Summary of Climate Change Projections for New Mexico

NEW MEXICO emnrd Energy, Minerals and Natural Resources Department

Prepared by Adaptation International and CLIMAS for EMNRD as part of FEMA's Building Resilient Infrastructure and Communities (BRIC) program (EMT-2020-BR-098-0001)
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NEW MEXICO emnrd Energy, Minerals and Natural Resources Department

Acknowledgments

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Cover Photo: Clayton Sunset November 2, 2014. Courtesy of EMNRD.

adaptation international groundworkstudio CLIMAS KLA TOOLE DESIGN

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Introduction

This technical report was developed as part of a year-long planning process that began in March of 2023 and was funded by FEMA's Building Resilient Infrastructure and Communities (BRIC) program (EMT-2020-BR-098-0001) to follow NOAA's steps to resilience planning framework (as described in the Steps to Resilience toolkit) and develop a state-level *Adaptation and Resilience Plan.* The plan is intended to increase the resilience of state agencies, tribal and local governments, and local stakeholders to natural hazards exacerbated by projected changes in climate and the associated impacts. The New Mexico Energy Minerals and Natural Resources Department (EMNRD) is administering the initiative via the Energy Conservation and Management Division's (ECMD) Climate Policy Bureau as part of the state's broader commitment to climate resilience as articulated in Governor Michelle Lujan-Grisham's [E.O. 2019-003](#).

Resilience

A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.

Understanding the Science of Climate Change

Human activity (such as the burning of fossil fuels like coal, oil, and natural gas) is responsible for the changes we are seeing in our climate. The greenhouse gasses (GHGs) such as carbon dioxide and methane that are added to the Earth's atmosphere as the result of these activities absorb solar radiation that bounces off the Earth's surface. Normally, this radiation would escape back into space, but these gasses trap and re-radiate heat that warms the Earth's surface, much like a blanket traps heat and warms someone when they are sleeping; this is known as the greenhouse effect.[1] The impacts of this warming, and of climate changes, are being felt and observed across the globe, but the specific impacts vary regionally due to a multitude of factors.

Climate vs. Weather

Climate is the long-term average of weather conditions over a given area; whereas *weather* is what is happening in the atmosphere at a given place and time. For example, the temperature and amount of rain on June 19th, 2023, in Santa Fe is the weather, while the average temperature or precipitation in December (typically averaged over a 30-year span) is the climate. Climate can be calculated across different spatial scales: globally, regionally, and locally. Each scale is useful for understanding different components of the climate system.

[1] Rosen, J. (2021). The Science of Climate Change Explained: Facts, Evidence, and Proof. The New York Times. April 19. https://www.nytimes.com/article/climate-change-global-warming-faq.html

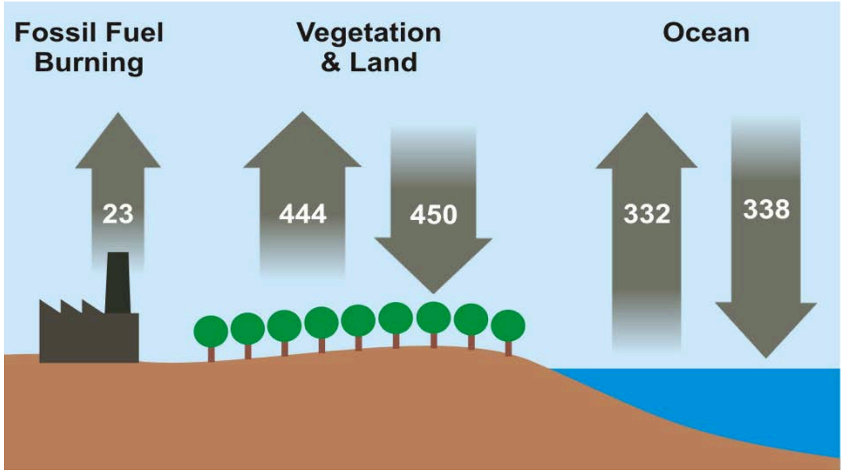


Figure 1: *The global carbon cycle which is traditionally in balance is thrown off by human use of fossil fuels and the resulting emissions of greenhouse gasses. This figure shows the Carbon cycle for the 1990s. Note that without human burning of fossil numbers would be basically in balance. Numbers are in billions of tons of CO_2 (IPCC AR4[2]).*

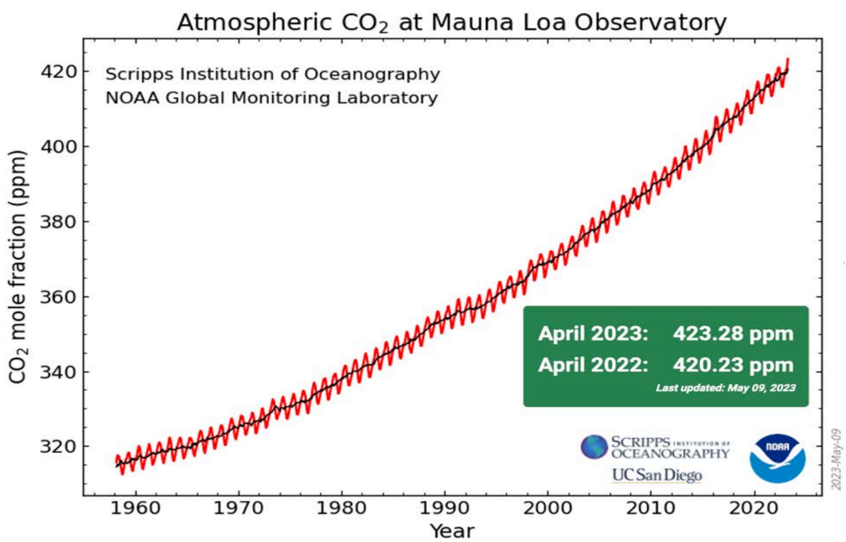


Figure 2: *Measurements of global average atmospheric concentrations of carbon dioxide taken at the Mauna Loa observatory from 1960 through 2023. Updated May 9th, 2023. Data available at: http://www.esrl.noaa.gov/gmd/ccgg/trends/*

Future greenhouse gas emissions (carbon dioxide, methane, and others) will depend on the choices residents, local governments, states, and countries make over the coming decades. To better understand how the climate is changing and will continue to change in the future, scientists create “scenarios” that represent plausible futures based on a range of different greenhouse gas emissions profiles. These are projections used to drive climate models and not predictions of the future. Taken together, the projections provide a range of what future climate

[2] IPCC. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press.

MAY look like based on a complex series of assumptions about societal decisions. For example, the RCP 8.5 (Representative Concentration Pathway) scenario corresponds to a future where atmospheric concentrations of carbon dioxide and other GHGs continue to rise over the rest of the century.[3] Average global temperatures are likely to increase substantially more than 3.6 °F (2 °C) under RCP 8.5 and lead to significant warming. A lower emissions scenario (RCP 4.5) represents significant near-term reductions in emissions and helps illustrate the range of potential future conditions. Both scenarios have a similar amount of warming over the next two decades, but diverge significantly by the end of the century, highlighting the importance of taking action to both reduce emissions (stay on the lower emission path) and prepare or adapt to the changing conditions.

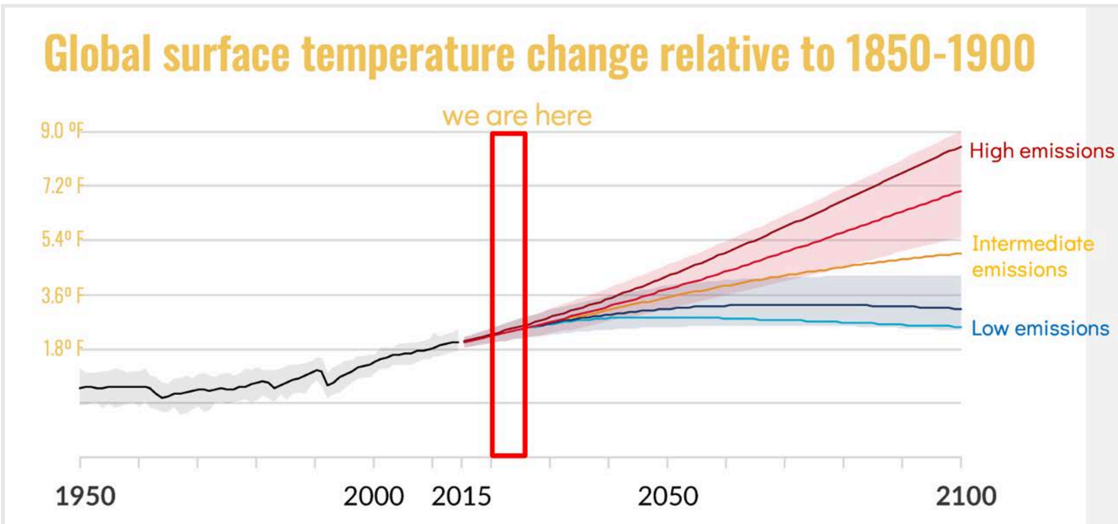


Figure 3: Example of the use of climate change scenarios and how different scenarios correspond to different amounts of warming over time. These scenarios, summarized by the IPCC in 2021[4] highlight how both high (dark red line and red shading showing the range of projections in that scenario) and low (dark blue line with blue shading showing range of projections in that

Climate Data, Uncertainty, and Decision Making

Many of the decisions we make every day are based on less-than-perfect knowledge. For example, while GPS-based applications on smartphones can provide a travel-time estimate for our daily drive to work, an unexpected factor like a sudden downpour or fender bender might mean a ride originally estimated to be 20 minutes could actually take longer. Fortunately, even with this uncertainty we are confident that our trip is unlikely to take less than 20 minutes or more than half an hour—and we know where we are headed. We have enough information to plan our commute.

– Guidance from the Fourth National Climate Assessment (Jay et al. 2018)

[3] Hayhoe, K., J. Edmonds, R.E. Kopp, A.N. LeGrande, B.M. Sanderson, M.F. Wehner, and D.J. Wuebbles. (2017). Climate models, scenarios, and projections. In Climate Science Special Report: Fourth National Climate Assessment, Volume I. D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, pp. 133-160, doi:10.7930/J0WH2N54.

