



RESILIENT MAMMOTH LAKES

VULNERABILITY ASSESSMENT

PUBLIC REVIEW DRAFT | APRIL 2019

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PUBLIC REVIEW DRAFT | APRIL 2019

**Prepared for the Town of Mammoth Lakes Community and Economic Development
Department**



Prepared by PlaceWorks



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List of Abbreviations

- ACS:** American Community Survey
- APG:** Adaptation Planning Guide
- CAL FIRE:** California Department of Forestry and Fire Protection
- Cal OES:** California Office of Emergency Services
- CCAT:** Climate Change Action Team
- CEC:** California Energy Commission
- CEMA:** California Emergency Management Agency
- CNRA:** California Natural Resources Agency
- COC:** Continuum of care
- CO₂:** Carbon dioxide
- FEMA:** Federal Emergency Management Agency
- GHG:** Greenhouse gas
- OPR:** California Governor's Office of Planning and Research
- PACE:** Property-assessed clean energy
- RCP:** Representative Concentration Pathway
- SCE:** Southern California Edison
- VRESA:** Valentine Reserve Ecological Study Area

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1.Introduction

PURPOSE OF THE VULNERABILITY ASSESSMENT

"Climate change is already underway in the Sierra Nevada region, affecting heat and precipitation extremes, with long warming trends, declining snowpack, and changes in streamflow timing. These ongoing trends foreshadow larger changes to come."

- California Fourth Climate Change Assessment ¹

The threats posed by climate change have become increasingly apparent in all regions of California, as they have throughout much of the world. Increases in the levels of greenhouse gases (GHGs) in Earth's atmosphere have caused shifts in the global climate system, with serious consequences for people, the built environment, and natural systems. In California, these changes have led to multi-year droughts, dangerously high temperatures, massive wildfires, significant flooding, and many other changes. Even if global GHG emissions ceased tomorrow, this changed climate would likely persist for centuries. ²

The Town of Mammoth Lakes recognizes the harm that climate change can do to the community. In response, the Town initiated the Resilient Mammoth Lakes project, which is a comprehensive review of how climate change and its related hazards may affect the town in the coming years and decades. A key project outcome is the identification of strategies that can help the Town become more resilient to these effects. This effort will address the safety and well-being of Mammoth Lakes, including residents and visitors, buildings and infrastructure, economic activities, and natural resources. The project will include an update to the Safety Element and other relevant sections of the Town's General Plan, integrating resiliency into the long-term blueprint for the town's growth and development. Resilient Mammoth Lakes will also look at housing challenges and how the Town can maintain a strong housing sector while improving affordability and equity.

The first step in the Resilient Mammoth Lakes effort is to prepare a vulnerability assessment. A vulnerability assessment is a detailed analysis of how a changing climate can harm the various elements of the Town, including people, physical structures, and other community assets. The assessment looks at how severe climate change effects are likely to be on the Town's people and assets; and identifies which groups of people and assets face the greatest threat. The vulnerability assessment will be the foundation for the Resilient Mammoth Lakes project and help meet state requirements to address climate change as part of the Town's General Plan Safety Element, and to update other elements of the General Plan as needed to support improved resiliency. This report summarizes the results of the vulnerability assessment for the Town of Mammoth Lakes.

COMMUNITY PROFILE

The Town of Mammoth Lakes is part of the eastern Sierra Nevada region of California, an area of parallel steep mountain ranges and deep valleys. The town sits directly east of the Sierra Nevada crest, where the elevation drops suddenly from heights of over 14,000 feet. The landscape of Mammoth Lakes is dominated by the Sierra Nevada, especially Mammoth Mountain, an 11,059-foot-tall volcanic peak in the western part of the community, and Mammoth Crest, an 11,515-foot-tall ridgeline southwest of the town.

What is resiliency?

Resiliency is the ability of someone or something to resist harm and to recover from damage (physical and otherwise). Higher levels of resiliency mean that a person or thing is less likely to be harmed by negative conditions.

What is adaptation?

Adaptation is a change made by people or things in response to existing or future threats, in order to better reduce the harmful effects of these threatening conditions.

What is vulnerability?

Vulnerability is a measure of how someone or something can be harmed by a hazardous event or other negative conditions. The more vulnerable someone or something is, the greater the potential for harm.

Mammoth Lakes is home to approximately 8,300 full-time residents and is the only incorporated community in Mono County, a large area covering over 3,000 square miles from the Sierra Nevada crest to the Nevada state border.³

The Town of Mammoth Lakes covers 25 square miles, although only the area within the 4-square-mile urban growth boundary is developed. Land uses in Mammoth Lakes are a mix of residential single- and multi-family homes, condominiums, and apartments, visitor lodging, commercial properties, and leisure and recreation-focused properties. Mammoth Mountain, home to the Mammoth Mountain Ski Area, sits west of the town's developed area. South of the urban growth boundary is the 156-acre Valentine Reserve Ecological Study Area. Further south is the Mammoth Lakes Basin, part of a long chain of mountain lakes. Much of Mammoth Lake's land outside of the urban growth boundary is part of the federally managed Inyo National Forest, which includes part of the John Muir Wilderness.



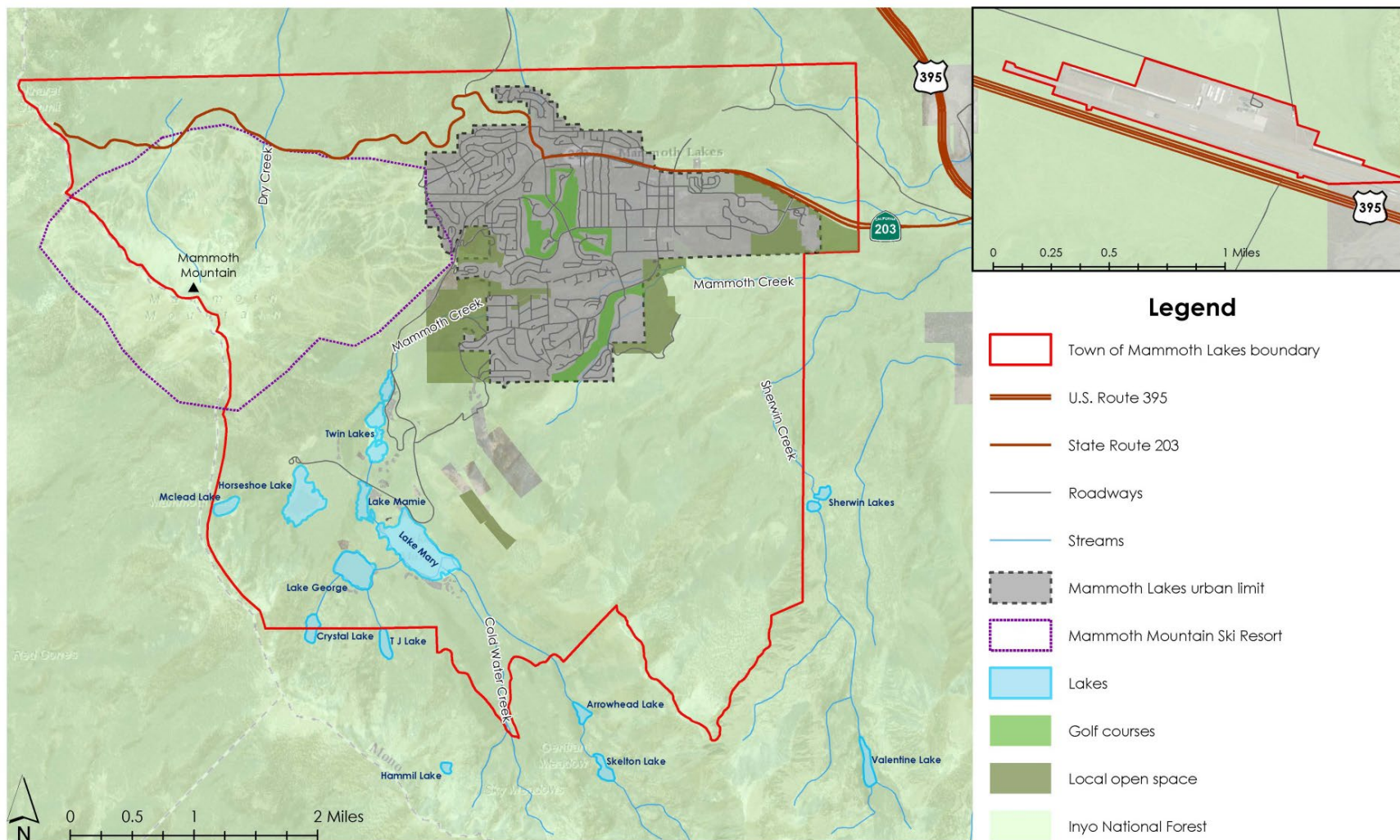
Mammoth Lakes and the surrounding area, as seen from the top of Mammoth Mountain.

State agencies divide California into several distinct climate zones, and Mammoth Lakes is part of Climate Zone 16. This area covers most high-elevation areas of California, including the Sierra Nevada, the Basin and Range territory, the Modoc Plateau, Trinity Alps, and the higher reaches of the Coast Ranges in southern California.⁴ On average, annual temperatures in Mammoth Lakes range between 57 and 29 degrees Fahrenheit. July is the warmest month (with average temperatures between 78 and 47°F), and February is the coldest (with average temperatures between 39 and 16°F). The town receives an average of approximately 23 inches of rain and 206 inches of snow annually, although this number varies significantly from year to year. Most precipitation falls during winter, although unlike most of California, Mammoth Lakes usually sees some rainfall during the summer months. Temperatures below freezing have been recorded in all months of the year, and temperatures of 80 °F or higher have been recorded between May and October.⁵ The natural setting and undeveloped landscape of the eastern Sierra Nevada makes it a prime place for outdoor recreation. Visitors made an estimated 1.8 million leisure trips to Mammoth Lakes in 2017, many for the abundant winter sports, hiking, bicycling, and other outdoor activity opportunities in and around the town.⁶ The Mammoth Mountain Ski Area is one of the most popular ski resorts in the United States, and Mammoth Lakes is close to a number of other popular destinations, including Yosemite National Park and Devils Postpile National Monument. While tourism has helped create a strong economy in Mammoth Lakes, it has also led to challenges. Close to two-thirds of all houses in Mammoth Lakes are reserved for visitors, seasonal workers, and seasonal residents, which has helped drive up the cost of housing in the community.⁷ The dependence on visitors also makes Mammoth Lakes

vulnerable to disruptions in the tourism industry, which will be discussed further in other chapters of this report.

Mammoth Lakes' primary transportation access is from State Route 203 and the Mammoth Scenic Loop via US Route 395, the primary road in the eastern Sierra Nevada and the only major roadway in the region that is open year-round. It runs north toward Lake Tahoe and Carson City, and south to the high desert north of Los Angeles and San Bernardino. State Route 120, approximately 25 miles north of Mammoth Lakes, runs east-west from the Central Valley, over the Tioga Pass and the Sierra Nevada crest to the Nevada border. Large portions of this road are closed in the winter. Mammoth Yosemite Airport, owned by the Town and located east of Mammoth Lakes, provides the only commercial air service in the region. **Map 1** provides an overview of the town, including the urbanized areas and the surrounding natural lands.

MAP 1: TOWN OF MAMMOTH LAKES OVERVIEW



Sources: Town of Mammoth Lakes, Mono County, United States Geological Survey, National Oceanic and Atmospheric Administration, ESRI

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2. Method

ADAPTATION PLANNING GUIDE METHOD

Mammoth Lakes' vulnerability assessment follows the recommended process in California's Adaptation Planning Guide (APG). This document was published in 2012 by the California Natural Resources Agency (CNRA) and the California Office of Emergency Services (Cal OES), formerly the California Emergency Management Agency, and describes the steps for local governments to identify and reduce the harmful effects of climate change. The APG suggests that vulnerability assessments follow a five-stage process as described in this section.



Identify exposures: In a vulnerability assessment, an exposure is an effect (usually a negative one) of climate change, such as an increase in the frequency or severity of a natural disaster. To prepare this vulnerability assessment, the Town looked at which effects of climate change are expected to occur in and around Mammoth Lakes, as well as those that may already be occurring.

Identify sensitivities: A sensitivity is someone or something that may be harmed by climate change, either a group of people or an asset of the community (buildings, infrastructure, natural ecosystems, and others). The Town prepared a list of the various types of people and assets in and around Mammoth Lakes that could be affected by climate change to be included in the vulnerability assessment.

Analyze potential impacts: Impacts are the harmful effects of climate change on one or more sensitivities. For example, if an increase in extreme heat events is the exposure, then the greater risk of heat-related illness on susceptible persons is the impact. Every population and asset in Mammoth Lakes is likely to experience different impacts. In this vulnerability assessment, the Town looked at the potential impacts to each sensitivity from each identified exposure.

Evaluate adaptive capacity: Adaptive capacity is the ability of people and assets to resist the impacts of climate change and to recover from them. The Town looked at the adaptive capacity of each sensitivity for each identified exposure as part of the vulnerability assessment.

Adjust for risk and onset: Some effects of climate change are more likely than others, or may not take place for a long period of time. In the language of vulnerability assessment, “risk” refers to the chance of an effect, and “onset” refers to the period of time when the effect can plausibly happen. If there are two effects that cause similar impacts, but one is less likely to happen (the risk is lower) or one is not likely to happen for several decades (the onset is later), it is a lower-priority hazard for the Town to address. The APG recommends that communities adjust the results of a vulnerability assessment so that they accurately reflect the risk and onset of each exposure. ⁸

ASSESSMENT PROCESS

Following the APG's recommended process, the Town selected the exposures and sensitivities that made the most sense to analyze in the vulnerability assessment. The Town looked at various guidance documents and reports to select these exposures and sensitivities, including the APG, the Mono County/Town of Mammoth Lakes Hazard Mitigation Plan, and the Town's General Plan. Town staff revised this list to make sure that the vulnerability assessment better reflects the local conditions in and around Mammoth Lakes. Chapter 3 contains a complete list of selected exposures, and Chapter 4 contains the list of sensitivities identified within the Town.

Once these were identified, the Town next looked at which exposures are likely to affect which sensitivities, because not all exposures affect all populations and assets. For example, human health hazards impact most population sensitivities, but they would not affect the structural stability of a bridge or a dam. The Town next assessed the impacts and adaptive capacity for each relevant exposure.

The Climate Change Action Team (CCAT) reviewed the impact, adaptive capacity, and vulnerability scores to provide local knowledge and additional accuracy for the assessment. The CCAT included local and regional stakeholders representing five key systems: social systems, built systems, natural systems, economic systems, and cultural systems.

Impact and Adaptive Capacity

The difference between impact and adaptive capacity can be subtle, but it is important to understand. Impact is the potential harm that the exposure could cause, and adaptive capacity is the ability to resist the harm or to recover from it.

For example, consider two houses next to each other in a forest. The chance of a wildfire occurring in the area and destroying or doing severe damage to both houses is similar for each, so the impact is the same. However, if one house is surrounded by defensive space and is built with fire-resistant materials, it is more likely to resist the negative effects of the wildfire than the other, so this house would have a greater adaptive capacity.

ASSESSING IMPACT

To assess the impacts the exposures will have on the sensitivities, the Town considered various questions to help ensure that the assessment broadly covers the range of potential harm. The questions address physical impacts, the length of the impact, and how many people could be directly or indirectly harmed. Some examples of these questions are:

- What type of impacts may occur?
- Could the impacts cause physical injury or damage? If not, is there a risk of behavioral or mental harm, loss of economic activity, or other nonphysical harm?
- How many people or assets could be affected by both direct and indirect harm?
- How long would the impacts persist after the exposure?
- Is there a substantial chance of death or widespread destruction?

Based on the results of the impact assessment (IM), the Town ranked each sensitivity on a five-point scale (0 to 4) for each relevant exposure. IM0 is the lowest score (lowest impact), and IM4 is the highest score (highest impact). An impact is considered a negative quality, and therefore a higher impact score means that there is a higher potential for harm to the community. A lower impact score means that there is a lower potential for harm to the community. The CCAT also informed the impact scoring based on their local knowledge of the area and roles in social, built, natural, economic, and cultural systems. Adhering to the method of the APG, the Town adjusted these scores up or down to account for risk and onset.

The rubric below provides more detail about what each score means.

ASSESSING ADAPTIVE CAPACITY

The Town next evaluated the adaptive capacity of the individual sensitivities for each relevant exposure. Following a similar process as used to analyze impacts, the Town considered various questions to help make sure that the adaptive capacity assessment covers the full potential of a sensitivity to resist and recover from harm. Examples of these questions include:

- Are there existing programs, policies, or funding to provide assistance? Can affected community members or agencies take advantage of these programs or funding?
- Are there barriers that limit response or recovery? Are these barriers financial limitations, political challenges, lack of access to technology or other resources, or others?
- Do alternatives exist in or near the Town of Mammoth Lakes?

TABLE 1: IMPACT SCORING MATRIX

IMPACT SCORE	MEANING (POPULATIONS AND ECOSYSTEMS)	MEANING (BUILDINGS AND INFRASTRUCTURE, COMMUNITY SERVICES, ECONOMIC DRIVERS)
IM0. Minimal Impact	Community members may not notice any change.	Damage, interruption in service, or impacts on the local infrastructure and economy are small or intermittent enough to mostly go unnoticed.
IM1. Low Impact	Community members notice minor effects. Daily life may experience mild, occasional disruptions.	There is minor but noticeable damage, interruption in service, or negative impacts to the economy.
IM2. Moderate Impact	There is a marked impact to the community. Quality of life may decline, and impacts may be chronic or substantial at times.	Damage, service interruptions, and other impacts are clearly evident. Impacts may be chronic and occasionally substantial.
IM3. Significant Impact	The well-being of the community declines significantly. The current lifestyle and behavior of the community may no longer be possible.	Buildings, infrastructure, and services may often or always be unable to meet community demand. Impacts are chronic in nature and large sections of the economy experience major hardships.
IM4. Severe Impact	There is a severe risk of widespread injury or death to people, or of significant to total ecosystem loss.	Buildings, infrastructure, and services cannot function as intended or needed. Economic activities are not viable.

Based on the results of the adaptive capacity (AC) assessment, the Town ranked each sensitivity on a five-point scale (0 to 4) ranging from AC0 (the lowest adaptive capacity) to AC4 (the highest adaptive capacity). Adaptive capacity is considered a positive attribute, so a higher adaptive capacity score means that the sensitivity may be more adaptable to the exposure. A lower adaptive capacity score means that a sensitivity may have a harder time adjusting to the changing conditions. The CCAT also informed the adaptive capacity scoring using their local knowledge of the area and roles in social, built, natural, economic, and cultural systems. As recommended by the APG,

the Town adjusted the adaptive capacity scores to ensure that they reflect risk levels and onset periods.

The rubric below provides more detail about what each score means.

TABLE 2: ADAPTIVE CAPACITY SCORING MATRIX

IMPACT SCORE	MEANING (ALL SENSITIVITIES)
AC0. No Adaptive Capacity	Currently, there are no feasible means of adapting.
AC1. Low Adaptive Capacity	Adaptive solutions are available, but they are expensive, technologically difficult, and/or politically unpopular.
AC2. Some Adaptive Capacity	Some adaptation methods are available, but not always feasible. Adapting may create significant challenges for some sensitivities.
AC3. High Adaptive Capacity	Adaptation solutions are feasible for most or all sensitivities. There may be occasional or small-scale challenges to implementing adaptation methods.
AC4. Outstanding Adaptive Capacity	Sensitivities can adapt with little or no effort. Quality of life is unchanged or may improve.

VULNERABILITY SCORING

The Town used the impact and adaptive capacity scores for each sensitivity and relevant exposure to determine the vulnerability score. The vulnerability (V) score reflects how susceptible the sensitivity is to harm from a particular exposure.

