Southern Nevada

EXTREME HEAT VULNERABILITY

Analysis

RTC

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Front cover photo source: Benjamin Hager/Las Vegas Review-Journal

EXECUTIVE SUMMARY

Southern Nevada has among the hottest climates in the U.S. and has been identified as one of the fastest-warming regions in the country. And recent research predicts the region will experience a significant increase in the frequency and intensity of extreme heat events in the coming decades. Increasing temperatures in the region are associated with and contribute to a host of negative impacts – from poorer air quality to added wear and tear on infrastructure. But, most importantly, studies have found a clear link between increasing temperatures and increasing heat-related deaths and hospitalizations.

Despite the history of adverse health impacts associated with extreme heat in our region, experts hold that many of these outcomes are preventable. Reducing future adverse outcomes require developing effective and coordinated responses, as well as improving the awareness of health officials and the general public about the health risks associated with extreme heat. This is especially critical in areas with populations most vulnerable during extreme heat events.

To identify such areas in Southern Nevada, a heat vulnerability index and map were developed, using the three components of heat vulnerability as a foundation. The spatial analysis found that the areas in Southern Nevada with populations most vulnerable to extreme heat are largely concentrated in and around the region's urban core and east side. These areas include many of the region's older neighborhoods. The populations in these areas are typically more racially and ethnically diverse and economically challenged than other parts of the region. And because these areas are also at lower elevations than much of the western half of the valley, they experience naturally higher temperatures.

The results of the spatial analysis can be used by public health officials, city planners, and service providers to better understand who is most at risk during extreme heat events and target resources that help minimize health impacts, whether through short-term emergency management efforts or longer-term urban planning interventions.

Photo source: Forbes
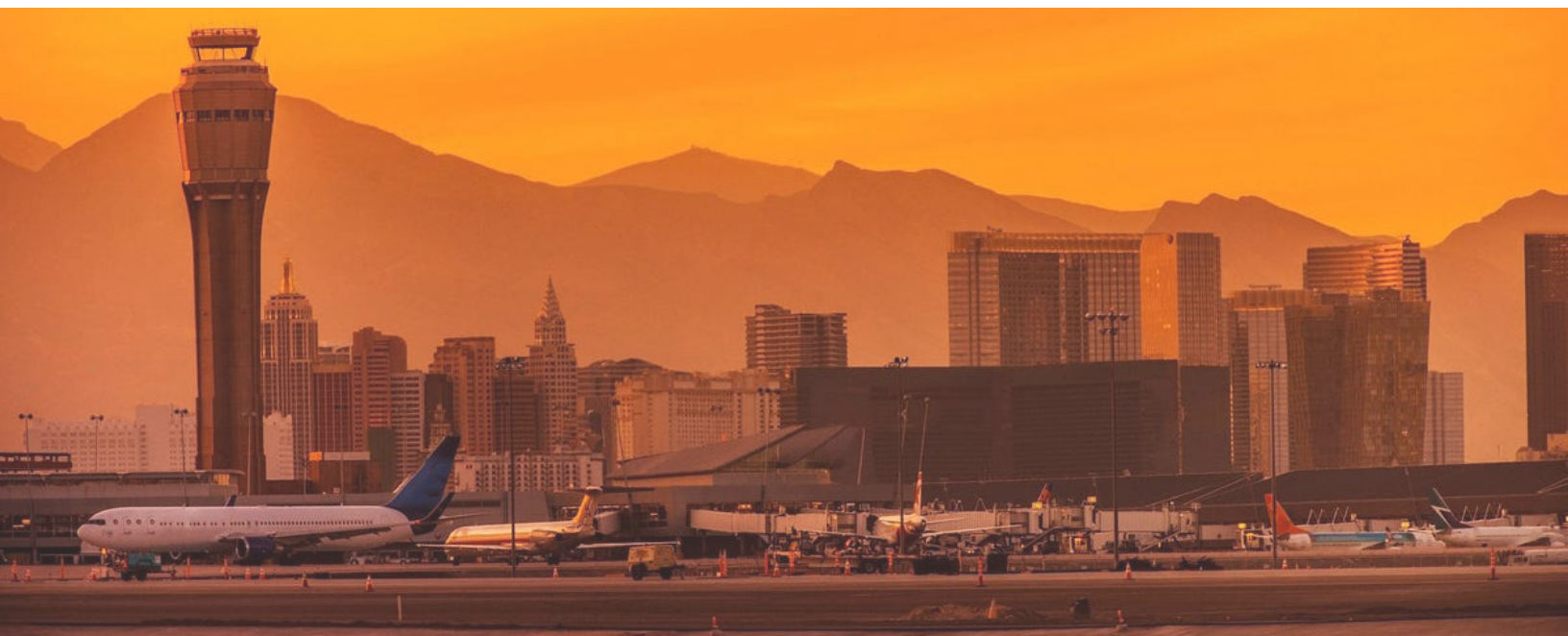
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INTRODUCTION