[4] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. In Press.

scenario) emissions scenarios create similar amounts of warming over the next two decades and then diverge significantly by the end of the century.

While there is inherent uncertainty in projecting future changes, there is high confidence in our understanding of the greenhouse effect and the knowledge that human activities are changing the climate in unprecedented ways. ***We have enough information to make decisions based on that understanding***.

Climate Change Drivers and Impacts

The State of New Mexico is taking an important step in continuing to develop our understanding of climate projections and future climate conditions. This investment will allow for a proactive and informed approach to address the challenges posed by a changing climate. Looking at historical climate and weather conditions as well as considering future conditions can help identify risks, develop adaptation strategies, guide long-term planning, inform infrastructure decisions, promote environmental stewardship, and guide policy development toward a more sustainable and resilient future.

This summary looks at the two key climate-related drivers of change (Temperature and Precipitation) and some of the subsequent climate hazards that are already and will continue to affect the state, government operations, critical infrastructure, natural resources, economy, culture, and the health and vitality of all New Mexicans.

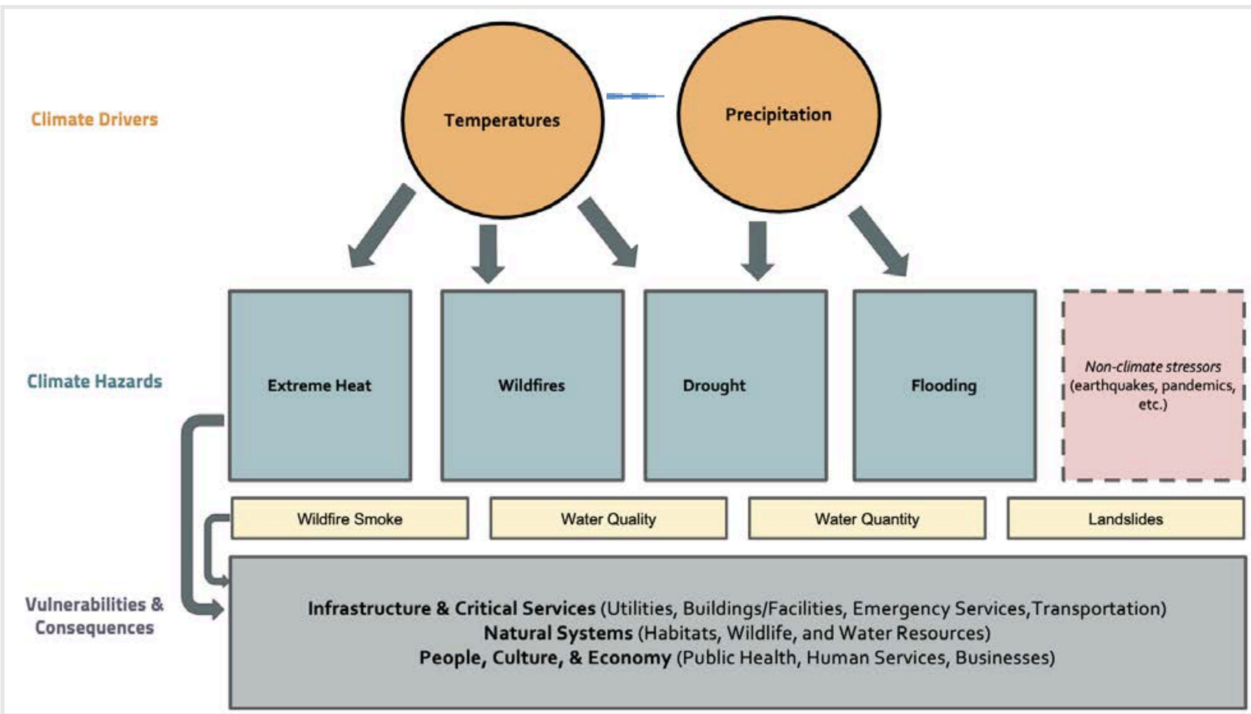


Figure 4: *How changing climate conditions such as temperature and precipitation can affect climate and weather-related hazards and impacts infrastructure, services, natural systems, and the people of New Mexico. The diagram is meant to be illustrative and not exhaustive of the connections between these drivers of change and their impacts.*

Changing Climate Conditions: Past and Future

The state of New Mexico has a widely varied topography from arid lowland and desert environments to high-elevation plateau and mountainous regions. In general, the state has a predominantly arid or semi-arid climate, characterized by limited rainfall and high levels of sunshine throughout the year. Average annual temperatures vary by community and elevation. Summers are generally warm with high temperatures in the 80s or 90s (degrees Fahrenheit) throughout much of the state. Winter temperatures are cooler with highs in the 50s or 60s and lows dipping below freezing throughout much of the state. The lowland parts of the state (generally 3,000-6,000 feet above sea level) typically receive less than 12 inches of precipitation annually. Mountainous regions of the state (generally 8,000-10,000 feet above sea level) may receive 20 to 30 inches of precipitation annually with approximately half of that precipitation falling as snow and providing water to the State as that snow melts.

Temperatures (Historical and Projected)

While temperatures can vary significantly based on individual locations, elevations, and micro-climates, average annual temperatures for the State as a whole can provide a good indicator of observed temperature changes. Since the start of the instrumental record in 1895, average annual temperatures in New Mexico have increased ~ 0.2°F per decade with an even more significant increase occurring since the 1970s.

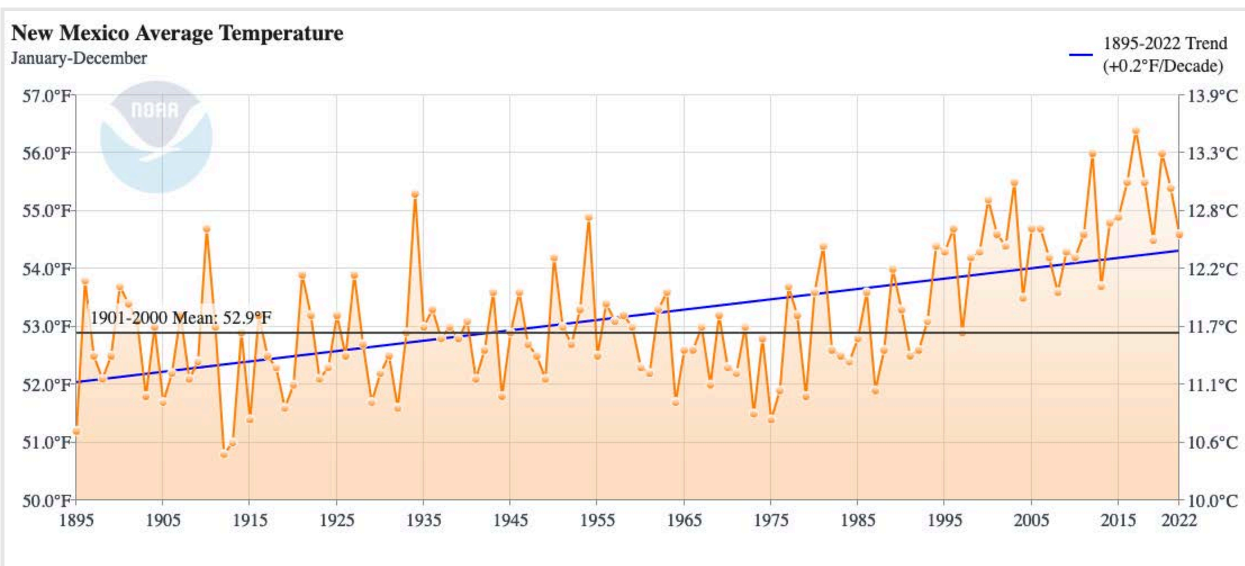


Figure 5: *Average annual temperatures in New Mexico. NOAA National Centers for Environmental information, Climate at a Glance: State Time Series, retrieved on May 8, 2023, from https://www.ncdc.noaa.gov/cag.*

The overall average warming trend can be seen at all scales. The snapshot below shows the observed temperatures in New Mexico Climate Division 2: Northern Mountains. There has been a significant rise in temperatures over the last 40-50 years with all of the average annual temperatures in the last 20 years above the long-term average.

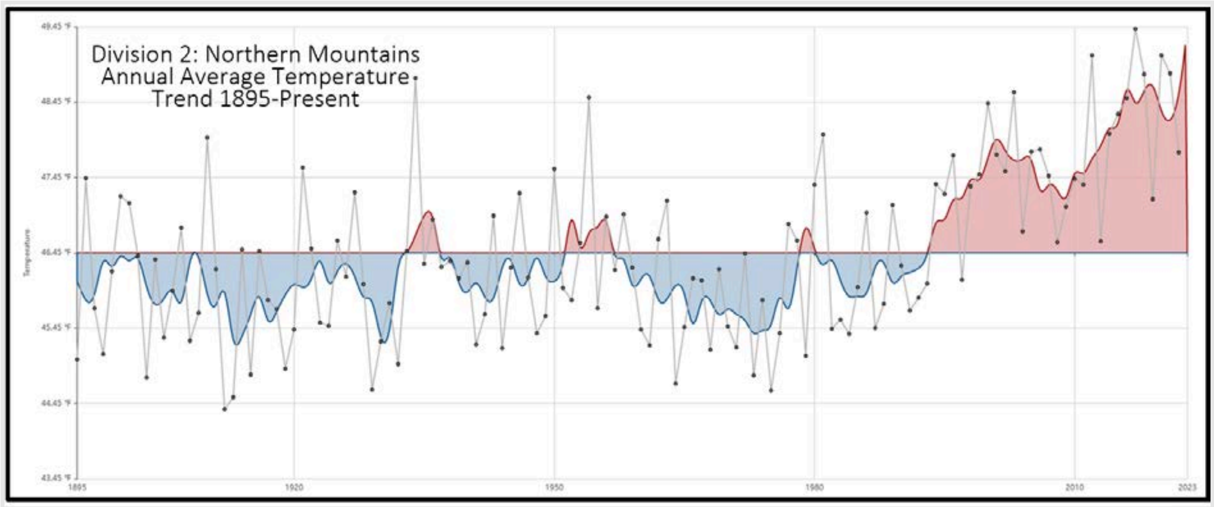


__Figure 6:__ Observed average annual temperatures in New Mexico Climate Division 2: Northern Mountains from 1895-present. Note the significant increase in temperatures over the last 40 years and that all of the last 20 years have been above the long term average. Data from NCDC monthly and annual temperature dataset. Figure from SCIPP Climate Trends Tool.

