truckloads to remove
Displaced Households	27
Shelter Requirements	15

Source: HAZUS-MH Global Summary Report, WSP Analysis

Table 4-20 Direct Economic Losses by County (In thousands of Dollars)

	Capital Stock Losses					Income Losses				
	Cost Structural Damage	Cost Non-struct. Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Montana										
Prairie	24	53	16	0	0.06	12	2	4	5	116
Treasure	35	76	26	1	0.14	18	4	5	7	172
McCone	57	120	40	1	0.07	26	9	13	13	280
Sheridan	143	363	149	4	0.10	94	40	66	44	903
Yellowstone	10,257	31,653	12,079	385	0.27	6,265	3,181	3,870	3,364	71,054
Big Horn	554	1,953	761	12	0.28	362	142	183	144	4,111
Carbon	3,168	13,974	6,003	91	1.21	1,953	862	1,099	920	28,071
Carter	66	162	56	2	0.15	36	12	19	14	367
Custer	549	1,589	575	13	0.18	356	232	294	186	3,794

	Capital Stock Losses					Income Losses				
	Cost Structural Damage	Cost Non-struct. Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Musselshell	208	553	194	6	0.14	130	61	92	52	1,296
Garfield	34	73	21	1	0.07	16	6	7	7	165
Richland	196	474	153	4	0.06	115	52	70	57	1,120
Wibaux	16	33	8	0	0.05	8	2	3	3	75
Fallon	86	185	58	2	0.08	53	22	32	21	459
Roosevelt	206	585	221	10	0.09	126	43	74	56	1,323
Golden Valley	75	178	65	3	0.24	38	11	16	15	401
Stillwater	1,346	6,046	2,513	76	0.66	740	279	361	294	11,655
Powder River	117	361	140	5	0.26	66	40	45	29	803
Wheatland	220	675	255	5	0.39	128	48	76	58	1,465
Rosebud	389	1,154	443	10	0.18	261	99	149	139	2,644
Valley	256	748	266	5	0.10	161	79	121	94	1,730
Dawson	170	362	104	4	0.05	97	47	65	53	902
Daniels	57	146	56	2	0.08	31	29	32	15	370
Total	**18,232**	**61,518**	**24,201**	**642**	**0.21**	**11,091**	**5,301**	**6,697**	**5,590**	**133,272**
Region Total	**18,232**	**61,518**	**24,201**	**642**	**0.21**	**11,091**	**5,301**	**6,697**	**5,590**	**133,272**

Source: HAZUS-MH Global Summary Report, WSP Analysis

Historic and Cultural Resources

Older and historic buildings, which are often significant cultural resources for a region, will typically be more vulnerable to damage in an earthquake. Historic building stock is commonly made of unreinforced masonry, which is more vulnerable to damage from earthquakes, in addition to being constructed before the adoption of modern building and seismic codes. Many of the historic downtown buildings in the towns in Carbon and Stillwater counties may be particularly vulnerable.

Natural Resources

Secondary hazards associated with earthquakes will likely have some of the most damaging effects on the environment and natural resources. Earthquake-induced landslides can potentially impact surrounding habitat.

Development Trends Related to Hazards and Risk

Future population growth and building development in general will increase the exposure of the Eastern Region to earthquake by increasing the number of people and value of building inventory in the planning area. Development in the Eastern Region planning area where regulated through building standards through modern code adoption and enforcement can help limit potential vulnerabilities.

Risk Summary

Overall earthquake is considered a **Low** significance hazard due the unlikely nature of a severe earthquake in the Eastern Region, and the lack of history of damaging events in the planning area.

- Effects on people: People can be injured or killed in earthquakes due to falling items or structures, as well as from cascading events triggered by the earthquake. Regionwide, a maximum of 37 injuries are estimated by the HAZUS scenario, as well as 27 displaced households.
- Effects on property: Impacts on property include direct damage to structures from the shaking. Regionwide, 1,783 buildings are estimated to be at least moderately damaged, with 3 of them completely destroyed, resulting in $133.27 million in building damage.
- Yellowstone and Carbon counties have the highest potential losses; Stillwater, Wheatland and Big Horn counties also have higher loss ratios.
- Effects on the economy: economic impacts can be from direct damages to structures as well as lost wages and income. The total economic loss is projected to be $380.16 million.
- Effects on critical facilities and infrastructure: Linear facilities, such as pipelines, railroads, and roadways, are largely at much greater risk than other facility types. $246.89 million in damages to linear facility networks are projected.
- Unique jurisdictional vulnerability: the vulnerability is generally low throughout the Eastern Region, but the potential for damage is greater in the southwestern portion of the Eastern Region.
- Related hazards: landslide, dam incidents

Table 4-21 Risk Summary Table: Earthquake

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	Low		In general, counties in the eastern region have lower vulnerability with the exception of the southwestern counties
Big Horn	Medium	Hardin, Lodge Grass	None
Carbon	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	Greater losses expected near Red Lodge and Fromberg.
Carter	Low	Ekalaka	None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Crow Tribe	Low		None
Custer	Low	Ismay, Miles City	None
Daniels	Low	Scobey, Flaxville	None
Dawson	Low	Richey, Glendive	None
Fallon	Low	Plevna, Baker	None
Garfield	Low	Jordan	None
Golden Valley	Low	Ryegate, Lavina	None
McCone	Low	Circle	None
Musselshell	Low	Roundup	None
North Cheyenne Tribe	Low		None
Powder River	Low	Broadus	None
Prairie	Low	Terry	None
Richland	Low	Fairview, Sidney	None
Roosevelt	Low	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	None
Rosebud	Low	Colstrip, Forsyth	None
Sheridan	Low	Outlook, Westby, Plentywood, Medicine Lake	None
Stillwater	Medium	Columbus	Greater losses expected near Columbus.
Treasure	Low	Hysham	None
Valley	Low	Fort Peck, Glasgow, Nashua, Opheim	None
Wheatland	Medium	Harlowton, Judith Gap	Greater losses expected near Harlowton.
Wibaux	Low	Wibaux	None
Yellowstone	Medium	Billing, Laurel, Broadview	Greater losses expected near Laurel and Billings.

4.2.7 Flooding

Hazard/Problem Description

Riverine flooding is defined as when a watercourse exceeds its "bank-full" capacity and is usually the most common type of flood event. Riverine flooding generally occurs because of prolonged rainfall, or rainfall that is combined with soils already saturated from previous rain events. The area adjacent to a river channel is its floodplain. In its common usage, "floodplain" most often refers to that area that is inundated by the 100-year flood, the flood that has a 1 percent chance in any given year of being equaled or exceeded. Other types of floods include general rain floods, thunderstorm generated flash floods, alluvial fan floods, snowmelt, rain on snow floods, dam failure and dam release floods, and local drainage floods. The 100-year flood is the national standard to which communities regulate their floodplains through the National Flood Insurance Program (NFIP).

The potential for flooding can change and increase through various land use changes and changes to land surface. A change in environment can create localized flooding problems inside and outside of natural floodplains by altering or confining watersheds or natural drainage channels. These changes are commonly created by human activities. These changes can also be created by other events such as wildland fires. Wildland fires create hydrophobic soils, a hardening or "glazing" of the earth's surface that prevents rainfall from being absorbed into the ground, thereby increasing runoff; erosion, and downstream sedimentation of channels.

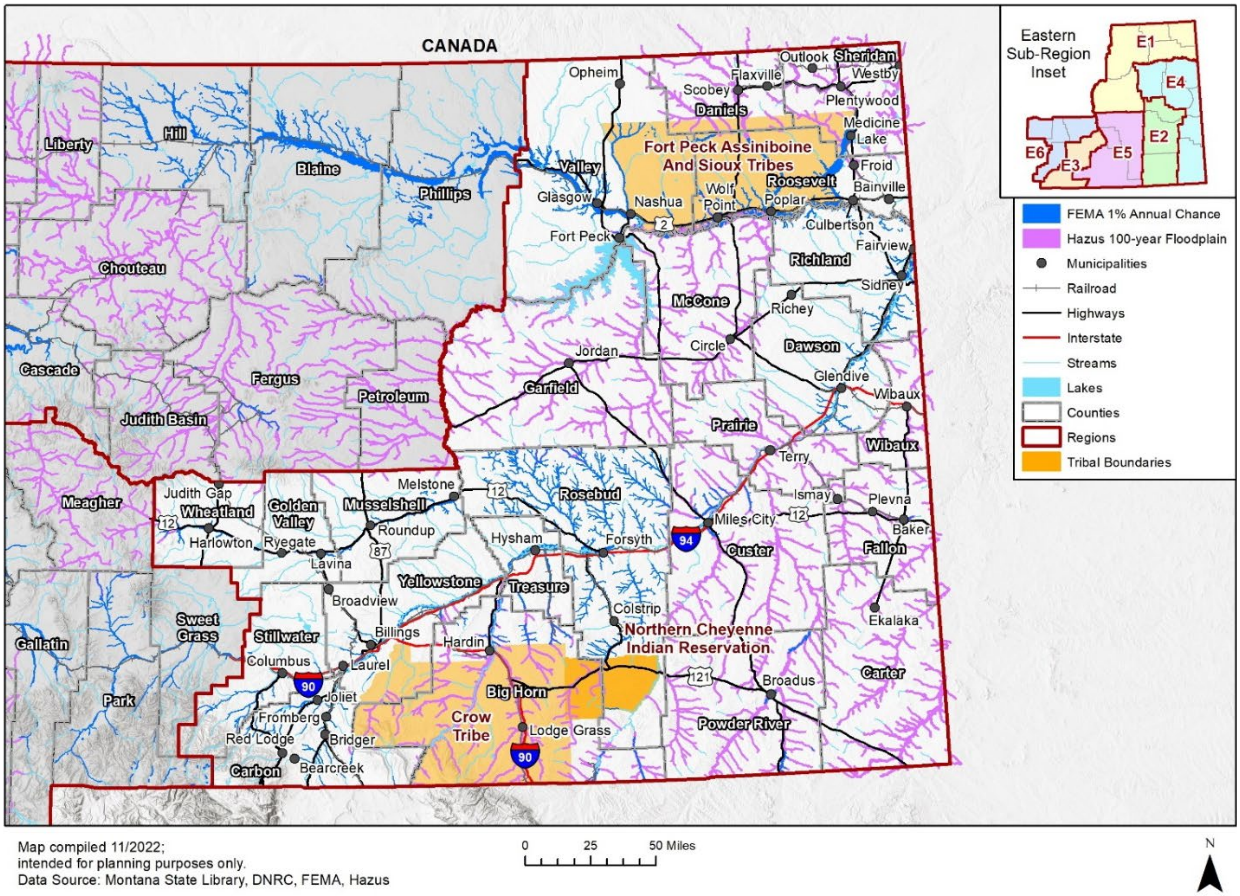
Montana is susceptible to the following types of flooding:

- Rain in a general storm system
- Rain in a localized intense thunderstorm
- Melting snow
- Rain on melting snow
- Ice Jams
- Levee failure
- Dam failure
- Urban stormwater drainage
- Rain on fire damaged watersheds

Slow rise floods associated with snowmelt and sustained precipitation usually are preceded with adequate warning, though the event can last several days. Flash floods are also characteristic. Flash floods, by their nature, occur very suddenly but usually dissipate within hours. Even flash floods are usually preceded with warning from the NWS in terms of flash flood advisories, watches, and warnings. Also, a Miles City levee failed an initial eligibility inspection under the P.L. 84-99 program in the late 1990's due to several deficiencies. This type of flooding can cause breaches, meaning that part of the levee breaks away and leaves a large opening for water to rush through. Sometimes water seeps underneath the levee, causing flooding and/or weakening the levee's overall stability, which can be hard to detect in advance. New and repaired levee systems are now in place in Miles City to provide flood protection. The average total annual precipitation in Montana is roughly 15.37 inches. The average total annual snowfall is 49 inches. Generally, the flood season extends from late spring and early summer, when snowmelt runoff swells rivers and creeks, to fall. Much of the rainfall occurs with thunderstorms during April to August. Within the Eastern Region, Carbon County, where the Custer Gallatin National Forest is located, has the highest annual average of precipitation with 16.98 inches. Figure 4-28 illustrates the geographical area affected by flooding based on the National Flood Hazard Layer (NFHL) and Hazus geospatial flood datasets.

Geographical Area Affected

Figure 4-28 Eastern Region Flood Hazards (NFHL and Hazus)



The Missouri River, along with the tributaries within the watershed are Eastern Montana's primary waterways that result in flood hazards. Among the tributaries located within the different watersheds are the Big Muddy, Poplar, Powder, Rosebud, Tongue and Yellowstone waterways. The Missouri River is the longest river in the United States, rising in the Rocky Mountains of the Eastern Centennial Mountains of Southwestern Montana and flowing east and south, and then flowing from east to west through Richland and Roosevelt counties, and then proceeding westward. Flooding along the Missouri typically occurs during the spring and is caused by long rainstorms and due to snowmelt runoff. Localized thunderstorms during the summer monsoons can also result in flash flooding throughout the Eastern Region planning area. In addition to flooding from the Yellowstone River, a large portion of the Eastern Region near Billings in Yellowstone County is also prone to flooding along ditches and drains and other open waterways owned and maintained by private ditch companies that carry water away from the City towards the Yellowstone River during flooding, irrigation from field runoff, and other stormwater runoff. The geographical extent of flooding across the Eastern Region is **Limited.**

Past Occurrences

Flooding is a natural event and rivers and tributaries in the study area have experienced periodic flooding with associated floods and flash floods. There has been 10 federally declared disasters within the 23 counties and three Indian Reservations located in the Eastern Region from 1975 to 2022. The federal declarations since 2010 to present are summarized in Table 4-22 below. According to the NCEI database, Montana's

Eastern Region has also incurred $23,587,000 in property damages, $665,000 in crop damages and three deaths due to flooding since 1996.

Table 4-22 Federally Declared Flooding Events Montana Eastern Region 1974-2022

Year	Declaration Title	Disaster Number	County/Reservation Impacted
2022	SEVERE STORM AND FLOODING	DR-4655-MT	Carbon, Stillwater, Treasure, Yellowstone
2019	FLOODING	DR-4437-MT	Daniels, McCone, Powder River, Stillwater, Treasure, Valley
2019	FLOODING	DR-4405-MT	Carbon, Custer, Golden Valley, Musselshell, Treasure
2018	FLOODING	DR-4388-MT	Valley
2014	ICE JAMS AND FLOODING	DR-4172-MT	Dawson, Golden Valley, Musselshell, Prairie, Rosebud, Richland, Stillwater, Wheatland
2013	FLOODING	DR-4127-MT	Custer, Dawson, Garfield, McCone, Musselshell, Rosebud, Valley
1987	SEVERE STORMS & FLOODING	DR-777-MT	Garfield, McCone, Rosebud, Valley
1986	HEAVY RAINS, LANDSLIDES & FLOODING	DR-761-MT	Daniels, Dawson, Valley
1978	SEVERE STORMS & FLOODING	DR-558-MT	Big Horn, Carbon, Powder River, Rosebud, Stillwater, Treasure, Yellowstone
1975	RAINS, SNOWMELT, STORMS & FLOODING	DR-472-MT	Wheatland

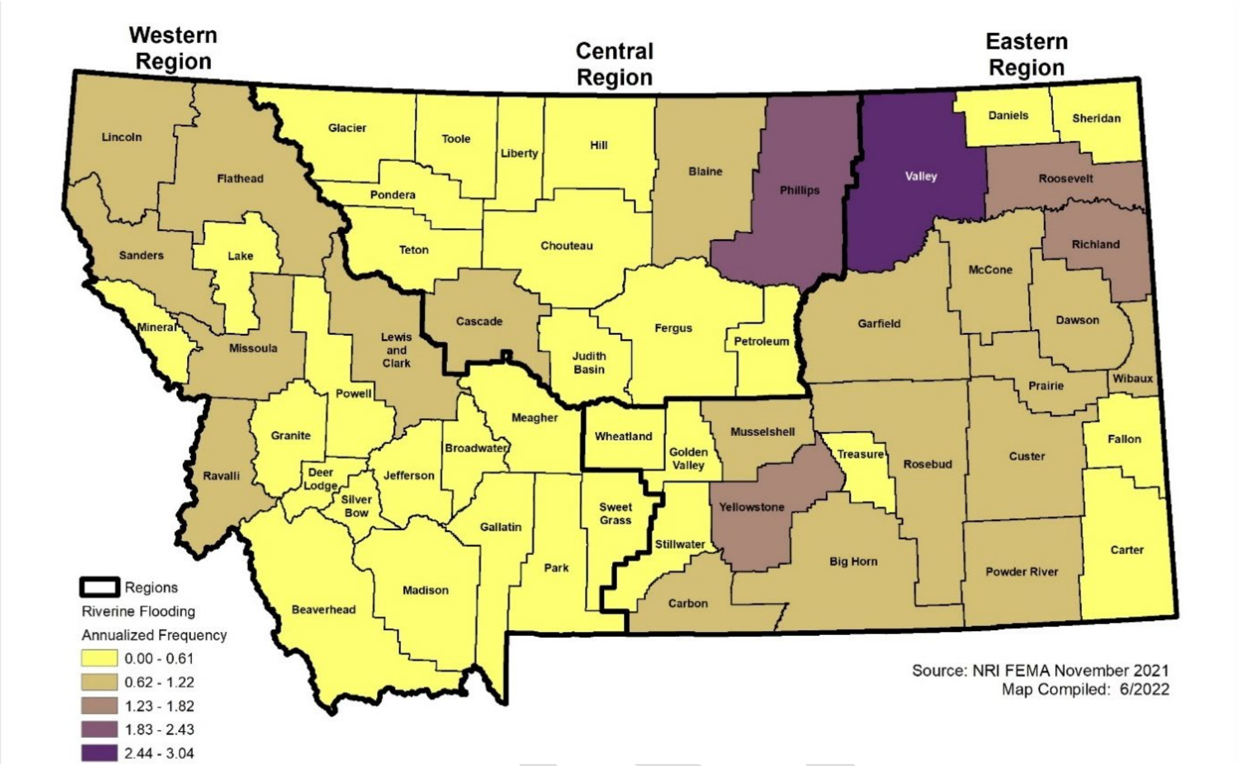
Source: FEMA 2022

Frequency/Likelihood of Occurrence

The Eastern Region has experienced multiple catastrophic flood events resulting in large-scale property damages. Snowmelt runoffs present a threat of serious flooding along rivers and creeks in the study area each year. Flash floods that produce debris flows and mudflows occur regularly and have caused significant damages in the past to homes, roads, bridges, and culverts. Based on the historical record of the ten federally declared events in the past 47 years from 1975 to present within the Eastern Region, the Region has a major flood resulting in a FEMA declaration every 5 years on average. Using past occurrences as an indicator of future probability, flooding has the probability of future occurrence rating of **Likely** throughout the Eastern Region.

Figure 4 depicts the annualized frequency of riverine flooding at a county level based on the NRI. The mapping shows a trend toward increased likelihood of flooding in the northern portion of the Eastern Region with Valley County having a 2.44 – 3.04 annualized frequency of riverine flooding; this trend is supported by the County having the highest number of flood insurance claims (see discussion in Vulnerability subsection). Richland and Roosevelt counties have a 1.83 – 2.43 annualized frequency of riverine flooding while all other counties in the study area have a 0.00 – 1.22 frequency.

Figure 4-29 Annualized Frequency of Riverine Flooding by County



Climate Change Considerations

To date, projections from climate models have been mixed about whether climate warming will increase or decrease precipitation in Montana (Whitlock C, Cross W, Maxwell B, Silverman N, Wade AA. 2017. 2017 Montana Climate Assessment. Bozeman and Missoula MT: Montana State University and University of Montana, Montana Institute on Ecosystems. 318 p. doi:10.15788/m2ww8w. Available at: https://montanaclimate.org/). However, because warmer air can hold more moisture, events producing heavy rainfall and flooding can be expected to increase as temperatures rise in the years to come. In general, rising temperatures tend to lead to more extreme precipitation events and, depending on the surface conditions, more potential for flash flooding.

Warming is likely to directly affect flooding in many mountain settings, as catchment areas receive increasingly more precipitation as rain rather than snow, or more rain falling on existing snowpack. Warming is also expected to continue to reduce the annual snowpack, which could reduce flood risk related to rain-on-snow events by reducing the quantity of water resources available for release stored as snow. Yet, warming could also increase the amount of winter and spring precipitation that falls as rain rather than snow, thereby accelerating snowmelt and increasing flood risk ((Whitlock C, Cross W, Maxwell B, Silverman N, Wade AA. 2017. 2017 Montana Climate Assessment. Bozeman and Missoula MT: Montana State University and University of Montana, Montana Institute on Ecosystems. 318 p. doi:10.15788/m2ww8w. Available at: https://montanaclimate.org/). In some such settings, river flooding may increase as a result – even where precipitation and overall river flows decline.

According to the 2018 National Climate Assessment, river basins including the Missouri River Basin will experience gradual runoff declines during this century but flooding in the region is generally expected to increase. In Montana, however, there are no specific projections or trends that have been noted to indicate that more substantial or more frequent flooding events can be expected to occur.

Climate change may also lead to more ice-jam flooding along mountain streams, when heavy rainfall or upstream melting raises stream flows to the point of breaking up the ice cover, which can pile up on bridge piers or other channel obstructions and cause flooding behind the jam. Once the ice jam breaks up, downstream areas are vulnerable to flash floods. Climate change could create conditions ripe for ice-jam floods. The increasing possibility of midwinter thaws and heavy rainfall events could increase the risk of sudden ice break up. Flooding can be further exacerbated if the ground is still frozen and unable to soak up rainwater.

Potential Magnitude and Severity

Magnitude and severity can be described by several factors that contribute to the relative vulnerabilities of certain areas in the floodplain. Development, or the presence of people and property in the hazardous areas, is a critical factor in determining vulnerability to flooding. Additional factors that contribute to flood vulnerability range from specific characteristics of the floodplain to characteristics of the structures located within the floodplain. The following is a brief discussion of some of these flood factors which pose risk.

- **Elevation:** The lowest possible point where floodwaters may enter a structure is the most significant factor contributing to its vulnerability to damage, due to the higher likelihood that it will come into contact with water for a prolonged amount of time.
- **Flood depth:** The greater the depth of flooding, the higher the potential for significant damages due to larger availability of flooding waters.
- **Flood duration:** The longer duration of time that floodwaters are in contact with building components, such as structural members, interior finishes, and mechanical equipment, the greater the potential for damage.
- **Velocity:** Flowing water exerts forces on the structural members of a building, increasing the likelihood of significant damage (such as scouring).
- **Construction type:** Certain types of construction and materials are more resistant to the effects of floodwaters than others. Typically, masonry buildings, constructed of brick or concrete blocks, are the most resistant to damages simply because masonry materials can be in contact with limited depths of flooding without sustaining significant damage. Wood frame structures are more susceptible to damage because the construction materials used are easily damaged when inundated with water.

Major flood events present a risk to life and property, including buildings, contents, and their use. Floods can also affect lifeline utilities (e.g., water, sewage, and power), transportation, the environment, jobs, and the local economy.

Past flood events in Montana's Eastern Region have damaged roads, bridges, private property, businesses, and critical lifeline facilities. Future events may result in greater damages depending on patterns of growth, land use development and climate change. In summary, the magnitude of flood hazards in the Eastern Region is **Critical.**

National Flood Insurance Program Policy Analysis

The NFIP aims to reduce the impact of flooding on private and public structures by providing affordable insurance to property owners and by encouraging communities to adopt and enforce floodplain management regulations. These efforts help mitigate the effects of flooding on new and improved structures. The State has analyzed NFIP flood-loss data to determine areas of Montana's Eastern Region with the greatest flood risk. Montana's Eastern Region flood-loss information was obtained from FEMA's "Montana's Coverage Claims" for Montana's Eastern Region, which documents losses from 1978. This section was updated based on information obtained from FEMA's PIVOT database through Montana Department of Natural Resources and Conservation (MT DNRC) dated August 10, 2022.

There are several limitations to analyzing flood risk entirely on this data, including:

- Only losses to participating NFIP communities are represented; Petroleum County is not a participant in the NFIP
- Communities joined the NFIP at various times since 1978,
- The number of flood insurance policies in effect may not include all structures at risk to flooding, and
- Some of the historical loss areas have been mitigated with property buyouts.

Montana's Eastern Region has a total of $951,790,600 in NFIP coverage, with 1,005 total flood claims, 1,272 current polices and $7,868,905 dollars paid out total due to flood damage and losses. NFIP data and statistics for the Eastern Region is summarized in Table 4-23 below. Yellowstone County has the highest amount of dollars paid out due to flood claims with $1,814,878, followed by Valley County with $1,590,563 in claims.

Table 4-23 Montana Eastern Region NFIP Statistics

County	Date Joined	Effective Firm Date	Dollars Paid (Historical)	Flood Claims	Current Policies	Coverage ($)
Big Horn	9/2/1981	9/2/1981	$245,116.75	16	8	$1,901,900.00
Carbon	11/4/1981	7/5/2017	$1,089,354.17	61	77	$20,190,100.00
Carter	$0	$0	$0	$0	$0	$0
Custer	9/1/1987	7/22/2010	$400,061.25	155	730	$119,513,500.00
Daniels	$0	$0	$0	$0	$0	$0
Dawson	5/1/1999	05/01/99(L)	$144,610.47	7	8	$2,465,500.00
Fallon	8/4/1988	8/4/1988	$0	1	2	$700,000,000
Garfield	3/20/1979	3/20/1979	$0	1	11	$562,600
Golden Valley	9/16/1981	11/5/2021	$0	$0	1	$255,000
McCone	6/4/2007	6/4/2007	$0	$0	$0	$0
Musselshell	3/1/2001	11/15/2019	$1,201,833.38	60	18	$1,624,700
Petroleum	11/15/2019	11/15/2019	$0	$0	$0	$0
Phillips	5/19/1987	5/19/1987	$173,303.74	50	13	$1,182,900
Powder River	6/1/2010	06/01/10(L)	$25,382	7	4	$616,000
Prairie	5/8/1979	5/8/1979	$0	$0	$0	$0
Richland	12/4/1985	8/15/2019	$96,344.22	12	14	$3,589,400
Roosevelt	11/1/1996	11/01/96(L)	$59,144.95	8	5	$942,500
Rosebud	9/1/1997	11/15/2019	$15,452.01	12	5	$1,443,000
Sheridan	2/4/2019	6/4/2007	$72.89	1	$0	$0
Stillwater	11/15/1985	10/16/2015	$915,175.10	56	64	$16,937,600
Treasure	12/18/1986	12/18/86(M)	$0	$0	2	$47,000
Valley	1/1/1987	01/01/87(L)	$1,590,365.62	274	23	$3,043,600
Wheatland	9/16/1981	9/16/1981	$20,726.62	18	6	$439,000
Wibaux	3/4/1988	2/18/1998	$77,084.26	3	6	$430,300
Yellowstone	11/18/1981	11/6/2013	$1,814,878.16	263	275	$76,606,000
		Total	$7,868,905.37	1005	1272	$951,790,600.00

Source: FEMA Pivot NFIP Data as of August 10th, 2022; FEMA Community Status Book Report

Repetitive Loss

Table 4-24 below lists the repetitive loss structures that have been identified throughout the Eastern Region study area. Valley County has the highest amount of repetitive loss structures, claims and totals paid out overall with 25 structures, 27 repetitive loss claims, and nearly $1 million dollars paid out due to repeated flooding and flood insurance loss claims. This is followed by Yellowstone County which has 21 repetitive loss structures, 53 repetitive loss claims and $747,592.02 in funding paid. It should be noted that a flood insurance claim can be filed when a property and its adjacent property is inundated.

Table 4-24 Eastern Region Repetitive Loss Properties by County

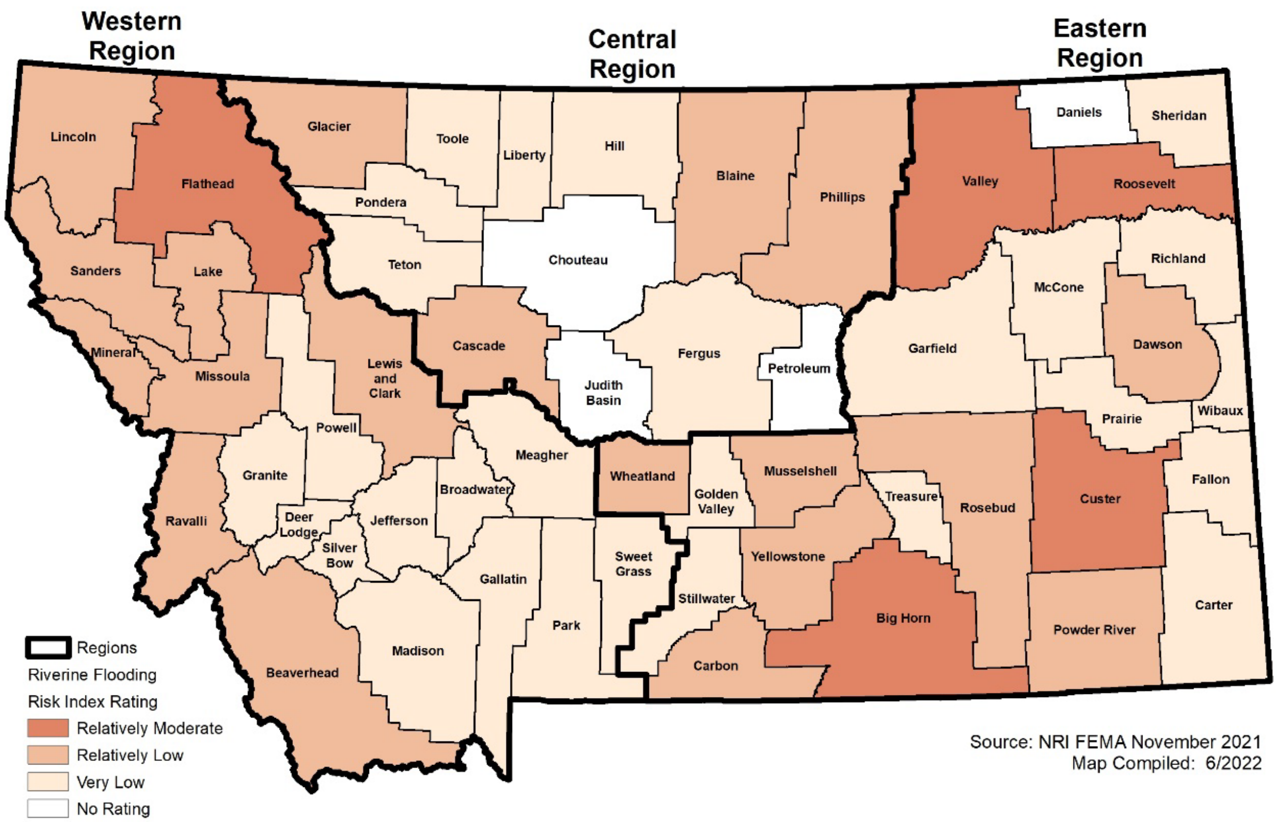
County	Repetitive Loss Structures per County	Repetitive Loss Claims	Structure Type Single - Family	Structure Type – Multi-Family	Structure Type – Business/Non-Residential	Total Paid Out
Carbon County	3	7	3	-	-	$76,356.50
Dawson County	1	2	1	-	-	$137,967.31
Musselshell County	8	19	7	-	1	$638,988.46
Philips County	3	5	3	-	-	$27,673.46
Valley County	25	57	21	1	3	$946,466.37
Yellowstone County	21	53	19	-	2	$747,592.02
Total	**61**	**143**	**54**	**1**	**6**	**$2,575,044.12**

Source: FEMA Pivot NFIP Data as of August 10th, 2022; FEMA Community Status Book Report

Vulnerability Assessment

Figure 4 depicts the risk index rating for riverine flooding based on FEMA's NRI. The NRI defines risk as the potential for negative impacts as a result of a natural hazard and determines a community's risk relative to other communities by examining the expected annual loss and social vulnerability in a given community in relation to that community's resilience. The Eastern Region has four counties with a relatively high riverine flooding risk based on the NRI. They are Big Horn, Custer, Roosevelt, and Valley counties, all of which have a higher risk of riverine flooding. This can be attributed to both the Missouri and Yellowstone watersheds passing through each of these areas. There are seven counties that are classified as having a relatively low riverine flooding risk level. These counties within the Eastern Region are Carbon, Dawson, Musselshell, Powder River, Rosebud, Wheatland, and Yellowstone. The other remaining 11 counties are considered to have a low riverine flooding risk and Daniels County has no rating in correlation to riverine inundation risks currently.

Figure 4-30 Risk Index Rating for Riverine Flooding by County



There is an increased risk of flash flooding and debris flows in Montana in general as a result of recent active fire seasons. Most burn areas will be prone to flash flooding and debris flows for at least two years after the fire. Locations downhill and downstream from burned areas are most susceptible, especially near steep terrain. Rainfall that would normally be absorbed will run off extremely quickly after a wildfire, as burned soil can be as water repellant as pavement. As a result, much less rainfall is required to produce a flash flood. As water runs downhill through burned areas it can create major erosion and pick up large amounts of ash, sand, silt, rocks and burned vegetation.

People

Vulnerable populations in Montana's Eastern Region include those that live within known floodplains or near areas vulnerable to flash floods, as well as people traveling through or in areas used for recreational purposes prone to flash flooding. Within the Eastern Region Custer County has the highest amount of people located in the floodplain with 6,711. This is followed by Yellowstone County with 1,830. The third highest amount of people reside in Big Horn County with 856. Certain populations are particularly vulnerable, such as those living in close proximity to flood hazard areas. Of these totals, this can include the elderly and very young, those living in long-term care facilities, mobile homes, hospitals, low-income housing areas, or temporary shelters, people who do not speak English well, tourists and visitors, and those with developmental, physical, or sensory disabilities. Table 4-25 below highlights the people who are located on reservation land that are located in the floodplain, including a significant number of persons of the Crow Tribe.

The impacts of flooding on vulnerable populations can potentially be the most severe. Families may have fewer financial resources to prepare for or recover from a flood, and they may be more likely to be uninsured or underinsured. Individuals with disabilities may need more time to evacuate, so evacuation notices will need to be issued as soon as feasible, and communicated by multiple, inclusive methods. Population totals for the counties located in Montana's Eastern region are shown in Table 4-25 below.

Table 4-25 Eastern Region Population Located in the 1% Annual Chance Floodplain

County	Population
Big Horn	856
Carbon	709
Carter	147
Crow Tribe	681
Custer	6,711
Daniels	2
Dawson	340
Fallon	84
Fort Peck	337
Garfield	60
Golden Valley	32
McCone	46
Musselshell	393
Northern Cheyenne Indian Reservation	5
Powder River	219
Prairie	5
Richland	218
Roosevelt	353
Rosebud	64
Sheridan	391
Stillwater	605
Treasure	15
Valley	418
Wheatland	204
Wibaux	64
Yellowstone	1,830
Total	14,789

Sources: DNRC, Hazus, FEMA NFHL

Within the Eastern Region, the highest amount of people in the study area located in the 0.2% annual chance of flooding is in Yellowstone County with 1,183 people. This is followed by Carbon County with 225. Dawson County has 155 people. Populations and people located in the 0.2% annual chance floodplain are listed in Table 4-26.

Table 4-26 Eastern Region Population Located in the 0.2% Annual Chance Floodplain

County	Population
Big Horn	0
Carbon	225
Dawson	155
Fallon	41

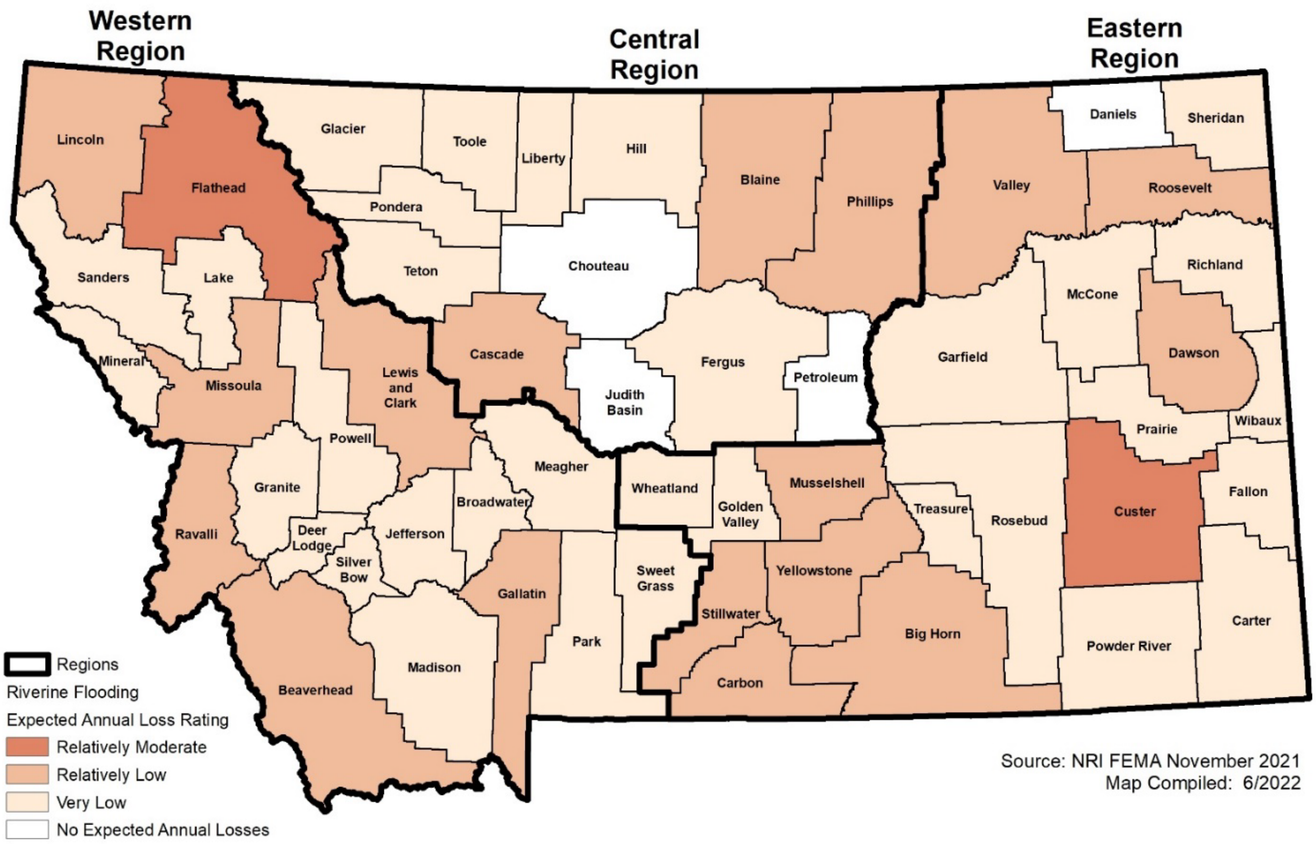
County	Population
Golden Vall	18
Musselshell	50
Richland	45
Rosebud	0
Stillwater	170
Wheatland	106
Yellowstone	1,183
Total	1,992

Sources: DNRC, Hazus, FEMA NFHL

Property

The NRI defines risk as the potential for negative impacts as a result of a natural hazard and determines a community's risk relative to other communities by examining the expected annual loss and social vulnerability in a given community in relation to that community's resilience. This information is categorized in Figure 4 below. Montana's Eastern Region has one county with a relatively moderate expected loss rating based on the NRI: Custer County. This also coincides with Custer County having substantial floodplain development in and around Miles City, though levees in the area provide some level of protection. Other counties with relatively low expected loss rating due to floods include Carbon, Big Horn, Dawson, Musselshell, Roosevelt, Stillwater, Valley and Yellowstone counties.

Figure 4-31 Expected Annual Loss Rating Riverine Flooding by County



GIS analysis was used to further estimate Montana's Eastern Region potential property and economic losses. The April 2022 MSDI Cadastral Parcel layer was used as the basis for the inventory of developed parcels.

GIS was used to create a centroid, or point, representing the center of each parcel polygon, which was overlaid on the best available floodplain layer. Multiple flood layers from different sources were used in the analysis to create a full coverage of flood hazard for the Eastern Region through the utilization of FEMA's NFHL (as of 6/1/2022), and other sources. The DNRC provided digitized flood mapping from paper maps that FEMA has not yet converted over to the NFHL. FEMA Region VIII also provided 1% annual chance flood risk areas based on Hazus flood models to help fill in areas where FEMA has not mapped. For the purposes of this analysis, the flood zone that intersected the centroid was assigned as the flood zone for the entire parcel. Another assumption with this model is that every parcel with an improvement value greater than zero was assumed to be developed in some way. Only improved parcels, and the value of those improvements, were analyzed and aggregated by region, county, jurisdiction, property type and flood zone. The summarized results for the Eastern Region are shown below. More detailed summarized results for each county and community by property type are shown in the tables and maps provided within each jurisdictional Annex.

Table 4-27 below summarize the counts and improved value of parcels in the region, broken out by each county, that fall within the 1% chance floodplains. Additionally, Table 4-27 summarizes the table also shows loss estimate values which are calculated based upon a proportion of the improved value and estimated contents value and FEMA depth-damage relationships. A two-foot flood is assumed for the purposes of this planning-level flood loss estimate, which generally equates to a 25% loss based on structure and contents value.

Custer County has the highest amount of properties exposed to flooding and an estimated loss value of over $131 Million. Yellowstone County has loss values with over $70 Million in estimated losses, followed by Carbon County with estimated loss parcel values with over $38 Million in losses. Overall Montana's Eastern Region has $1.5Billion in total value exposed and a combined estimated loss of over $384 Million for 1% annual chance flooding. There are also 7,050 parcels located in the floodplain and 14,789 people at risk in the Eastern Region. The jurisdictional break down for each county is located within each annex. The summarized results for the Eastern Region are shown in Table 4-27 below.

Table 4-27 Eastern Region Parcels at Risk to 1% Flood Hazard by County and Jurisdiction

County	Improved Parcels	Improved Value	Content Value	Total Value	Estimated Loss
Big Horn	320	$42,048,541	$28,419,080	$70,467,621	$17,616,905
Carbon	390	$94,893,650	$59,013,360	$153,907,010	$38,476,753
Carter	117	$9,409,733	$7,233,297	$16,643,030	$4,160,757
Custer	3,011	$339,329,544	$186,052,204	$525,381,748	$131,345,437
Daniels	19	$1,306,490	$1,274,230	$2,580,720	$645,180
Dawson	184	$23,263,219	$12,985,725	$36,248,944	$9,062,236
Fallon	60	$7,098,177	$4,648,789	$11,746,966	$2,936,741
Garfield	54	$3,949,454	$3,149,022	$7,098,476	$1,774,619
Golden Valley	26	$2,615,550	$2,147,890	$4,763,440	$1,190,860
McCone	73	$5,663,177	$4,813,339	$10,476,516	$2,619,129
Musselshell	221	$12,948,261	$8,252,576	$21,200,837	$5,300,209
Powder River	164	$11,476,921	$8,399,881	$19,876,802	$4,969,200
Prairie	12	$1,438,540	$1,351,150	$2,789,690	$697,423
Richland	156	$18,497,151	$13,398,821	$31,895,972	$7,973,993
Roosevelt	170	$42,111,267	$49,333,508	$91,444,775	$22,861,194
Rosebud	76	$9,189,124	$7,556,857	$16,745,981	$4,186,495
Sheridan	235	$23,978,537	$14,143,794	$38,122,331	$9,530,583
Stillwater	291	$55,596,478	$32,888,481	$88,484,959	$22,121,240

County	Improved Parcels	Improved Value	Content Value	Total Value	Estimated Loss
Treasure	44	$4,493,676	$4,232,678	$8,726,354	$2,181,589
Valley	361	$41,285,741	$28,490,501	$69,776,242	$17,444,060
Wheatland	113	$11,816,349	$10,001,820	$21,818,169	$5,454,542
Wibaux	38	$2,031,999	$1,344,740	$3,376,739	$844,185
Yellowstone	915	$168,328,469	$114,391,695	$282,720,164	$70,680,041
Total	**7,050**	**$932,770,048**	**$603,523,431**	**$1,536,293,479**	**$384,073,370**

Sources: DNRC, Hazus, FEMA NFHL,

The three tribal reservations located with the Eastern Region were identified to have 412 improved parcels with an estimated loss of over $22 Million. The Crow Tribe in particular has $11,984,383 in estimated losses and the Fort Peck Assiniboine and Sioux tribes have $10,106,363 in estimated losses due to flooding. While the Northern Cheyenne Indian Reservation is vastly smaller with $499 in estimated losses. There is a total of 1,023 people on reservation land located within the 1% annual chance of flooding Special Flood Hazard Area (SFHA). At the time of the flooding risk analysis for the Eastern Region, there is no 0.2% risk for the Tribal Nations as it is currently no mapped. Totals are listed in Table 4-28 below.

Table 4-28 Eastern Region Parcels at Risk to 1% Annual Chance by Tribe

Tribal	Improved Parcels	Improved Value	Content Value	Total Value	Estimated Loss	Population
Crow Tribe	230	$28,443,085	$19,494,447	$47,937,532	$11,984,383	681
Fort Peck Assiniboine and Sioux Tribe	181	$21,611,356	$18,814,097	$40,425,453	$10,106,363	337
Northern Cheyenne Indian Reservation	1	$1,330	$665	$1,995	$499	5
Total	**412**	**$50,055,771**	**$38,309,209**	**$88,364,980**	**$22,091,245**	**1,023**

Sources: DNRC, Hazus, FEMA NFHL,

Table 4-29 below summarize the counts and improved value of parcels in the region, broken out by each county, that fall within the 0.2% chance floodplains. Additionally, Table 4-29 summarizes the table also shows loss estimate values which are calculated based upon the improved value and estimated contents value.

Yellowstone County has the highest amount of properties exposed to 0.2% annual chance flooding and an estimated loss value of $27,446,012. Carbon County is second in loss values with over $7 Million in estimated losses. Stillwater County ranks third in estimated loss parcel values with over $6 Million in presumed losses. Overall Montana's Eastern Region has $202,028,564 in total value exposed and a combined estimated loss of $50,507,141 for the 0.2% annual chance flooding. There are also 942 parcels located in the floodplain and 1,992 people at risk in the Eastern Region at what is classified by FEMA to be a Zone X-shaded. Note that many areas are not mapped by FEMA, or have the Zone-X shaded mapped, thus the true risk is likely much larger to these more severe but less frequent floods; these areas are not required to be regulated by the NFIP either. The jurisdictional break down for each county is located within each annex. The summarized results for the Region are shown in Table 4-29 below.

Table 4-29 Eastern Region Parcels at Risk to 0.2% Flood Hazard by County and Jurisdiction

County	Improved Parcels	Improved Value	Content Value	Total Value	Estimated Loss	Population
Big Horn	3	$129,490	$129,490	$258,980	$64,745	-
Carbon	103	$18,241,620	$9,788,475	$28,030,095	$7,007,524	225
Dawson	76	$8,190,582	$4,670,336	$12,860,918	$3,215,230	155

County	Improved Parcels	Improved Value	Content Value	Total Value	Estimated Loss	Population
Fallon	22	$3,873,675	$2,850,223	$6,723,898	$1,680,974	41
Golden Valley	14	$907,333	$716,397	$1,623,730	$405,932	18
Musselshell	32	$1,934,689	$1,320,100	$3,254,789	$813,697	50
Richland	25	$4,373,014	$2,751,437	$7,124,451	$1,781,113	45
Rosebud	1	$220,840	$220,840	$441,680	$110,420	-
Stillwater	81	$17,796,252	$9,852,691	$27,648,943	$6,912,236	170
Wheatland	47	$2,769,818	$1,507,214	$4,277,032	$1,069,258	106
Yellowstone	538	$70,086,518	$39,697,532	$109,784,050	$27,446,012	1,183
Total	942	$128,523,831	$73,504,733	$202,028,564	$50,507,141	1,992

Sources: DNRC, Hazus, FEMA NFHL, *Tribal Reservations parcel data is reflected in their respective counties

Critical Facilities and Lifelines

To estimate the potential impact of floods on critical facilities, a GIS overlay was performed of the flood hazard layer with critical facility point locations data. Critical facilities at-risk to the 1% annual chance flood by county and FEMA Lifeline are listed in Table 4-30 below. Impacts to any of these facilities could have wide ranging ramifications, in addition to property damage and other cascading impacts.

Table 4-30 Eastern Region Critical Facilities at Risk to 1% Annual Chance of Flood by Facility Type

County	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Total
Big Horn	4	1	5	0	0	4	58	72
Carbon	0	0	4	1	0	0	50	55
Carter	0	0	1	0	0	0	29	30
Custer	2	7	6	1	1	10	32	59
Daniels	0	0	0	0	0	0	23	23
Dawson	0	0	3	0	0	0	38	41
Fallon	2	2	1	0	0	1	24	30
Garfield	0	0	0	0	0	0	15	15
Golden Valley	0	0	1	0	0	0	5	6
McCone	0	0	2	0	0	0	19	21
Musselshell	0	0	1	0	0	0	17	18
Petroleum	0	0	0	0	0	0	1	1
Phillips	0	0	0	0	0	0	1	1
Powder River	0	0	1	0	0	1	18	20
Prairie	0	0	0	0	0	0	16	16
Richland	0	0	1	1	0	0	24	26
Roosevelt	1	3	3	0	0	2	27	36
Rosebud	0	0	1	0	0	0	36	37
Sheridan	0	2	2	0	0	0	51	55
Stillwater	0	0	2	1	0	0	38	41
Treasure	0	0	1	0	0	0	7	8
Valley	3	6	5	0	0	0	46	60
Wheatland	0	1	2	0	0	0	12	15
Wibaux	0	0	1	0	0	0	9	10
Yellowstone	6	5	2	2	0	1	55	71

County	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Total
Total	18	27	45	6	1	19	651	767

Sources: Montana DNRC, FEMA, HAZUS, HIFLD 2022, Montana DES, NBI

The 1% annual chance of flooding for the Eastern Region shows that the majority of facilities that have the most critical facilities at risk to flood damage are within the Transportation lifelines with 651 total. It should be noted that the majority of these are bridges and may have a lower risk of flooding. Bridges like these can be a cause of concern. Food, Water and Shelter facilities have the second highest FEMA Lifeline facilities at risk with 45 total. Energy critical facilities are third with 45 total facilities. Energy facilities could be at risk of losing power, potentially affecting the surrounding communities.

Economy

Flooding can have major negative impacts on the local and regional economy, including indirect losses such as business interruption, lost wages, reduced tourism and visitation, and other downtime costs. Flood events can cut off customer access to a business as well as close a business for repairs or permanently. A quick response to the needs of businesses affected by flood events can help a community maintain economic vitality in the face of flood damage. Responses to business damages can include funding to assist owners in elevating or relocating flood-prone business structures. Tourism and outdoor recreation are an important part of the Region's economy. If part of the Eastern Region planning area were damaged by flooding, tourism and outdoor recreation could potentially suffer, as witnessed during the Yellowstone flooding in 2022. Additionally, flooding can impact the economy through the direct damages and losses to property and costs to recover, as summarized in the property section above.

Historic and Cultural Resources

Floodplains and their adjacent areas are regularly used for environmental conservation, leisure, recreation, and tourism. Historic and cultural resources are also known to occur within floodplains. In the event of a major flooding event, damages to historic and cultural resources are possible.

Natural Resources

Natural resources are generally resistant to flooding and floodplains provide many natural and beneficial functions. Nonetheless, after periods of previous disasters such as drought and fire, flooding can impact the environment in negative ways. Areas recently suffering from wildfire damage may erode because of flooding, which can temporarily alter an ecological system. Fish can wash into roads or over dikes into flooded fields, with no possibility of escape.

Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams during floods, as these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

Development Trends Related to Hazards and Risk

Potential expansion in the future and construction overall in Eastern Montana's floodplains can heighten the susceptibility of the region to flooding by expanding the amount of people and value of the property inventory within the planning area. Development in Eastern Montana's SFHA should be enforced using hazard mitigation measures available through the NFIP and local floodplain activities. Such as floodproofing, relocation, elevation or demolition and relocation to low-risk areas. Other influences that should be considered in projections of future flood risks are land cover, flow and water-supply management, soil moisture and channel conditions. In addition to discouraging development in flood-prone areas and protecting natural systems such as wetlands, local government planners and engineers in urbanized parts of the Region should consider infrastructure designs that accommodate growth and future trends in precipitation.

Risk Summary

The Eastern Region averages a major flood event every 5 years which equates to a probability of future occurrence rating of **likely** throughout the Eastern Region. Flooding has a high significance hazard overall in the region but there is significant variability by jurisdiction.

- There is an estimated 14,789 people located within the 1% Annual Chance of Flooding within the Eastern Region. Custer County makes up nearly half with 6,711 people, followed by Yellowstone County with 1,830 people and Big Horn County with 856 people. These three counties make up 80% of the people located within the designated 1% floodplain.
- The Eastern Region has a total of $384 Million in estimated property losses due to flood damages. Custer, Yellowstone, and Carbon counties have the highest estimated loss totals with the study area. These three counties make up more than half of the potential property losses within the region.
- Flooding can have major negative impacts on the local and regional economy, including indirect losses such as business interruption, lost wages, reduced tourism and visitation, and other downtime costs.
- There is a total of 767 critical facilities in the Eastern Region exposed to flood hazards. The highest exposure of FEMA Lifeline facilities are transportation (bridges) followed by the Food, Water, Shelter category.
- Related hazards: Dam Failure, Landslide, Wildfire

Table 4-31 Risk Summary Table: Flooding

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	High		
Big Horn County	Medium	Hardin, Lodge Grass	Crow Tribe has more exposure to flooding.
Carbon County	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	None
Carter County	Medium	Ekalaka	None
Crow Tribe	Medium		NA
Custer County	High	Ismay, Miles City	High risk with Miles City and portions of the unincorporated area due to population and property in the floodplain; some risk is mitigated through levees (currently not showing as certified to provide 1% annual chance flood protection) and other preventive measures in Custer County.
Daniels County	Medium	Scobey, Flaxville	None
Dawson County	Medium	Richey, Glendive	None
Fallon County	Medium	Plevna, Baker	None
Fort Peck Assiniboine and Sioux Tribe	Medium		None
Garfield County	Medium	Jordan	None
Golden Valley County	Medium	Ryegate, Lavina	None
McCone County	Medium	Circle	None
Musselshell County	Medium	Roundup	None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Northern Cheyenne Indian Reservation	Medium		NA
Powder River County	Medium	Broadus	None
Prairie County	Medium	Terry	None
Richland County	Medium	Fairview, Sidney	None
Roosevelt County	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	None
Rosebud County	Medium	Colstrip, Forsyth	None
Sheridan County	Medium	Outlook, Westby, Plentywood, Medicine Lake	None
Stillwater County	Medium	Columbus	None
Treasure County	Medium	Hysham	None
Valley County	High	Fort Peck, Glasgow, Nashua, Opheim	None
Wheatland County	Medium	Harlowton, Judith Gap	None
Wilbaux County	Medium	Wibaux	None
Yellowstone County	High	Billing, Laurel, Broadview	None

4.2.8 Hazardous Materials Incidents

Hazard/Problem Description

A hazardous material incident is defined as any actual or threatened uncontrolled release of a hazardous material, its hazardous reaction products or the energy released by its reactions that pose a significant risk to human life and health, property and/or the environment. Hazardous materials incidents may also include chemical, biological, radiological, nuclear, and explosive (CBRNE) incidents. CBRNE incidents can cause a variety of impacts in Montana, depending on the nature of the incident, material used, and environmental factors.

Hazardous materials incidents can occur anywhere hazard materials are stored or transported. There are no designated transportation routes throughout the region, Although there are several fixed facilities within some of the city limits. Routes that are used for transporting nuclear and hazardous materials through the Eastern Region by vehicle are Interstate 15 and State Highways 2, 87, 191, and 200. In the 2018 SHMP, it's noted that a 0.25-mile buffer is placed around all highways, major roadways, railroads, and Risk Management Program (RMP) facilities as a proxy for potential impact areas. The major highways and railways within Montana and its Eastern Region are shown in Figure 4 and Figure 4 below.

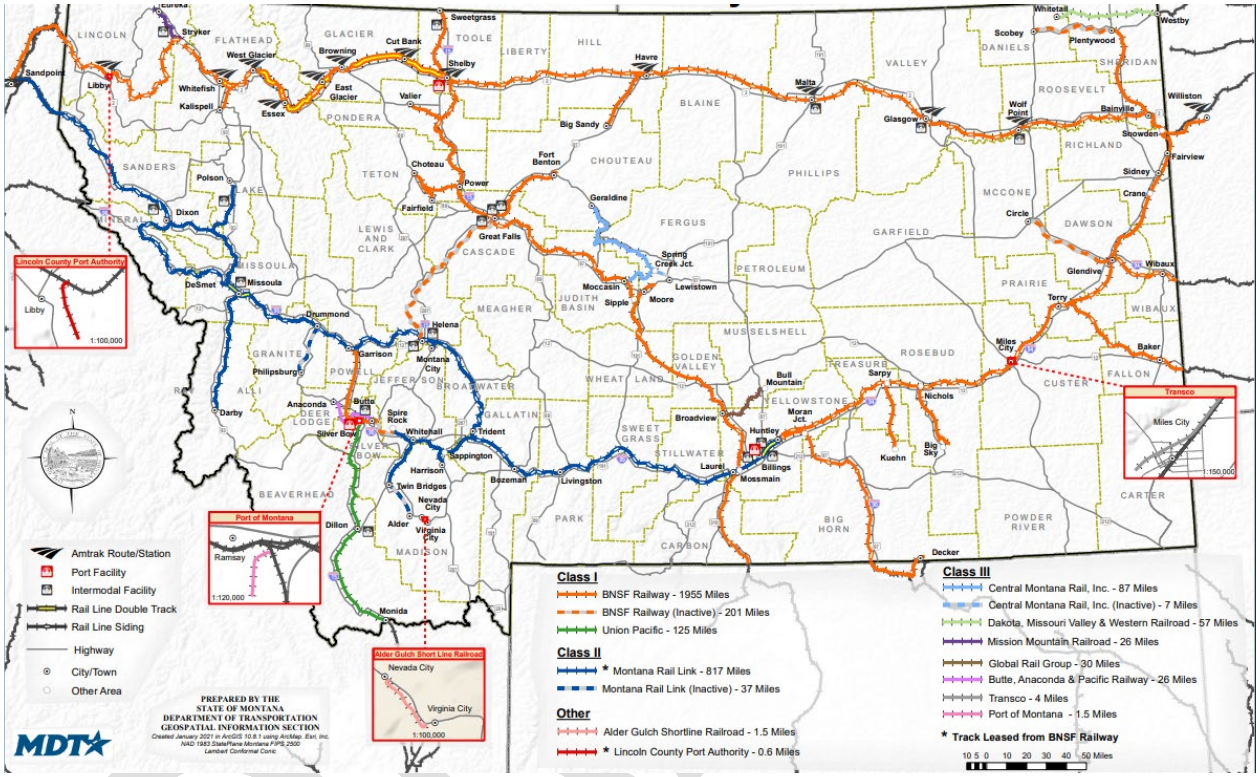
In 2020 there were 42 Tier II facilities located throughout Eastern Montana, although most are located along Interstate 94 and State Highways 2, 12, 87, 212, and 310. Tier II facilities store regulated hazardous materials that exceed certain threshold amounts.

As a general rule, any hazmat release is anticipated to have an impact of no more than one mile around the spill area. The impact to life and property from any given release depends primarily on:

- The type and quantity of material released.

- The human act(s) or unintended event(s) necessary to cause the hazard to occur.
- The length of time the hazard is present in the area.
- The tendency of a hazard, or that of its effects, to either expand, contract, or remain confined in time, magnitude, and space.
- Characteristics of the location and its physical environment that can either magnify or reduce the effects of a hazard.

Figure 4-32 Montana's Rail Systems



Geographical Area Affected

Hazmat incidents can occur at a fixed facility or during transportation. Hazardous materials facilities are identified and mapped by the counties they reside in, along with the types of materials stored there; facilities generally reside in and around communities. The EPA requires facilities containing certain extremely hazardous substances to generate Risk Management Plans (RMPs) and resubmit these plans every five years. As of 2022 there are 42 RMP facilities located in Montana’s Eastern Region. In transportation, hazardous materials generally follow major shipping routes where possible (including road, rail, and pipelines), creating a hazard area immediately neighboring these routes.