Vulnerability is assessed on a scale of 1 to 5:

- **V1:** Minimal Vulnerability
- **V2:** Low Vulnerability
- **V3:** Moderate Vulnerability
- **V4:** High Vulnerability
- **V5:** Severe Vulnerability

The matrix below shows how impact and adaptive capacity scores combine and translate into a vulnerability score.

TABLE 3: VULNERABILITY SCORING MATRIX

		IMPACT SCORE				
		IM0	IM1	IM2	IM3	IM4
ADAPTIVE CAPACITY SCORE	AC0	V3	V4	V5	V5	V5
	AC1	V2	V3	V4	V5	V5
	AC2	V1	V2	V3	V4	V5
	AC3	V1	V1	V2	V3	V4
	AC4	V1	V1	V1	V2	V3

Appendix 1 shows the full results of the vulnerability assessment.

DATA SOURCES

The vulnerability assessment must be based on the best available science and information. The Town used data from a variety of credible sources to prepare the vulnerability assessment, determine the impact and adaptive capacity scores, and support the conclusions presented in this report. These sources include scholarly research, locally provided data, and state and federal data.

SCHOLARLY RESEARCH

Much of the information came from an extensive body of scientific research that discusses how climate change may affect people and community assets. In most cases, this research was not conducted in the Town of Mammoth Lakes, but the results are applicable and relevant. Much of this research is peer reviewed, which ensures greater accuracy, including studies published in the *Proceedings of the National Academy of Science*, *Geophysical Research Letters*, and *Climate Change*. The Town augmented the information in these studies and reports with websites and publications from scientific and academic institutions, government organizations, and credible local and national sources, including updated climate modeling from the UCLA Center for Climate Science.

LOCAL DATA

Local government agencies have already prepared a number of plans and reports that support the vulnerability assessment or contain information relevant to the analysis. The Town relied on several local plans and reports to prepare the vulnerability assessment, including:

- Groundwater Management Plan for the Mammoth Basin Watershed (2005)
- The Town of Mammoth Lakes General Plan (2007)
- 5-Year Capital Improvement Plan 2012-2013 (2012)
- Mono County Emergency Operations Plan (2012)
- Mammoth Community Water District Urban Water Management Plan (2015)
- Mammoth Yosemite Airport Layout Plan Update Narrative (2015)
- Mammoth Lakes Community Housing Action Plan (2017)
- Mono County and the Town of Mammoth Lakes Hazard Mitigation Plan (2018)
- Point-in-Time Homeless County CA-530 Alpine, Inyo, Mono Counties CoC (2018)

The Town also relied on spatial data maintained by the Town and Mono County. These data show the locations of various buildings and infrastructure, different land uses, boundaries, critical facilities, and other items of importance to the vulnerability assessment.

STATE AND FEDERAL DATA

The Town supplemented the scholarly research and local data with data from state and federal agencies, including published reports and datasets. The Town relied on information from several agencies, including the Centers for Disease Control and Prevention, Federal Emergency Management Agency (FEMA), the California Energy Commission, Cal OES, the California Governor's Office of Planning Resources (OPR), CNRA, and the California Department of Forestry and Fire Protection (CAL FIRE). The Town also relied on the US Census Bureau for demographic data, including information about the numbers of disadvantaged persons in the community. Key state resources include the following guidance documents, reports, and tools.

- The state's Adaptation Planning Guide and the Fourth Climate Change Assessment, including the Sierra Nevada Regional Report, provided extensive information about climate-related exposures and vulnerabilities, as did federal reports such as the National Climate Assessment.
- Cal-Adapt, a web-based tool developed by the California Energy Commission (CEC), provided highly specific information about historic climate conditions and future climate projections.
- Documents from CNRA, such as the Safeguarding California Plan (2018 Update) and California Climate Adaptation Strategy reports, provided additional information about state climate vulnerabilities and adaptation strategies.



3. Hazards of Concern

The effects of climate change, particularly the negative effects, are known as exposures. These are usually changes to existing climate-related conditions or hazards, such as a decrease in snow levels. In some cases, an exposure can be an entirely new hazard, such as a new pest insect that did not live in the area before.

SELECTED EXPOSURES

The Town reviewed scientific reports and datasets to identify the exposures that can create hazardous conditions in and around Mammoth Lakes. These sources include many state and federal reports as well as local planning documents such as the Mono County/Mammoth Lakes Local Hazard Mitigation Plan. During review of the initial list, Town staff recommended including extreme heat, landslides and mudflows, and severe winter weather as exposures based on their experience and understanding of hazard conditions within the community. Members of Mammoth Lake's CCAT also commented on the initial list and suggested additional exposures to include, primarily identifying smoke and ash as a distinct exposure from wildfires.

Resilient Mammoth Lakes is focused on reducing potential harm from climate change, resulting in a vulnerability assessment that only looks at climate-related hazards. As a

result, hazardous situations not linked to climate change are not part of this effort. For example, this vulnerability assessment does not consider the potential harm from volcanic activity in the Long Valley Caldera because there is no connection between climate change and volcanic activity.

The Mammoth Lakes vulnerability assessment considers 10 different exposures:

- Drought
- Extreme heat
- Flooding
- Forestry pests and diseases
- Human health hazards
- Landslides and mudflows
- Severe weather
- Severe winter weather
- Smoke and ash
- Wildfire.

SNOWFALL

In addition to the 10 selected exposures, snow is a major issue in Mammoth Lakes. Snow provides major economic benefits, is a vital water source, and contributes to the town's unique character. However, it can also lead to potentially dangerous conditions. Snow is associated with many of the exposures in this vulnerability assessment, including drought, flooding, and severe winter weather. Recognizing that snow intersects with multiple exposures, this vulnerability assessment considers snow as a component of multiple hazards. This consideration includes amounts and timing of snowfall, depth of snowpack, and timing of snow melt. This approach ensures that snow is considered in all aspects of the vulnerability assessment, and that the connections between snow and various hazards are clear.

EXPOSURE CONSIDERATIONS

When selecting these exposures and applying them to Mammoth Lakes, the Town acknowledged the following considerations.

CLIMATE SCENARIOS

This section includes descriptions of potential future conditions in and around Mammoth Lakes as a result of climate change. Like any forecast, there is some uncertainty in these projections. Climate change is caused by greenhouse gas (GHG) emissions, and so changes in the amount of GHG emissions, how long they are emitted, and the amount of emissions emitted in the near-term compared to the distant future will all have an effect on the severity of potential climate change effects. These uncertainties depend

in part on factors such as population levels, economic activities, government policies, and personal behavior.

This vulnerability assessment uses data and reports that look at multiple scenarios of future GHG emissions and severity of climate change. The global scientific community most commonly uses four different scenarios, known as Representative Concentration Pathways (RCPs):

- RCP 2.6: This scenario assumes that global GHG emissions peak around 2020, and then decline quickly. Under this scenario, emissions of carbon dioxide (CO₂) from human activities zero around 2075.
- RCP 4.5: This scenario assumes that global GHG emissions peak around 2040, then decline. Carbon dioxide emissions decline to less than half of current levels by 2080.
- RCP 6: This scenario assumes that global GHG emissions peak around 2060. Human-caused carbon dioxide emissions decline after 2060, although they remain above current levels at the end of the century.
- RCP 8.5: This scenario assumes that global emissions continue to climb until at least the end of the century.⁹

In California, the most accurate and detailed data is available for the RCP 4.5 and RCP 8.5 scenarios, and so Mammoth Lakes used these two scenarios to prepare this vulnerability assessment. The data under the RCP 2.6 and RCP 6 scenarios is only available at a large scale, and would not provide enough detail to accurately identify changes to climate conditions in and around Mammoth Lakes.

WEATHER AND CLIMATE

This vulnerability assessment recognizes the importance of considering weather and climate as two different things. “Weather” is the set of conditions at a particular time and place, and “climate” is the long-term average of conditions. For example, depending on the specific day and time, the temperature in Mammoth Lakes may be 90 degrees or –10 degrees Fahrenheit. These daily conditions are the weather. However, the average temperature in Mammoth Lakes is generally between 29 and 57 degrees Fahrenheit.⁵ This description of the usual conditions is the climate.

It is difficult to accurately forecast the weather more than a few days in advance, because there can be so much variation in the day-to-day conditions. However, because climate is a long-term average, it can be forecasted for years or decades with a higher degree of accuracy. This allows climate scientists to make reasonable forecasts of what climate conditions will be like decades into the future. Because climate is an average, climate projections do not say whether a condition will or will not occur, only how likely the condition is. For example, if climate projections say that the average temperature is likely to increase, a day with very cold temperatures does not mean these projections are wrong, but only that very cold days are likely to become less common.

DOWNSCALING

The data used throughout this vulnerability assessment comes from scientifically verified climate models. These models work by dividing the Earth's surface into cells using a grid, then forecasting the conditions in each cell. Smaller cells allow the model to forecast the difference in conditions between smaller areas, but require much more computing power. Modern-day climate models have much smaller cells than older ones, but the cells of these models may still be too large to inform local-level climate adaptation planning.^{10,11}

To make the data outputs from these models easier for local governments to use, they require a process called "downscaling." This process takes data from a model and uses various mathematical techniques to apply the results to a much finer grid of cells, creating much more detailed projections. Scientists have downscaled the results from several global climate models for California. State guidance documents recommend that adaptation planning efforts such as Resilient Mammoth Lakes use an average of downscaled results from multiple climate models, which can be more accurate than using a single model.¹² This vulnerability assessment uses an average of California's four "priority" climate models when possible, and an average of other vetted models if the priority ones are not available.

EXPOSURE PROFILES

DROUGHT

"Climate change is...likely to exacerbate the region's frequent and severe droughts."

- California Fourth Climate Change Assessment ¹

A drought is where conditions are drier than normal for a long period of time, making less water available for people and ecosystems. Usually, it takes more than one dry year to create drought conditions.¹³ During droughts, communities may have to restrict how much water they use. Economic activities that depend on rain or snow, including boating, skiing, and agriculture, may have to be cut back or halted. In more severe cases, water supplies may be so low that people may have to limit use to essential purposes only. Ecosystems can suffer during droughts, if plants and animals do not get enough water to thrive. Droughts can cause plants to dry up, creating more fuel for wildfires or making plants more vulnerable to harm from pests and diseases.

Snowpack

Snowpack is the amount of snow that accumulates during the winter. When temperatures increase in the spring, the snowpack begins to melt, supplying many of California's rivers and lakes with water until rain and snow return to the state in autumn.

Droughts are a regular part of the climate throughout California. In the past 50 years, there have been four major statewide droughts, plus smaller regional droughts.¹³ However, climate change is expected to increase both the number of droughts and their intensity throughout the state, pushing drought conditions beyond normal historical levels.¹ This includes an expected increase in the risk of the most severe droughts, those that last for a decade or longer.^{14,15}

CHANGES IN SNOW CONDITIONS

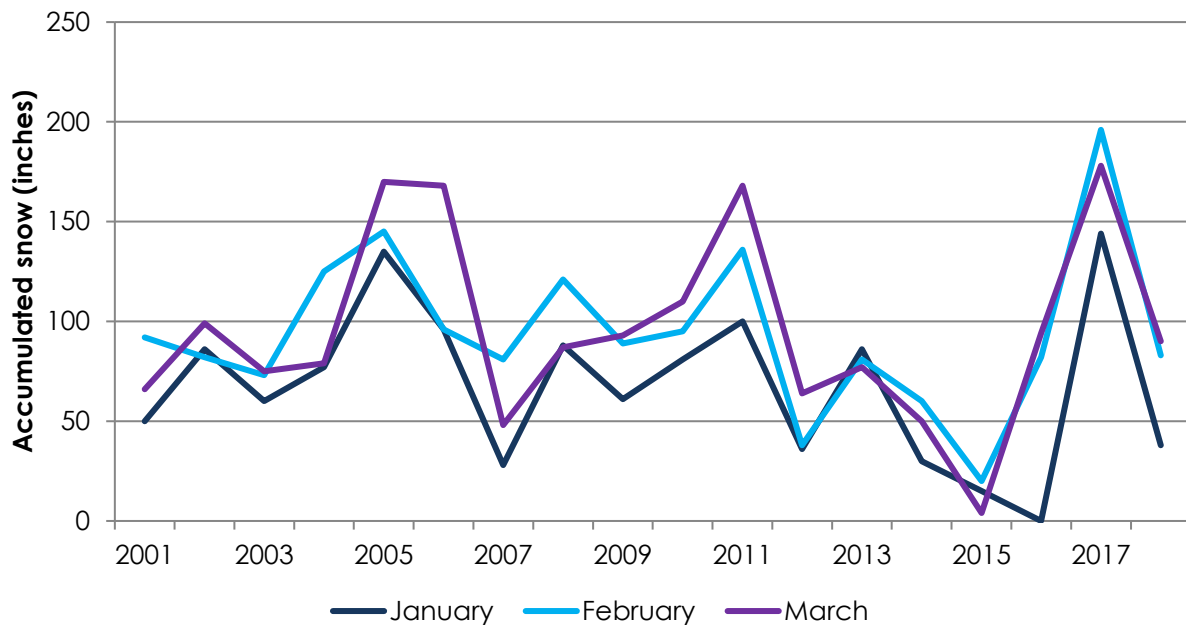
In Mammoth Lakes, drought conditions and water supply depend on the local snowpack. Most precipitation in Mammoth Lakes falls as snow. The town receives about 23 inches of rainfall annually, but over 200 inches of snow. **Error! Bookmark not defined.** Overall precipitation levels are not expected to change much, but the snowline around Mammoth Lakes is expected to change significantly because more precipitation is expected to fall as rain rather than snow, reducing the amount of snow that builds up over the winter. Warmer temperatures are expected to melt the snowpack sooner, which is likely to cause higher-than-normal runoff from the snowpack in late winter and early spring. However, the amount of melting snow and other runoff around Mammoth Lakes is projected to be approximately half of normal levels by the summer, as the reduced snowpack melts away sooner. Throughout much of the Sierra Nevada, snowpack levels are expected to decline by as much as 90 percent by 2100. Immediately around Mammoth Lakes, April snowpack levels are projected to decrease by 45 percent or more, as shown in **Map 2**.¹⁶ In the central Sierra Nevada, which includes Mammoth Lakes, years with unusually low snowpack levels (sometimes called “snow droughts”) are expected to happen two to four times more often by 2100 than they have historically.¹



Snow persists on the mountains around Mammoth Lakes for several months.

Figure 3-1 shows the accumulated snow on the ground in the months of January, February, and March at Mammoth Pass near Lake McCloud from the years 2001 to 2018. There is significant variability in snowfall from year to year, which is expected to become even more variable as droughts become more frequent and intense. Note the low snow levels in 2012, marking the start of one of the most intense droughts the state has seen in over 1,200 years, followed by the spike in snow levels in 2017 when the drought ended.

Figure 3-1: Accumulated Snow Levels at Mammoth Pass (2001-2018)



Data from California Department of Water Resources

EXTREME HEAT

"By the end of the century, temperatures in the Sierra Nevada are projected to warm by 6 to 10 degrees Fahrenheit on average."

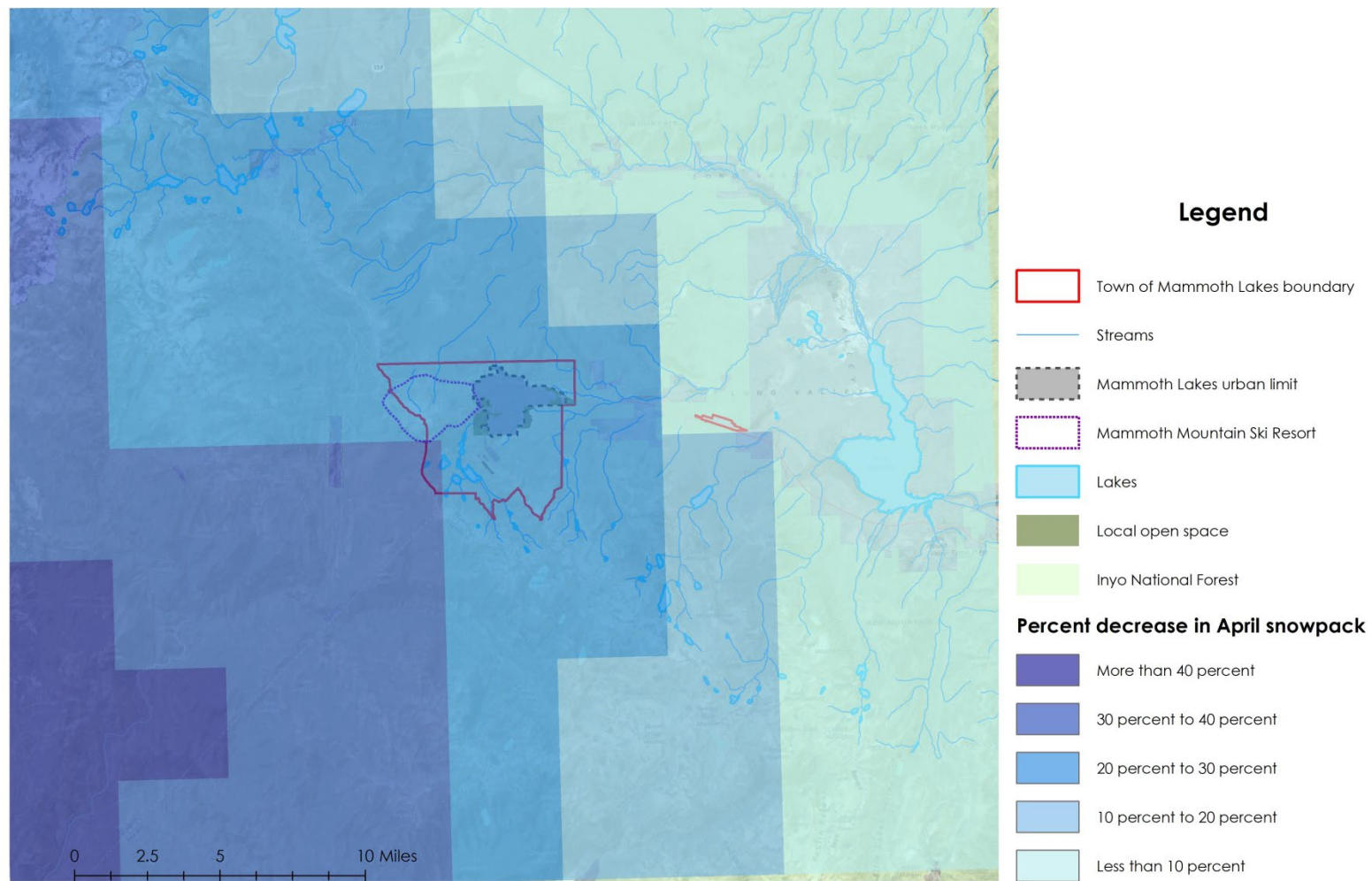
- California Fourth Climate Change Assessment¹

Extreme heat is when temperatures rise significantly above normal levels. It can cause heat-related illnesses, such as heat cramps, heat exhaustion, and heat stroke. These temperatures can harm animals and plants that are not used to such conditions. Some types of infrastructure, including power lines, face greater stresses during high temperatures that make failure more likely. Very high temperatures make people less likely to venture outside, hurting economic activities that depend on outdoor activities. Extreme heat can also increase the risk of wildfires by drying out plant material, and prolonged high temperatures can contribute to drought conditions.



Even at the peak of summer, temperatures in Mammoth Lakes are usually below 80 degrees.