Climate projections can be analyzed at a variety of scales, and the appropriate scale depends on the climate exposure and the topographical and geographical features of the area. For this project, the State of New Mexico is using two different time periods for future temperature and precipitation projections: mid-century (2041-2060) and late century (2061-2080). The mid-century time period is useful for planning and for most infrastructure design and construction (25 years from now). The late-century time period provides projections that can be used to better understand the magnitude of the challenges facing the State.

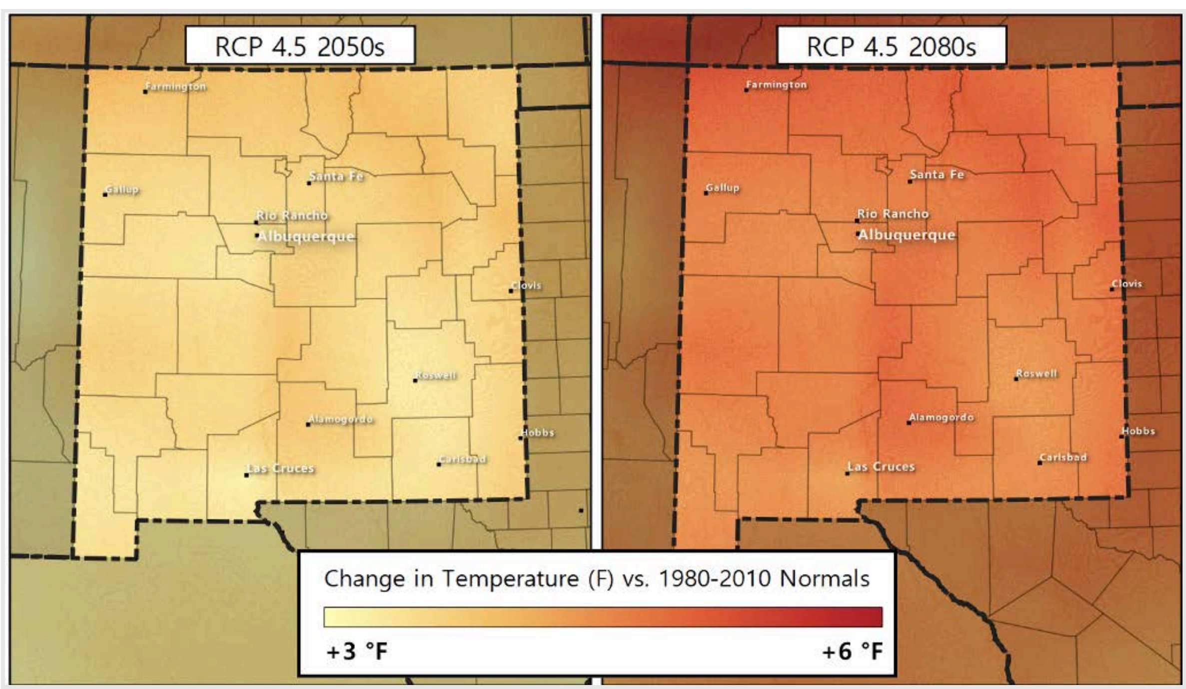


Figure 7: *CMIP5 Ensemble Average Change in Temperature (F) for the 2050s and 2080s periods under the RCP 4.5 scenario. Source: Adaptwest CMIP5 Downscaled Bioclimatic Data, (Wang et al. 2016), retrieved at: https://adaptwest.databasin.org/pages/adaptwest-climatena-cmip5/*

Precipitation (Historical and Projected)

There is even more variability both spatially and temporally with precipitation across the state. Average annual precipitation (1901-2000) is 13.99 inches, yet there is significant variation between years, with statewide average precipitation levels falling below 10 inches multiple times in the last several decades. Statewide averages reach 20 inches or more in other years. This variability is driven by many factors that will not change in the near future. For example, ocean moisture is mostly limited to monsoon storms moving northward from the Gulf of California, northwestward tropical storm remnants from the Gulf of Mexico, or southward winter storms bearing moisture from weather systems originating in the Pacific Northwest and Canada. All of these systems are heavily impacted by the precipitation production effects of mountain ranges outside of the state, which places most of New Mexico in what is known as a "rain shadow," or area where low elevation areas receive little precipitation as clouds move high into the atmosphere and drop their moisture as they travel over mountain ranges. New Mexico's high elevation mountain ranges intersect with these weather systems and prompt the production of snow and rain. For low-lying areas, highly unpredictable storm systems resulting from the remnants of major continental weather patterns provide some rain, but in a highly variable fashion. As a result, precipitation varies not only between years - with there being wet years and dry years - but also from place to place, and from community to community. For example, some portions of the Northwestern Desert region frequently receive less than seven inches of rain, due to limited access to critical monsoon moisture and rain shadow effect of multiple mountain ranges.

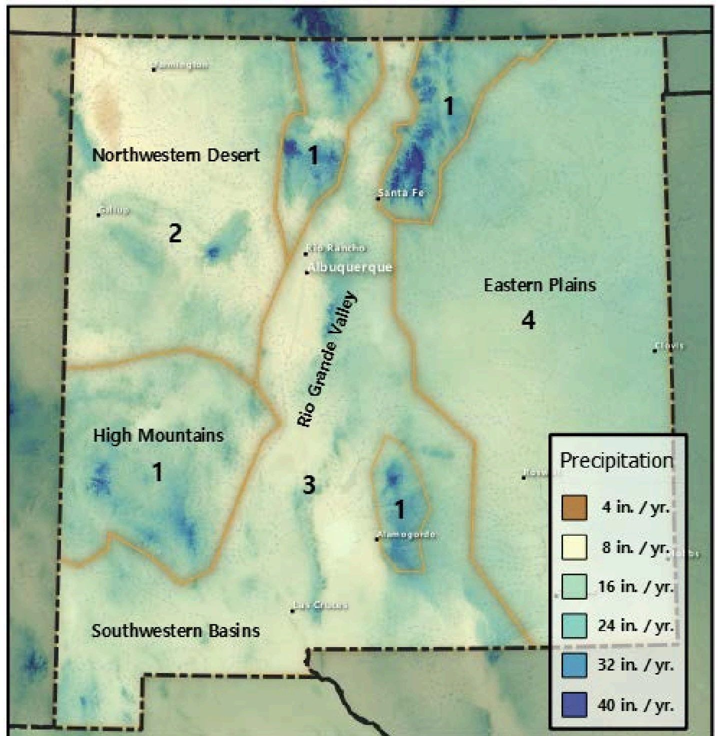


Figure 8: Climate Regions analyzed in the 2021 Leap Ahead Report (numbered with orange boundaries) and average annual precipitation for the 1991-2020 period. Sources: Adaptation International; Adaptwest 1991-2020 Worldclim/PRISM Bioclimatic Data, retrieved from https://adaptwest.databasin.org/pages/adaptwestclimatena

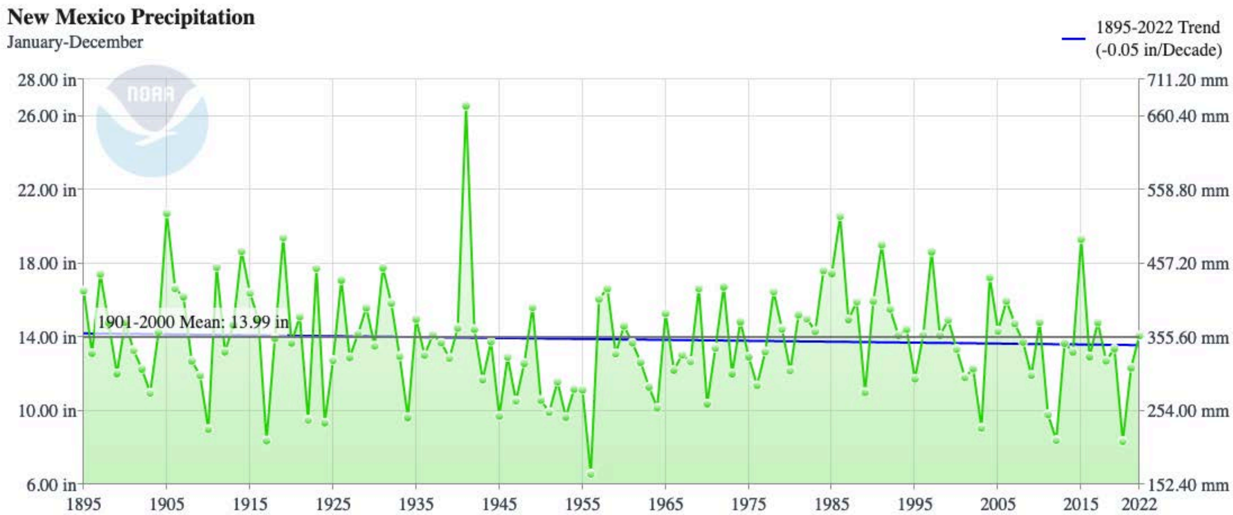
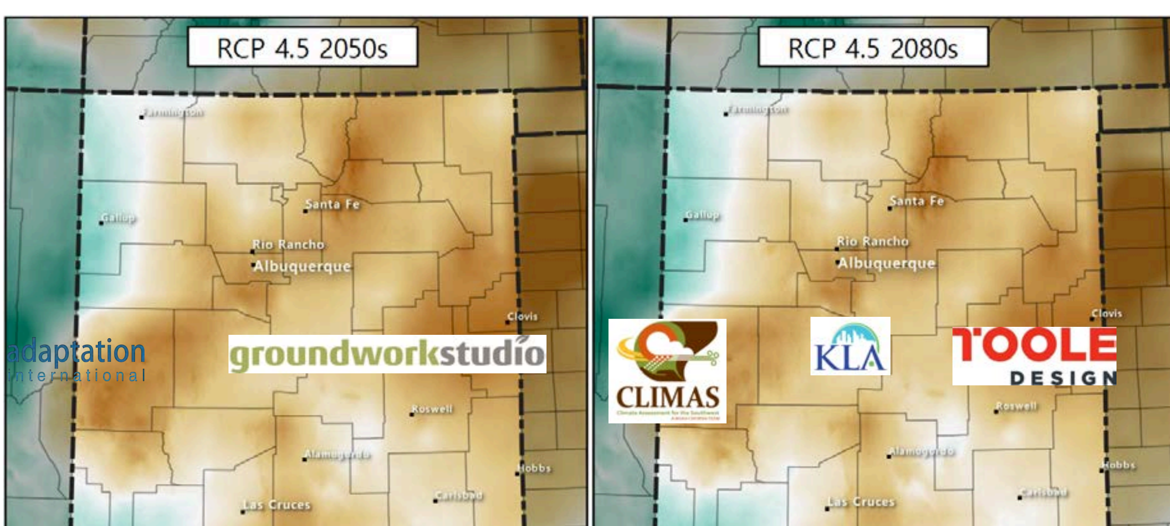