Information provided by the National Pipeline Mapping System (NPMS) indicate several pipelines conveying gas or hazardous liquids across the planning area. Pipeline ruptures can result in major spills, or even explosions. These pipelines also pass through areas where denser populations of people and property are located. Powder River County had the most pipeline hazmat incidents (41 incidents or 25% of all pipeline incidents in the Eastern Region), followed by Yellowstone County with 20% of all pipeline incidents, and Fallon County which had 13% of all pipeline incidents in the Region.

The designated transportation routes, and gas and hazardous liquid pipelines for these counties are shown in Figure 4, Figure 4, Figure 4 and Figure 4-36**.** below. This figure illustrates the geographical area affected by hazardous material incidents along transportation routes. Overall hazardous material incidents have a **Limited** geographical extent in the Eastern Region.

Figure 4-33 Eastern Region Hazardous Materials Transportation Routes

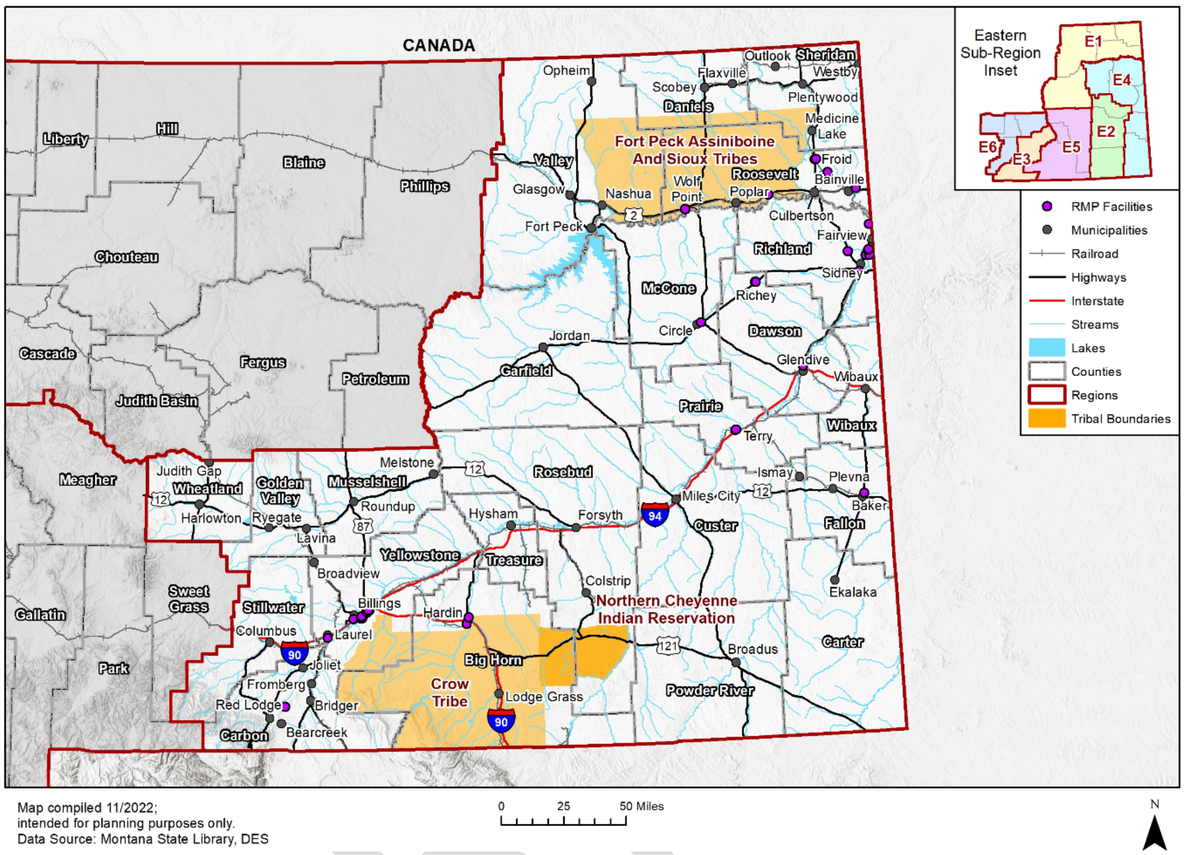
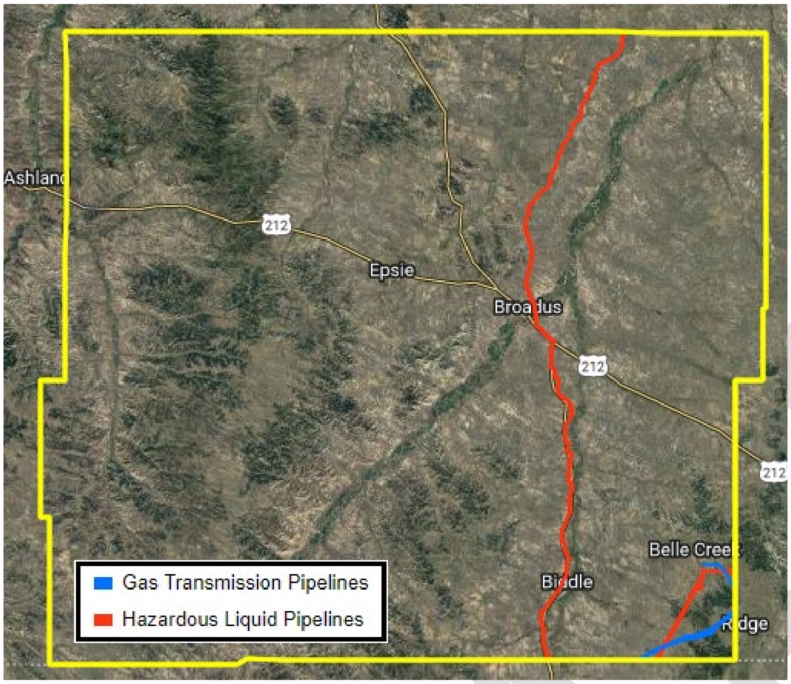
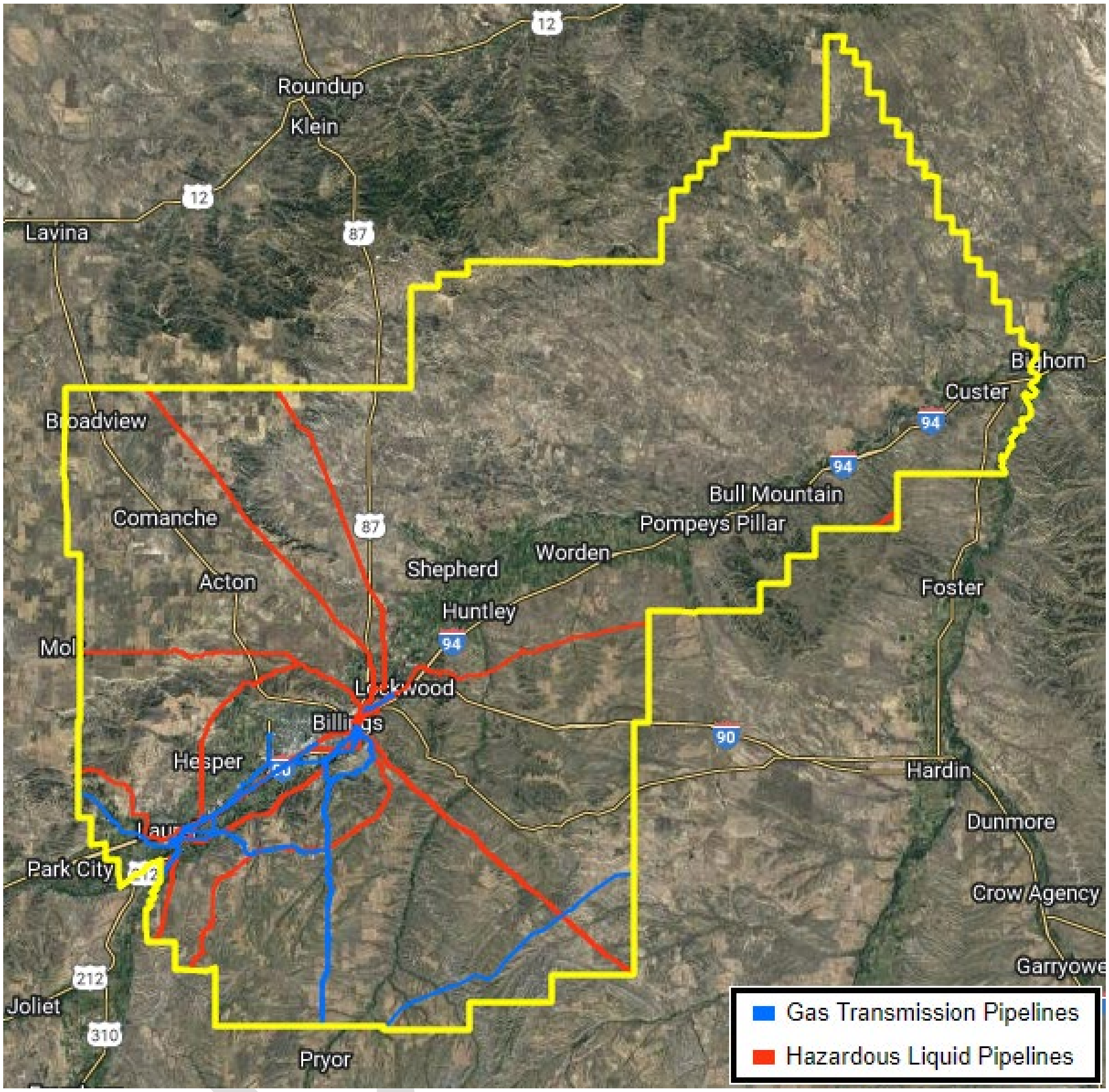


Figure 4-34 Pipelines Located Within Powder River County



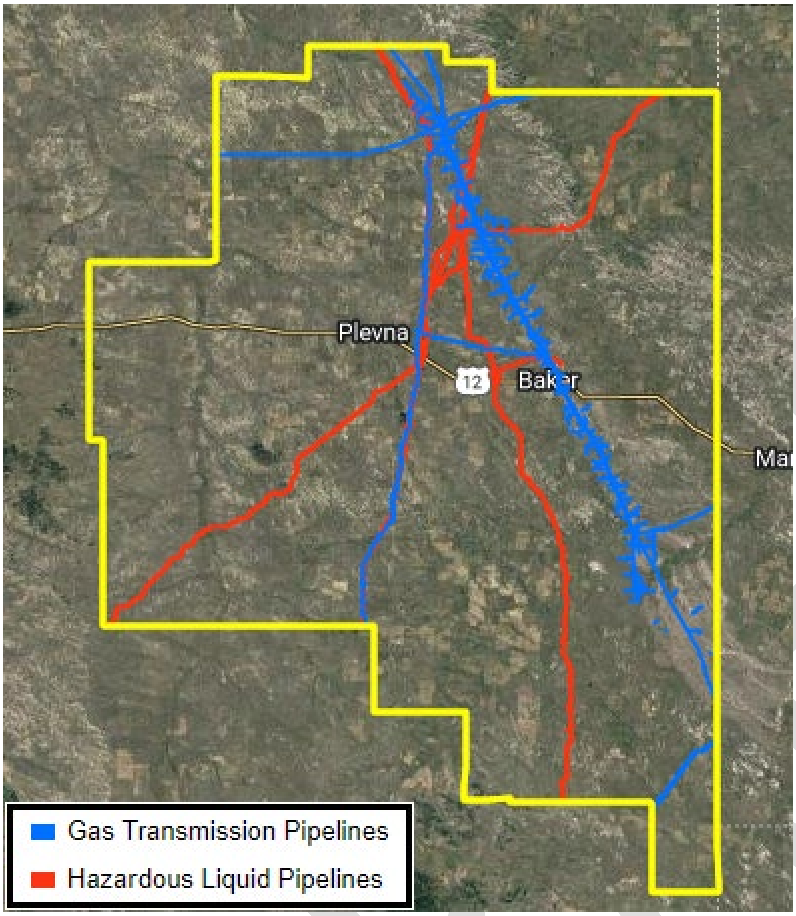
Source: National Pipeline Mapping System

Figure 4-35 Pipelines Located Within Yellowstone County



Source: National Pipeline Mapping System

Figure 4-36 Pipelines Located Within Fallon County



Source: National Pipeline Mapping System

Past Occurrences

There are a variety of mechanisms to get an idea of the number and types of past hazardous materials incidents in the Eastern Region. One such repository is the catalog of hazardous materials spill and accident reports at the National Response Center (NRC) as part of the Right to Know Network (RTK NET). According to this database, between 1990 and 2022 there were three incidents reported across the two Tribal Reservations and 1,156 incidents in the counties within the region. Table 4-32 below shows the 32-year record for reported incidents in Montana's Eastern Region.

Table 4-32 NRC Reported Incidents Central Montana Region 1990-2022

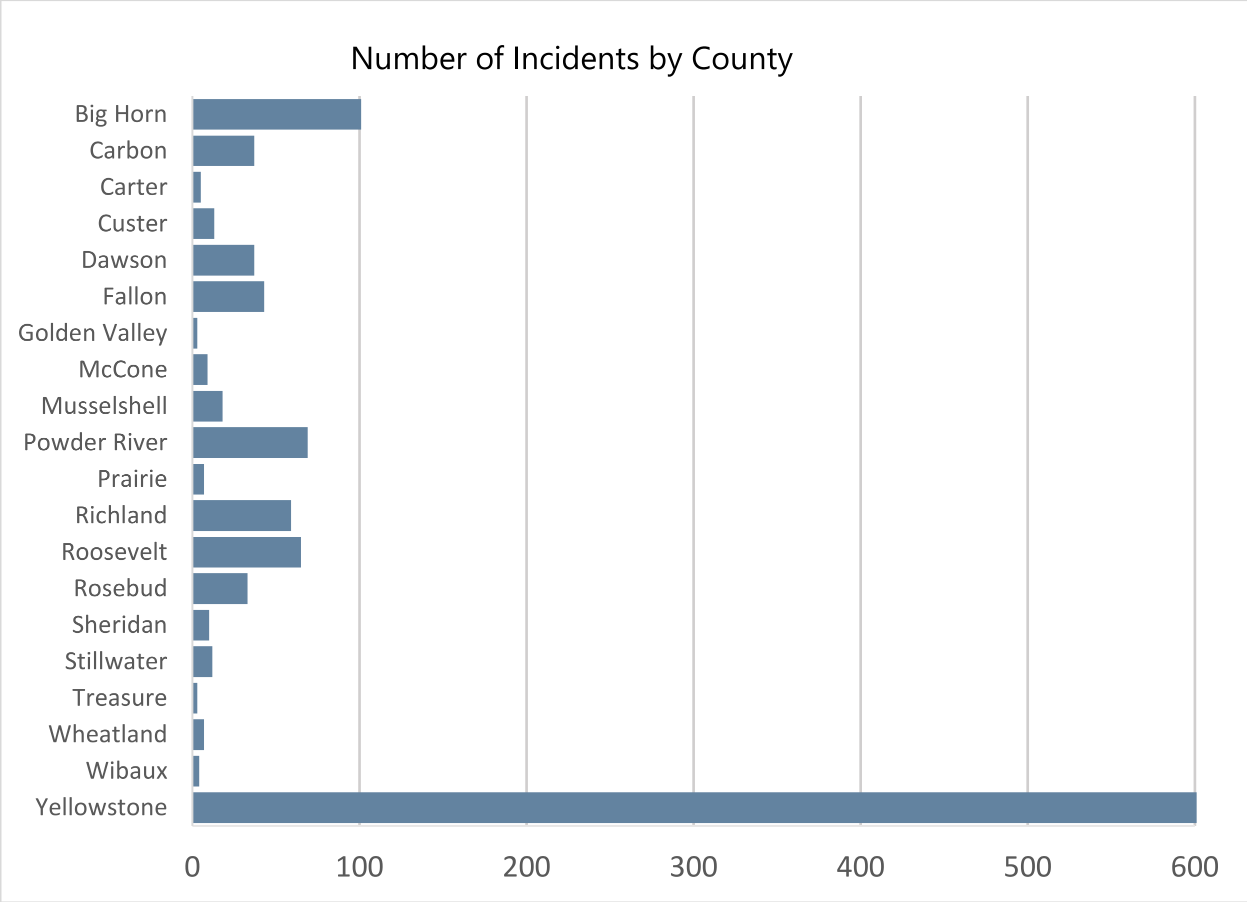
County	# of Incidents
BIG HORN	101
CARBON	37
CARTER	5
CUSTER	13
DAWSON	37
FALLON	43
GOLDEN VALLEY	3

County	# of Incidents
MCCONE	9
MUSSELSHELL	18
POWDER RIVER	69
PRAIRIE	7
RICHLAND	59
ROOSEVELT	65
ROSEBUD	33
SHERIDAN	10
STILLWATER	12
TREASURE	3
WHEATLAND	7
WIBAUX	4
YELLOWSTONE	621

Source: National Response Center Incident Report Database

According to the data, during the time period between 1990 and 2022 the Eastern Region saw an average of 35 NRC-reported incidents per year, which means that each county can reasonably expect multiple hazardous materials responses annually. Yellowstone and Big Horn counties have had the highest amount of hazmat incidents and spills. Figure 4 shows the number of hazardous material incidents by county between 1990 and 2022.

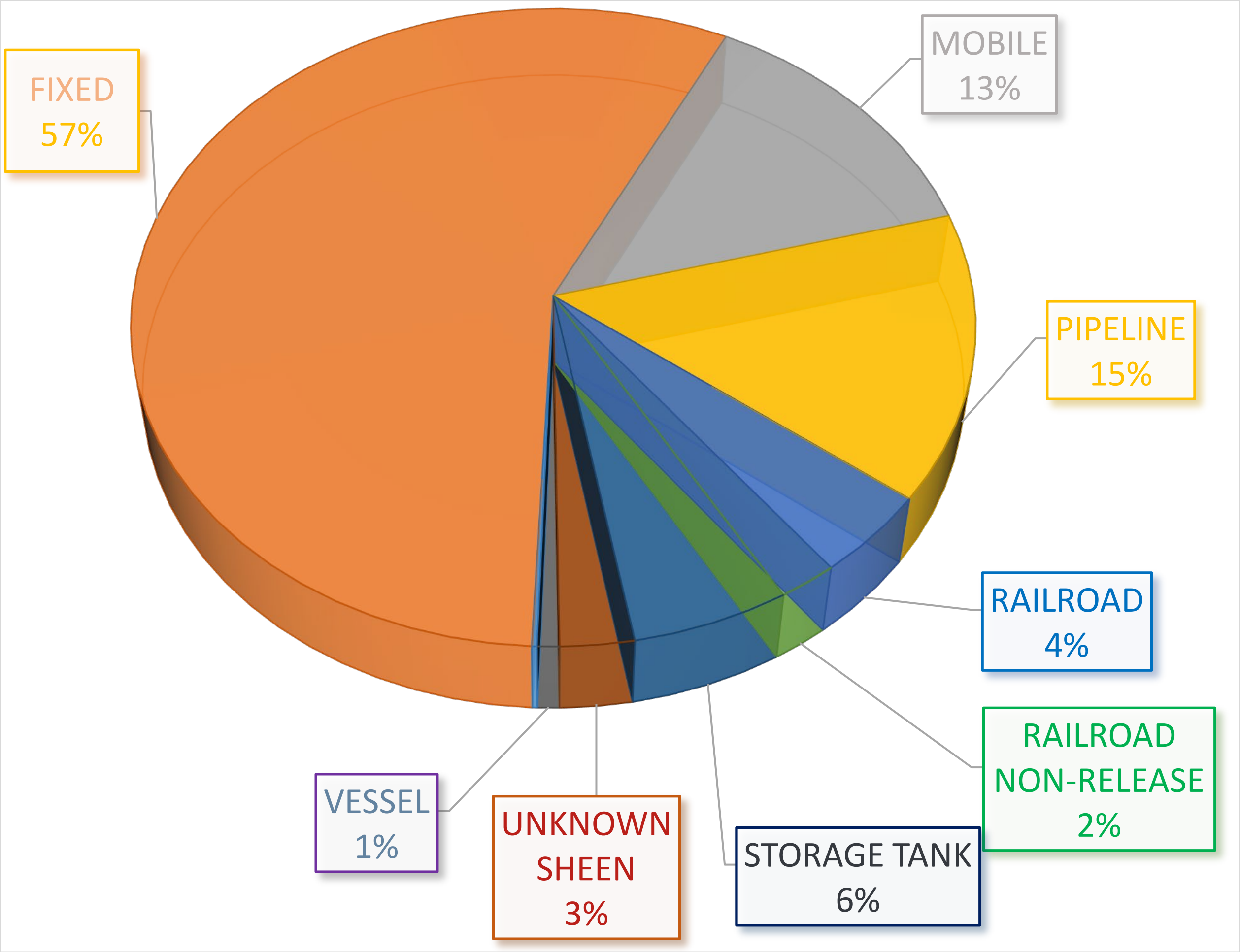
Figure 4-37 Hazardous Materials Incidents Reported to the NRC by County – Eastern Region: 1990-2022



Source: National Response Center Incident Report Database

Figure 4 shows the percentage of each type of incident over the 32-year period between 1990 and 2022. Spills from fixed non-mobile facilities such as Tier II or RMP facilities have the highest percentage of hazmat incidents reported, accounting for 57% total. The second most common percentage of incident types accrued are pipeline incidents with 16%. Regular maintenance and detailed planning locations are necessary to ensure that these incident types are properly accounted and prepared for. Mobile incidents are third with 13% of the total. These can occur when hazmat materials are being transported along state highways and interstates and where injuries or fatalities are more likely to potentially occur.

Figure 4-38 Hazardous Materials Incidents Reported to the NRC by Type - Eastern Region: 1990-2022



Source: National Response Center Incident Report Database

Frequency/Likelihood of Occurrence

The study area experiences multiple hazardous materials incidents each year, with different degrees of effect. Based on the history of past occurrences, there is a 100% chance that the Eastern Region will be impacted by a hazardous materials incident in any given year making this hazard have a **Highly Likely** potential for occurrence. Hazardous material spills and releases, both from fixed facilities and during transport, will continue to occur in Montana's Eastern Region annually.

Climate Change Considerations

Modifications in future conditions are unlikely to impact the rates of occurrence for human-caused hazards, such as hazardous material incidents. Nevertheless, it is possible that an increase or change in the occurrence of other hazards, such as severe storms and fire events, may increase the likelihood of an accidental hazardous materials release from transportation events.

Potential Magnitude and Severity

Potential effects that could occur from hazardous waste spills or releases include:

- Injury
- Loss of life (human, livestock, fish, and wildlife)
- Evacuations
- Property damage
- Air pollution
- Surface or ground water pollution/contamination
- Interruption of commerce and transportation

Various considerations go into the impacts of a hazardous materials release, including method of release, the type of material, location of release, weather conditions, and time of day. This makes it complicated to pinpoint definite impacts. It can still be ascertained that items found in the study area will have at least one of the impacts listed above. The overall magnitude for hazardous material incidents is **Negligible.**

Vulnerability Assessment

The Eastern Region has energy pipelines, railroad tracks which carry many types of hazardous materials, and state highways running through its boundaries. A variety of hazardous materials originating in the Region or elsewhere are transported along these routes and could be vulnerable to accidental spills. Consequences can vary depending on whether the spill affects a populated area vs an unpopulated but environmentally sensitive area.

No specific hazardous materials routes are designated in Eastern Region; any routes used to carry hazardous materials introduce an element of risk of materials release to the area immediately adjacent to them. The Region noted that many petroleum and other flammable products are transported by truck, and many have mixed payloads that don't list material amounts. Extractive industries for oil and natural gas were identified as the biggest source of hazardous materials within and moving through the Eastern Region.

People

Hazardous materials incidents can cause injuries, hospitalizations, and even fatalities to people nearby. People living near hazardous facilities and along transportation routes may be at a higher risk of exposure, particularly those living or working downstream and downwind from such facilities. For example, a toxic spill or a release of an airborne chemical near a populated area can lead to significant evacuations and have a high potential for loss of life.

In addition to the immediate health impacts of releases, a handful of studies have found long term health impacts such as increased incidence of certain cancers and birth defects among people living near certain chemical facilities. However there has not been sufficient research done on the subject to allow detailed analysis.

Property

The impact of a fixed hazardous facility, such as a chemical processing facility is typically localized to the property where the incident occurs. The impact of a small spill (i.e., liquid spill) may also be limited to the extent of the spill and remediated if needed. A blanket answer for potential impacts is hard to quantify, as different chemicals may present different impacts and issues.

Property within a half mile in either direction of designated hazardous materials routes is at increased risk of impacts. While cleanup costs from major spills can be substantial, they do not typically cause significant long-term impacts to property. However, some larger incidents involving pipelines, railroads, or explosive materials may cause significant and overwhelming damage to the surrounding communities.

Critical Facilities and Lifelines

There are 42 RMP facilities located throughout the Eastern Region. Some of these are discussed in more detail in the County Annexes. Yellowstone County has nine of these facilities, and Richland County has eight.

These two counties possess over 40% of the RMP facilities within the study area. The RMP facilities for each county in the Eastern Region are summarized in Table 4-33 below.

Table 4-33 RMP Facilities in the Eastern Region

County	Jurisdiction	Number of Facilities
Big Horn	Big Horn County	2
Carbon	Carbon County	3
Dawson	Dawson County	2
	Richey	2
Fallon	Fallon County	1
McCone	McCone County	2
Prairie	Prairie County	1
Richland	Richland County	8
Roosevelt	Froid	4
	Roosevelt County	6
Yellowstone	Billings	2
	Yellowstone County	9
Total	Total	42

Source: http://www.rtknet.org/db/erns, HIFLD 2022

Economy

Potential losses can vary greatly for hazardous material incidents. For even a small incident, there are cleanup and disposal costs. In a larger scale incident, cleanup can be extensive and protracted. There can be deaths or injuries requiring doctor's visits, hospitalization, and disabling chronic injuries. Soil and water contamination can occur, necessitating costly remediation. Evacuations can disrupt home and business activities. Large-scale incidents can easily reach $1 million or more in direct damages.

Historic and Cultural Resources

Hazardous material incidents may affect a small area at a regulated facility or cover a large area outside such a facility. Impacts to cultural resources could include contamination of important cultural sites for the tribes of the Eastern Region. Additionally, loss of access to outdoor recreation opportunities could result from hazmat incidents.

Natural Resources

Hazardous material incidents may affect a small area at a regulated facility or cover a large area outside such a facility. Widespread effects occur when hazards contaminate the groundwater and eventually a potential county or jurisdiction's water supply, or they migrate to a major waterway or aquifer. Impacts on wildlife and natural resources can also be significant. These types of widespread events may be more likely to occur during a transportation incident, such as a pipeline spill, and can have far reaching and devastating impacts on the natural environment and habitats if they occurred near one of the several wildlife refuges in the Eastern Region planning area.

Development Trends Related to Hazards and Risk

Future development is expected to increase the number of people potentially exposed to the impacts of hazardous materials incidents. The number of hazardous materials that are stored, used, and transported across the Region may continue to increase over the coming years if regional growth continues.

Risk Summary

The Eastern Region experiences multiple hazardous materials incidents each year, with different degrees of effect. Based on the history of past occurrences, there is a 100% chance that the Eastern Region will see a hazardous materials incident in any given year, however programs in place for fixed hazardous facilities minimize risk. The significance for hazardous material incidents overall is **Low.**

- Hazardous materials incidents can cause injuries, hospitalizations, and even fatalities to people nearby. In addition to the immediate health impacts of releases, a handful of studies have found long term health impacts such as increased incidence of certain cancers and birth defects among people living near certain chemical facilities.
- The impact of a fixed hazardous facility, such as a chemical processing facility is typically localized to the property where the incident occurs. The impact of a small spill maybe limited to the extent of the spill and remediated if needed.
- Potential losses can vary greatly for hazardous material incidents. For even a small incident, there are cleanup and disposal costs. In a larger scale incident, cleanup can be extensive and protracted.
- Yellowstone County has nine of these facilities, and Richland County has eight. These two counties possess over 40% of the RMP facilities within the study area.
- Related Hazards: Cyber- Attack, Human Conflict, Transportation Accidents

Table 4-34 Risk Summary Table: Hazardous Materials Incidents

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	Low		
Big Horn	Medium	Hardin, Lodge Grass	Big Horn County experienced 101 hazardous materials incidents between 1990 and 2022. This accounts for 9% of the total incidents in the Eastern Region.
Carbon	Low	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	None
Carter	Low	Ekalaka	None
Custer	Low	Ismay, Miles City	None
Crow Tribe	Low		None
Daniels	Low	Scobey, Flaxville	Daniels County does not have gas or hazardous liquid pipelines within County limits and has not reported an NRC hazardous materials incident during the past 32 years.
Dawson	Low	Richey, Glendive	None
Fallon	Low	Plevna, Baker	Fallon County has an extensive network of gas and hazardous liquid pipelines.
Fort Peck	Low		None
Garfield	Low	Jordan	Garfield County has not reported an NRC hazardous materials incident during the past 32 years.
Golden Valley	Low	Ryegate, Lavina	None
McCone	Low	Circle	None
Musselshell	Low	Roundup	Musselshell County has sparce transmission line and, no RMP facilities.
Northern Cheyenne	Low		None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Powder River	Medium	Broadus	Powder River Canyon has experienced 66 NRC hazardous materials incidents in the last 32 years.
Prairie	Low	Terry	None
Richland	Medium	Fairview, Sidney	Richland County has an extensive network of gas and hazardous liquid pipelines, a large number of RMP facilities, and a history of hazmat incidents.
Roosevelt	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	Roosevelt County has a moderate history of hazardous materials incidents and the third highest number of RMP facilities in the State.
Rosebud	Low	Colstrip, Forsyth	None
Sheridan	Low	Outlook, Westby, Plentywood, Medicine Lake	None
Stillwater	Low	Columbus	None
Treasure	Low	Hysham	Treasure County has few gas hazardous liquid transmission lines and few prior hazmat incidents.
Valley	Low	Fort Peck, Glasgow, Nashua, Opheim	Valley County has not reported an NRC hazardous materials incident during the past 32 years.
Wheatland	Low	Harlowton, Judith Gap	None
Wibaux	Low	Wibaux	None
Yellowstone	High	Billing, Laurel, Broadview	Yellowstone County has reported experienced more hazardous materials incidents in the last 32 years than all other Eastern Region counties combined.

4.2.9 Landslide

Hazard/Problem Description

A landslide is a general term for a variety of mass movement processes that generate a downslope movement of soil, rock, and vegetation under gravitational influence. Landslides are a serious geologic hazard common to almost every state in the United States. It is estimated that nationally they cause up to $2 billion in damage and 25 to 50 deaths annually.

Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly. Gravity is the force driving landslide movement. Factors that allow the force of gravity to overcome the resistance of earth material to landslide movement include saturation by water, steepening of slopes by erosion or construction, alternate freezing or thawing, earthquake shaking, and volcanic eruptions.

Landslides are typically associated with periods of heavy rainfall or rapid snow melt and tend to worsen the effects of flooding that often accompanies these events. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides, rockfall or other geological events.

Landslides are defined as a rapid slipping of a mass of earth or rock from a higher elevation to a lower level under the influence of gravity and water lubrication. More specifically, rockslides are the rapid downhill movement of large masses of rock with little or no hydraulic flow, similar to an avalanche. Water-saturated soil or clay on a slope may slide downhill over a period of several hours. Earthflows of this type are usually not serious threats to life because of their slow movement, yet they can cause blockage of roads and do extensive damage to property.

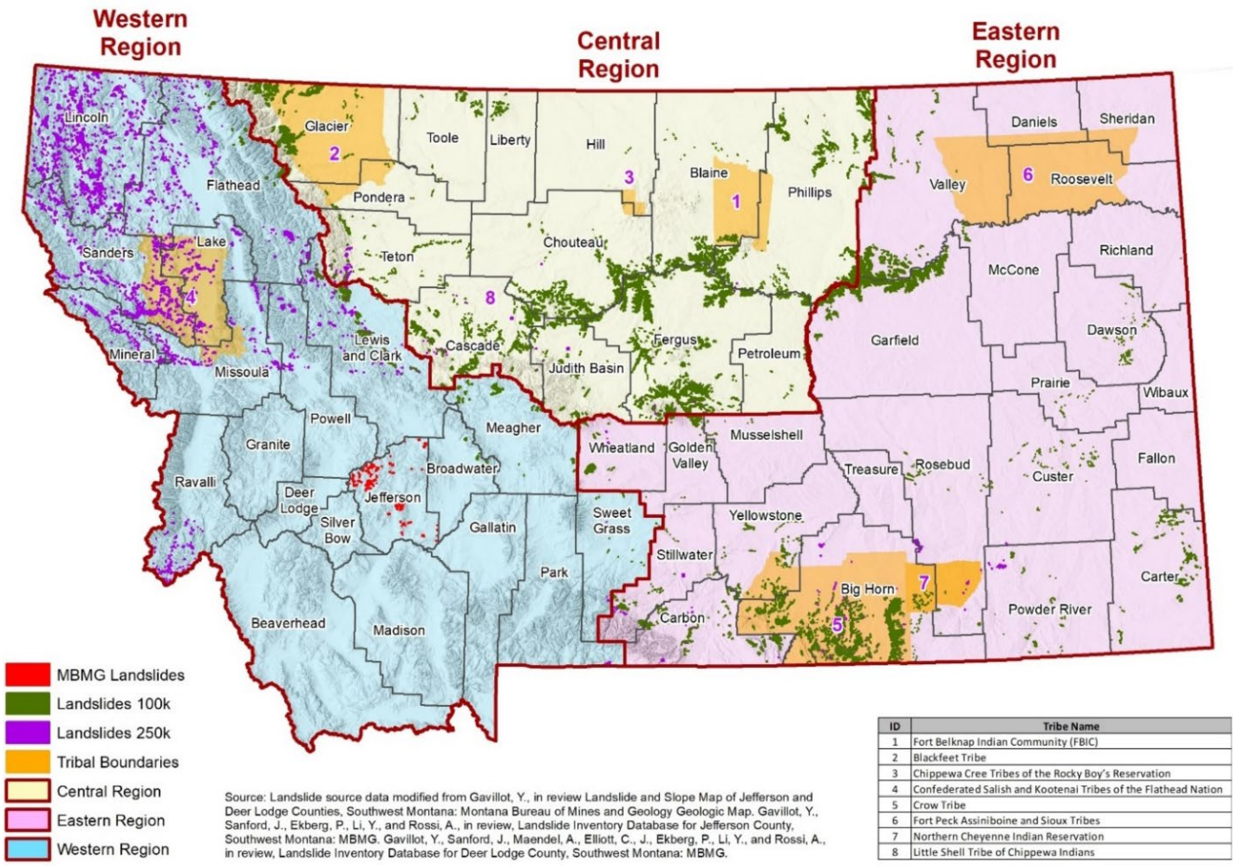
Geographical Area Affected

Areas that are generally prone to landslide hazards include existing old landslides, the bases of steep slopes, the bases of drainage channels, and developed hillsides where leach-field septic systems are used.

Areas that are typically considered safe from landslides include areas that have not moved in the past, relatively flat-lying areas away from sudden changes in slope, and areas at the top or along ridges, set back from the tops of slopes. Eastern Montana, in contrast to Western Montana which is more mountainous and elevated, is exposed to a lower landslide risk. Counties in the southern portion of the region like Carbon, Yellowstone, and Big Horn, where some tribal reservations are located, have more landslide areas mapped. This are also landslide areas mapped along the Missouri River valley within Garfield County. The Eastern Region's overall area affected is **Limited.**

The landslide inventory for Montana's Eastern Region is shown in Figure 4 below, based on mapping from various scales and sources. Landslides mapped at a 1:100,000 scale are color coded in green and landslides at 1:250,000 scale are illustrated in purple. Other mapping of landslides by the Montana Bureau of Mines and Geology (MBMG) are color coded in red and reflected in Figure 4-39 below.

Figure 4-39 Montana Hazard Mitigation Planning Region Landslides



ID	Tribe Name
1	Fort Belknap Indian Community (FBIC)
2	Blackfeet Tribe
3	Chippewa Cree Tribes of the Rocky Boy's Reservation
4	Confederated Salish and Kootenai Tribes of the Flathead Nation
5	Crow Tribe
6	Fort Peck Assiniboine and Sioux Tribes
7	Northern Cheyenne Indian Reservation
8	Little Shell Tribe of Chippewa Indians

In certain areas of Montana landslides do occur. Over the years, several landslides have been addressed by the State of Montana and in particular the Montana Department of Transportation (MDT). MDT has stabilized some landslide-prone areas that have affected the State's highways.

Past Occurrences

Table 4-35 provides information regarding past landslides in the Eastern Region of Montana. There has been two federally declared events within the project area from 1974 to present.

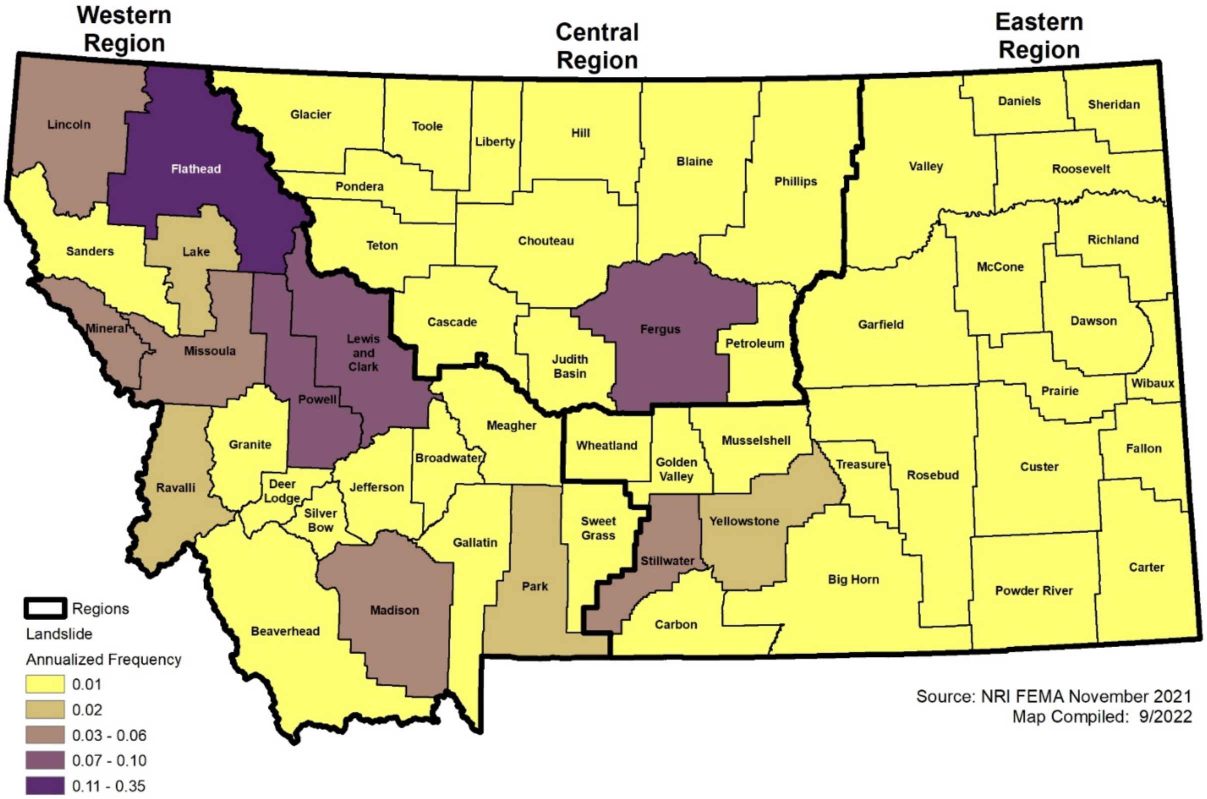
Table 4-35 Eastern Montana Landslides (1950 – 2022)

Date	Counties Affected	Comments
1986	Daniels, Dawson, Valley	A disaster declaration was declared after heavy rains, landslides, and flooding in the affected areas.

Frequency/Likelihood of Occurrence

Although historical landslide occurrence data is limited it can be assumed that these geological processes will continue to occur and result in an **Occasional** likelihood of occurrence in the future. Landslides and expansive soils may typically occur most often during wet climate cycles or following heavy rains, but in certain areas of the study area. It is plausible to presume that destructive events have among a 10 and 100 percent chance of occurrence with the next year, or a recurrence interval of 10 years or less. Hence, landslides, rockfalls or debris flows are predicted to occasionally occur. Heavy periods of precipitation or substantial development could have an influence on slope strength. Characteristically, there is a landslide/rockfall "season" that correlates with enhanced freeze-thaw phases and wetter weather in the spring and summer. Within the Eastern Region all 23 counties and three Indian Reservations have a Landslide Annualized Frequency of 0.01, except Yellowstone and Stillwater counties. Although this is the lowest risk rating that the NRI categorizes, landslides can still be a detrimental and unexpected natural hazard if not taken into proper account. The expected frequency results for the Eastern Region is shown in Figure 4-40 below.

Figure 4-40 NRI Annualized Landslide Frequency Montana Eastern Region



Climate Change Considerations

Landslides or mudflows can be triggered by climatic events, such as periods of intense rainfall and runoff events. Projected climate change-associated variance in rainfall events may result in more high intensity events, which may increase landslide frequency. In addition, the increased potential of wildfire occurrence also escalates the risk of landslide and debris flows in the period following a wildfire, when slopes lack vegetation to stabilize soils and burned soil surfaces create more rainfall runoff. As climate change affects the length of the wildfire season, it is possible that a higher frequency of large fires may occur into late fall, when conditions remain dry, and then be followed immediately by more intense rainfall in the winter and spring months. Worldwide, 4,500 people are killed on average each year due to landslides. The landslide risk is set to escalate even further in the future under two increasing trends—climate change and urbanization.

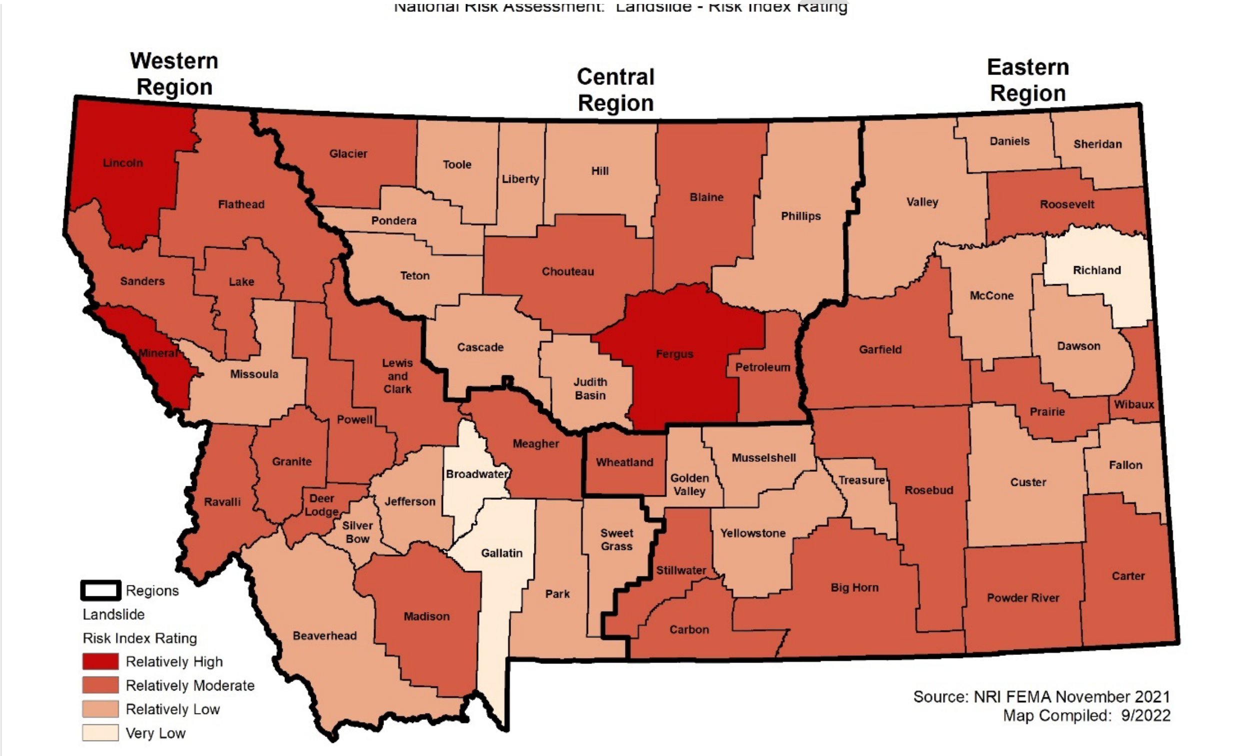
Potential Magnitude and Severity

The extent of landslides and debris flow events within the Eastern Montana Region range from **Negligible** to also significant, depending on the event. While landslides and rockslides can result in the destruction of infrastructure such as roadways, water, and sewer lines, electrical and telecommunications utilities and drainage where they are present, the potential magnitude of landslides, rockfall and debris flows would typically be isolated in most counties in the region. However even a small, isolated event has potential to close state or US highways in the region that can result in long detours for days or weeks. With the added cost of detours, and the potential for life safety impacts, some landslides could have greater costs. There is relatively limited potential for complete destruction of buildings and death and injury from landslides and debris flow.

Vulnerability Assessment

Figure 4-41 depicts the risk index rating for landslide at a county level based on the NRI. The mapping shows that most of the Eastern Region is rated as a mixture of relatively moderate and low. The counties with a Landslide Risk Rating of relatively moderate consist of Big Horn, Carbon, Carter, Garfield, Powder River, Prairie, Roosevelt, Stillwater and Wilbaux counties. The Eastern Montana counties with a relatively low landslide risk rating consist of Carter, Daniels, Dawson, Fallon, Golden Valley, McCone, Musselshell, Sheridan, Treasure, Valley, and Yellowstone counties. The one county in the Eastern Region with a low rating is Richland County which borders North Dakota and contains more of a plains landscape.

Figure 4-41 Risk Index Rating for Landslide by County



People

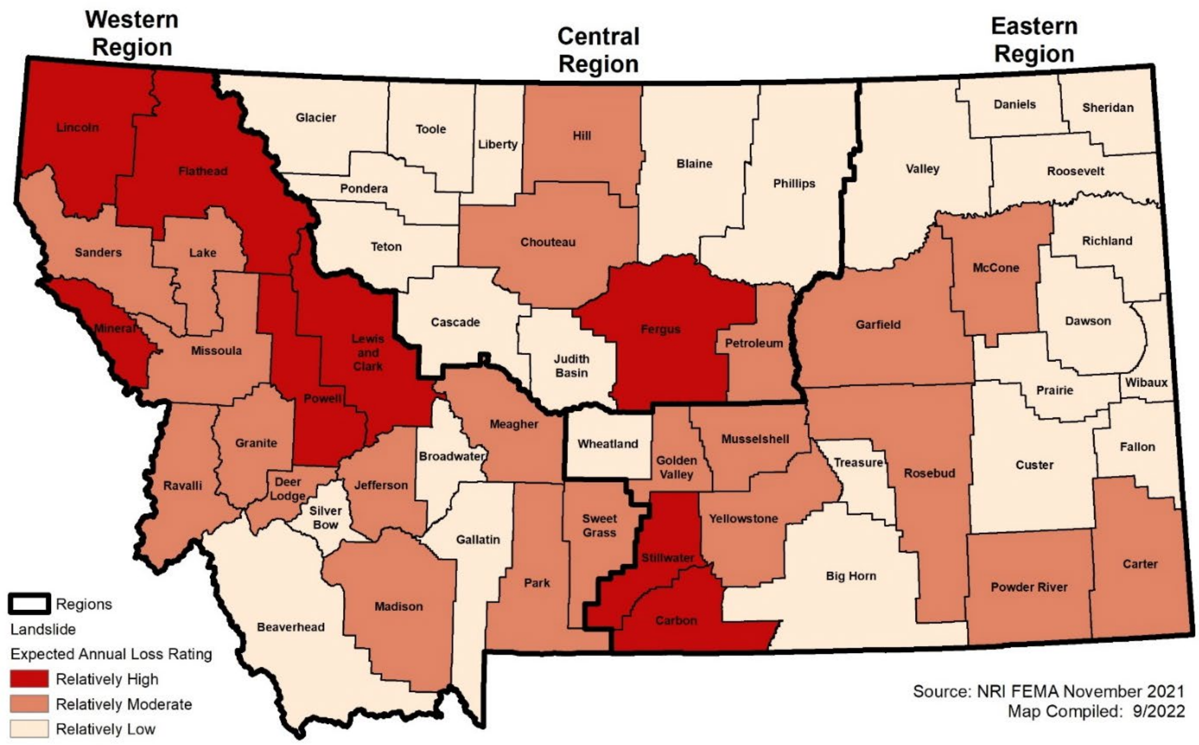
People exposed to landslide hazards are most at risk to death or injury from these hazards. This includes not only people residing in areas prone to landslides but also outdoor recreationists and travelers in the region. There have been no recorded deaths or injuries due to landslides in Montana, so the likelihood of this in the future is minimal, but still possible. Landslides typically result in property damage, not risk to human life. However, injuries could occur to those traveling in a vehicle in canyon and valley areas where rockfall has a higher confidence of occurring.

Property

Landslides directly damage engineered structures in two general ways: 1) disruption of structural foundations caused by differential movement and deformation of the ground upon which the structure sits, and 2) physical impact of debris moving downslope against structures located in the travel path. Landslides have been known to create temporary dams in some locations, partially or fully blocking rivers at the toe of the slide. These dams can subsequently burst as the pressure of the impounded water builds, leading to flood damage for structures and communities downstream as well.

Within the Eastern Region, Carbon and Stillwater counties has an expected annual loss rating due to landslides that is relatively high. This is followed by Carter, Garfield, McCone, Powder River, Rosebud and Yellowstone counties have a relatively moderate estimation of annualized losses due to landslide damages. The other 12 counties in the Eastern Region have an expected annual loss of relatively low damages due to landslide hazards. The risk for each county in the Eastern Region is detailed in Figure 4-42 below.

Figure 4-42 NRI Expected Annual Loss Rating Montana Eastern Region



Critical Facilities and Lifelines

Transportation systems are usually the most unprotected critical facility type in the region to rockfall, landslide and debris flow incidents. Residents and visitors alike are impacted when roads are damaged by rockfall and landslides. The loss of transportation networks could potentially cause secondary damage to the overall region's infrastructure, including revenue, transportation availability, emergency response mechanisms and other essential capabilities by preventing the means of these resources from activating or moving between locations.

Extension, bending, and compression caused by ground deformation can break lifelines. Failure of any component along the lifeline can result in failure to deliver service over a large region. Once broken, transmission of the commodity through the lifeline ceases, which can have catastrophic repercussions down the line: loss of power to critical facilities such as hospitals, impaired disposal of sewage, contamination of water supplies, disruption of all forms of transportation, release of flammable fuels, and so on. Therefore, the overall impact of lifeline failures, including secondary failure of systems that depend on lifelines, can be much greater than the impact of individual building failures.

Economy

Losses as a result of geologic hazards can result in economic damages sustained to buildings and property. These losses can also result in indirect losses, such as lowered property values in hazard exposure areas, the extended closing of businesses that are damaged, and as a result lost wages and revenue if workers are not able to go to work. Also, tourism can be interrupted.

Historic and Cultural Resources

Landslides and other geologic hazards are considered a natural process; however, they can have varying impacts to the natural environment, with the potential to permanently alter the natural landscape. For example, landslide effects on the environment, natural resources, and historic and cultural assets could be very destructive depending on the size of the landslide event and secondary/cascading effects from an event (e.g., rockfall). The biggest impact would likely be on older properties such as wooden or masonry buildings.

Natural Resources

Landslides and other geologic hazards are considered a natural process; however, they can have varying impacts to the natural environment, with the potential to permanently alter the natural landscape. For example, landslide effects on the environment and natural resources could be very destructive depending on the size of the landslide event and secondary/cascading effects from an event (e.g., rockfall). Additionally, rockfalls to rivers can cause blockages causing flooding, damage rivers or streams, potentially harming water quality, fisheries, and spawning habitat. Also, hillsides that provide wildlife habitat can be lost for prolonged periods of time.

Development Trends Related to Hazards and Risk

In general, the Eastern Region has a lower risk for landslide and other geological hazards in comparison to the entire state of Montana. For most of the geologic hazards profiled, the greatest risk is along the Missouri River where geography makes processes such as landslides and mudflows more likely. As counties such as Glacier and Cascade see growth in population and housing units the exposure could increase as well unless careful consideration of landslide hazards is included in land use decisions. Steps to mitigate these risks should be taken as the Eastern Region accommodates future growth, such as mapping of hazard areas, adoption and enforcement of engineering and building codes for soil hazards, and ordinances to limit development on steep slopes.

Risk Summary

- Although historical landslide occurrence data is limited it can be assumed that these geological processes will continue to occur occasionally in the future but the overall risk to landslides is **Low**.
- People exposed to landslide hazards are most at risk to death or injury from these hazards. This includes not only people residing in areas prone to landslides but also outdoor recreationists and travelers in the region.
- Within the Eastern Region, Carbon and Stillwater both have an expected annual loss rating due to landslides of relatively high. Carbon and Stillwater counties has an expected annual loss rating due to landslides of relatively high. Meanwhile Carter, Garfield, McCone, Powder River, Rosebud and Yellowstone counties have a relatively moderate estimation of annualized losses due to landslide damages.
- Losses as a result of geologic hazards can result in economic damages sustained to buildings and property.
- Transportation systems are usually the most unprotected critical facility type in the region to rockfall, landslide and debris flow incidents. Residents and visitors alike are impacted when roads are damaged by rockfall and landslides.
- Related Hazards: Earthquake, Floods, Severe Summer Weather, Wildland and Rangeland Fire

Table 4-36 Risk Summary Table: Landslide

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	Low		None
Big Horn County	Low	Hardin, Lodge Grass	None
Carbon County	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	Unincorporated areas with greater topographical relief may be more susceptible.
Carter County	Low	Ekalaka	None
Crow Tribe	Low		None
Custer County	Low	Ismay, Miles City	None
Daniels County	Low	Scobey, Flaxville	Daniels County has reported landslide events following heavy rain and flooding.
Dawson County	Low	Richey, Glendive	County has reported landslide events following heavy rain and flooding.
Fallon County	Low	Plevna, Baker	None
Fort Peck Assiniboine and Sioux Tribe	Low		None
Garfield County	Low	Jordan	None
Golden Valley County	Low	Ryegate, Lavina	None
McCone County	Low	Circle	None
Musselshell County	Low	Roundup	None
Northern Cheyenne Indian Reservation	Low		None
Powder River County	Low	Broadus	None
Prairie County	Low	Terry	None
Richland County	Low	Fairview, Sidney	None
Roosevelt County	Low	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	None
Rosebud County	Low	Colstrip, Forsyth	None
Sheridan County	Low	Outlook, Westby, Plentywood, Medicine Lake	None
Stillwater County	Medium	Columbus	None
Treasure County	Low	Hysham	None
Valley County	Low	Fort Peck, Glasgow, Nashua, Opheim	None
Wheatland County	Low	Harlowton, Judith Gap	None
Wilbaux County	Low	Wibaux	None
Yellowstone County	Low	Billing, Laurel, Broadview	Unincorporated areas of with more topography to the southwest may be more susceptible to landslides.

4.2.10 Severe Summer Weather

Hazard/Problem Description

According to the 2018 SHMP, severe summer weather includes thunderstorms, high winds, hail, lightning, tornadoes, extreme heat, and microbursts that typically occur between May and October of each year in Montana. A brief description of these weather phenomena is presented below. More information on thunderstorm winds, high winds, and microbursts can be found in 4.2.13 Tornadoes & Windstorms.

Hail

Hail forms when updrafts carry raindrops into extremely cold areas of the atmosphere where the drops freeze into ice. Hail falls when it becomes heavy enough to overcome the strength of the updraft and is pulled by gravity towards the earth. The process of falling, thawing, moving up into the updraft and refreezing before falling again may repeat many times, increasing the size of the hailstone. Hailstones are usually less than two inches in diameter but have been reported much larger and may fall at speeds of up to 120 mph. Severe hail is classified as hail 1-inch in diameter or large. Hail is typically associated with thunderstorms and occurs in the summer months in the Eastern Region.

Lightning

Lightning is an electrical discharge that results from the buildup of positive and negative charges within a thunderstorm and the earth's surface. When the buildup becomes strong enough, lightning appears as a "bolt". This flash of light usually occurs within the clouds or between the clouds and the ground. Lightning's electrical charge and intense heat can electrocute on contact, split trees, ignite fires, and cause electrical failures. A visible electrical discharge is produced by a thunderstorm. The discharge may occur within or between clouds, between the cloud and air, between a cloud and the ground or between the ground and a cloud. Cloud-to-ground lightning is the most damaging and dangerous type of lightning, though it is also less common. It frequently strikes away from the rain core, either ahead or behind the thunderstorm, and can strike 5-10 miles from the storm in areas that most people do not consider to be a threat.

Extreme Heat

Extreme heat occurs from a combination of high temperatures (significantly above normal, or above 90 degrees) and high humidity over a long period (2 to 3 days). At certain levels, the human body cannot maintain proper internal temperatures and may experience heat stroke. The "Heat Index" is a measure of the effect of the combined elements on the body. In extreme heat, evaporation is slowed and

the body must work extra hard to maintain a normal temperature. This can lead to death by overworking the human body. Extreme Heat often results in the highest number of annual deaths among all weather-related hazards.

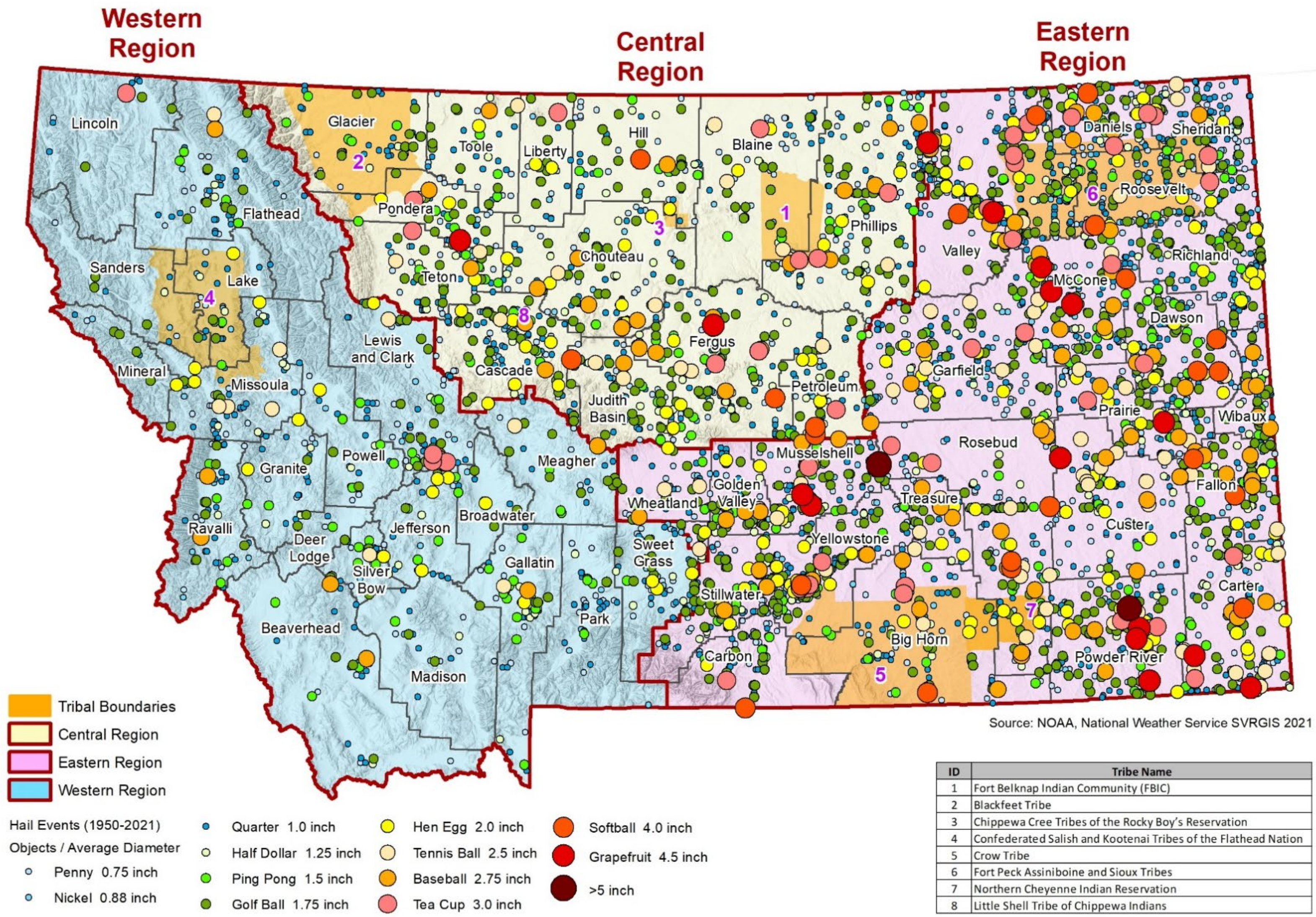
Heavy Rain

Heavy rain is typically associated with thunderstorm conditions and can result in flash flooding. On occasion, heavy rains and melting snow have been reported to cause ice jams and further the accumulation of flash flooding. It is rarely reported in Montana that flash floods cause an accumulation of water in structures in the planning area.