MAP 2: DECREASE IN APRIL SNOWPACK, 1991-2000 TO 2091-2100



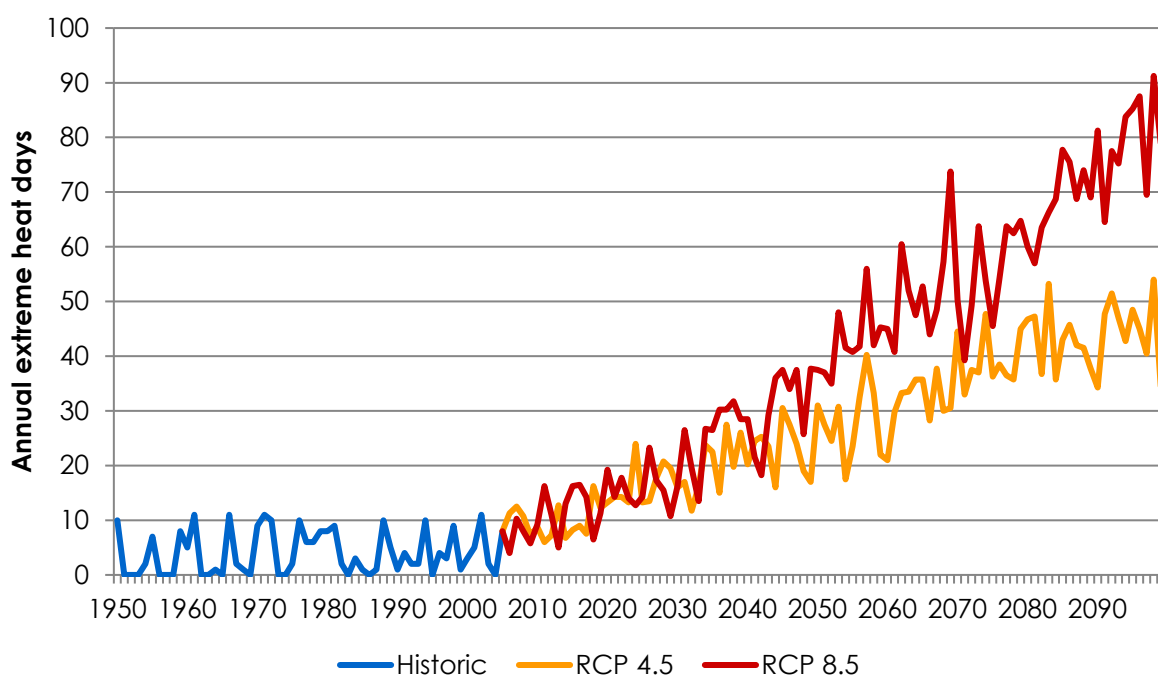
Sources: UCLA Center for Climate Science, Town of Mammoth Lakes, Mono County, United States Geological Survey, National Oceanic and Atmospheric Administration, ESRI

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“Extreme heat” is a relative term. Temperatures of 100 degrees are normal in locations like Palm Springs, but almost unprecedented in San Francisco. In Mammoth Lakes, an extreme heat day is a day where the temperature reaches 79.1 degrees or higher.¹⁷ Although this may not sound like a particularly high temperature, the danger is that the temperatures are much higher than usual and so can be harmful for people and assets that are not accustomed to them.

Historically, Mammoth Lakes has experienced an average of four extreme heat days a year. This number is expected to increase dramatically because of climate change. By the middle of the 21st century (2035-2064), Mammoth Lakes is likely to see an average of between 26 and 37 extreme heat days per year. By the end of the century, the town is projected to experience an average of 42 to 67 extreme heat days per year. **Figure 3-2** shows the historical and projected extreme heat days in Mammoth Lakes.

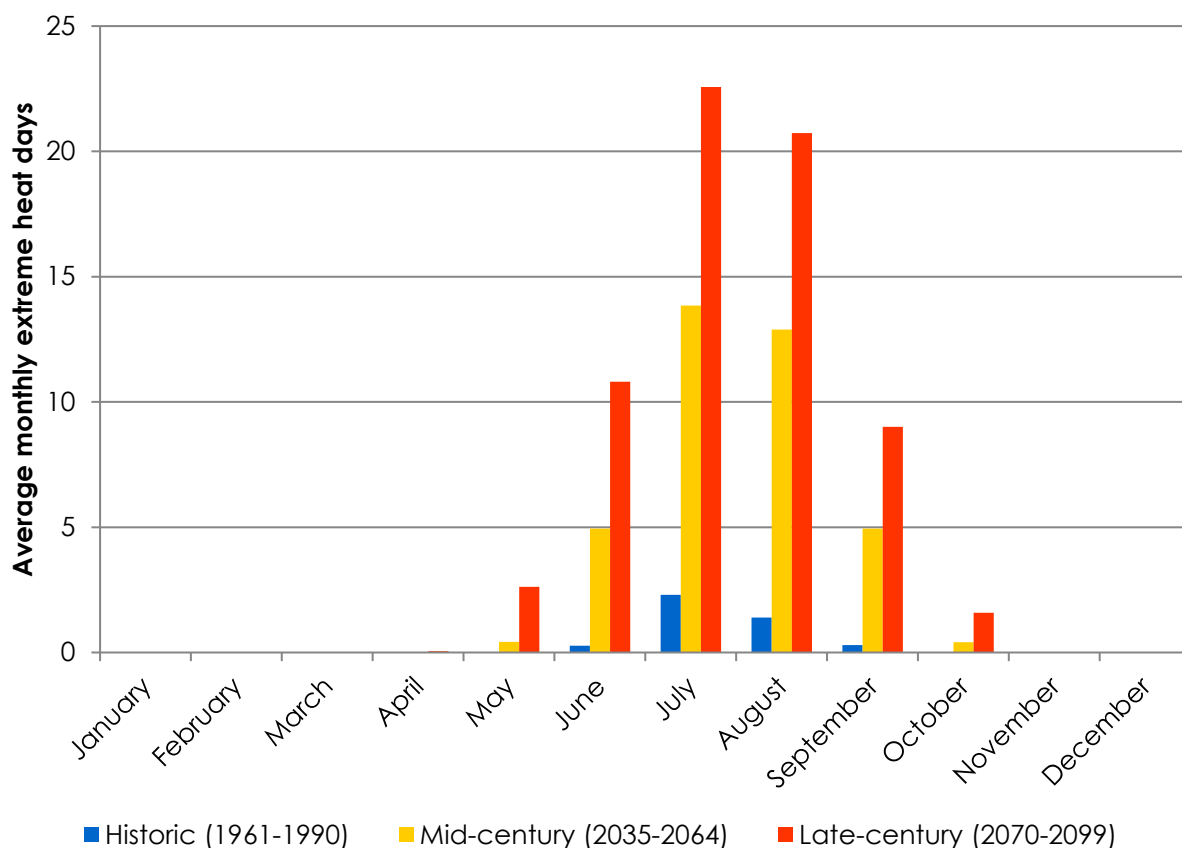
Figure 3-2: Annual Extreme Heat Days in Mammoth Lakes (1950-2099)



Data from California Energy Commission

This change is expected to cause a number of other effects, including longer heat waves, extreme heat days that occur earlier or later in the year, and higher overall temperatures.¹⁷ As an example, **Figure 3-3** shows the historical and projected number of extreme heat days each month under the RCP 8.5 scenario. Note that by the end of the century, extreme heat days could occur as early as March, and the majority of days in July and August may qualify as extreme heat events.

Figure 3-3: Monthly Extreme Heat Days in Mammoth Lakes (RCP 8.5 Scenario)



Data from California Energy Commission

CHANGES IN SNOW CONDITIONS

Extreme heat conditions themselves are unlikely to affect snow conditions in and around Mammoth Lakes, but general increases in temperatures are likely to create significant changes. Warmer temperatures mean that there will be fewer days with temperatures cold enough to allow for snowfall, meaning that Mammoth Lakes can expect to see more rain and less snow even if the total level of precipitation does not change. Warmer temperatures in the later winter and spring mean that snow is likely to melt faster during this period, creating a greater risk of flooding. This also increases the risk of rain falling on accumulated snow ("rain-on-snow" events), which further increases the potential for flooding.¹

FLOODING

"Warming is likely...to increase both the frequency and magnitudes of floods from the southern Sierra Nevada."

- California Fourth Climate Change Assessment¹

A flood is when there is too much water on the ground to be carried away by drains or creeks, or to soak into the soil. The water instead builds up in normally dry areas and can cause significant harm. Floodwaters can be deep enough to drown people and may move fast enough to carry people or heavy objects (such as cars) away. In some cases, floods can be strong enough to lift buildings off of their foundations. Even standing water can be harmful if the water is high enough to get inside buildings or vehicles. Floods can be caused by heavy rainfall or long periods of moderate rainfall, rapidly melting snow, or clogged drains during periods of rainfall or snowmelt. In rare instances, a break in a dam, water pipe, or water tank can also cause flooding. Floods that develop very quickly are called flash floods, and can be especially dangerous because there may be little or no warning.

Map 3 shows the areas in and around Mammoth Lakes that are officially designated as floodplains by FEMA, although flooding can occur outside of these mapped areas.

Although climate change is expected to increase the frequency and intensity of droughts, scientists also project that it will increase the frequency and intensity of floods in and around Mammoth Lakes, although overall precipitation levels are not expected to change very much. Up to half of California's precipitation comes from a relatively small number of intense winter storms. These storms are expected to become even more intense with climate change. In the Sierra Nevada, the amount of precipitation from these storms is projected to increase by 5 to 30 percent.¹ Very rare and extreme storms, such as the 200-year storms that historically only have a 0.5 percent chance of happening each year, are expected to become at least three times more frequent.¹⁸

Drought, Flood, and Precipitation

Scientists expect overall precipitation levels in Mammoth Lakes to remain about the same, but both droughts and floods are likely to happen more often. How is this possible?

Climate change is likely to shift precipitation patterns in California toward the extremes. Storms are expected to become stronger, dropping more precipitation statewide. At the same time, dry periods are likely to become drier, and occur more often.

The "normal" conditions in California are likely to become more extreme during both wet and dry periods. However, the more intense and frequent very wet and very dry periods are expected to average out, so overall precipitation levels are not expected to change much.

CHANGES IN SNOW CONDITIONS

Change to snowfall and snowpack in and around Mammoth Lakes is expected to contribute to an increase in flooding. A greater proportion of precipitation is expected to fall as rain rather than snow, and because rain runs off quickly rather than melting over a long period of time, rain events are more likely to cause flooding. Warmer temperatures are projected to cause snow to melt faster, especially in the late winter and early spring, when runoff in the eastern side of the Sierra Nevada may be 150 percent to 240 percent above normal levels. When there is a rain-on-snow event, the rain increases the rate of snowmelt, which adds to the potential flooding hazard.¹ During these events, the snow also blocks storm drains, increasing the flood risk even more. Rain-on-snow instances are expected to occur more often in the future.

FORESTRY PESTS AND DISEASES

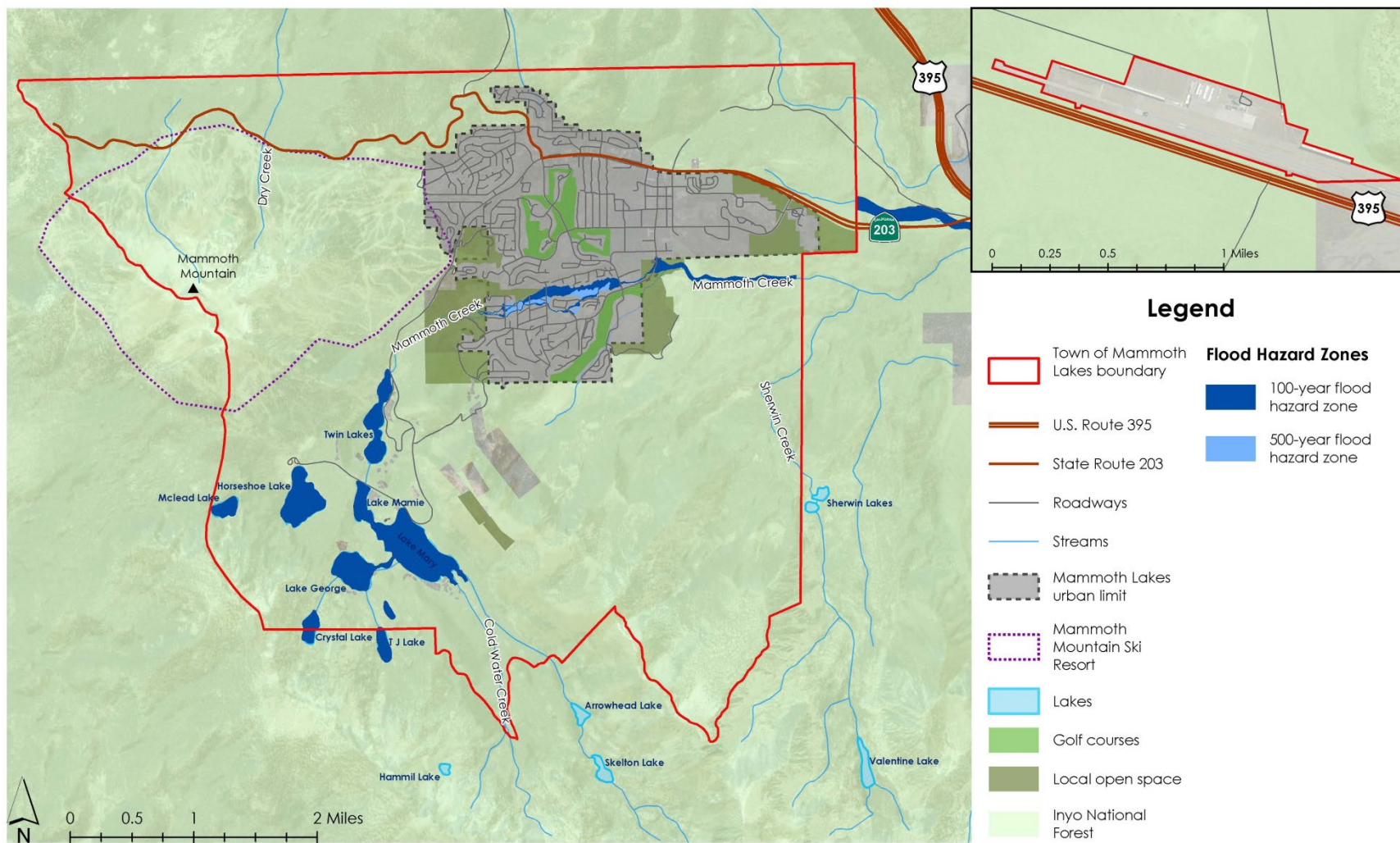
"Many species will face...shifting disease and parasite dynamics."

- California Fourth Climate Change Assessment¹

The forests of California face harm from a number of insects and other pests, diseases caused by bacterial or viruses, fungal infections, and other conditions that can affect the health of forest trees and plants. Bark beetles are among the most widely known of these forestry pests and diseases in California because of the devastation they have caused in the Sierra Nevada over the past few years, but there are many others. Pest or disease infections can cause trees and other plants to grow more slowly, damage them so they are less able to function in an ecosystem, or kill them outright. Forest and wilderness managers can cure or treat some pests or diseases, or control their spread. However, in some cases, there is nothing that can be done.

Forestry pests and diseases are harmful to the health of the forest, but can also be damaging to the local community. In places where forests are a scenic and recreation attraction, and an important contributor to local quality of life, forestry pests and diseases can cause significant economic harm. Dead trees or tree limbs may fall, especially during high winds, and can damage or destroy buildings and structures, cars, and other property. Falling trees or tree limbs may block roadways and cause injuries or even fatalities to community members and visitors. Dead trees and other plants can also create more fuel for wildfires. **Map 4** shows the recent tree mortality levels in and around Mammoth Lakes.

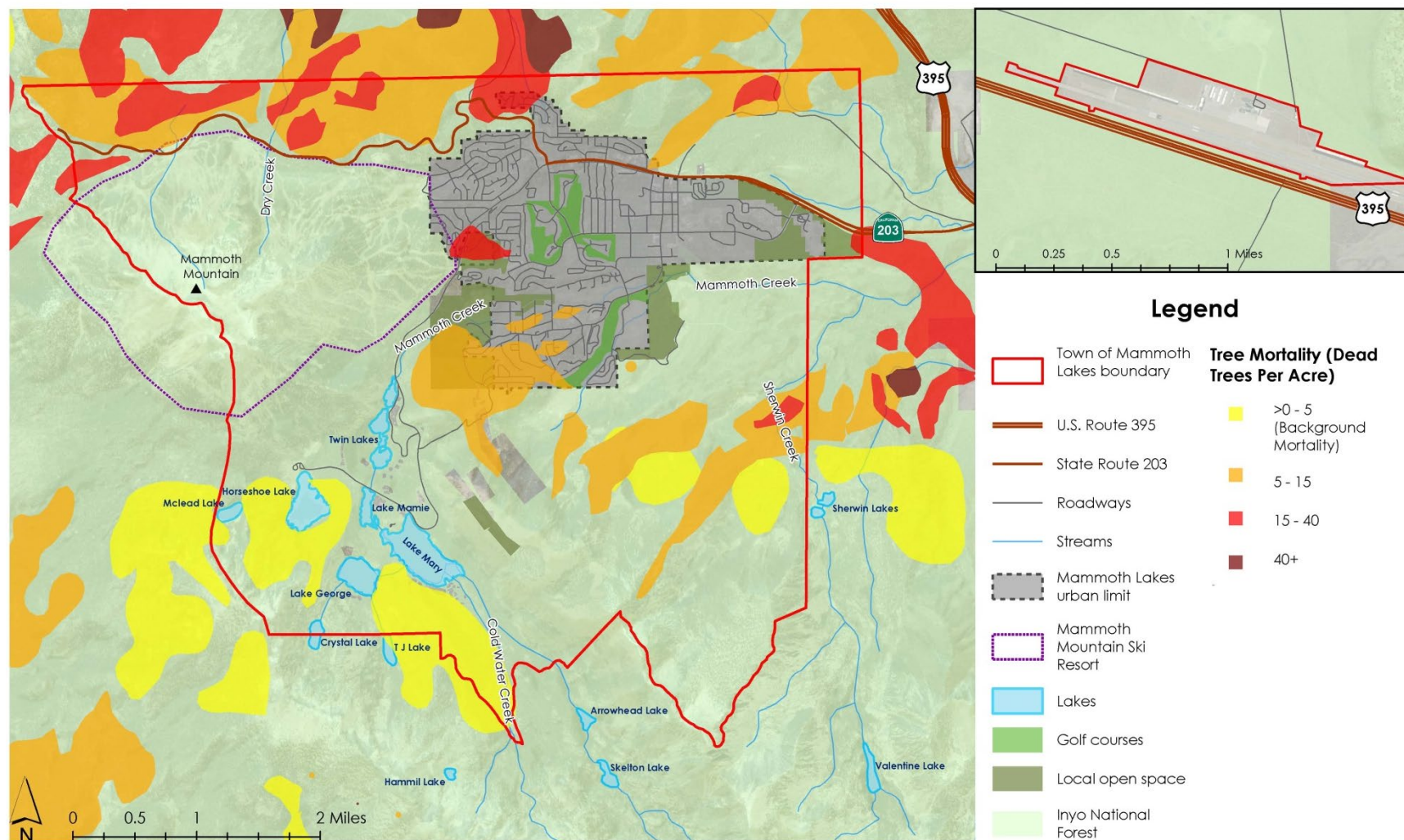
MAP 3: MAMMOTH LAKES FLOOD HAZARD ZONES



Sources: Federal Emergency Management Agency, Town of Mammoth Lakes, Mono County, United States Geological Survey, National Oceanic and Atmospheric Administration, ESRI

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MAP 4: MAMMOTH LAKES 2017 TREE MORTALITY



Sources: California Department of Forestry and Fire Protection, Town of Mammoth Lakes, Mono County, United States Geological Survey, National Oceanic and Atmospheric Administration, ESRI

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The warmer temperatures brought on by climate change are expected to help increase the spread of forestry pests and diseases. Many pests and disease-carrying organisms are more active when the temperature is warm. This is especially true in Mammoth Lakes, when the average winter temperatures are cold enough to kill many pest species and force others to become dormant. As temperatures increase, these pests may start becoming active earlier in the year and may remain active later in the year, creating a bigger “window” for damage. Increases in drought and extreme heat, which are other effects of climate change, place stress on trees and other plants, weakening them and making them more likely to be harmed by a pest or disease.¹⁹

CHANGES IN SNOW CONDITIONS

There is no direct connection between forestry pest and disease regimes and changes in snow conditions in and around Mammoth Lakes. It is possible that snow accumulating on the branches of trees killed or weakened by pests or diseases can cause the branches to fall, creating a risk of injury, death, or property damage. Because total snowfall levels are likely to decline, but there is expected to be an increase in the severe storms that create heavy snowfall events, it is not known how changes in snow conditions may affect this risk.