Extreme heat events cause more fatalities in the U.S. than any other climate-related hazard, according to Centers for Disease Control and Prevention (CDC) estimates. During the 15-year period from 2004 and 2018, nearly 11,000 deaths were attributed to heat (Vaidyanathan et al. 2020), more than hurricanes, tornadoes, and floods, all of which garner far greater publicity. When looking at the total scope of health impacts caused by extreme heat in the U.S. each year, the numbers are becoming more and more alarming to public health experts. On average, heat results in more than 75,000 health incidents annually, according to the CDC (see Figure 1).

And with a warming climate, the frequency, duration and intensity of extreme heat events are predicted to continue to rise (Seneviratne et al. 2018), increasing the risk of heat-related illness and mortality across the country.

In Southern Nevada, which has one of the hottest climates in the U.S. and has been identified as the fastest-warming region in the country, extreme heat poses a serious and increasing threat to the health of both residents and visitors. During the 10-year period from 2009 to 2018, there were nearly 600 heat-related deaths in Southern Nevada, according to Southern Nevada Health District (SNHD) records, with numbers spiking in the most recent years.

Despite the recent increase in heat-related illness and death, experts contend that most of these outcomes are preventable. Reducing future adverse outcomes will require developing effective and coordinated responses, as well as improving the awareness of public health officials and the general public about the health risks associated with extreme heat. This is especially critical in areas with populations most vulnerable to extreme heat.

EXTREME HEAT, for the purposes of this report, is a relative term to refer to conditions above a location's baseline normal temperatures as well as to the higher temperatures during heat waves.

For more discussion on specific definitions of extreme heat conditions, see the EPA's "Excessive Heat Events Guidebook."

While increasing attention has been paid to climate change and extreme heat in Southern Nevada in recent years[1], much of the planning and study has concentrated on mitigation efforts. The SOUTHERN NEVADA EXTREME HEAT VULNERABILITY ANALYSIS took a slightly different approach, focusing on vulnerability to extreme heat. Through the development of a heat vulnerability index and map, the analysis identified areas in the region where populations are at high risk to extreme heat. These findings can help public health officials, city planners, and service providers target resources that help minimize health impacts, whether through short-term emergency management efforts or longer-term urban planning interventions.

This report provides an overview of the research and approach taken to identify areas in Southern Nevada with populations most vulnerable to extreme heat, including:

- A synopsis of Southern Nevada's warming climate and its impact on heat-related health outcomes

- Factors that increase risk for heat-related illness and death

- Development of a heat vulnerability index to determine the spatial distribution of the vulnerability to extreme heat in the region

- Discussion of results, including profiles of four areas of high vulnerability in Southern Nevada

- A survey of actions other cities and regions have explored to address extreme heat

VULNERABILITY is typically defined as the inability of a specific group or population to appropriately respond or adapt to a specific harmful stressor.

[1] Examples include: Clark County's "Sustainability & Climate Action Plan" (2021); City of Las Vegas's 2050 Master Plan (2021); Ongoing research by the Guinn Center for Policy Priorities, and at the University of Nevada, Las Vegas (UNLV) and Desert Research Institute (DRI); The Southern Nevada Water Authority's examination of the impact of increasing temperatures on outdoor workforce.

FIGURE 1

HEAT-RELATED ILLNESS & DEATH IN THE U.S.

Extreme heat has long threatened public health in the United States. According to data captured by the U.S. Centers for Disease Control & Prevention (CDC), heat results in more than 75,000 health incidents on average each year, including:

702 deaths

67,512 emergency room visits

9,235 hospitalizations

BACKGROUND

Climate change impacts on Southern Nevada

Southern Nevada has among the hottest climates in the U.S. with temperatures regularly exceeding 100°F during summer months[2]. The region has also been identified as the fastest-warming in the country, according to a *Climate Central* analysis. The Las Vegas region's average annual temperature has increased nearly 6°F between 1970 and 2018, more than a degree higher than the next fastest-warming metropolitan area[3], according to the analysis. Recent research predicts Southern Nevada, and the southwestern U.S. generally, to experience a significant increase in the frequency and intensity of extreme heat events in the coming decades (Jones et al. 2015).