Geographical Area Affected

The geographic extent of summer weather is **Extensive**. The entire Eastern Region is vulnerable to experiencing severe summer weather, but there are regional variations apparent when looking at the frequency of events. Some types of hazards, such as extreme heat events, occur on a regional scale and typically impact several or all counties in the Eastern Region planning area at once. Other hazards, such as lightning, hail, and heavy rain, impact more local areas. Lightning tends to strike a single point and it is rare for lightning to strike people or property multiple times in one storm event. Hail and heavy rain generally occur in small pockets of an accompanying storm. Figure 4 below shows the history of hail events in the Eastern Region.

Figure 4-43 Hail Events in Montana by Region (1955-2021)



ID	Tribe Name
1	Fort Belknap Indian Community (FBIC)
2	Blackfeet Tribe
3	Chippewa Cree Tribes of the Rocky Boy's Reservation
4	Confederated Salish and Kootenai Tribes of the Flathead Nation
5	Crow Tribe
6	Fort Peck Assiniboine and Sioux Tribes
7	Northern Cheyenne Indian Reservation
8	Little Shell Tribe of Chippewa Indians

Source: NOAA

Past Occurrences

The National Centers for Environmental Information (NCEI) database was used to gather information on historic severe summer weather events in the Eastern Region of Montana. The NCEI data is a comprehensive list of oceanic, atmospheric, and geophysical data across the United States and aggregated by county and zone. It is important to note that weather events that occurred on Crow Tribe and North Cheyenne Tribe are also included in the dataset tables down below. However, instead of individual records, tribal data records were grouped into the closest/nearest County.

The NCEI dataset contains information on hail events from 1955 to March of 2022, in addition to lightning, heavy rain, and excessive heat events from 1996 to March of 2022. Table 4-37 summarizes the data from NCEI. It is important to note that not all severe summer weather events get reported by the NCEI and losses are estimates, therefore, actual losses may be higher than those reported below. Based on this data, hail is the most frequently occurring and damaging severe summer weather event in the Eastern Region. Excessive heat and lightning events have resulted in casualties. Excessive heat events had no reported property or crop damages in the NCEI dataset.

Table 4-37 **Summary of Losses by Hazard in the Eastern Region**

	Deaths	Injuries	Property Loss	Crop Loss	Days with Events	Total Events
Excessive Heat	1	0	-	-	4	7
Hail	0	5	$31,580,100	$ 31,954,000	1,008	5,062
Heavy Rain	0	0	$2,000	-	67	150
Lightning	5	12	$ 68,100	-	21	21
Total	6	17	$ 31,650,200	$ 31,954,000	1,100	5,240

Source: NCEI

There are variations in losses and frequency of hazards across the Eastern Region. According to the NCEI database, the counties of Yellowstone and Valley experienced significantly more hail events than the rest of the planning area. Valley County also experienced the greatest number of reported heavy rain events in the planning area, followed by Carbon County. Twelve counties have reported previous lightening events. Six counties have documented excessive heat events. Table 4-38 and Figure 4-44 display the summary of total severe weather events by county.

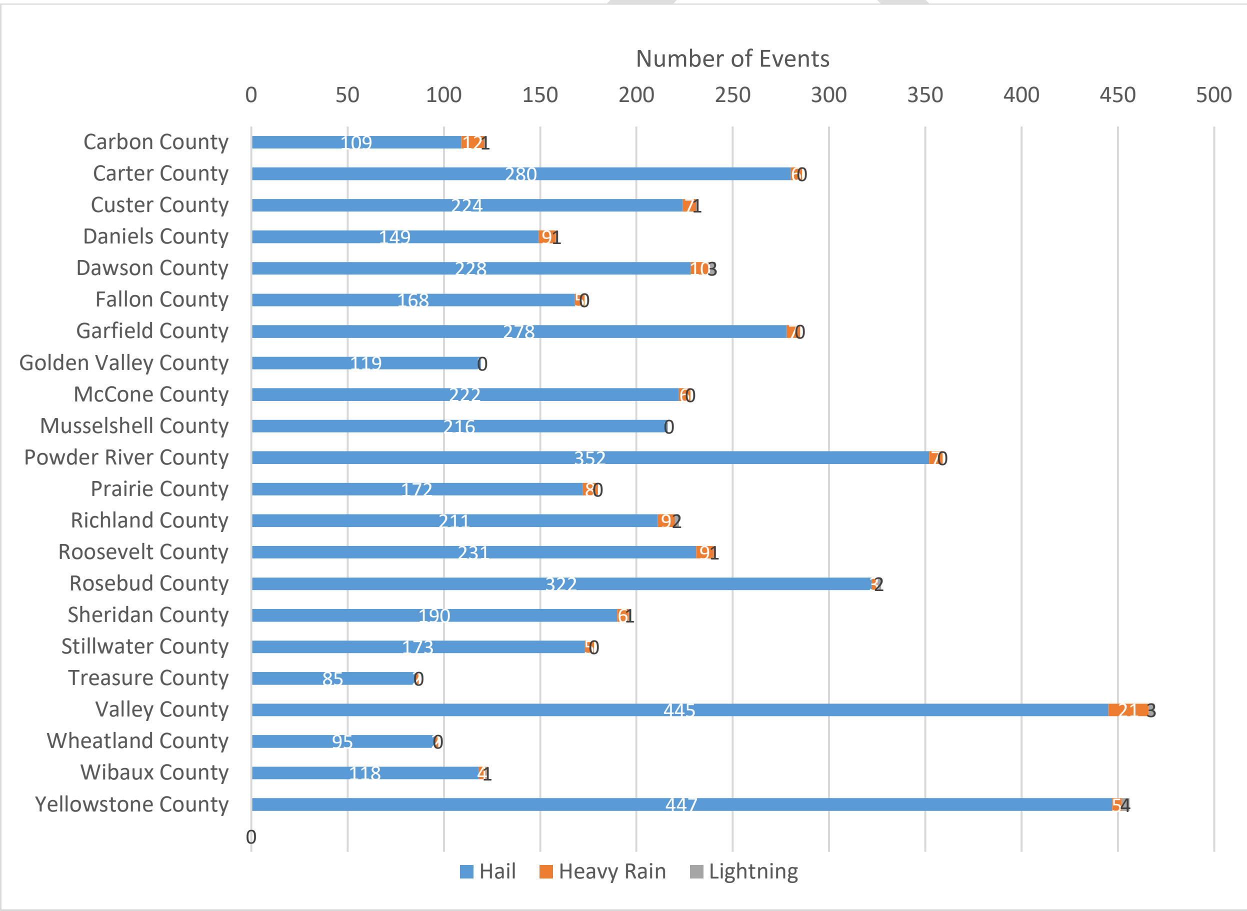
Table 4-38 Summary of Severe Summer Weather Events by County in the Eastern Region

	Excessive Heat	Hail	Heavy Rain	Lightning
Big Horn	-	228	5	1
Carbon	-	109	12	1
Carter	-	280	6	0
Custer	-	224	7	1
Daniels	1	149	9	1
Dawson	2	228	10	3
Fallon	-	168	5	0
Garfield	1	278	7	0
Golden Valley	-	119	1	0
McCone	-	222	6	0
Musselshell	-	216	1	0
Powder River	-	352	7	0
Prairie	-	172	8	0

	Excessive Heat	Hail	Heavy Rain	Lightning
Richland	1	211	9	2
Roosevelt	1	231	9	1
Rosebud	-	322	3	2
Sheridan	-	190	6	1
Stillwater	-	173	5	0
Treasure	-	85	2	0
Valley	1	445	21	3
Wheatland	-	95	2	0
Wibaux	-	118	4	1
Yellowstone	-	447	5	4
Total	7	5,062	150	21

Source: NCEI

Figure 4-44 Summary of Severe Summer Weather Events by County in the Eastern Region



Source: NCEI, Graph by WSP USA

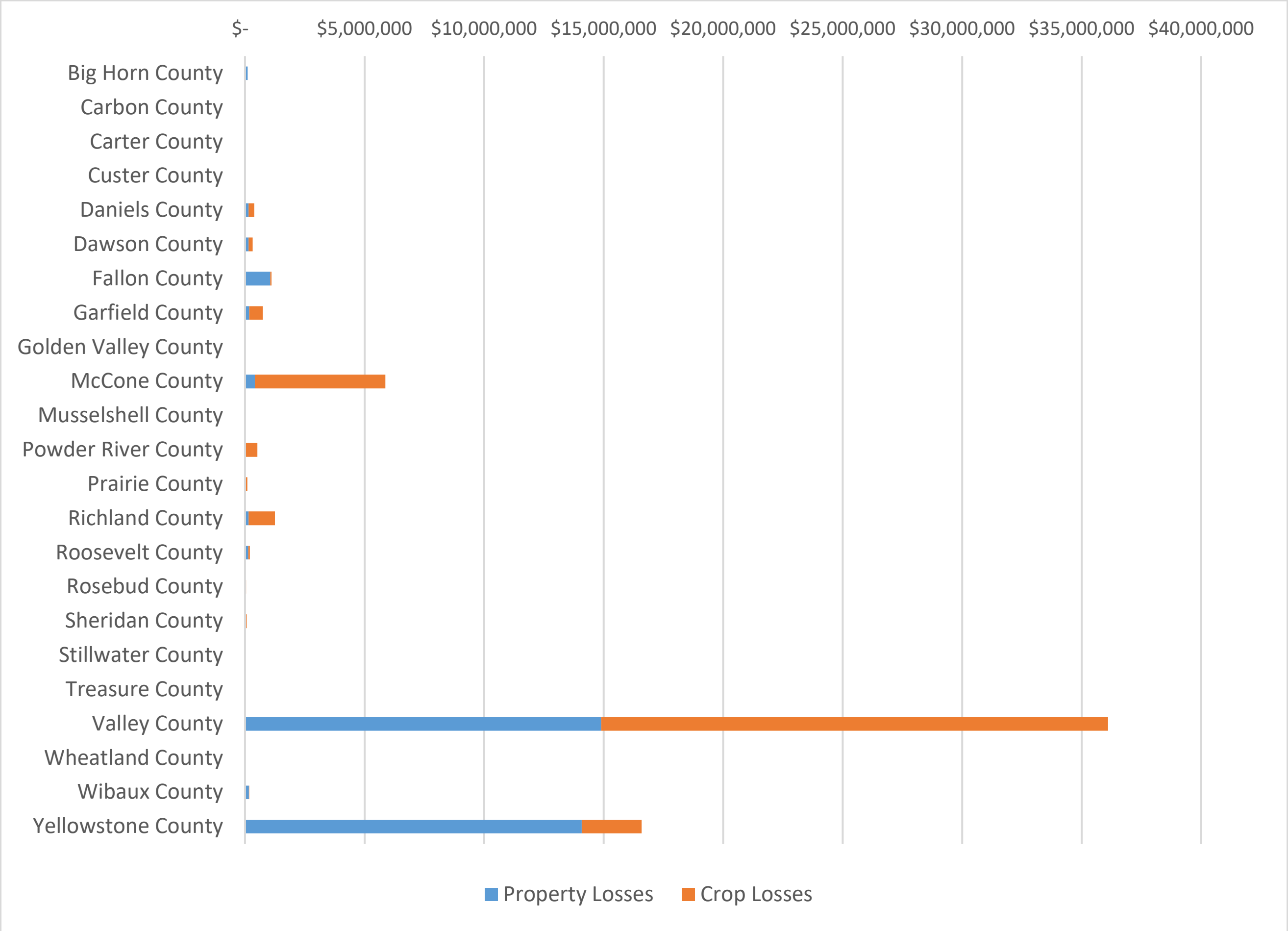
There are also variations between counties in the Eastern Region in terms of losses from severe summer weather events. A summary of losses reported by the NCEI dataset by county is displayed in Table 4-39 and Figure 4-45. Based on this data, Valley County has experienced both the greatest property loss and crop loss from severe summer weather events. All crop losses and nearly all property losses are due to hail events in the Eastern Region. There have also been 17 reported injuries due to hail and lightning, and five deaths due to lightning in the Eastern Region.

Table 4-39 Summary of Losses by County in the Eastern Region

	Deaths	Injuries	Prop. Loss	Crop Loss
Big Horn	1	0	$115,000	0
Carbon	1	0	0	0
Carter	0	0	$5,000	0
Custer	1	0	$500	0
Daniels	0	0	$156,000	$230,000
Dawson	1	1	$154,000	$168,000
Fallon	0	0	$1,055,000	$55,000
Garfield	0	1	$183,000	$555,000
Golden Valley	0	0	0	0
McCone	0	3	$419,100	$5,455,000
Musselshell	0	0	0	0
Powder River	0	0	$15,000	$505,000
Prairie	0	0	$16,000	$85,000
Richland	0	4	$152,000	$1,100,000
Roosevelt	0	1	$138,500	$60,000
Rosebud	0	3	$31,000	$5,000
Sheridan	0	0	$42,000	$25,000
Stillwater	0	0	$5,000	0
Treasure	0	0	0	0
Valley	0	2	$14,902,600	$21,206,000
Wheatland	0	0	$5,000	0
Wibaux	0	0	$170,000	$5,000
Yellowstone	1	2	$14,085,500	$2,500,000
Total	5	17	$31,650,200	$31,954,000

Source: NCEI

Figure 4-45 Summary of Severe Summer Weather Events by County in the Eastern Region



Source: NCEI, Graph by WSP USA

The NCEI dataset reports details on several of the severe summer weather events in the Eastern Region:

- July 4, 1998 (Yellowstone County): Several reports of hail up to 1.75 inches in diameter were reported in and around Billings from spotters, amateur radio operators and law enforcement. The hail severely damaged several cars and roofs. The hail also caused heavy damage to crops in the Billings area. The property and crop losses of this event were $4,000,000 and $1,000,000 respectively.
- July 31, 1998 (Yellowstone County): Numerous observations of large hail were reported by spotters, amateur radio operators and NWS personnel. The hail damaged several vehicles in the Billings area, and also caused heavy damage to crops. This event resulted in $8,000,000 of property losses and $1,000,000 of crop losses.
- June 25, 1999 (Custer County): A 14-year-old boy was struck and killed by lightning while standing on a front tire of a tractor in a field.
- May 16, 2001 (Rosebud County) Three men suffered minor injuries when lightning struck their truck as they were crack sealing on Interstate 94.
- June 16, 2007 (Valley County): During the late afternoon and evening of June 16, 2007, a high precipitation supercell thunderstorm tracked from across northern Montana, just to the north of a warm front. This was the most devastating hailstorm to affect the area since at least 1999, and prompted 22 severe thunderstorm and 6 tornado warnings in Glasgow county warning area. Properties such as

homes, vehicles and businesses suffered severe damage. Trees were uprooted. Horses and cattle were injured by hail and wind, so were wildlife such as birds and small animals. Acres of crops such as alfalfa, wheat and corn were also completely destroyed. This event results in $8,000,000 of property losses and $15,000,000 of crop losses. According to the NCEI database, the overall estimated damage in this event, including hail and wind damage, as well as the subsequent flooding, is estimated to be $34.2 million.

- June 16, 2010 (Valley County): A strong system ejecting out of the central Rockies brought heavy rainfall and severe thunderstorms to the area during the evening. This episode produced an EF1 tornado in northern McCone County and a microburst in eastern Roosevelt County that killed one person near Froid, Montana. This event also caused $2,000 of property damage.

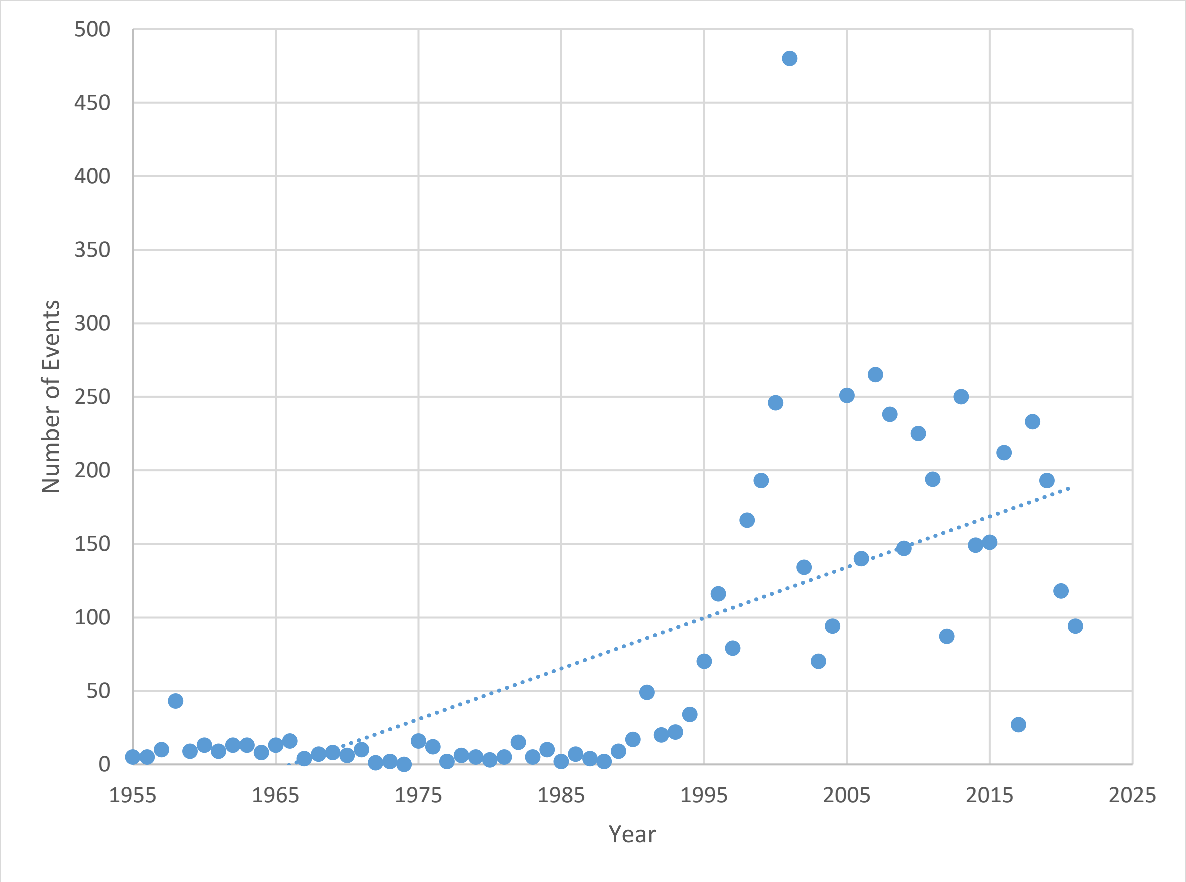
Frequency/Likelihood of Occurrence

The frequency of severe summer weather events in the Eastern Region is ranked as **Highly Likely**. All counties in the planning area are likely to experience a severe summer hazard yearly. Since 1955, 5,240 severe summer weather events over 1,100 days have been recorded in the Eastern Region. As discussed above, there are variations in frequency and severity of damage from severe summer weather across the Eastern Region. Several few counties in the Eastern Region, including counties of Valley, Powder River, Yellowstone, Rosebud, Carter, and Garfield had highest exposure to severe weather in the 2018 SHMP. As shown above in the NCEI data demonstrated, Valley and Yellowstone Counties experience a higher frequency of reported events than the rest of the counties in the Eastern Region.

A total of 5,062 hail events on 1,008 days have been recorded in the Eastern Region planning area over a 67 year period from 1955-2022. While there is some variation between counties in Eastern Region, all counties are likely to experience at least one hail event per year. Counties such as Wheatland and Treasure averages less than two extreme hail events per year, while some counties, such as Yellowstone and Valley Counties, average more than six hail events per year. Figure 4-46 displays the trend of hail events by year in the Eastern Region, showing a generally increasing trend in the frequency of hail events from 1955 to 2021.F

While all counties in the Eastern Region will experience lightning throughout the year, some counties have historically higher numbers of reporting damaging lightning events than others. According to the NCEI dataset, Anaconda-Deer Lodge County and Ravalli County most frequently experience damaging lightning events, while many other counties have no recorded events. Moreover, while most counties in the planning area have a comparatively low number of recorded heavy rain and excessive heat events, this is more likely due to the fact the events were not reported to the NCEI dataset.

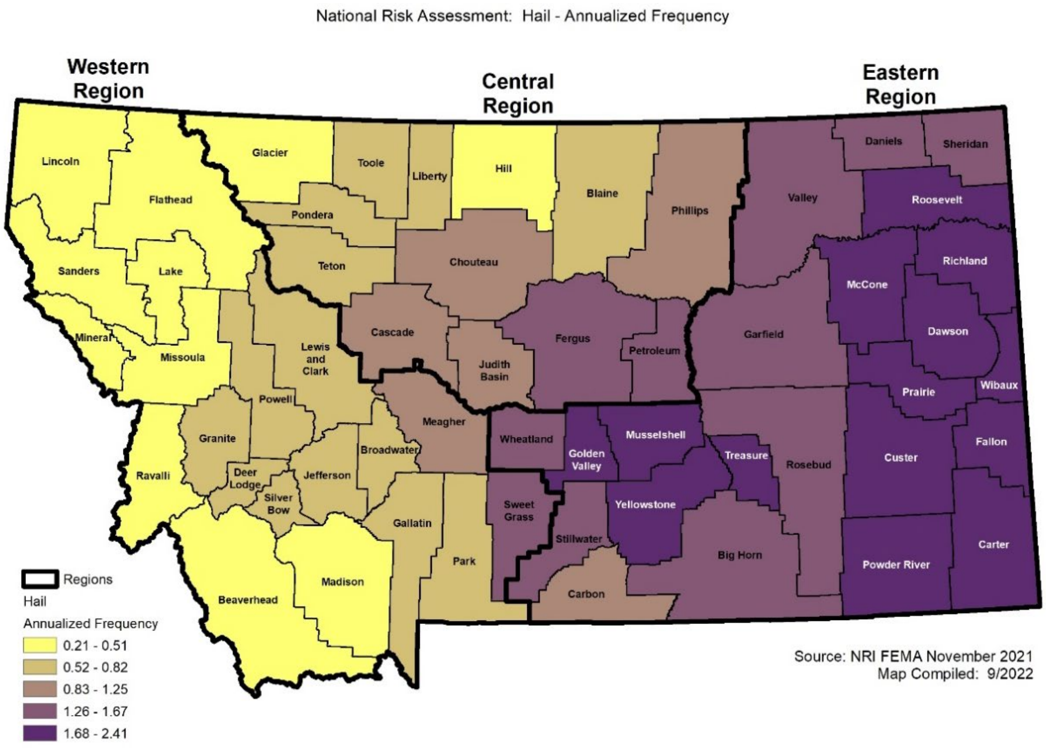
Figure 4-46 Hail Events by Year in the Eastern Region (1955-2021)



Source: NCEI, Chart by

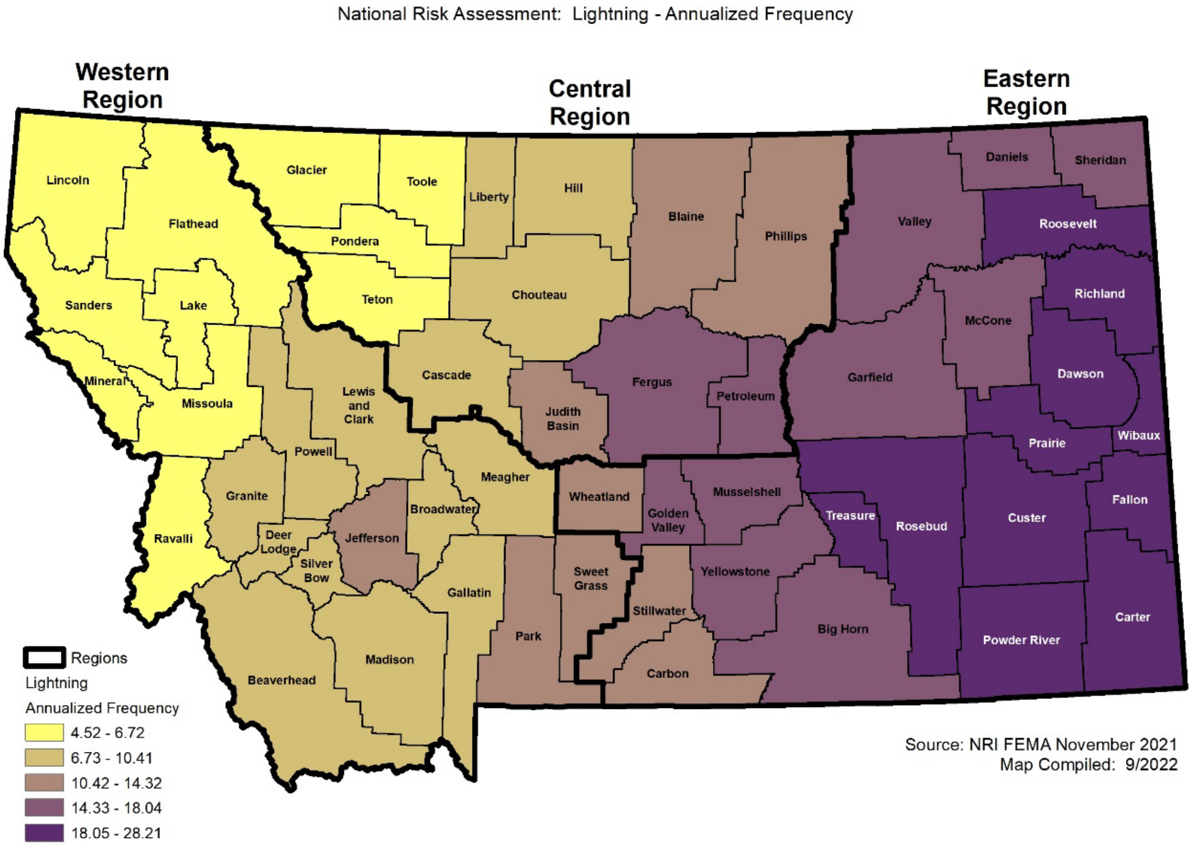
The figures below depict annualized frequency of hail and lightning at a county level based on the NRI. The mapping shows that most of the counties in the region will have high annualized frequency in hail and lightning events.

Figure 4-47 NRI Annualized Frequency of Hail Events by County



Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Figure 4-48 NRI Annualized Frequency of Lightning Events by County



Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Climate Change Considerations

The frequency of severe weather events has increased steadily over the last century. According to the 2018 SHMP the number of weather-related disasters during the 1990s was four times that of the 1950s and cost 14 times as much in economic losses. Historical data shows that the probability of severe weather events increases in a warmer climate. There has been a sizable upward trend in the number of storms causing large financial and other losses. Climate change presents a challenge for risk management associated with severe weather.

Moreover, according to the 2018 SHMP, Montana has seen an uptick in average temperature of about 2 degrees Fahrenheit in the last 50 years, while precipitation has stayed largely the same. At the same time, temperatures at the extremes – the absolute coldest and absolute warmest temperatures of the year have shifted upwards by about 10 degrees for the absolute low, with more days falling into the hotter extreme.

With regards to hail events, which are the most frequent and severe summer weather events in the Eastern region, in a 2021 paper in the Nature journal, scientists from Universität Bern, the University of New South Wales, and the Karlsruhe Institute of Technology investigated the impact of climate change on hailstorms. They concluded that hailstorm severity is expected to increase with climate change in most regions, as climate change favors the development of bigger hailstones. On the other hand, however, scientists also noted that it is uncertain whether or not climate change will make hailstorms more common (Elton 2022).

In addition, the 2018 SHMP mentions that projected changes in summer and fall precipitation are small; however, the number of days with heavy precipitation is expected to increase by mid-century. The HMPC noted that an increase in the number of days with extreme high temperatures could be a significant issue in the Eastern Region since, while new buildings are constructed with air conditioning, it is common for residents living in older buildings to not have air conditioning due to the usually mild summers.

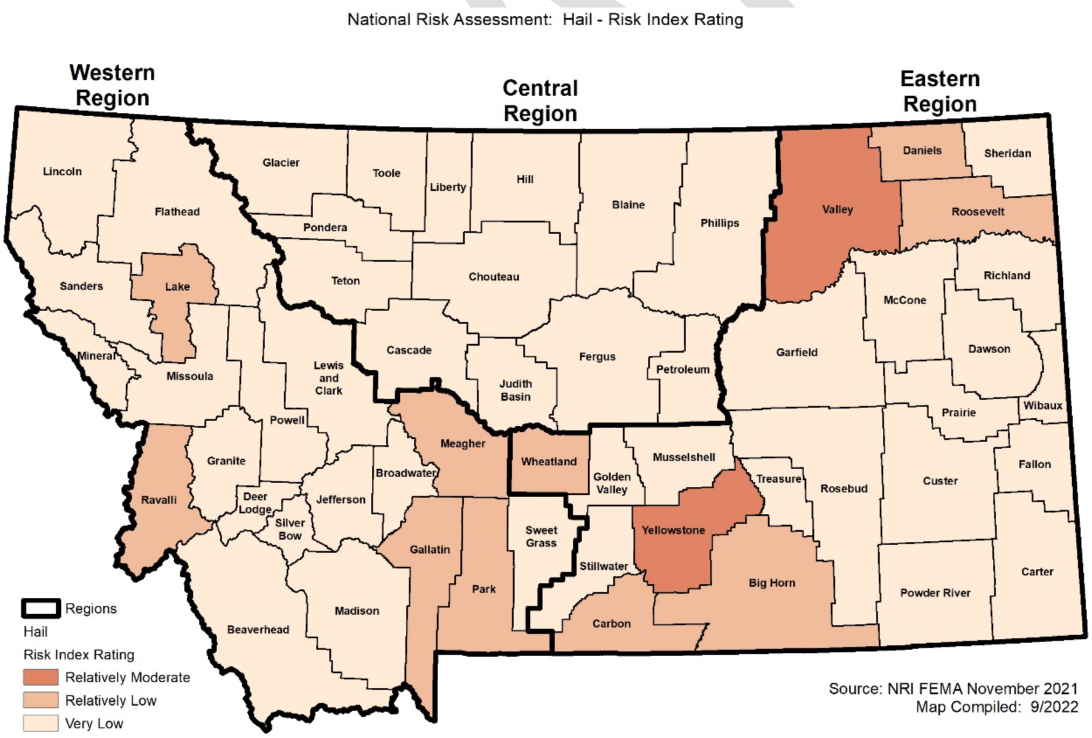
Potential Magnitude and Severity

As mentioned in the 2018 SHMP, severe summer weather can cause damage to buildings, homes, and other property but rarely cause death, serious injury, or long-lasting health effects. Straight-line winds are responsible for most thunderstorm damage. The NWS reports that severe summer weather has caused $51.5 million in property damage and $26.3 million in crop damage over the past 60 years in the State. Eight deaths and 31 injuries were attributed to lightning strikes. Across the country, large hail results in nearly $1 billion in damage annually to property and crops. In the Eastern Region alone, 6 fatality, 17 injuries, $31,650,200 in property damages and $31,954,000 crop damages have been recorded since 1955.

Vulnerability Assessment

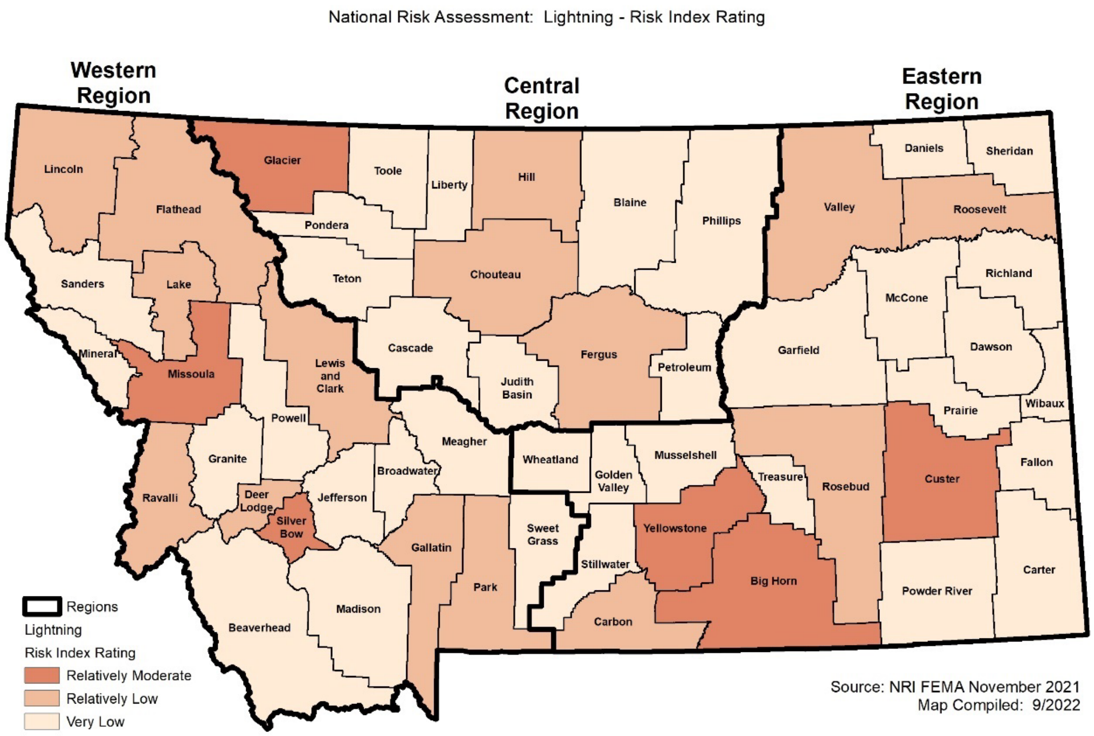
Figure 4-49 illustrates the relative Risk Index (RI) rating to hail and lightning events for Montana counties based on data in the NRI. The RI calculation takes into account various factors, including the expected annual losses from these events, social vulnerability, and community resilience in each county across Montana. Most counties in the region have a very low to moderate rating; none have a high or very high RI rating.

Figure 4-49 NRI Risk Index Rating for Hail



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Figure 4-50 NRI Risk Index Rating for Lightning



People

According to the Center for Disease Control (CDC), extreme heat is one of the leading causes of weather-related deaths in the United States. In the absence of shelter, any summer storm can pose a threat to people stuck outside. Although all people may be affected by the health-related impacts of severe summer weather, the elderly, young children, and people with weakened immune systems are often the most susceptible. Additionally, residents living in dense urban areas are disproportionately impacted by heat due to the "heat island effect", where city buildings and roads absorb more heat than vegetation and therefore cities are at a higher risk of extreme temperatures. Hail can cause serious injuries to unprotected people. Similarly, outdoor enthusiasts and workers are most vulnerable to lightning strikes. Individuals without proper air conditioning or shelter, especially members of the population who are 65 years and older, are most vulnerable to extreme heat events due to the stress that long-term high temperatures put on the body. Heavy rain will generally not cause injuries but could pose a threat to commuters if the event results in flash flooding.

Property

All outdoor property is equally at risk of severe summer weather events. Roofs, windows, and cars are frequently reported as receiving damage in a hail event. One of the most significant damaging property events from severe summer weather events occurred when a severe hail event significantly damaged houses, garages, vehicles, and farms in Valley County. Estimated damages in property & crop losses reached $31,000,000.

Fire due to lightning strikes has also been known to cause property damage in the Eastern Region. Reported events have happened in various counties such as Yellowstone County, Wibaux County, and Rosebud County. There was two reported instances of lightning damaging houses and other properties. While there are no reported property damages from excessive heat, extreme heat can expand metal and cause infrastructural defects. Heavy rain that results in flash flooding or standing water can cause significant damage to a foundation of a home. The NCEI database shows previous occurrences of heavy rain events during which secondary hazards including flooding and landslide hazards happened, resulting in properties such as houses being flooded and damaged.

Critical Facilities and Lifelines

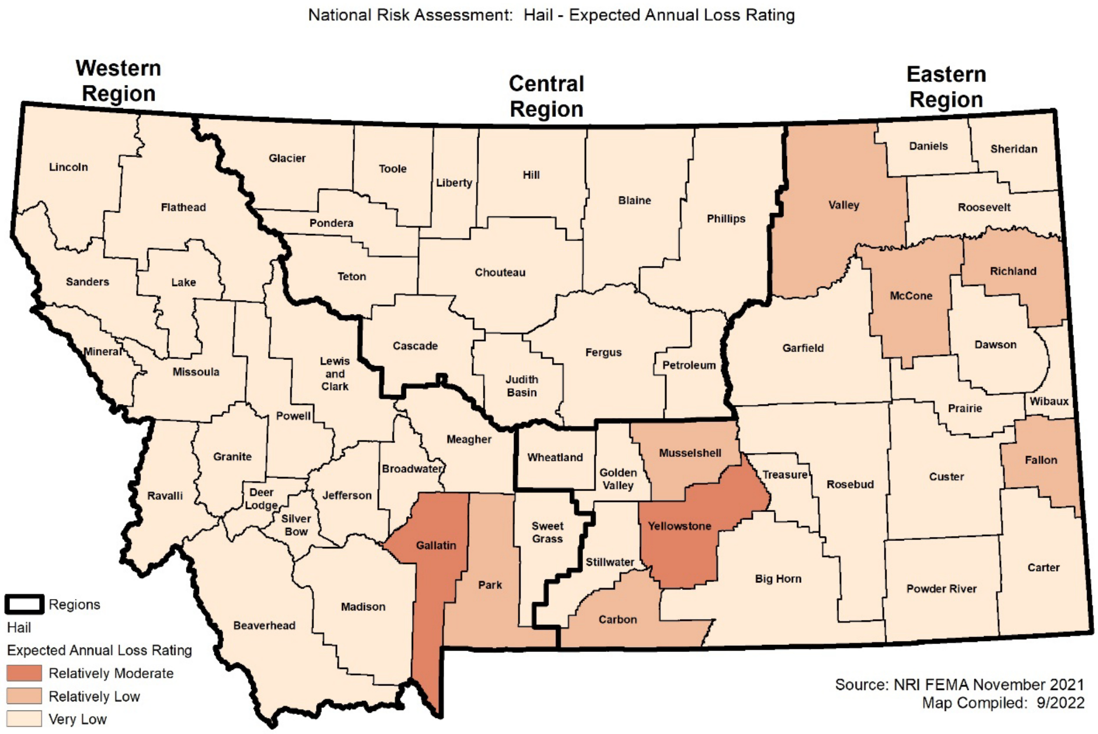
All infrastructure and critical facilities are equally at risk since severe storms indiscriminately affect the entire planning area. Extreme heat can cause infrastructural defects when structures are made of materials that expand under extreme heat, such as wood and metal. Roads have been known to crack under extreme heat conditions. It is also possible for power transformers to detonate and cause fires, as well as general failures within the electric system due to sagging power lines that can result in blackouts. Hail and heavy rain can also accumulate along highways and prevent commuters and emergency responders from traveling quickly and safely.

Economy

As seen from the NCEI dataset, severe summer storms can result in significant economic losses, particularly hail. Losses can be seen when severe storm events cause direct damage to property or crops, but indirect losses can be a result of these storms as well. The 2018 SHMP notes that increasing extreme temperature events will impact tourism in the future and reduce revenue from tourists. Businesses will need to close, and commuters will be unable to drive to work due to flash flooding or extreme hail events. These will result in disruption in local economies.

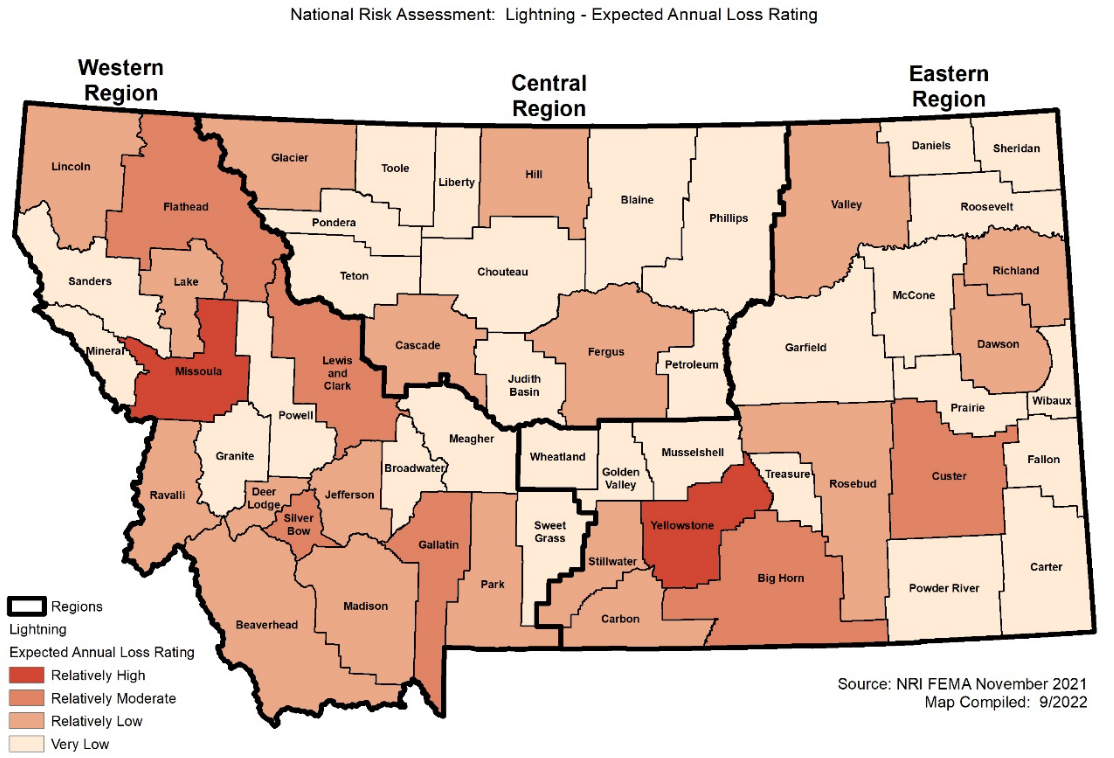
Figure 4-51 illustrates the relative risk of Expected Annual Loss (EAL) rating due to hail and lightning for Montana counties based on data in the NRI. For hail, most counties in the region have a very low to relatively low EAL rating. Yellowstone has a relatively moderate rating. For lightning, the majority of the Counties have a very low to relatively low rating. Big Horn and Custer Counties have a relatively moderate rating. Yellowstone County has a relatively high rating. For The EAL calculation takes into account agriculture value exposed to hail and lightning, annualized frequency for hail and lightning, and historical losses.

Figure 4-51 NRI Hail Expected Annual Loss Rating



Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Figure 4-52 NRI Lightning Expected Annual Loss Rating



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Historic and Cultural Resources

Historic and cultural resources are equally as exposed to severe weather events as any other infrastructure. Buildings in poor condition or that are not built to code are more likely to experience damage from severe weather events.

Natural Resources

Vegetation such as trees, crops, and landscape are vulnerable to extreme heat events. Similarly, hail has been documented to cause significant crop damage in the planning area and was also documented to break branches off trees. The most significant crop damages reported by the NCEI occurred in Yellowstone and Valley counties. Lightning has also been documented to strike trees and cause fires, which can impact vegetation and crops.

Development Trends Related to Hazards and Risk

According to the 2018 SHMP, the State has adopted the 2012 International Building Code (IBC). The IBC includes a provision that buildings must be constructed to withstand a wind load of 75 mph constant velocity and three-second gusts of 90 mph. Additionally, as temperatures continue to rise and city infrastructure is developed, there is an increasing threat of heat-related illness to people living in urban areas. Incorporating green spaces in urban areas and using building materials that are more reflective or lighter in color are some ways to mitigate the impacts of urban heat islands.

Risk Summary

- The hazard significance of severe summer weather (excessive heat, hail, heavy rain, and lightning) in the Eastern Region is ranked as **High**
- The entire Eastern Region can be impacted by severe summer weather; therefore, the geographic extent is rated as **Extensive**
- 1,100 days of severe summer weather events occurred in the Eastern Region over the course of 67 years, from 1955 to March 2022. This averages roughly 16.4 days with severe summer event(s) per year; therefore, the probability of future occurrence is ranked as **Highly Likely.**
- Six deaths, 17 injuries, $31,650,200 in property damages, and $31,954,000 in crop damages occurred from severe weather events since 1955, therefore the potential magnitude is ranked as **Critical.**
- People most vulnerable to severe summer weather events are children, the elderly, individuals with preexisting medical conditions, outdoor workers/enthusiasts, and people living in dense urban areas.
- All outdoor property is vulnerable to severe weather events. Properties and vehicles are most frequently reported as damaged property in the Eastern Region.
- Critical infrastructure such as roadways and electric equipment are especially vulnerable to severe summer weather. Power outages, house fires, and damages to vehicles have been documented by the NCEI dataset.
- Economic losses typically occur from severe hail events and associated cost of repairs from hail damage. Areas with high infrastructure, such as major cities, are more likely to experience economic damages from hail than urban areas due to greater quantity of property to be damaged.
- Related hazards: Drought, Wildfire. Wind & tornadoes

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences
Eastern Region	High		
Big Horn	Medium	Hardin, Lodge Grass	None
Carbon	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	None
Carter	Medium	Ekalaka	None
Crow Tribe	Medium		None
Custer	Medium	Ismay, Miles City	None
Daniels	Medium	Scobey, Flaxville	None
Dawson	Medium	Richey, Glendive	None
Fallon	Medium	Plevna, Baker	None
Garfield	Medium	Jordan	None
Golden Valley	Medium	Ryegate, Lavina	None
McCone	Medium	Circle	A higher number of weather-related events have occurred in McCone County
Musselshell	Medium	Roundup	None
North Cheyenne Tribe	Medium		None
Powder River	Medium	Broadus	None
Prairie	Medium	Terry	None
Richland	Medium	Fairview, Sidney	None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences
Roosevelt	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	None
Rosebud	Medium	Colstrip, Forsyth	None
Sheridan	Medium	Outlook, Westby, Plentywood, Medicine Lake	None
Stillwater	Medium	Columbus	None
Treasure	Medium	Hysham	None
Valley	High	Fort Peck, Glasgow, Nashua, Opheim	A higher number of weather-related events have occurred in Valley County
Wheatland	Medium	Harlowton, Judith Gap	None
Wibaux	Medium	Wibaux	None
Yellowstone	High	Billing, Laurel, Broadview	A higher number of weather-related events have occurred in Yellowstone County

4.2.11 Severe Winter Weather

Hazard/Problem Description

According to the 2018 SHMP, severe winter weather presents one of the greatest threats to life of any hazard in Montana. Statistics on winter deaths are difficult to obtain, but nationwide there are on average 100 lives directly and indirectly lost to winter weather, more than lightning, hurricanes, or tornadoes. Winter storms are considered to be deceptive killers because most deaths are indirectly related to the storm. People die in traffic accidents on snow- or ice-covered roads, from hypothermia due to prolonged exposure to cold, and from heart attacks due to overexertion.

Winter storms may be categorized as blizzards, heavy snow, ice storms, winter storms, and winter weather. These storms vary in size and intensity and may affect a small part of the state or several states at once. The NWS defines common winter storm characteristics as follows:

Blizzard: A blizzard means that the following conditions are expected to prevail for a period of 3 hours or longer:

- Sustained wind or frequent gusts to 35 miles an hour or greater; and
- Considerable falling and/or blowing snow (i.e., reducing visibility frequently to less than ¼ mile).

Cold/Wind Chill: Increased wind speeds accelerate heat loss from exposed skin, and the wind chill is a measure of this effect. No specific rules exist for determining when wind chill becomes dangerous. As a general rule, the threshold for potentially dangerous wind chill conditions is about -20°F.

Heavy Snow: This generally means:

- Snowfall accumulating to 4" or more in depth in 12 hours or less; or
- snowfall accumulating to 6" or more in depth in 24 hours or less.

- In forecasts, snowfall amounts are expressed as a range of values, e.g., "8 to 12 inches." However, in heavy snow situations where there is considerable uncertainty concerning the range of values, more appropriate phrases are used, such as "...up to 12 inches..." or alternatively "...8 inches or more...”

Ice Storm: An ice storm is used to describe occasions when damaging accumulations of ice are expected during freezing rain situations. Significant accumulations of ice pull down trees and utility lines resulting in loss of power and communication. These accumulations of ice make walking and driving extremely dangerous.

Winter Storm: A winter weather event that has more than one significant hazard (i.e., heavy snow and blowing snow; snow and ice; snow and sleet; sleet and ice; or snow, sleet, and ice) and meets or exceeds locally/regionally defined 12 and/or 24-hour warning criteria for at least one of the precipitation elements. Normally, a Winter Storm would pose a threat to life or property.

Winter Weather: A winter precipitation event that causes a death, injury, or a significant impact to commerce or transportation, but does not meet locally/regionally defined warning criteria. A Winter Weather event could result from one or more winter precipitation types (snow, or blowing/drifting snow, or freezing rain/drizzle). The Winter Weather event can also be used to document out-of-season and other unusual or rare occurrences of snow, or blowing/drifting snow, or freezing rain/drizzle.

Geographical Area Affected

All counties in the Eastern Region are impacted by severe winter weather; therefore, the geographic extent of severe winter storms is ranked as **Extensive**. The 2018 SHMP explains that the entire State is considered equally vulnerable to severe winter weather. Arctic cold fronts typically enter the state from the northeast and may cross the Continental Divide, affecting mainly the western portion of the State rather than the Eastern Region. Arctic fronts meeting wet maritime fronts often combine to cause heavy snowfall, which can occur in all parts of the State. The lowest temperatures are typically experienced in the northeast, whereas the heaviest snowfall most often occurs in the mountain region in the southwest portion of the Eastern Region.

Past Occurrences

The NCEI database was used to gather information on historic severe winter weather events in the Eastern Region of Montana. It is important to note that weather events that occurred on Crow Tribe and North Cheyenne Tribe are also included in the dataset tables down below. However, instead of individual records, tribal data records were grouped into the nearest County. The NCEI dataset contains information on severe winter weather events from 1996 to March of 2022. The specific hazards selected for severe winter weather consist of blizzard, cold/wind child, heavy snow, ice storm, winter storm, and winter weather events.

Table 4-42 summarizes the data from NCEI. It is important to note that not all severe winter weather events get reported by the NCEI and losses are estimates, therefore actual losses may be higher than those reported below. Based on this data, winter storms are the most frequently occurring and damaging type of severe winter weather event in the Eastern Region. Heavy snow is another frequently occurring event in the Region. Blizzards, heavy snow, and winter storms are the only types of severe winter weather with documented property losses. Blizzards, cold/wind chill, winter storm and winter weather events have resulted in a total of 14 injuries and 13 deaths in the Eastern Region.

Table 4-40 Summary of Losses by Hazard in the Eastern Region

	Deaths	Injuries	Property Loss	Days with Events	Total Events
Blizzard	1	5	$1,792,000	68	307
Cold/Wind Chill	4	0	$0	93	397

	Deaths	Injuries	Property Loss	Days with Events	Total Events
Heavy Snow	2	4	$1,236,000	210	701
Ice Storm	0	0	$0	11	56
Winter Storm	3	1	$6,331,700	285	1,138
Winter Weather	5	7	$0	71	209
Total	13	14	$9,359,700	738	2808

Source: NCEI

There are variations in losses and frequency of hazards across the Eastern Region. Due to the regional nature of severe winter storms, the NCEI records all severe winter weather events by zone rather than by county. The zones used by NCEI can extend over county lines, and many counties contain more than one zone. Table 4-43 and Figure 4-53 displays a list of the total number of severe winter weather events by zone. It is possible to see the variation between zones, with the Red Lodge Foothills zone having the most significant number of events.

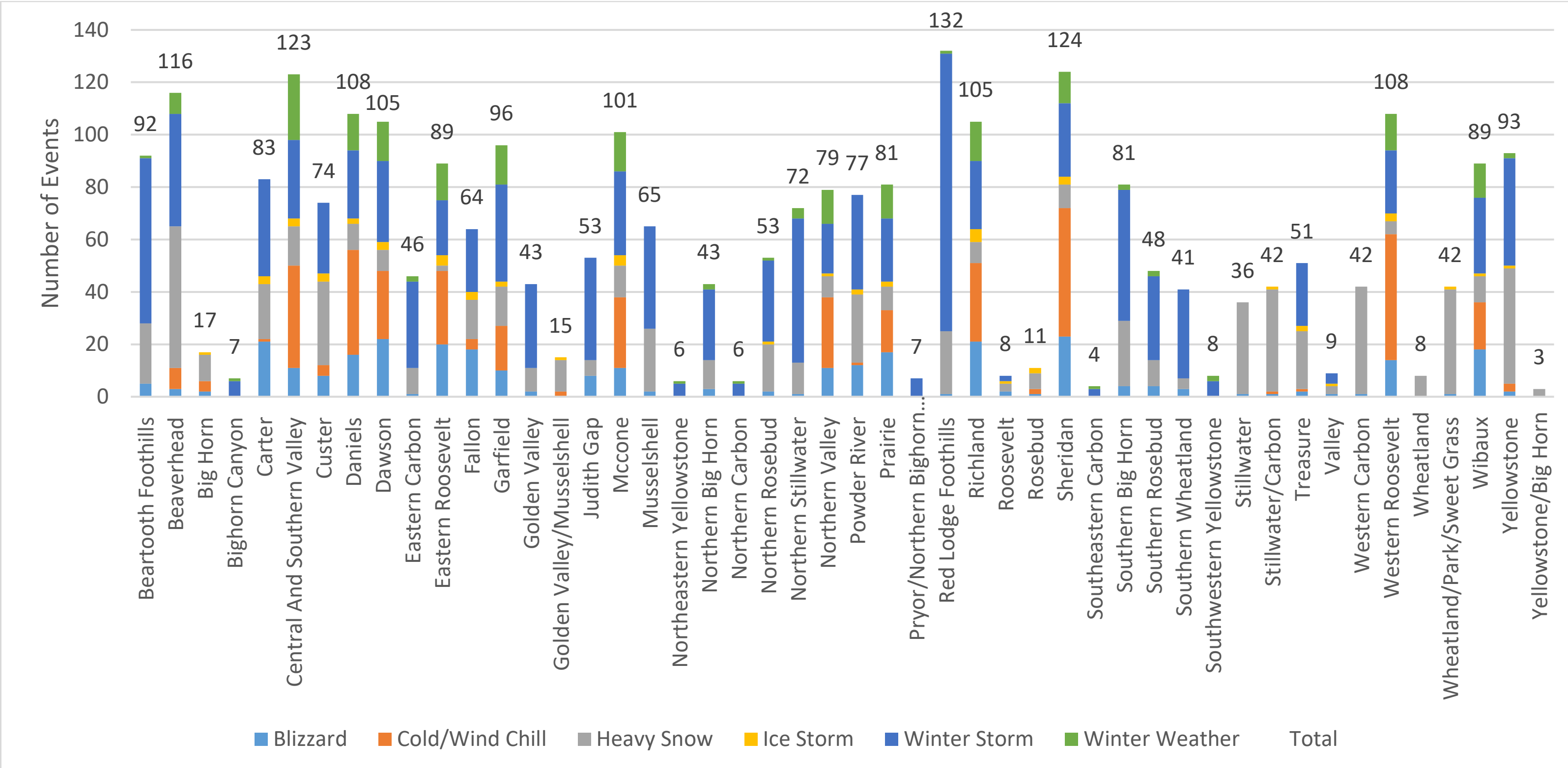
Table 4-41 Summary of Severe Winter Weather Events by Zone in the Eastern Region

Zone Name	Blizzard	Cold/Wind Chill	Heavy Snow	Ice Storm	Winter Storm	Winter Weather	Total
BEARTOOTH FOOTHILLS (ZONE)	5	0	23	0	63	1	92
BEAVERHEAD (ZONE)	3	8	54	0	43	8	116
BIG HORN (ZONE)	2	4	10	1	0	0	17
BIGHORN CANYON (ZONE)	0	0	0	0	6	1	7
CARTER (ZONE)	21	1	21	3	37	0	83
CENTRAL AND SOUTHERN VALLEY (ZONE)	11	39	15	3	30	25	123
CUSTER (ZONE)	8	4	32	3	27	0	74
DANIELS (ZONE)	16	40	10	2	26	14	108
DAWSON (ZONE)	22	26	8	3	31	15	105
EASTERN CARBON (ZONE)	1	0	10	0	33	2	46
EASTERN ROOSEVELT (ZONE)	20	28	2	4	21	14	89
FALLON (ZONE)	18	4	15	3	24	0	64
GARFIELD (ZONE)	10	17	15	2	37	15	96
GOLDEN VALLEY (ZONE)	2	0	9	0	32	0	43
GOLDEN VALLEY/MUSSELSHELL (ZONE)	0	2	12	1	0	0	15
JUDITH GAP (ZONE)	8	0	6	0	39	0	53
MCCONE (ZONE)	11	27	12	4	32	15	101
MUSSELSHELL (ZONE)	2	0	24	0	39	0	65
NORTHEASTERN YELLOWSTONE (ZONE)	0	0	0	0	5	1	6
NORTHERN BIG HORN (ZONE)	3	0	11	0	27	2	43
NORTHERN CARBON (ZONE)	0	0	0	0	5	1	6

Zone Name	Blizzard	Cold/Wind Chill	Heavy Snow	Ice Storm	Winter Storm	Winter Weather	Total
NORTHERN ROSEBUD (ZONE)	2	0	18	1	31	1	53
NORTHERN STILLWATER (ZONE)	1	0	12	0	55	4	72
NORTHERN VALLEY (ZONE)	11	27	8	1	19	13	79
POWDER RIVER (ZONE)	12	1	26	2	36	0	77
PRAIRIE (ZONE)	17	16	9	2	24	13	81
PRYOR/NORTHERN BIGHORN MOUNTAINS (ZONE)	0	0	0	0	7	0	7
RED LODGE FOOTHILLS (ZONE)	1	0	24	0	106	1	132
RICHLAND (ZONE)	21	30	8	5	26	15	105
ROOSEVELT (ZONE)	2	0	3	1	2	0	8
ROSEBUD (ZONE)	1	2	6	2	0	0	11
SHERIDAN (ZONE)	23	49	9	3	28	12	124
SOUTHEASTERN CARBON (ZONE)	0	0	0	0	3	1	4
SOUTHERN BIG HORN (ZONE)	4	0	25	0	50	2	81
SOUTHERN ROSEBUD (ZONE)	4	0	10	0	32	2	48
SOUTHERN WHEATLAND (ZONE)	3	0	4	0	34	0	41
SOUTHWESTERN YELLOWSTONE (ZONE)	0	0	0	0	6	2	8
STILLWATER (ZONE)	1	0	35	0	0	0	36
STILLWATER/CARBON (ZONE)	1	1	39	1	0	0	42
TREASURE (ZONE)	2	1	22	2	24	0	51
VALLEY (ZONE)	1	0	3	1	4	0	9
WESTERN CARBON (ZONE)	1	0	41	0	0	0	42
WESTERN ROOSEVELT (ZONE)	14	48	5	3	24	14	108
WHEATLAND	0	0	8	0	0	0	8
WHEATLAND/PARK/SWEET GRASS (ZONE)	1	0	40	1	0	0	42
WIBAUX (ZONE)	18	18	10	1	29	13	89
YELLOWSTONE (ZONE)	2	3	44	1	41	2	93
YELLOWSTONE/BIG HORN	0	0	3	0		0	3
Total	307	397	701	56	1,138	209	2,808

Source: NCEI

Figure 4-53 Summary of Severe Winter Weather Events by Zone in the Eastern Region



Source: NCEI, Chart by WSP

The NCEI dataset reported $8,300,000 in total property losses in the Eastern Region since 1996. There was no crop damage reported in the Region. Only four zones accounted for the over $8 million in property damages. Table 4-44 below summarizes property loss by zone in the Eastern Region.