HUMAN HEALTH HAZARDS

“Climate change will also have indirect impacts on public health, including increased vector-borne diseases.”

- California Fourth Climate Change Assessment²⁰

Human health hazards are bacteria, viruses, parasites, and other organisms that can cause diseases in people. Some of these diseases may only cause mild inconvenience, while others could be potentially life threatening. Climate-related human health hazards are usually diseases carried by animals that are considered pests, such as mice and rats, mosquitos, and ticks. Even if these animals are not carrying diseases, they can be irritating or unclean. Throughout California, the primary climate-related human health hazards are hantavirus pulmonary syndrome (a respiratory disease carried by rodents, fatal to 38 percent of people who contract it), Lyme disease (a disease carried by ticks that can cause flu-like symptoms and long-term damage), and West Nile virus (a mosquito-borne disease that is harmless or mild for most people, but can cause serious and potentially fatal neurological conditions for some). ^{20,21,22,23}

As with forestry pests and diseases, changes in temperature and precipitation patterns are expected to increase the population of some disease-carrying organisms, make them active during a longer part of the year, or cause them to spread into areas where they did not live before. Warmer temperatures and more frequent droughts can increase the spread of West Nile virus.²⁴ The disease is rare in Mono County and there

are no records of human infection, although the right species of mosquito does exist in the area.^{25,26} Increases in intense precipitation can cause rapid plant growth, which can increase the population of deer mice who carry the virus that causes Hantavirus pulmonary syndrome. Although there have been only 18 cases of hantavirus pulmonary syndrome reported in Mono County between 1980 and 2017 which makes it an uncommon disease, more cases have occurred in Mono County than anywhere else in California.²⁷ The tick that causes Lyme disease has not been found in Mono County, although it has been found in neighboring counties and may become more active in areas where precipitation levels increase.^{24,28}

CHANGES IN SNOW CONDITIONS

There is no direct connection between snow conditions and human health hazards. It is possible that rapid snow melt in the late winter and spring can lead to rapid plant growth, which may increase the population of some pest species or those that carry disease.

LANDSLIDES AND MUDFLOWS

"Heavy rainfall events are likely to cause periodic flooding...and in some cases, erosion or mudslides."

- California Fourth Climate Change Assessment¹⁹

A landslide happens when a slope, like the side of a hill or mountain, becomes unstable, causing soil and rocks to slide down slope. Landslides are most common on steep slopes made up of loose soil and other material, but they can also occur on shallower slopes. This vulnerability assessment looks at landslides that are caused by precipitation, although the shaking of an earthquake can also trigger landslides. This vulnerability assessment does not include specific types of landslides that are associated with volcanic eruptions. The types of landslides caused by precipitation are usually debris flows (a landslide made up of a very wet mix of rock, soil, and other material) and mudflows (also called mudslides, which are made up mostly of very wet soil, with little or no other material).²⁹

During or after periods of heavy or long-lasting rainfall, or during times of high snowmelt, the material on the side of a slope can absorb enough water that it becomes loose triggering a landslide. Debris flows and mudflows are quick moving, around 10 to 20 miles per hour (mph), although some flow at speeds of 50 to 60 mph. Because they are so fluid, a debris flow or mudflow can flow for long distances past the base of the slope where it originated, affecting a larger area. Landslides can damage or destroy buildings or other structures in their path, block roads, and injure or kill people caught in them. The force of a landslide can also tear up vegetation and fill in water bodies, harming local ecosystems.

Climate change does not directly cause more frequent or intense landslides, but it is expected to cause an increase in the conditions that can lead to landslides. Climate

change is expected to increase the amount of precipitation that falls during intense storms, and higher levels of precipitation can saturate the ground and make a landslide more likely. Wildfires also increase the likelihood of landslides by removing vegetation that helps slow down water and holds materials together along slopes. In addition, soils within wildfire burn areas typically become altered in a way that increases erosion and water runoff, further exacerbating slope instability. Because climate change is projected to increase wildfire activity, it is possible that this could also increase the size and/or intensity of future landslides.⁶

CHANGES IN SNOW CONDITIONS

The anticipated changes in snow conditions in and around Mammoth Lakes could increase the potential for landslides in the area. Warmer temperatures in the late winter and early spring are projected to cause a 150 to 240 percent increase in runoff from rain and melting snow on the eastern Sierra Nevada, which may increase the risk of landslides.¹

SEVERE WEATHER

"Climate change will continue to increase the frequency and severity of some extreme weather events around the world and in California."

- California Fourth Climate Change Assessment¹⁹

Severe weather includes intense winds, lightning, hail, and related events. Strong storms are usually the cause of severe weather, although some types of strong winds can happen without a storm. Severe winds can damage or destroy buildings, knock over trees, and damage power lines and electrical equipment (potentially sparking wildfires). Hail can damage buildings and plants (and in extreme cases can injure people); and lightning can spark fires, injure people, or cause fatalities. Strong winds are the most common type of severe weather in and around Mammoth Lakes, and usually occur multiple times a year. In some cases, these high winds can reach hurricane speeds, especially on Mammoth Mountain itself, which has reported wind gusts in excess of 100 mph in the past several years. Several high wind events have caused damage in Mammoth Lakes, but no injuries or deaths



If drains for melting snow are plugged, runoff from rain-on-snow events may not drain properly and can lead to flooding.

from wind have been reported in the town. There is no reported damage from hail in Mammoth Lakes, although lightning did strike a man and cause injuries in the town in the summer of 2004.³⁰

The connection between climate change and severe weather is not as well established as other exposures, but new evidence does suggest that severe weather events may occur more often, and that they may be more intense than in the past.¹⁹ Strong storms are projected to become stronger, and the most intense storms could become more frequent.⁶ This could lead to an increase in the frequency and intensity of severe weather events that are associated with these storms. Climate change may affect strong winds that are not associated with intense storms, but scientists are not clear on how these wind patterns might change, or whether they would even change at all.¹⁹

CHANGES IN SNOW CONDITIONS

Severe weather itself is unlikely to affect snow conditions in and around Mammoth Lakes. However, the intense rainfall that can accompany severe weather may lead to rain-on-snow events if there is accumulated snow on the ground. These events increase the rate of melting snow, which can lead to greater flood risks.

SEVERE WINTER WEATHER

"Climate change will prompt variable and unpredictable snowfall in California's mountainous areas."

- *Safeguarding California*³¹

Severe winter weather includes blizzards, ice storms, and extreme cold events. Blizzards and ice storms can damage buildings and other structures, knock over power lines and trees, and block roadways. Ice can form on roadways and paths, creating slippery conditions that make it difficult or even hazardous to get around. Very cold temperatures create a health risk for people who are exposed to them, including the possibility of trench foot, frostbite, or hypothermia.

In a mountain community like Mammoth Lakes, significant snowfall and very cold temperatures are a normal part of the climate. The town itself often sees at least one month a year with several feet of snow, and Mammoth Mountain and surrounding peaks often receive much more snow. Low temperatures also regularly drop below 0 degrees Fahrenheit at least a few times a year.^{Error! Bookmark not defined.}

Winter storms may become more intense in and around Mammoth Lakes because of climate change. Intense storms are expected to become stronger, and the most intense types of storms (those that have a small chance of occurring in any given year) may become more frequent. Strong storms that happen during very cold temperatures can create severe winter conditions, so there is a potential for severe winter weather to become more frequent and intense in Mammoth Lakes. Warmer temperatures are likely to mean that severe winter weather occurs during a smaller period of the year, as

temperatures in late autumn and early spring may become too warm for a strong winter storm.¹ However, these storms can still cause flooding and create other severe weather, even if conditions are too warm for snow and ice.

Warmer temperatures are expected to decrease the frequency and intensity of extreme cold events, just as they are likely to increase the frequency and intensity of extreme heat events. Historically, the average minimum temperature in Mammoth Lakes is approximately 25 degrees Fahrenheit. By the middle of the century, the average minimum temperature is projected to increase to 30 or 31 degrees. By the end of the century, scientists project the minimum temperature in Mammoth Lakes will be 32 to 35 degrees, or 7 to 10 degrees warmer than the historical average.³²

CHANGES IN SNOW CONDITIONS

Although warmer temperatures are expected to lead to more rain and less snow in and around Mammoth Lakes, it is likely that temperatures will still be low enough to allow for snowfall during part of the year. If winter storms become more intense, this is likely to cause periods of heavy snowfall. Changes in temperature and storm intensity are likely to make severe winter weather and heavy snowfall happen less consistently and impact the predictability of severe winter weather and heavy snow conditions.³¹

SMOKE AND ASH

"The smoke produced by wildfire is a serious threat to human health."

- Fourth Climate Change Assessment¹

The flames from wildfires are a severe threat to the safety of people and property, but the smoke and ash they produce can also be dangerous. Smoke is made up of gases and very small particles, usually no bigger than a few microns (about 0.000039 inches) across, which can be inhaled into the lungs when people breathe smoky air. These particles can aggravate peoples' eyes and lungs and cause health problems, especially in people with existing conditions or less robust respiratory systems. Ash, which is made up of larger particles, can also be dangerous if it is inhaled and may be harmful to people with sensitive skin. If smoke and ash get indoors, the particles and smell can be difficult to get rid of. Ash gets very heavy if wet, and in some cases wet ash on a building's roof or a tree branch can become heavy enough to cause damage. Even if smoke and ash levels do not become high enough to pose a health risk, they can lead to unpleasant conditions that may restrict outdoor activity and tourism.

Part of the harm associated with smoke and ash is that it can spread far beyond the area burned by a wildfire. Smoke and ash conditions can reach dangerous levels more than 100 miles away from an active wildfire location. For example, residents in Mammoth Lakes reported being affected by smoke from the December 2017/January 2018 Thomas Fire, which burned over 220 miles south of the town.

Wildfires are expected to become more intense, to burn larger areas, and to happen during a longer period of the year due to climate change.^{1,19} This means that there are likely to be more days with higher levels of smoke and ash in and around Mammoth Lakes as well as throughout the rest of the state. It is possible that the average intensity of days with high smoke and ash levels will increase, although further research is needed.

CHANGES IN SNOW CONDITIONS

As wildfires occur earlier and later in the year, it is possible that wildfires in parts of the state may be actively burning while there is snow on the ground in Mammoth Lakes. This could cause smoke and ash particles to settle on snow, making the snow darker. Because darker objects absorb more of the sun's energy, they heat up faster, and so darker snow is likely to melt faster.

WILDFIRE

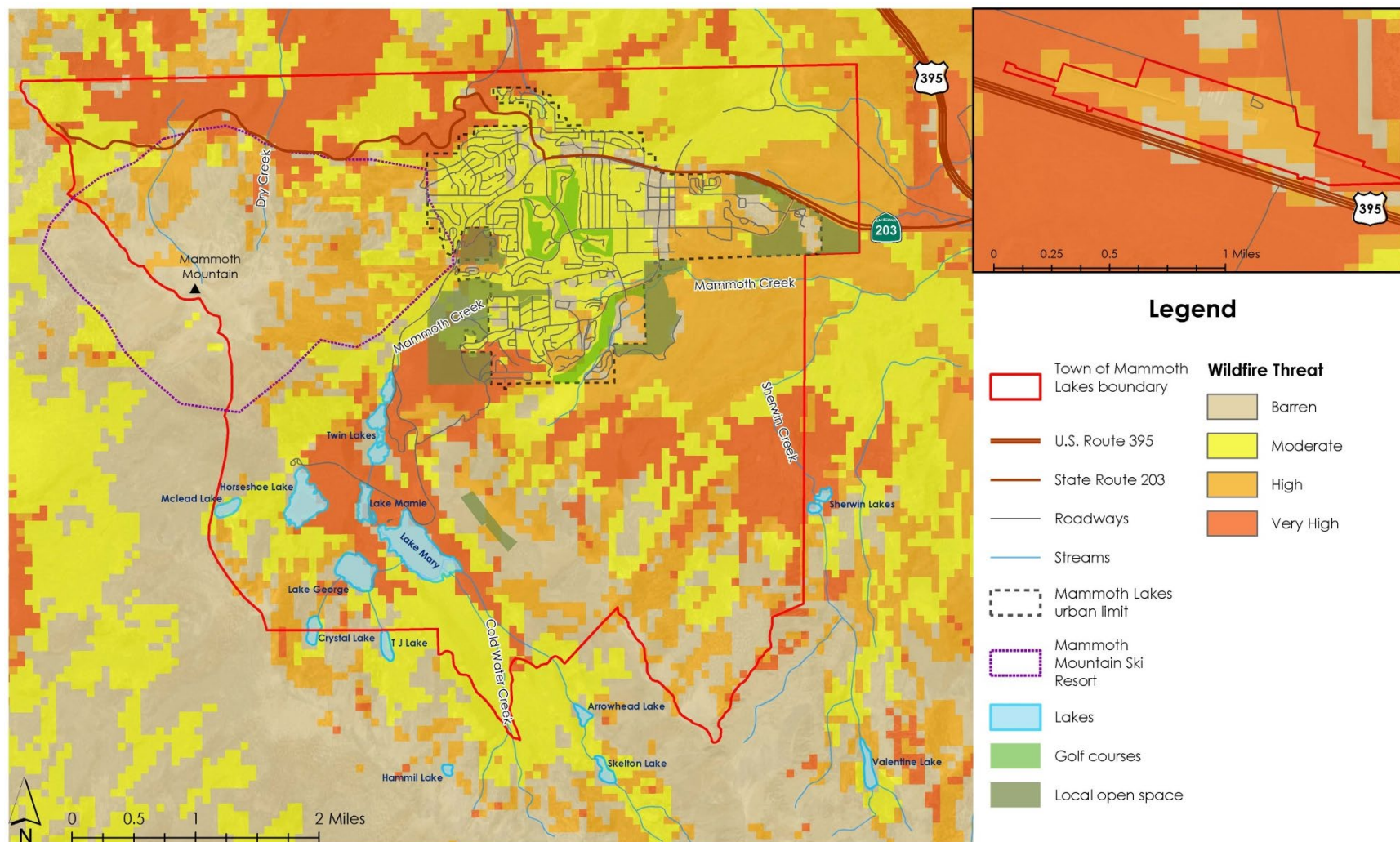
"In the Sierra Nevada, currently projected changes in climate are associated with large increases in the area burned by wildfire and in the frequency of large fires."

- *Fourth Climate Change Assessment¹*

Wildfires are a regular feature of the landscape in much of California, and when they burn in natural areas away from buildings and structures, are not typically hazards (although the smoke and ash produced from these fires can be dangerous). However, wildfires can easily move into the developed areas between urban and wildland zones, known as the wildland-urban interface (WUI). This exposes people and property to the flames, creating a high risk of injury, death, and property damage and destruction. Regardless of where they occur, wildfires can also do significant damage to natural lands and ecosystems. They can be sparked by lightning, malfunctioning equipment, vehicle crashes, or many other causes.

Historically, California wildfires happen in late summer and autumn, when temperatures are high and plant matter is dry. However, climate change is likely to extend the fire season throughout much (or even all) of the year. Extreme heat, drought, and dead trees caused by forestry pests and diseases can all create more fuel for a wildfire. Wildfires can also create hazardous conditions long after the fire is extinguished. Hillsides burned by wildfires are more likely to experience a landslide, particularly after heavy rainfall or snowmelt. **Map 5** shows the current wildfire threat level in and around Mammoth Lakes.

MAP 5: MAMMOTH LAKES CURRENT WILDFIRE THREAT LEVELS

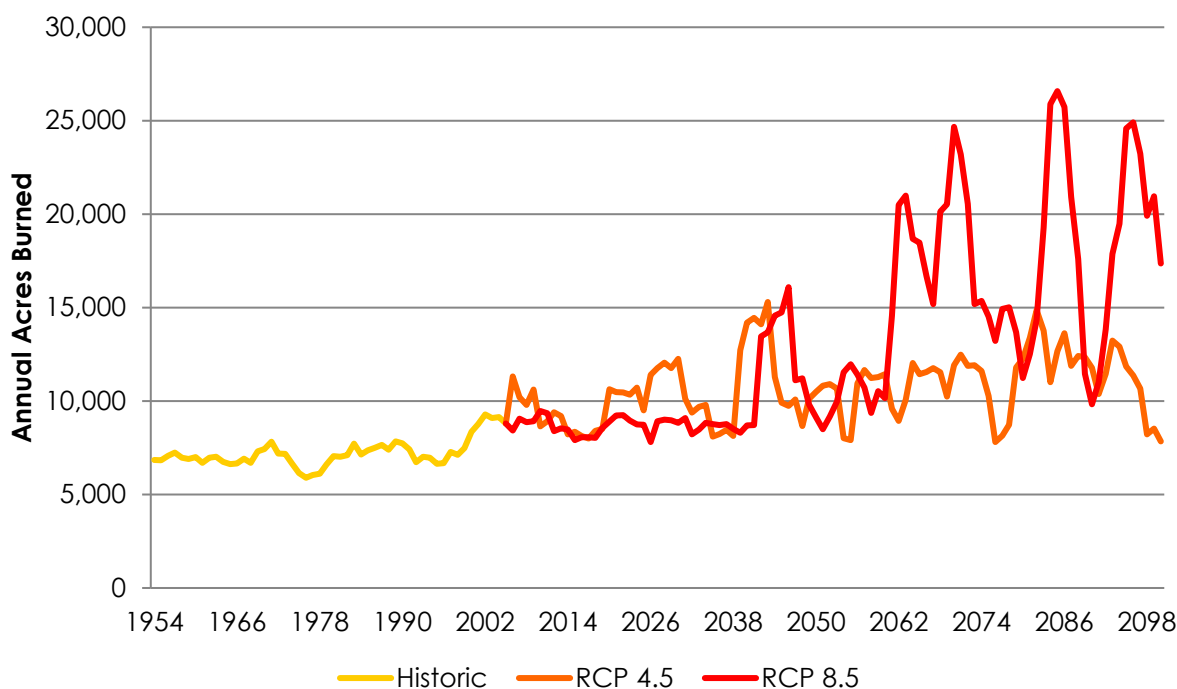


Sources: California Department of Forestry and Fire Protection, Town of Mammoth Lakes, Mono County, United States Geological Survey, National Oceanic and Atmospheric Administration, ESRI

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In the Sierra Nevada, scientists project that climate change will lead to a large increase in the size of the areas burned by wildfires. Large fires (bigger than 24,700 acres, or about 38.6 square miles) are expected to become more frequent. This projected increase includes “extreme” fires, which are far more severe than other wildfires and have historically been rare.¹ In Mono County specifically, the average area burned by wildfires each year is expected to increase from historical levels of about 6,980 acres to 11,020 to 12,360 acres by the middle of the century, an increase of 58 to 77 percent. By the end of the century, Mono County is projected to see an average of 11,320 to 17,810 acres burned annually, an increase of approximately 62 to 155 percent. Under more extreme climate scenarios, countywide burned areas could be as large as 25,000 acres in some years.³³ **Figure 3-4** shows annual averages of estimated historical and projected future acres burned by wildfire in Mono County.

Figure 3-4: Historical and Projected Annual Burned Acres in Mono County (1954-2100)



Historic data is modeled, not observed. All data presented is a five-year rolling average. Data from the California Energy Commission.

CHANGES IN SNOW CONDITIONS

There is no direct connection between wildfires and snow conditions. Wildfires are unlikely to start when there is snow on the ground, as wet material does not burn easily. If a wildfire is actively burning when snowfall occurs, the heat from the fire would melt the snow, but the water from the melting snow would likely extinguish or significantly constrain the fire.