Increasing temperatures in the region are associated with and contribute to a host of negative impacts – from exacerbating drought and poorer air quality to the stretching out of the allergy season and added wear and tear on infrastructure. But, most importantly, studies have found a clear link between increasing temperatures and increasing heat-related deaths and hospitalizations. A recent analysis of heat waves and heat-related death in Southern Nevada between 2007 and 2016 found a statistically significant correlation between the two (Bandala et al. 2019).

Health records offer a glimpse into extreme heat's toll on health locally.

[2] The average daytime high during summer months was 104°F between 2015 and 2019, and there were 84 days that exceeded 100°F in Southern Nevada in 2019, according to data provided the National Weather Service's Las Vegas Office.

[3] El Paso, Texas at 4.74°F

FIGURE 2

Days exceeding 100°F in Southern Nevada

Data source: National Weather Service, Las Vegas Office
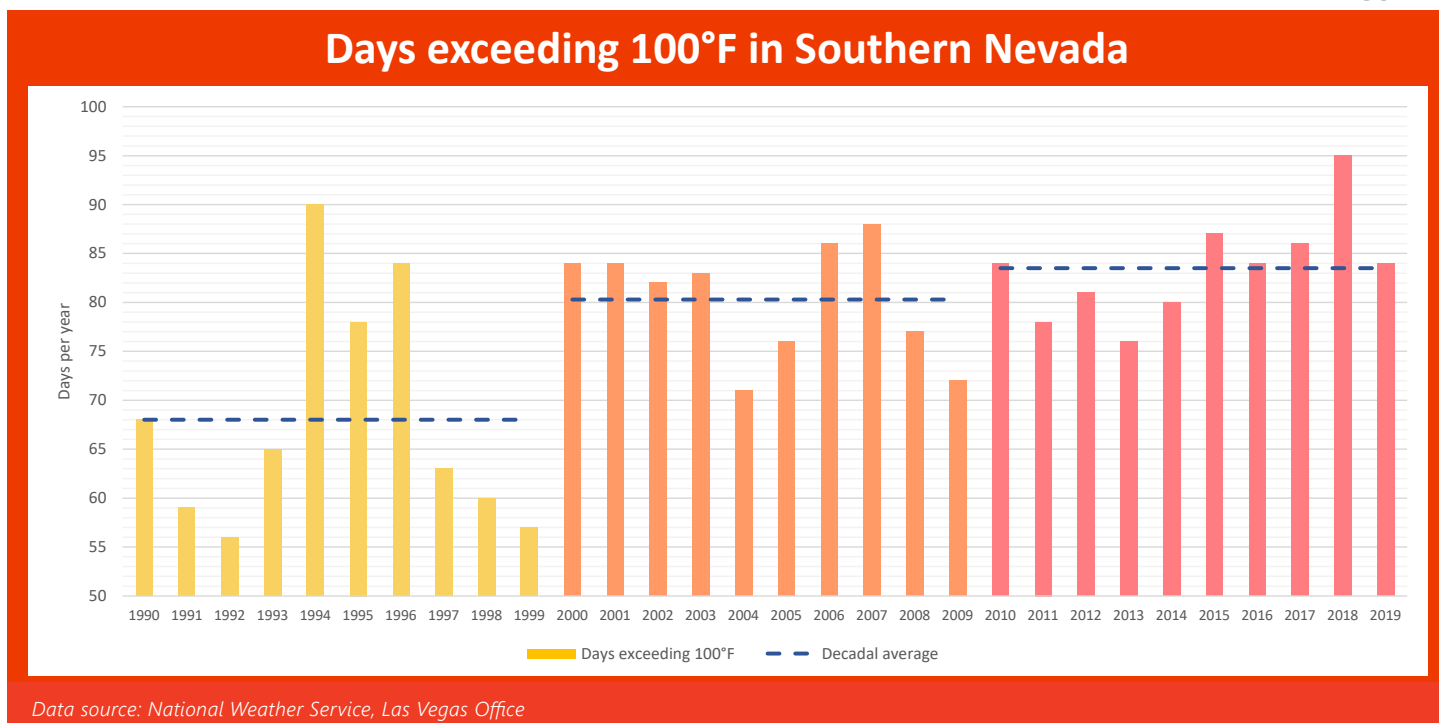
There were 568 heat-related deaths[4] in Southern Nevada over the 10-year period from 2009-2018, according to data provided by SNHD, with numbers spiking in the most recent years. From 2016-2018 – a three year period – there were 619 heat-related emergency room visits or hospitalizations[5] in the region. And these numbers are almost certainly an undercount, according to public health and medical experts, due to the way this data is captured at hospitals and emergency rooms and on death certificates.