Table 4-42 Summary of Property Losses from Winter Weather Events by Zone in the Eastern Region

Zone	Total Property Damage ($)
BIG HORN (ZONE)	1,200,000
CARTER (ZONE)	4,500,000
DAWSON (ZONE)	57,000
GARFIELD (ZONE)	240,000
MCCONE (ZONE)	2,000
NORTHERN VALLEY (ZONE)	5,000
PRAIRIE (ZONE)	10,000
RICHLAND (ZONE)	435,000
ROOSEVELT (ZONE)	362,000
SHERIDAN (ZONE)	2,500,000
WIBAUX (ZONE)	34,700
YELLOWSTONE (ZONE)	14,000
Total	9,359,700

Source: NCEI

The NCEI reported details on several significant events in the Eastern Region:

- **November 1, 2000:** A major winter storm hit eastern Montana leaving over 1,500 residents without power as nearly 2,000 power poles snapped in half. The storm started as rain and produced several hours of sleet before changing to snow. After the ice turned to all snow, strong winds from 30 to 45 mph with gusts to 60 mph developed creating blizzard conditions with 6 to 12 inches of snow. Drifts up to 5 and 6 feet were reported in Sheridan County. This event impacted quite a few zones/counties in the Eastern Region and resulted in a combined $3,306,700 of property losses.
- **April 9, 2001:** An early spring snowstorm impacted parts of South Central and Southeast Montana on April 8th and April 9th. Southern Big Horn County was the hardest hit. An estimated 600 power poles were knocked down from heavy, wet snow, ice, and wind. Thousands of people were without power for up to 7 days. The hardest hit area was along Route 314 in the Kirby/Decker area and in the western end of the Northern Cheyenne Indian Reservation. This event resulted in $1,200,000 of property losses.
- **February 19, 2009:** An arctic cold front moved across the forecast area during the late evening hours of the 19th and early morning hours of February 20th. Upslope flow developed behind the front. This resulted in heavy snow across the foothills of the Beartooth/Absaroka Mountains with minor accumulations across the plains. However, very slick roads resulted in dangerous traveling conditions. As a result of the icy roads, a 16-year-old girl died in a one-vehicle crash on Interstate 90 near Dunmore, Montana. In addition, two women died in a two-vehicle crash on Highway 212, about 8 miles west of Ashland. Although road conditions were icy and snow packed at the time of the accidents, Montana State Patrol reported speed was also a factor.
- **March 29, 2009:** A second major snowstorm and blizzard within a week's time brought heavy snow and strong winds to portions of Southern Montana and Northern Wyoming. This storm impacted areas that were hit hard by the March 23-24 storm. Winds across the area were sustained in the 25 to 35 mph range with gusts from 30 to 40 mph. These winds combined with heavy snow resulted in visibilities being reduced to a quarter mile at many locations. In addition, snowfall exceeded 12 in Carbon,

Stillwater and Custer Counties. The storm resulted in one death. A 19-year-old woman was killed on Highway 39 near Forsyth after losing control of her car on the snow-covered highway. This event resulted in $1,500,000 of property losses.

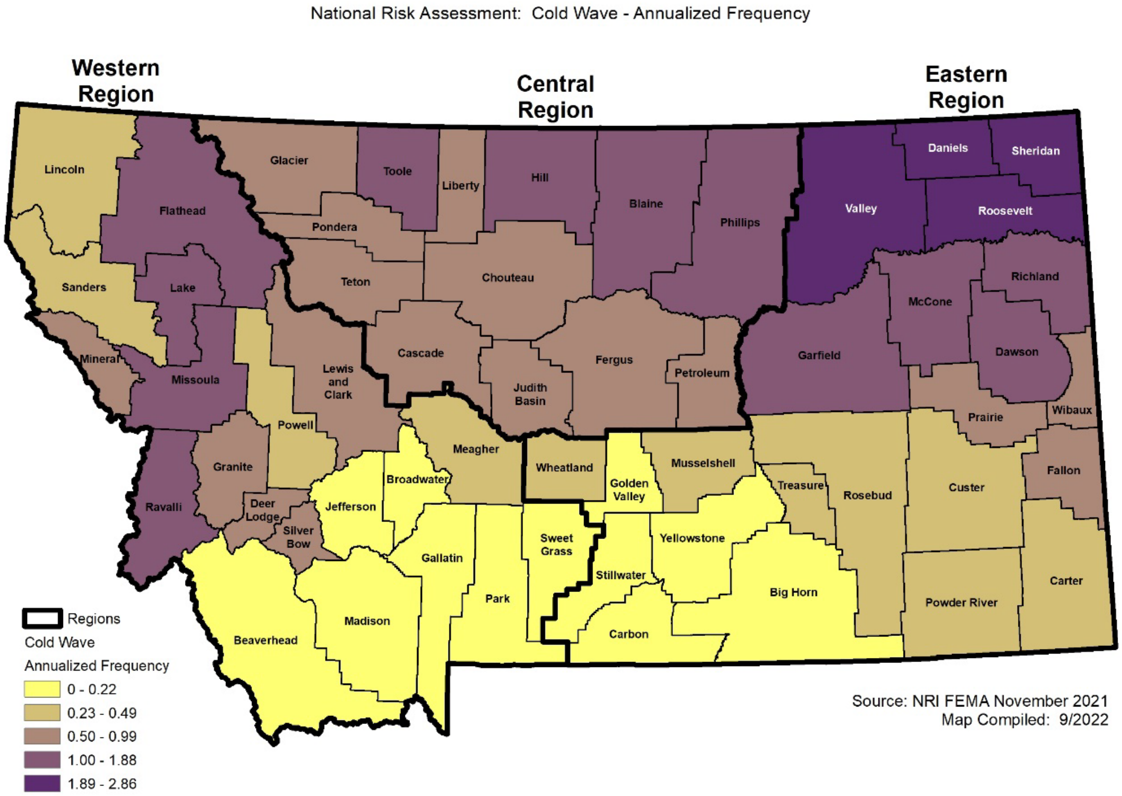
- **November 9, 2012:** A low pressure system from the Gulf of Alaska descended over the Rocky Mountain region, then moved northeast, emerging over the northern high plains. An arctic air mass from Alberta combined with warmer temperatures from the south to steer plentiful moisture through the area, bringing the first major winter storm of the season to northeast Montana. This event caused three deaths and one injury, as well as $25,000 in property losses.
- **May 10, 2016:** A very strong low-pressure system from the pacific northwest stalled over southern Montana and northern Wyoming with plentiful moisture. Significant amounts of moderate and heavy rain spread across many locations while enough cold air from the Canadian Rockies wrapped around the system to change the precipitation to a heavy, very wet snow for some higher elevations of central and northern Montana. This event resulted in $240,000 of property losses.

Frequency/Likelihood of Occurrence

The frequency of severe winter weather in the Eastern Region is ranked as **Highly Likely**. Severe winter weather impacts the state annually with blowing and drifting snow, extreme cold, hazardous driving conditions, and utility interruption. The NCEI dataset reported 738 days with severe weather events over 26 years, which averages to nearly 29 days a year with severe winter weather events in the Eastern Region. According to the 2018 SHMP, winter weather typically affects the state from November to April each year, but late storms can extend into June, causing extreme impacts to the agricultural industry.

Figure 4-54 below depicts the annualized frequency of cold events at a county level based on the NRI. The mapping shows a trend toward increased likelihood in the northern part of the Region, particularly Daniels, Valley, Roosevelt, and Sheridan counties.

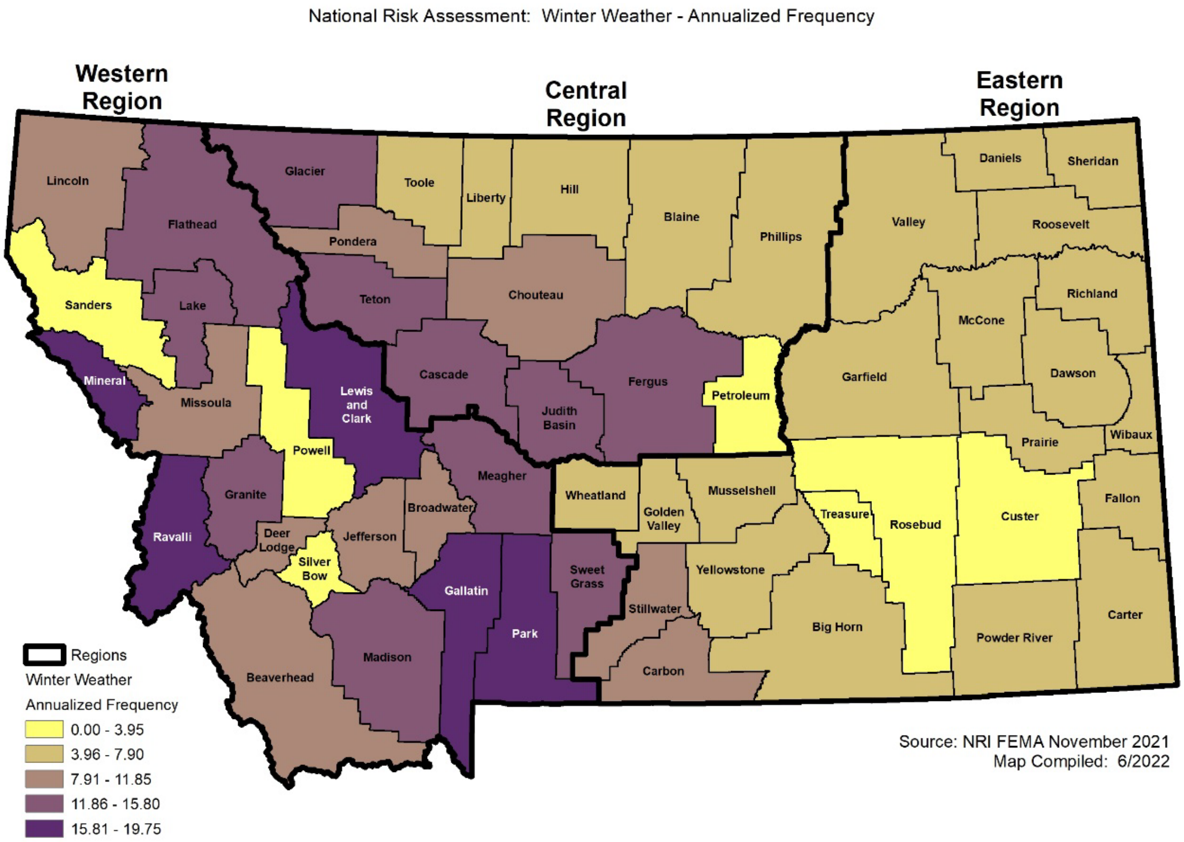
Figure 4-54 NRI Annualized Frequency of Cold Events by County



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

The figure below depicts annualized frequency of winter weather events at a county level based on the NRI. The mapping shows a trend towards increased likelihood in the southwestern region, particularly Stillwater and Carbon counties.

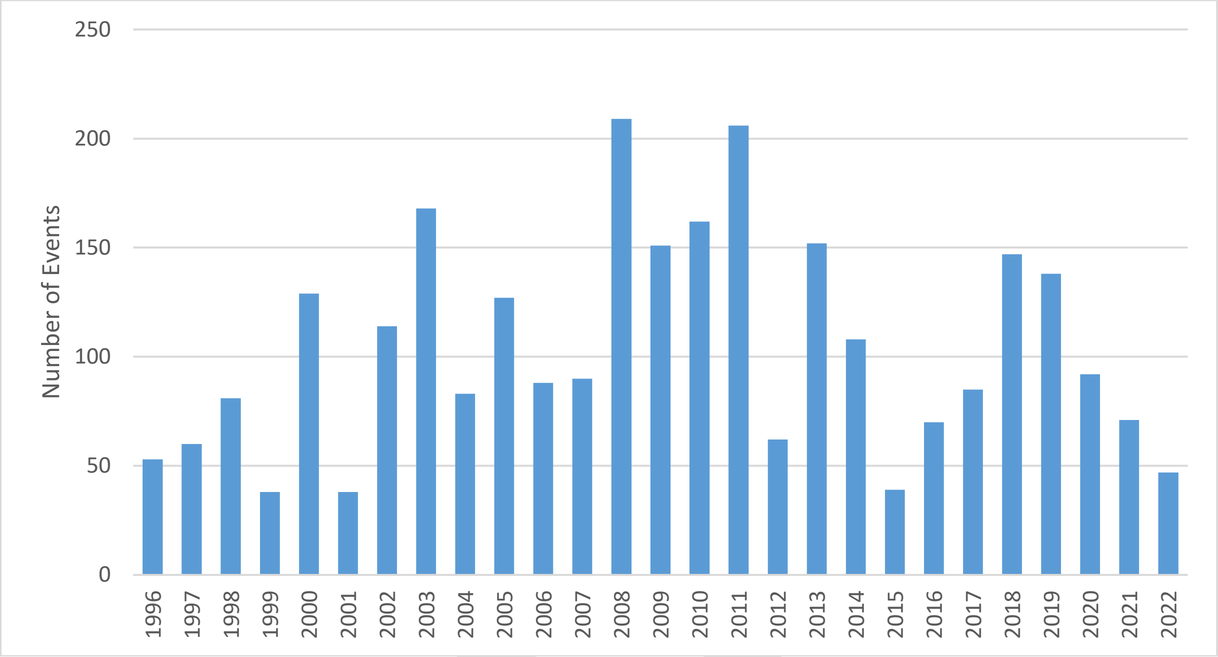
Figure 4-55 NRI Annualized Frequency of Winter Weather Events by County



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

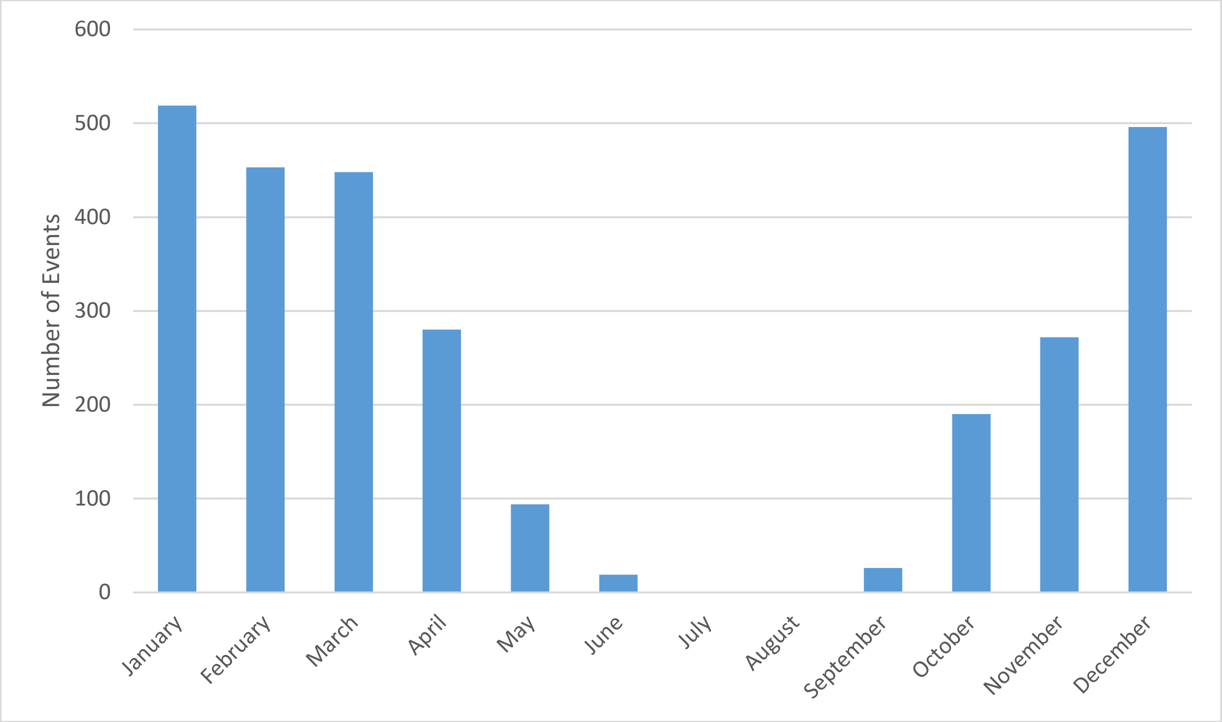
Figure 4-56 displays the yearly trend of severe winter weather event from 1996 to March of 2022 and Figure 4-57 displays the monthly trend of severe winter weather events in the Eastern Region. There is evident variation in the frequency of events between years in the Region. While most events occur from November to April, severe winter weather has been recorded in the region in September and June.

Figure 4-56 Yearly Trend of Winter Weather Events in the Eastern Region (1996-2022)



Source: NCEI, Chart by WSP

Figure 4-57 Monthly Trend of Winter Weather Events in the Eastern Region (1996-2022)



Source: NCEI, Chart by WSP

Climate Change Considerations

The 2018 Montana SHMP states that the frequency of severe weather events has increased steadily over the last century. The number of weather-related disasters during the 1990s was four times that of the 1950s and cost 14 times as much in economic losses. Historical data shows that the probability of severe weather events increases in a warmer climate. There has been a sizable upward trend in the number of storms causing large financial and other losses. Climate change presents a challenge for risk management associated with severe weather.

Montana has seen an uptick in the State's average temperature of about 2 degrees F in the last 50 years, while precipitation has stayed largely the same. At the same time, temperatures at the extremes – the absolute coldest and absolute warmest temperatures of the year have shifted upwards by about 10 degrees for the absolute low, with more days falling into the hotter extreme as well (Independent Record, Temps Getting Warmer, Nobel-Winning Scientist Says, March 6, 2018).

Changing extremes in precipitation are projected across all seasons, including higher likelihood of both increasing heavy rain and snow events. Winter and spring precipitation is projected to increase in the northern states of the Great Plains, relative to the 1971-2000 average. Winter storms have increased in frequency and intensity since the 1950s, and their tracks have shifted northward over the US. Projected changes in summer and fall precipitation are small, however, the number of days with heavy precipitation is expected to increase by mid-century. An increase in moisture in snow can also lead to an increase in property damage due to the weight of the snow on structures.

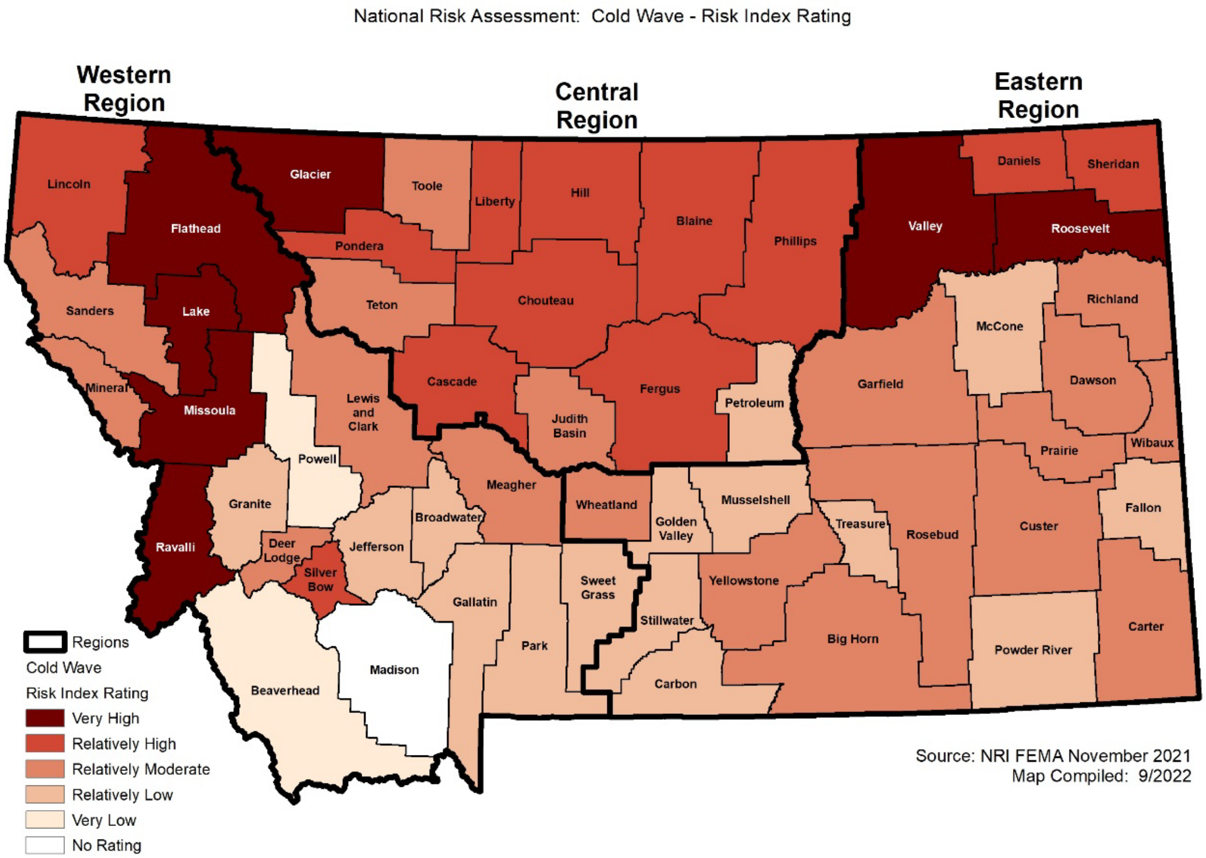
Potential Magnitude and Severity

The 2018 Montana SHMP explains that the magnitude of severe weather is measured by the severity of the event and the resulting damage. Winter storms are generally slow in developing and advance notice often lessens their effects on the population. Severe winter weather that results in loss of life, extended road closures, long-term power outages, or significant isolation problems represent high-magnitude weather events for Montana. Routine damages to property are largely due to frozen pipes. Collapsed roofs from snow loads are not common due to the low percent moisture in typical snow loads. In the Eastern Region, millions of dollars have been lost in property damage, in addition to the loss of life and several injuries, most of which occurred from a transportation accident due to severe winter weather. Several disaster declarations were issued in the Eastern Region due to severe winter storms on December 6, 2000, May 28, 2001 and June 13, 2008. In the Eastern Region, NCEI reported 13 deaths, 14 injuries, and almost $9.4 million in property losses; therefore, magnitude of severe winter weather is ranked as **Critical**.

Vulnerability Assessment

The figure below illustrates the relative RI rating due to cold for Montana counties based on data in the NRI. The NRI calculation takes into account various factors, including the expected annual losses from these events, social vulnerability, and community resilience in each county across Montana. Valley and Roosevelt counties have a very high rating. Daniels and Sheridan counties have a relatively high rating. The rest of the counites are rated relatively moderate or relatively low.

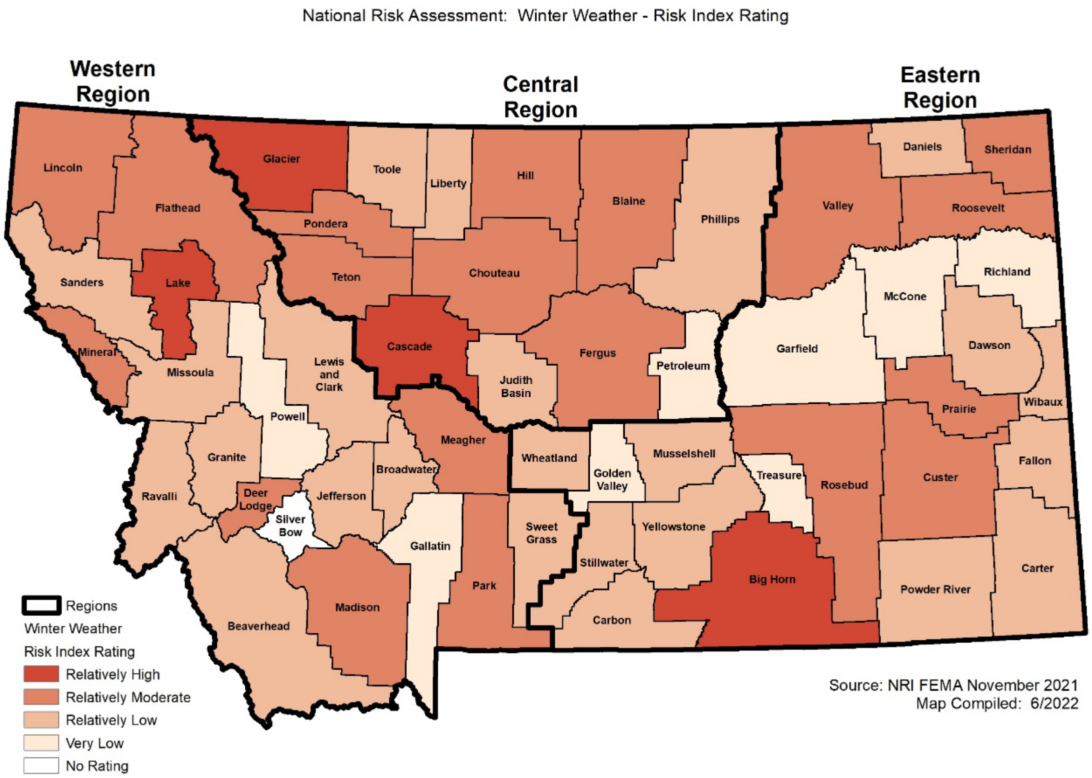
Figure 4-58 NRI Risk Index Rating for Cold



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

The figure below illustrates the relative RI rating due to winter weather for Montana counties based on data in the NRI. Most counties in the region have a very low to relatively moderate rating. Big Horn County is rated as relatively high.

Figure 4-59 NRI Risk Index Rating for Winter Weather



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

People

Major problems typically only occur during record snowfalls and extended periods of below-zero temperatures. Initial consequences include threats to vulnerable populations from utility interruption, freezing pipes, and snow removal costs. Individuals who depend on electricity are vulnerable during blackouts caused by severe winter weather. People without appropriate shelter or who work outside are more vulnerable to cold-related illnesses. The NCEI reported 13 deaths and 14 injuries due to severe winter weather events. In most cases of injury or death reported by the NCEI database due to winter weather events, the impacted individuals were on the road during a severe winter weather event and suffered injuries due to an accident. There were cases of death where the victims died due to hypothermia caused by cold wind chill and blizzard events.

Property

All outdoor property is vulnerable to severe winter weather events. Accumulation of snow and ice on roofs can cause collapse, especially on old or poorly constructed facilities. Ice storms can coat the exterior of a facility and can cause superficial damages. Prolonged cold can cause significant damages to poorly insulated facilities. The NCEI database reported property losses in the Eastern Region were primarily due to downed powerlines and poles that resulted in widespread blackouts, as well as damages to cars from traffic accidents.

Critical Facilities and Lifelines

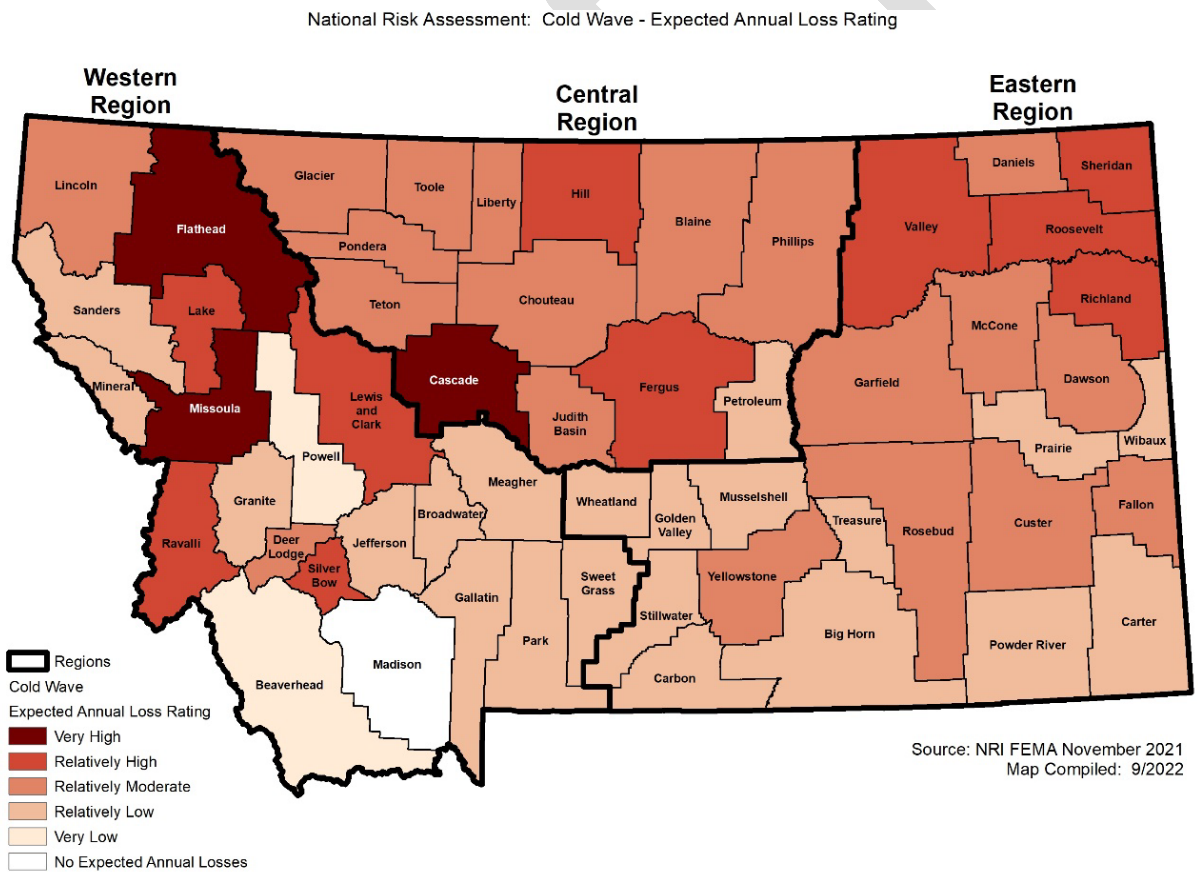
Winter weather can impact roads, decrease the speeds of vehicles, and create traffic jams. Blowing or drifting snow and ice can make it difficult for commuters to get to work and for emergency responders to reach areas in need. Overall, winter weather makes it difficult and dangerous for travel of any kind, which can lead to the isolation of groups of people who are vulnerable and stranded commuters. Additionally, the accumulation of snow and ice on powerlines can cause damages that result in power loss. A power outage in the winter months is increasingly dangerous during periods of extremely cold temperatures and wind chill.

Economy

Economic losses can result from business interruptions due to poor road conditions and/or power outages. Additionally, losses could result from damages due to power lines and roofs from the accumulation of heavy snow and ice. The NCEI reported almost $9.4 million in property losses in the Eastern Region.

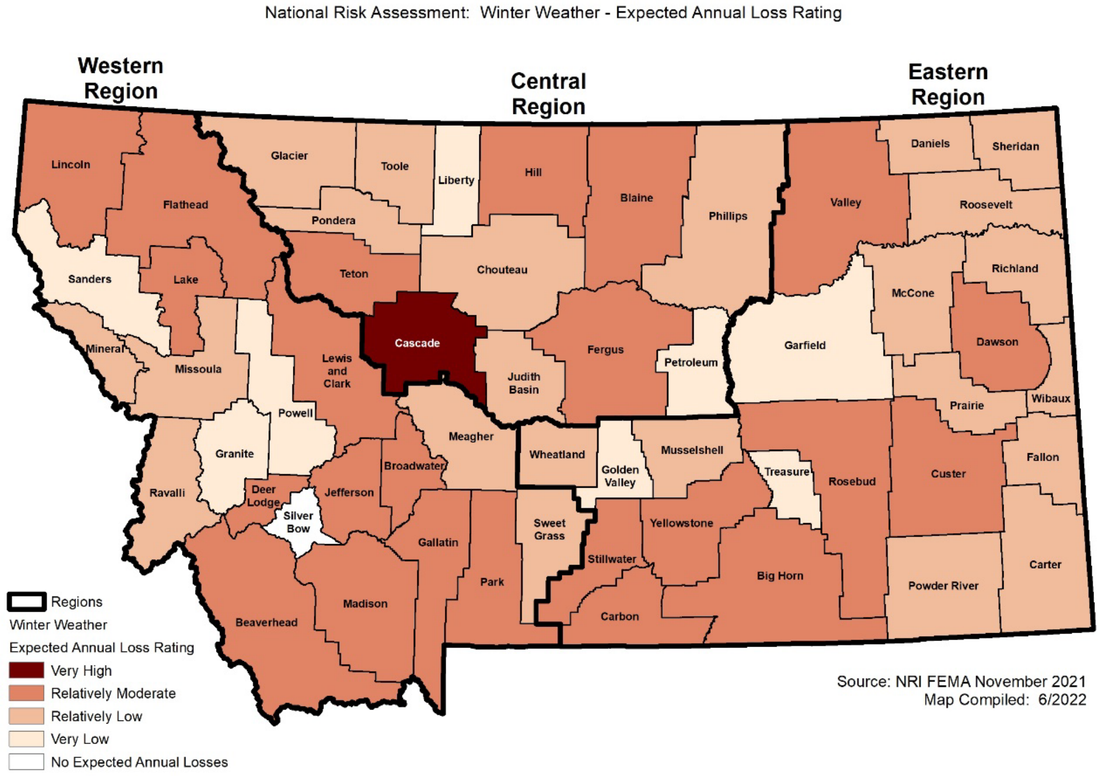
The figures below illustrate the relative risk of Expected Annual Loss (EAL) rating due to cold waves and winter weather for Montana counties based on data in the NRI. For cold waves, most counties in the region have a relatively low to relatively moderate rating; Valley, Roosevelt, Sheridan and Richland Counties are rated as relatively high. For winter weather, most counties have a relatively low to relatively moderate rating. Garfield, Golden Valley and Treasure Counties are rated as very low. The EAL calculation takes into account agriculture value exposed, annualized frequency of events, and historical loses.

Figure 4-60 NRI Expected Annual Loss Rating from Cold Waves



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Figure 4-61 NRI Expected Annual Loss Rating from Winter Weather



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Historic and Cultural Resources

Like general property, heavy snow and ice could cause damages to historic buildings, especially those that are in poor condition or not built to code. Historic buildings are less likely to be built with proper insulation to protect property and people inside from extreme cold temperatures and wind chill.

Natural Resources

Trees, landscaping, and crops can be damaged due to prolonged periods of extreme cold weather and the accumulation of snow and ice. Trees that break due to the weight of snow and ice have also been reported in the NCEI dataset.

Development Trends Related to Hazards and Risk

The 2018 Montana SHMP reports that Montana snow is generally dry and snow loads do not threaten roof collapse in most areas. However, the northwestern portion of the State where snow contains greater moisture content should consider building regulations that require a stricter design standard for flat roofs to ensure they can support maximum snow loads. The Statehas adopted the 2012 IBC. The IBC includes a provision that buildings must be constructed to withstand a wind load of 75 mph constant velocity and three-second gusts of 90 mph. Buildings must be designed to withstand a snow load of 30 pounds per square foot minimum.

Risk Summary

In summary, the Severe Winter Weather hazard is considered to be overall high significance for the Eastern Region. Variations in risk by jurisdiction are summarized in the table below, followed by key issues noted in the vulnerability assessment.

- Severe winter weather includes blizzards, cold/wind chill, heavy snow, ice storm, winter weather, and winter storm. The hazard significance rating for this hazard is a **Medium**
- These events can impact anywhere in the planning region; therefore, the hazard extent is rated as **Extensive**
- The NCEI data reported 1,738 days with severe weather events over 26 years, which averages to nearly 28 days a year with severe winter weather events in the Eastern Region; therefore, the future occurrence is rated as **Highly Likely**
- The NCEI reported 13 death, 14 injuries, and $9,359,700 in property damages, therefore the magnitude is rated as **Critical**
- People who are dependent on electricity and populations who work outdoors or in transportation are most vulnerable to severe winter weather events. People who do not have appropriate shelter or who live in homes without proper insulation from winter weather, such as homeless populations and those in mobile homes, are most vulnerable to winter weather.
- Power outages and poor road conditions are likely impacts of severe winter storms. Structures can collapse under the weight of snow and ice. Most property damage in the Region occurred due to car accidents because of poor road conditions from winter storms.
- Significant economic losses can occur from business and transportation disruptions, as well as from repairing damaged infrastructure
- Related hazards: Extreme Temperatures, Windstorms, Transportation Accidents

Table 4-43 Risk Summary Table: Severe Winter Weather

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	Medium		
Big Horn	Medium	Hardin, Lodge Grass	None
Carbon	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	None
Carter	Medium	Ekalaka	None
Crow Tribe	Medium		None
Custer	Medium	Ismay, Miles City	None
Daniels	Medium	Scobey, Flaxville	None
Dawson	Medium	Richey, Glendive	None
Fallon	Medium	Plevna, Baker	None
Garfield	Medium	Jordan	None
Golden Valley	Medium	Ryegate, Lavina	None
McCone	Medium	Circle	None
Musselshell	Medium	Roundup	None
North Cheyenne Tribe	Medium		None
Powder River	Medium	Broadus	None
Prairie	Medium	Terry	None
Richland	Medium	Fairview, Sidney	None
Roosevelt	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	None
Rosebud	Medium	Colstrip, Forsyth	None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Sheridan	Medium	Outlook, Westby, Plentywood, Medicine Lake	None
Stillwater	Medium	Columbus	None
Treasure	Medium	Hysham	None
Valley	Medium	Fort Peck, Glasgow, Nashua, Opheim	None
Wheatland	Medium	Harlowton, Judith Gap	None
Wibaux	Medium	Wibaux	None
Yellowstone	Medium	Billing, Laurel, Broadview	Likely greater risk due to presence of more property and infrastructure vulnerable to winter weather.

4.2.12 Human Conflict

Hazard/Problem Description

Human conflict includes terrorism, active shooters, and civil unrest. Descriptions of these hazards are presented below:

Terrorism

The FBI defines terrorism, domestic or international, as the unlawful use of force or violence against persons or property to intimidate or coerce a government or civilian population in furtherance of political or social objectives. The US State Department designates 72 groups as Foreign Terrorist Organizations around the world. There is no similar list of domestic terrorist groups. The Global Terrorism Database (GTD) maintained by the National Consortium for the Study of Terrorism and Responses to Terrorism lists 241 groups known or suspected of carrying out terrorist attacks on US soil since 1970.

Incidents involving weapons of mass destruction (WMDs) are a special subset of terrorism and mass violence incidents. Such incidents may involve chemical, biological, radioactive, nuclear, or explosive (CBRNE) weapons with the potential to cause high numbers of injuries or fatalities.

Historically explosives have been the most common terrorist weapon, accounting for 51% of all attacks since 1970. Hazard impacts are typically instantaneous; secondary devices may be used, lengthening the duration of the hazard until the attack site is determined to be clear. The extent of damage is determined by the type and quantity of explosive. Effects are generally static other than cascading consequences and incremental structural failures. Some areas could experience direct weapons' effects: blast and heat; others could experience indirect weapons' effect.

Biological terrorism is the use of biological agents against persons or property. Liquid or solid contaminants can be dispersed using sprayers/aerosol generators or by point of line sources such as munitions, covert deposits and moving sprayers. Biological agents vary in the amount of time they pose a threat. They can be a threat for hours to years depending upon the agent and the conditions in which it exists.

Another type of biological attack is agroterrorism, directed at causing societal and economic damage through the intentional introduction of a contagious animal disease or fast-spreading plant disease that affects livestock and food crops and disrupts the food supply chain. Such an attack could require the agriculture industry to destroy livestock and food crops, disrupt the food supply both nationally and globally, and could also affect consumer confidence in the food supply resulting in tremendous economic damage for potentially an extended period.

Chemical terrorism involves the use or threat of chemical agents against persons or property. Effects of chemical contaminants are like biological agents. Radiological terrorism is the use of radiological materials against persons or property. Radioactive contaminants can be dispersed using sprayers/aerosol generators, or by point of line sources such as munitions, covert deposits and moving sprayers or by the detonation of a nuclear device underground, at the surface, in the air or at high altitude.

Active Shooter

The FBI defines an active shooter as one or more individuals actively engaged in killing or attempting to kill people in a populated area. Implicit in this definition is the shooter's use of one or more firearms. The "active" aspect of the definition inherently implies the ongoing nature of the incidents, and thus the potential for the response to affect the outcome. Typically, active shooters are not interested in taking hostages or attaining material gain, and frequently are not even interested in their own survival. Unlike organized terrorist attacks, most active shooter incidents are carried out by one or two individuals. School shootings are a special subset of active shooter incidents.

The US Department of Homeland Security notes that "in most cases, active shooters use firearms(s) and there is no pattern or method to their selection of victims…situations are unpredictable and evolve quickly…and are often over within 10 to 15 minutes." However, the presence or suspected presence of secondary devices can lengthen the duration of the event until the attack site is determined to be clear. Although this definition focuses on an active shooter, the elements remain the same for most active threat situations.

Civil Unrest

The federal law defines civil disorder, or civil unrest, as "any public disturbance involving acts of violence by assemblages of three or more persons, which causes an immediate danger of or results in damage or injury to the property or person of any other individual" (18 U.S. Code 232). FEMA noted that civil unrest can be triggered by a variety of reasons, including "disputes over exploitation of workers, standard living conditions, lack of political representation, poor health care and education, lack of employment opportunities, and racial issues" (FEMA 1993).

Geographical Area Affected

Although human conflict events can occur anywhere in the Eastern Region, individual events will typically only impact localized cities. Past events indicate that the reported terrorist attack and civil unrest events in the Eastern Region have been concentrated to eight (8) cities in the Region listed below. Therefore, geographic extent of these events is rated as **significant**.

- Rosebud County
  – Lame Deer
- Custer County
  – City of Miles City
- Carbon County
  – Town of Joliet
  – City of Red Lodge
- Big Horn County

- Crow Agency
- City of Hardin

- Yellowstone County

- City of Billings
- City of Laurel

Acts of terrorism are typically a pre-meditated, targeted attack on a specific place or group such as religious or ethnic groups or sites of significant economic, strategic, military, or cultural significance. Consequently, areas of higher risk include densely populated cities and counties and military facilities. Large venue events, such as a sporting event attended by tens of thousands of people might be considered a desirable target. Again, such events typically occur in densely populated areas since those areas can provide the infrastructure support (hotels, eateries, etc.) for large numbers of people. Even a small-scale terrorist incident in one of these locations would likely cause cascading impacts to the communities in Eastern Montana. Like terrorist attacks, active shooter incidents most frequently occur in high-population areas. The FBI report Active Shooter Incidents, 20-Year Review from 2000-2019 found that 29% of active shooter incidents in the U.S. occur in businesses open to pedestrians, 15% in open spaces, 13% in schools (Pre-K-12), and 12% in businesses closed to pedestrians.

Civil unrest, such as protests and demonstrations, can also occur anywhere. The 2020 George Floyd protests occurred in cities across the United States and even extended to other counties across the world. Highly populated cities are more likely to see large protests that can turn violent and result in property damage and death. Protests can also be localized to a single city or organization.

Past Occurrences

Terrorism

The GTD catalogues more than 200,000 domestic and international terrorist attacks from 1970 to 2020. Table 4-46 displays a list of the GTD reported seven events that have occurred in the State of Montana since 1970. Of the seven terrorist attack events reported in Montana, one occurred in the Eastern Region. This terrorist attack occurred in the City of Billings (Yellowstone County) on March 15, 1970, and was aimed at the police. No injuries or deaths were recorded. These events are listed in Table 4-46:

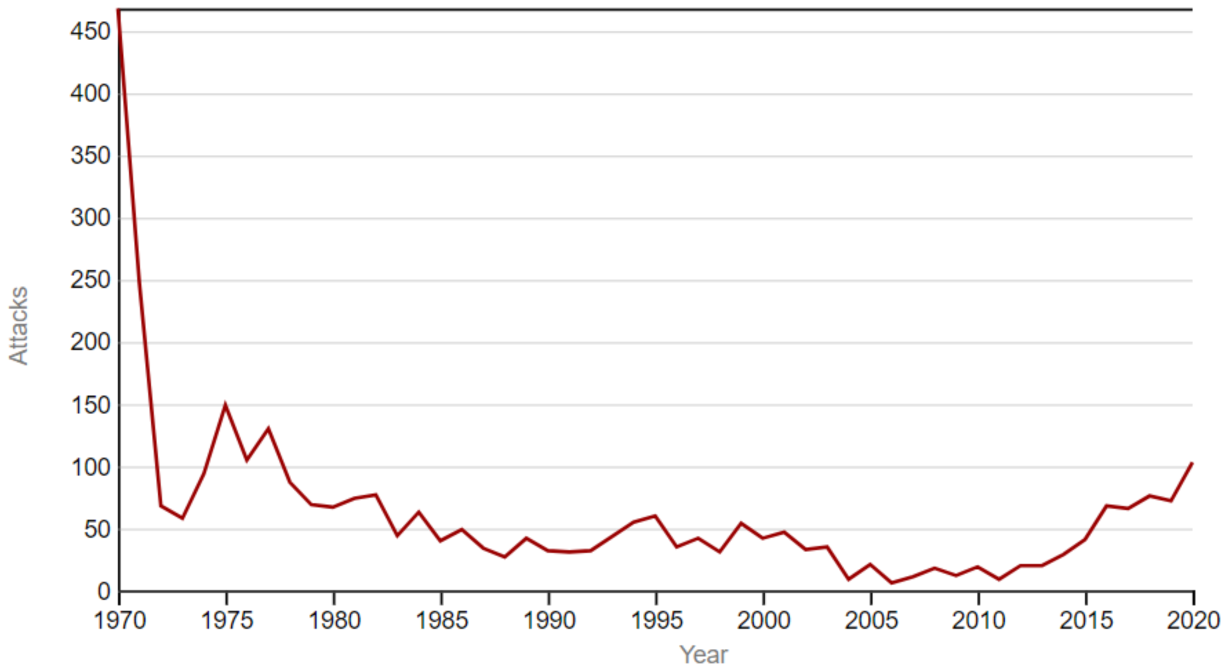
Table 4-44 Terrorist Attacks in the State of Montana 1970-2020

Date	City	Perpetrator Group	Fatalities	Injuries	Target Type
2017-05-16	Three Forks	Anti-Police extremists	2	5	Police
1997-04-02	Bozeman	Anti-Abortion extremists	0	0	Abortion Related
1994-10-11	Kalispell	Anti-Abortion extremists	0	0	Abortion Related
1994-01-00	Helena	Anti-Abortion extremists	0	0	Abortion Related
1992-01-18	Helena	Anti-Abortion extremists	0	0	Abortion Related
1987-04-19	Missoula	Aryan Nation (suspected)	0	0	Police
1970-03-15	Billings	Unknown	0	0	Police

Source: *GTD 1970-2020*

As shown in Figure 4, GTD data shows that there was an overall decreasing trend in the number of terrorist attacks from 1970 to 2005. However, since 2010, there has been an uptake in the number of terrorist attacks in the United States once again.

Figure 4-62 Terrorist Attacks on US Soil, 1970-2020



Source: GTD, https://www.start.umd.edu/gtd/

The increase in attacks over the last decade has been driven primarily by domestic, not international, terrorism. A domestic terrorist attack is a terrorist attack in which victims "within a country are targeted by a perpetrator with the same citizenship as the victims" (Predicting Malicious Behavior: Tools and Techniques for Ensuring Global Security). A recent report by the Center for Strategic and International Studies records 980 domestic terrorist attacks in the US since 1994, with sharp growth over the last 10 to 15 years. Figure 4-63 shows the increase in domestic terrorist attacks from 1994 to 2021 broken down by the ideology of the attacker. As shown in the chart, the rise in domestic terrorist attacks since 2015 has been largely driven by violent far-right groups. Data for 2021 was not complete at the time of this risk assessment, and this explains the drop in attacks shown for that year.

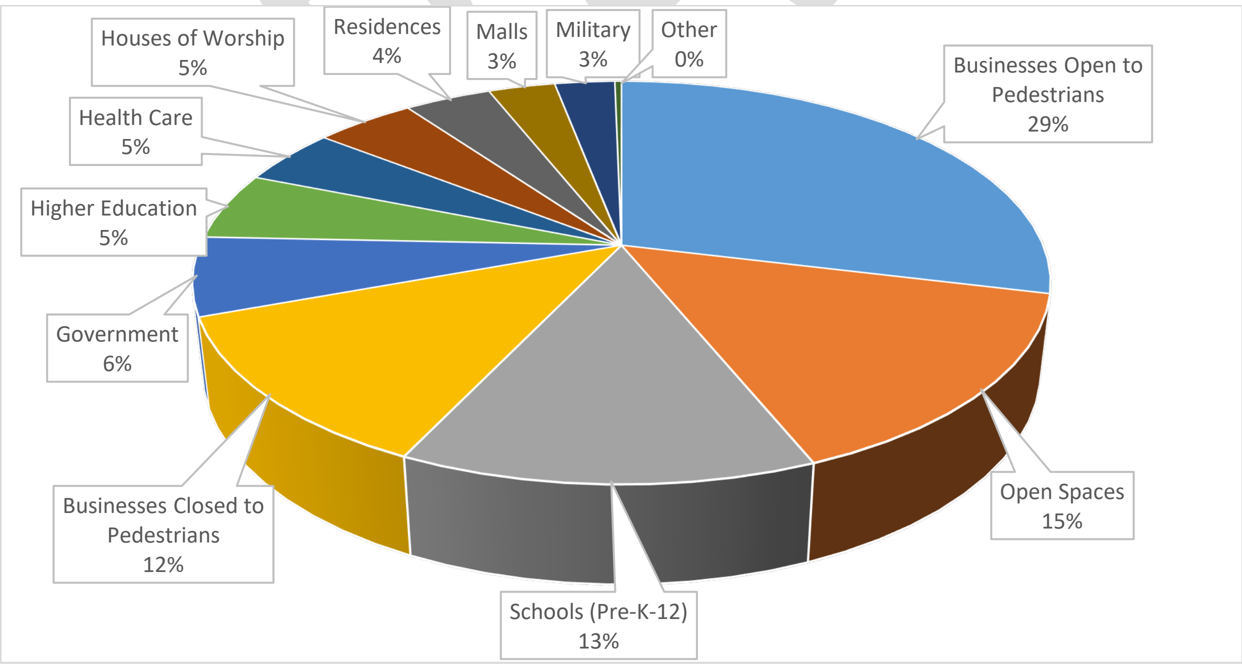
Figure 4-63 Domestic Terrorist Attacks in the US, 1994-2021

Source: Center for Strategic and International *Studies*

Active shooters

The FBI reported 434 active shooter incidents from 2000 to2021 in the United States: 333 of these events occurred between 2000 to2019 and were reported in the FBI 20-year active shooter review. Figure 4 shows the location of where these incidents took place. The FBI reported an additional 40 incidents in 2020 and 61 incidents in 2021. While none of these 434 incidents took place in the State of Montana, trends from past events can be used to predict the likelihood of future events.

Figure 4-64 Active Shooter Incident Locations, 2000-2019



Source: FBI report Active Shooter Incidents, 20-Year Review 2000-2019

Civil Unrest

Count Love is an open-source database containing a comprehensive list of U.S. protests from January 20th, 2017, to January 21st, 2021. The dataset reported 27,270 protests across 4,042 cities in the United States. In Montana alone, 293 protests were reported across the State: 228 in the Western Region, 42 in the Eastern Region, and 23 in the Eastern Region. Table 4-47 provides details on these events. 5,178 people attended these protests in total.

Table 4-45 Protests in the Eastern Region, Jan. 2017 – Jan. 2021

Date	City	County	Attendees	Event
1/26/2021	Billings	Yellowstone	30	Civil Rights
1/6/2021	Billings	Yellowstone	50	Executive
8/29/2020	Hardin	Big Horn		Other
8/16/2020	Red Lodge	Carbon	200	Other
7/30/2020	Billings	Yellowstone	100	Other
6/7/2020	Billings	Yellowstone	1300	Racial Injustice
5/30/2020	Billings	Yellowstone	50	Racial Injustice
4/19/2020	Billings	Yellowstone	100	Healthcare
2/24/2020	Hardin	Big Horn		Other
12/17/2019	Billings	Yellowstone		Executive
9/23/2019	Hardin	Big Horn	100	Other
8/29/2019	Hardin	Big Horn	100	Other
6/12/2019	Billings	Yellowstone	20	Civil Rights
5/21/2019	Billings	Yellowstone	60	Civil Rights
5/21/2019	Billings	Yellowstone	10	Civil Rights
4/5/2019	Billings	Yellowstone	400	Other
2/26/2019	Billings	Yellowstone		Education
2/26/2019	Miles City	Custer		Education
2/14/2019	Lame Deer	Rosebud		Other
1/19/2019	Billings	Yellowstone		Civil Rights
12/31/2018	Lame Deer	Rosebud	100	Other (Criminal Justice)
11/1/2018	Crow Agency	Big Horn		Legislative
10/31/2018	Miles City	Custer	5	Healthcare
9/6/2018	Billings	Yellowstone	50	Executive
7/25/2018	Billings	Yellowstone	20	Executive
6/30/2018	Billings	Yellowstone	100	Immigration (Families Belong Together)
6/26/2018	Billings	Yellowstone	60	Civil Rights (Pro-Choice)
6/9/2018	Billings	Yellowstone	150	Healthcare (Opioid Epidemic)
4/7/2018	Billings	Yellowstone	100	Guns (Second Amendment)
3/24/2018	Billings	Yellowstone	3	Guns
3/24/2018	Billings	Yellowstone	400	Guns (March for Our Lives)
3/14/2018	Billings	Yellowstone		Guns (National Walkout Day)
1/26/2018	Billings	Yellowstone		Education (School Choice)
1/20/2018	Billings	Yellowstone	1000	Civil Rights (Women's March)
1/20/2018	Miles City	Custer	60	Civil Rights (Women's March)
9/5/2017	Billings	Yellowstone	10	Immigration
6/17/2017	Billings	Yellowstone	200	Civil Rights (Pride)
5/12/2017	Billings	Yellowstone	100	Executive

Date	City	County	Attendees	Event
4/29/2017	Billings	Yellowstone	100	Environment (People's Climate March)
4/21/2017	Billings	Yellowstone	50	Executive
3/28/2017	Laurel	Yellowstone	100	Education (Principal Fired)
1/21/2017	Miles City	Custer	50	Civil Rights (Women's March)

Source: https://countlove.org/

Frequency/Likelihood of Occurrence

The probability of a terrorist attack, active shooter attack, and civil unrest can be difficult to quantify, largely due to different definitions and data collection methods. In Montana, seven terrorist attacks have been reported in the State since 1970, only one of which took place in the Eastern Region. The FBI recorded 434 active shooter incidents from 2000 to2021, none of which occurred in the State. While both terrorist attack and active shooter attacks are rare in Montana, civil unrest is a more common occurrence. Over the course of 4 years from 2017 to 2021, 42 protest events were recorded in the Eastern Region of Montana, most of which occurred in the City of Billings. This averages out to about 10 or 11 protests per year in the Eastern Region. Based on the limited number of past events, the likelihood of these events is **Occasional**.

Climate Change Considerations

Climate change has the potential to impact terrorism and civil unrest in the future. Extreme weather has been known to worsen social tensions, poverty, and hunger. Social instability and global conflict brought on by climate change could result in an increase in the number of both domestic and international terrorist attacks and civil unrest. While it is unlikely that climate change will have a significant impact on human conflict in the Eastern Region of Montana, if conditions continue to worsen, it is possible in the future.

Potential Magnitude and Severity

The severity of these incidents can be measured in multiple ways including length of incident, fatalities, casualties, witnesses, and number of perpetrators. Although an active threat may only directly impact one specific piece of infrastructure (e.g., a school, theater, or concert venue), it indirectly impacts the community in many ways, including ongoing closures for investigation, local and national media logistics, VIP visits, mental health concerns, need for additional support services, avoidance of similar infrastructure, and subsequent impacts to businesses. The psychological impact is often much worse than the direct impacts and can continue to affect a community for years. Thus, the overall significance of this hazard is **Critical**.

Terrorism

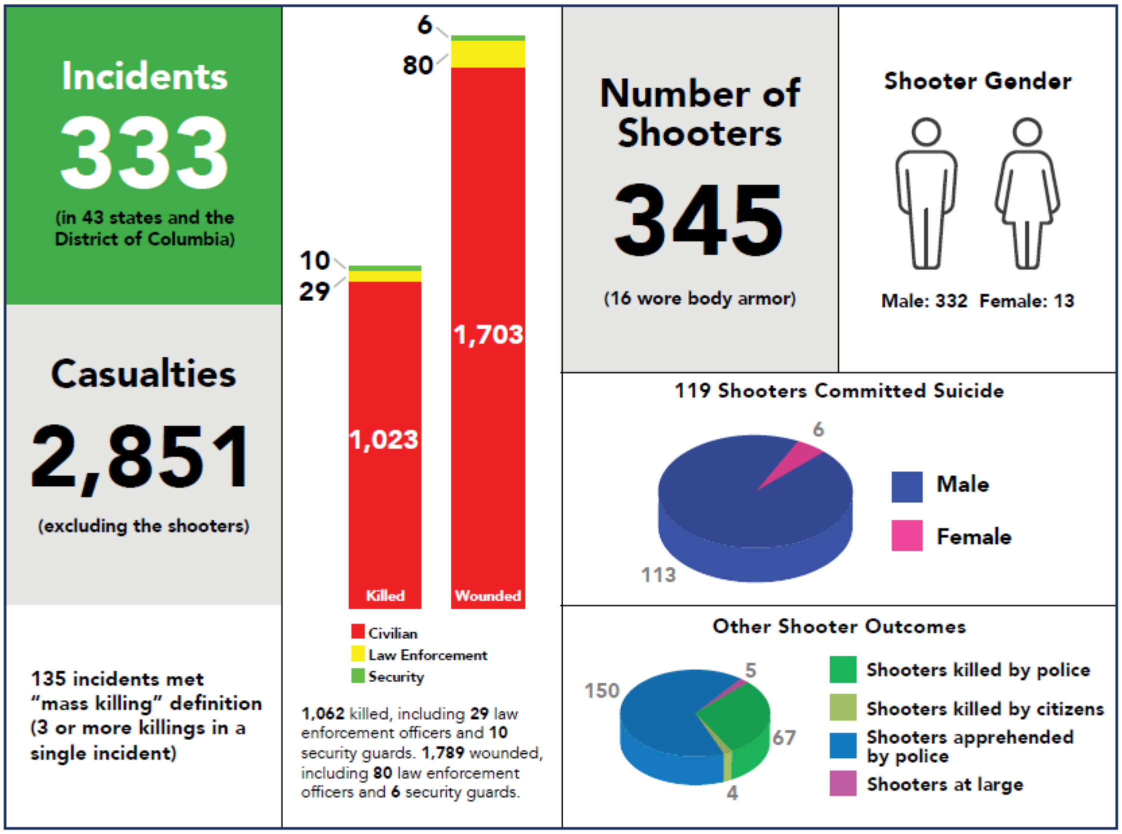
The GTD catalogues more than 200,000 terrorist attacks between 1970 and 2020 (the most recent year the GTD has analyzed). Those incidents averaged roughly one fatality and five injuries per incident. However, this data is to a large extent skewed by a handful of deadly attacks. These five attacks account for 64% of the fatalities and 87% of the injuries from terrorist attacks in the US:

- **September 11, 2001**, attacks on New York and Washington, DC, which killed 1,385 and injured 10,878 – more than all other terrorist attacks in the US since 1970 combined.
- **October 1, 2017,** shooting at the Route 91 Harvest Festival concert in Las Vegas, Nevada, which killed 59 and wounding 851.
- **April 4, 2013,** Boston Marathon Bombing killed three and injured 264.
- **April 19, 1995**, bombing of the Murrah Federal Building in Oklahoma City, killing 168 and injuring 650.
- **September–October 1984** salmonella food poisoning attack in Dalles, Oregon, which sickened 751 people.