Figure 9: *Average annual precipitation in New Mexico. NOAA National Centers for Environmental information, Climate at a Glance: State Time Series, retrieved on May 8, 2023, from https://www.ncdc.noaa.gov/cag.*

On the other hand, the state's high elevation mountain ranges may receive more than 40 inches of precipitation a year, with significant snowfall during the winter season even when the rest of the state remains dry. Because of this, mountain precipitation of the greater Rio Grande River basin and its various upslope ranges is critical to the broader state's overall water supply. In the Rio Grande Valley and Southwestern Basins (home to Albuquerque, Santa Fe, Las Cruces, and much of the state's population) summertime monsoon rainstorms are a major contributor to annual rainfall, bringing with them the risk of flash flooding and damage to homes. In the eastern plains and other low-lying parts of the state, groundwater resources and intermittent stream flows from local rainfall also play critical roles in irrigation, industry, and domestic supply, especially late in the year when streamflow from mountain snowpack runs low. Here, remnants from both monsoon and tropical storm precipitation play key roles in water supplies, creating high levels of unpredictability from year to year.

Because of this, higher average temperatures have the potential push the state's already highly variable water resources into an even more unpredictable and potentially restrictive mode, with potential consequences for New Mexico's communities, farms, and businesses. Scientists know that a warmer climate holds more moisture, and it is likely that while total annual precipitation within New Mexico is not projected to change drastically, several important changes are likely to



occur. First, extreme precipitation events will increase both in magnitude and frequency as the climate warms, both during and outside of monsoon season. These events can occur over a period of hours or days. These more intense periods of localized rainfall have the potential to create flash flood conditions. At the same time, long-term increases in temperature will also hasten the rate at which water moves through the state's basins and ecosystems. Steadily warming temperatures will lead to more evaporation and evapotranspiration (use of water by plants) which will dry out the soils, induce faster onset of snowmelt, reduce run-off to streams, and increase the need for water within agricultural, industrial, and other human systems. When combined, these factors point to the need to also plan for the increasing occurrence of drought conditions for land managers, community leaders, and water planners. The State of New Mexico's 2022 LEAP Ahead report highlights this, identifying the potential for a 5% decrease in water availability in streams per decade for the next 50 years[5].

Figure 10: *Projected change in average annual precipitation across the state by the 2050s (2041 -2060) and the 2080s (2071-2090) for the lower emissions scenario (RCP 4.5). Projected changes range from a 10% decrease to a potentially slight depending on location. Source: Adaptwest CMIP5 Downscaled Bioclimatic Data, (Wang et al. 2016), retrieved at: https://adaptwest.databasin.org/pages/adaptwest-climatena-cmip5/*

While some projections may show precipitation increases, such as the Northwestern Desert, these increases may also bring heightened impacts from erosion due to extreme rainfall events, while at the same time failing to overcome the increased demand from ecosystems and the atmosphere as temperatures rise. In the high elevation mountains, potential for long-term minor reductions in precipitation will bring with them major impacts, affecting forests and river basins and the timing of seasons as winters shorten, summers lengthen, and wildfire conditions predominate as higher temperatures drive widespread aridification. In the Rio Grande and Southwestern Basins region, extreme heat exposure in the region's many cities and towns will be amplified by urban heat island effects from pavement and buildings at the same time as reservoirs and rivers run dry earlier in the year due to higher evaporation and evapotranspiration. Higher temperatures and heavily depleted groundwater reserves in some locations will make adaptations to alluvial aquifer water use and surface water conservation critical to its various agricultural and industrial communities' well-being.

Climate Hazards

There are four main climate hazards driven by a changing climate that will affect the State: wildfires, drought, flooding, and extreme heat. Each of these hazards will directly and indirectly impact people, infrastructure, natural systems, and the economy in important ways. Some hazards, like flooding or wildfire, can create immediate threats to human health and safety, whereas other hazards, like drought, can be chronic and more slowly degrade quality of life, the built environment, natural systems, and aspects of the State's economy. All of these hazards have direct and indirect consequences for the physical, emotional, mental, and spiritual health of the communities affected. Historically overly burdened communities are likely to be affected

[5] New Mexico Bureau of Geology and Mineral Resources, 2022, Climate change in New Mexico over the next 50 years: Impacts on water resources: New Mexico Bureau of Geology and Mineral Resources, Bulletin 164.

first and worst by these impacts. Understanding how these climate hazards have already impacted the county as well as how they may be exacerbated due to climate change is an essential step in working to build resilience.

Wildfire

As the historic 2022 wildfires highlight, wildfires pose a significant direct and indirect risk to communities, business, agriculture, and economy of the state. The two largest wildfires in state history both happened in 2022, the Herman's Peak/Calf Canyon Fire and the Black Fire. These fires burned over 300,000 acres of land, more than half of which was private land. 15,500 households were evacuated, and over 2,500 firefighters worked to fight the fire.[6] Before that, the Las Conchas Fire (2011) started in the Santa Fe National Forest and quickly grew into a massive wildfire. The fire burned a total area of approximately 156,293 acres and affected parts of Los Alamos County and the Jemez Mountains region. The fire forced the evacuation of thousands of residents and caused significant damage to land, wildlife, and property.

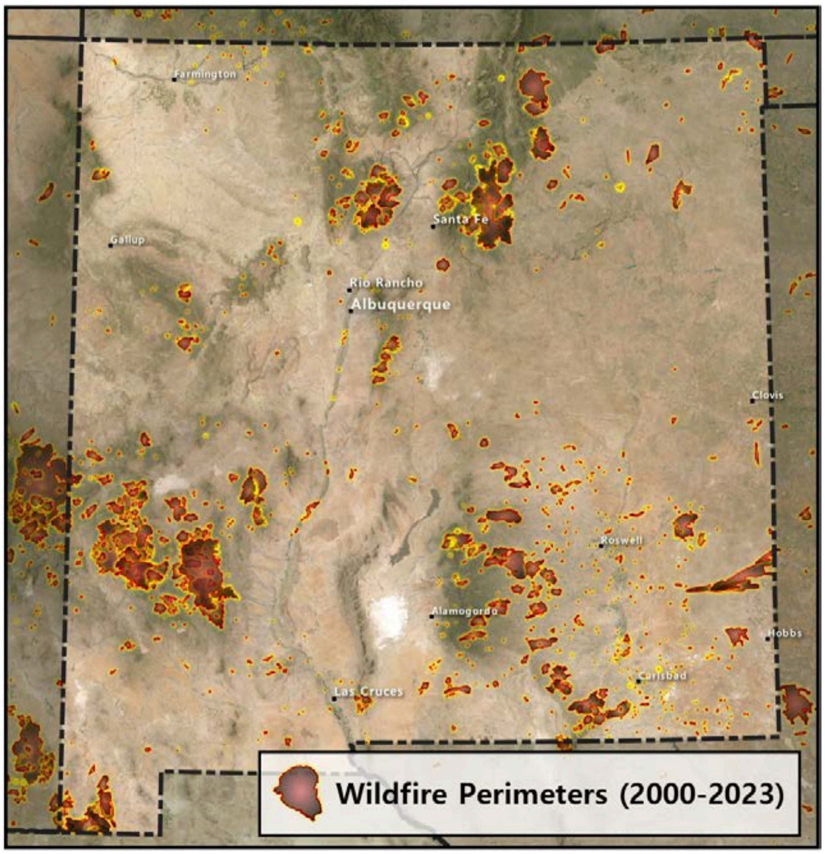


Figure 11: *Historic Wildfire Perimeters from the years 2000-2023. Sources: New Mexico EMNRD Wildfire Perimeter Data; National Interagency Fire Center Historical Perimeters, accessed at: https://data-nifc.opendata.arcgis.com/*

[6] New Mexico Forest and Watershed Restoration Institute. "Hermit's Peak and Calf Canyon Fire." ArcGIS StoryMaps, August 24, 2022. https://storymaps.arcgis.com/stories/d48e2171175f4aa4b5613c2d11875653.

New Mexico has a higher wildfire risk than 78% of U.S. states[7] and already has 50 more days a year of extreme wildfire risk than it did in the 1970s[8]. Wildfire risk is generally associated with direct impacts to people and property. These impacts include damage or loss of homes and infrastructure, injuries and death to people, pets, and animals, and destruction of forests and other ecosystems. The indirect effects of wildfires, including smoke inhalation, poor air quality, disruptions to critical infrastructure, environmental degradation, and other problems, can and often do have an impact on lives, economy, and health and well-being of New Mexicans. For example, smoke from regional and intrastate wildfires can significantly impact air quality for residents, particularly for those with pre-existing health conditions. Smoke can damage respiratory systems, limit outdoor activity, and exacerbate existing health conditions. Post-wildfire rainfall can create landslides, debris flows, and large sediment loads in rivers. After wildfire, lands are susceptible to introduction or expansion of invasive species, which can outcompete and displace native species.