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4. Critical Vulnerabilities

Populations and assets, also known as sensitivities, are the people, buildings and infrastructure, economic assets, ecosystems and natural resources, and key community services in the Town of Mammoth Lakes that can be affected by climate change. Critical vulnerabilities are those sensitivities that may be affected by each of the climate related hazards discussed in Chapter 3.

Populations	People with something in common that may make them more vulnerable to climate-related hazards than the average person.
Buildings and Infrastructure	Structures, homes, nonresidential buildings, and other land uses that provide various services to Mammoth Lakes community members.
Important Economic Assets	Properties and activities that make significant contributions to the Mammoth Lakes economy.
Ecosystems and Natural Resources	Different types of wild and natural land.
Key Community Services	Important functions to community members provided by government agencies and private companies.

POPULATION AND ASSET CONSIDERATIONS

In selecting and assessing the various populations and assets to include in the vulnerability assessment, it is important to keep a few considerations in mind, including: 1) differences in the population universes between datasets, 2) the limitations of the data sources that Mammoth Lakes used to prepare this assessment, and 3) how some population and asset categories may appear to refer to the same thing.

POPULATION UNIVERSES

Statistics, especially statistics related to population, uses the concept of a “universe.” In this context, a universe refers to an entire group of people being measured or studied. For example, in a political poll that is conducted among registered voters, the universe is registered voters, since people who are not registered voters are not counted.

This concept is important for the Mammoth Lakes Vulnerability Assessment because some of the demographics used have different universes. Most of the demographic data come from the US Census Bureau’s American Community Survey (ACS), and most of this data has a universe of either all residents or all households in Mono County. However, a few that are different include:

- Data on persons with limited English proficiency only counts people who are at least five years old, since young children generally are not proficient in any language.

- Statistics that only count the noninstitutionalized population (e.g. people not in prisons or long-term care homes).

This does not affect the outcome of the vulnerability assessment, but it can create slight differences in the number of people counted as part of each population.

DATA LIMITATIONS

As discussed in **Chapter 1**, the vulnerability assessment pulls in data from a wide array of sources. The Town of Mammoth Lakes took care to only use reliable, credible sources with the best available information. In some cases, the vulnerability assessment is constrained by the lack of available high-quality information. For example, there is no accurate information about the number or characteristics of homeless persons in Mammoth Lakes, and so this assessment cannot identify specific vulnerabilities that reflect any unique factors among the Town's homeless population.

RELATED ASSETS

Throughout the 70 populations and assets in the vulnerability assessment, there are a few that may appear redundant. For example, the vulnerability assessment looks at both public safety buildings (as a Buildings and Infrastructure asset) and at public safety response (as a Community Service asset). In order to be as comprehensive as possible, the vulnerability assessment looks at physical structures separately from the services or benefits they provide. In the same way, this assessment looks at vulnerable people separately from the homes they live in or the industries where they are employed.

This is because the effects of climate change on one type of population or asset can be different from the effects on related populations and assets. For example, if a landslide destroyed a single access road such as Fairway Drive, it would have a significant impact on public safety services in and around the Snowcreek neighborhood, particularly if staff or resources were needed from elsewhere in Mammoth Lakes. However, the loss of the Fairway Drive would do no damage to police or fire stations. Similarly, a drought can have a major effect on water and wastewater services by reducing the amount of water available to the community, but droughts have little or no physical effect on water and wastewater pipelines, pumps, or treatment facilities.

TOWN OF MAMMOTH LAKES

The vulnerability assessment evaluated the Town of Mammoth Lakes on a macro-level scale to assess how vulnerable the Town is to climate change hazards. This analysis considered the overall function, economy, and services of the Town and how they will respond to exposures. This is not an average of the vulnerability of all individual sensitivities, but instead assesses the vulnerability of the Town overall.

The town overall is most vulnerable to impacts from wildfire, as well as smoke and ash. Conifer fir forests are highly susceptible to wildfires during extreme heat and persistent drought conditions. A wildfire in or surrounding the Town, or poor air quality in the region, may deter tourists from traveling, staying, or spending money in or around Mammoth Lakes, which could cause substantial damage to the local economy. Services such as air services and delivery of vital goods may be constrained and unable to meet the needs of the community. Reduced air quality can also exacerbate health problems for residents and visitors. While the Town can implement sustainable forest management practices that include clearing understories and removing dead or diseased trees, as well as providing air filters and shelters for those who cannot escape the smoke and ash, these options can be expensive, and the Town may still be unable to efficiently respond to the needs of the community.



The forests around Mammoth Lakes provide many benefits, but also help make the town at risk of wildfires.

POPULATIONS

The vulnerability assessment looked at the following 18 populations that may be disproportionately harmed by the effects of climate change.

SENSITIVITIES

Children. Children are those that are 10 years of age or younger. According to the 2016 ACS, approximately 651 children live in the Mammoth Lakes, or approximately 8.1 percent of the total population.

Cost-burdened Households. Cost-burdened households are those that spend 30 percent or more of their income on rent or mortgage payment. According to the 2016 ACS, approximately 1,033 households in Mammoth Lakes are cost-burdened, or approximately 37 percent of all households.

Homeless Persons. Persons who do not have a permanent home, including those who live in their vehicles. According to the 2018 Continuum of Care Program (COC) homeless count there are approximately 156 homeless persons in Inyo County, Mono County, and Alpine County areas, although numbers may vary seasonally.³⁴ Approximately 99 percent of homeless individuals are unsheltered in the region.

Households in Poverty. Households with an income below the poverty limit, which is \$25,100 for a household of four people. Approximately 199 households in Mammoth

Lakes live in poverty, or approximately 7.1 percent of the total households which poverty status can be determined.

Low-Income Households. Households with an income of 80 percent or less of the median income, which is approximately \$49,000 in the Mammoth Lakes. Approximately 910 households or 32.6 percent of all households in the town are within the low-income category.

Outdoor Workers. People who mostly work outdoors, including construction workers and people who work for the Mammoth Lakes Ski Resort or Inyo National Forest.

Persons Living in Mobile Homes. Persons who live in mobile homes (not including recreational vehicles, or RVs). The 2016 ACS reports approximately 344 households in Mammoth Lakes live in mobile homes, or approximately 3.5 percent of the total number of households.

Persons Living on a Single Access Road. Persons living on local roadways that are the sole route in and out of the neighborhood or area. Several neighborhoods along Old Mammoth Road are only accessible via one roadway.

Persons in Overcrowded Households. People living in households with more than one person per room in the house, not including bathrooms. The 2016 ACS reports approximately 96 households in Mammoth Lakes living in overcrowded or severely overcrowded (more than 1 and a half people per room) conditions, or approximately 3 percent of the total occupied housing units.

Persons with Chronic Health Problems. People who have a long-term or permanent health condition that can create regular challenges in their day-to-day lives. These health problems include cancer, asthma, heart disease, and arthritis.

Persons with Disabilities. Persons with any kind of disability, including mobility challenges, hearing and/or vision impairments, behavioral or emotional health issues, and challenges living independently or taking care of themselves. Some people may have more than one disability. According to the 2016 ACS, approximately 303 people in Mammoth Lakes have a disability, or approximately 3.8 percent of the total noninstitutionalized population.

Persons with Limited English Proficiency. People who say they do not speak English “well”, or “very well,” although the Census Bureau does not formally define what these terms mean. The 2016 ACS reports that approximately 1,029 people in the Mammoth Lakes who are at least 5 years old have limited English proficiency, or approximately 13.3 percent of the total population. Other languages spoken in the town include Spanish, Indo-European languages, and Asian and Pacific Islander languages.

Persons without Access to Lifelines. These are individuals who do not have access to basic technology or services, such as transportation or modern telecommunication. These persons may live in areas where these lifelines are not available or feasible, may

not be able to afford these lifelines, or for personal reasons may choose not to have them. While data is not available on all persons without lifelines, the 2016 ACS reports that approximately 161 households in the town do not have vehicles, or approximately 5.8 percent of all households.

Renters. People who live in homes that they (or the head of their household) do not own. According to the 2016 ACS, approximately 1,687 households in Mammoth Lakes are renters, or approximately 60 percent of all households.

Seasonal Residents and Tourists. People who visit Mammoth Lakes for short periods of time, and who are not permanent residents in the town. According to the 2014 Mammoth Lakes Housing Element, the population of roughly 8,300 full-time residents can quintuple during the peak winter skiing season to around 35,000 to 40,000 people. Approximately 51.7 percent of the entire housing stock in the town is dedicated to seasonal, recreational, or occasional use.

Senior Citizens. Persons 65 years of age or older. The 2016 ACS reports that there are approximately 216 senior citizens in Mammoth Lakes, or approximately 3 percent of the total population.

Senior Citizens Living Alone. Senior citizens who are the only people living in their homes, although they may have one or more caretakers. According to the 2016 ACS, approximately 51 senior citizens live alone in Mammoth Lakes, or approximately 23.6 percent of all senior citizens.

Undocumented Persons. People who do not have formal permission to live in the United States (they do not have citizenship, permanent residency, visas, or other similar status). There are no official counts of how many undocumented persons live in Mammoth Lakes, but a 2017 study estimated that the total number of undocumented persons in Alpine, Amador, Calaveras, Inyo, Mariposa, Mono, and Tuolumne counties (including those living in incorporated areas) was 3,000.³⁵

Financial Assistance Programs

Financial assistance programs called Property Assessed Clean Energy (PACE) programs can help homeowners with financial burdens retrofit or upgrade their homes to become more resilient to climate change hazards. These programs provide low interest loans specifically tailored to sustainable home improvements. Programs within Mammoth Lakes and Mono County include YgreneWorks, CaliforniaFIRST, HERO, and Alliance NRG.

CRITICALLY VULNERABLE SENSITIVITIES

Several groups of people are considered critically vulnerable, meaning that they face high or severe vulnerabilities as a result of one or more climate-related exposures.

Children: The primary threats to children in Mammoth Lakes are from extreme heat and smoke and ash. Children can be exposed to extreme heat when playing outside or participating in athletic activities, creating a risk for substantial health related impacts. During times of elevated smoke and ash levels in the air they may spend more time outdoors compared to adults and they may be more likely to be affected by wildfire smoke because their airways are still developing and they breathe more air per pound of body weight than adults.³⁶ While children can stay hydrated in extreme heat, and wear respiratory masks during elevated smoke and ash conditions, children may have a lower level of awareness that may prevent them from taking preventative measures. Additionally, not all children have access to air conditioned spaces that both cool and filter the air, and such children could be at a higher risk for health problems. Other hazards that children are moderately vulnerable to include human health hazards, severe weather, severe winter weather, and wildfire.

Scoring

As discussed in Chapter 2, the scoring for the vulnerability assessment is as follows:

- V1: Minimal vulnerability
- V2: Low vulnerability
- V3: Moderate vulnerability
- V4: High vulnerability
- V5: Severe vulnerability

Cost-burdened households, households in poverty, and low-income households: Cost-burdened households, households in poverty, and low-income households in the town each have financial burdens that put them at a greater risk to climate change hazards. While cost burdened households are moderately vulnerable to hazards, low-income households and households in poverty have less adaptive capacity and therefore are more vulnerable. Both low-income households and households in poverty are highly vulnerable to severe winter weather because they are more likely to live in structures that are less insulated or cannot afford to turn on the heater during extremely cold temperatures. Although homes can be retrofitted to be more insulated, retrofitting buildings can be expensive and may not be financially feasible. The expense of retrofitting and repairing damaged buildings also makes households in poverty severely vulnerable to flooding and landslides and mudflows. Financial assistance programs such as Property Assessed Clean Energy (PACE) are available to assist with upgrades to homes, but households may be unaware or unable to participate in these services. Households in poverty are also highly vulnerable to drought, extreme heat, forestry pests and diseases, human health hazards, and wildfires due to extra costs associated with increased utility prices, additional medical care, and property maintenance associated with adapting to these hazards.

Homeless: Homeless persons lack access to permanent and often temporary shelter, which make them highly vulnerable to extreme heat, human health hazards, severe weather, and severe winter weather. A lack of shelter increases the potential for exposure to pathogens, smoke, and extreme heat conditions that can cause cardiovascular and respiratory illnesses. Homeless individuals may also not have access to medical care, which can make it harder for them to recover from such illnesses. The town currently does not have designated homeless shelters, and therefore homeless individuals and families may not be able to seek adequate shelter during severe weather and severe winter storms. Homeless individuals are also moderately vulnerable to flooding and wildfire.

Outdoor Workers: Individuals working outdoors face a much greater exposure to climate hazards because they do not work in sheltered locations and often have physically intensive work. If outdoor workers cannot work, they often face economic hardships. Therefore, outdoor workers are most vulnerable to extreme heat and smoke and ash conditions. Extreme heat can cause individuals to overheat and cause dehydration and heat stroke and smoke and ash can irritate the respiratory system and create difficulty breathing if exposed to extended periods. Outdoor worksites can make water, shelter, and protective gear available, although not all sites may do so even when required to. Persons working outdoors are often aware of the warning signs of heat-related illnesses, although, access to medical care may be more limited in remote outdoor work sites. Other exposures that threaten outdoor workers include drought, forestry pests and diseases, human health hazards, severe weather, and severe winter weather.

Persons living in mobile homes: Mobile homes are generally less structurally resilient than conventionally built houses, making them more susceptible to damage by flooding, landslides, severe weather, and wildfire. Persons living in mobile homes usually do not own the land their mobile homes sit on, making it harder for them to install protective landscaping, create adequate defensible space, and retrofit the structure. The construction standards of mobile homes are regulated by the state and so may not be as responsive to unique local conditions (unlike conventional houses, which must be built to state standards as well as any additional regulations mandated by local governments). The General Plan Housing Element contains policies to support efforts to weatherize and retrofit existing homes. Flood and fire insurance are often available for manufactured homes.³⁷ However persons in mobile homes may have lower or fixed income and may not be able to repair structures or rebuild if their homes are damaged or destroyed. Persons living in mobile homes are also moderately vulnerable to severe winter weather and smoke and ash.

Persons living on single access roads and persons without access to lifelines: Both persons living on single access roads and persons without access to lifelines may face difficulty evacuating and recovering from hazards due to limited accessibility to the community. Persons living on single access roads are particularly susceptible to becoming stranded due to flooding, fallen trees from forestry pests, landslides, severe winter weather, and wildfire. Single access roads can be cleared of debris, but if these

roadways are severely damaged, it may be difficult for residents to evacuate or simply buy essential supplies at local stores. The Multi-Jurisdiction Hazard Mitigation Policy Measure 7.1 provides wind and visibility tracking technology that can assist with warning notifications and help with emergency notifications for those on single access roads.³⁸ Notifications may assist in evacuation efforts; however, persons without access to lifelines may face additional challenges because of their inability to access the community and essential facilities during hazardous conditions, making them highly vulnerable to flooding, severe winter weather, and wildfire. These persons are also moderately vulnerable to extreme heat, forestry pests and diseases, human health hazards, landslides, severe weather, and smoke and ash from wildfires.



People living along Old Mammoth Road may be stranded during extreme events.

Persons with chronic health problems and persons with disabilities: Persons with chronic health problems and persons with disabilities both have existing conditions that make it difficult to adapt to worsening climate hazards. Persons with chronic health problems may find it challenging to adapt to temperature and air quality changes from extreme heat and smoke and ash, and those with disabilities may have a harder time evacuating from or preparing for flooding, severe winter weather, and wildfire. Persons with chronic health problems may have weakened immune systems that leave them more susceptible to human health hazards. Treatment for chronic illnesses may also require life support systems such as dialysis or breathing equipment that requires electricity, which can be turned off or lost during severe weather and severe winter weather conditions. During emergencies, the Inyo Mono Advocates for Community Action has specific services that can assist disabled citizens during hazardous events.³⁸

Senior citizens and senior citizens living alone: Senior citizens and senior citizens living alone are vulnerable to a number of different exposures. Seniors living alone have higher vulnerability to more exposures than any other group analyzed. All seniors are susceptible to heat-related illnesses, pathogens, and poor air quality, and they may have reduced mobility that makes it difficult to evacuate in hazardous conditions. Additionally, seniors living alone may not have the social connections with the community or caretakers that can aid in preparation, evacuation, or recovery during flooding, landslides, severe weather, severe winter weather, or wildfires. Mono County does have transportation services, in home support services, and a registry for seniors to inform emergency response teams of special needs during disasters and evacuations.³⁹ All of these programs help to improve the adaptive capacity of senior citizens, but overall these persons have a low ability to adapt. This is especially true for senior citizens living alone, who are severely vulnerable to severe winter weather, smoke and ash, and wildfire. However, all seniors, including senior living alone, are also severely vulnerable to extreme heat.

Senior Citizens and Evacuations

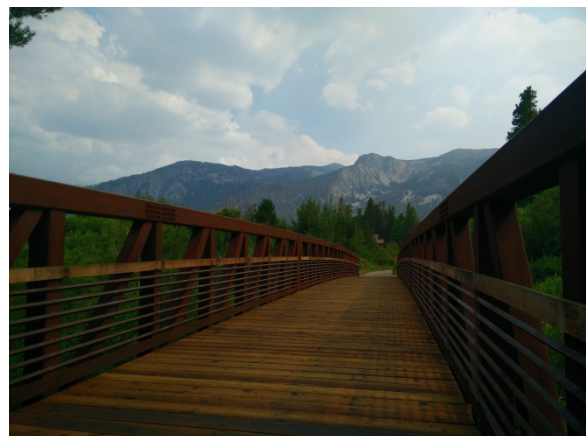
Evacuations are one of the biggest challenges to improving resiliency among senior citizens, especially senior citizens living alone. Difficulty seeing or hearing, cognitive impairments, and mobility challenges can all make it more difficult for senior citizens to recognize when evacuations may be needed and to act accordingly. Some seniors have little or no access to transportation, further impeding evacuations and requiring them to rely on others for assistance.

BUILDINGS AND INFRASTRUCTURE

There are 23 types of buildings and infrastructure in this vulnerability assessment. Some buildings and infrastructure are owned by the Town, Mono County, or other government agencies. Others are private property.

Bridges and Culverts. Bridges may carry roads or trails. Tunnels and culverts transport water or pedestrians under bridges, roads, or other infrastructure. Mammoth Lakes contains pedestrian and road bridges and tunnels in the urban limit and within the Lake Mary recreational area.

Commercial Buildings. Buildings that contain retail and wholesale stores, offices, warehouses, industrial facilities, or any other place where goods or services are produced or sold. These buildings are typically privately owned and can have one or more business within the building. In Mammoth Lakes,



The Waterford Bridge across Mammoth Creek is an important link between the Old Mammoth Road neighborhoods and the rest of the town.

commercial buildings are scattered throughout the town.

Communication Facilities. These facilities include public radio and television transmitters, cell phone towers, emergency communication antennae, and a wide range of other public and private communication infrastructure systems. Most of these are located in the center of the town and on Mammoth Mountain, with additional facilities scattered along Highway 203 and US Route 395.

Community Centers. Facilities where people within the community can meet for social, educational, or recreational activities. They are owned by the City government or by special government districts. **Map 6** shows the locations of these various community facilities.

Dams. A barrier to hold back water and raise its level, resulting in a reservoir. The Twin Lakes dam holds back the water that has created a system of lakes including Mary Lake, Lake Mamie, and Twin Lakes.

Electrical Substations. Electrical substations are facilities that convert electricity from one voltage to another, making it suitable for long-distance transmission or for use by homes, businesses, and other electrical customers. There is one substation, owned by Southern California Edison, in the town.

Electrical Transmission Lines. Electrical transmission lines are power lines that carry high-voltage electricity long distances between power plants and electrical customers. There are transmission lines, owned by Southern California Edison, directly east of Mammoth Lakes running along the US Route 395 corridor.