Active Shooter

Figure 4 summarizes the outcomes of 333 active shooter incidents in the US from 2000 to2019 studied by the FBI. Casualties for active shooter incidents vary widely, with 2,851 casualties from 333 incidents, averaging over 8 deaths per incident.

Figure 4-65 Active Shooter Incident Outcomes, 2000-2019



Source: FBI report Active Shooter Incidents, 20-Year Review 2000-2019

Civil Unrest

Civil unrest resulting in large scale protests and demonstrations can have significant impacts to people and infrastructure in a community. The U.S. Crisis Monitor is a database to facilitate efforts in tracking, preventing, and mitigation political violence in America in partnership with the Armed Conflict Location and Event Data Project (ACLED). The U.S. Crisis Monitor reported that in 2020, 11 people in the United States were killed while participating in political demonstrations and another 14 died in incidents linked to political unrest. Property damage, such as broken windows and vandalism, are also commonly reported during violent protests in the United States.

Vulnerability Assessment

People

Most terrorist attacks are primarily intended to kill and injure as many people as possible. Physical harm from a firearms attack or explosive device is not completely dependent on location, but risk is greater in areas where higher numbers of people gather. If a biological or chemical agent were released indoors, it could result in exposure to a high concentration of pathogens, whereas an outdoors release could affect many more people but probably at a lower dose. Symptoms of illness from a biological or chemical attack could go undetected for days or even weeks. Local healthcare workers may observe a pattern of unusual illness or early warning monitoring systems may detect airborne pathogens. People could also be affected by an attack on food and water supply. In addition to impacts on physical health, any terrorist attack would likely cause significant stress and anxiety.

Similarly, most active shooters primarily target people, attempting to kill or injure large numbers of individuals. The number of injuries and fatalities are highly variable, dependent on many factors surrounding the attack including the location, the number of type of weapons used, the shooter's skill with weapons, the amount of people at the location, and law enforcement response time. Psychological effects of the incident, on not only victims and responders but also the public, may last for years. Civil unrest and large political demonstrations can also result in death or injuries to protestors, responders, and community members.

Property

The potential for damage to property is highly dependent on the type of attack. Terrorist attacks involving explosives or other weapons, may damage buildings and infrastructure. For most attacks, impacts are highly localized to the target of the attack, although attacks could potentially have much broader impacts. Active shooter incidents rarely result in significant property damage, although crime scene measures may deny the use of targeted facilities for days after the incident. Civil unrest can result in damaged property such as broken windows, vandalism, damaged vehicles, stolen property, and fires.

Critical Facilities and Lifelines

Impacts to critical infrastructure would depend on the site of the attack. Short or long-term disruptions in operations could occur, as well as gaps in continuity of business or continuity of government, depending on who the victims of the attack are, and whether a continuity plan is in place. While active shooter incidents rarely cause major property damage directly, indirect effects can be significant, such as the loss of critical facilities for days or weeks due to crime scene concerns. Terrorists could disrupt communication and electric systems through cyber-attacks. Additionally, terrorism, active shooter incidents, and civil unrest can result in a drain on first responder resources and personnel for days to weeks following the incident.

Economy

Active shooter or terrorist incidents could have significant economic impacts. Specific examples could include short-term or permanent closing of the site of the attack. Another economic impact could be caused by general fear – as an example, an attack in a crowded shopping center could cause potential patrons to avoid similar places and disrupt economic activity. Potential economic losses could include cost of repair or replacement of damaged facilities, lost economic opportunities for businesses, loss of food supplies, disruption of the food supply chain, and immediate damage to the surrounding environment.

As an extreme example, after the September 11, 2001, terrorist attacks in New York and Washington the U.S. stock market lost $1.4 trillion, the Gross Domestic Product of New York City lost an estimated $27 billion, and commercial air travel decreased by 20%.

Historic and Cultural Resources

Terrorists have been known to target sites with historic or cultural significance. Civil unrest and protests also frequently target historically or politically significant areas, such as capital buildings, which can be damaged during a civil unrest event if a protest turns violent. Additionally, active shooters can target cultural significant areas if the motive is for religious or political reasons.

Natural Resources

Generally, active shooter incidents would not have an impact on the natural environment. Agro-terrorism or chemical terrorism could result in significant damage to the environment in areas near the attack. These events can pollute the environment and cause nearby plants and animals to get sick or die. Contaminated material that gets into the air or water supply can affect humans further away from the incident site.

Development Trends Related to Hazards and Risk

The link between increased development and terrorist attacks is uncertain at best. Many terrorist attacks have targeted larger metropolitan areas, so a larger population could potentially make public events more attractive targets. Population growth and development could expose more people and property to the impacts of an explosive or other large-scale attack.

Depending on the motivation behind the attack, incidents will most likely be focused on so-called "soft targets." Protective design of buildings can reduce the risk of an active shooter incident, and if one occurs, can mitigate, or reduce the impacts and number of potential victims.

Risk Summary

In summary, the human conflict hazard is overall **Medium** significance for the Region. Variations in risk by jurisdiction are summarized in the table below, followed by key issues noted in the vulnerability assessment.

- There were no recorded incidents of active shooters , one recorded terrorist attack, and forty-two (42) recorded civil unrest cases in the Eastern Region, most of which occurred in Billings; therefore, the ranking of frequency for human conflict is rated as **occasional**
- Based on potential for death, injury, and significant damage to critical infrastructure and property, magnitude is ranked as **critical**
- Although human conflict events can occur anywhere in the Region, individual events will typically only impact localized cities. Past events indicate that these events in the Eastern Region have primarily occurred in 8 cities in the Region; therefore, geographic extent of these events is rated as **significant**
- Impacts on people from human conflict include injury and death, as well as psychology damage from being in an incident
- Impacts on property include vandalism, theft, and damage. Total destruction of property is possible in the case of an extreme terrorist attack.
- Significant economic damages are possible in the case of a significant terrorist attack due to repairs and business closures
- In a severe human conflict case, it would be possible for significant disruption of critical facilities including loss of power, transportation interruptions, and disruption of first responders
- Unique jurisdictional vulnerability: the City of Billings experienced a disproportionate amount of civil unrest
- Related Hazards: Cyber-attack

Table 4-46 Risk Summary Table: Human Conflict

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?	Notes
Eastern Region	Medium			
Big Horn	Medium	Hardin, Lodge Grass	Miles City had four documented civil unrest cases; Lodge Grass had none	
Carbon	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	Joliet had one documented civil unrest incident	
Carter	Medium	Ekalaka	N/A	
Crow Tribe	Medium		N/A	
Custer	Medium	Ismay, Miles City	Miles City had four documented civil unrest cases, Ismay had none	
Daniels	Medium	Scobey, Flaxville	None	
Dawson	Medium	Richey, Glendive	None	

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?	Notes
Fallon	Medium	Plevna, Baker	None	
Garfield	Medium	Jordan	N/A	
Golden Valley	Medium	Ryegate, Lavina	None	
McCone	Medium	Circle	N/A	
Musselshell	Medium	Roundup	N/A	
North Cheyenne Tribe	Medium		N/A	
Powder River	Medium	Broadus	N/A	
Prairie	Medium	Terry	N/A	
Richland	Medium	Fairview, Sidney	None	
Roosevelt	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	None	
Rosebud	Medium	Colstrip, Forsyth	Lame Deer had two civil unrest cases, neither Colstrip nor Forsyth had documented human conflict	
Sheridan	Medium	Outlook, Westby, Plentywood, Medicine Lake	None	
Stillwater	Medium	Columbus	N/A	
Treasure	Medium	Hysham	N/A	
Valley	Medium	Fort Peck, Glasgow, Nashua, Opheim	None	
Wheatland	Medium	Harlowton, Judith Gap	None	
Wibaux	Medium	Wibaux	N/A	
Yellowstone	High	Billing, Laurel, Broadview	Billings experienced more than half of the total civil unrest incidents in the Region and the only terrorist attack, Laurel had one documented civil unrest incident	

4.2.13 Tornadoes & Windstorms

Hazard/Problem Description

Windstorms

Windstorms represent the most common type of severe weather. Often accompanying severe thunderstorms (convective windstorms), they can cause significant property and crop damage, threaten public safety, and disrupt utilities and communications. Straight-line winds are generally any wind not associated with rotation and in rare cases can exceed 100 miles per hour (mph). The NWS defines high winds as sustained wind speeds of 40 mph or greater lasting for one hour or longer, or winds of 58 mph or greater for any duration. Windstorms are often produced by super-cell thunderstorms or a line of thunderstorms that typically develop on hot and humid days. According to the 2018 SHMP, high winds can occur with strong pressure gradients or gusty frontal passages. These winds can affect the entire State with wind speeds of more than 75-100 mph.

For this hazard, three different classifications of windstorms were analyzed: high winds, strong winds, and thunderstorm winds. The most significant distinction between high winds and thunderstorm winds in the NCEI dataset is that high winds are most frequently reported in the winter months (December, January, and February) and are recorded on a zonal scale, whereas thunderstorm winds are most reported in the summer months (June, July, and August) and recorded on a local county or city scale. Strong winds are another type of windstorm, which originates from thunderstorms and are any wind exceeding 58 mph. Strong winds are the least frequently documented category of wind in the Eastern Region. Despite these differences, the wind speeds and associated impacts from these winds are comparable.

Tornadoes

Tornadoes are one of the most destructive types of severe weather. According to the 2018 SHMP, a tornado is a violently rotating column of air in contact with the ground and extending from the base of a thunderstorm. Until 2006, tornadoes were categorized by the Fujita scale based on the tornado's wind speed. The Enhanced Fujita (EF) Scale was implemented in place of the Fujita scale and began operational use on February 1, 2007. The EF scale has six categories from zero to five representing increasing degrees of damage. It was revised to better align wind speeds closely with associated storm damage. It also adds more types of structures as well as vegetation, expands degrees of damage, and better accounts for variables such as differences in construction quality. The EF-scale is a set of wind estimates based on damage. It uses three-second estimated gusts at the point of damage. These estimates vary with height and exposure. Forensic meteorologists use 28 damage indicators and up to 9 degrees of damage to assign estimated speeds to the wind gusts. Table 4-49 describes the EF-scale ratings versus the previous Fujita Scale used prior to 2007 (NOAA 2007).

Table 4-47 The Fujita Scale and Enhanced Fujita Scale

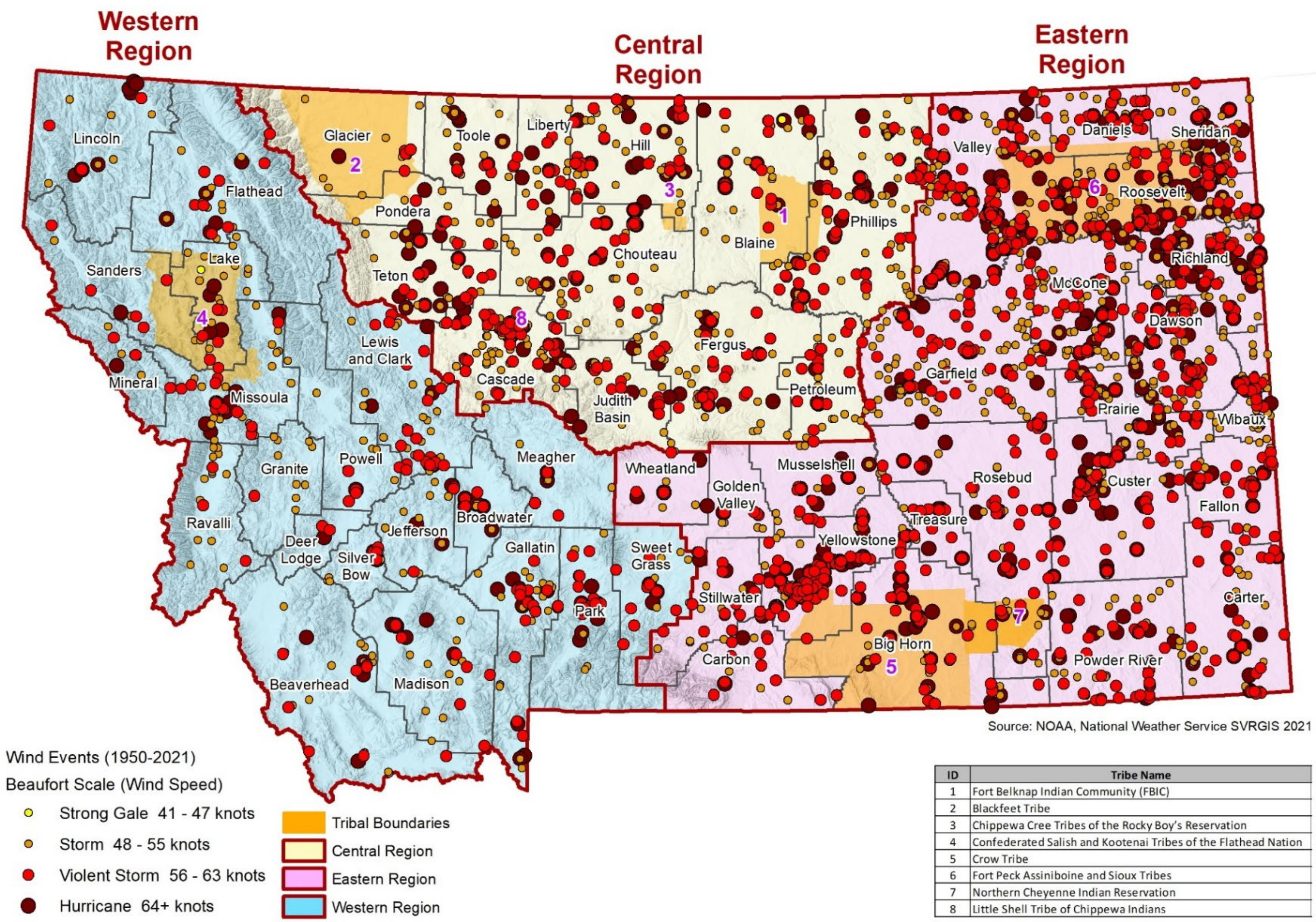
Fujita Scale	Derived		Operational EF Scale			
F Number	Fastest ¼ mile (mph)	3-second gust (mph)	EF Number	3-second gust (mph)	EF Number	3-second gusts (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

Notes:
EF = Enhanced Fujita; F = Fujita; mph = Miles per Hour

Geographical Area Affected

The spatial extent rating for both tornadoes and wind hazards is **Extensive**. Windstorms and tornadoes can occur anywhere in the Eastern Region. However, the 2018 Montana SHMP highlights that the greatest monetary losses due to property damages are likely to occur in cities with concentrated infrastructure. Tornadoes could also potentially occur anywhere in the planning area. Figure 4-66 and Figure 4-67 display the historic wind and tornado events in the State by region.

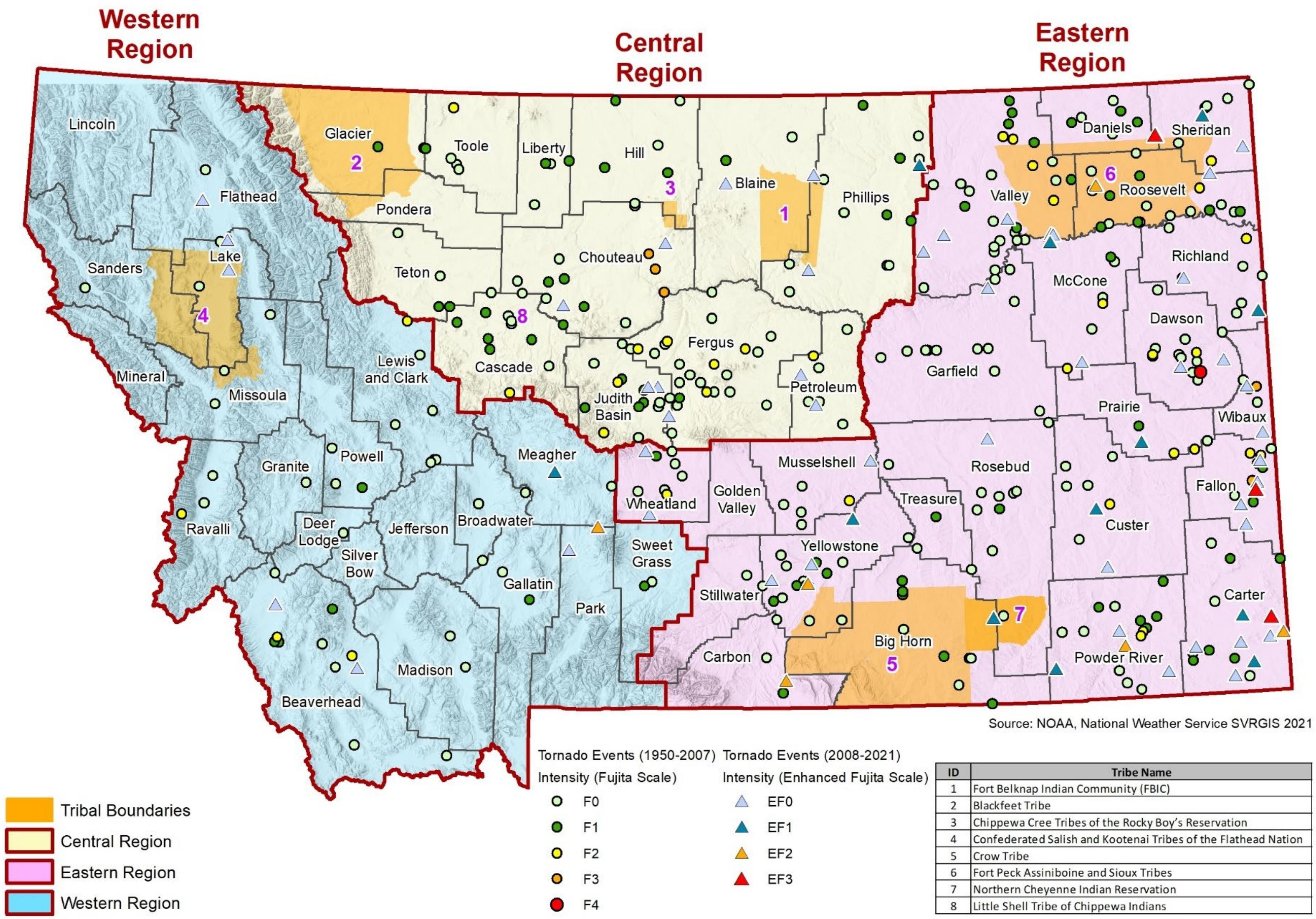
Figure 4-66 Wind Events in Montana by Region 1955-2021



ID	Tribe Name
1	Fort Belknap Indian Community (FBIC)
2	Blackfeet Tribe
3	Chippewa Cree Tribes of the Rocky Boy's Reservation
4	Confederated Salish and Kootenai Tribes of the Flathead Nation
5	Crow Tribe
6	Fort Peck Assiniboine and Sioux Tribes
7	Northern Cheyenne Indian Reservation
8	Little Shell Tribe of Chippewa Indians

Source: NOAA

Figure 4-67 Past Tornado Events in Montana by Region (1950-2021)



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5	Crow Tribe
6	Fort Peck Assiniboine and Sioux Tribes
7	Northern Cheyenne Indian Reservation
8	Little Shell Tribe of Chippewa Indians

Source: NOAA

Past Occurrences

The NCEI database was used to gather information on historic severe summer weather events in the Eastern Region of Montana. The NCEI data is a comprehensive list of oceanic, atmospheric, and geophysical data across the United States and aggregated by county and zone. It is important to note that weather events that occurred in Crow Tribe and North Cheyenne Tribe are also included in the dataset tables down below. However, instead of individual records, tribal data records were grouped into the nearest county. The NCEI uses unique methods of recording various hazards. High wind and strong wind are recorded by zone rather than by county and these datasets begin in 1996. Thunderstorm wind is recorded by county and the dataset starts in 1955. Tornadoes are also recorded by county and the dataset begins in 1950. All these datasets contain information up to March 2022.

The NCEI database reported 4,730 windstorm events on 1,218 days and 252 tornado events on 172 days. A summary of these events is captured in Table 4-50. In total, over $68.4 million was lost in property damages and over $10.6 million in crop losses. Eleven fatalities and 35 injuries were also reported in the Eastern Region. It is important to note that due to the nature of the NCEI data, losses from unreported events are not included in the dataset and some losses may be duplicated between counties; therefore, the real losses from severe windstorms and tornadoes are likely different than what is displayed in the table below, but estimates are useful for planning purposes.

Table 4-48 Summary of Losses by Hazard in the Eastern Region

	Deaths	Injuries	Property Loss	Crop Loss	Days with Events	Total Events
High Wind	0	3	$930,000	$0	404	1,492
Strong Wind	0	0	$8,000	$0	4	5
Thunderstorm Wind	7	15	$25,199,200	$10,550,000	810	3,233
Tornadoes	4	17	$42,279,250	$80,000	172	252
Total	11	35	$68,416,450	$10,630,000	1,390	4,982

Source: NCEI

The NCEI dataset reports variation in the frequency of events across the Eastern Region. Thunderstorm Winds are the most common type of windstorm event. The Southern Wheatland Zone experiences the highest frequency of high wind events. Both the Southern Wheatland and Central and Southern Valley Zones also experience a high frequency of high wind events in comparison to the other zones in the planning area. Table 4-51 and Figure 4-68 below display a summary of high wind and strong wind events by zone.

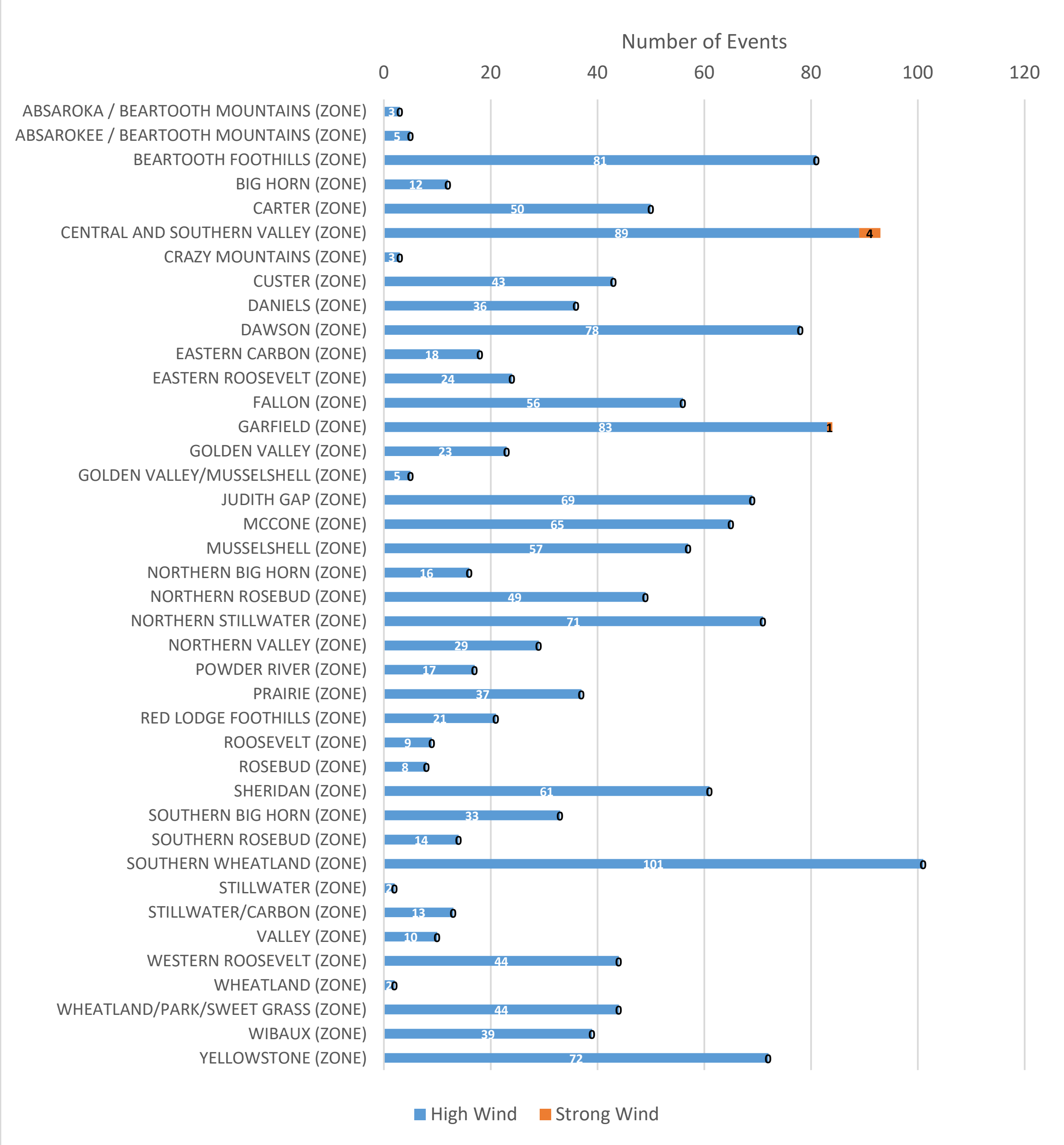
Table 4-49 Total High Wind and Strong Wind Events by Zone (1996 to 2022)

	High Wind	Strong Wind	Total
ABSAROKA / BEARTOOTH MOUNTAINS (ZONE)	3	0	3
ABSAROKEE / BEARTOOTH MOUNTAINS (ZONE)	5	0	5
BEARTOOTH FOOTHILLS (ZONE)	81	0	81
BIG HORN (ZONE)	12	0	12
CARTER (ZONE)	50	0	50
CENTRAL AND SOUTHERN VALLEY (ZONE)	89	4	93

	High Wind	Strong Wind	Total
CRAZY MOUNTAINS (ZONE)	3	0	3
CUSTER (ZONE)	43	0	43
DANIELS (ZONE)	36	0	36
DAWSON (ZONE)	78	0	78
EASTERN CARBON (ZONE)	18	0	18
EASTERN ROOSEVELT (ZONE)	24	0	24
FALLON (ZONE)	56	0	56
GARFIELD (ZONE)	83	1	84
GOLDEN VALLEY (ZONE)	23	0	23
GOLDEN VALLEY/MUSSELSHELL (ZONE)	5	0	5
JUDITH GAP (ZONE)	69	0	69
MCCONE (ZONE)	65	0	65
MUSSELSHELL (ZONE)	57	0	57
NORTHERN BIG HORN (ZONE)	16	0	16
NORTHERN ROSEBUD (ZONE)	49	0	49
NORTHERN STILLWATER (ZONE)	71	0	71
NORTHERN VALLEY (ZONE)	29	0	29
POWDER RIVER (ZONE)	17	0	17
PRAIRIE (ZONE)	37	0	37
RED LODGE FOOTHILLS (ZONE)	21	0	21
ROOSEVELT (ZONE)	9	0	9
ROSEBUD (ZONE)	8	0	8
SHERIDAN (ZONE)	61	0	61
SOUTHERN BIG HORN (ZONE)	33	0	33
SOUTHERN ROSEBUD (ZONE)	14	0	14
SOUTHERN WHEATLAND (ZONE)	101	0	101
STILLWATER (ZONE)	2	0	2
STILLWATER/CARBON (ZONE)	13	0	13
VALLEY (ZONE)	10	0	10
WESTERN ROOSEVELT (ZONE)	44	0	44
WHEATLAND (ZONE)	2	0	2
WHEATLAND/PARK/SWEET GRASS (ZONE)	44	0	44
WIBAUX (ZONE)	39	0	39
YELLOWSTONE (ZONE)	72	0	72
Total	1,492	5	1,497

Source: NCEI

Figure 4-68 Total High Wind and Strong Wind Events by Zone (1996 to 2022)



Source: NCEI, Chart by WSP

Similar to high wind and strong wind, there are variations between counties in the Eastern Region regarding thunderstorm wind and tornado events. Valley County experienced the greatest number of recorded events in both thunderstorm wind and tornado events. In total, there were 3,233 thunderstorm wind events since 1955 and 252 tornado events since 1950 in the Eastern Region. Table 4-52 displays a summary of these events.

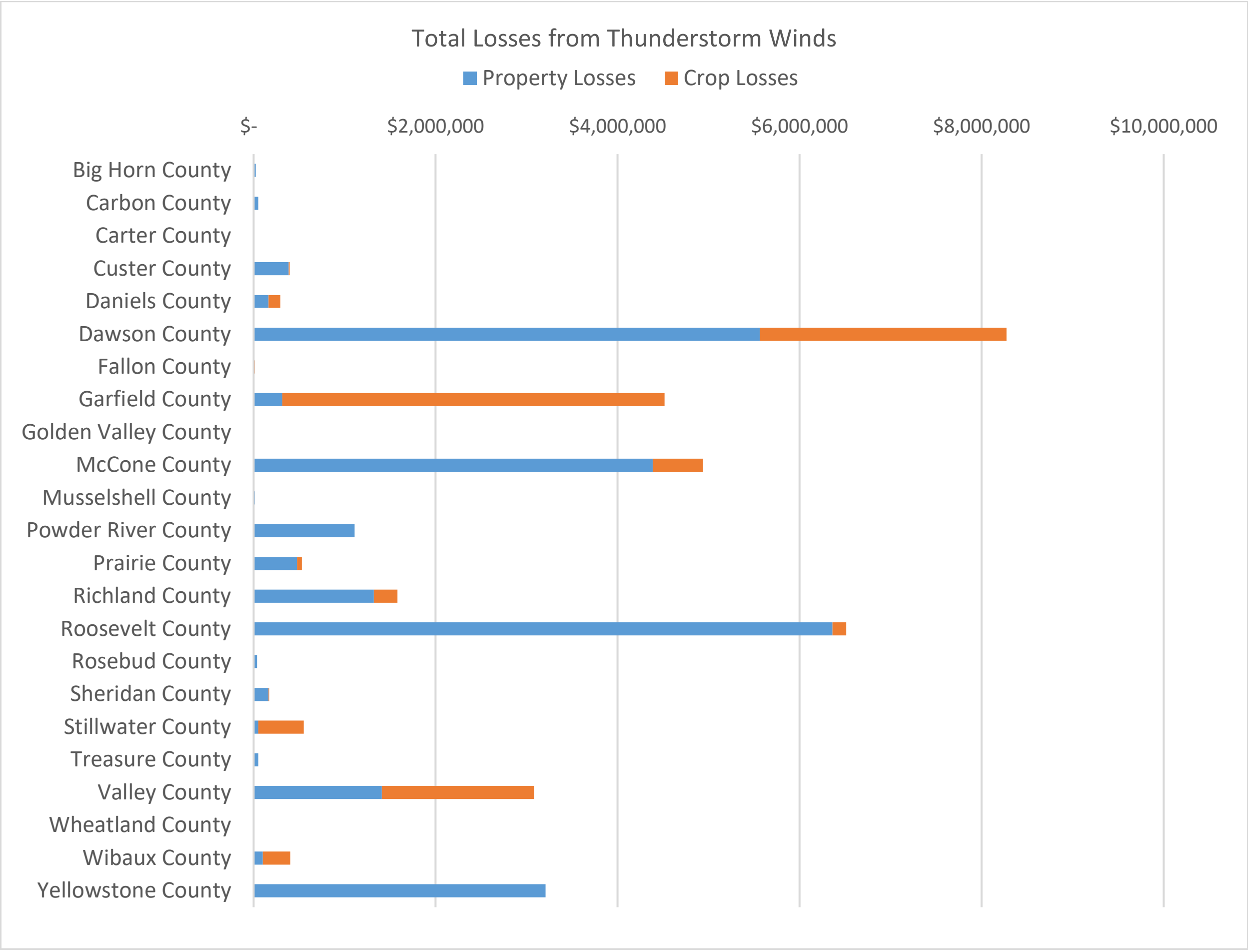
Table 4-50 Total Thunderstorm Wind and Tornado Events by County

	Thunderstorm Wind	Tornadoes
BIG HORN CO.	128	11
CARBON CO.	28	3
CARTER CO.	105	18
CUSTER CO.	215	8
DANIELS CO.	68	9
DAWSON CO.	205	15
FALLON CO.	91	14
GARFIELD CO.	221	12
GOLDEN VALLEY CO.	14	0
MCCONE CO.	161	9
MUSSELSHELL CO.	43	5
POWDER RIVER CO.	121	18
PRAIRIE CO.	102	3
RICHLAND CO.	192	13
ROOSEVELT CO.	236	16
ROSEBUD CO.	172	9
SHERIDAN CO.	107	10
STILLWATER CO.	66	1
TREASURE CO.	47	3
VALLEY CO.	512	39
WHEATLAND CO.	23	7
WIBAUX CO.	76	8
YELLOWSTONE CO.	300	21
Total	3,233	252

Source: NCEI

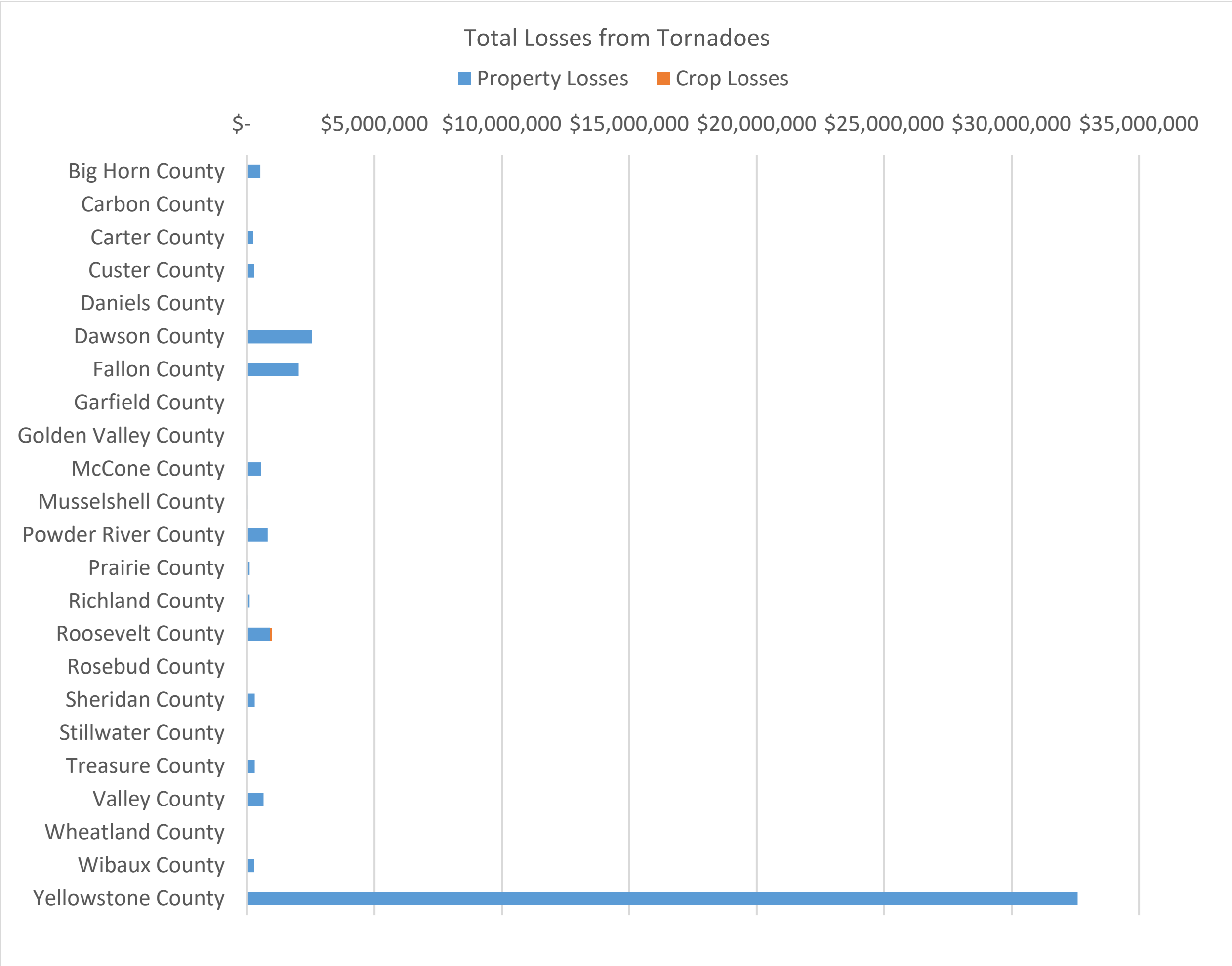
Figure 4-69 and Figure 4-70 display crop and property losses by county from tornado and thunderstorm wind events. According to the dataset, Roosevelt County experienced the highest property loss and Dawson and Garfield Counties experienced the greatest crop loss from thunderstorm wind events. Yellowstone County experienced the greatest property loss from tornado events.

Figure 4-69 Total Losses from Thunderstorm Wind by County



Source: NCEI, Chart by WSP

Figure 4-70 Total Losses from Tornadoes by County



Source: NCEI, Chart by WSP

The NCEI reported details on significant events in the Eastern Region:

- **July 13, 2005:** A severe bow echo raced from west to east across Roosevelt County and caused extensive damage from Poplar to Culbertson between 8 and 9 pm. Various properties and crops suffered from severe damage, including but not limited to: two hangers from the airport were blown off; quite a few vehicles were blown off track; homes and businesses suffered roof and siding damage; large grain bins were destroyed; many trees were also damaged. This event resulted in $3M of property damage.
- **November 12, 2007:** A strong cold front moved across Western Montana and produced heavy snowfall and high winds in the Bitterroot and Sapphire Mountains as well as high winds in the Anaconda and Deer Lodge areas. This event resulted in $650,000 of property damage and 2 injuries.
- **June 20, 2010:** A very moist and unstable atmosphere was in place across portions of the Billings Forecast area during the afternoon and evening of the 20th. A moist, southeast surface flow, strong wind shear aloft, and ample afternoon heating provided the necessary ingredients for severe weather. Numerous thunderstorms, some of which became rapidly severe producing tornadoes and large hail, developed across South Central Montana. Debris from an arena impacted other nearby businesses creating additional damage, mainly in the form of broken windows. Debris from the arena was reported

to have landed as far away as a mile from the tornado touchdown. This event resulted in $30M of property damage.

- **July 27, 2015:** A low-pressure circulation over southeastern Montana; favorable winds, and warm, moist air all combined with an approaching strong upper-level storm system quickly developed and maintained well-organized severe thunderstorms over many locations; there was also a macroburst in the Glendive area. This event resulted in $2.5M of property damage.
- **September 28, 2019:** Strong east winds developed on the western side of the Whitefish and Mission ranges as high pressure settled into north-central Montana resulting in considerable damage. Severe wind caused various damages, including but not limited to: damages to trees and powerlines; power outages that lasted for almost two days for thousands of customers; boat and dock damage as waves reached certain heights. This event resulted in $300,000 in property damage.

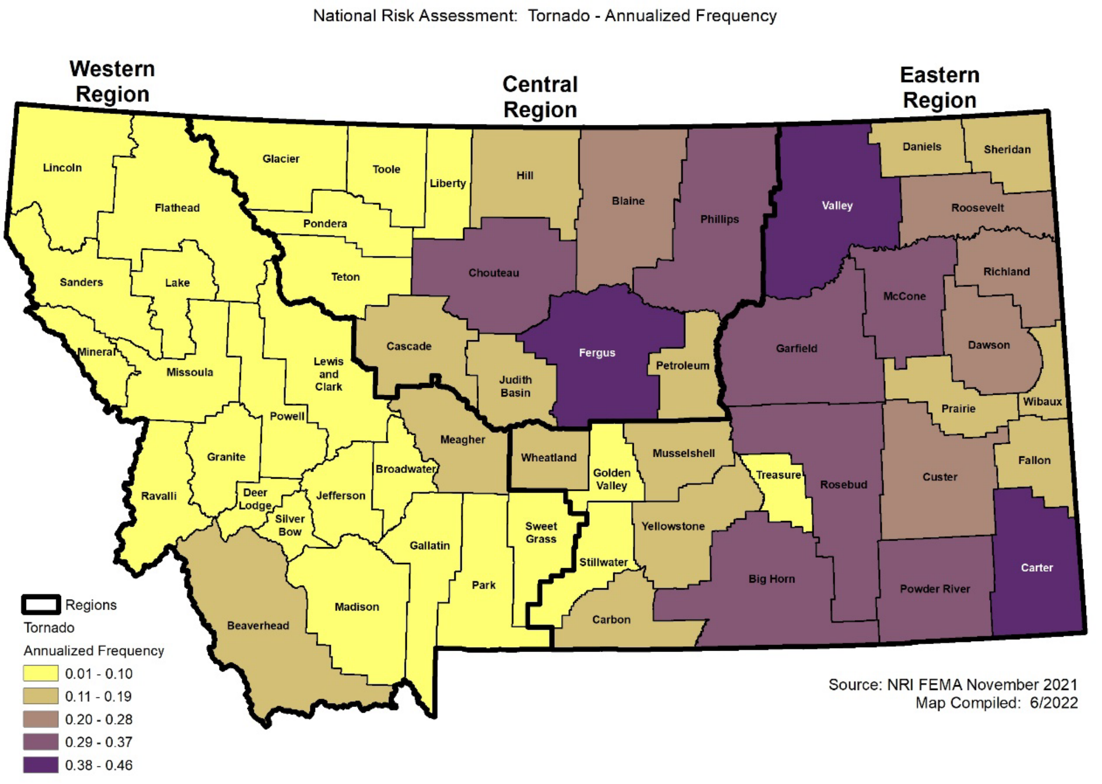
Frequency/Likelihood of Occurrence

According to the NCEI dataset, there has been 4,982 total recorded severe windstorm and tornado events on 1,390 days over the past 72 years in the Eastern Region; therefore, there is an average of nearly 20 days with severe wind and tornado events per year in the planning area. This corresponds to a **Highly Likely** probability of occurrence.

Strong wind is the least documented type of windstorm in the Region and thunderstorm winds are the most common. Based on the NCEI dataset, tornadoes are likely to occur somewhere in the Region around 3.5 times a year on average. Valley County experienced the greatest number of recorded events in both thunderstorm wind and tornado events. The highest number of high wind events occur in the Southern Wheatland and Southern and Central Valley zones.

Figure 4-71 below depicts the annualized frequency of tornado events at a county level based on the NRI. The mapping shows a trend towards increased likelihood in the western and southern regions, particularly in Valley and Carter Counties. Counties in the eastern and northeastern portions of the Region have a relatively lower frequency of tornado events.

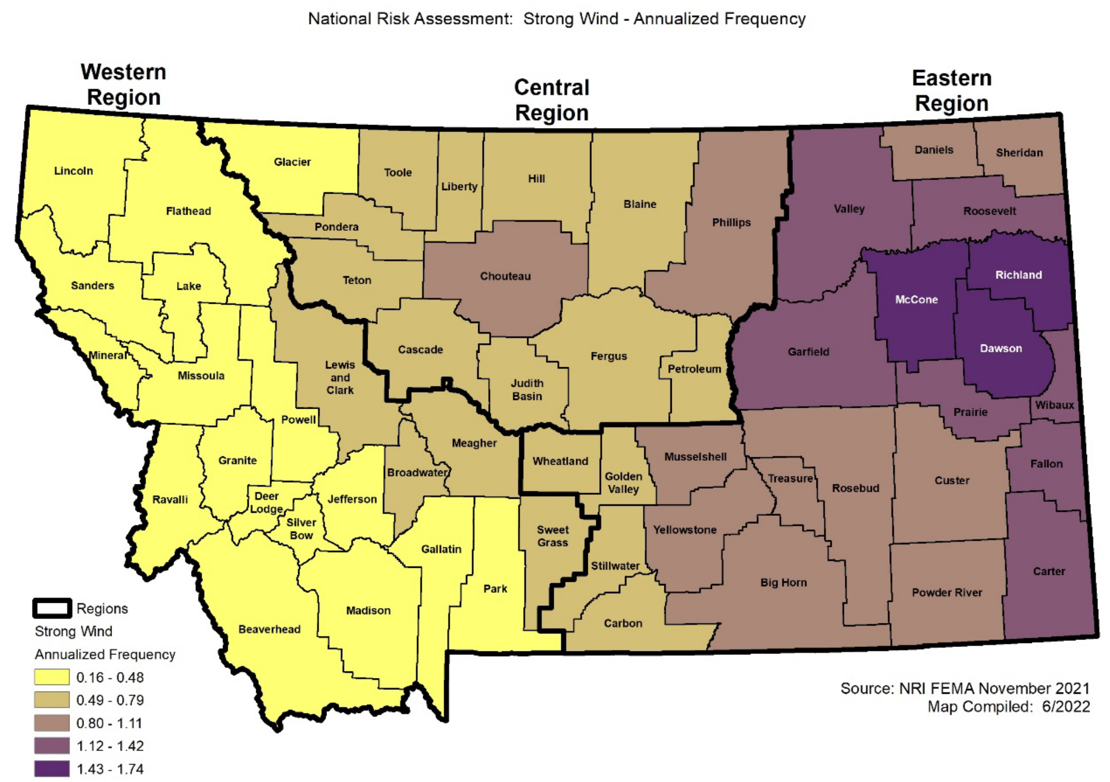
Figure 4-71 Annualized Frequency of Tornado Events by County



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Figure 4-72below depicts the annualized frequency of strong wind events at a county level based on the NRI. A majority of the counties in the region are ranked as moderate and moderate to high frequency, with the highest frequency of events occurring in McCone, Richland, and Dawson Counties.

Figure 4-72 Annualized Frequency of Strong Wind Events by County



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Climate Change Considerations

According to the 2018 Montana SHMP, population exposure and vulnerability to severe weather are likely to increase because of climate change. Severe weather events may occur more frequently, which would lead to increased exposure and vulnerability. Although all people may be affected by the health-related impacts of climate change, the elderly, young children, and people with weakened immune systems are often the most susceptible.

Ongoing research compiled in the recent climate assessment has resulted in different conclusions on the effect of climate change on wind regimes. The August 2021 IPCC report argues that in most places, wind speeds will be drastically reduced because of climate change, whereas in 2019, Scientific American reported that winds across the world were speeding up. Unusual wind patterns combined with other climate change issues, such as hotter water temperatures, can also cause problems. At this time, these changing factors are not well understood and are still being incorporated into state and regional research and risk analysis (Garrison 2022).

For other types of extreme weather events, such as tornadoes and severe thunderstorms, more research is also needed to understand how climate change will affect them. These events occur over much smaller scales, which makes observations and modeling more challenging. Projecting the future influence of climate change on these events can also be complicated by the fact that some of the risk factors for these events may increase with climate change, while others may decrease, like the complexity of predicting future wind patterns, which is mentioned above. Even though some studies predict that climate change could provide the opportunity for more severe thunderstorms to form, this does not necessarily mean that more tornadoes will occur, given that only about 20% of supercell thunderstorms produce tornadoes. The fourth National Climate Assessment summarizes the complicated relationship between tornadoes and climate change: "…extreme weather, such as tornadoes, are also exhibiting changes which may be linked to climate change, but scientific understanding isn't detailed enough to project direction and magnitude of future change." ("Tornadoes And Climate Change" 2022)

Potential Magnitude and Severity

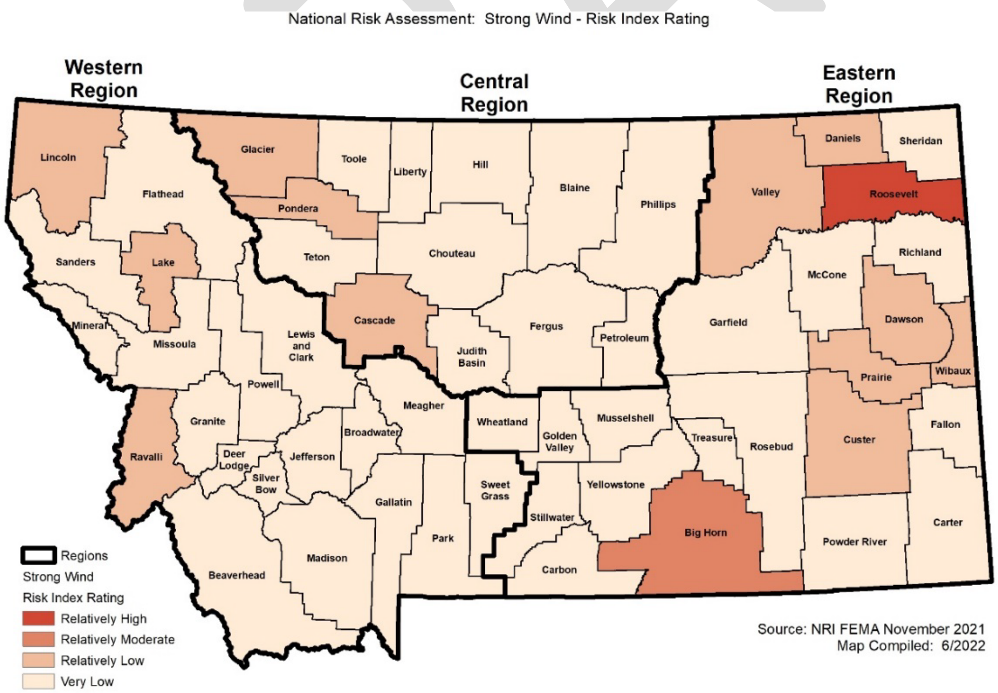
To calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it reflects common occurrence. While it is possible these estimates are greater than actual losses due to potential duplicates in the dataset, these losses provide an understanding of the likely magnitude in the planning area.

Overall, windstorm or tornado impacts in Eastern Region would likely be **Critical**. While wind occurs rather frequently in the area, most events cause little to no damage. The impact on quality of life or critical facilities and functions in the affected area would be minimal. Injuries or deaths are possible due to wind-thrown trees in the backcountry or from other blown debris.

Vulnerability Assessment

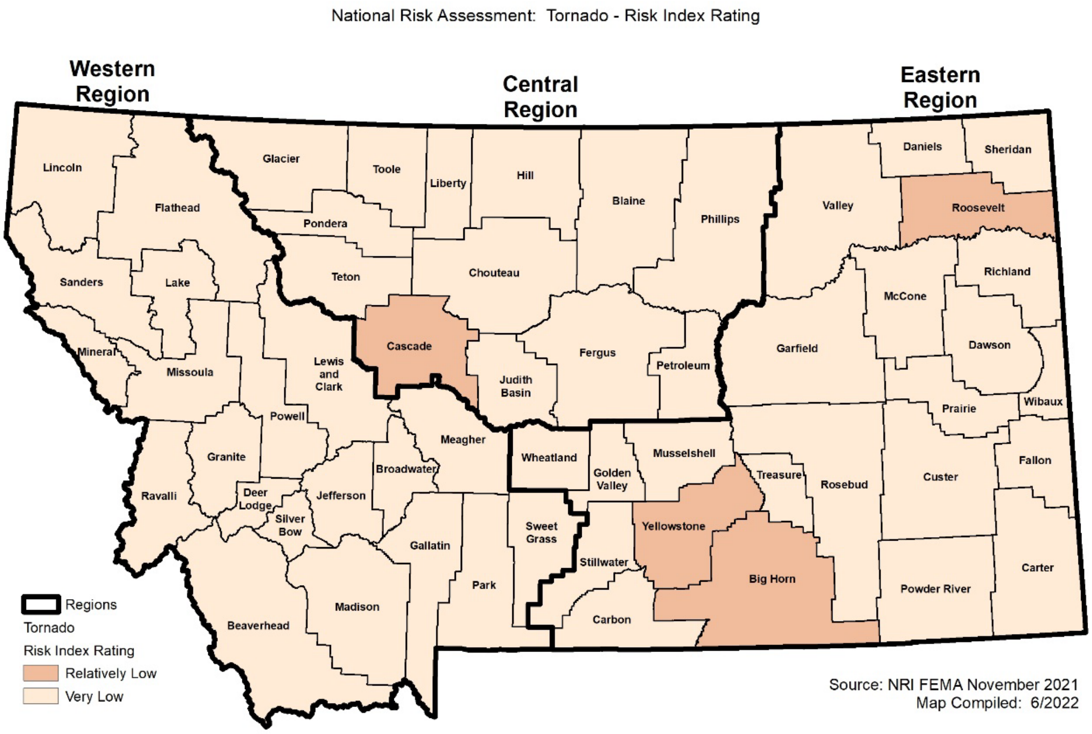
The figure below illustrates the relative RRI rating due to strong wind and tornadoes in Montana counties based on data in the NRI. The NRI calculation takes into account various factors, including the expected annual losses, social vulnerability, and community resilience in each county across Montana. Most counties in the region have a very low to moderate rating for strong wind events while Roosevelt County has a relatively high rating. For tornado events, counties in the region have a very low to relatively low rating; none have a high or very high RI rating.

Figure 4-73 NRI Risk Index Rating for Strong Wind



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Figure 4-74 NRI Risk Index Rating for Tornadoes



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

People

The entire Eastern Region planning area is vulnerable to windstorms and tornadoes. Certain areas are more exposed due to geographic location and local weather patterns. Populations living at higher elevations with large stands of trees or power lines may be more susceptible to wind damage and blackout. While tornadoes typically occur on flat plains, where conditions are most favorable for these events, tornadoes have been known to cross rivers and travel up mountains.

Vulnerable populations are the elderly, low-income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages due to severe wind or tornadoes can be life-threatening to those dependent on electricity for life support. These populations face isolation and exposure during thunderstorm wind, high wind, and tornado events and could suffer more secondary effects of the hazard.

Individuals caught in the path of a tornado who are unable to seek appropriate shelter are especially vulnerable. This may include individuals who are out in the open, in cars, or who do not have access to basements, cellars, or safe rooms. Hikers and climbers in the area may also be more vulnerable to severe weather events. Visitors to the area may not be aware of how quickly a thunderstorm can build in the mountains.

Property

All property is vulnerable during thunderstorm and high wind events, but properties in poor condition or particularly vulnerable locations may risk the most damage. Generally, the damage is minimal and goes unreported. Property located at higher elevations and on ridges may be more prone to wind damage. Property located under or near overhead lines or large trees may be damaged in the event of a collapse.

Like severe wind, all critical facilities and infrastructure are likely exposed to tornadoes. Older buildings in the Eastern Region planning area may be built to low code standards or none at all, making them more susceptible to severe wind and tornado events. Mobile homes are disproportionately at risk due to the design of homes. Tornadoes also often create flying debris which can cause damage to homes, vehicles, and landscape. In the Eastern Region, property damages due to wind and tornadoes totaled over $68.4M. Reported impacts from high wind in the planning area include damage to trees, mobile homes, roofs, power lines, and vehicles.

Critical Facilities and Lifelines

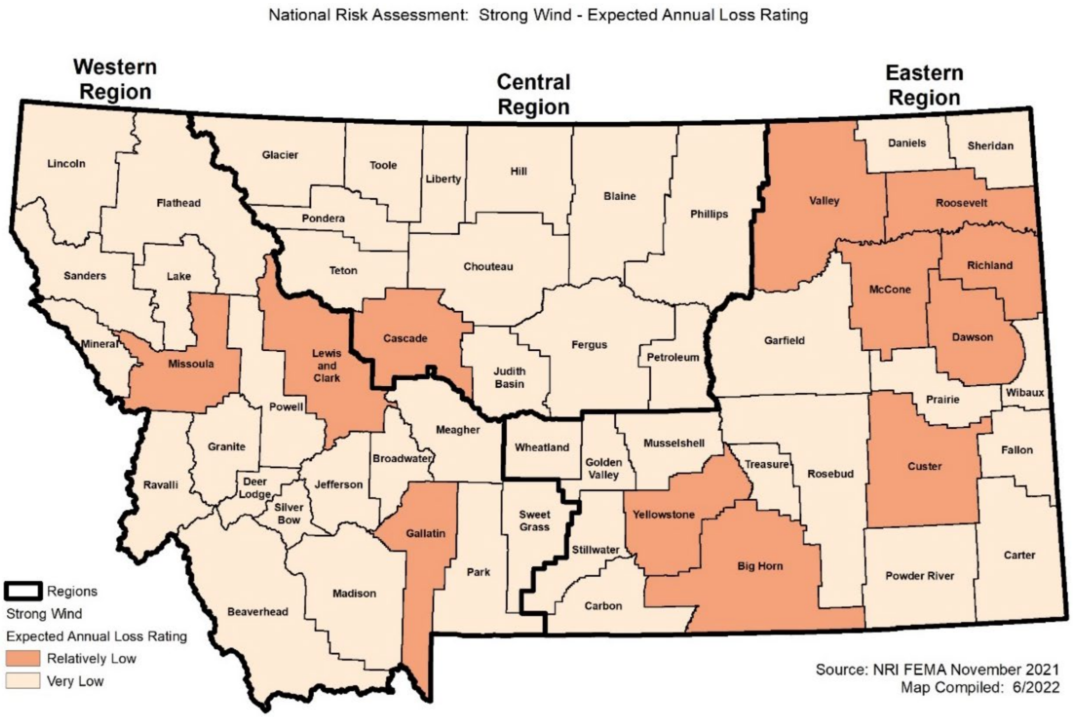
Incapacity and loss of roads are the primary transportation failures resulting from windstorms and tornadoes. These hazards can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Of particular concern are roads providing access to isolated areas and the elderly. The most common problems associated with these weather events are loss of utilities. Downed power lines can cause blackouts, leaving large areas isolated, which was reported several times in the NCEI dataset. Phone, water, and sewer systems may not function. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

Economy

Loss of power and minimal damage following a tornado or severe windstorm event could cause disruptions to the local economy through forced temporary closures of businesses and preventing people from traveling to work. More severe events could result in significant economic disruption and hinder recovery through the forced extended or permanent closure of businesses damaged in the event. Additionally, events that cause significant property damage could negatively impact the local economy. Most financial losses due to wind and tornadoes are related to direct property damages as well as subsequent debris removal, response, and repair activities.

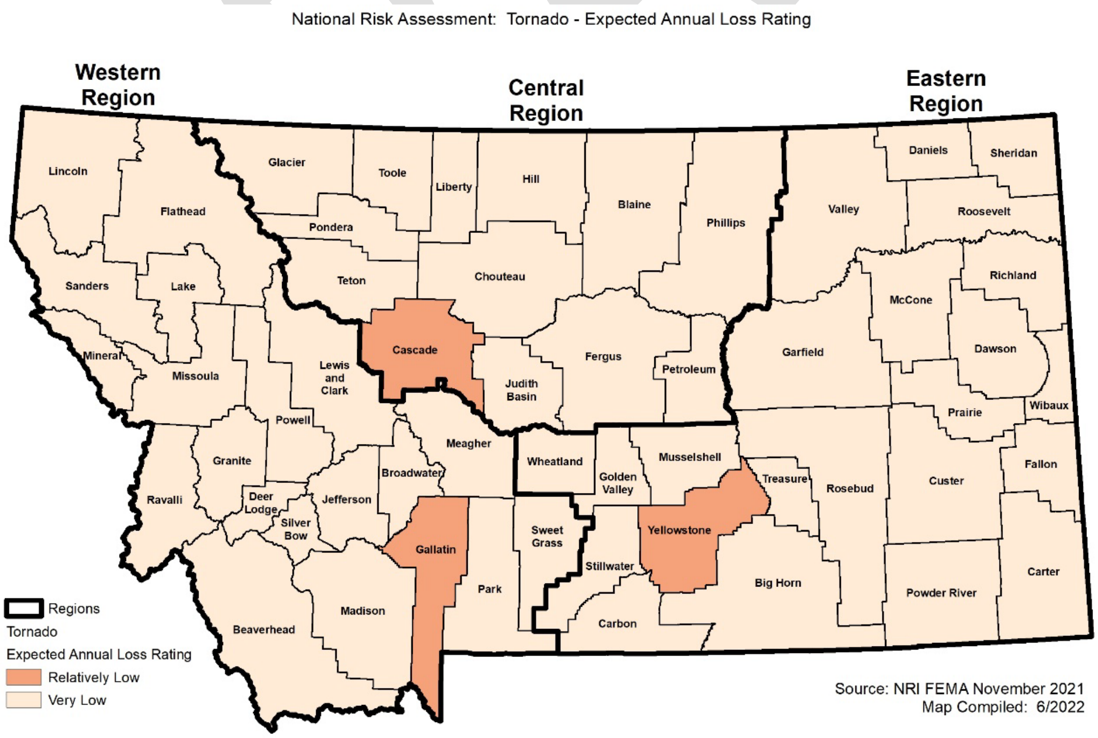
Figure 4-75 and Figure 4-76 below illustrates the relative risk of EAL rating due to strong wind and tornadoes for Montana counties based on data in the NRI. Most counties in the region have a relatively moderate rating; none has high or very high-risk EAL rating. The EAL calculation takes into account agriculture value exposed to these events, annualized frequency, and historical losses. The EAL rating is thus heavily based on agricultural impacts.