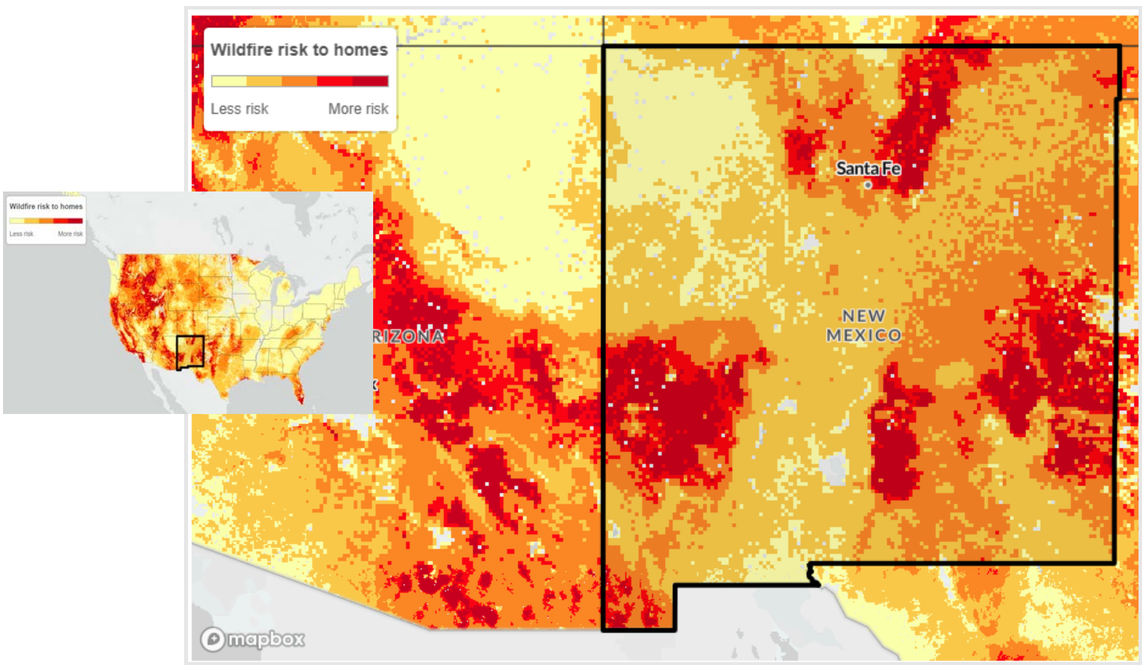


Figure 12: *Wildfire risk map to homes across the state. Data from: https://wildfirerisk.org/explore/risk-to-homes/35/*

Wildfire risk is increasing because of climate change and is expected to continue to increase over time due to increasing development that pushes people closer to and into the wildland urban interface. Furthermore, factors that help wildfires ignite and spread are exacerbated by

[7] Short, Karen C. "Spatial Wildfire Occurrence Data for the United States, 1992-2020 [FPA_FOD_20221014]." Accessed June 22, 2023. https://doi.org/10.2737/RDS-2013-0009.6.
[8] Owen, G. "Collaboratively Assessing Critical Social-Ecological System Buffers to Help Build Regional Climate Resilience: The Climate Assessment for the Southwest." Progress Report: June 1, 2021 - May 31, 2022. Tucson, AZ: CLIMAS, May 31, 2022. https://www.climas.arizona.edu/sites/climas.arizona.edu/files/CLIMAS_report_2022_final.pdf.

changes to wind, temperature, and precipitation as a result of climate change. The State has explored these risks in greater detail in the 2020 Forest Action Plan.[9]

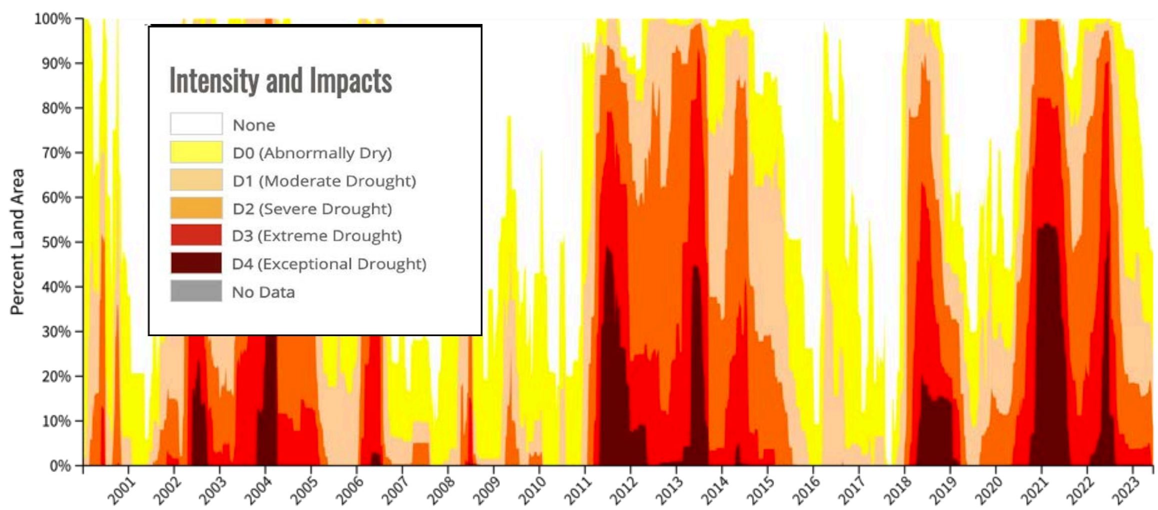
[9] New Mexico Energy, Minerals and Natural Resources Department, Forestry Division. 2020. 2020 New Mexico Forest Action Plan: A Collaborative Approach to Landscape Resilience. New Mexico Energy, Minerals and Natural Resources Department, Forestry Division. Santa Fe, NM. Available: https://www.emnrd.nm.gov/sfd/wp-content/uploads/sites/4/NMFAP_2020_v1-1_2021_03_12b_web.pdf

Drought

Drought is the result of a natural decline in precipitation over an extended period and occurs in virtually every climate on the planet, including areas of both high and low precipitation. Drought conditions occur during extended periods of time with limited or no precipitation, sometimes over months or years. “Megadroughts,” multi-decadal droughts that occur across a vast region, can last for decades.[10] Drought conditions often take several seasons to develop and dissipate. The severity of drought can be aggravated not only by high temperatures and a lack of precipitation, but also by other climatic factors such as prolonged high winds, low relative humidity, and extreme heat. The following four definitions are commonly used to describe different types of droughts and demonstrate the complexity of the hazard:

1. Meteorological drought: Degree of dryness, expressed as a departure of the actual precipitation from the expected average or normal precipitation amount, based on monthly, seasonal, or annual time scales.
2. Hydrological drought: Effects of precipitation shortfalls on stream flows, and reservoir, lake, and groundwater levels.
3. Agricultural drought: Soil moisture deficiencies relative to water demands of crops.
4. Socioeconomic drought (or water management drought): Shortage of water due to the demand for water exceeding the supply. The severity of a drought depends on several factors: duration, intensity, geographic extent, and water supply demands for both human use and vegetation.

Over the last 20 years, there have been multiple periods of drought where nearly the whole state was in severe drought conditions or worse. The multiyear periods from 2011-2015 and 2020-2023 highlight how the state can be subject to multiple years of drought conditions.



U.S. Drought Monitor
New Mexico

[10] Freedman, A & Frees, D. (2020). The Western U.S. is Locked in the Grips of the First Human-Caused Mega-Drought, Study Finds. Washington Post. April 16. https://www.washingtonpost.com/weathe[illegible]imate-change/

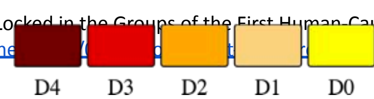


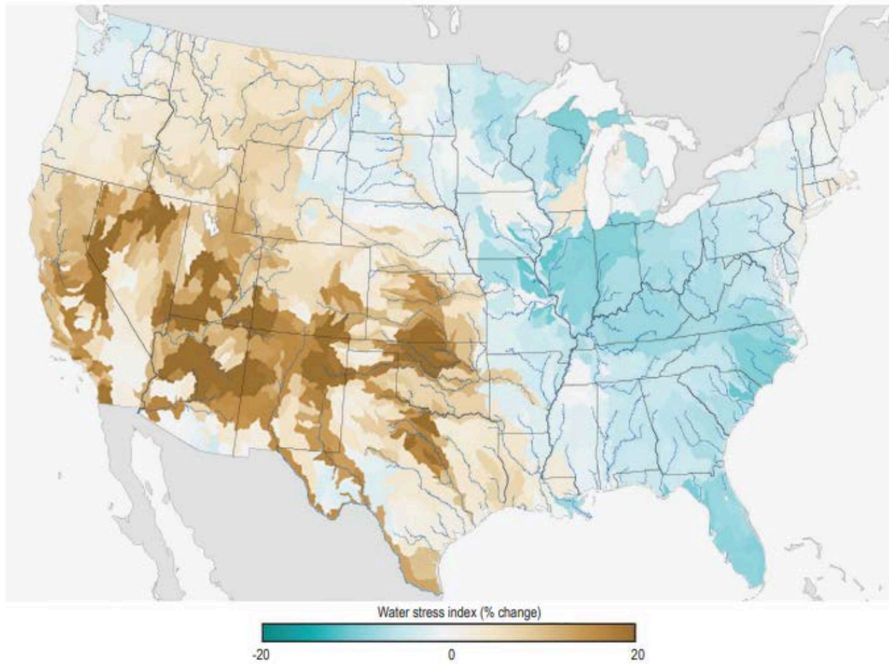
***Figure 13:** Drought history of New Mexico with the percentage of land in each drought category (y-axis) shown by year (x-axis). Data a figure from the National Integrated Drought Information System.* [*https://www.drought.gov/states/new-mexico#historical-conditions*](https://www.drought.gov/states/new-mexico#historical-conditions)

In 2022, the state was in the later stages of a multi-year drought and the Elephant Butte Reservoir (the state's largest reservoir) was at 4% of its overall capacity. Not only do these drought conditions directly impact water quality and quantity, but they also impact the region's ecosystems, food production, energy systems, infrastructure, human health, the economy, and the cultural and spiritual lifeways of Tribes located in the region.