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[4] Data source: Death certificates from the Nevada Electronic Death Registry System provided by the Nevada Department of Public and Behavioral Health Office of Analytics. Heat-related death is defined by having one of the following ICD-10 codes as the underlying or contributing cause of death: X30 - Exposure to excessive natural heat; T67 - Effects of heat and light.

[5] Data source: Hospitalization billing data provided by the Center for Health Information Analysis at University of Nevada, Las Vegas. Hospitalization for heat-related illness is defined by having one of the following ICD-10-CM billing codes in any diagnosis field: X30 - Exposure to excessive natural heat; T67 - Effects of heat and light.

Extreme heat and human health

A wide body of research has established a clear link between extreme heat and health risks. Exposure to extreme heat, or even moderate increases in temperature for populations not accustomed to heat, can stress the body's ability to maintain an ideal temperature and increase the risk of experiencing a range of adverse health outcomes (Reid et al. 2009), including heatstroke, heat exhaustion, and hyperthermia.

Temperature extremes can also worsen serious chronic conditions, including cardiovascular and cerebrovascular diseases and diabetes-related conditions. Additionally, heat can impact human health in a variety of indirect ways, most notably through negative air quality impacts. Higher temperatures contribute to the build-up of harmful air pollutants that exacerbate respiratory conditions (Tibbetts 2015).

UNEQUAL IMPACT OF EXTREME HEAT

Extreme heat, like many other weather-related and environmental dangers, has disproportionate impacts across communities. And a growing body of research points to low-income populations and communities of color bearing the brunt of heat's negative impacts.

Decades of discriminatory housing and land use policies in the U.S. have resulted in present-day heat-related disparities. A recent study published in *Climate* found that across the country, formerly redlined[i] areas were exposed to greater heat relative to their non-redlined neighbors (Hoffman et al. 2020).

In an effort to address these historical inequities, cities are being more intentional about targeting resources and taking actions aimed at addressing these environmental injustices.

The city of Phoenix, for example, is working with residents in historically underserved neighborhoods to improve infrastructure and develop neighborhood-specific heat action plans.

And through the "Beat the Heat" initiative in Philadelphia, community groups and residents in a predominantly Black and Latinx neighborhood that experiences hotter temperatures than the rest of the city worked with city departments to development a heat relief plan and distribute fans and air conditioning units to residents.
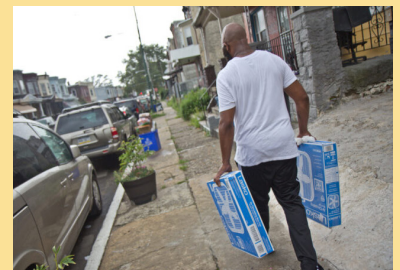

Photo source: Kimberly Paynter/WHYY
Fans being delivered to residents in one of Philadelphia's most heat vulnerable areas.

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[i] Redlining was a racist practice outlawed in the U.S. in the 1960s that effectively blocked Black and other people of color from obtaining home loans in certain areas or at all.

Heat vulnerability factors

While everyone is vulnerable to the effects of extreme heat to some extent, impacts are not evenly distributed. Certain populations are more at risk due to environmental, demographic, socioeconomic, and physiological factors. Current examination and discussion of extreme heat vulnerability center around three components of heat vulnerability, which take these factors into account:

- **Exposure to extreme heat** – Weather patterns, as well as both the natural and built environments can influence levels of exposure to extreme heat.