Figure 4-75 NRI Strong Wind Expected Annual Loss Rating



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Figure 4-76 NRI Tornado Events Expected Annual Loss Rating



Map by WSP, Data Source: FEMA National Risk Index, https://hazards.fema.gov/nri/determining-risk

Historic and Cultural Resources

Historic and cultural resources are equally as exposed to severe weather events as any other infrastructure. As mentioned previously, historic infrastructure is less likely to be built to code and can be more vulnerable to damage during wind and tornado events.

Natural Resources

The environment is highly exposed to severe winds and tornadoes. Large swaths of tree blowdowns can occur, particularly in the beetle-killed forests prevalent in the county. Severe winds can trigger or spread wildfires under some conditions. Crops are also at risk of losses. The NCEI dataset reported over $10.6 M in crop losses from windstorm and tornado events in the Eastern Region.

Development Trends Related to Hazards and Risk

All future development will be exposed to severe winds and tornadoes. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. Development regulations that require safe rooms, basements, or other structures that reduce risk to people would decrease vulnerability but may not be cost-effective given the relative infrequency of damaging tornadoes in the Eastern Region.

The State of Montana has adopted the 2012 International Building Code IBC. The IBC includes a provision that buildings must be constructed to withstand a wind load of 75 mph constant velocity and three-second gusts of 90 mph. Buildings must be designed to withstand a snow load of 30 pounds per square foot minimum.

Risk Summary

In summary, the tornadoes and windstorms hazard is considered to be of overall high significance for the Region. with key issues summarized below. Variations in risk by jurisdiction are summarized in the table below.

- Severe windstorms (high wind, strong wind, thunderstorm wind) and tornado events are rated as having **High** overall significance for the Eastern Region
- These events can impact anywhere in the planning region; therefore, the hazard extent is rated as **Extensive**.
- The NCEI data reported 1,390 days with severe weather events over 72 years, which averages to nearly 20 days a year with severe winter weather events in the Eastern Region; therefore, future occurrence is rated as **Highly Likely.**
- The NCEI reported 11 deaths, 35 injuries, over $68.4 million in property damages and over $10.6 million in crop damages, therefore, the magnitude is rated as **Critical**
- People who are dependent on electricity and populations who work outdoors or in transportation are most vulnerable to severe windstorm events and tornadoes. Individuals living in mobile homes are also disproportionately likely to experience losses from wind and tornado events.
- Power outages and damage to buildings are frequently reported impacts to property of severe windstorm events and tornadoes.
- Downed power lines resulting in communication and electricity failures are the most common impacts on critical facilities
- Significant economic losses are possible in the event of a severe windstorm or tornado due to infrastructure repair and business/service disruptions
- Related Hazards: Wildfire, Severe Summer Weather, Severe Winter Weather, Transportation Accidents

Table 4-51 Risk Summary Table: Tornadoes and Windstorms

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences
Eastern Region	Medium		
Big Horn	Medium	Hardin, Lodge Grass	None
Carbon	Medium	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	None
Carter	Medium	Ekalaka	None
Crow Tribe	Medium		None
Custer	Medium	Ismay, Miles City	None
Daniels	Medium	Scobey, Flaxville	None
Dawson	High	Richey, Glendive	There have been a higher number of wind events that resulted in losses in Dawson County
Fallon	Medium	Plevna, Baker	None
Garfield	Medium	Jordan	There have been a higher number of wind events that resulted in losses in Garfield County
Golden Valley	Medium	Ryegate, Lavina	None
McCone	Medium	Circle	There have been a higher number of wind events that resulted in losses in McCone County
Musselshell	Medium	Roundup	None
North Cheyenne Tribe	Medium		None
Powder River	Medium	Broadus	None
Prairie	Medium	Terry	None
Richland	Medium	Fairview, Sidney	None
Roosevelt	High	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	There have been a higher number of wind events that resulted in losses in Roosevelt County
Rosebud	Medium	Colstrip, Forsyth	None
Sheridan	Medium	Outlook, Westby, Plentywood, Medicine Lake	None
Stillwater	Medium	Columbus	None
Treasure	Medium	Hysham	None
Valley	High	Fort Peck, Glasgow, Nashua, Opheim	There have been a higher number of wind events that resulted in losses in Valley County
Wheatland	Medium	Harlowton, Judith Gap	None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences
Wibaux	Medium	Wibaux	None
Yellowstone	High	Billing, Laurel, Broadview	There have been a higher number of wind events that resulted in losses in Yellowstone County

4.2.14 Transportation Accidents

Hazard/Problem Description

This hazard encompasses air transportation, highway transportation, waterway transportation, railway transportation, and wild animal vehicle collisions. The transportation incidents can involve any mode of transportation that directly threatens life and which results in property damage and/or death(s)/injury(s) and/or adversely impact a community's capabilities to provide emergency services. Incidents involving buses and other high occupancy vehicles could trigger a response that exceeds the normal day-to-day capabilities of response agencies.

Air Transportation

An air transportation incident may involve a military, commercial or private aircraft. Airplanes and helicopters are used to transport passengers for business and recreation as well as thousands of tons of cargo. A variety of circumstances can result in an air transportation incident; mechanical failure, pilot error, enemy attack, terrorism, weather conditions and on-board fire can all lead to an air transportation incident.

Highway Transportation

Highway transportation incidents are complex. Contributing factors can include a roadway's design and/or pavement conditions (e.g., rain, snow, and ice), a vehicle's mechanical condition (e.g., tires, brakes, lights), a driver's behavior (e.g., speeding, inattentiveness, and seat belt usage), the driver's condition (e.g., alcohol use, age-related conditions, physical impairment) and driver inattention by using a wireless device. In fact, the driver's behavior and condition factors are the primary cause in an estimated 67 percent of highway crashes and a contributing factor in an estimated 95 percent of all crashes.

Railway Transportation

A railway transportation incident is a train accident that directly threatens life and/or property, or adversely impacts a community's capabilities to provide emergency services. Railway incidents may include derailments, collisions and highway/rail crossing accidents. Train incidents can result from a variety of causes; human error, mechanical failure, faulty signals, and/or problems with the track. Results of an incident can range from minor "track hops" to catastrophic hazardous material incidents and even human/animal casualties.

Waterway Transportation

A waterway incident is an accident involving any water vessel that threatens life, property, or adversely affects a community's capability to provide emergency services. Waterway incidents primarily involve pleasure watercraft on rivers and lakes. Waterway incidents may also include events in which a person, persons, or object falls through the ice on partially frozen bodies of water. Impacts include fuel spillage, drowning, and property damage.

Wild Animal Vehicle Collisions

Wild animal vehicle collisions consist of any roadway transportation accident where an animal is involved in the accident. These accidents typically occur at dusk, from 6pm-9pm, when deer and other wildlife are most active and when the visibility of drivers decreases. Deer are the most common wild animal involved in roadway transportation accidents in the United States and in the Eastern Region.

Geographical Area Affected

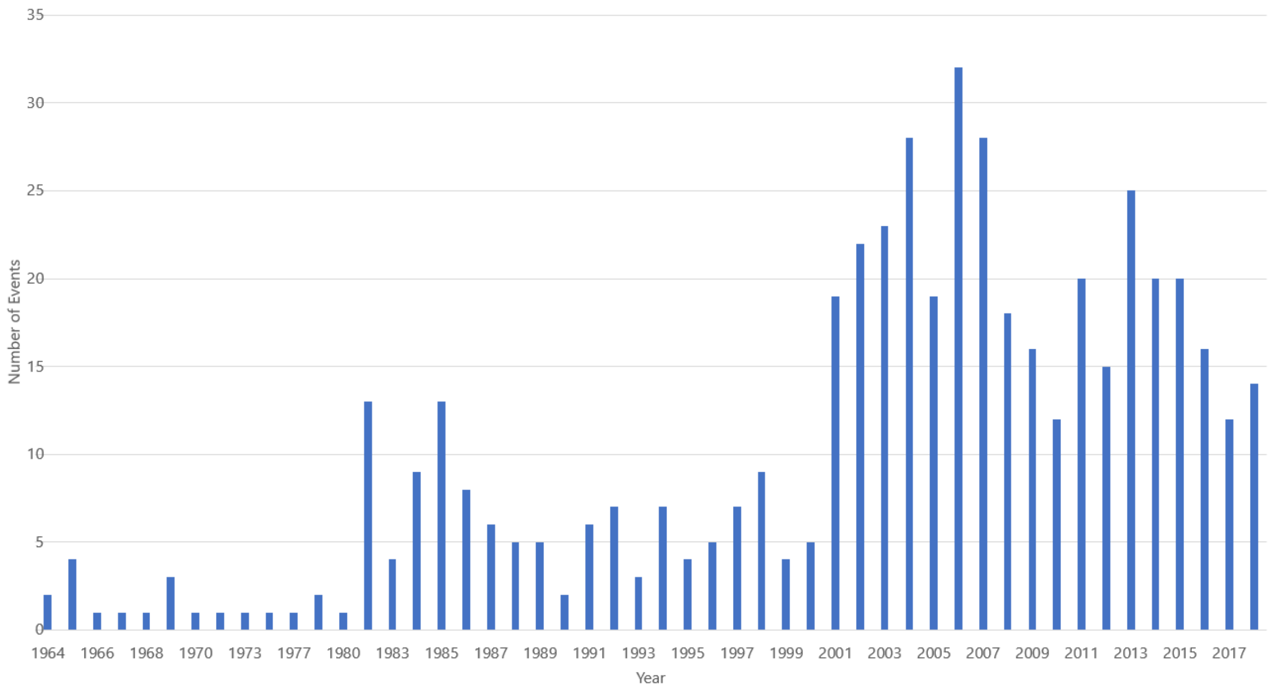
All counties in the Eastern Region are prone to transportation incidents. Due to transportation accidents typically occurring along roadways, waterways, or near airports, the significance rating for the geographic area affected in the Eastern Region is rated as **Significant** (10-50% of planning area). Roads with frequently reported roadway transportation accidents in the Eastern Region include Highway 2, Highway 12, U.S. Route 191, Interstate 90, and Interstate 94. The BNSF railway is the most significant railway running through the Eastern Region; therefore, the counties that contain the BNSF railway will be more likely to experience railway accidents. The Eastern Region is also home to Billings Logan International Airport, as well as several smaller regional or general aviation airports, any of which could be the location of an aircraft accident. However, documented aircraft crashes have happened across the planning area and are most frequently documented as being small civilian aircrafts.

Past Occurrences

Air Transportation Incidents:

The National Transportation Safety Board (NTSB) reported 505 air transportation incidents in the State from 1964 to 2018. Figure 4-77 displays the annual trends of total fatal air transportation accidents. The greatest number of incidents were reported in 2006 with 32 total incidents. Since 2001, there has been a significant increase in the number of events reported. Most crashes have been small, private planes. Small Cessna and Piper aircrafts were frequently reported in the dataset.

Figure 4-77 Annual Aircraft Incidents in the State of Montana



Source: *NTSB, Chart by WSP*

Highway Transportation Incidents:

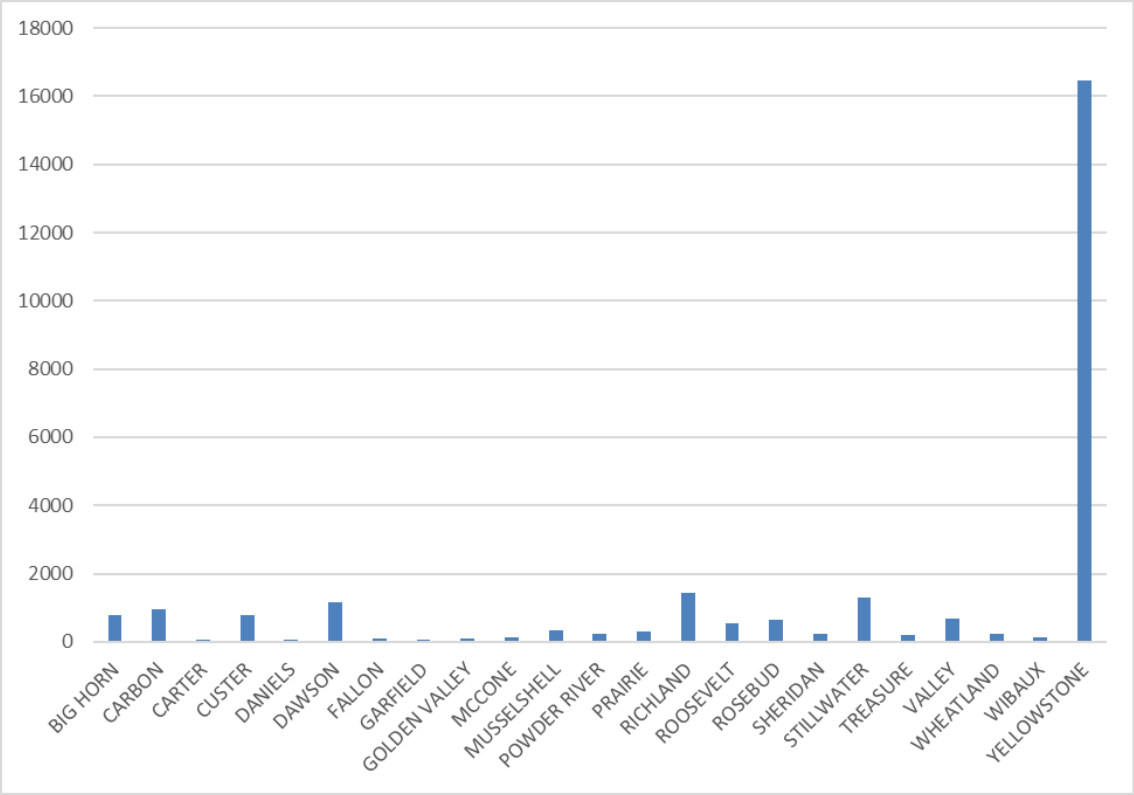
The Montana Department of Transportation's Office of Traffic and Safety maintains traffic crash statistics and location maps by county. Table 4-54 and Figure 4 shows the trend of crashes in the Eastern Region between 2016 and 2020. This dataset was extracted from the MDT's Crash Database compiled for the purpose of safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings. The dataset has reported 26,984 road transportation events over the course of 4 years across the counties in the Eastern Region. Yellowstone County had the greatest number of reported crash events by far, with a total of 16,475 reported events, comprising 61% of the total incidents in the Region from 2016- to 2020.

Table 4-52 Roadway Crash Statistics by County in the Eastern Region (2016-2020)

County	Number of Accidents (2016-2020)
BIG HORN	782
CARBON	966
CARTER	68
CUSTER	777
DANIELS	78
DAWSON	1,153
FALLON	87
GARFIELD	77
GOLDEN VALLEY	95
MCCONE	134
MUSSELSHELL	342
POWDER RIVER	227
PRAIRIE	307
RICHLAND	1,447
ROOSEVELT	534
ROSEBUD	656
SHERIDAN	234
STILLWATER	1,291
TREASURE	203
VALLEY	694
WHEATLAND	218
WIBAUX	139
YELLOWSTONE	16,475
Grand Total	26,**984**

Source: *Montana Department of Transportation 2016-2020*

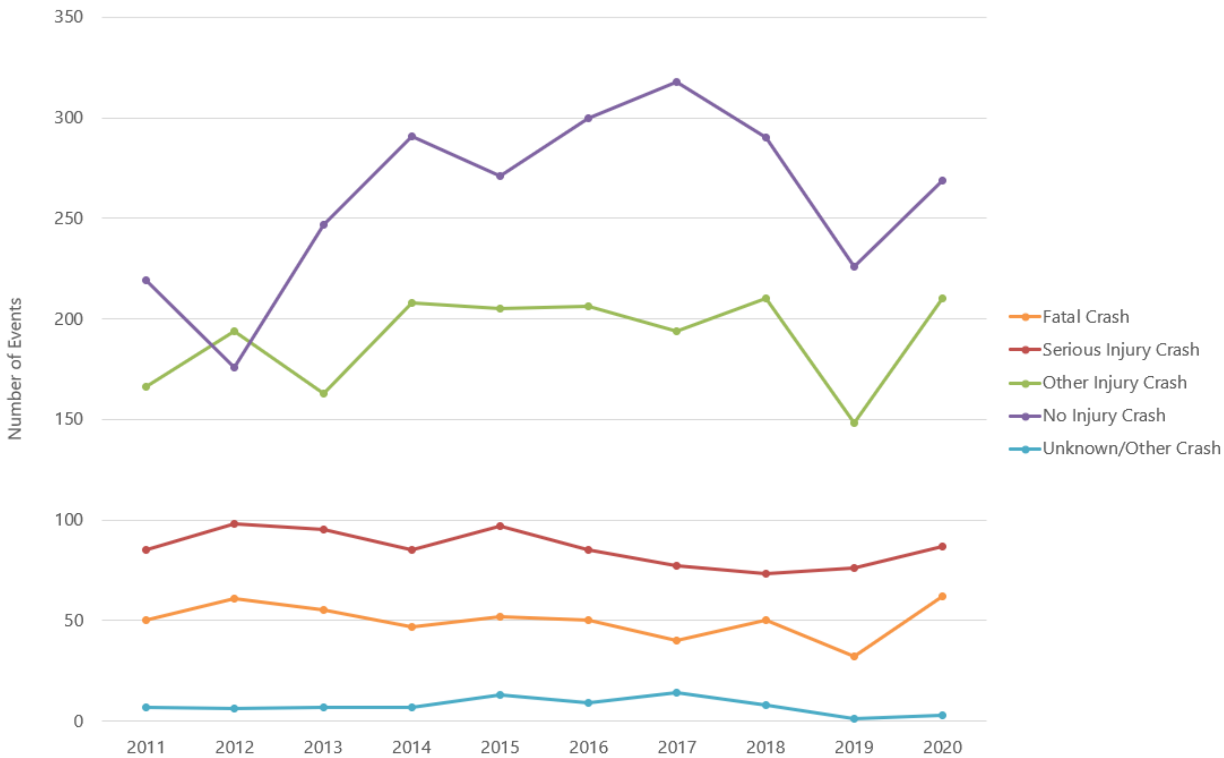
Figure 4-78 Roadway Crash Statistics by County in the Eastern Region (2016-2020)



Source: Montana *Department of Transportation 2016-2020*

The Montana DoT also reported crash severity from 2011 to 2020 for the entire state of Montana. Figure 4 displays the temporal trends of crash severity. Throughout the state, accidents with no injury are most commonly reported, followed by accidents with minimal injuries. Since 2011, 499 fatal crashes have been reported across the state and 858 serious injury crashes. There is an average of 49.9 fatal crashes per year in the State of Montana.

Figure 4-79 Roadway Crash Severity in Montana (2011-2020)

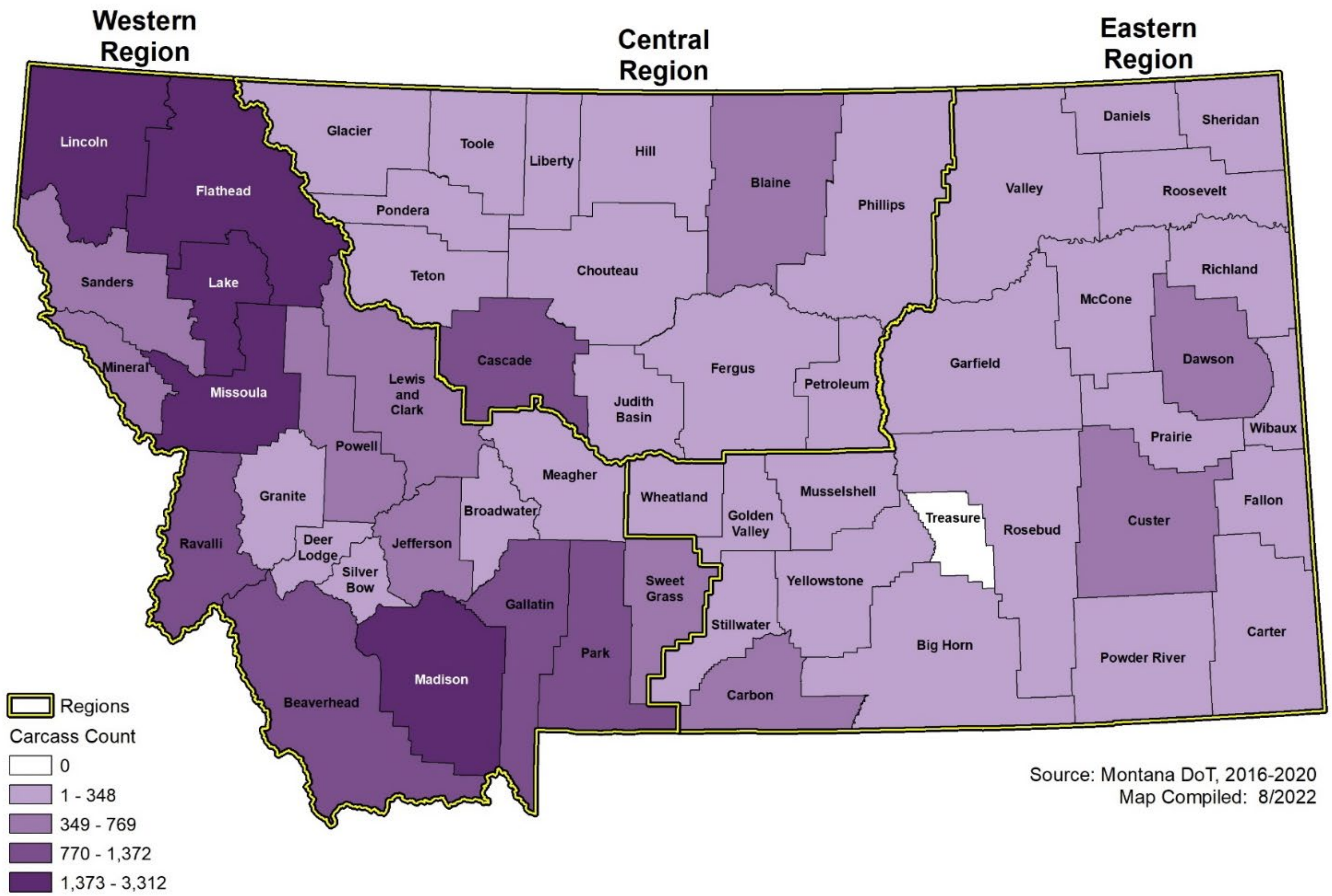


Source: Montana Department of Transportation 2011-2020

Wildlife Car Accidents

The Montana DoT also documented the number of accidents caused by wildlife and the animal carcasses recovered. Montana DoT emphasizes that this dataset is best used to identify patterns in wildfire car accidents, but the data is incomplete due to not all carcasses being reported on a regular schedule or some carcasses not being reported at all. According to the Montana DoT dataset, there were 28,652 wildlife car accidents from 2016 to2020. Figure 4 displays the animal carcass data by county in Montana. Most of the Eastern Region has experienced between 1-348 wildlife car accidents, however, Carbon, Custer, and Dawson County have experienced significantly more.

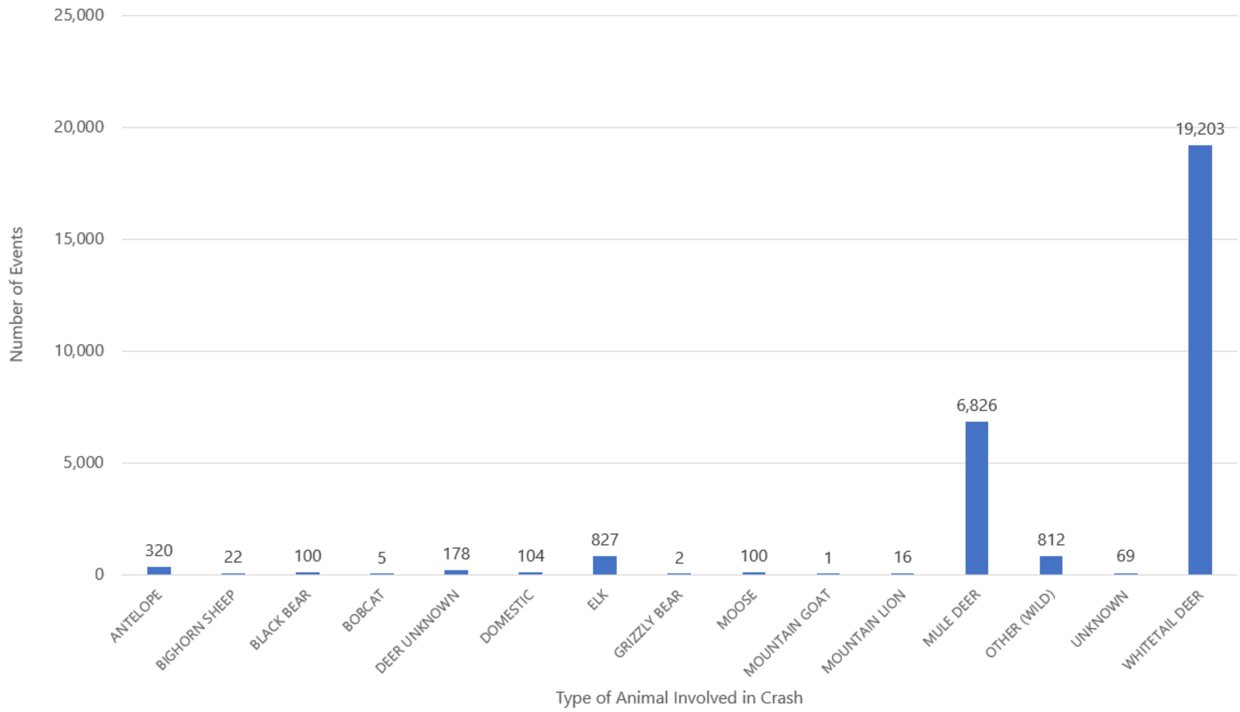
Figure 4-80 Wildlife Crash Statistics by County in Montana (2016-2020)



Source: Montana DoT, Map by WSP

Figure 4-81 displays a breakdown of the crashes by species of animal involved. Whitetail deer was by far the most reported animal with 19,203 incidents in the past 4 years, followed by mule deer in second place with 6,826 reported incidents.

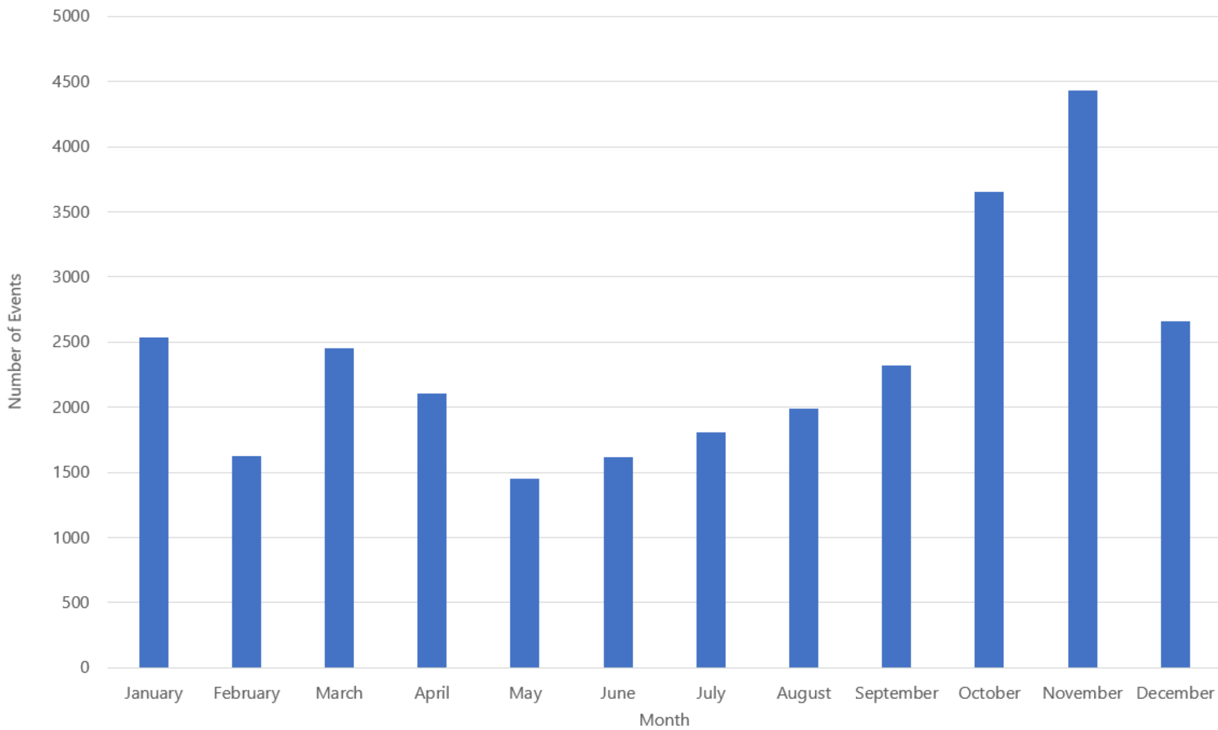
Figure 4-81 Wildlife Crash Statistics by Carcass Type in the Montana (2016-2020)



Source*: Montana Department of Transportation 2016-2020*

The Montana DOT also reported on the date that these wildlife accidents occurred. Figure 4-82 displays the temporal trends of these crashes. The greatest frequency of events occurs in the months of October and November. This is likely because deer mating season occurs at this time of year and therefore, they are more active and likely to wonder onto roadways. Accidents with deer are most likely to occur from 6 pm – 9 pm due to the crepuscular nature of deer, meaning that they are most active during twilight.

Figure 4-82 Wildlife Crash Statistics by Month in Montana (2016-2020)



Source: Montana Department of Transportati*on 2016-2020*

Waterway Transportation Incidents

Montana has a number of glacial-fed lakes and free-flowing rivers that provide opportunities for tourism and recreation. Several major rivers in the Eastern Region include the Yellowstone River and Missouri River. Fort Peck Lake also provides space for outdoor recreation in the Eastern Region. With extensive opportunities for water recreation in the state, there are associated risks including boating accidents and drownings.

The U.S. Coast Guard documents annual recreational boating statistics across the United States. Table 4-55 below displays information from the annual reports for the State from 2017 to2021. In total, 82 accidents have been reported in Montana over the past 5 years, resulting in 32 deaths and 41 injuries, as well as $450,925.95 in property damages.

Table 4-53 Boating Accidents by Year in Montana (2017-2021)

	Number of Accidents				Persons Involved			
Year	Total	Fatal	Non-Fatal	Property Damage	Total	Deaths	Injured	Damages
2021	16	4	6	6	12	5	7	$56,050.00
2020	25	7	9	9	20	7	13	$178,600.00
2019	13	4	6	3	13	5	8	$59,275.95
2018	19	9	6	4	22	13	9	$144,900.00
2017	9	2	3	4	6	2	4	$12,100.00
Total	82	26	30	26	73	32	41	$450,925.95

Source: U.S. Coast Guard 2017-2021 Recreational Boating Statistics

Frequency/Likelihood of Occurrence

Overall, transportation accidents are all but certain to occur on a yearly basis; therefore, the frequency/likelihood of occurrence is rated as **Highly Likely** for the Eastern Region. Air traffic overall is more limited and any planes that crash are likely to be small planes with no more than a pilot and potentially one to a few passengers. However, since there are many commercial planes that fly over the Eastern Region, there is always a chance for a major crash. More people are utilizing air travel now than in the past. The NTSB documented 505 aircraft accidents over 54 years, which averages over 9 aircraft accidents per year across the region. The trend of increasing numbers of people flying is likely to continue as will the crowdedness of airports and the skies above Montana.

Although traffic engineering, inspection of traffic facilities, land use management of areas adjacent to roads and highways, and the readiness of local response agencies have increased, highway incidents will continue to occur. As the volume of traffic on the state's streets, highways, and interstates increases, the number of traffic accidents will likely also increase. The combination of large numbers of people on the road, wildlife, unpredictable weather conditions, potential mechanical problems, and human error always leaves the potential for a transportation accident open. Local jurisdictions should continue to look at where traffic signals and speed limit changes are needed to protect the public. Montana DoT reported 26,984 roadway traffic accidents from 2016 to 2020 in the Eastern Region, or an average of 6,746 accidents per year. Collisions involving wildlife is commonly reported in Montana. The Montana DoT carcass database reported 28,652 accidents resulting in an animal carcass from 2016 to 2020, or an average of 7,163 accidents a year.

Many ponds, rivers, and lakes are used for recreation, including angling, boating, and swimming. The number of users of Montana lakes and rivers is increasing with increased tourism and population growth in the area. Minor incidents involving one or two boats and/or individuals can occur that tie up response resources and cause death and injury are possible but unlikely each year. Incidents will be recreational-related, as opposed to transportation-related, because the waterways are too small to support barges. Waterway accidents are less likely to occur than roadway incidents. However, the U.S. Coast Guard reported 82 waterway accident events from 2017 to 2021 across the State of Montana, or an average of 16 events per year.

Based on the available information, the probability of air transportation, highway, waterway, or railway incident that directly threatens life and which results in property damage and/or death(s)/injury(s) and/or adversely impact a community's capabilities to provide emergency services is "Highly Likely" as multiple occurrences happen each year.

Climate Change Considerations

If projections regarding milder winters come to fruition, climate change impacts may reduce the number of transportation incidents associated with some severe weather. However, if ice occurs, rather than snow, this could result in higher incidents of weather-related accidents. Extreme heat can also impact the performance of motor vehicles, especially planes. Increasing temperatures due to climate change could therefore pose threats to aircrafts.

Potential Magnitude and Severity

The U.S. Department of Transportation Federal Highway Administration issued a technical advisory in 1994 providing suggested estimates of the cost of traffic crashes to be used for planning purposes. These figures were converted from 1994 dollars to 2020 dollars. The costs are listed below in Table 4-56. Injuries and deaths are also impacts of transportation accidents. While transportation accidents are frequent in the Eastern Region, most accidents result in minor property injuries to vehicles involved; therefore, the magnitude ranking for transportation incidents in Eastern Region is **Limited**.

Table 4-54 Costs of a Traffic Crash

Severity	Cost per injury (in 2020 $)
Fatal	$4,645,467
Evident Injury	$64,320
Possible Injury	$33,948
Property Damage Only	$3,573

Source: U.S. Department of Transportation Federal Highway Administration Technical Advisory T 7570.2, 1994. Adjusted to 2020 dollars

Vulnerability Assessment

People

All people are vulnerable to transportation accidents in the Eastern Region. Travelers, truckers, delivery personnel, and commuters are always at risk on the road. During rush hours and holidays the number of people on the road is significantly higher. This is also true before and after major gatherings such as sporting events, concerts, and conventions. Pedestrians and bystanders of the community are less vulnerable unless they are in the roadway. Any individual incident will have a direct impact on only a few people. Individuals involved in a transportation accident can have cuts, bruises, broken bones, loss of limbs, and death. It is also common for individuals involved in an accident to experience psychological effects from a severe accident.

Not all people are equally vulnerable to transportation incidents. According to a study, An Analysis of Traffic Fatalities by Race and Ethnicity 2021, by the Governors Highway Safety Association, found that traffic fatalities are more common in low-income areas and among Native and Black Americans. The study found that in 2020, total traffic deaths in the United States rose by 7.2%, but total traffic deaths among Black Americans increased by 23%. The study reported several reasons for this, including poor road quality in low-income areas, pedestrians being disproportionally Black, and members of the low-income population being unable to stay home from work during the pandemic.

Property

All property is vulnerable to transportation accidents, including the modes of transportation themselves and all associated equipment. Roadway accidents can impact surrounding infrastructure, including surrounding buildings, poles, or guardrails. Railway accidents frequently result in damages to the railway tracks which can be expensive to repair and result in delays in the transportation of goods. Aircraft accidents frequently result in damaged or destroyed planes, as well as damage to infrastructure in the landing area. Boating incidents can cause extensive damage to ships, bridges, and docks.

Critical Facilities and Lifelines

Transportation accidents can result in delayed responses for emergency vehicles and severe or multi-car accidents can put a strain on response services and hospital capacity. The transportation of goods can also be delayed due to road closures from an accident. Power outages are also possible due to damages infrastructure.

Economy

There are significant economic impacts likely to result from transportation accidents. Cost of repairing property and hospital bills for those impacted by the accident can be substantial. The U.S. DoT reported the estimated cost of a fatality is over $4.6 million in damages. Additionally, lost revenue from business disruptions and disruptions in the transportation of goods can be significant.

Historic and Cultural Resources

Historic and cultural resources are equally vulnerable to transportation accidents as other types of property.

Natural Resources

Transportation accidents to natural resources is minimal. These accidents can result in debris and fuel leakage into the environment, which can harm the surrounding ecosystem. Trees and other landscaping can be damaged when a vehicle leaves the roadway. Wildlife is also at risk to injury or death due to vehicles on the road. Significant threat to natural resources could occur if a transportation accident involving hazardous materials occurs.

Development Trends Related to Hazards and Risk

Increasing roadway infrastructure and number of cars on the road will likely result in an increase in the number of transportation accidents in the Eastern Region. Increase in air travel is likely to continue and therefore the increase in number of aircraft disasters. Construction and re-routing of local roads also increases the chances of a traffic accident.

Risk Summary

In summary, the transportation accidents hazard is considered to be overall **Medium** significance for the Region. Variations in risk by jurisdiction are summarized in the table below, as well as key issues noted in the vulnerability assessment.

- These events typically impact areas along roadways, railways, waterways, or near airports; therefore, the hazard extent is rated as **Significant**.
- The data sources used for each type of transportation accidents reported significantly more than one accident a year, therefore, frequency is rated as **Highly Likely.**
- While transportation accidents commonly occur, most accidents impact only the people and vehicles involved and therefore magnitude is ranked as **Limited.**
- People who work in transportation and spend extensive time on the road, such as truck drivers or deliver drivers, are most likely to experience transportation accidents. Studies have found that Black and Native Americans are disproportionately likely to be involved in a transportation accidents and accidents are more likely to occur in low-income areas.
- Transportation accidents are likely to cause damage to the vehicles involved as well as surrounding infrastructure. First responder services may be delayed due to multi-car pileup accidents or significant train derailments.
- Significant economic losses can result from business interruptions due to delays in the transportation of goods and from repairs to transportation vehicles and infrastructure.
- Critical infrastructure such as bridges and major roads can be blocked off or closed due to major roadway accidents. Railroads can also be closed for extended periods of time due to track damage, which would limit the movement of goods in and out of the areas impacted.
- The frequency of transportation accidents is frequent across jurisdictions, but some counties such as Yellowstone County are likely to experience greater losses due to larger populations and greater concentration of transportation systems
- Related Hazards: Hazardous Materials Accident

Table 4-55 Risk Summary Table: Transportation Accidents

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	Medium		
Big Horn	Low	Hardin, Lodge Grass	Railway in Big Horn County, through Hardin and Lodge Grass
Carbon	Low	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	N/A

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Carter	Low	Ekalaka	N/A
Crow Tribe	Low		Studies have shown Native American populations may be at increased vulnerability for traffic accidents
Custer	Low	Ismay, Miles City	Railway through Miles City; I-94 crosses county
Daniels	Low	Scobey, Flaxville	None
Dawson	Low	Richey, Glendive	Railway through Glendive; I-94 crosses county
Fallon	Low	Plevna, Baker	Railway through Plevna and Baker, Highway 12 crosses county
Garfield	Low	Jordan	None
Golden Valley	Low	Ryegate, Lavina	Railway crosses county
McCone	Low	Circle	N/A
Musselshell	Low	Roundup	Highways 12 and 87 intersect in central Musselshell County
North Cheyenne Tribe	Low		Studies have shown Native American populations may be at increased vulnerability for traffic accidents
Powder River	Low	Broadus	N/A
Prairie	Low	Terry	Railway through Terry; I-94 crosses county
Richland	Low	Fairview, Sidney	None
Roosevelt	Low	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	Railway through Wolf Point and Poplar; Highway 2 crosses county
Rosebud	Low	Colstrip, Forsyth	Railway through Forsyth; I-94 crosses county
Sheridan	Low	Outlook, Westby, Plentywood, Medicine Lake	Railway through County, crosses through multiple towns
Stillwater	Medium	Columbus	Railway through County; I-90 crosses county
Treasure	Low	Hysham	Railway through Hysham; I-94 crosses county
Valley	Medium	Fort Peck, Glasgow, Nashua, Opheim	Railway through Valley County,
Wheatland	Low	Harlowton, Judith Gap	Railway through County; Highways 12 and 191 intersect in Harlowton
Wibaux	Low	Wibaux	Railway through Wibaux; I-94 crosses county
Yellowstone	Medium	Billing, Laurel, Broadview	Billings is the largest city in the State, and Yellowstone County is the most populous county. This high level of traffic volume coupled with extensive transportation infrastructure of multiple modes gives Yellowstone County the greatest numbers of incidents by far in the region

4.2.15 Volcanic Ash

Hazard/Problem Description

A volcano is a vent in the earth's crust, or a mountain formed by the eruption of subsurface material including lava, rock fragments, ash, and gases, onto the earth's surface. Volcanoes produce a wide variety of hazards that can damage and destroy property and cause injury and death to people caught in its path. These hazards related to volcanic activities include: eruption columns and clouds, volcanic gases, lava/pyroclastic flows, volcanic landslides, and mudflows or debris flows (called lahars). Large explosive eruptions can cause damage several hundred miles away from the volcano, primarily from ashfall. The distribution of ash from a violent eruption is a function of the weather, particularly wind direction and speed and atmospheric stability, as well as the duration of the eruption. As the prevailing wind in the mid-latitudes of the northern hemisphere is generally from the west, volcanic ash is usually spread eastward from the volcano. Exceptions to this rule do, however, occur. Ash fall, because of its potential widespread distribution, offers some significant volcanic hazards.

Volcanic eruptions are generally not a major concern in Montana due to the relatively low probability of events in any given year. However, Montana is within a region with a significant component of volcanic activity and has experienced the effects of volcanic activity as recently as 1980 during the eruption of Mount St. Helens in the State of Washington.

Based on the evidence of past activity, volcanoes can be considered "active", "dormant", or "extinct." "Active" volcanoes usually have evidence of eruption during historic times. Volcanoes have a wide degree of variability in their eruptions, from mild lava flows to large explosions that eject tons of material and ash into the air. The degree of volcano hazard depends largely on if the volcano has a reasonable probability of erupting, the nature of the eruption, and the associated hazards that may be triggered. There are 20 active or potentially active volcanoes in the United States. The two volcanic centers affecting Montana in recent geologic time are: 1) the Cascade Range of Washington, Oregon, and California; and 2) the Yellowstone Caldera in Wyoming and eastern Idaho. Based on the historic trends of past eruptions, volcanic eruptions in the Cascade Mountains are more likely to impact Montana than Yellowstone eruptions. The primary effect of the Cascade volcanic eruptions in Montana would be ash fall.

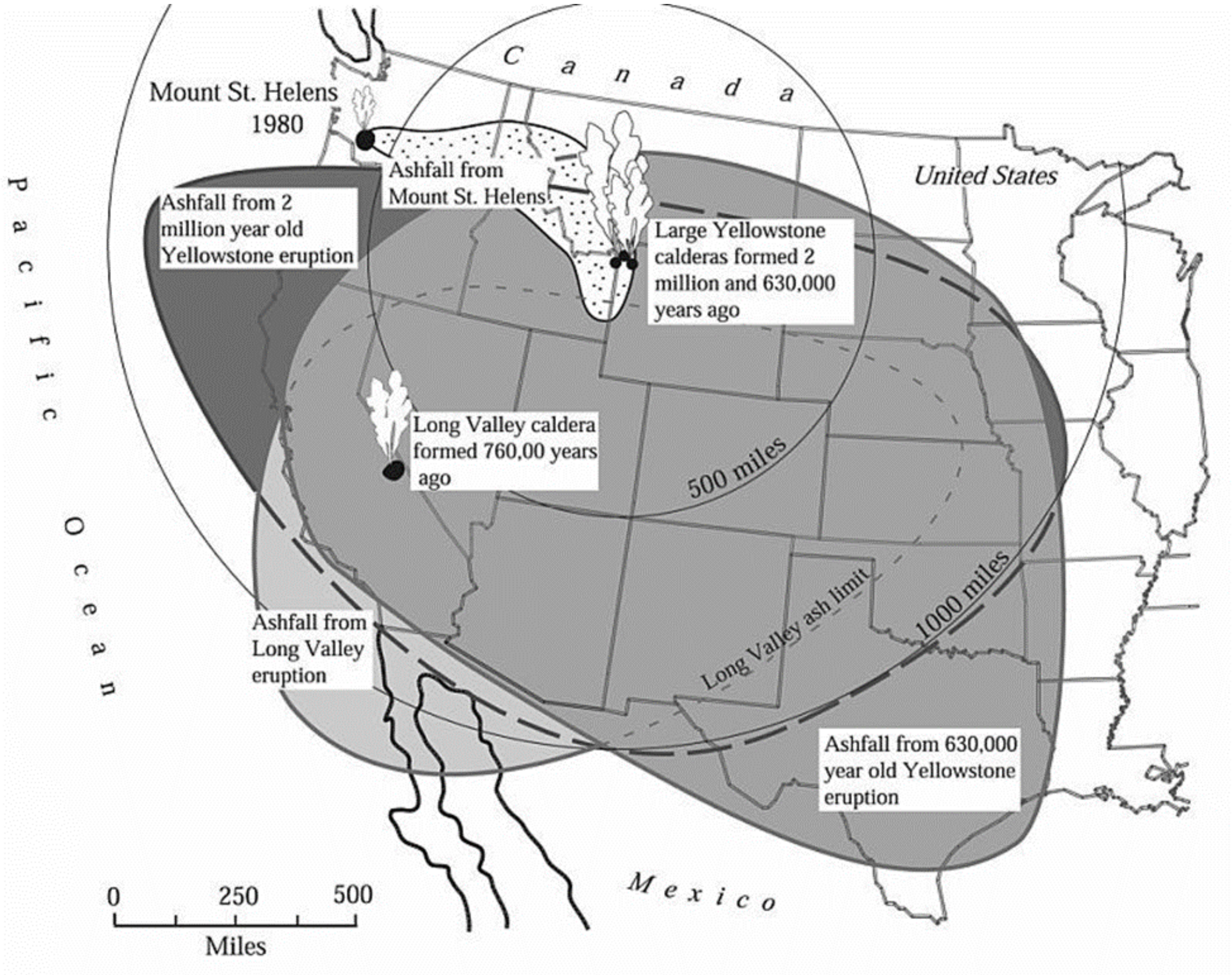
The distribution of ash from a violent eruption is a function of the weather, particularly wind direction and speed and atmospheric stability, and the duration of the eruption. As the prevailing wind in the mid-latitudes of the northern hemisphere is generally from the west, volcanic ash is usually spread eastward from the volcano. Exceptions to this rule do, however, occur. Ash fall, because of its potential widespread distribution can result in significant volcanic hazards.

According to the U.S. Geological Survey, Yellowstone National Park has been identified as a prominent hot spot for geologic activity. The hot spot is presumed to exist under the continental crust in the region of Yellowstone National Park and northwestern Wyoming. Large calderas under the park were produced by three gigantic eruptions during the past two million years, the most recent of which was approximately 600,000 years ago. That particular volcanic eruption blasted molten rock into the air at 1,000 times the volume of the 1980 Mount St. Helen's eruption subsequently collapsing to create the Yellowstone Caldera (Tracking Changes in Yellowstone's Restless Volcanic System, USGS Website). Ash deposits from these volcanic eruptions have been mapped in Iowa, Missouri, Texas, and northern Mexico. Thermal energy from the hot spots fuel hot pools, springs, geysers, and mud pots in the park today. According to recent surveys, parts of the Yellowstone region rise and fall as much as 1 centimeter a year, indicating the area is still geologically active (Kious, Jacqueline and Robert Tilling ND). However, these measurable ground movements, which most likely reflect hydrothermal pressure changes, do not necessarily signal renewed volcanic activity in the area." (Kious, Jacqueline and Robert Tilling ND)

Geographical Area Affected

The geographical extent of volcanic ash is **Extensive**. All areas of the Eastern Region would be affected by a volcanic eruption of the Yellowstone caldera. According to the 2018 Montana SHMP, western and southwestern Montana are most vulnerable to eruptions and ashfall from the Cascade Volcanoes. As shown in Figure 4-83 below, almost all of the state of Montana has been covered with volcanic ash at some point in the recent geologic history.

Figure 4-83 Areas of the United States once covered by volcanic ash from major eruptions



Source: U.S. Geological Survey

Past Occurrences

Since the late 1700s, volcanic eruptions in the continental United States have occurred in Oregon, Washington, and California. The most recent volcanic activity in the Yellowstone region occurred 70,000 years ago in the form of a lava flow. However, the volcanic ash fallout from the eruption of Mount St. Helens in 1980 was the most recent occurrence of volcanic activity to impact the region. Local news sources reported the sky appeared to be foggy, and a thin layer of gritty, dull, grey powder was deposited in many areas of Montana. The 2018 Montana SHMP notes travel was restricted in western Montana for over a week because of concerns for public health, and that the main hazards associated with ash were reduced visibility (resulting in closed roads and airports), clogging of air filters, and a health risk to children, the elderly, and people with cardiac or respiratory conditions.

Frequency/Likelihood of Occurrence

The frequency of volcanic as in the Eastern Region is ranked as **Unlikely**. Ashfall from a Cascade Volcano is the primary hazard to which the State may be vulnerable in the future. Future eruptions in the Cascades are certain and have occurred at an average rate of 1-2 times per century during the last 4,000 years. Seven volcanoes in the Cascades have erupted in the last 200 years. The next eruption in the Cascades could affect hundreds of thousands of people. The effect in Montana would depend on the interaction of such variables as source location, frequency, magnitude and duration of eruptions, the nature of the ejected material and the weather conditions. Therefore, the entire State may be considered vulnerable to ashfall to some degree in the event of a volcanic eruption.

Three major periods of activity in the Yellowstone system have occurred at intervals of approximately 600,000 years, with the most recent occurring about 600,000 years ago. The evidence available is not sufficient to confirm that calderas such as the one in Yellowstone erupt at regular intervals, so the amount of time elapsed is not necessarily a valid indicator of imminent activity. There is no doubt, however, that a large body of molten magma exists, probably less than a mile beneath the surface of Yellowstone National Park. The presence of this body has been detected by scientists who discovered that earthquake waves passing beneath the park behave as if passing through a liquid. The only liquid at that location that could absorb those waves is molten rock. The extremely high temperatures of some of the hot springs in the park further suggest the existence of molten rock at shallow depth. A small upward movement in the magma could easily cause this magma to erupt at the surface. If a major eruption occurred, the explosion would be "comparable to what we might expect if a major nuclear arsenal were to explode all at once, in one place" (Roadside Geology of Montana, Alt and Hyndman, 1986).

Climate Change Considerations

While climate change is not expected to impact the size or frequency of eruptions, eruptions themselves can have a huge impact on climate. Eruptions can inject millions of tons of gases and debris into the atmosphere, which can circulate far away from the incident site and disrupt normal climate patterns. Large-scale volcanic activity may only last a few days, but the massive outpouring of gases and ash can influence climate patterns for years, influencing both heating and cooling.

For example, the 1883 eruption of the Krakatoa volcano in Indonesia resulted in far reaching global climate impacts, with the average summer temperatures in the Northern Hemisphere falling by 0.72 degrees Fahrenheit the year after the eruption. The 1815 Mt. Tambora eruption, also in Indonesia, was the deadliest volcanic eruption in recorded history. It also led to global climate impacts resulting in 1816 being referred to as "the Year Without a Summer". According to NASA, average global temperatures dropped with frost and snow experienced in the middle of summer as far away as New England and Europe, leading to massive crop losses and famine. A similar scale eruption of the Yellowstone Caldera would also likely eject massive amounts of gasses which would affect the global climate, as well as the Eastern Montana.

Potential Magnitude and Severity

The potential magnitude and severity of volcanic ash is **Limited**. Populations living near volcanoes are most vulnerable to volcanic eruptions and lava flows, although volcanic ash can travel and affect populations many miles away and cause aviation issues. The USGS notes specific characteristics of volcanic ash. Volcanic ash is composed of small, jagged pieces of rocks, minerals, and volcanic glass the size of sand and silt. Very small ash particles can be less than 0.001 millimeters across. Volcanic ash is not the product of combustion, like the soft fluffy material created by burning wood, leaves, or paper. Volcanic ash is hard, does not dissolve in water, is extremely abrasive and mildly corrosive, and conducts electricity when wet.

Volcanic ash is formed during explosive volcanic eruptions. Explosive eruptions occur when gases dissolved in molten rock (magma) expand and escape violently into the air, and also when water is heated by magma and abruptly flashes into steam. The force of the escaping gas violently shatters solid rocks. Expanding gas also shreds magma and blasts it into the air, where it solidifies into fragments of volcanic rock and glass. Once in the air, wind can blow the tiny ash particles thousands of miles away from the volcano.

Cataclysmic eruptions of the Yellowstone volcano 2.0, 1.3, and 0.6 million years ago ejected huge volumes of rhyolite magma; each eruption formed a caldera and extensive layers of thick pyroclastic-flow deposits. The caldera is buried by several extensive rhyolite lava flows that erupted between 75,000 and 150,000 years ago.

Vulnerability Assessment

People

Volcanic ash poses a public health risk, especially to children, the elderly, and individuals with cardiac and respiratory considerations. The US Department of Health and Human Services tracks Medicare beneficiaries who rely on electricity-depending medical equipment, such as ventilators, oxygen concentrator equipment, and implanted cardiac devices. Many of these same individuals will be vulnerable to effects of volcanic ash. The abrasiveness of the volcanic ash particles can scratch the surface of skin and eyes and in general cause discomfort and inflammation, in addition to difficulties breathing or death if too much ash is inhaled.

Property

Extensive cleanup efforts were required throughout Montana after the Mount Saint Helen eruption in 1980. Ashfall can impact both the interior and exterior of buildings. The interior of buildings can be contaminated with ash that builds up in air vents and filters. The exterior of buildings can have abrasive damage to roofs and gutters can be blocked with ash which could lead to secondary flooding issues. If a rain event was to occur post eruption, it can turn ash into heavy, cement-like sludge that can lead to the collapse of roofs and difficulty when cleaning up.

Critical Facilities and Lifelines

Critical facilities and infrastructure are most vulnerable to the effects of ashfall. Volcanic eruption with ashfall can cause electricity outages and issues with power supply. The air intakes for generators will also be vulnerable to airborne ash post eruption. Telephone and radio communications can also be interrupted and electronic components and short-circuits, especially high-voltage circuits and transformers, can fail due to ashfall.

Wastewater collection systems are also vulnerable to damage from ashfall. Buildup of ash in drainage systems can result in stormwater flooding. Ash-laden sewage that makes its way to wastewater treatment plants can cause mechanical damage and, if it makes it further through the system, it will settle and reduce the capacity of biological reactors, increasing the volume of sludge and changing its composition.

Transportation infrastructure is also vulnerable to the impacts of ashfall. Roads, highways, and airport runways can be made impassable due to the slippery ash and reduction of visibility. The abrasive volcanic ash can have damaging effects on aircraft including melting the inside of engines and solidifying the turbine blades, ultimately causing the engine to stall. Volcanic ash can also lead to the failure of critical navigational and operational instruments.

Economy

In general, volcanic eruptions pose a risk to the tourism economy. Ashfall can disrupt travel into and out of all areas of the Eastern Region and create perilous conditions for residents, tourists, and nature alike. Ashfall can also lead to widespread power loss which could have lasting impacts on local businesses. The perception of risk after a volcanic event could also lead to a downturn in visitors to the region and have long-term negative impacts on the tourism industry in the Region.

Massive impacts to the natural environment can also lead to widespread agricultural losses as well, resulting in far reaching impacts to those related sectors of the economy.

Historic and Cultural Resources

The major vulnerability to volcanic activity in terms of cultural resources would be the recreational and tourism assets provided by the region's natural environment. The natural landscape can be cataclysmically altered or destroyed by explosive volcanic eruptions. The Mt. St. Helens eruption permanently altered the landscape around the mountain, which was a popular tourism destination for many resorts and outdoor activities, not only damaging vegetation but physically altering the topography and waterways around the volcano. While this kind of explosive eruption occurring in the Eastern Region is unlikely, damage from heavy ashfall could also potentially destroy vegetation and the natural landscape.

Natural Resources

Volcanic ash can collect carbon dioxide and fluorine gases that can be toxic to humans and have significant impacts on the natural environment. Windblown ash can spread and pollute areas that had previously been unaffected. Vegetation is also vulnerable to the impacts of ashfall. Ashfall can result in decreased plant photosynthesis and reduced pollination, impacting the overall vegetative population in the region. Visual inspection of vegetation in a large area of the State of Washington impacted by the Mount Saint Helens eruption showed three broad categories of plant damages: (1) Breakage due to the weight of ash (2) physiological changes such as decreased plant growth and (3) chemical damages to the leaves (Ayris, Delmelle, 2012).

Water bodies are also vulnerable to the effects of ashfall and can cause chemical changes that can affect water quality. The following table from the USGS Volcanic Ashfall Impacts Working Group show the typical effects of ashfall on the quality of surface waterbodies.

Table 4-56 Typical Effects of Ashfall on the Quality of Surface Water Bodies

Turbidity	Ash suspended in water will increase turbidity in lakes, reservoirs, rivers, and streams. Very fine ash will settle slowly, and residual turbidity may remain in standing water bodies. In streams, ash may continue to be mobilized by rainfall events, and lahars may be a hazard in some regions.
Acidity (pH)	Fresh ashfall commonly has an acidic surface coating. This may cause a slight depression of pH (not usually below pH 6.5) in low-alkalinity surface waters.
Potentially Toxic Elements	Fresh ash has a surface coating of soluble salts that are rapidly released on contact with water. The most abundant soluble elements are typically Ca, Na, K, Mg, Al, Cl, S and F. Compositional changes depend on the depth of ashfall and its 'cargo' of water-soluble elements; the area of the catchment and volume available for dilution; and the pre-existing composition of the water body. In rivers and streams, there will be a short-lived pulse of dissolved constituents In lakes and reservoirs, the volume is usually large enough that changes in composition are not discernible The constituents most likely to be elevated above background levels in natural waters are Fe, Al, and Mn, because these are normally present at very low levels. Thus, water is likely to become unpalatable due to discoloration or a metallic taste before it becomes a health hazard.

Source: USGS Volcanic Ashfall Impacts Working Group, [Volcanic Ash Impacts & Mitigation - Water Supply (usgs.gov)]

Development Trends Related to Hazards and Risk

As population increases in Eastern Montana and recreational usage continues to expand, more and more people and property are at risk from the effects of volcanic activity.

Risk Summary

Overall volcanic ash is considered a low significance hazard throughout the Eastern Region due to the long recurrence intervals between events. While low probability, effects can be widespread and cause serious impacts.