Flood Control Infrastructure. This infrastructure includes levees, dikes, drainage channels, and other infrastructure meant to help prevent the creeks and other water bodies in and around Mammoth Lakes from overflowing their banks and causing floods. The Mammoth Lakes Water District and Mono County are the agencies responsible for local flood control projects.

Gas Stations. An establishment along a roadway that sells gasoline and diesel products. Mammoth Lakes has 5 gas stations that are primarily located along Highway 203.

Government Offices. Government offices are the administrative and operational facilities of the Town of Mammoth Lakes and Mono County government. These include the Town and County offices on Meridian Boulevard and the Police Department on Thompson Way. **Map 6** shows the location of City government offices.

Grocery Stores. Stores that sell food, supplies, and household items. Mammoth Lakes has two general stores near Mammoth Mountain and Twin Lakes, in addition to a Vons supermarket located on Meridian Boulevard and various boutique grocery stores throughout the town.

Homes. Homes are any building intended for people to live in, including single-family homes, apartments, condominiums, and mobile homes. Most homes are located within the Mammoth Lakes Urban Limit.

Local Parks. There are a number of parks and open space areas in Mammoth Lakes, such as Community Center Park, Mammoth Creek Park, and Shady Rest Park.

Major Roads and Highways. Major roadways within the town include Highway 203, Lake Mary Road, Old Mammoth Road, and Meridian Boulevard. Mammoth Lakes is connected to the airport via US Route 395.

Mammoth Yosemite Airport. The Mammoth Yosemite Airport is located approximately 6 miles to the east of the town center along US Route 395 and provides year-round commercial air service to the Los Angeles area, as well as to other destinations during the winter ski season. The airport can also serve as a base for local and regional firefighting operations.

Medical Facilities. In Mammoth Lakes, the primary medical facility is Mammoth Hospital, located along Sierra Park Road on the eastern side of the town. Additional medical facilities are located within close proximity to the hospital.

Multi-Use Trails and Paths. These paths trails are mostly intended for hiking and biking, although some are suitable for equestrian activity, off-road vehicles, and snowmobiles. These trails may be paved or unpaved. Some trails connect to much larger networks, such as the 2,659-mile-long Pacific Crest Trail.

Old Buildings. Buildings that are 50 years or older. According to the 2016 ACS, approximately 1,087 homes are 50 years or older within Mammoth Lakes.

Power Plants. Power plants generate large amounts of electricity that is distributed through the state and regional electrical grid. There are 14 power plants in the unincorporated areas (not including small-scale facilities such as rooftop solar panels), including the large Ralston and Middle Fork hydroelectric power plants.

Public Safety Buildings. Public safety buildings include police and sheriff buildings, fire stations, California Highway Patrol facilities, and related structures such as dispatch centers, correction facilities, animal shelters, and emergency operation centers. Public safety buildings in Mammoth Lakes include the fire station, police station, and Mono County Superior Court. **Map 6** shows the location of these facilities.

Schools. Elementary schools, middle schools, and high schools, that serve Mammoth Lakes and the other communities in Mono County. They are mostly located along Meridian Boulevard and Highway 203 and include Mammoth High School, Mammoth Middle School, Mammoth Elementary School, Mammoth Lakes Academy, First 5 Mono County, Jan Work Community School, Imaca Headstart, Mammoth Montessori, and Crowley Christian Academy. The Mono County Office of Education and Mammoth

Lakes Unified School District are also located within the town limits. **Map 6** shows the location of schools in Mammoth Lakes.

Single Access Roads. These roadways are one of a few, or the only, ways in and out of some communities or neighborhoods. The single or limited number of entry and exit points does not make the road itself more vulnerable than other roads, but loss of these roadways can effectively cut off large numbers of people from the rest of Mammoth Lakes. Highway 203 is one of the primary access roads, though a number of other smaller examples exist.

Water and Wastewater Facilities. These facilities treat water for public use and treat wastewater so it can be safely discharged into the environment. There is one water and wastewater treatment plant in Mammoth Lakes, located along Meridian Boulevard on the eastern side of the town. **Map 6** shows water and wastewater facilities in Mammoth Lakes, including treatment plants.

CRITICALLY VULNERABLE SENSITIVITIES

Bridges and culverts: Many of the bridges and culverts within the town are located within flood hazard zones that make them more susceptible to damage from flooding events. The force of floodwater and debris can damage bridges and block culverts, compromising their structural integrity. Bridges and culverts can be retrofitted to resist the impacts of flooding; however, these retrofits can often be expensive and require grant or special funding. Bridges and culverts are also moderately vulnerable to hazards that can create instability in the ground such as landslides, or damage bridges and culverts such as severe weather and severe winter weather.

Community centers: The Mammoth Lakes Community Center, Mammoth Lakes Library, and other community gathering centers are located within primarily forested areas, which leave the community facilities susceptible to damage or destruction from wildfires. Defensible space and retrofits to the buildings can reduce the potential damage from a wildfire; however, the non-vital nature of the community center and other facilities, and the limited budgets for maintenance can prevent the retrofits from occurring.⁴⁰ Due to the location and the importance of community centers as a community asset, these facilities are also moderately vulnerable to flooding, landslides, severe weather, and smoke and ash.

Gas stations: Gas stations are a unique sensitivity for the town because they provide a vital good to the residents and visitors, but also store toxic chemicals that can be disturbed during hazardous conditions. Gas stations in Mammoth Lakes can be affected by mudflows or nearby landslides, which may cause a release of toxic chemicals into the air, soil, and water supplies, harming the surrounding community and natural environment.⁴¹ Gas stations are highly regulated due to the toxic chemicals onsite, however retrofitting gas stations can be difficult due to technology and financial means. Gas stations in the town are also susceptible to damage from flooding, fallen

trees due to forestry pests and diseases, high winds from severe weather, and snow from severe winter weather.

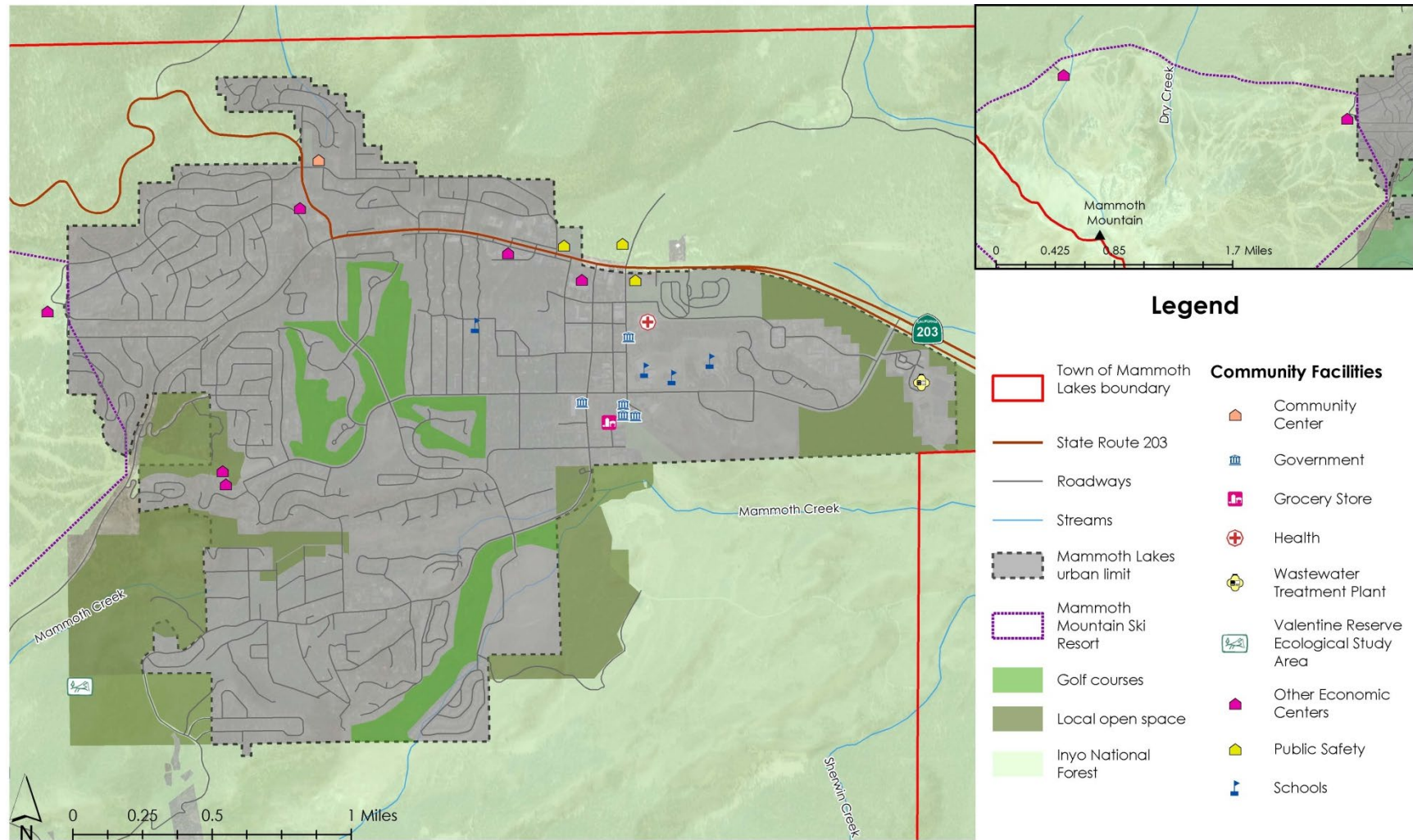
Homes and old buildings: Homes and old buildings are vulnerable to similar exposures because these sensitivities may not be able to be retrofitted or repaired due to financial or technological reasons. Older buildings were also constructed to meet older building codes, and often do not include features such as sprinklers and defensible space that are required in many newer buildings. Homes and old buildings are both highly susceptible to damage or destruction from landslides and mudflows, severe weather, and wildfire. Both are vulnerable to flooding, especially old homes, which can more easily be damaged beyond repair. Older buildings are also highly susceptible to damage from fallen trees from forestry pests and diseases, freezing temperatures and snow from severe winter weather, and high winds from severe weather. The Town General Plan contains specific policies for the rehabilitation of homes, upgrades to improve older units, building designs that reduce the risk of injury or damage from snow and ice.⁴²



While homes are vulnerable to a number of hazards, the Town has adopted policies to help design and retrofit homes to make them more resilient.

Local parks: Local parks in Mammoth Lakes are within high fire hazard severity zones, which make them susceptible to harm from the flames of a wildfire. Local parks may include open fields, playgrounds, and park facilities that are important to outdoor and organized recreation in the community. Park facilities may be damaged or destroyed by fires, and limited funding may make it difficult to repair or reconstruct local parks after a fire. Natural systems in local parks largely cannot be protected against wildfire, and while ecosystems will eventually recover, the parks may not be usable for recreational or scenic purposes for extended periods. The town may have to obtain grant funding to repair any damages created by wildfires.⁴³ Many of the local parks in the Town are surrounded by conifer forest ecosystems, and therefore are also vulnerable to forestry pests and diseases that can weaken trees, causing branches to fall and damage park buildings and infrastructure.

MAP 6: COMMUNITY FACILITIES



Sources: Town of Mammoth Lakes, Mono County, United States Geological Survey, National Oceanic and Atmospheric Administration, ESRI

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Major roads and highways: Major roads and highways within the town run through landslide and wildfire prone areas, which can damage or destroy these primary connections to surrounding region. US-395 or SR-203 could be blocked or destroyed by a landslide or mudflow, isolating the town from emergency assistance, goods, and services. Additionally, a wildfire or severe winter weather could block the two highways, along with Lake Mary Road, Old Mammoth Road, and Meridian Boulevard. This would substantially impact the health and welfare of the town, and the well-being of the community could decline. Roads and highways can be repaired if damaged; however, alternative routes in and out of Mammoth Lakes do not exist, especially in winter when the roads over the mountains are closed. The General Plan Goal M.9 contains specific policies for snow and ice management that optimize safety and minimize environmental damage, which can increase the resiliency of the major roads within the town.⁴⁴ Major roads and highways are also moderately vulnerable to flooding and severe weather.

Medical facilities: Medical facilities (including Mammoth Hospital, medical offices, and clinics) are at risk for damage by severe weather in the form of high winds, hail, and intense rainfall. These facilities are essential to the health and welfare of town residents and visitors and harm to these facilities can negatively affect the community. Medical facilities can be weatherized and retrofitted to defend against severe storms with the help of funding from the Mammoth Hospital Foundation.⁴⁵ However, these changes may be expensive and not structurally feasible for all facilities. Medical facilities are also vulnerable to flooding, landslides and mudflows, and smoke and ash intrusion into air circulation systems.

Multi-use trails and paths: Many multi-use trails and paths are in areas with tree cover, which can be directly affected by forestry pests and diseases. Diseased or weakened trees can fall over and onto the multi-use trails and paths during the winter and summer months, which may damage the trail or make it impassable. Additionally, multi-use trails and paths are often narrow, and run on top of, below, or along hillsides, rendering them susceptible to being destroyed or damaged by landslides and mudflows.¹ This can become chronic, which can impede on outdoor recreation and associated economic benefits. Trails and paths can be repaired through United States Forest Service or Town park maintenance crews from fallen trees and landslides or mudflows, although



The extensive trail network in and around the town can be damaged by several climate-related hazards.

damaged trails may take weeks or months to repair because the changes to the local topography or trails can make reconstruction a long and expensive process.⁴⁶ Alternative routes may be available, but not for all destinations. Due to the location in mostly forested areas, multi-use trails and paths are also susceptible to damage from wildfires.

Schools: The three public schools in Mammoth Lakes are within landslide prone areas or in potential mudflow paths. During school hours many children and school staff are on the campuses, which mean there could be a high number of injuries or deaths in the event the schools were damaged or destroyed by a landslide or mudflow. Schools can be retrofitted to protect the buildings and students from mudflows. Retrofits can be expensive, and the schools may not have the funding capacity and need grant funding to make those building alterations. As employment centers and education facilities, schools within the Town are also at risk to extreme heat, severe weather, severe winter weather, smoke and ash intrusion into heating and air conditioning systems, and wildfire exposures.

Single access roads: Single access roads are one of the most vulnerable infrastructure sensitivities in Mammoth Lakes, due to the remote nature and location in steep or highly forested areas. Old Mammoth Road, which becomes a single access road when Lake Mary Road closes in the winter, is severely vulnerable to flooding from Mammoth Creek and the Lakes District as shown in **Map 3**. Severe winter storms can leave single access roads impassable or damaged from snow and ice, subsequently isolating the communities that rely on these roads. In steep areas of the town, landslides can damage single access roads, or undermine the foundation and destroy the roadways all together. These roadways are also severely vulnerable to wildfires, which can damage single access roads or make them impassable during wildfire conditions, which can prevent people from evacuating safely. Many of the single access roads are located in highly forested areas, which increase the risk of a dead or diseased tree from falling on the road and making it impassable. Single access roads can be cleared and repaired following hazards, and the General Plan contain specific policies relating to snow and ice management, as well as roadway connections to reduce the damage to and the number of single access roads.⁴⁷ Due to the remote nature of the town, clearing and repairs could last over an extended period of time.

ECONOMIC ASSETS

Economic drivers are the primary contributors to the Mammoth Lakes economy. This category of the vulnerability assessment covers ten primary economic drivers, including outdoor recreation facilities and various major employers.

Golf Courses. The golf courses in Mammoth Lakes provide summer outdoor recreational opportunities for Town residents and visitors. The golf courses include Sierra Star Golf Course and Snow Creek Golf Course, located in the center of the town.

Hotels and Lodging. Establishments providing accommodations, meals, and other services to travelers or visitors. Lodging in Mammoth Lakes includes traditional hotels and motels, in addition to rental properties through Airbnb, VRBO, Home Away, and other short-term rental services.

Major Employers. The largest employers in Mammoth Lakes are spread throughout the town. They include the ski resort, educational facilities, hotels, health care facilities, and service related occupations.⁴⁸ These organizations employ over 300 people.

Mammoth Mountain Ski Resort. Mammoth Mountain Ski Resort is the primary economic resource for the town, which is located along Highway 203 on the western side of the town. The ski resort is one of the most popular winter recreation destinations in California. The resort includes approximately 3,500 skiable acres serviced by 28 lifts and gondolas throughout the mountain for winter and summer recreational activities.⁴⁹ The resort employs about 350 people. **Map 5** shows the Mammoth Mountain Ski Resort.

Outdoor Recreation. Outdoor recreation is a critical part of the Mammoth Lakes economy. It includes winter sports such as skiing and snowboarding; biking, hiking, and trail running; and all other types of outdoor activities. A number of outdoor recreation events, such as fishing derbies, Monster Energy Mammoth Motocross, Mammoth Kamikaze Bike Games, and U.S. Free Ski & Snowboard Grand Prix attract participants from across the United States and beyond.

Regionally Significant Parks. Regional, state, or national parks in close proximity to the Town that draw visitors to stay or travel through Mammoth Lakes. Such parks include Yosemite National Park, Mono Lake Tufa State Natural Reserve, Ansel Adams Wilderness, and Kings Canyon National Park.

Retail Activity. Retail stores located in the town that provide goods and services to both the community and visitors. Retail activity is primarily located near Mammoth Mountain, and along Highway 203 and Old Mammoth Road.

Scenic Views. A visual resource that attracts people to the town and wider area for its intrinsic beauty. This can include the views of the eastern Sierra, Mammoth Creek, or Lake Mary and the surrounding Lakes District.

State and Federal Protected Lands. Mammoth Lakes contains and is surrounded by land owned by State and Federal agencies, and much of this land is protected. The largest protected area is the Inyo National Forest, which includes most of the land outside of the town urban limit. Other lands surrounding the town include Ansel Adams Wilderness and John Muir Wilderness within the Inyo National Forest.

Fishing and Other Water Recreation. Fishing is the primary water recreation activity in the area, along with boating and swimming. Lakes and reservoirs, rivers, and even smaller streams and creeks can be suitable for these activities. The major water recreation sites in Mammoth Lakes include Horseshoe Lake, Twin Lakes, Lake Mary, Lake George, and Lake Mamie.

CRITICALLY VULNERABLE SENSITIVITIES

Hotels and lodging: Hotels and lodging in Mammoth Lakes rely on visitors to rent rooms and homes for both the summer and winter seasons. Hotels and lodging establishments are vulnerable to conditions that decrease tourism and harm tourist-serving activities and facilities, such as outdoor recreation and Mammoth Mountain Ski Resort. Therefore, hotels and lodging are highly vulnerable to visitors not visiting the town due to drought conditions, smoke and ash in the region, and



Hotels are key to maintaining the town's visitor-oriented economy, but are vulnerable to events that can cause a decline in tourism.

wildfires. Severe winter weather can also deter visitors from traveling and staying in the town. Hotels and lodging establishments can reduce operating costs and attempt to attract new visitor markets, but this strategy may be of limited success. The General Plan Economy Element contains specific policies to encourage a range of outdoor and indoor events, facilities, and services to enhance the resort economy, which can also increase resiliency of hotels and lodging within the town.⁵⁰ Some hotels and lodging are also located within the flood hazard zone of Mammoth Creek, and thus are at risk for damage from flooding events.

Major employers: Major employers are primarily based in the tourism industries, which rely on visitors in the town. If the ski resort is damaged or unusable in either the summer or winter, other major employers would face economic hardships. Major employers are most susceptible from economic hardship from smoke and ash, as well as wildfire. If visitors are deterred from traveling to the area because of wildfire threats or poor air quality, recreation, hospitality, and retail based employers would experience major economic hardships. Major employers are vulnerable to drought because it can decrease outdoor recreational opportunities due to lower snow and water levels. Landslides can isolate populations or damage key infrastructure, indirectly creating

hardships for the employees at these employers because they may not be able to get to or do their jobs. Due to the tourism-focused nature of the town's economy, visitors are needed to support the economy of the town. The town General Plan Economy Element does contain specific policies to encourage a range of outdoor and indoor events, facilities, and services to enhance the resort economy, which supports major employers within the town.⁵⁰ However, few major employment alternatives are available in the surrounding area for residents to find work.