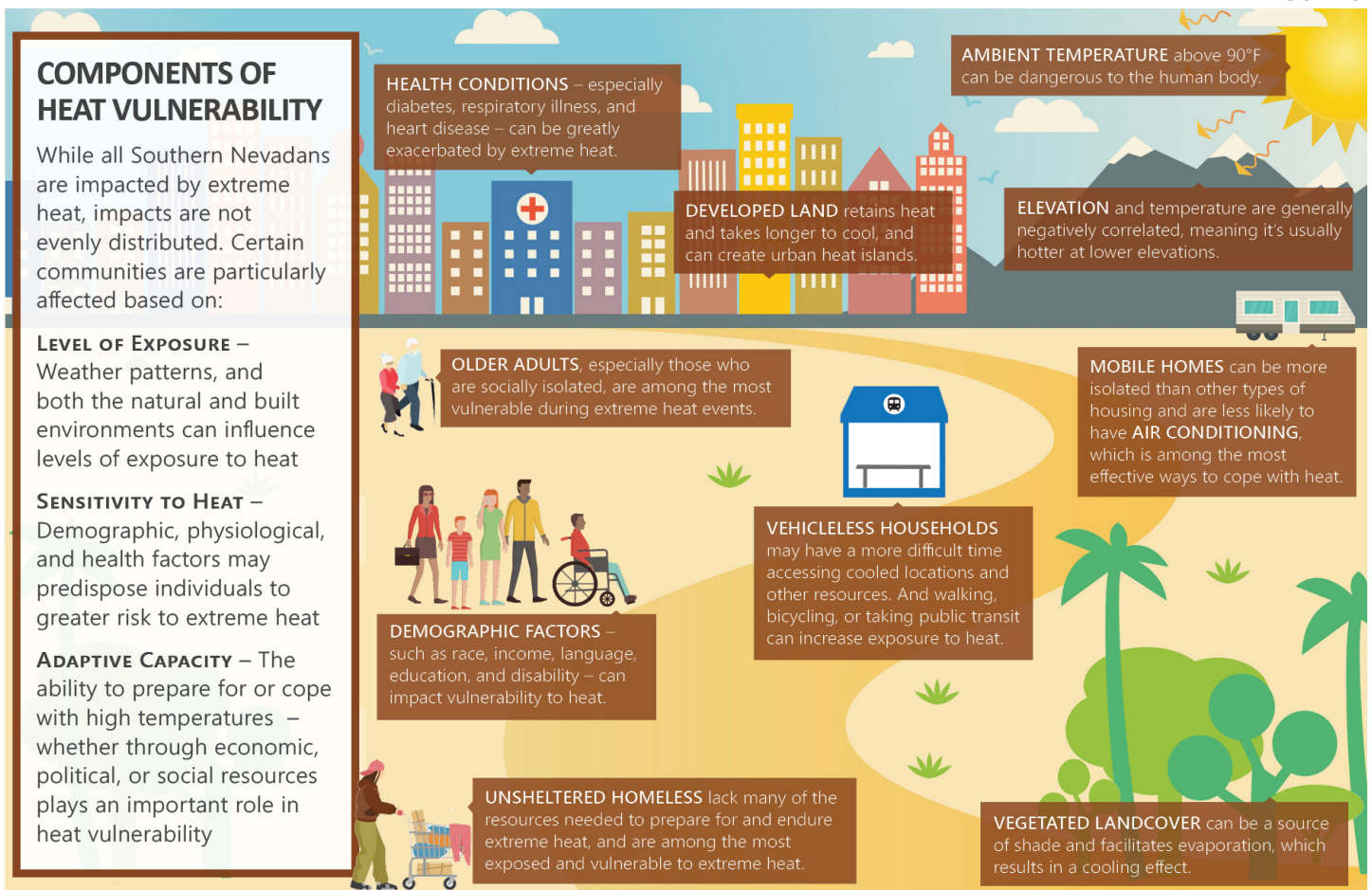- **Sensitivity to extreme heat** – Demographic, physiological, and health factors may predispose individuals to greater risk from exposure during extreme heat events.

- **Adaptive capacity** – The ability to prepare for or cope with extreme heat impacts, whether through economic, political, or social resources.

This framework served as a foundation for the Southern Nevada Extreme Heat Vulnerability Analysis. Taking this comprehensive and multidimensional approach to analyzing heat vulnerability that includes social, health, and place-based influences helps ensure the interventions developed as a result will target those most at risk, while also addressing environmental and social justice.

FIGURE 3

COMPONENTS OF HEAT VULNERABILITY

While all Southern Nevadans are impacted by extreme heat, impacts are not evenly distributed. Certain communities are particularly affected based on:

Level of Exposure – Weather patterns, and both the natural and built environments can influence levels of exposure to heat

Sensitivity to Heat – Demographic, physiological, and health factors may predispose individuals to greater risk to extreme heat

Adaptive Capacity – The ability to prepare for or cope with high temperatures – whether through economic, political, or social resources plays an important role in heat vulnerability

HEALTH CONDITIONS – especially diabetes, respiratory illness, and heart disease – can be greatly exacerbated by extreme heat.

AMBIENT TEMPERATURE above 90°F can be dangerous to the human body.