- Effects on people: Serious adverse health impacts can occur, such as scratches and abrasion to the skin and eyes from direct contact with ash, and ultimately death potentially if ash is inhaled and cements in the lungs.
- Effects on property: exterior of buildings can have abrasive damage to roofs and gutters can be blocked, and the collapse of roofs if too much ash accumulates.
- Effects on the economy: ashfall can lead to disruptions in the tourism industries, through the prevention of travel and access to affected areas, as well as massive losses to agriculture if heavy ashfall were to occur during the growing season.
- Effects on critical facilities and infrastructure: ash can seriously damage electrical and mechanical components of infrastructure, disrupt air travel and EMS/first responder operations, and lead to backups and damage of wastewater systems.
- Unique jurisdictional vulnerability: the vulnerability is largely uniform as this hazard would likely result in impacts on a large scale, regionwide manner.
- Related hazards: earthquake

Table 4-57 Risk Summary Table: Volcanic Ash

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	Low		
Big Horn	Low	Hardin, Lodge Grass	None
Carbon	Low	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	None
Carter	Low	Ekalaka	None
Crow Tribe	Low		None
Custer	Low	Ismay, Miles City	None
Daniels	Low	Scobey, Flaxville	None
Dawson	Low	Richey, Glendive	None
Fallon	Low	Plevna, Baker	None
Garfield	Low	Jordan	None
Golden Valley	Low	Ryegate, Lavina	None
McCone	Low	Circle	None
Musselshell	Low	Roundup	None
North Cheyenne Tribe	Low		None
Powder River	Low	Broadus	None
Prairie	Low	Terry	None
Richland	Low	Fairview, Sidney	None
Roosevelt	Low	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	None
Rosebud	Low	Colstrip, Forsyth	None
Sheridan	Low	Outlook, Westby, Plentywood, Medicine Lake	None
Stillwater	Low	Columbus	None
Treasure	Low	Hysham	None

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Valley	Low	Fort Peck, Glasgow, Nashua, Opheim	None
Wheatland	Low	Harlowton, Judith Gap	None
Wibaux	Low	Wibaux	None
Yellowstone	Low	Billing, Laurel, Broadview	None

4.2.16 Wildland and Rangeland Fire

Hazard/Problem Description

As defined by the National Wildfire Coordinating Group (NWCG), a "wildland fire" is any non-prescribed, non-structure fire that occurs in the wildland" (NWCG 2012). Eastern Montana's semi-arid to mesic climate, rural setting, variable terrain makes most of the region vulnerable to frequent and potentially severe wildfire. As such, wildfire is an ongoing concern for the residents of eastern Montana. The two main types of wildfires affecting the Eastern Region are rangeland fires (wildfires occurring on rangeland) and forest fires (wildfires occurring within a forest); however, while infrequent, wildfires can also occur in agricultural areas. Fires can occur at any time of the year in Montana, but historically, the fire season extends from spring to fall, with large fires being more common in the later summer months and early fall months when fire conditions are more probable. Prime wildfire conditions occur when accumulated fuels become sufficiently dry from high temperatures and drought and can more easily ignite. Furthermore, high winds during the summer and fall can favor the chance of wildfire spreading. Climate change has led to hotter summers and has caused an increase in fuel drying, which has resulted in increases to wildfire size, intensity, frequency, and fire season length (NIFC, 2022a) as well as wildfire suppression costs (NIFC, 2022b). Throughout Montana, these trends are expected to be exacerbated as climate change progresses (Whitlock et al 2017; Steblein 2021).

Historically, wildfire has been an important and normal component of the forest and rangeland ecosystems in eastern Montana. Wildfires are necessary for maintaining the natural conditions and ecology of the region (MT DNRC 2020a). Until the latter 20th century, fire suppression was the dominant fire management policy across private, state, and federal lands across the western U.S. As a result, high levels of fuels have built up in many fire prone ecosystems, including eastern Montana (MT DNRC 2020a). Management goals in wildland areas typically are focused on bringing fire regimes back to their natural historic range of variation. However, in areas with heavy human use, fuel maintenance and land management strategies will be required to replace the historic role of wildfires. These can include, but are not limited to, prescribed burns, targeted livestock grazing, and mechanical fuel removal treatments (MT DNRC 2020a).

Generally, there are three major factors that predict wildfire behavior and predict a given area's potential to burn. These factors include fuel, topography, and weather.

Fuel: In order for fire to occur, fuel (a combustible material) must be available to burn. Fires are generally determined by fuel type and volume. Generally, the various fuel types and fuel characteristics that cover a landscape have significant impacts on wildfire behavior. Fuel types vary drastically throughout the eastern Region. Fuel sources can vary from dead fine grasses, leaves, and needles to live large trees. Combustible manmade structures also contribute to fuel sources. Fuels can be modified by humans through land use and land management (e.g., prescribed burns, mechanical fuel removal, invasive plant management, and grazing, among others). Scott and Burgan's (2005) fire behavior fuel models were used to model fuels in in the Eastern Region of Montana.

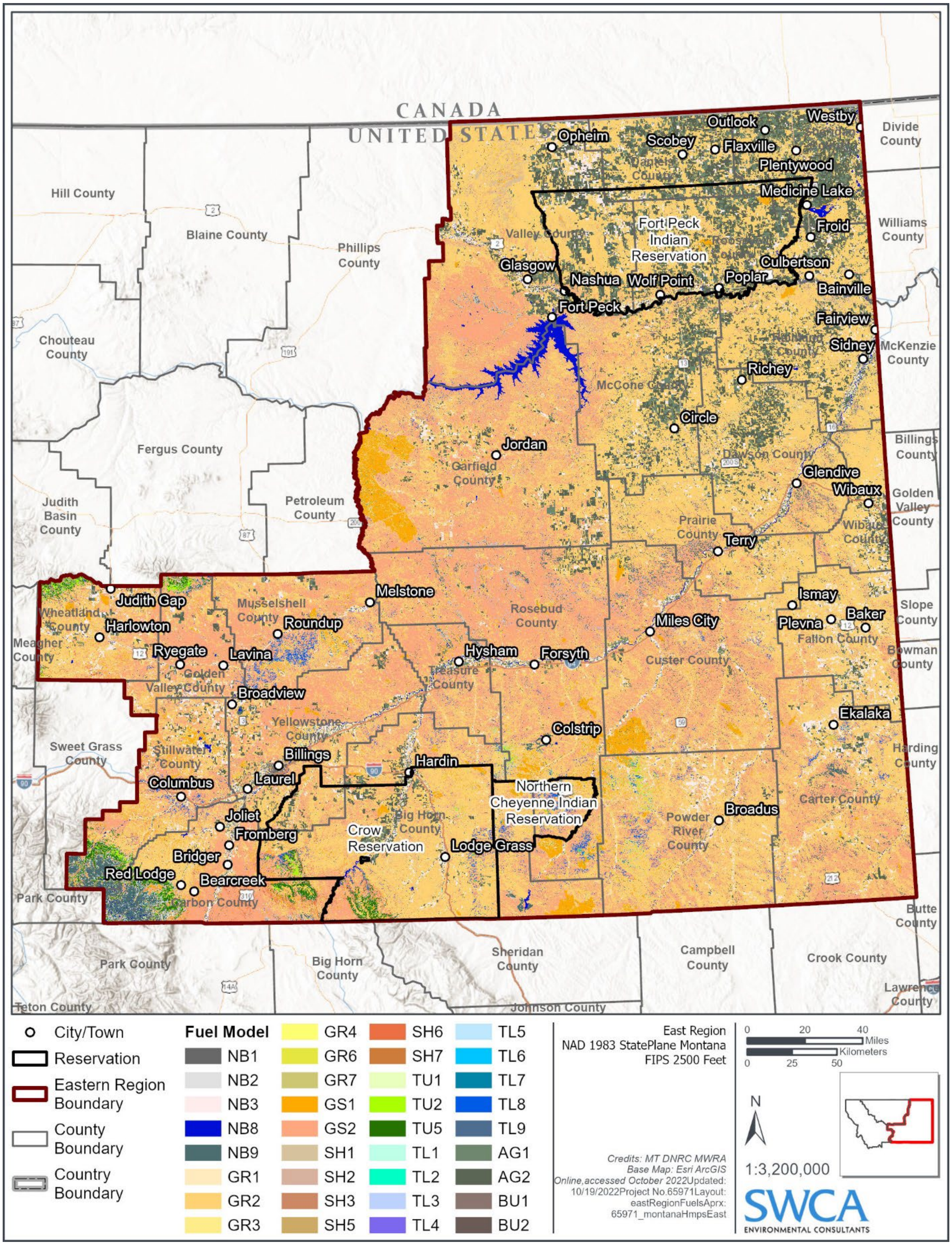
The primary fuel types in the Eastern Region are grass and grass-shrub fuels, as shown in Figure 4-84. Grass-shrub (GS2) fuels are the most commonly observed fuels in the region and are characterized as lands with up to 50% shrub cover with shrub height ranging from 1 to 3 feet high and accompanied with a moderate grass load. Wildfire spread rate for GS2 fuels is usually high (20-50 chains per hour [1 chain is equal to 66ft]) and flame lengths are moderate (4-8 feet). Sagebrush (Artemisia sp.) ecosystems usually exhibit GS2 fuels. GR2 (grass) fuels are also commonly observed fuels. Scott and Burgan (2005) describe GR2 fuels as moderately coarse continuous grass with an average depth of about 1 foot. Wildfire spread rate is usually high and flame lengths are moderate. Bunchgrass ecosystems typically exhibit GR2 fuels.

In the forested portions (e.g., the Beartooth Mountains, the Pryor Mountains, northern terminus of the Big Horns, and other scattered island mountainous terrain in the region) of the Eastern Region primary fuel types are timber-understory (TU2 and TU5) fuels. TU2 fuels are characterized by fuelbeds with a moderate litter load with a shrub component where wildfire spread rate is usually moderate (5-20 chains per hour) and flame lengths are predicted to be low (1-4 feet). Low-elevation forests comprised of species such as Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) usually exhibit TU2 fuels. TU5 fuels are characterized by fuelbeds with a high load of conifer litter and a shrub understory where wildfire spread rate and flame lengths are moderate. Higher elevation forests comprised of species such as subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), and lodgepole pine (*Pinus contorta*) usually exhibit TU5 fuels.

Topography: A region's topography is determined by slope and aspect. Normally, wildfire behavior, such as fire intensity and rate of spread, is more pronounced on steep slopes due to convective heat transfer (i.e., heat rising up the slope). South facing slopes are typically drier due to receiving more sunlight than north facing slopes. Thus, they normally contain drier and finer fuels that are more prone to producing faster rates of spread than the fuels seen on wetter north facing slopes. Eastern Montana's topography is diverse. It contains hilly rangelands; steep forested mountains; deep canyons; forested hills; valley rangelands; flat grasslands and shrublands; and flat farmlands.

Weather: Important weather characteristics, such as precipitation, wind speed, wind direction, temperature, relative humidity, and lightning can affect both the potential for wildfire and spread of wildfire. Low precipitation, high temperatures, and low relative humidity in drought years dry out live and dead fuels. These dry fuels can amplify wildfire activity and result in more extreme fire behavior. Additionally, antecedent wet years can build up finer fuels that may contribute to extreme wildfire behavior during summer or fall droughts. Weather regimes in the Eastern Montana region can vary drastically between low and high elevations, where the mountains to the east receive more precipitation than the eastern plains (PRISM 2022). Specifically, the Beartooth Mountains, Pryor Mountains, and Big Horn Mountains in Carbon and Big Horn Counties receive the most annual precipitation, while the plains to the east are comparatively dry. For precipitation across the Eastern Region, April through July are usually the wettest months of the year, December through February are usually the driest months. The latter summer and early fall months of August and September are comparatively dry compared to the spring and early summer months. Hazardous wildfire risk and activity are most likely to occur in late summer and early fall (Whitlock et al 2017)..

Figure 4-84 Wildfire Fuel Model of the Eastern Region

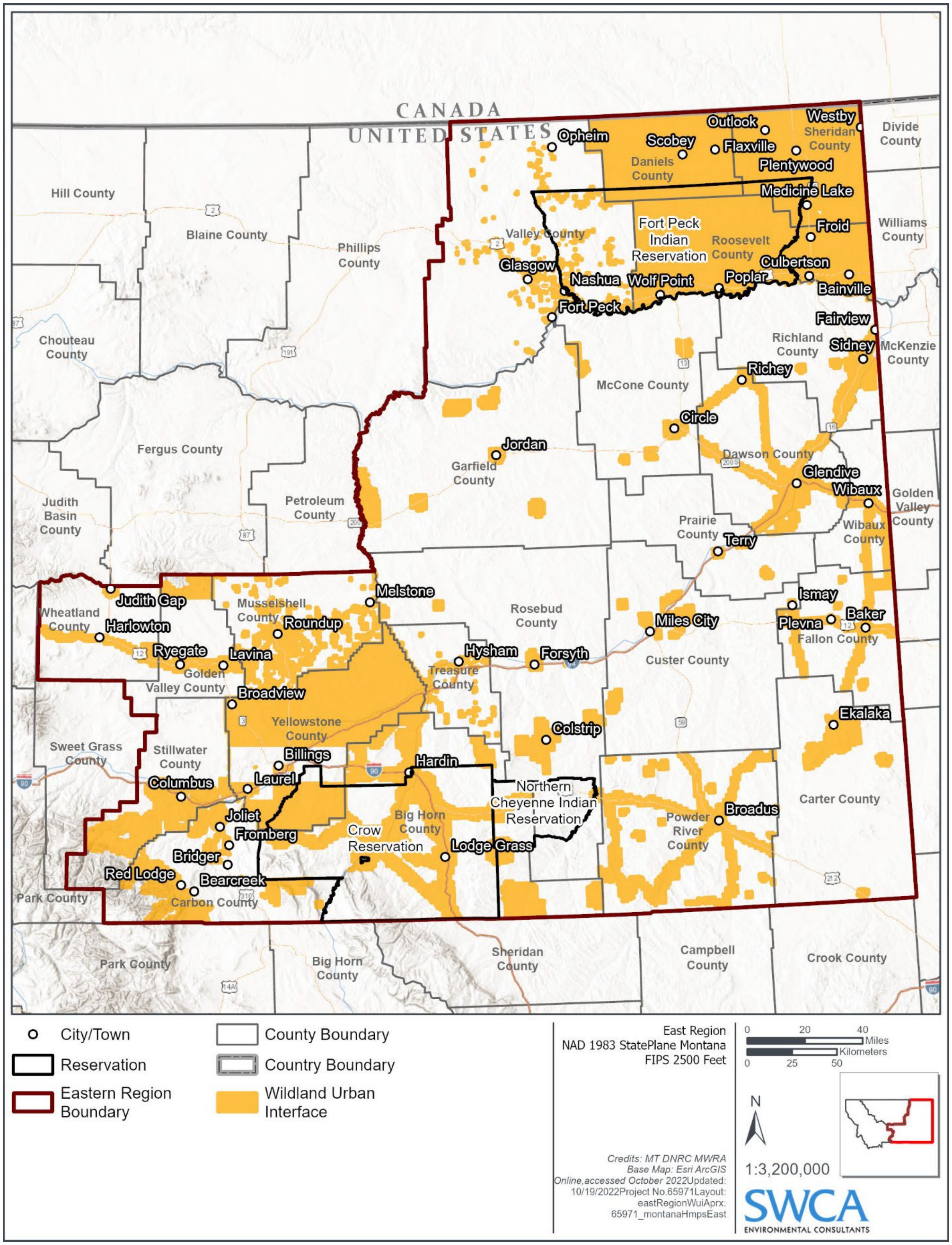


Source: MT DNRC 2022

Wildland-Urban Interface: The wildland-urban interface (WUI) is defined as the zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuel (MT MHMP 2018). Starting in 2011, Montana DNRC compiled WUI boundaries for all counties within the state based upon information provided from countywide Community Wildfire Protection Plans (CWPPs) or through consultation between the County and the MT DNRC. The methods for WUI delineation vary by County (MT DNRC, 2020b), which is why some WUI areas encompass an entire county land mass, and some areas are more nuanced, based on fuels, hazards, population density, infrastructure, and other factors. (see Figure 4-85).

In Eastern Montana, humans are a significant cause of wildfire ignitions. This is especially true is Eastern Montana's WUI, where wildfire risk is strongly with the WUI (e.g., exurban areas human caused ignitions and utilities and vehicle/roadside ignitions); however, lighting strikes during thunderstorms are also a major source of ignition (see Figure 4-85) (MT DNRC 2022a). Most of the counties in the Eastern Region, with some notable exceptions (e.g., the Billings area), have not experienced significant population trends or increases in development (U.S Census 2020); however, property located in the WUI will likely experience greater risk from wildfire due to increasing trends in human caused wildfires and a warming climate (MT DNRC 2020a).

Figure 4-85 Wildland Urban Interface Delineation



Source: MT DNRC 2020b

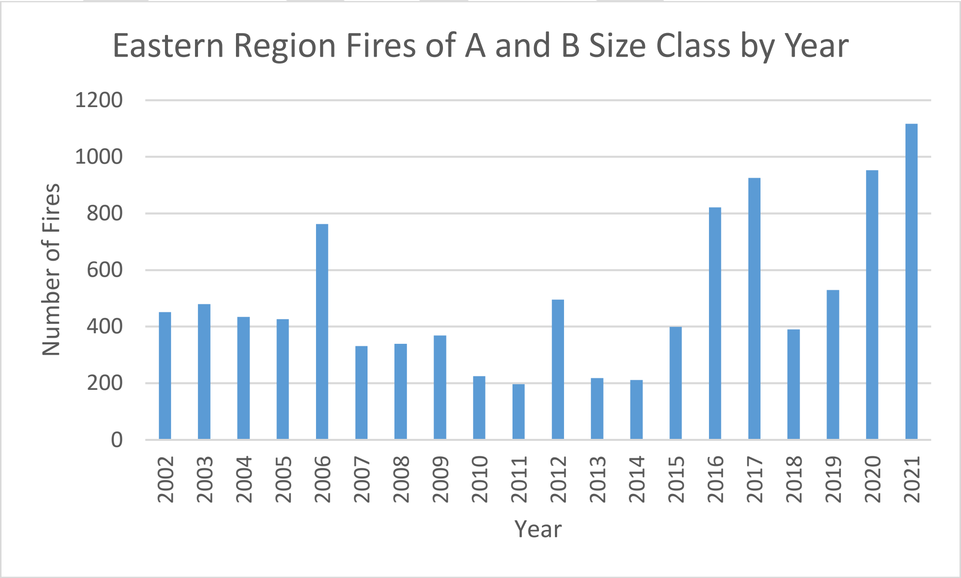
Geographical Area Affected

The climate of the Eastern Region varies from arid to semi-arid to mesic. All climates, combined with continuous loading of rangelands, grassland and some forest fuels, make most of the region susceptible to wildfire; the geographical area affected for wildfire is therefore **Extensive** (PRISM 2022; MTDNRC 2022). The two main types of fires that can occur in the Eastern Region are rangeland and forest fires. These fire types are reflected in the mapped risks from wildfire (in Figure 4-90 in the Wildfire Risk Section) The rangelands of the central portion the eastern regions that have complex topography and occasional patchwork of dry coniferous forests have historically been most at risk of wildfire (Figure 4-90). Large rangeland and forest fires in the region have most commonly occurred in the counties of Powder River, Big Horn, Yellowstone, Treasure, Rose Bud, Musselshell, Garfield, Carbon County, and Still Water (Figure-89). Almost the entire Eastern Region is at-risk and/or susceptible to wildfire. Large tracts of land with agricultural crop cover (especially in the northeastern portion of the region) are usually at less risk of wildfire compared to undeveloped rangelands and forests.

Past Occurrences

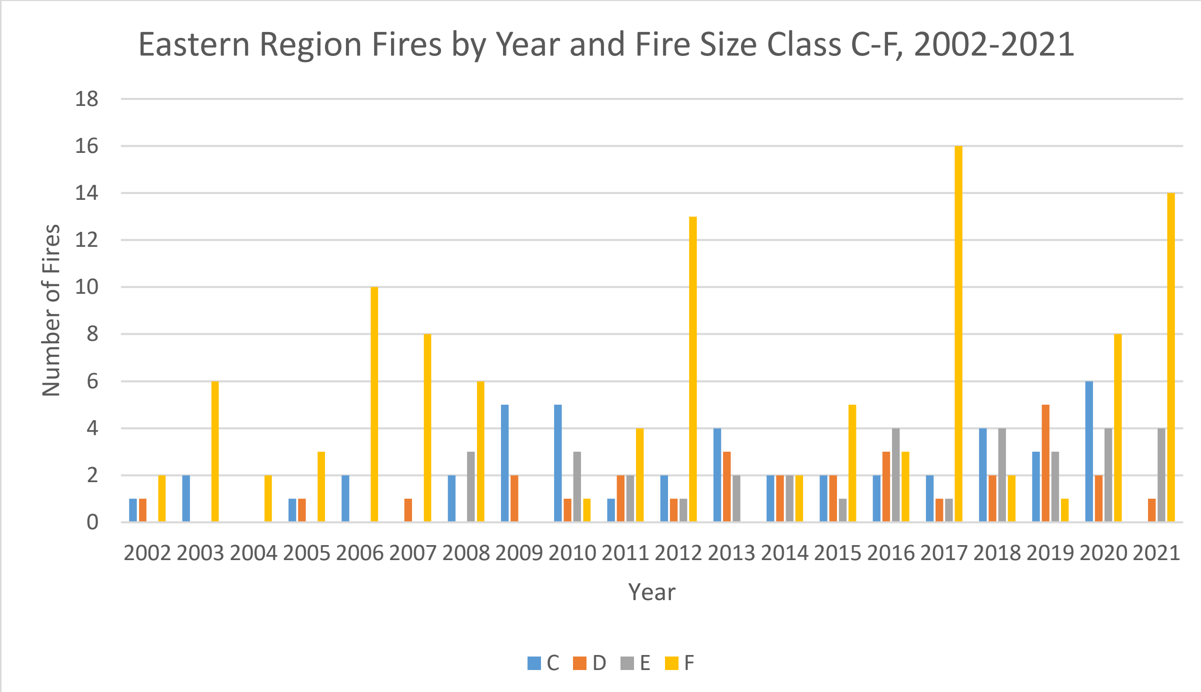
The Montana Wildfire Risk Assessment (MWRA) database, maintained by the Montana Department of Natural Resources and Conservation (MT DNRC), includes perimeter GIS layers for recent wildfires throughout the state of Montana (MT DNRC 2022a). According to the MWRA, wildfires in the Eastern Region occur on an annual basis and are usually contained early with little to no damage. Most wildfires are usually less than 1,000 acres; between 2002 and 2021 there have been 106 wildfires greater than 1,000 acres (Figure 4-63). Large (fires greater than 1,000 acres) and potentially destructive fires can occur in any year. Over the last 20 years there has been an increase in the number of Class F fires (fires greater than 1,000 acres). Years where there are larger and more destructive fires (e.g., the 2003, 2007, 2012, 2017 and 2021 wildfire seasons) are correlated with drought conditions and/or warmer growing season temperatures (PRISM 2022). Generally, the majority of wildfire occurrences are small (less than 10 acres) and cause no meaningful damage. From 2002 to 2021 there were 10,079 fires that burned 10 acres or less (Figure 4-62); however, in the same time frame there have also been 216 fires greater than 10 acres with approximately half of these (106 fires) being greater than 1,000 acres (Figure 6-63).

Figure 4-86 Number of Wildfire in Eastern Montana Region by Year and Size Class A-B, 2002 to 2021



* Size Class: A = 0.25 acre or less; B = greater than 0.25 to 10 acres.
Source: MT DNRC 2022

Figure 4-87 Number of Wildfire in Eastern Montana Region by Year and Size Class C-F, 2002 to 2021



* Size Class: A = 0.25 acre or less; B = greater than 0.25 to 10 acres; C = 10 to 100 acres; D = 100 to 300 acres; E = 300 to 1,000 acres; F = 1,000+ acres.

As shown in Figure 4-88, natural wildfire occurrences (e.g., lightning ignitions) in the Eastern Region are common and particularly common in the high elevation rangelands in south-central portion of the region where there are expansive tracts of, mostly, wild rangelands intermixed with patches of forests. Human caused wildfire occurrences are also common and are, generally, concentrated near the region's municipalities or infrastructure. Regional fire managers and emergency planners should take note that over the last decade there has been a consistent increase in the number of wildfires attributed to human causes. From 2017 to 2021 the number of human-caused wildfires outnumbered the number of natural caused wildfires (MT DNRC 2022a). Figure 4-89 shows the total acres burned by year.

Figure 4-88 Number of Wildfires by Cause, 2002 to 2021

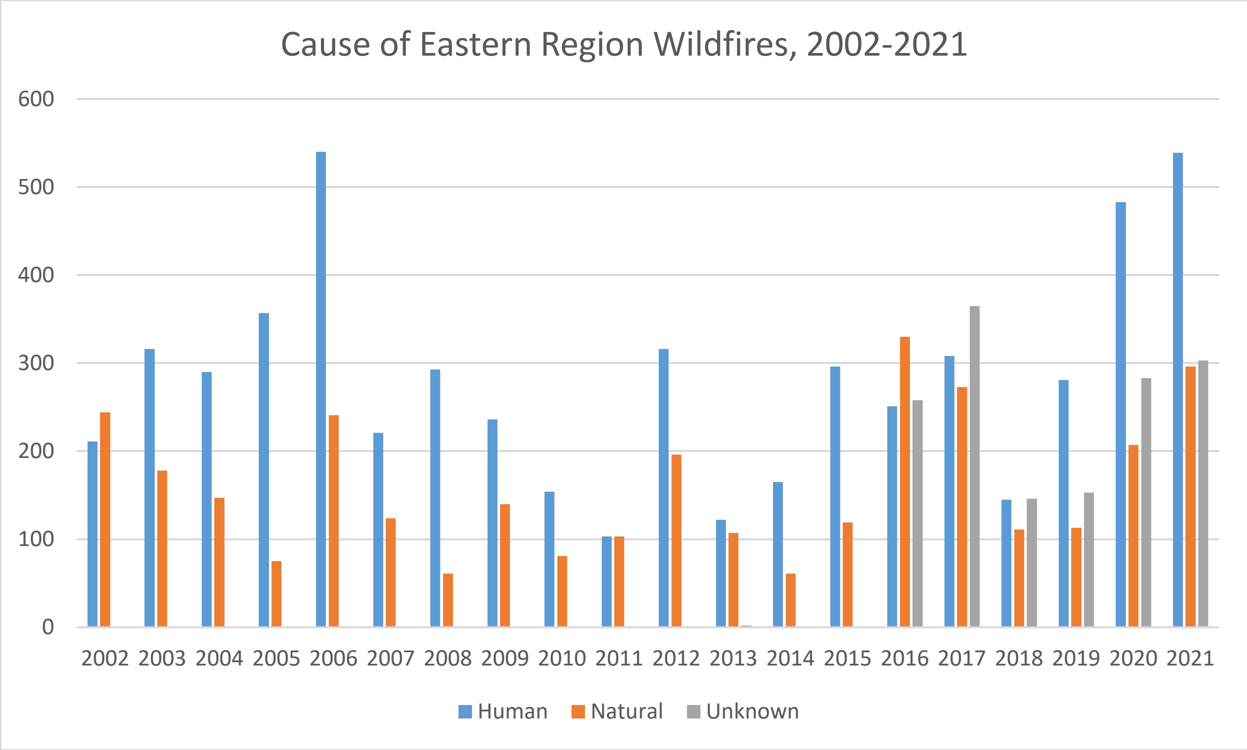
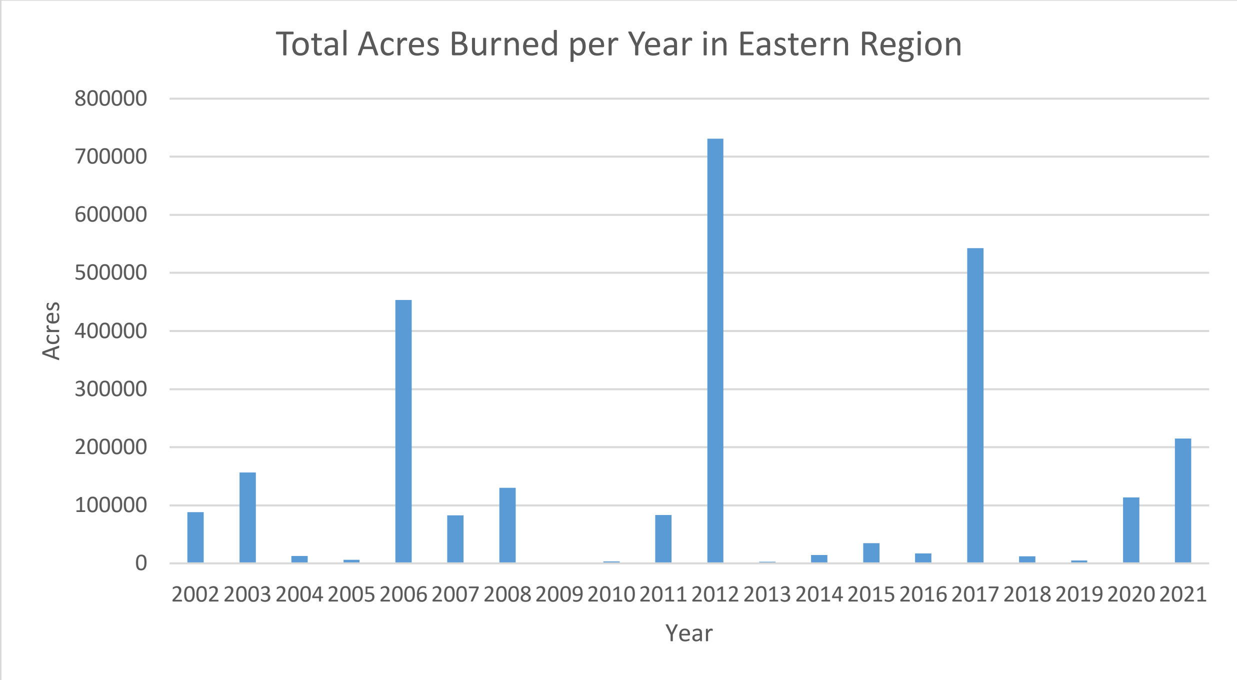


Figure 4-8989 Total Acres of Burned per Year in Eastern Region, 2002 to 2021



Over the last 20 years, the larger fires in the region have generally occurred in areas that are an intermix of rangelands and forests. Figure 4-90 shows the fire occurrence history in the Eastern Region. Figure 4-91 shows fire history in the Eastern Region.

Two notable wildfire incidents include the Ash Creek Fire (Figure 4-92) and the Lodgepole Complex (Figure 4-93). The Ash Creek Fire was a highly destructive lightning caused fire that occurred in the late spring and summer months of 2012. It impacted privately managed land, tribal managed lands, and Bureau of Land Management (BLM) managed lands. This fire burned 249,714 acres across Powder River County, Rosebud County, and the Northern Cheyenne Reservation. The fire destroyed 39 structures (including 19 residential homes); killed and displaced livestock; caused evacuations, and damaged regional infrastructure (Great Fall Tribune 2017; Billings Gazette 2013). Additionally, the Lodgepole Complex of 2017 burned 271,422 acres of Rangeland and Ponderosa Pine savannah in Petroleum and Garfield Counties. The Lodgepole Complex destroyed 16 homes and 16 structures. In total, the state spent $6 million fighting this fire (Garfield County 2017). Finally, to emphasize that wildfire risk is year-round, the West Wind Fire of Late November and early December of 2021 occurred in and around Denton, MT (in the Central Region) and was started by a powerline. This fire burned 10,644 acres of grasslands, pasture, and riparian wetlands. The fire was particularly destructive as it destroyed 25 primary structures, 18 secondary structures and 6 commercial structures in and around Denton (NWCG 2022). Among the structures lost were family homes, historic grain elevators, and a bridge (3KRTZ 2021). The consequences of these rangeland fires exemplify the threats that wildfire can pose in Eastern Montana’s rangelands.

Figure 4-90 Fire Occurrence History in Eastern Montana, 2002 to 2021

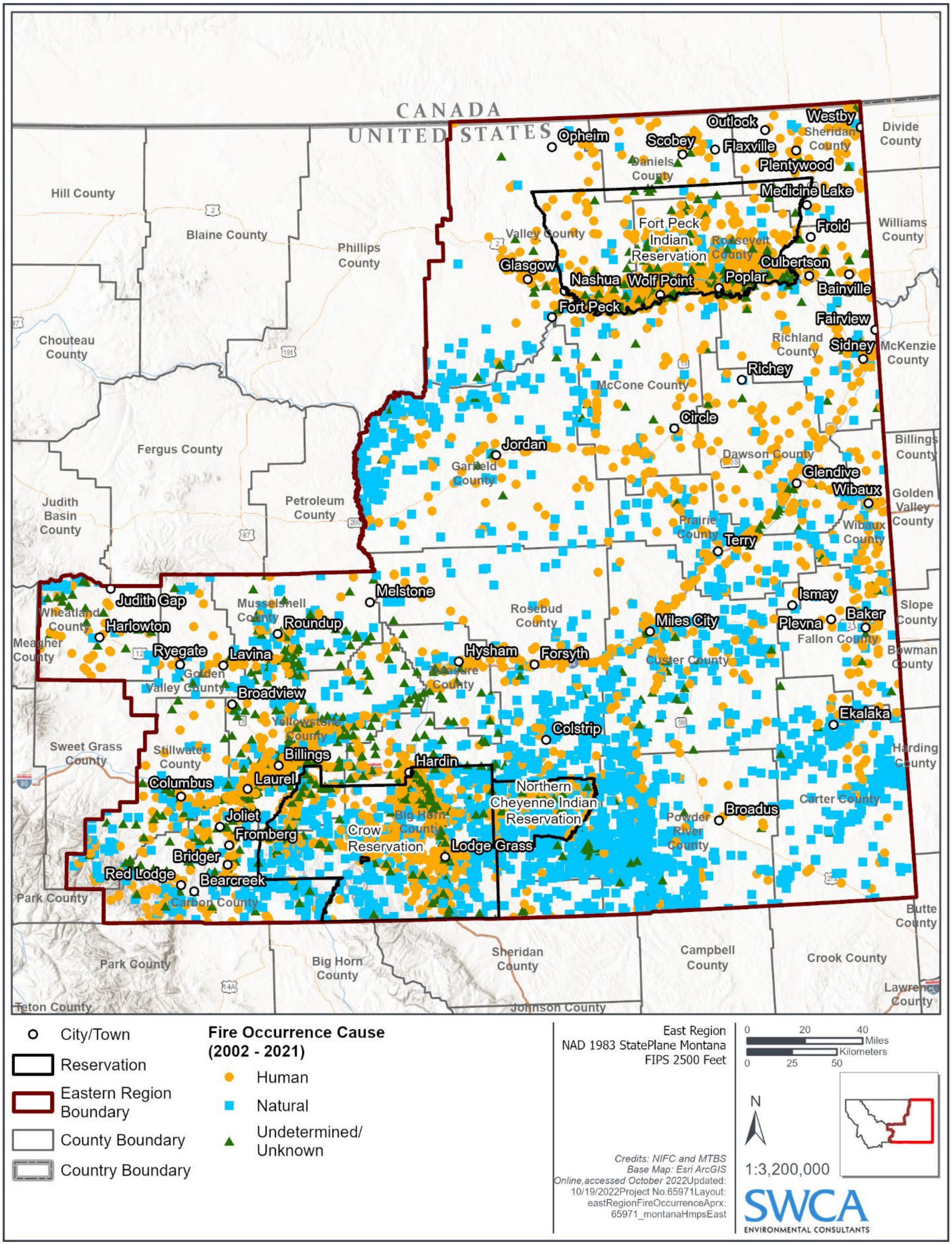
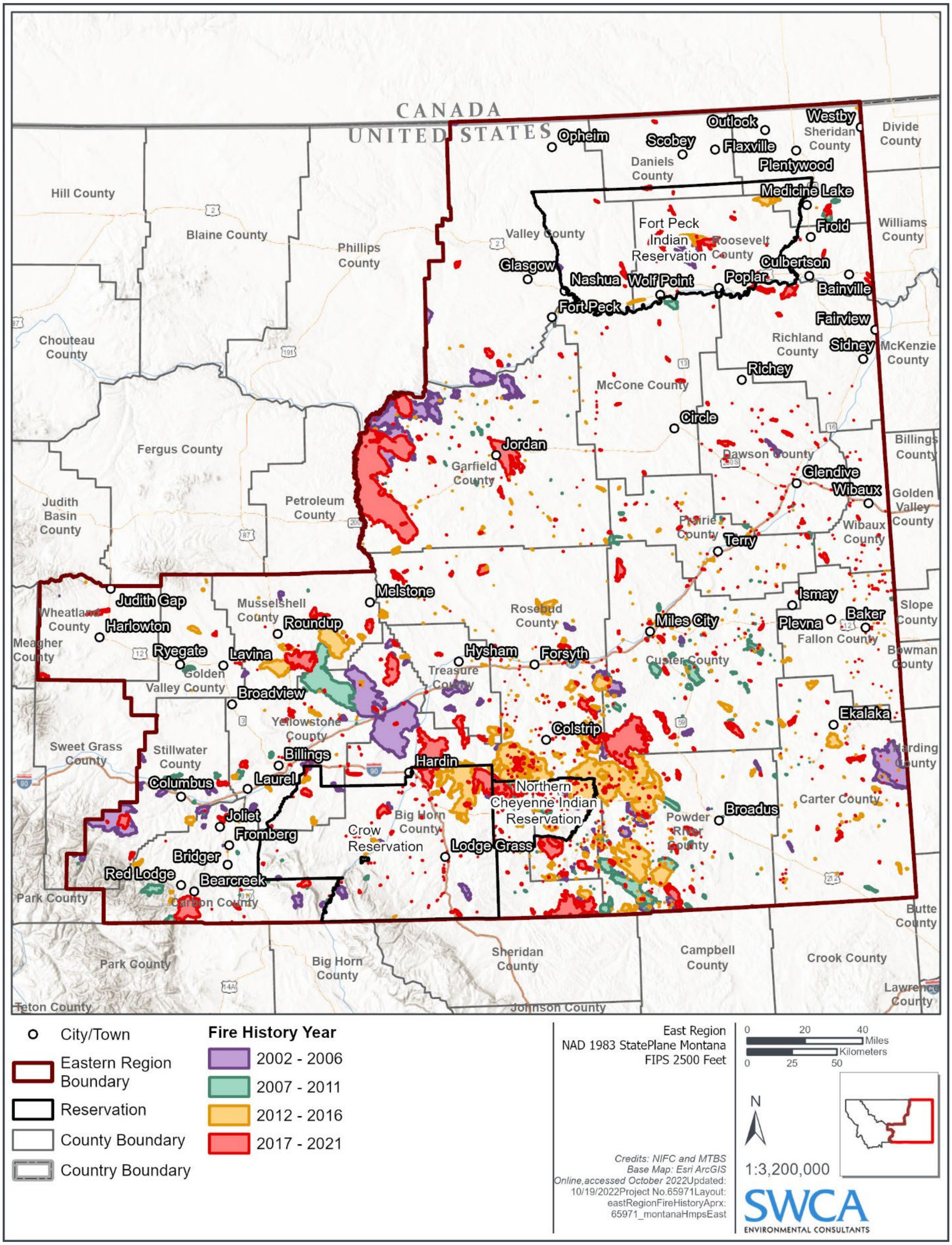
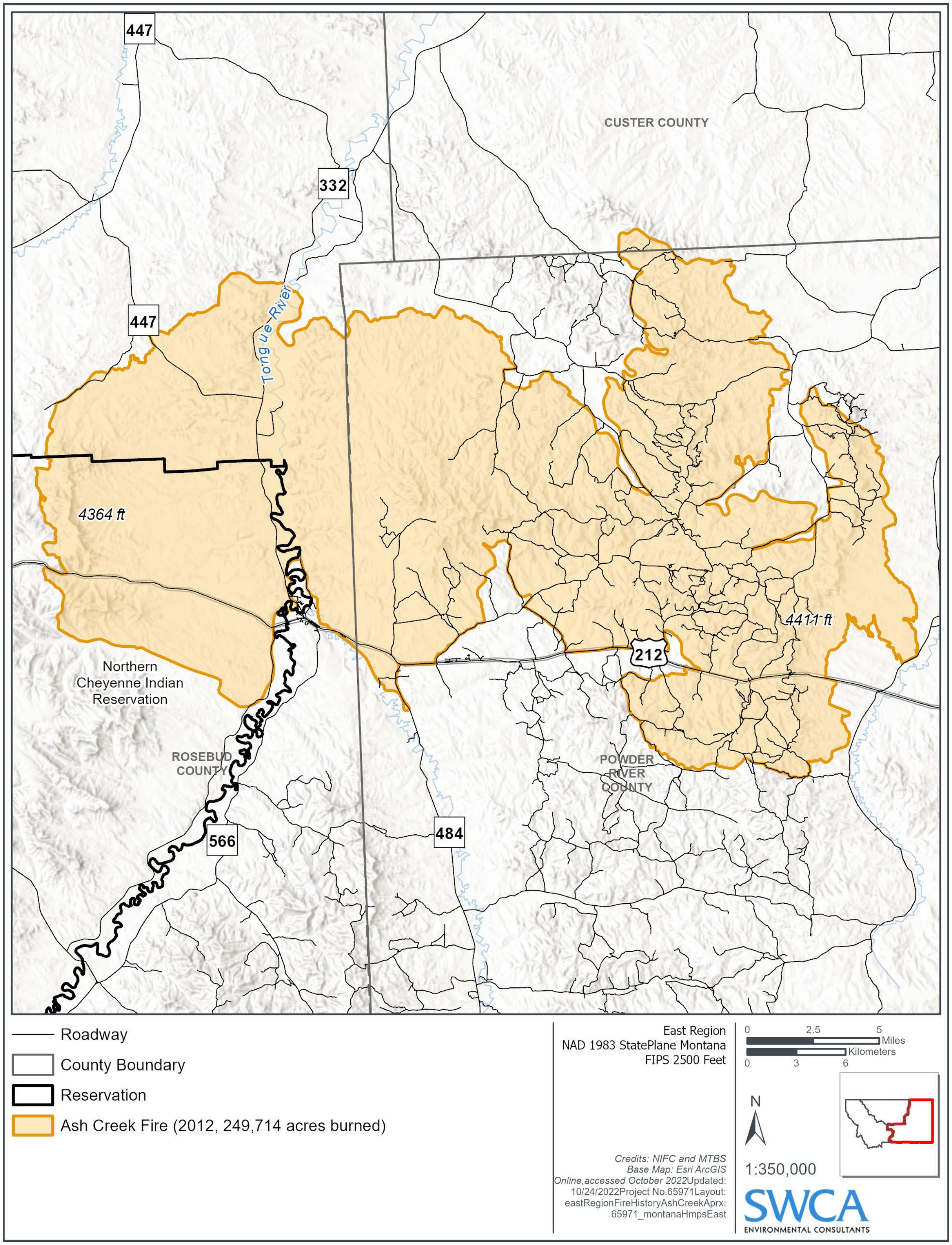


Figure 4-91 Fire History of Eastern Montana, Fire Perimeters, 2002-2021



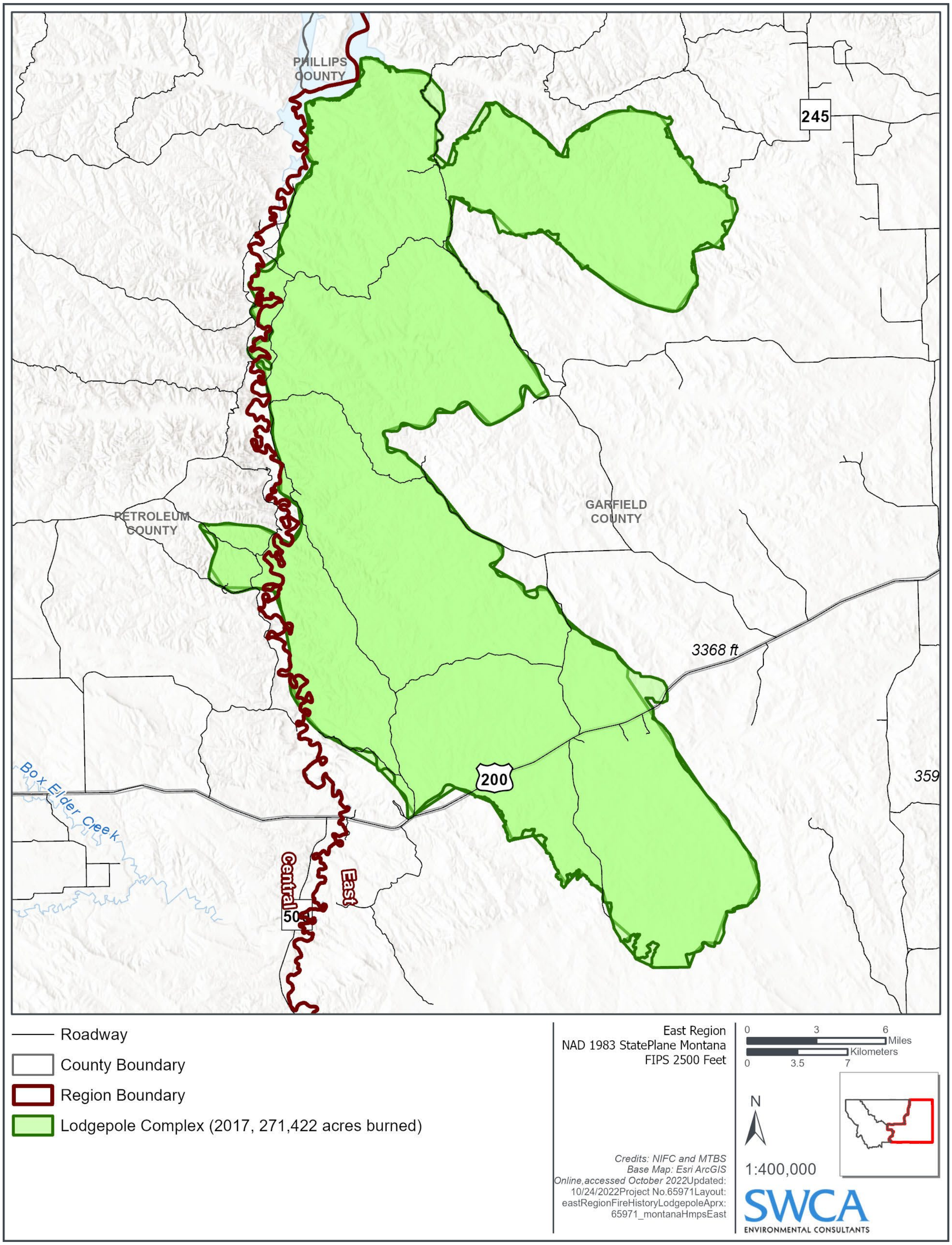
Source: MT DNRC 2022

Figure 4-92 Representative Large Rangeland Wildfire in the Eastern Region – Ash Creek Fire of 2021



Source: MT DNRC 2022

Figure 4-93 Representative Forest Fire in Eastern Region – 2017 Lodgepole Complex Fire



Source: MT DNRC 2022

Frequency/Likelihood of Occurrence

Wildfires occur every year throughout the region and could occur in any county in any given year; therefore, the probability of occurrence is **Highly Likely**. Generally, the rangelands in the central portions of the Eastern region exhibit a high annual burn probability, usually around 1% annual burn probability. These rangelands are typically hilly and exhibit complex topography. The regions with a patchwork of rangelands and dry coniferous forests exhibit the highest annual burn probability (2%). These regions are also topographically complex and are found in Powder River, Rosebud, and Yellowstone Counties. The northeastern portion of the Eastern Region displays the lowest annual burn probabilities. These areas are typically grasslands and/or farmlands with annual burn probabilities ranging from 0.01% to 0.1%. Figure 4-94 illustrates the annualized frequency of wildfire events by County. Figure 4-95 illustrates the annual burn probability for the Eastern Region.

Figure 4-94 Annualized Frequency of Wildfire Events by County

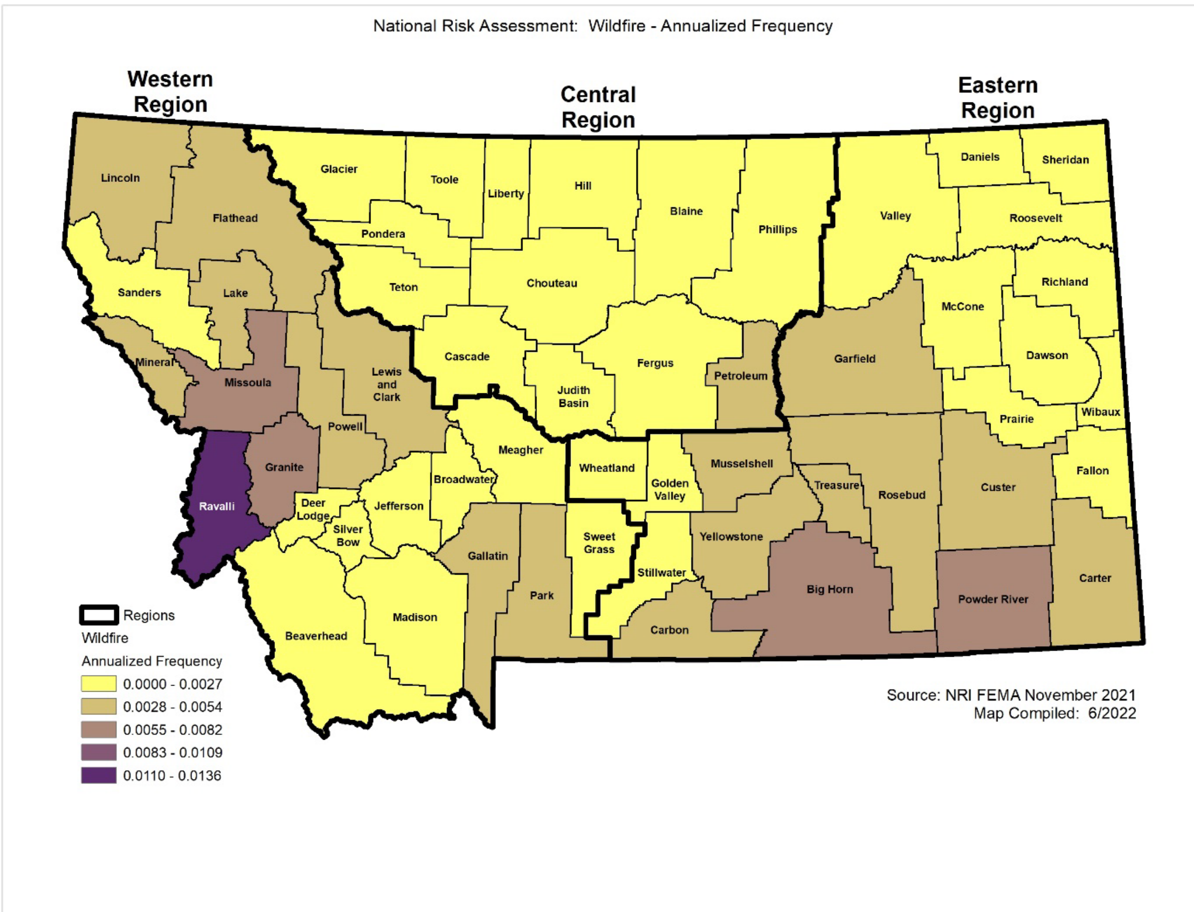
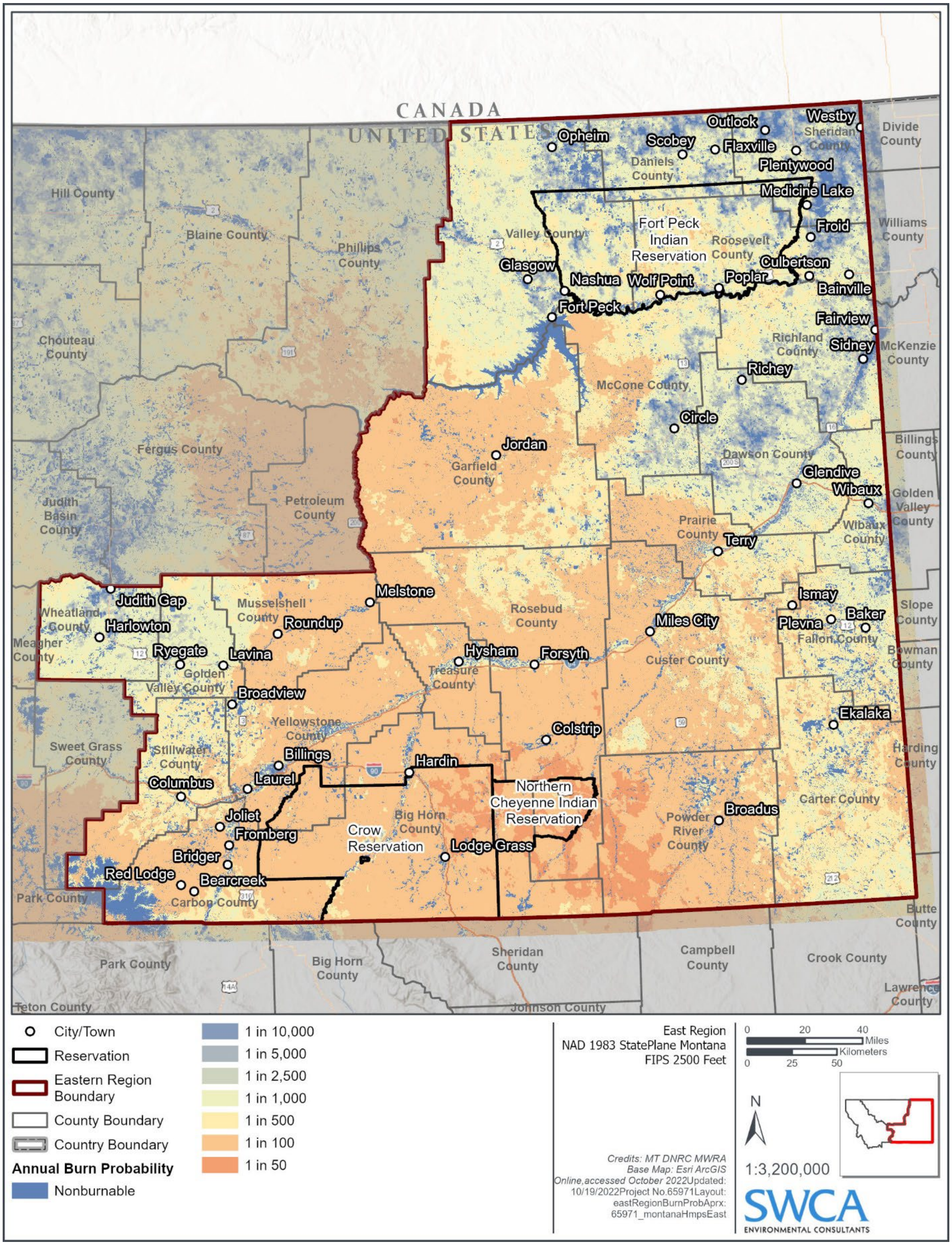


Figure 4-95 Eastern Montana Region Annual Burn Probability



Source: MT DNRC 2022

The counties with a high degree of undeveloped wildland rangelands and forests are usually more likely to experience wildfire and experience larger wildfires (see Table 4-60 for summary breakdown of wildfire statistics by county). Counties with a larger proportion of agricultural crop cover are less likely to experience wildfire (Table 4-60). While many rangeland wildfires in the region can be small, large rangeland fires can and do occur. It is important to note that the risk from wildfire is substantially higher during drought years. The years with the largest wildfires in Montana have normally occurred during periods of drought with associated high temperatures (Whitlock et al 2017).

Table 4-58 Average Number of Wildfires per year for Eastern Region Counties, 2002-2021

County/Reservation	Annual Average Number of Wildfire Occurrences (includes all ignitions)	Annual Average of Acres Burned
Big Horn	155.05	20,911.93
Carbon	13.20	3,918.39
Carter	16.05	5,522.75
Custer	14.75	8,896.93
Crow Reservation	134.70	7,243.89
Daniels	1.35	107.12
Dawson	5.85	415.19
Fallon	4.15	72.66
Fort Peck Reservation	115.45	1,254.90
Garfield	12.05	27,098.30
Golden Valley	1.75	211.68
McCone	4.25	418.30
Musselshell	6.05	6,748.50
Northern Cheyenne Reservation	59.55	6,297.85
Powder River	32.20	20,156.13
Prairie	7.20	435.34
Richland	5.05	634.89
Roosevelt	105.65	1,176.11
Rosebud	62.65	19,763.00
Sheridan	2.10	2.09
Stillwater	7.30	3,902.09
Treasure	2.10	1,047.03
Valley	14.65	1,294.70
Wheatland	3.05	358.06
Wibaux	3.50	160.42
Yellowstone	37.30	12,004.65

Climate Change Considerations

Annual average temperatures across the state, including daily minimums and maximums have risen 2.0 – 3.0°F between 1950 and 2015 (Whitlock et al 2017). Furthermore, Montana's growing season length has increased, as spring has come on earlier and fall freezes have occurred later. Between 1951 and 2010, Montana's growing season increased by 12 days. All regions of Montana are expected to experience warming in all seasons and under all future emissions scenarios. By 2050, Montana's average annual temperatures are expected to increase 4.5-6.0°F. Additionally, the number of days where 90°F will be exceeded will increase under future conditions. Finally, in the Eastern Region there has seen a significant increase in spring precipitation. However, compared to the rest of the state, the Eastern Region is also expected to experience the greatest increase in number of days where the temperature exceeds 90°F

(Whitlock et al 2017; Steblein 2021). Across the Eastern region, wetter springs could fuel the growth of more fine fuels while hotter summers could amplify fire risk.

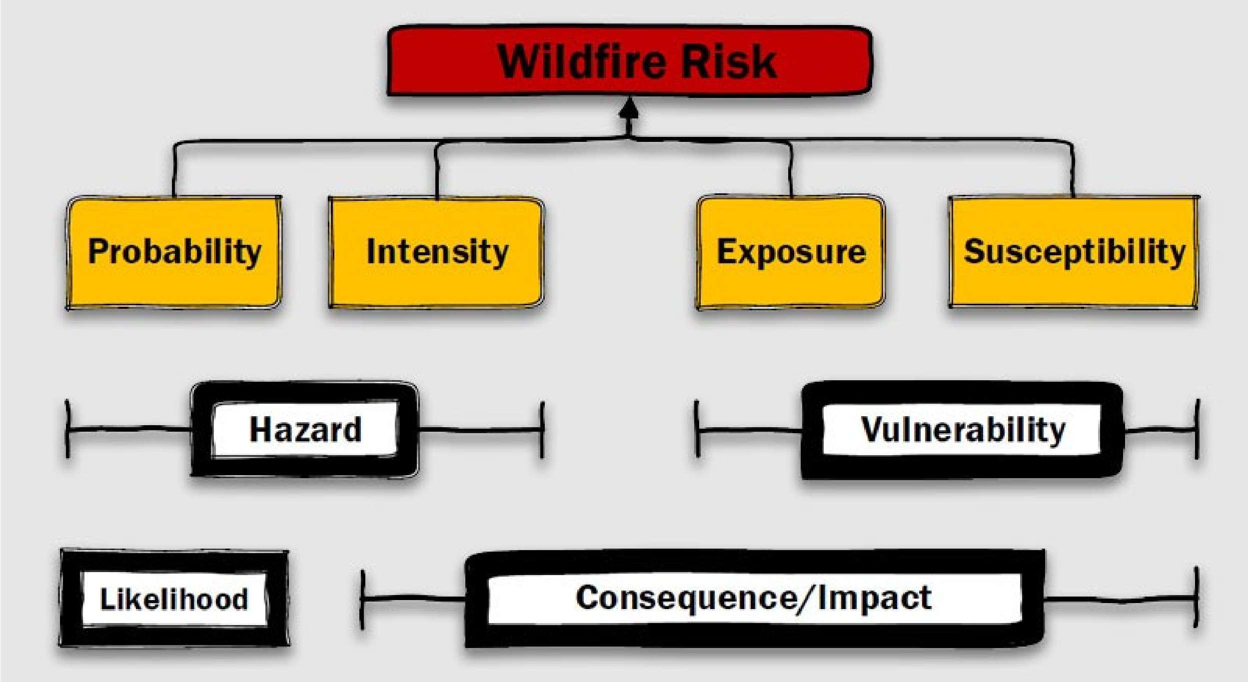
Taken together these climate change effects have contributed to increases in wildfire frequency and severity across the state and will exacerbate the future fire wildfire risk conditions across Eastern Montana. These climate impacts are also affecting forest and rangeland health. Hotter and longer summers and prolonged drought are known to put increased physiological stress on trees and increase mortality caused by diseases. such as mountain pine beetle, Douglas-fire beetle, and spruce budworm, among others. Degraded forest health, significantly attributed to climate change, has already been linked with increased fire risk throughout large portions of Montana's forested regions (MT DNRC 202c). As climate change exacerbates disease outbreaks in Montana's forested areas, there will be an increased build up in hazardous fuels (Whitlock et al 2017). Currently large tracts of Ponderosa Pine forests in the Eastern Region are experiencing attacks from pine beetles (MT DNRC 2021). These attacks are especially prevalent in Powder River and Rosebud Counties (MT DNRC 2021). These attacks are resulting in decreased forest health and build-up in dead, dry fuels. Additionally, climate change can result in an increase in invasive grass and weed abundance in grasslands and rangelands, which can contribute to increased wildfire risk in these systems (Whitlock et al 2017). As the fire season increases there will be a higher likelihood of wildfires coinciding with high wind events during fall, winter, and spring storms, especially during drought years. When wildfire, wind, and drought converge they can create conditions for particularly destructive wildfires, even outside of the traditional wildfire season (e.g., the Denton, MT West Wind Fire of December 2021, a wildfire that occurred in the Central Region).