Warmer temperatures and less snowpack will mean decreases in river flows especially in the summer and fall. Flow in the state's major river systems is projected to decrease 16% to 28% in the next 50 years.[11] As temperatures warm, these conditions will likely be accentuated due to increasing aridity and drying of the region. The recent LEAP Ahead Report notes that: "*The trend toward aridity will tremendously amplify the impacts of future droughts by changing the underlying longer-term climatic conditions upon which temporary drought conditions are superimposed.[12]"* Higher temperatures will mean more evaporation and more evapotranspiration and thus drier soils. Droughts can harm natural vegetation, threaten crops and ranching, lead to soil destabilization (with plant losses or wildfires), affect the health of animal populations, and ultimately decrease water availability for municipal uses.

[11] Dunbar, N W, D S Gutzler, K S Pearthree, F M Phillips, P W Bauer, C D Allen, D DuBois, et al. "Climate Change in New Mexico Over the Next 50 Years: Impacts on Water Resources," December 20, 2022.

[12] New Mexico Bureau of Geology and Mineral Resources, 2022, Climate change in New Mexico over the next 50 years: Impacts on water resources: New Mexico Bureau of Geology and Mineral Resources, Bulletin 164. Pg. 17



Projected change in water stress for river basins by mid-century (2040–2061) compared to historical average (1900–1970). Brown colors represent higher water stress (generally drier conditions). This figure is borrowed from R. Lindsey in "Climate change to increase water stress in many parts of U.S.," 2013, published by NOAA through www.climate.gov.

Figure 14: *Projected change in water stress throughout the country by the mid-century (2040-2061). Note that water stress is projected to increase across all or nearly all watersheds in the State. Available from https://www.ncdc.noaa.gov/cag*

Research suggests that the region will continue to experience more intense and longer drought conditions, fueled by hotter temperatures and a reduction in snowpack due to climate change.[13] Precipitation in New Mexico can be influenced by El Niño-Southern Oscillation (ENSO) events. While not always true, El Niño events generally correspond to wetter winters in New Mexico, particularly in the higher elevation mountain regions and La Niña events correspond to drier conditions that increase the potential for drought[14]. Despite some wet years, the entire southwest region of North America has been in the midst of one of the most severe droughts in the last 1,200 years over the last two decades. With changing climate conditions, both single year droughts and 20-year droughts (like that of the first part of the century) will become more likely. Researchers project that there is a 50% change of a 21-year drought like the current drought occurring again before the end of the 21st century[15]. So, it is important for the State to plan not only for extreme drought years, but for multiple years with limited amounts of precipitation.

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[13] Gonzalez, P., Garfin, G.M., Breshears, D.D., Brooks, K.M., Brown, H.E., Elias, E.H., Gunasekara, A., Huntly, N., Maldonado, J.K., Mantua, N.J., Margolis, H.G., McAfee, S., Middleton, B.R., Udall, B.H. (2018). Southwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25

[14] National weather Service. What is the Effect of La Niña on Precipitation across New Mexico. Available. https://www.weather.gov/abq/clifeature_laninaprecip

[15] Cook, B. I., Mankin, J. S., Williams, A. P., Marvel, K. D., Smerdon, J. E., & Liu, H. (2021). Uncertainties, limits, and benefits of climate change mitigation for soil moisture drought in southwestern North America. Earth's Future, 9, e2021EF002014. https://doi. org/10.1029/2021EF002014

Flooding

Flooding in the state has historically been limited to areas in and around rivers and streams and is generally infrequent but can be severe. A few of the major flood events since 2000 include:

- Rio Grande Flood (2006) where heavy rainfall in central and northern New Mexico caused the Rio Grande to flood, leading to significant damage to agricultural areas and infrastructure.
- Albuquerque Flash Flood (2013) where intense rainfall resulted in flash flooding in Albuquerque, causing widespread damage to homes, roads, and businesses.
- La Luz Canyon Flood (2013) where heavy rain in the La Luz Canyon area caused flash flooding, leading to significant damage in the town of Alamogordo.

The National Weather Service warns New Mexican residents about the risk of summer thunderstorms during the monsoon season. These periods of intense rainfall produce more water than the ground can absorb, and the water can be channelized creating large water flows. They can occur with little or no warning, trigger catastrophic mudslides or debris flows and can even be deadly. Since 1959, 65 New Mexicans have lost their lives in flash floods[16].

Currently 17% of New Mexican properties (144,816 properties) have a greater than 26% chance of being flooded in the next 30 years[17]. The majority of the flood risk is in and around streams and rivers, as evidenced by this FEMA Flood Insurance Rate Map from a portion of Albuquerque. However, impervious surfaces and local topography can mean that other areas without direct connections to the streams and rivers are also at risk of flooding.

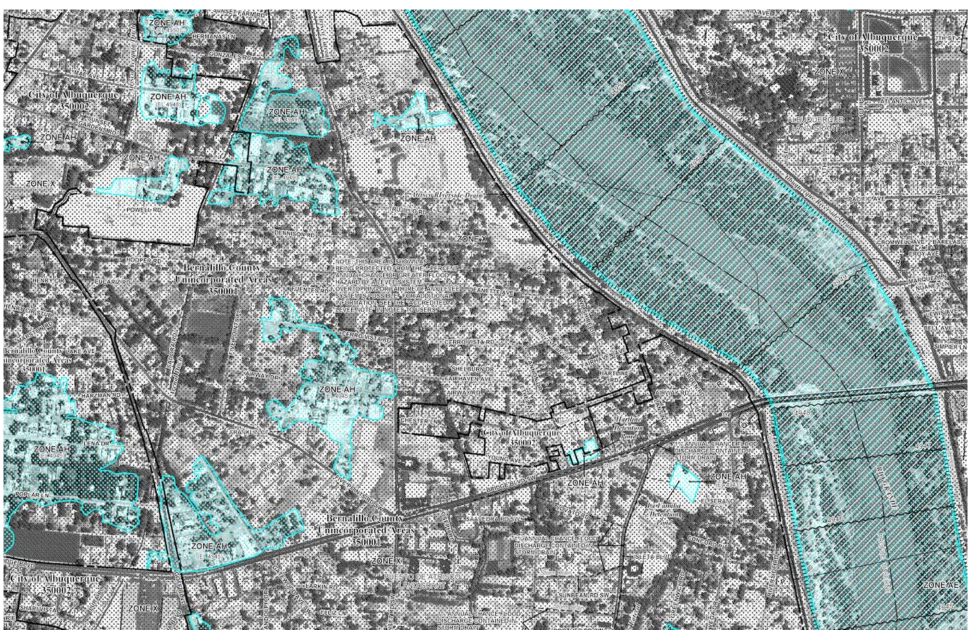

Figure 15: Example of local flood risk as determined by FEMA for a portion of Downtown Albuquerque. Blue shaded regions are the 1% annual flood risk areas (Zone AE & Zone AH) FEMA Flood Insurance Rate Map – Bernalillo County, Panel 333 of 385 Map

[16]National Weather Service, Monsoon Awareness – Flash Floods https://www.weather.gov/abq/prepawaremonsoonflashfloods

[17]Risk Factor, State of New Mexico Flood Risk Summary. https://riskfactor.com/state/new-mexico/35_fsid/flood

Number 35001C0333H. Additional information available:
https://msc.fema.gov/portal/search?AddressQuery=Bernalillo%20County

Extreme Heat

Locally hot days are distinct from the National Weather Service's "Extreme heat days" (days with a Heat Index above 125°F[18]). Many population centers for the state are at higher elevations meaning that temperatures rarely exceed 100 degrees Fahrenheit but can still be hot. Not only does an increase in temperatures and extreme heat days directly impact the residents of New Mexico, transportation systems, agricultural systems, water infrastructure, and natural resources, it also strains energy systems and increases GHG emissions due to an increase in the demand for cooling.

Extreme heat does not affect everyone equally. Historically overburdened populations, those with underlying chronic health conditions, older adults, kids, and outdoor workers are likely to be affected first and worst due to physiological differences and the potential inability to access places to cool off. In the last decade, heat-related deaths in the state have increased tenfold between 2013 and 2021.[19] In 2020 (the last full year with complete data), the Department of Health received reports of 313 heat-related illness hospital visits[20].

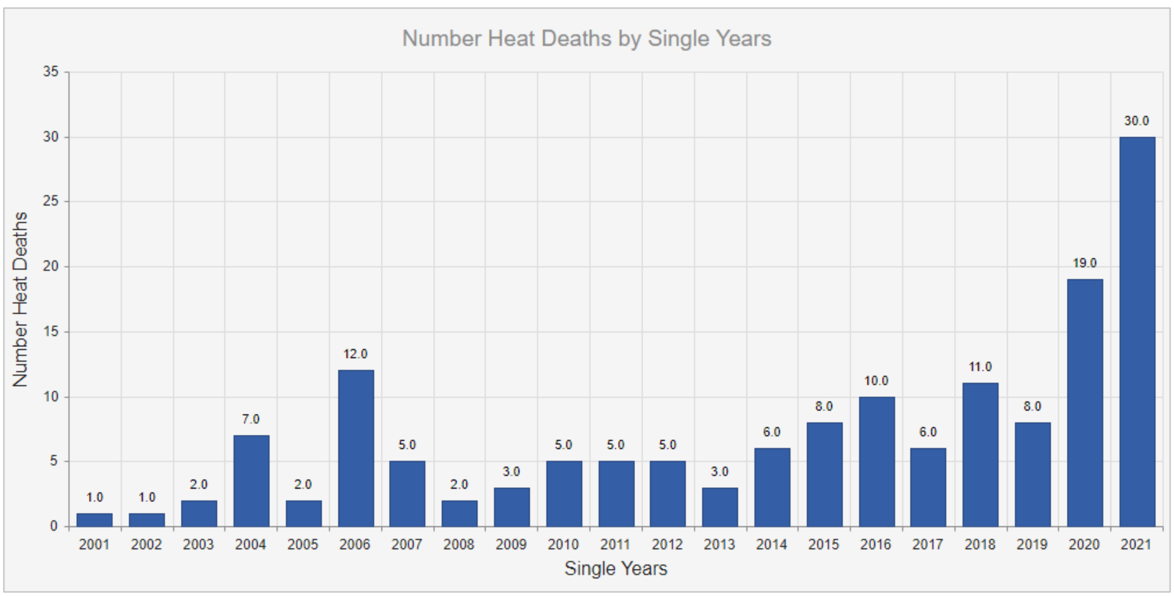

Figure 16: *Number of heat deaths annually statewide, 2001 - 2021. Source: New Mexico Environmental Public Health Tracking.*

[18] The 6th National Risk Assessment Hazardous Heat. First Street Foundation, August 15, 2022. https://report.firststreet.org/6th-National-Risk-Assessment-Hazardous-Heat.pdf.
[19] New Mexico Department of Health Surveillance Data – Presentation to Climate Resilience Workshop May 25, 2023
[20] NM-EPHT. "Complete Health Indicator Report of Heat Stress Hospitalizations," April 26, 2022. https://nmtracking.doh.nm.gov/dataportal/indicator/complete/EnvHlthHeatHosp.html.