Mammoth Mountain Ski Resort: Drought, landslides, severe weather, severe winter weather, and smoke and ash all threaten Mammoth Mountain Ski Resort. Landslides, severe weather, and severe winter weather can make conditions on the mountain unsafe for outdoor activities, and in some cases, landslides can damage or destroy facilities or a ski run. Artificial snow can help supplement natural snowfall, but it may not be feasible during intense droughts. However, Mammoth Mountain Ski Resort has expanded summer biking operations and used more of the snow-free ski area to adjust to drought conditions.¹ High levels of smoke and ash can deter visitors from traveling to the area, subsequently harming the ski resort as an economic asset. Mammoth Mountain Ski Resort can harden itself against severe weather and severe winter weather, and to some degree against landslides, but alternatives during dangerous conditions are often not available to meet visitors' demands.

Outdoor recreation: Outdoor recreation is an essential part of the town's economy, and can be directly threatened by drought, extreme heat, severe winter weather, smoke and ash, and wildfire. Water sports and winter mountain sports can be directly impacted if there is not enough water and snow to draw people to the area, causing economic hardship for Mammoth Lakes. Outdoor recreation facilities may shut down or reduce hours during extreme heat or severe winter weather, and people may be less willing to travel to Mammoth Lakes for

Major Industries in Mammoth Lakes

There are approximately 5,237 employed persons, 16 years or older within the town. Approximately one third of the employed population works in management, education, and health care occupations; approximately one third work in public safety, building, and food service jobs; and one third are employed in sales and office occupations, natural resources and construction, or production and material moving services.



The Lake District is a major draw for fishing and other water recreation activities. Drought, poor air quality, and wildfires can all harm this important resource.

skiing, hiking, biking, and horseback riding. Outdoor recreation activities can also be significantly curtailed as a result of smoke and ash during regional wildfires. Mammoth Lakes is a member of the Community Planning Assistance for Wildfire, which promotes mitigation efforts for wildfire; however, wildfires in the region can still affect outdoor recreation activities in the town.⁵¹ Poor air quality created by wildfires can force outdoor recreation venues or events to shut down so as to protect the health of participants and visitors. Wildfires may also damage outdoor recreation facilities, rendering them unusable.

Retail activity: Wildfires and poor air quality may deter visitors from traveling to and spending money in Mammoth Lakes. The absence of visitors may create economic hardships for business owners in Mammoth Lakes, as long as the wildfire is burning and threatening the town's air quality. Some retail activity can still occur if visitors are not traveling to the area, because local residents rely on the retail centers within Mammoth Lakes. However, this retail activity may not be substantial enough to cover the economic losses created by a lack of visitors to the area, and some businesses may not cater to residents. Very high smoke and ash levels may leave particles or unpleasant smells on retail goods, making them difficult to sell and causing further economic losses. Due to the high reliance on visitors to Mammoth Lakes, retail activity is also indirectly vulnerable to drought, extreme heat, flooding, and severe winter weather.

Scenic views: Scenic views can be directly harmed by reduced visibility created by smoke and ash, as well as wildfires that destroy forested ecosystems and indirectly impact water and lake ecosystems. If scenic views are harmed, this could lead to fewer visitors, creating economic hardships for hotels and businesses in the area. Drought and forestry pests and diseases can also make the local scenery less appealing, and may contribute to a higher risk of wildfires and smoke and ash in and around Mammoth Lakes. Currently, there are no feasible means of the scenic views adapting to smoke and ash.

State and federal protected land: The town and its surroundings are in a high fire hazard severity area, and so state and federal protected land are at risk for being burned by wildfire. If drought, forestry pests and diseases, or other factors have led to large numbers of dead or dying trees and other plants, the ecosystems can be especially vulnerable. Facilities on these lands are also at risk of damage or destruction from wildfire. State and federal protected lands have a low ability to recover due to a lower likelihood to attract visitors if damaged. Although these lands can be protected and managed to be more resilient to wildfires, these measures may not be financially feasible. Burned areas or those with other ecosystem damage are less likely to draw visitors. Based on the ecosystem of the state and federal protected land being primarily conifer forests, these lands are also vulnerable to drought, forestry pests and diseases, severe weather, and smoke and ash.

Fishing and other water recreation: Fishing and other water recreation rely on clean water from the local mountain watershed. Drought, smoke and ash, and wildfire threaten this important economic resource. If water levels drop too low because of

drought, recreational activities will be constrained and may not be possible. Smoke and ash can reduce water quality, harming fish and other wildlife that depend on the lakes. Water recreation sites could be affected by wildfires, and subsequent landslides or mudflows after wildfires from the surrounding unstable slopes can damage recreation facilities surrounding lakes and rivers. This can deter individuals from fishing and swimming in the lake system, and reduce the number of people traveling to the area during the water recreation season. Water recreation sites may not be able to adapt to poor water quality, as water treatment may not be possible, and fish die offs may not be preventable. Water recreation sites may also be able to offer alternative activities that are less dependent on water supplies, allowing them to remain economically viable; however, these are limited and could be cost-prohibitive.

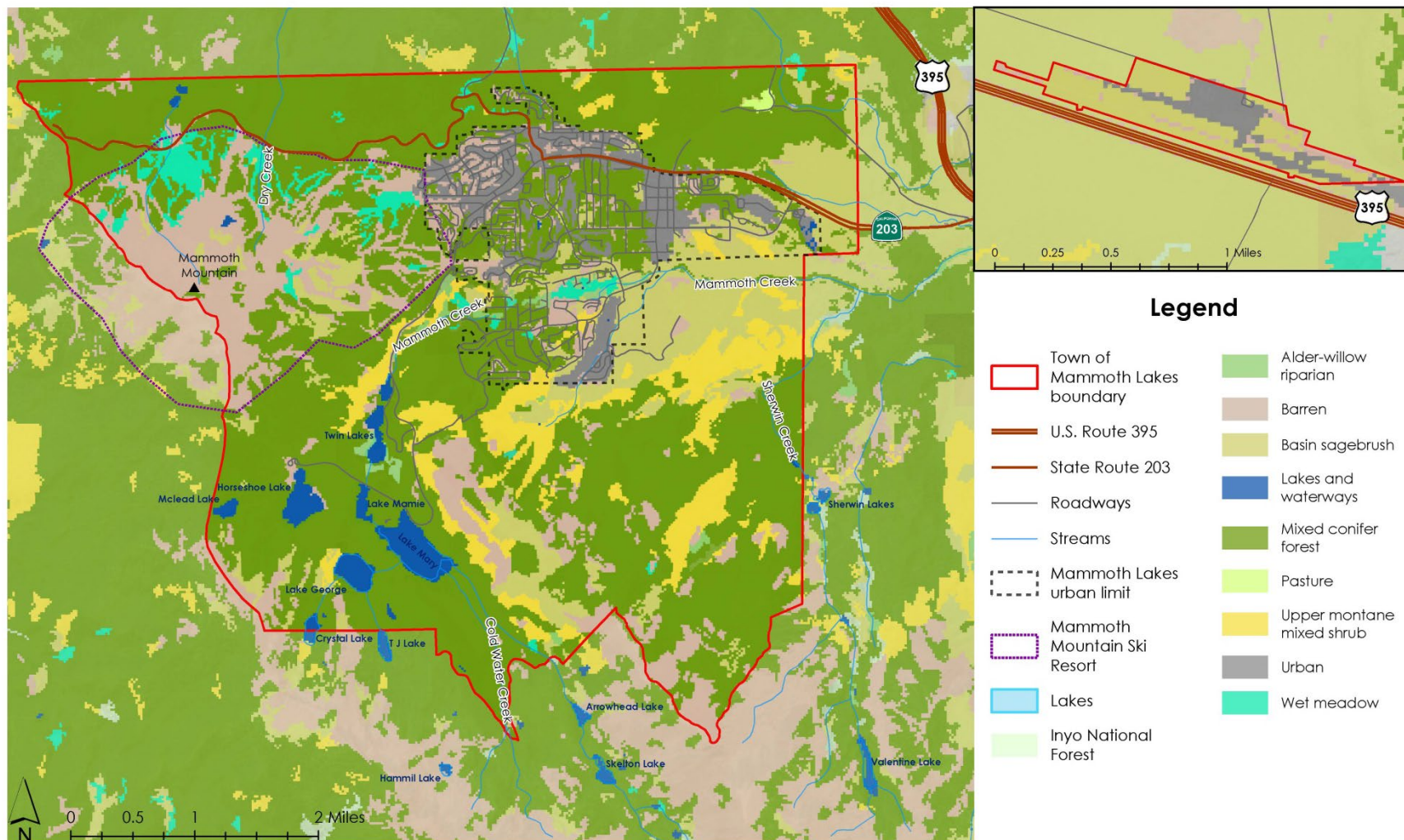
ECOSYSTEMS AND NATURAL RESOURCES

There are six primary ecosystem types in Mammoth Lakes, although many of these can be subdivided into specific habitats. The vulnerability assessment analyzes these six ecosystems, in addition to the Valentine Reserve Ecological Study Area and groundwater supplies. **Map 7** shows the location of these vegetation communities in Mammoth Lakes. **Table 4** lists these six wild vegetated areas as well as developed and wild unvegetated areas and their acreage in Mammoth Lakes.

TABLE 4: ECOSYSTEM COVERAGE IN THE TOWN OF MAMMOTH LAKES

ECOSYSTEM	ACRES	PERCENT OF WILD VEGETATED AREA	PERCENT OF TOWN AREA
Wild vegetated areas			
Alder-Willow Riparian	104	0.8%	0.6%
Basin Sagebrush	2,019	15.5%	12.5%
Lakes and Waterways	296	2.3%	1.8%
Mixed Conifer Fir	9,079	69.7%	56.5%
Upper Montane Mixed Shrub	1,189	9.0%	7.4%
Wet Meadow	348	2.7%	2.2%
All wild vegetated areas	13,035	100%	81%
Developed and wild unvegetated areas			
Barren	2,186	-	13.5%
Agricultural Land	18	-	0.1%
Urban	800	-	5.0%
Total developed and wild unvegetated areas	3,004	-	19%
Total town area	16,039	-	100%
Source: California Department of Fish and Wildlife			

MAP 7: VEGETATION COMMUNITIES



Sources: Town of Mammoth Lakes, Mono County, California Department of Fish and Wildlife, United States Geological Survey, National Oceanic and Atmospheric Administration, ESRI

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Alder-Willow Riparian. This ecosystem is located along the banks of the Mammoth Creek and most drainage channels in the town. Alder-Willow Riparian consists of plant species such as quaking aspen, mountain alder, American dogwood, and willow, with various herbaceous species that provide significant understory cover and habitat for birds and mammals within the community.

Basin Sagebrush. The basin sagebrush community occurs on dry slopes and plains at low elevations in Mammoth Lakes, and consists of annuals and perennial bunchgrasses that are sparsely distributed. Plant species within this ecosystem include soft woody shrubs, basin big sagebrush, antelope bitterbrush, and snowberry.

Groundwater Supplies. Groundwater is water that is held underground in the soil, or in pores and crevices in rock. The town sits above the Mammoth Hydrologic Basin, which is part of the 71 square-mile-large Long Valley Groundwater Basin.⁵² The groundwater supplies flow northeast and east from Mammoth Crest to the Hot Creek Gorge in the Upper Owens Valley. The Mammoth Basin has groundwater ranging from less than 10 feet below the surface in the upper aquifer, to at least 500 feet deep in the lower aquifer.

Lakes and Waterways. Lakes and waterways include lakes, rivers, creeks, and streams. The southwest portion of the Town of Mammoth Lakes consists of a series of nine lakes: 1) Lake Mary, 2) Horseshoe Lake, 3) Twin Lakes, 4) Lake George, 5) Crystal Lakes, 6) TJ Lake, 7) Lake Mamie, 8) McCloud Lake, and 9) Lake Barrett. The lake system drains into Mammoth Creek, which runs east towards Hot Creek and Lake Crowley.

Mixed Conifer Fir. The mixed conifer fir is the largest ecosystem within the town, and is dominated by red fir on steep, north facing slopes at elevations ranging from 9,000 to 11,000 feet above sea level.⁵³ Other species in this ecosystem include western white pine, mountain hemlock, Jeffrey pine, white fir, and lodgepole pine. The understory is dominated by Greenleaf manzanita, huckleberry oak, and snowbush.

Ecosystem Shifts

Climate change in Mammoth Lakes is expected to alter where different ecosystems are found. The most significant changes in local ecosystems are shifts in forest composition. Conifer forests in particular are more sensitive to a warmer climate. Species that cannot adapt to new conditions or migrate to other areas are particularly vulnerable to these changes. Conifer species, which already live in the coolest and highest-elevation parts of Mammoth Lakes, make up one such ecosystem that may have less available habitat space in future years as temperatures become warmer. More frequent and intense wildfires can cause other changes, disrupting normal cycles of fire and regrowth that may cause forests to have difficulty recovering, leading forest habitats to shift to shrub-dominated land cover.

Upper Montane Mixed Shrub. This ecosystem is often found alongside the Mixed Conifer Fir community in open areas created by disturbance, on steep slopes or rocky sites where conifers are unable to establish, on south facing slopes, and in drier areas. Upper Montane Mixed Shrub is typically located in elevations ranging from 6,000 to 9,000 feet above sea level.⁵³ Plant species in this ecosystem includes Greenleaf manzanita, snowbush, and huckleberry oak.

Valentine Reserve Ecological Study Area. The Valentine Reserve Ecological Study Area consists of 156 acres located in the southeast region of the town, between Lake Mary Road and Old Mammoth Road. This area contains habitat mix of several habitats, including montane forest, montane chaparral, Great Basin sagebrush, high montane riparian vegetation, and wet montane meadows.

Wet Meadow. A wet meadow occurs in areas where water is at or near the surface following spring runoff, which are located along Mammoth Creek and to the north of Mammoth Mountain as shown in **Map 6**. This ecosystem contains perennial vegetation consisting of species such as corn lily, sedge, and wire rush, with lodgepole pine and willows located in high elevation wet meadow communities.

CRITICALLY VULNERABLE SENSITIVITIES

Alder-Willow Riparian: Hardwood forest species are highly vulnerable to pests and diseases and wildfire, especially those that have been weakened by drought or extreme heat. These tree species are susceptible to sudden oak death and root diseases, which can cause tree die off, and decimate nesting habitat for Bank swallows, and Willow flycatchers are at risk of damage or destruction. Most plant species in this ecosystem have an elevated risk of damage from wildfires burning at hotter temperatures, which can also destroy important habitat for the Sierra Nevada mountain beaver.⁵³ Typically, fires help hardwood forests stay healthy by occasionally burning areas of thick, dense trees. The burned areas then provide sunlight and nutrients for grasses, wildflowers, and small trees to grow. However, wildfires burning at higher temperatures and occurring more frequently can destroy the soil and make it more difficult for hardwood forests to effectively recover. Some adaptation methods are available for hardwood forests, and over time the habitat can move upslope to avoid pests and diseases. Fuel loads can also be managed to control wildfires, although changes to forest management practices may take a very long time to have an effect, or may not be financially feasible.¹

Basin sagebrush: Basin sagebrush ecosystems are highly susceptible to damage from drought conditions, and can also be harmed by extreme heat and landslides in the Town. High-mountain meadow and scrubland have a high susceptibility to decreases in precipitation. Herbaceous species in particular, such as sedges and rushes, can suffer harm during drought, although some trees in this ecosystem (such as white alder and big leaf maple), may also be at risk. This can destroy important nesting habitat for the Sage-grouse.⁵³ Fertility of these plants is unaffected by droughts, allowing them to recover when normal precipitation levels return. However, seeds are expected to be

viable for a smaller period of time under climate change scenarios, which could make recovery more difficult after long droughts. There is potential for this ecosystem to shift ranges into higher elevations toward the Sierra Nevada crest, although particularly severe droughts may prevent this from happening.¹ Shifts in the ecosystem may also affect the habitat location for California big horn sheep, Pallid bats, and hunting territory for Sierra Nevada Red Fox.⁵³



Sagebrush ecosystems in and around the town are highly vulnerable to drought conditions.

Lakes and waterways: The lakes and waterways in and surrounding Mammoth Lakes depend on snow melt throughout the year to maintain healthy ecosystems. Both drought and smoke and ash can have a detrimental impact on these ecosystems due to lack of water and reduced water quality created by poor air quality. Lakes may have lower water levels during drought events, and streamflow can decrease or stop during dry months. This can reduce the habitat availability for Owens Valley springsnail, Mountain yellow-legged frog, and Sierra Nevada mountain beaver. Smoke and ash can fall or be washed into lakes and waterways, polluting the water to the point that the ecosystem health begins to suffer. Ash can reduce water quality and cause die off of fish species such as Owens tui chub, Owens sucker, and Owens speckled dace.⁵³ Lakes and waterways may have a difficult time recovering from increased levels of smoke and ash and may be unable to adapt to prolonged droughts.

Mixed conifer fir: Mixed conifer forests are severely vulnerable to extreme heat and forestry pests and diseases, and are also highly vulnerable to drought and wildfire. Very high temperatures and a lack of water can stress the trees, making them more susceptible to damage from pests or infestation. Forestry pests such as bark beetles can decimate conifer forests in their weakened states when trees are unable to resist infestation.¹ Diseased or dying forests are more susceptible to wildfire threats, which can burn through conifer forests that have been weakened by drought, extreme heat, and forestry pests and diseases. This can in turn threaten nesting habitat for Bald eagles, California spotted owls, and Great gray owl species. Mammals such as the American marten, Pacific fisher, and Sierra Nevada red fox may also see reduced habitat availability.⁵³ Because mixed conifer forests are the primary ecosystem in Mammoth Lakes, harm to these ecosystems can have the most widespread impacts on the town. Many conifers have a reduced capacity to effectively recover from extreme heat, drought, and forestry pests and diseases. Seed longevity is projected to decrease, and fertility can decline slightly, making it harder for forests to reestablish themselves. Conifer forests can migrate upslope to adapt to warmer temperatures and extreme heat, also known as ecosystem shift, but the ecosystem may not move quick enough to combat the rising temperatures.⁵⁴ These forests can also be managed to prevent wildfire

decimation; however, land management faces regulatory, financial, and personnel restrictions that limit the ability to effectively manage forests.¹

Valentine Reserve Ecological Study Area

(VRESA): The Valentine Reserve Ecological Study Area is primarily made up of conifer forests which are highly vulnerable to drought, extreme heat, and wildfires, as well as severely vulnerable to forestry pests and diseases. Stress from drought and extreme heat can substantially weaken this area, leaving it vulnerable to pests and diseases. A weakened ecosystem can lead to tree die-off that can be detrimental to the VRESA and increase the potential for wildfire to completely burn through the area. The VRESA has not been regularly managed in the past and the ability to manage the land for drought, extreme heat, forestry pests and diseases, and wildfire hazards is uncertain.



The conifer-dominated habitats of the VRESA are at risk from a number of hazards.

Wet meadow: Wet meadows are driven by water processes, which are largely dependent on snowpack and runoff. Wet meadows are highly vulnerable to drought conditions because of the potential disruption to water supplies. Extreme heat and wildfires may make these conditions worse. Damage to this ecosystem can also affect habitat availability for the Yosemite toad.⁵³ Wet meadows are resilient to higher temperatures and wildfire, and may be able to adapt to new conditions, but they rely on readily available water to stay healthy and so face increased harm from drought events.



Wet meadow ecosystems, such as Snowcreek Meadow, are particularly vulnerable to drought conditions.

COMMUNITY SERVICES

There are nine key services examined as part of this vulnerability assessment:

Air Services. Air services include private planes and commercial airlines that provide access to and from other regions of California and the United States. The Mammoth-Yosemite Airport offers commercial flights to and from San Francisco, Denver, and the Los Angeles region, although some flights only operate seasonally.