Potential Magnitude and Severity

Montana Wildfire Risk Assessment

The Montana Wildfire Risk Assessment (MWRA) provides information about the wildfire hazard and risk to highly valued resources and assets (HVRAs) across Montana. This information is essential for planning wildfire response, fuel management, and land planning. The MWRA is a quantitative assessment of how human and natural resources are both influenced and affected by wildfire. The MWRA considers the following state-wide spatial components when quantifying wildfire risk: likelihood of fire burning, the intensity of a potential fire, the exposure of assets and resources based on their location, and the susceptibility of those assets and resources (MT DNRC 2020c). Wildfire vulnerability to wildfire is determined by wildfire exposure and susceptibility, whereas wildfire hazard is determined by wildfire intensity and wildfire probability. This conceptual relationship is depicted in Figure 4-96. Overall based on the combination of the likelihood of a wildfire, the intensity of a wildfire, and the exposure of assets, the magnitude for the Eastern Region is **Critical.**

Figure 4-96 Conceptual Breakdown of the Components and Meaning of the Montana Wildfire Risk Assessment



Source: MT DNRC 2022

MWRA Components

Wildfire Hazard. Wildfire hazard is determined by wildfire intensity and wildfire probability (MT DNRC 2022a). Areas that experience frequent and intense wildfire have the greatest wildfire hazard, while areas that experience low intensity fires over longer time scales have the lowest wildfire hazard.

Wildfire likelihood is the annual probability of wildfire burning in a specific location. At the community level, wildfire likelihood is averaged where housing units occur. It is the probability that any specific location may experience wildfire in any given year. It does not say anything about the intensity of fire if it occurs. Wildfire likelihood is derived from fire behavior modeling across thousands of simulations of possible fire seasons. Factors contributing to the model, such as weather, topography, and ignitions are varied based on trends observed in recent decades. It is important to note that wildfire likelihood is not predictive and does not reflect any currently forecasted weather or fire danger conditions (MT DNRC 2022a). The regions of Eastern Montana that display an intermix of rangelands and ponderosa pine forests are more likely to experience wildfire than continuous rangelands. Rangelands dominated by grass-shrub fuels (GS) are more likely to experience wildfire than rangelands dominated by only grass fuels (GR). Agricultural areas and alpine areas above tree line are least likely to experience wildfire (Figure X).

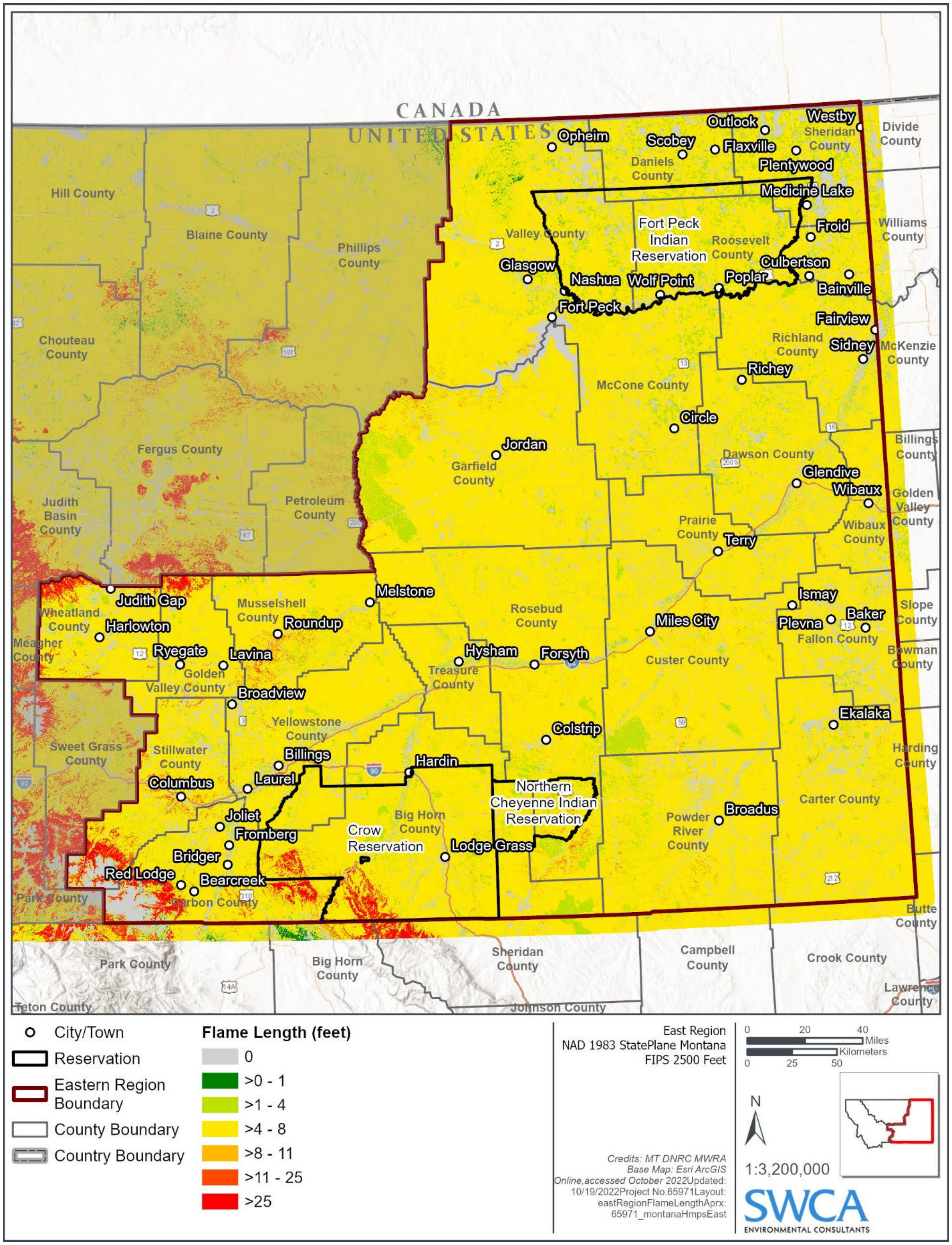
Wildfire intensity is a measure of the energy expected from a wildfire and is mainly determined by the topography and vegetative fuels of a landscape. Greater fuel loads (e.g., forests compared to grass lands), especially on steeper terrain, typically produce greater wildfire intensity. Wildfire intensity is technically measured in units of heat transfer per length of fire perimeter. However, it can also be observed and expressed in terms of flame length (MT DNRC 2022a). The MWRA (MT DNRC 2022a) uses wildfire intensities calculated in fire behavior modeling simulations. Modeled tall flame lengths (i.e., more intense fires) are more likely to occur in regions comprised of forested areas (Figure 4-97). More intense and taller fires are usually more difficult to control (Table 4-61). Only the forested portions with steep slopes in the Eastern Region are predicted to have flame lengths greater than 25 feet when conditions are extreme enough. The vast majority of the region is predicted to have flame lengths 4 to 8 feet in length. Areas with extensive crop cover are more likely to experience flames lengths under 4 feet.

Table 4-59 Control Efforts Associated with Different Flame Lengths

Flame Length	Interpretations
Less than 4 feet	• Fires can generally be attacked at the head or flanks by firefighters using hand tools. • Handline should hold fire.
4 to 8 feet	• Fires are too intense for direct attack in the head with hand tools. • Handline cannot be relied on to hold the fire. • Dozers, tractor-plows, engines, and retardant drops • can be effective.
8 to 11 feet	• Fires may present serious control problems: torching, crowning, and spotting. • Control efforts at the head will probably be ineffective.
over 11 feet	• Crowning, spotting, and major fire runs are probable. • Control efforts at the head of the fire are ineffective.

Source: Andrews et al. 2011

Figure 4-97 Eastern Montana Region Estimated Flame Length



Source: MT DNRC 2022

Vulnerability: Wildfire vulnerability to wildfire is determined by wildfire exposure and susceptibility (MT DNRC 2022a). For example, fire susceptible structures and/or infrastructure located in high fire intensity and high fire likelihood environments would have high exposure and high susceptibility to fire. In other words, they would be vulnerable to wildfire.

Wildfire exposure. Exposure is the spatial coincidence of wildfire likelihood and intensity to homes and communities. Homes are exposed to wildfire if they are located where there is any chance wildfire could occur (i.e., burn probability is greater than zero). Communities can be directly exposed to wildfire from adjacent wildland vegetation (e.g., homes situated in a forest), or indirectly exposed to wildfire from embers and home-to-home ignition (MT DNRC 2022a).

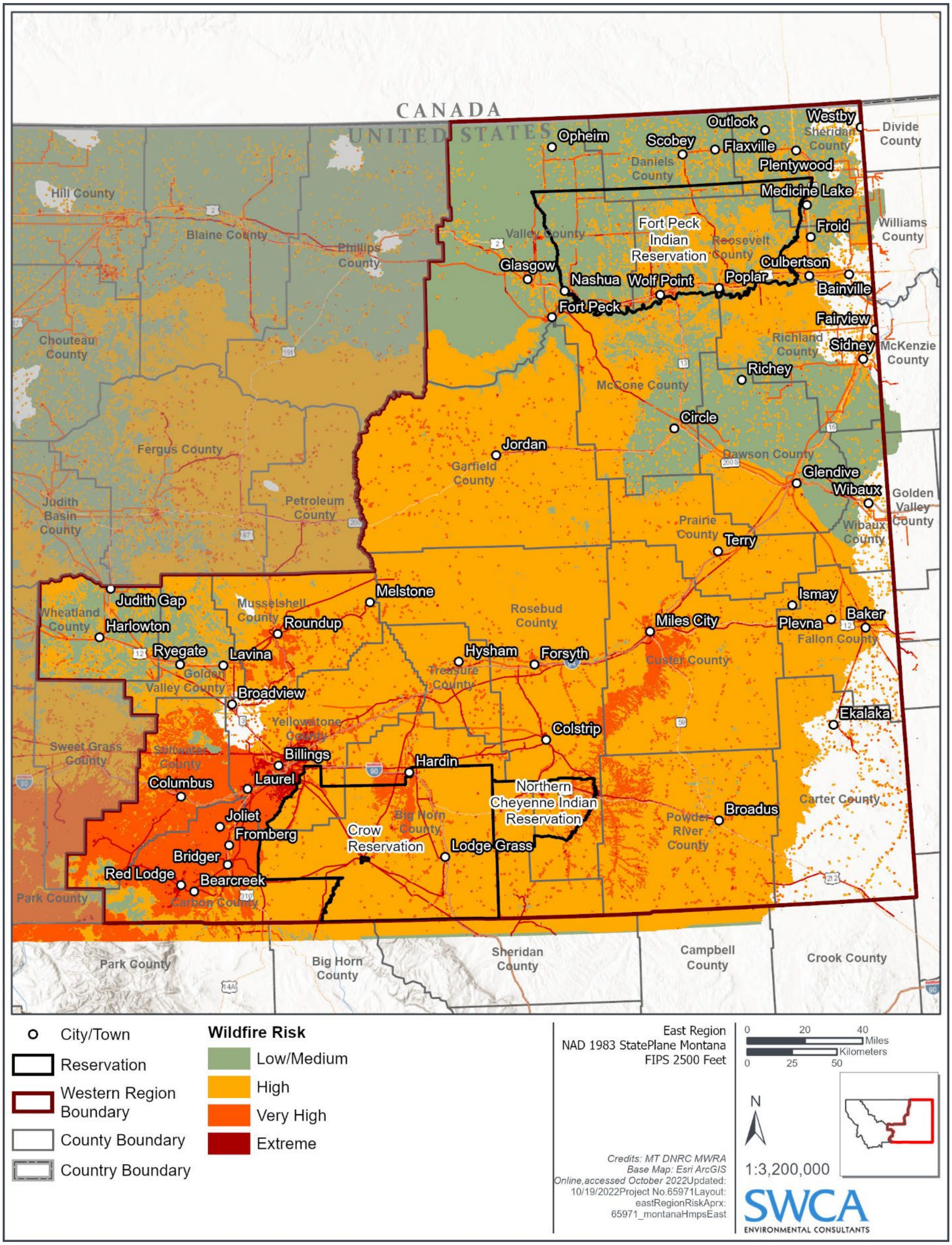
Wildfire susceptibility. Susceptibility is the propensity of a home or community to be damaged if a wildfire occurs. The susceptibility of a Highly Valued Resource or Asset (HVRA) to wildfire is determined by how easily it is damaged by varying degrees of wildfire intensity and type. Assets that are fire-hardened and can withstand very intense fires without damage (i.e., low susceptibility), whereas non-fire hardened structures are more easily damaged by fire (i.e., high susceptibility). The MWRA generalizes the concept of susceptibility. The MWRA assumes all homes that encounter wildfire will be damaged, and the degree of damage is directly related to wildfire intensity. The greater the wildfire intensity, the greater the percent damage to the structure. A community's wildfire risk is the combination of likelihood and intensity (together called "hazard") and exposure and susceptibility (together called "vulnerability") (MT DNRC 2022a).

Wildfire Risk

As described previously, wildfire risk is calculated by combining the following components: likelihood of fire burning, the intensity of a potential fire, the exposure of assets and resources based on their location, and the susceptibility of those assets and resources (MT DNRC 2022a). To quantitatively assess wildfire risk MWRA utilized an expected net value change (eNVC) analysis. The eNVC is an effects analysis that helps to quantify wildfire risk to various highly valued resources and assets (HVRA) for example homes, infrastructure, water resources, utility lines etc. (Finney, 2005; Scott et al., 2013; MT DNRC 2020c). The methodology is described in detail in the MWRA Report (https://mwra-mtdnrc.hub.arcgis.com/documents/montana-wildfire-risk-assessment-report/explore). As shown in Figure 4-98, the overall risk of loss to those HVRAs is categorized from low to extreme.

The risk to highly valued resources and assets from wildfire varies from low/medium to extreme throughout the region but the risk from wildfire to people and property is usually greatest within and near the inhabited areas (Figure 4-98) (i.e., see extreme risk ratings in inhabited areas). The municipalities most notably at risk from wildfire include, but are not limited to, Red Lodge, Bridger, Bear Creek, Columbus, Billing's sub-urban and ex-urban communities, Roundup, Hardin, and Miles City. Across the region, agricultural areas generally have low to medium risk from wildfire, while the rangelands and forested areas range from high to extreme risk from wildfire, respectively. Forests and rangelands in areas with more complex topography and/or drier climates generally have higher risk than forests and rangelands on flatter or less complex topography.

Figure 4-98 Eastern Region Wildfire Risk Summary as Determined by eNVC



*Blank areas hav**e burnable fuels but no HVRAs have been mapped for the area (MT DNRC 2020c).**
Source: MT DNRC 2022

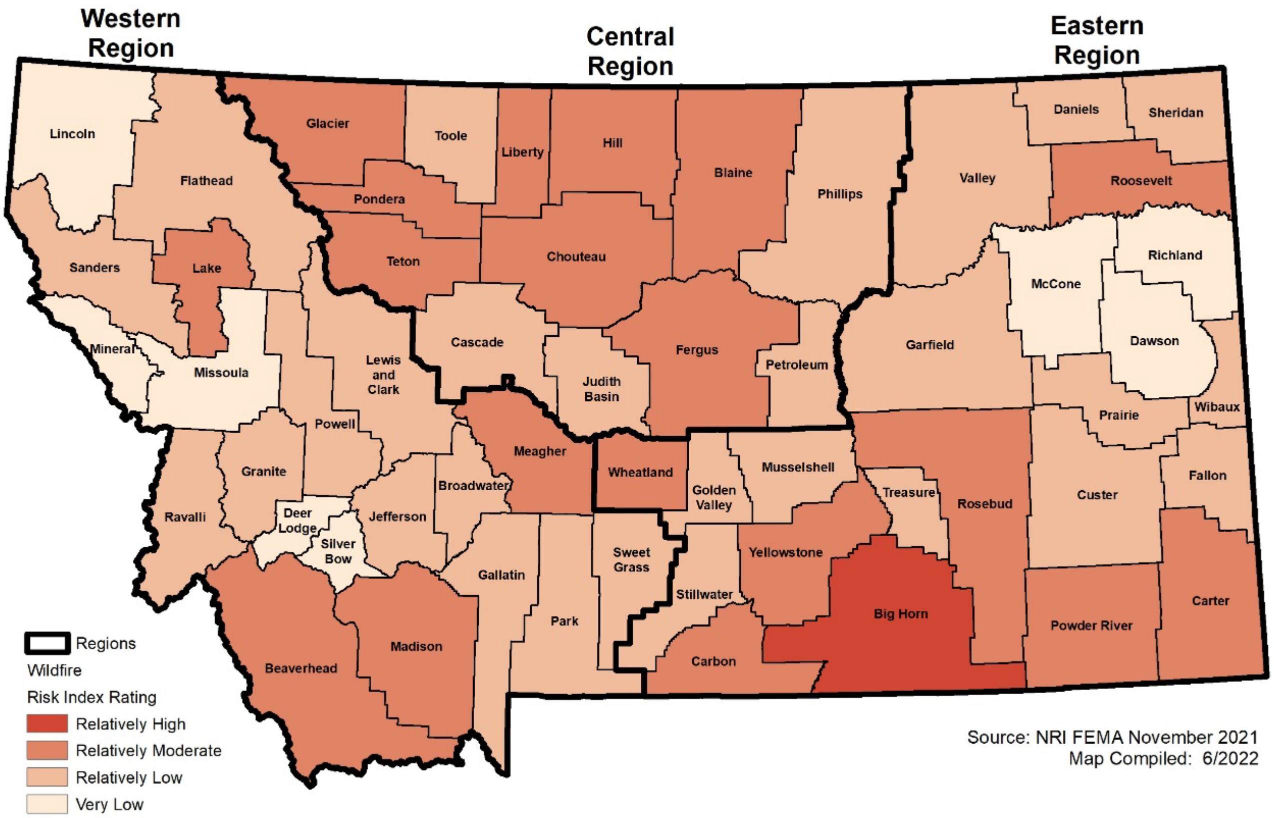
It is important to note, however, that many of the towns and municipalities throughout the region have very high to extreme risk from wildfire, regardless of the risk of surrounding landscapes. This is because the expected net value change (eNVC) risk assessment model provides more weight in assessing detrimental changes (or expected losses) to structures and infrastructure than to wildlands or agricultural areas. Thus, HVRAs (typically structures or infrastructure) are given higher levels of weight (i.e., importance) in the model. The results of these expected losses are then summed by each pixel displayed in the map. Thus, areas (or pixels) with a high concentration of HVRAs (e.g., towns and municipalities) will display far greater risk to wildfire even if the likelihood of fire occurring on the surrounding landscape is low. Thus, the results of these eNVC risk assessment should be taken in context and interpreted with caution. To summarize, the observed trends are mainly driven by risk to structures and infrastructure within the region's towns and municipalities (Figure 4-99). Most of these structures/infrastructure are susceptible to fire (where they tend to be damaged if a wildfire occurs) and are exposed (located where there is a chance wildfire could occur), to some degree, to wildfire occurrence, which accounts for the high risk overall (Figure 4-99).

Generally, however, towns/municipalities surrounded by undeveloped forests and rangelands (i.e., landscapes with a higher probability of fire occurring and fire spreading) have higher levels of risk to wildfire than towns surrounded by more agricultural areas. However, agricultural fires can and do occur (see Denton fire of 2021) and these fires can have substantial economic impacts (Agricultural Climate Network 2021). It is also important to note that the MWRA was developed by the MT DNRC at the statewide scale. Assessments at these scales may omit finer resolution, and more precise assessment of risk, as well as input by local subject matter experts. Some county-wide or multi-county community wildlife protection plans (CWPPs) have been developed for counties covering the Eastern region. For example, the 2016 Powder River County CWPP provides a fine-scale local, wildfire risk assessment that incorporates recent wildfire effects, community input, and recent wildfire mitigation efforts (Powder River County Commission 2016). CWPPs for all counties in Eastern Montana can be accessed at the MT DNRC website (see http://dnrc.mt.gov/divisions/forestry/fire-and-aviation/cwpps) (note: many CWPPs in Eastern Montana have not been updated in over decade). In the event that a County has recently completed a CWPP with fine scale risk assessment, land managers and fire responders should carefully consider if those locally derived assessments provide a more accurate, authoritative dataset for use in addressing and mitigating wildfire risk, than the statewide assessment.

Vulnerability Assessment

Figure 4-99 depicts the risk index rating for wildfire at a county level based on the NRI. The western and southeastern parts of the region show a trend towards a relatively low rating, while the central, northern, and northeastern parts of the region trend towards a relatively moderate rating.

Figure 4-99 Risk Index Rating for Wildfire by County



People

The most exposed population are those that are living within the WUI. The WUI in the Eastern Region is expansive, but generally, population densities within the WUI are highest in the region's more populated municipalities/towns. More populated areas, generally, have more property and, thus, a greater degree of property exposure to wildfire. Counties with higher portions of their property and infrastructure exposed to fire prone landscapes (e.g., greater wildfire risk to structures and infrastructure) will have more of their population vulnerable to the negative effects of wildfire than counties with lower portions of property and infrastructure exposed to fire prone landscapes The vulnerability to property is discussed further below

People can also experience deleterious mental and physical health effects from fire. A study conducted in California found that extreme wildfire (and it associated impacts) can result in post-traumatic stress disorder, depression, and exacerbate pre-existing mental illness (Silveira et al 2021). Another study conducted in California found that particulate air pollution from wildfire had greater impacts on respiratory health than particulate air pollution from traditional sources (e.g., vehicle and power plant emissions) (Aguilera et al 2021). In Montana specifically, a study conducted on pulmonary function for community members living in Seeley Lake found that that lung function diminished significantly when exposed to extreme levels of smoke during the 2017 wildfire season (mostly due to the Rice Ridge Fire) and that lung function continued to decline even one year post fire (Orr et al 2020). In the Western U.S, ten of the largest years for wildfire (by total acres burned) have occurred since 2004. These large wildfires have been directly linked to poor air quality and have led to adverse physical and mental health effects and costs to society (EPA 2022). As climate change progresses, it is likely Eastern Montana will have larger and more frequent wildfires. Planning to address the needs of populations at risk will be become increasingly important to mitigate property damage and health impacts from wildfire.

Populations especially at risk from wildlife include socially vulnerable populations. As defined by the U.S Forest Services Wildfire Risk to Communities (USFS 2022) socially vulnerable populations include the following: families living in poverty, people with disabilities, people over 65 years, people who have difficulty with English, households with no car, and people living in mobile homes. Across the Eastern region, wildland fire fighters are also populations at risk from wildfire. Wildland fire fighting is an inherently dangerous profession where firefighters risk their health and lives while battling fires. During the 2017 Lolo Peak Complex in western Montana, two wildland fire fighters were killed while battling the fire (Reuters, 2017). Wildland fire fighters are especially vulnerable to medium- and long-term health and safety risks associated with smoke and chemical inhalation and other conditions while firefighting, as well as immediate risks that may endanger their lives due to the fire environment.

In order to determine the total general population living in wildfire risk areas, the structure count of residential buildings within the various wildfire risk areas and applying the census estimated household size for each county to the total number of structures. This provides an estimated figure for the number of residents living in areas exposed to elevated wildfire risk.

Across the Eastern Region counties, there are an estimated 8,743 residents exposed to High risk wildfire areas, 100,683 residents exposed to Very High risk wildfire areas, and 92,179 residents exposed to Extreme risk wildfire areas, as summarized in Table 4-62 below. Additionally, based on this analysis there are an estimated 2,381 people residing within wildfire risk areas on the Crow Reservation, 5,211 people on the Fort Peck Reservation, and 353 people on the Northern Cheyenne Indian Reservation. However, these residents are included in the counts for their respective counties of residence in the table below.

Table 4-60 Population Within Wildfire Risk Areas in Eastern Montana

County	High Risk Population	Very High Risk Population	Extreme Risk Population
Big Horn	350	1,380	5,390
Carbon	241	3,810	7,397
Carter	53	318	261
Custer	460	5,766	3,399
Daniels	199	1,098	437
Dawson	707	5,242	970
Fallon	163	1,417	913
Garfield	31	357	689
Golden Valley	86	457	131
McCone	239	528	550
Musselshell	254	1,890	2,509
Powder River	62	236	682
Prairie	97	888	292
Richland	1,441	3,853	133
Roosevelt	660	2,591	3,873
Rosebud	130	2,303	3,280
Sheridan	390	1,464	1,540
Stillwater	1,124	6,458	1,415
Treasure	46	315	33
Valley	475	2,387	3,356
Wheatland	172	1,927	59
Wibaux	62	559	19
Yellowstone	1,300	55,442	54,852

County	High Risk Population	Very High Risk Population	Extreme Risk Population
Total	8,743	100,683	92,179

Source: MSDI 2022, MWRA, US Census Bureau

Property

The potential impacts of wildfire on property include crop loss; timber loss; injury and death of livestock and pets; devaluation of property; and damage to infrastructure, homes and other buildings located throughout the wildfire risk area. The greatest potential impact on property, buildings and infrastructure is likely to occur to those structures located within high and very high hazard zones including the WUI, and buildings and infrastructure located within fire prone forests and rangelands lands.

Federal, state, and county lands throughout the Eastern Regions have high amounts of property and infrastructure that are susceptible to wildfire. Public property lost or damaged by wildfire can exhaust budgets (due to rebuilding and repair efforts), result in degraded conditions (e.g., damaged roads and recreational facilities), and degrade the value of natural resources (which could inhibit leasing efforts and result in lost revenue generation). There are multiple state and federal grants available which can ease costs due to damages from wildfire (MT DNRC 2022b; FEMA 2022)).

Another method of estimating vulnerability is to determine the value of structures that are located within wildfire risk areas. Another method of estimating vulnerability is to determine the number and value of structures that are located within wildfire risk areas. For this plan update loss estimations for the wildfire hazard were modeled by using April 2022 MSDI Cadastral Parcel layer as the basis for the inventory of developed parcels. GIS was used to create a centroid, or point, representing the center of each parcel polygon, which was then intersected with the Montana Wildfire Risk Assessment (MWRA) data. Wildfires typically result in a total building loss, including contents. Content values were estimated as a percentage of building value based on their property type, using FEMA/HAZUS estimated content replacement values. This includes 100% of the structure value for commercial and exempt structures, 50% for residential structures and 100% for vacant improved land. Improved and contents values were summed to obtain a total exposure value. Table 4-63 and Table 4-66 below summarizes the estimated exposed value of improvements in each wildfire risk category for the counties and the Tribes in the Eastern Region. Figure 4-100 show the wildfire risk to structures in the Eastern Region. Loss Ratio is the ratio of the improved parcels at risk compared to the overall number of improved parcels in each county.

Table 4-61 Exposure and Value of Structures at High Risk to Wildfire by County

County	Improved Parcels	Improved Value	Content Value	Total Value	Loss Ratio
Big Horn	261	$69,696,592	$80,783,876	$150,480,468	9%
Carbon	248	$52,826,918	$43,797,984	$96,624,902	4%
Carter	109	$14,510,555	$12,844,693	$27,355,248	12%
Custer	342	$57,135,447	$45,742,464	$102,877,911	7%
Daniels	217	$27,659,178	$24,814,628	$52,473,806	13%
Dawson	508	$68,141,966	$45,277,149	$113,419,115	12%
Fallon	155	$23,759,705	$17,623,048	$41,382,753	9%
Garfield	145	$12,924,853	$12,390,997	$25,315,850	16%
Golden Valley	89	$9,995,274	$7,954,322	$17,949,596	14%
McCone	238	$24,405,086	$19,610,653	$44,015,739	17%
Musselshell	236	$22,969,386	$17,882,548	$40,851,934	8%
Powder River	154	$15,626,169	$14,252,815	$29,878,984	15%

County	Improved Parcels	Improved Value	Content Value	Total Value	Loss Ratio
Prairie	137	$11,667,759	$9,932,175	$21,599,934	16%
Richland	752	$169,699,932	$119,830,227	$289,530,159	15%
Roosevelt	394	$56,489,395	$44,629,488	$101,118,883	12%
Rosebud	197	$20,528,752	$17,777,771	$38,306,523	7%
Sheridan	340	$45,788,993	$41,760,992	$87,549,985	12%
Stillwater	680	$179,346,702	$124,273,341	$303,620,043	14%
Treasure	86	$10,736,876	$8,950,580	$19,687,456	19%
Valley	438	$80,198,087	$68,976,744	$149,174,831	10%
Wheatland	126	$18,929,630	$14,766,850	$33,696,480	10%
Wibaux	71	$10,416,620	$9,028,040	$19,444,660	12%
Yellowstone	800	$500,526,347	$352,211,744	$852,738,091	1%
Total	6,**723**	$1,503,980,222	$1,155,113,124	$2,659,093,346	6**%**

Sources: MSDI 2022, MWRA

Table 4-62 Exposure and Value of Structures at Very High Risk to Wildfire by County

County	Improved Parcels	Improved Value	Content Value	Total Value	Loss Ratio
Big Horn	470	$84,697,265	$55,600,450	$140,297,715	16%
Carbon	2,090	$547,758,151	$338,899,010	$886,657,161	33%
Carter	194	$16,622,939	$11,777,870	$28,400,809	22%
Custer	2,619	$355,987,960	$205,139,052	$561,127,012	51%
Daniels	597	$49,379,383	$29,321,872	$78,701,255	37%
Dawson	2,534	$298,389,201	$160,992,812	$459,382,013	59%
Fallon	666	$82,437,643	$50,468,650	$132,906,293	39%
Garfield	211	$20,592,843	$13,824,137	$34,416,980	24%
Golden Valley	235	$27,723,611	$20,667,195	$48,390,806	37%
McCone	279	$23,816,544	$16,536,307	$40,352,851	20%
Musselshell	1,027	$104,380,896	$60,240,354	$164,621,250	36%
Powder River	213	$31,077,010	$29,785,330	$60,862,340	21%
Prairie	431	$23,090,380	$13,659,171	$36,749,551	49%
Richland	1,620	$276,214,590	$150,699,173	$426,913,763	33%
Roosevelt	881	$71,918,345	$43,188,463	$115,106,808	28%
Rosebud	970	$105,865,876	$63,965,597	$169,831,473	35%
Sheridan	758	$83,050,450	$64,111,850	$147,162,300	27%
Stillwater	2,865	$567,115,185	$316,256,337	$883,371,522	58%
Treasure	210	$16,963,574	$10,550,781	$27,514,355	48%
Valley	1,161	$160,221,477	$90,507,557	$250,729,034	27%
Wheatland	871	$67,516,048	$39,657,448	$107,173,496	66%
Wibaux	293	$23,250,971	$14,174,318	$37,425,289	49%
Yellowstone	24,939	$6,151,318,658	$3,597,410,593	$9,748,729,251	39%
Total	46,134	$9,189,389,000	$5,397,434,321	$14,586,823,321	39**%**

Sources: MSDI 2022, MWRA

Table 4-63 Exposure and Value of Structures at Extreme Risk to Wildfire by County

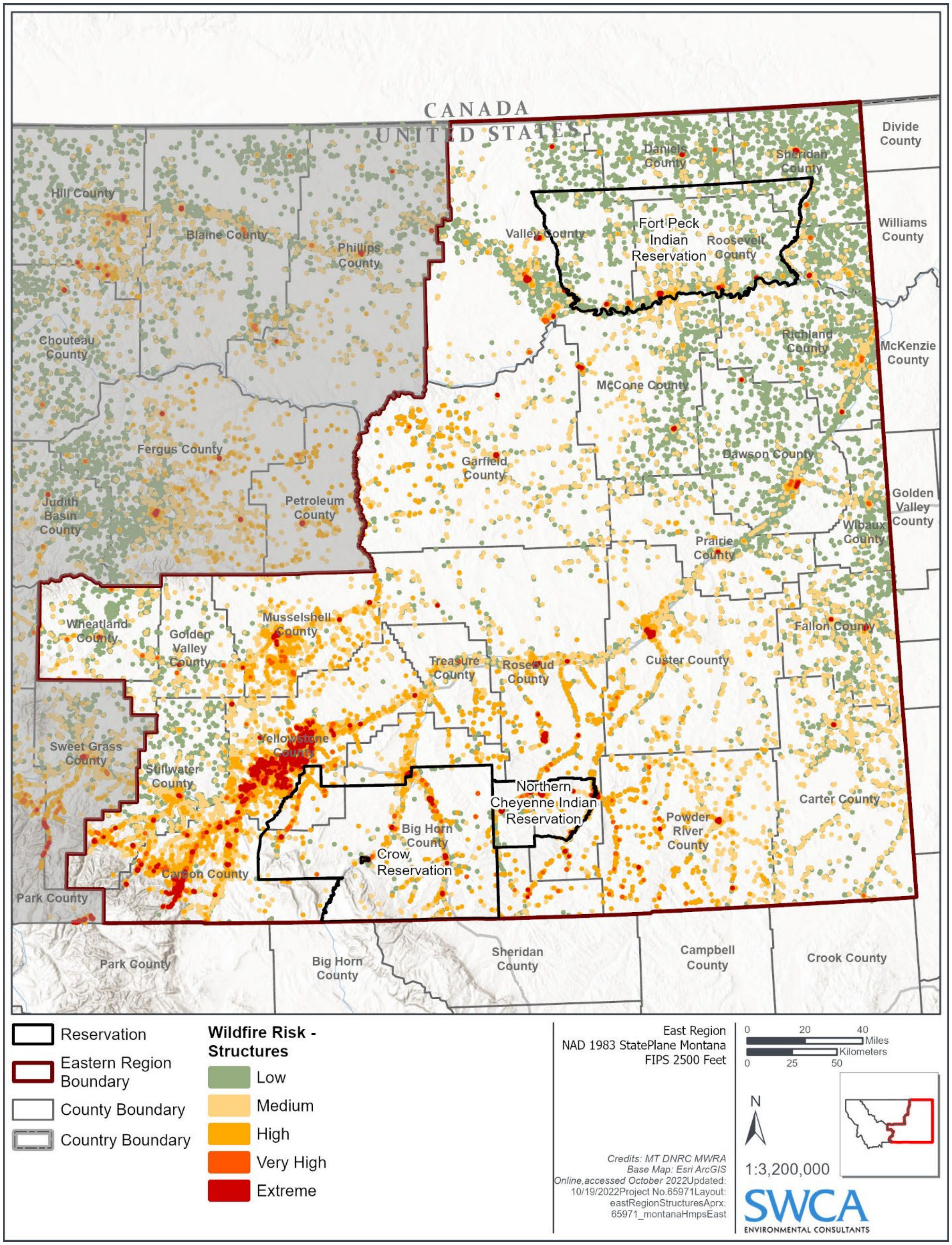
County	Improved Parcels	Improved Value	Content Value	Total Value	Loss Ratio
Big Horn	1,550	$202,949,949	$137,934,621	$340,884,570	53%
Carbon	3,296	$693,167,480	$378,618,127	$1,071,785,607	52%
Carter	152	$14,455,913	$11,113,807	$25,569,720	17%
Custer	1,521	$217,038,271	$114,139,069	$331,177,340	30%
Daniels	228	$24,807,057	$15,066,852	$39,873,909	14%
Dawson	466	$54,701,745	$33,992,742	$88,694,487	11%
Fallon	439	$54,146,980	$36,121,450	$90,268,430	26%
Garfield	300	$23,256,363	$13,039,702	$36,296,065	33%
Golden Valley	69	$4,487,390	$2,921,733	$7,409,123	11%
McCone	266	$23,428,567	$13,039,210	$36,467,777	19%
Musselshell	1,267	$116,264,790	$72,757,969	$189,022,759	44%
Powder River	339	$26,943,938	$14,775,338	$41,719,276	33%
Prairie	132	$9,161,738	$4,667,220	$13,828,958	15%
Richland	65	$6,399,632	$3,980,141	$10,379,773	1%
Roosevelt	1,233	$102,809,163	$59,724,939	$162,534,102	39%
Rosebud	1,241	$135,645,674	$81,799,109	$217,444,783	45%
Sheridan	752	$92,607,505	$57,328,988	$149,936,493	27%
Stillwater	602	$101,028,261	$56,171,507	$157,199,768	12%
Treasure	20	$793,239	$471,790	$1,265,029	5%
Valley	1,596	$207,970,575	$114,419,411	$322,389,986	38%
Wheatland	27	$2,881,529	$2,102,472	$4,984,001	2%
Wibaux	10	$1,265,355	$875,373	$2,140,728	2%
Yellowstone	24,107	$5,095,993,537	$2,674,222,521	$7,770,216,058	38%
Total	39,678	$7,212,204,651	$3,899,284,086	$11,111,488,737	33%

Sources: MSDI 2022, MWRA

Table 4-64 Eastern Region Parcel Exposure and Value of Structures at Risk to Wildfire by Tribe

Tribe	Extreme	Very High	High	Medium	Total Improved Parcels	Improved Value	Content Value	Total Value	Loss Ratio
Crow Tribe	294	278	157	325	1,054	$151,771,796	$122,155,017	$273,926,813	69%
Fort Peck Assiniboine and Sioux Tribe	975	523	335	849	2,682	$268,133,296	$229,133,296	$497,786,897	68%
Northern Cheyenne Indian Reservation	112	7	2	9	130	$8,645,052	$6,278,875	$14,923,837	93%
Total	1,381	808	494	1,183	3,866	$429,070,449	$357,567,098	$786,637,547	69%

Figure 4-100 Wildfire Risk to Structures in the Eastern Region



Source: MT DNRC 2022

Critical Facilities and Lifelines

- Buildings, equipment, vehicles, and communications and utility infrastructure are exposed and lost to wildfires every year. Potential risk exists to water treatment facilities, government buildings, public safety facilities and equipment, and healthcare services. Scour on bridge pilings may result in bridge and road closures. Wildfire impacts to critical facilities can include structural damage or destruction, risk to persons located within facilities, disruption of transportation, shipping, and evacuation operations, and interruption of facility operations and critical functions. To estimate the potential impact of wildfire on critical facilities and lifelines a GIS vulnerability analysis was performed similarly to the property vulnerability analysis, by intersecting the Montana Wildfire Risk Assessment (MWRA) data with critical facility data from HIFLD, Montana DES, and National Bridge Inventory (NBI).
- Summary tables of these results are shown below in Table 4 through Table 4, highlighting the type and number of facilities in each county that are located in High, Very High, or Extreme Wildfire risk areas.

Table 4-65 Critical Facilities at Risk to Extreme Wildfire Hazards

County	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Total
Big Horn	33	30	15	2	0	12	10	102
Carbon	24	26	10	0	2	23	13	98
Carter	8	1	0	0	1	5	3	18
Custer	20	15	0	0	1	9	3	48
Daniels	2	0	0	0	0	0	0	2
Dawson	10	0	0	0	1	1	1	13
Fallon	13	7	1	0	0	12	0	33
Garfield	11	1	1	0	1	7	5	26
Golden Valley	2	1	1	0	1	5	1	11
McCone	13	1	1	0	0	4	1	20
Musselshell	16	18	9	0	2	10	3	58
Petroleum	-	-	-	-	-	-	-	-
Phillips	-	-	-	-	-	-	-	-
Powder River	14	2	2	0	1	9	0	28
Prairie	4	5	0	0	1	0	0	10
Richland	2	1	0	0	1	4	0	8
Roosevelt	31	5	2	0	1	18	2	59
Rosebud	40	22	10	0	3	19	5	99
Sheridan	4	3	1	0	0	5	0	13
Stillwater	15	17	0	0	0	4	1	37
Treasure	6	8	0	0	0	0	0	14
Valley	13	1	3	0	1	9	5	32
Wheatland	6	1	0	0	0	4	0	11
Wibaux	1	0	0	0	0	4	0	5
Yellowstone	108	42	14	2	10	36	39	251
Total	396	207	70	4	27	200	92	996

Source: HIFLD 2022, Montana DES, NBI, MWRA

Table 4-66 Critical Facilities at Risk to Very High Wildfire Hazards

County	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Total
Big Horn	1	1	4	0	0	4	37	47
Carbon	5	5	3	2	1	2	46	64
Carter	3	1	1	0	0	3	6	14
Custer	1	3	4	1	3	12	15	39
Daniels	9	13	0	0	0	11	1	34
Dawson	14	5	1	3	1	17	26	67
Fallon	3	24	1	0	0	2	8	38
Garfield	1	0	0	0	0	4	5	10
Golden Valley	0	12	0	0	1	4	3	20
McCone	1	10	0	0	1	0	8	20
Musselshell	0	0	0	0	0	1	9	10
Petroleum	-	-	-	-	-	-	-	-
Phillips	-	-	-	-	-	-	-	-
Powder River	0	0	0	0	0	2	5	7
Prairie	1	5	1	0	1	9	2	19
Richland	17	21	4	3	1	12	20	78
Roosevelt	12	23	2	1	0	14	4	56
Rosebud	4	10	1	0	0	4	28	47
Sheridan	12	18	0	0	2	11	7	50
Stillwater	3	4	3	0	2	21	42	75
Treasure	0	4	0	0	1	4	4	13
Valley	31	37	2	1	1	12	17	101
Wheatland	10	19	0	0	2	9	4	44
Wibaux	3	7	1	0	1	5	6	23
Yellowstone	50	18	16	15	2	42	134	277
Total	181	240	44	26	20	205	437	1,153

Source: HIFLD 2022, Montana DES, NBI, MWRA

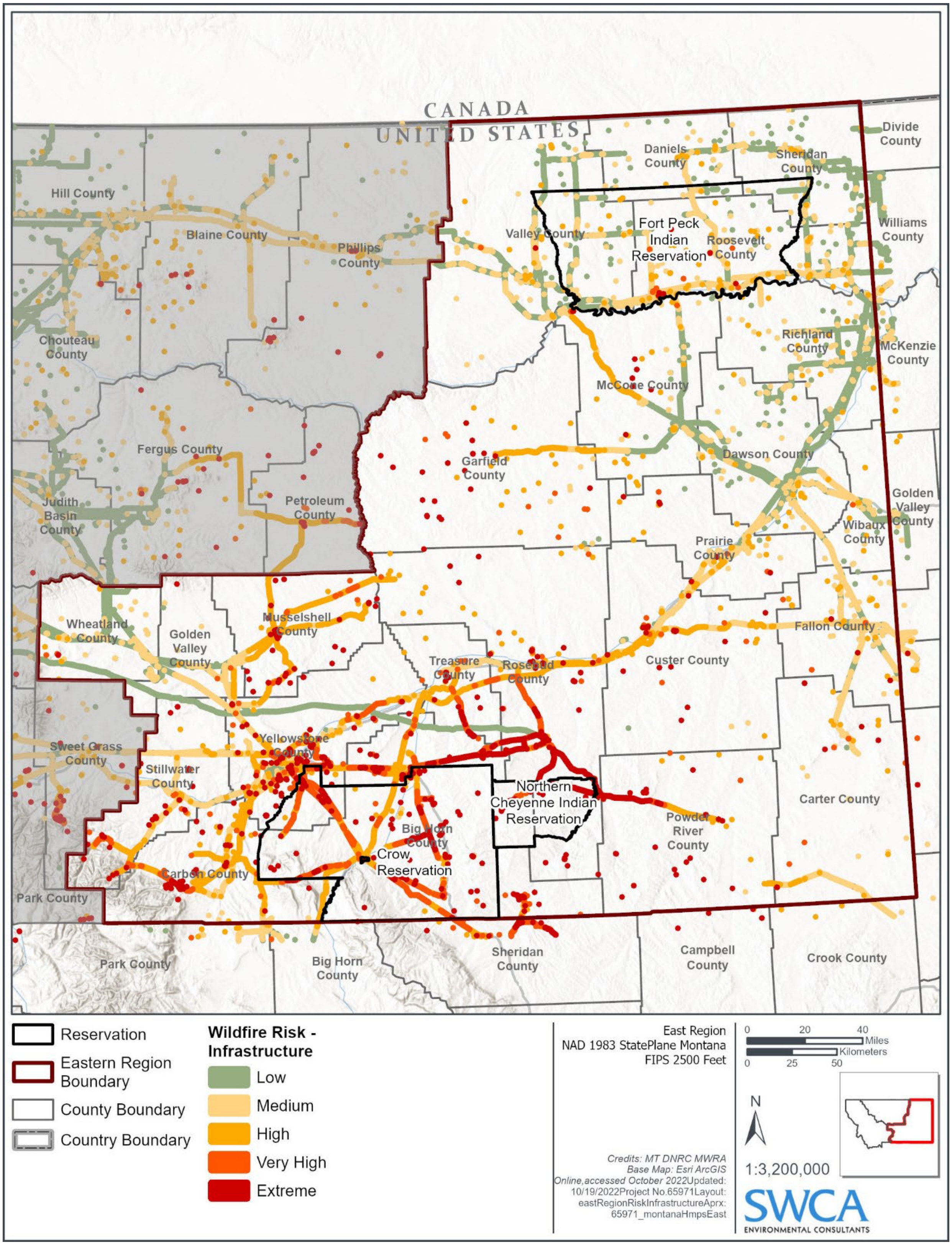
Table 4-67 Critical Facilities at Risk to High Wildfire Hazards

County	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Total
Big Horn	0	8	2	1	0	0	33	44
Carbon	5	2	1	0	0	0	6	14
Carter	0	1	0	0	0	1	13	15
Custer	4	0	0	1	0	1	31	37

County	Communications	Energy	Food, Water, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Total
Daniels	1	1	0	0	0	0	16	18
Dawson	4	2	0	1	0	2	42	51
Fallon	0	0	1	2	0	0	18	21
Garfield	2	0	1	0	0	1	8	12
Golden Valley	0	0	1	0	0	0	6	7
McCone	0	1	0	2	0	0	14	17
Musselshell	2	0	1	0	0	0	4	7
Petroleum	-	-	-	-	-	-	-	-
Phillips	-	-	-	-	-	-	-	-
Powder River	0	0	0	0	0	1	7	8
Prairie	1	0	0	1	0	0	27	29
Richland	3	2	0	6	0	2	38	51
Roosevelt	4	0	2	3	0	0	29	38
Rosebud	3	0	1	1	0	0	51	56
Sheridan	5	0	2	1	0	0	27	35
Stillwater	10	0	1	3	0	0	24	38
Treasure	1	0	1	0	0	0	20	22
Valley	9	0	0	0	0	0	31	40
Wheatland	0	1	3	0	0	0	9	13
Wibaux	0	0	0	0	0	0	6	6
Yellowstone	13	1	0	4	1	1	39	59
Total	67	19	17	26	1	9	499	638

Source: HIFLD 2022, Montana DES, NBI, MWRA

Figure 4-101 Wildfire Risk to Infrastructure in the Eastern Region



Source: MT DNRC 2022

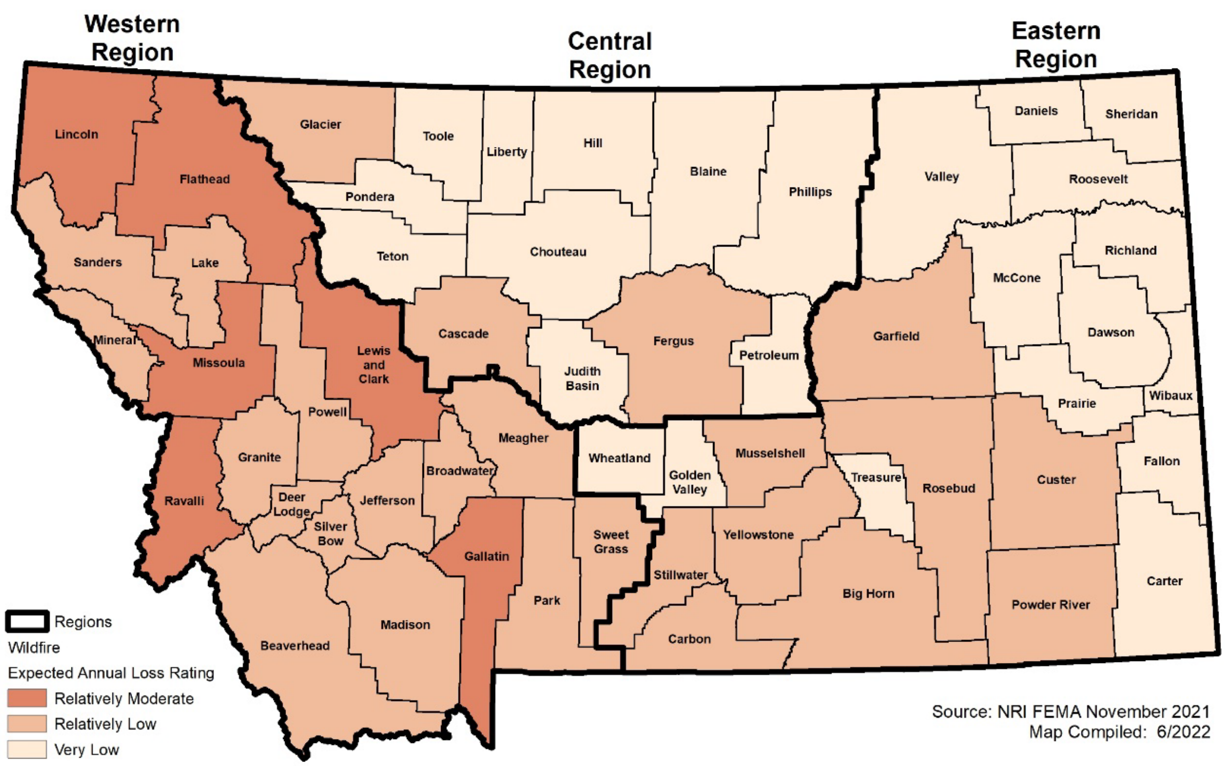
Economy

The economic impacts of wildfire include loss of property, direct agricultural sector job loss, secondary economic losses to businesses in or near wildland resources like parks and national forests, and loss of public access to recreational resources. Damage to these assets or disruption of access to them can have far reaching negative impacts to the local economy in the form of reduced revenues, in addition to the monetary losses resulting from direct building losses. Fire suppression may also require increased cost to local and state government for water acquisition and delivery, especially during periods of drought when water resources are scarce.

Tourism and outdoor recreation are vital components of the Eastern Region economy. Wildland fires can have a direct impact on the County's scenery and environmental health, adversely affecting the presence of tourism activities and the ability of the regions residents to earn a living from the related industries. The Eastern Region's scenic beauty and cultural resources are a main draw for tourism, so the entire region can suffer economic losses from tourists not coming to the area due to wildfires.

Figure 4-102 illustrates the relative risk of EAL rating due to wildfire. Most counties in the Eastern Region have very low risk, although Garfield, Rosebud, Custer, Powder River, Musselshell, Big Horn, Yellowstone, Stillwater, and Carbon have a slightly higher risk score (but still relatively low overall).

Figure 4-102 NRI Wildfire Expected Annual Loss Rating by County



Historic and Cultural Resources

Historic structures are often at high risk to wildfire due to wood frame construction methods and being constructed long before modern building and fire codes. Cultural resources include the natural and recreational resources also mentioned in the Economy and Natural Resources sections. These resources add not only monetary value and ecosystem goods and services to the region but can also serve as a source of regional identity and pride for the residents of the Eastern Region. This makes these vital resources for the various communities which are vulnerable to wildfire.

Natural Resources

Wildfire can be both beneficial and destructive to the Eastern Region's natural resources. In the rangeland and forest systems of Eastern Montana, fire is an essential component of the region's ecosystems and is necessary to maintain its native ecology (MT DNRC 2020a). However, in recent decades fire suppression, fuel buildup, climate change, and non-native invasive plant species have altered the natural fire regimes and increased the likelihood of high severity wildfire. These changing conditions have put much of the region's natural resources at risk (MT DNRC 2020a).

Across the western U.S, watershed vulnerability to wildfire has increased with the increasing wildfire conditions. Larger and more extreme, high severity wildfires have resulted in degradation to watershed quality. High severity wildfires can result in increased flows (due to increased hydrophobicity of the burned soil); higher amounts of sedimentation and contamination (due to destabilization of topsoil), loss of aquatic habitat, and degradation of aquatic ecology (Montana Free Press 2022; Rhoades et al 2019). As watersheds become more vulnerable to wildfire, more mitigation efforts will be required to protect watershed health.

Recreation is a valuable natural resource in the region. The region contains vast areas of highly valued public lands, which include, but are not limited to, the Eastern portion of the Beartooth Mountains and Wilderness; The Yellowstone River; The Missouri River; The Big Horn Canyon National Recreation Area; The Little Big Horn Battlefield National Monument; Charles M Russell National Wildlife Refuge; Custer National Forest; BLM managed lands, and multiple state parks. Increasing wildfire conditions can put these recreational resources at risk. Increasing wildfire conditions, especially extreme large fires, can threaten access (due to temporary closures), impact air and water quality, and alter visual aesthetics. Taken together, these impacts can potentially deter visitation and hurt the region's tourist economy (Kim and Jakus 2019).

Timber extraction in the Eastern region is carried out in limited capacity and predominantly occurs in areas with continuous forests, such as the eastern edge of the Beartooth's and the southern Big Snowy Mountains. Increasing wildfire conditions can halt timber sales (due to closures) and damage and potentially destroy harvestable trees, impacting the timber industry. In recent years forest wildfires have become larger and more severe. Historically, however, wildfires of all frequencies and severities occurred in the regions forests and were necessary for maintaining stand structure and native forest ecology (MT DNRC 2020c). Timber management should be aligned with fire management, such that it allows natural fire regimes and their dependent ecology to be restored and/or persist while minimizing the vulnerability of region's timber industry.

Public and privately managed rangelands across the Eastern Region provide ample grazing for livestock, making the region highly valued for ranching. Increasing wildfire conditions can put ranches and livestock at risk and threaten this region's industry in the event of large fires. However, it is important to note that, historically, the rangelands throughout the region required a mosaic of conditions created by wildfire (i.e., a landscape that exhibits different severities of wildfire and time since wildfire) to maintain their native ecology. For instance, wildfire can clear woody shrubs, favor the growth of grasses and forbs, and increase vegetative productivity (Cooper et al 2011); all of which can bolster ranching in the region. Wildfire should be carefully managed to both maintain the region's natural ecology and to minimize risk to local ranchers.

Wildfire can also threaten the regions farmlands. Currently counties with a proportion of farmlands are less vulnerable to wildfire. However, much of the region has an intermix of farmland and undeveloped rangelands. These would likely be more vulnerable to wildfire. For example, wildfire on undeveloped rangelands could threaten nearby farms and their crops. This is especially possible in the later summer and early fall when wildfire could threaten dry fields of wheat. When wheatfields do catch fire they spread at fast rates, are hard to control, and can cause crop loss and property damage (Western Farm Press 2017). Additionally, indirect impacts from wildfire, primarily smoke impacts, can also negatively affect produce harvest, quality, and sales (AEI 2021). Overall, increasing wildlife conditions are making the Eastern Region's farmlands more vulnerable to wildfire.

Development Trends Related to Hazards and Risk

In recent decades, many counties in Eastern Montana have either experienced population declines or no meaningful population trends. Stillwater and Yellowstone Counties, however, have experienced a large growth in population. Most population growth in the Eastern Region has occurred in and around Billings. Many of the new developments occurring in and around Billings (including the surrounding communities) is occurring within the WUI. Trends across the state and the Western U.S have demonstrated that the WUI is a desirable location for development, even though it presents increased wildfire risk [MT DNRC 2020a]. Current houses/structures and future houses/structures in high-risk WUI areas places lives and property in the path of wildfires. Furthermore, the increasing wildfire risk brought on by climate change is also putting greater risk on homes and infrastructure already located within the WUI throughout the region. Regulating growth and decreasing fire risk in these areas will be a delicate balance between protecting private property rights and promoting public safety. Local governments may wish to consider regulation of subdivision entrance/exit roads and bridges for the safety of property owners and fire personnel, building considerations pertaining to land on slopes greater than 25% (in consideration of access for fire protection of structures), and water supply requirements to include ponds, access by apparatus, pumps, and backup generators. Such standards serve to protect residents and property, as well as emergency services personnel. Additionally, as climate change progresses, the wildfire conditions will likely be exacerbated. Regional planners and property owners should also consider efforts to improve the wildfire resiliency of homes, structures, and critical infrastructure currently situated in the WUI to prepare for potential increased risk from wildfire.

Risk Summary

In summary, wildland and rangeland fire is considered to be overall High significance for the Region. Variations in risk by jurisdiction are summarized in the table below, as well as key issues from the vulnerability assessment. The frequency of wildfires in the Eastern region is variable, but, generally, the forested and rangeland areas have a higher burn probability and somewhere in the region fires occur annually.

- Wildfire ignitions occur most frequently in the southwestern and western portions of the Eastern Region, where there are large portions of mostly undeveloped rangelands.
- The counties with large areas of forests and rangelands in the western part of the Eastern Region are likely to experience the most acres burned in any given year.
- Socially vulnerable populations are likely to experience the worst effects of wildfire.
- Property, structures, and critical infrastructure is at moderate to extreme risk from throughout the region.
- Jurisdictions surrounded by more fire prone landscapes (e.g., forests and rangelands), generally, have structures and critical infrastructure most at risk to extreme wildfire.
- As climate change increases, drought will be more likely and the detrimental impacts on human health and the built environment from wildfire will likely increase.
- Related Hazards: Drought, Flooding, Severe Summer Weather (lightning)

Table 4-68 Risk Summary Table: Wildland and Rangeland Fire

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Eastern Region	High		
Big Horn	High		None
Carbon	High	Bearcreek, Bridger, Joliet, Fromberg, Red Lodge	Higher risk located within the WUI near the incorporated towns

Jurisdiction	Overall Significance	Additional Jurisdictions	Jurisdictional Differences?
Carter	Medium	Ekalaka	Lower risk than the Region but higher risk in WUI around Ekalaka
Crow Tribe	High		High risk located within the WUI within the reservation lands
Custer	High	Ismay, Miles City	None
Daniels	Low	Scobey, Flaxville	Lower risk than Region
Dawson	Low	Richey, Glendive	Lower risk than Region
Fallon	Medium	Plevna, Baker	Higher risk around Plevena, Baker, and Ismay WUI
Garfield	High	Jordan	None
Golden Valley	Low	Ryegate, Lavina	WUIs in the County, such as Town of Jordan
McCone	Low	Circle	Lower risk than Region
Musselshell	High	Roundup	None
North Cheyenne Tribe	High		WUI areas within the reservation lands
Powder River	High	Broadus	None
Prairie	Medium	Terry	Lower risk than Region
Medium	Low	Fairview, Sidney	Lower risk than Region
Roosevelt	Medium	Wolf Point, Poplar, Froid, Bainville, Poplar, Culbertson	Lower risk than Region
Rosebud	High	Colstrip, Forsyth	None
Sheridan	Low		Lower risk than Region
Stillwater	Medium	Columbus	Lower risk than Region
Treasure	Medium	Hysham	Lower risk than Region
Valley	Medium	Fort Peck, Glasgow, Nashua, Opheim	None
Wheatland	Low	Harlowton, Judith Gap	Lower risk than Region
Wibaux	Low	Wibaux	None
Yellowstone	High	Billing, Laurel, Broadview	None