The number of hot days each year is projected to increase across the state. For example, in Dona Ana County, days over 99°F are projected to more than triple in the next 30 years.

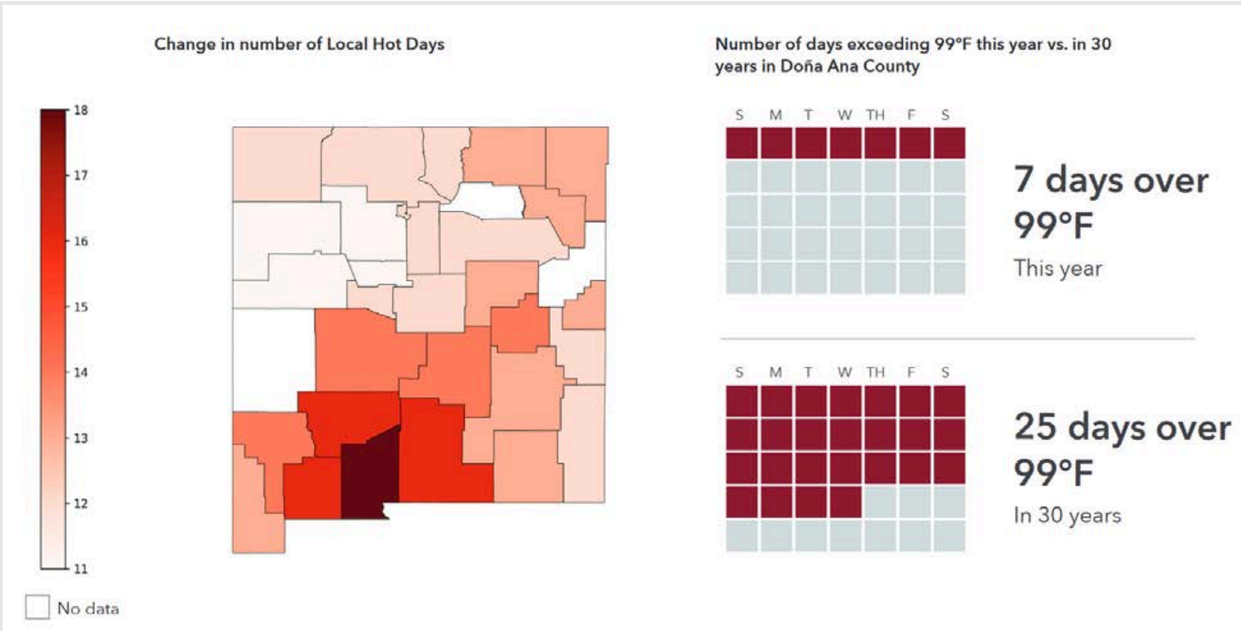

Figure 17: *Number of extreme heat days (with high temperatures above 99 degrees Fahrenheit in Dona County now and in 30 years[21].*

[21] The 6th National Risk Assessment Hazardous Heat. First Street Foundation, August 15, 2022. https://report.firststreet.org/6th-National-Risk-Assessment-Hazardous-Heat.pdf.

Extreme Winter Storms and Cold

Even with warming temperatures, the state will not be immune to extreme winter storms and extreme cold events. A historic cold wave affected the state and much of the south central United States during February 9–18, 2021. According to the NOAA's National Centers for Environmental Information for the eastern plains region: *"...temperatures remained below freezing for 7 consecutive days and fell below -10°F in a few locations, with the coldest temperature being -17°F at Lake Maloya. The extreme cold temperatures, heavy snow (more than 10 inches in numerous locations), severe icing, and accompanying power outages caused catastrophic damage.*[22]*"*

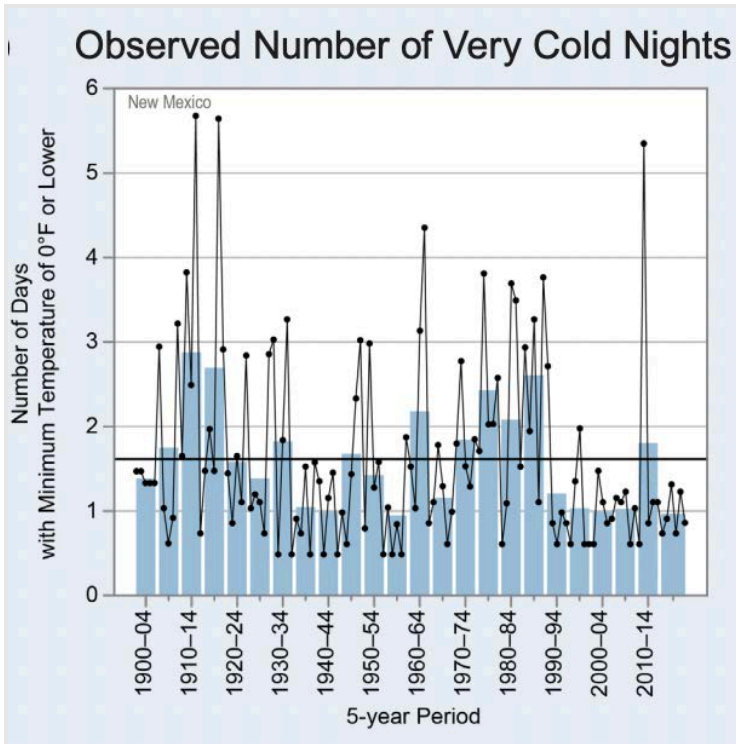

***Figure 18:** Number of extreme cold days (with minimum temperatures below zero degrees Fahrenheit on average across New Mexico). Data from NOAA National Centers for Environmental Information.*

While these cold snaps are unlikely to disappear, there is a decreasing trend in the number of very cold with the statewide average of only 1 to 2 nights a year below freezing. Of course, local temperatures, particularly in the higher elevation areas frequently experience more cold nights than the statewide average.

[22]New Mexico State Summary, 2022, NOAA National Centers for Environmental Information. Page 1. https://statesummaries.ncics.org/downloads/NewMexico-StateClimateSummary2022.pdf

A Quick Look at Extreme Wind Events and Dust Storms

New Mexico experiences extreme winds somewhat regularly and these events can have extensive impacts when they create a dust storm. These dust events can occur without much warning. There is a climate connection as they depend on amount of atmospheric moisture, stability of the atmosphere, temperature, sunlight, and winds. CLIMAS has been working closely with the NM State Department of Transportation to better understand these events, gather data, and build predictive capacity as well as awareness of what to do during a dust storm event[23]. Climate models currently have a limited ability to make projections about how the frequency and intensity of these events will change over time.

Climate Projections at the Community Level

To get a better sense of how the projected changes in climate will affect individual communities across the state, it is possible to look at detailed historical weather observations and future projections of downscaled climate data at the community scale. Included below are snapshots of observed changes in averages and projected changes in temperature (yellow cells in the left column) and precipitation (blue cells in the left column) for four communities in New Mexico[24]. The range in projections accounts for variation between outputs from the CMIP5 Ensemble Average for RCP 4.5 and RCP 8.5 global emissions scenarios, presented as “RCP 4.5 to RCP 8.5”. Extreme temperature days (days with high temperatures above 90 degrees Fahrenheit or lows below

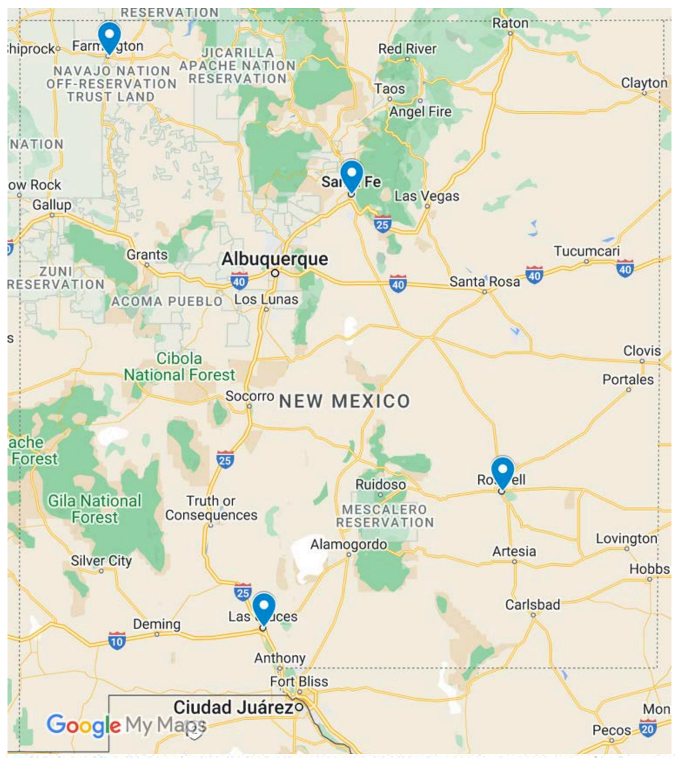

Figure 19: Four communities selected for an initial set of climate projections summaries based on their geographic locations across the state and availability of long term weather records. Clockwise from top left): Farmington, Santa Fe, Roswell, and Las Cruces.

[23] DuBois, D. 2022. Dust Mitigation Monitoring Project, Final Report. Prepared for NMDOT Research Bureau. Prepared by New Mexico State University, Department of Plant and Environmental Sciences.

[24] Historical Data: NOAA NCEI Daily Climate Observational Data for “State University Station NM US”, accessed at: https://www.ncei.noaa.gov/maps/daily/ . Projection Data compiled by Adaptation International from the National Climate Change Viewer and MACAv2MetData datasets, accessed at: https://apps.usgs.gov/nccv/maca2/maca2_counties.html and https://www.climatologylab.org/maca.html

freezing) are also shown in the bottom two rows.