Communication. Communication services include radio, television, cellular and land-line phone, and Internet. These services can be delivered via wires or wirelessly, and most are delivered by private companies. Communication services are often used for entertainment but are also vital for information sharing, social connections, accessing healthcare and educational services, and seeking jobs, among many other tasks.

Emergency Medical Response. Emergency medical response services are usually ambulances but may also be fire or police respondents if ambulances are not available. In areas where the roads become impassable, emergency medical response may arrive by helicopter. These services are critical in providing rapid and urgent medical care.

Electricity Delivery. Electricity service in the Town of Mammoth Lakes is delivered through high-capacity utility lines, connected to small local electrical lines. Electricity is needed for vital functions such as space heating and telecommunications as well as many other forms of entertainment and comfort. The electricity provider in Mammoth Lakes is Southern California Edison (SCE).

Public Health. Public Health services provide public programming and medical services to support residents and visitors. The Mono County Public Health Department and Mammoth Hospital provide a suite of services that includes children's and adult medical services, emergency preparedness program, immunization program, and public health community clinics.

Public Safety Response. Public safety services are provided by law enforcement and fire agencies. These agencies include the Town of Mammoth Lakes Police Department, CAL FIRE and fire protection districts, Mammoth Lakes Fire Department, and (in limited cases) the California Highway Patrol and the United States Forest Service. Public safety services include an on-hill emergency hotline for Mammoth Mountain Ski Area, public services announcements, and evacuation assistance for the Town.

Public Transit Access. Public transit access is provided by the Eastern Sierra Transit agency. This agency provides transit services to the eastern sierra region including Mammoth Lakes, Sierra Hikers, Dial-a-Ride, and longer routes along US Route 395. The town has a year-round free trolley service, with 3 routes, that connects residential areas to the Village Lodge, the Welcome Center, and the town center. During the winter season, the transit routes expand to 6 routes and night time trolley services.

Solid Waste and Recycling Services. Solid waste and recycling services involve the collection, recycling, and disposal of solid waste created by homes and businesses. In partnership with local companies, the Town of Mammoth Lakes provides curbside waste collection services through the Sierra Conservation Project, recycling and hazardous waste disposal through Mammoth Disposal and the transfer station, and paper shredding services through ShredPro Inc.

Water and Wastewater Services. These services involve treating and transporting water to be used by customers, and transporting and treating wastewater so it can be safely released into the environment. Water and wastewater services are provided by the Mammoth Community Water District, which is critical to ensuring public and environmental health. Water services are supplied by a combination of water from Mammoth Creek (Lake Mary), the Mammoth groundwater basin, and recycled water, which is treated by Mammoth Community Water District. Surface water diversion can range between 337 and 2,670 acre feet per year based on permit and license terms, in addition to natural variability in snowpack runoff and timing. Recycled water can produce a maximum of 640 acre feet per year and the Town is limited to a total of 4,387 acre feet per year of water use based on an agreement to end litigation between LADWP and MCWD in 2010.⁵⁵

Vital Goods. Delivery of goods and services that provide basic needs for health and comfort. These include food, fuels such as gasoline and propane, medicine, basic hygienic supplies, and clothing, among others. Vital goods in the Town of Mammoth Lakes are currently transported via truck freight on Highway 395.

CRITICALLY VULNERABLE SENSITIVITIES

Air services: Air services depend on visibility and wind speeds that allow the aircraft to safely land and take off from Mammoth Yosemite Airport. Thus, air services are vulnerable to severe winter weather, smoke and ash, and wildfire. Severe winter weather can cause white outs and high winds that can impede on the ability of air services to reach the Mammoth Lakes Yosemite Airport. Smoke and ash can impact the air quality in the area and the Federal Aviation Administration could place flight restrictions in the region.⁵⁶ Wildfires in the region can cause delays or cancellation of air services to Mammoth Yosemite Airport. The airport also serves as a staging area for CALFire crews and may not be handle the capacity of the fires crews and commercial or private air services during a wildfire. This impact would be temporary but may be chronic as more wildfires occur in the region. The Town relies in part on air services to bring seasonal



In addition to serving visitors, the Mammoth Yosemite Airport is an important base for firefighting services and can act as a critical link for vital goods and services if Route 395 is closed.

residents and tourists into the area, and thus the economy would be negatively impacted if air services were hindered. Air services could be rerouted to the airport in Bishop if there are no flight restrictions; however, this airport is farther from the Town and does not have the same services for commercial flights as the Mammoth Yosemite Airport.

Electricity delivery: Electricity delivery is dependent on overhead powerlines that are owned by SCE and are susceptible to extreme heat, fallen trees from forestry pests and diseases, and high winds. Extreme heat can regularly cause power outages due to a combination of mechanical failure of electrical equipment, heat damage to the above-ground infrastructure, and a high demand for electricity due to air conditioning units. Electricity lines that are also close to forested areas could be damaged by falling trees that result from pests and diseases. These impacts could become chronic as the forest ecosystems weaken. High winds from severe weather or severe winter weather can also cause SCE to turn off the electricity flowing through the utility lines, which would disrupt electricity delivery to the Town. SCE can retrofit power lines and other equipment to insulate them against extreme heat events and severe weather, and remove diseased or dead trees surrounding the lines to protect them against falling trees. These measures can both be expensive and may not be feasible in all cases.

Public health: Public health services may not be able to meet the demands of the community if there is a major human health hazard, given the community's remote location and limited access to regional health networks. This could lead to spreading of illnesses or a lack of medical services for those in need, subsequently leading to higher illness and mortality rates within the community. Public Health services, including those provided by Mammoth Hospital, are funded by the regional, state, and federal government, which may not have the funds to cover all services that the community needs to treat human health hazards, including environmental health issues and pathogens. Some members of the community rely on low-cost public health services due to lack of financial means to obtain alternative medical treatment.

Public safety response: Public safety response is highly dependent on roadways being open and clear for vehicles to reach community members in need. Because of this, public safety response is highly vulnerable to landslides and wildfires, and moderately vulnerable to forestry pests and diseases, flooding, severe weather, severe winter weather, and smoke and ash. Landslides and mudflows can block roadways, making it difficult to evacuate individuals or respond to public safety calls. The impacts could be long term, as debris or land shifts can take time to clean up and recover from. When a wildfire is burning in the town or in the region, public safety personnel may be assigned to help fight the fire. Remaining public safety responders may not be able to meet the needs of the community. This impact would be temporary, but could become chronic if wildfires increase in the region. Public safety response may face challenges adapting to landslides, as they are often unpredictable in nature. Additionally, public safety responder teams can be added during wildfire events to respond to all emergencies if the Town has the financial means to do so.

Public transit access: Public transit access depends on clear and safe road conditions to remain an effective service, and thus it is highly vulnerable to flooding, landslides, and severe winter weather, with moderate vulnerability to forestry pests and diseases, severe weather, and wildfire. Public transit access can be negatively impacted if roads are washed out during flood events, crumble due to landslides, or become impassable due to snow and ice conditions. Individuals who rely on public transit may not be able to find other transportation options. This also impacts individuals on single access roads, persons without access to lifelines, and other community members in need. Service disruptions could be substantial at times. Public transit in Mammoth Lakes can find alternative routes if roads are washed out or plow if covered in snow, but roads damaged by landslides may not be able to be repaired for public transit. There is only one transit line that goes through the entire town, and thus alternative transit options are not feasible.

Water and wastewater services: Water and wastewater services are severely vulnerable to drought and highly vulnerable to smoke and ash and wildfire conditions. Extended droughts can cause significant reduction in water supplies and the ability of wastewater services to function. The Town can implement stringent water conservation measures and use more recycled water, although wastewater services will still need an ample supply of water to function sufficiently. Smoke and ash from wildfires, or debris from landslides or mudflows, can reduce water quality in surface water bodies and create backups in wastewater infrastructure. Wastewater infrastructure could also be damaged if the wildfire burns through more urban areas. Contaminated water supplies can be filtered to remove most contaminants from drinking water and wastewater infrastructure can be repaired after a fire. However, both of these are expensive and may take weeks or months to complete after a fire occurs. Water and wastewater services may also be disrupted by flooding, if floodwaters get into water or wastewater infrastructure and cause overflow issues, or if the infrastructure is damaged by flood events.

Vital goods: Due to the remote location of Mammoth Lakes, the delivery of vital goods is severely vulnerable to severe winter weather, and highly vulnerable to flooding, landslides, severe weather, and wildfire. Severe winter weather, severe weather, flooding, and landslides can create dangerous conditions on the roadways and prevent vital goods from being delivered to Mammoth Lakes. If a wildfire was burning in the region, road closures may interrupt the delivery of vital goods, causing hardship on town residents and visitors. This could harm the entire community if stores do not have enough of supplies such as food or medicine, or if residents using propane for home heating do not have a sufficient supply of fuel. The impacts could persist for days or weeks depending on the severity of the winter storm. The town could attempt to adapt by creating local food supplies, although such options are likely limited and there are no local sources of propane. The Town could also fly in vital goods, although this option would be expensive and not always feasible due to dangerous conditions created by winter weather, wildfires, and severe storms. If prices increase and become unaffordable, local residents may not be able to afford these vital goods.

CONCLUSION

Out of the 70 assets the Town analyzed, 46 sensitivities are highly or severely vulnerable to one or more exposures. The resilience of these sensitivities can increase through the implementation of adaptation measures. Adaptation is the adjustment to natural and human systems in response to actual or expected changes in climate conditions, to reduce the harmful effects of actual or expected changes.⁸ The following is a list of example adaptation measures that can reduce vulnerability in Mammoth Lakes:

- Identify funding opportunities, including potential grant assistance programs, to support repairs of structural concerns in homes and apartments occupied by households in poverty.
- Promote the creation of community support networks to check on persons without access to lifelines, seniors living alone, and persons with disabilities during dangerous conditions.
- Encourage people living on single access roads to maintain enough emergency supplies to last at least three days.
- Work with electrical providers to ensure that they have the capabilities to rapidly access and repair remote transmission lines during and after extreme events.
- Work with state and federal agencies to support fuel and pest management activities on state and federal lands.
- Conserve and expand healthy conifer cover in forested areas to protect ecosystem services including carbon sequestration, soil retention, and water supply.
- Coordinate with utility providers to conduct regular evaluations and retrofits of energy transmission and delivery infrastructure.
- Coordinate with Mammoth Mountain Ski Resort to support additional recreational activities that are less dependent on snowpack levels.

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Glossary

100-year flood: A flood that has a 1 percent chance (one in 100) of occurring in any given year.

500-year flood: A flood that has a 0.2 percent chance (one in 500) of occurring in any given year.

Adaptation: Adjustments to natural and human systems in response to actual or expected changes in climate conditions, to reduce the harmful effects of actual or expected changes.

Adaptive capacity: The ability of a sensitivity to recover from and adequately adapt to the effects of climate change, including climate-related hazards.

Carbon dioxide (CO₂): A colorless, odorless gas produced by natural and human processes, including burning fossil fuels. The most common greenhouse gas and the single greatest contributing gas to climate change.

Climate change: A long-term change in the average meteorological conditions (such as temperature, precipitation, and wind) in an area. It can be caused by natural or human factors, but in this report, refers to the rapid human-caused climate change that is currently occurring.

Community asset: A valued feature of a community that may be harmed by climate change. Community assets may include buildings and facilities, key services, ecosystems, economic drivers, and infrastructure.

Downscaling: The process of determining small-scale information from a larger-scale data set, allowing for more accurate and locally specific data.

Exposure: The effects of climate change, such as changes to the frequency or intensity of a hazard event.

Flash flood: A dangerous type of flood that occurs very quickly, with little warning. Flash floods are usually a result of sudden, intense precipitation.

Greenhouse gas (GHG): A gas that can accumulate in the atmosphere, where it traps heat close to the Earth's surface. While some level of these gases is necessary to maintain a comfortable temperature on Earth, an increased concentration traps additional heat, resulting in climate change. Greenhouse gases can be emitted through both natural and human processes.

Impact: In the context of climate adaptation, the effects (especially the negative effects) of a hazard or other conditions associated with climate change.

Lifeline: A basic necessity that enables people to connect to others outside of their homes and to obtain goods, services, and information. Examples include access to telecommunication or an effective mode of transportation.

Model: A representation of the climate system, such as a virtual simulation, that is used to study climate and simulate climactic conditions.

Onset: The period of time in which exposures begin to occur.

Representative Concentration Pathway (RCP): A scenario of future GHG emission levels and rates, categorized by the average increase in thermal radiation levels.

Resilience: The ability to resist harm and recover from hazards.

Risk: The chance that a hazard event or other negative effect will occur.

Sensitivity: A population or community asset that may be negatively affected by climate change.

Snowpack: Snowfall that accumulates in cold mountain areas and remains frozen for a long period. In California, snowpack in the Sierra Nevada provides a large amount of water to the state during the summer and early autumn months as it melts.

Threat: The potential of a hazard to do harm to sensitivities.

Vulnerability: The overall susceptibility of a population or community asset to be harmed by climate change. It is a function of both the risk of the hazard and the threat that the hazard poses to the sensitivity. A vulnerability may refer to a specific weakness or other feature of a sensitivity that may increase the threat faced from a hazard.

Vulnerable population: A group of people with a shared characteristic that may make them more susceptible to the harmful effects of climate change. Vulnerable populations may be defined by their age, physical or mental health, socio-economic characteristics, or other factors

Appendix 1: Full Vulnerability Assessment Results

SENSITIVITIES	DROUGHT	EXTREME HEAT	FLOODING	FORESTRY PESTS AND DISEASES	HUMAN HEALTH HAZARDS	LANDSLIDES AND MUDFLOWS	SEVERE WEATHER	SEVERE WINTER WEATHER	SMOKE AND ASH	WILDFIRE
Town of Mammoth Lakes	V3	V2	V3	V3	V1	V2	V3	V3	V4	V5
Populations										
Children		V4			V3		V3	V3	V4	V3
Cost-burdened households	V3	V3	V3	V3	V2	V3	V2	V3	V2	V2
Homeless persons		V5	V3		V5		V5	V5	V5	V3
Households in poverty	V4	V4	V5	V4	V4	V5	V3	V5	V3	V4
Low-income households	V3	V3	V3	V3	V3	V3	V3	V5	V3	V2
Outdoor Workers	V3	V4		V3	V3		V3	V3	V5	V3
Persons living in mobile homes		V2	V4		V2	V4	V4	V3	V3	V4
Persons living on single access roads			V5	V4	V1	V4	V3	V5		V5
Persons in overcrowded households		V2			V3				V3	
Persons with chronic health problems		V4	V3	V2	V5	V2	V4	V3	V4	V2
Persons with disabilities		V3	V3	V2	V3	V3	V3	V2	V3	V3
Persons with limited English proficiency		V2	V1		V2	V1	V2	V1	V2	V2
Persons without access to lifelines		V3	V4	V3	V3	V3	V3	V4	V3	V3
Renters		V1	V1		V2	V3	V2	V1	V3	V1
Seasonal residents and tourists	V2	V1	V1		V2	V2	V3	V2	V3	V3
Senior citizens		V5	V3	V3	V3	V3	V3	V4	V4	V4

SENSITIVITIES	DROUGHT	EXTREME HEAT	FLOODING	FORESTRY PESTS AND DISEASES	HUMAN HEALTH HAZARDS	LANDSLIDES AND MUDFLOWS	SEVERE WEATHER	SEVERE WINTER WEATHER	SMOKE AND ASH	WILDFIRE
Senior citizens living alone		V5	V4	V4	V4	V4	V4	V5	V5	V5
Undocumented persons		V3	V2		V3	V2	V3	V3	V2	V3
Buildings and Infrastructure										
Bridges and culverts			V4			V3	V3	V3	V1	
Commercial buildings		V1	V3	V2			V2	V2	V3	V3
Communication facilities		V2	V1	V1		V3	V2			V3
Community centers		V2	V3			V3	V3	V1	V3	V4
Dams	V1		V2			V3			V1	
Electrical substations		V2	V1			V3	V2			V2
Electrical transmission lines		V3		V1			V3	V3		V3
Flood control infrastructure			V1	V1		V2	V2			
Gas stations		V2	V3	V3		V4	V3	V3		V2
Government offices		V2	V3			V3	V3	V1	V3	V3
Grocery stores		V2	V3			V2	V3		V3	V2
Homes		V3	V4	V3		V4	V4	V3	V3	V4
Local parks	V1	V1	V2	V3		V1	V2			V4
Major roads and highways		V2	V3	V2		V5	V3	V4		V4
Mammoth Yosemite Airport		V1	V2				V1	V1	V2	V3
Medical facilities		V2	V3			V3	V4	V1	V3	V1
Multi-use trails and paths	V2		V2	V4		V4	V1	V1	V2	V3
Old buildings		V3	V5	V4		V4	V4	V4	V4	V4
Power plants	V1		V1			V1				

SENSITIVITIES	DROUGHT	EXTREME HEAT	FLOODING	FORESTRY PESTS AND DISEASES	HUMAN HEALTH HAZARDS	LANDSLIDES AND MUDFLOWS	SEVERE WEATHER	SEVERE WINTER WEATHER	SMOKE AND ASH	WILDFIRE
Public safety buildings		V1	V2	V2		V3	V3	V1		V2
Schools		V3	V2			V4	V3	V3	V3	V3
Single access roads			V5	V4		V5		V5	V3	V5
Water and wastewater facilities	V2	V1	V3			V2	V2		V3	V3
Important Economic Assets										
Fishing and other water recreation	V5	V1	V1	V2		V3	V3	V1	V5	V4
Golf courses	V2	V3	V1	V2		V3	V2		V3	V3
Hotels and lodging	V4	V2	V3		V2	V2	V2	V3	V4	V5
Major employers	V4	V3	V2	V2		V4	V3	V2	V5	V5
Mammoth Mountain Ski Resort	V5	V3	V3	V2		V4	V5	V5	V5	V3
Outdoor recreation	V4	V4	V3	V3	V3	V3	V3	V4	V5	V4
Regionally significant parks	V3	V3	V3	V3	V2	V3	V3	V2	V4	V3
Retail activity	V3	V3	V3		V2	V2	V2	V3	V4	V4
Scenic views	V3		V2	V3		V1	V2	V2	V5	V5
State and federal protected lands	V3	V2	V1	V3		V2	V3		V3	V4
Ecosystems and Natural Resources										
Alder-willow riparian	V3	V2	V1	V4		V1	V3	V2	V2	V4
Basin sagebrush	V4	V3	V2	V1		V3		V1	V1	V1
Groundwater supplies	V3	V1	V1				V1			
Lakes and waterways	V5	V3		V2		V3		V1	V5	
Mixed conifer forest	V4	V5		V5		V1	V3	V1	V1	V4
Upper Montane mixed scrub	V3	V2		V2		V2			V1	V3

SENSITIVITIES	DROUGHT	EXTREME HEAT	FLOODING	FORESTRY PESTS AND DISEASES	HUMAN HEALTH HAZARDS	LANDSLIDES AND MUDFLOWS	SEVERE WEATHER	SEVERE WINTER WEATHER	SMOKE AND ASH	WILDFIRE
Valentine Reserve Ecological Study Area	V4	V4	V1	V5		V1	V2	V1	V3	V4
Wet meadow	V3	V3	V1	V2		V1			V2	V3
Key Community Services										
Air services			V1				V3	V4	V4	V4
Communication		V2	V1	V1		V2	V2	V1		V3
Emergency medical response		V2	V3	V3	V3	V3	V3	V2	V3	V2
Electricity delivery	V2	V4	V1	V5		V2	V3	V3		V3
Public health		V2	V3		V4			V1	V1	
Public safety response		V2	V3	V3		V4	V3	V3	V3	V4
Public transit access			V4	V3		V4	V3	V4		V3
Solid waste and recycling services		V1	V3	V2	V1	V2	V2	V3	V1	V1
Vital goods	V1	V2	V4	V3	V3	V4	V4	V5	V2	V4
Water and wastewater services	V5	V1	V3			V2	V2	V3	V4	V4

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