Santa Fe

Located at the transition of the Santa Fe Mountain Range and the northern reaches of the New Mexico Rio Grande Basin, Santa Fe (population estimate 89,000) has a generally mild climate, but the climate is changing. Average annual maximum temperatures have already increased 4.2°F since the first half of the 20th century and are projected to continue to increase throughout the century. Precipitation patterns are highly variable and will continue to be so in the future. The number of days with temperatures below freezing is projected to decrease drastically while the number of days with temperatures above 90°F are projected to continue their upward trend adding between one and 2.5 months a year with high temperatures above this threshold by the end of the century.

Table 1: *Summary of observed changes and future projections for Santa Fe, NM, based on MACAv2Metdata CMIP5 downscaled ensemble climate projections and historical data from NOAA Santa Fe Number 2 Stations [GHCNID: USC00298085 & Santa Fe, NM US - GHCNID: USC00298072].*

Variable	Observed Changes (1900-1950 vs. 1990-2020)	Additional Change by Mid-Century (2041-2060)	Additional Change by End of Century (2061-2080)
Annual Average Temperature	+0.7	+3.8 to +4.9	+4.5 to +7.4
Annual Average Max Temperature	+4.2	+4.2 to +5.3	+4.9 to +8.1
Annual Average Minimum Temperature	-2.4	+3.5 to +4.5	+4.2 to +6.8
Winter Average Temperature	+0.4	+3.8 to +4.7	+4.3 to +7.1
Spring Average Temperature	+1.2	+3.7 to +4.9	+4.5 to +7.0
Summer Average Temperature	+1.4	+3.9 to +5.1	+4.6 to +7.8
Fall Average Temperature	-0.2	+3.8 to +5.0	+4.8 to +7.8
Annual Precipitation	-7.6%	+0.0% to +0.9%	+2.2% to -4.0%
Winter Precipitation	-6.9%	+1.4% to +5.8%	+1.6% to -2.3%
Spring Precipitation	-29.8%	0.0% to -4.4%	+0.0%. to -10.3%
Summer Precipitation	+3.5%	-0.8% to -0.9%	+1.3% to -4.7%
Fall Precipitation	-1.8%	+0.5% to +6.8%	+6.0% to 1.0%
Hot Days (High Above 90 F) Per Year	+19.3	+19 to +49	+33 to +77
Cold Days (Low Below 32 F) Per Year	+21.4	-27 to -102	-32 to -125

Las Cruces

Located in the southernmost portion of the New Mexico Rio Grande Basin and Southwestern Basins Region, Las Cruces (estimated population 114,000) has a hot desert climate with limited precipitation and long, hot, and dry summers punctuated by intermittent thunderstorms that linger into the fall. Here, records dating to the 1900s, show a steady increase in days with maximum high temperatures over 90°F and increasing aridity even as precipitation levels have remained close to their long-term averages. Projections for the region show below freezing temperature days falling dramatically, with last frost dates retreating into early March, while high temperature summer conditions extend into April and October. With no clear trend in precipitation projections, and the recent period bringing numerous serious drought episodes despite recent wetter-than-average conditions, communities here must prepare for further increases in aridity. At the same time, high levels of floodplain exposure require mitigation of risks associated with increased potential intensity of extreme rainstorms.

Table 2: *Summary of observed changes and future projections for Las Cruces, NM, based on MACAv2Metdata CMIP5 downscaled ensemble climate projections and historical data from NOAA State University Station [GHCNID: USC00290131 and USC00298535].*

Variable	Observed Changes (1900-1950 vs. 1990-2020)	Additional Change by Mid-Century (2041-2060)	Additional Change by End of Century (2061-2080)
Annual Average Temperature	+3.2	+4.0 to +4.7	+4.7 to +7.1
Annual Average Max Temperature	+2.1	+4.6 to +5.1	+5.2 to +7.7
Annual Average Minimum Temperature	+4.4	+3.5 to +4.3	+4.3 to +6.5
Winter Average Temperature	+3.0	+3.4 to +4.3	+3.9 to +6.5
Spring Average Temperature	+3.4	+4.2 to +4.9	+4.9 to +7.0
Summer Average Temperature	+3.3	+4.5 to +4.8	+5.1 to +7.4
Fall Average Temperature	+3.0	+4. to +4.9	+4.9 to +7.6
Annual Precipitation	+8.5%	+0.5 to +2.8	+3.9 to -1.3
Winter Precipitation	+10.8%	-6.3% to -2.4%	-7.3% to -15.4%
Spring Precipitation	-14.2%	-3.7% to -4.9%	+0.4% to -13.4%
Summer Precipitation	+14.4%	1.5% to 3.3%	+6.5% to +3.0%
Fall Precipitation	+7.3%	4.8% to 2.7%	+7.8% to +4.8%
Hot Days (High Above 90 F) Per Year	+21.2	+46 to +52	+54 to +71
Cold Days (Low Below 32 F) Per Year	-34.2	-36 to -43	-40 to -67

Farmington

The largest community in the Northwestern Desert region of the state, Farmington (estimated population 46,000) is the center of a cluster of communities within the driest portion of New Mexico. The community has seen a roughly 45% increase in extreme heat days since the early 20th century. With just 9.7 inches of rainfall per year at the Aztec Ruins NOAA weather station, the region is likely to become significantly drier even under climate projections showing higher precipitation due to increasing evaporation and evapotranspiration from plants, and greater atmospheric demand for moisture. Extreme winter weather will become less frequent as temperatures rise, and the historical summer temperature regime extends into May and September. Nearby mountain forests are vulnerable to heat stress and drought with the potential to expose soils to erosion. Energy demand for cooling in the region will increase as the areas will have up to 2.5 months of additional high heat exposure days in the RCP 8.5 scenario by the 2080s. These impacts will be felt most by vulnerable populations with poor health, high susceptibility to heat stress, or a lack of adequate housing insulation and cooling infrastructure.

Table 3: *Summary of observed changes and future projections for Farmington, NM, based on MACAv2Metdata CMIP5 downscaled ensemble climate projections and historical data from NOAA Aztec Ruins National Monument Station [GHCNID: USC00290692].*

Variable	Observed Changes (1900-1950 vs. 1990-2020)	Additional Change by Mid-Century (2041-2060)	Additional Change by End of Century (2061-2080)
Annual Average Temperature	+1.4	+4.0 to +5.2	4.8 to 7.7
Annual Average Max Temperature	+1.0	+4.3 to +5.5	5. to 8.2
Annual Average Minimum Temperature	+1.8	+3.8 to +4.9	4.6 to 7.2
Winter Average Temperature	+2.0	+4.2 to +5.2	4.8 to 7.9
Spring Average Temperature	+1.6	+4. to +5.2	4.8 to 7.3
Summer Average Temperature	+2.1	+4. to +5.2	4.7 to 7.9
Fall Average Temperature	-0.1	+3.8 to +5.1	4.8 to 7.9
Annual Precipitation	-0.9%	+2.1% to +4.9%	+3.8% to +0.4%
Winter Precipitation	+10.3%	+3.2% to +7.1%	+1.0% to +2.4%
Spring Precipitation	+2.9%	-1.2% to -2.4%	-0.7% to -8.2%
Summer Precipitation	-11.3%	+3.4% to +7.3%	+8.1% to +3.0%
Fall Precipitation	-1.9%	+2.2% to +6.9%	+4.6% to +2.4%
Hot Days (High Above 90 F) Per Year	+22.5	+19 to +49	+33 to +77
Cold Days (Low Below 32 F) Per Year	-19.3	-27 to -102	-32 to -125

Roswell

Located in the southern half of the Eastern Plains, Roswell's climate has warmed significantly over the last 120 years, with annual average temperatures for the 1990-2020 period more than 3°F higher than the 1900-1950 average. That period also saw an additional 33 days per year with high temperatures above 90°F. Precipitation has also decreased slightly as compared to the slightly wetter 1975-2005 period and future projections show the potential for further declines in all seasons. Future impacts to the area highlighted by the LEAP Ahead report include long term aridification due to increased temperatures, increased risks from more extreme storms, widespread stress to forests, grasslands, and shrublands, low flows in rivers, and numerous other impacts. Highly involved in agricultural activity, this area faces serious challenges as non-renewable groundwater resources continue to decline. Compromises to water quality due to increased sedimentation and other factors may also create challenges for planners and community members in this region.

Table 4: *Summary of observed changes and future projections for Roswell, NM, based on MACAv2Metdata CMIP5 downscaled ensemble climate projections and historical data from NOAA Roswell Industrial Park and Roswell Municipal Airport stations [GHCNID: USW00023043 & Roswell Industrial Air Park, NM US - GHCNID: USW00023009].*

Variable	Observed Changes (1900-1950 vs. 1990-2020)	Additional Change by Mid-Century (2041-2060)	Additional Change by End of Century (2061-2080)
Annual Average Temperature	+3.2	+3.8 to +4.8	+4.5 to +7.2
Annual Average Max Temperature	+3.6	+4.1 to +5.2	+4.8 to +7.8
Annual Average Minimum Temperature	+2.6	+3.4 to +4.4	+4.1 to +6.6
Winter Average Temperature	+2.2	+3.5 to +4.4	+3.9 to +6.6
Spring Average Temperature	+3.7	+3.7 to +4.9	+4.4 to +7.1
Summer Average Temperature	+4.1	+4.0 to +5.0	+4.7 to +7.6
Fall Average Temperature	+2.9	+3.8 to +4.9	+4.8 to +7.6
Annual Precipitation	-7.5	-0.5% to +1.3%	+1.3% to -2.1%
Winter Precipitation	-10.5%	-4.2% to -0.7%	-0.9% to -10.9%
Spring Precipitation	-18.8%	+1.4% to -0.8%	-0.7% to -8.3%
Summer Precipitation	-1.4%	-0.3% to +0.2%	+1.4% to -0.8%
Fall Precipitation	-5.9%	-0.8% to +1.0%	+3.1% to +3.2%
Hot Days (High Above 90 F) Per Year	+33.7	+46 to +52	+54 to +71
Cold Days (Low Below 32 F) Per Year	-10.9	-36 to -43	-40 to -67