DEVELOPED LAND retains heat and takes longer to cool, and can create urban heat islands.

ELEVATION and temperature are generally negatively correlated, meaning it's usually hotter at lower elevations.

OLDER ADULTS, especially those who are socially isolated, are among the most vulnerable during extreme heat events.

MOBILE HOMES can be more isolated than other types of housing and are less likely to have **AIR CONDITIONING**, which is among the most effective ways to cope with heat.

DEMOGRAPHIC FACTORS – such as race, income, language, education, and disability – can impact vulnerability to heat.

VEHICLELESS HOUSEHOLDS may have a more difficult time accessing cooled locations and other resources. And walking, bicycling, or taking public transit can increase exposure to heat.

UNSHELTERED HOMELESS lack many of the resources needed to prepare for and endure extreme heat, and are among the most exposed and vulnerable to extreme heat.

VEGETATED LANDCOVER can be a source of shade and facilitates evaporation, which results in a cooling effect.

DATA & METHODS

Heat vulnerability indicators

To identify indicators of the three components, an extensive review of heat vulnerability studies and indexes was completed, and local subject-matter experts were consulted. While reviewing existing studies and indexes produced by other cities and regions, a core set of variables found across the majority of analyses emerged. Our analysis began here with a dozen or so variables widely held to increase heat vulnerability. Local experts[6] were then consulted to better understand factors unique to the region to consider. In total, 18 indicators – which act as proxies to understanding the complex, interconnected nature of extreme heat vulnerability – were selected. The indicators, presented in the below table, are organized around the three components of heat vulnerability. (See Appendix A for additional detail on the selected indicators.)

	INDICATOR	VARIABLE DESCRIPTION	DATA SOURCE
EXPOSURE	Land surface temperature	Difference in daytime and nighttime land surface temperature from June 18 – 25, 2017[7] (1 km)	NASA, MODIS Land Surface Temperature and Emissivity (MOD11)
	Developed land	Percent of developed land (e.g., cement, asphalt, buildings, etc.)	Multi-Resolution Land Characteristics (MRLC) Consortium, National Land Cover Database (2016)
	Vegetated land cover	Percent of an area covered in vegetation (such as trees, shrubs, grass, etc.) from August 29, 2019 (10 m)	ESA Sentinel-2 Satellite, Normalized Difference Vegetation Index
	Mobile homes	Housing units that are mobile homes	U.S. Census Bureau, American Community Survey, 5-year Estimates (2014-2018)
	Air conditioning	Residential parcels without air conditioning	Clark County Assessor's Office, Residential Extraction dataset
	Elevation	Height above sea level	PRISM Climate Group, Oregon State University, Digital Elevation Model
ADAPTIVE CAPACITY	Disability	Population ages 18-64 with a disability (hearing, vision, cognitive, ambulatory, self-care, or independent living difficulty)	U.S. Census Bureau, American Community Survey, 5-year Estimates (2014-2018)
	Educational attainment	Adults 25 years and older who did not receive a regular high school diploma (or any foreign alternative)	U.S. Census Bureau, American Community Survey, 5-year Estimates (2014-2018)
	Language (limited English proficiency)	Population age 5 and older with limited English proficiency	U.S. Census Bureau, American Community Survey, 5-year Estimates (2014-2018)
	Poverty	Population age 20-64 with an income in the past 12 months below the poverty level	U.S. Census Bureau, American Community Survey, 5-year Estimates (2014-2018)
	Race (non-white population)	Population of a race other than "White (non-Hispanic or Latino)"	U.S. Census Bureau, American Community Survey, 5-year Estimates (2014-2018)
	Unsheltered homeless	Population of unsheltered homeless	Southern Nevada Homeless Continuum of Care, Point-in-time Homeless Count (2017-2019)
	Vehicleless households	Households without a vehicle	U.S. Census Bureau, American Community Survey, 5-year Estimates (2014-2018)
SENSITIVITY	Older adults	Population age 50 and older	U.S. Census Bureau, American Community Survey, 5-year Estimates (2014-2018)
	Isolated older adults	Adults 65 and older who live alone	U.S. Census Bureau, American Community Survey, 5-year Estimates (2014-2018)
	Diabetes	Diabetes-related health incidents per 100,000 (age adjusted)	Southern Nevada Health District, Nevada death certificate data (2013-2017); Nevada hospital discharge data (2016-2017)
	Heart disease	Cardiovascular-related health incidents per 100,000 (age adjusted)	Southern Nevada Health District, Nevada death certificate data (2013-2017); Nevada hospital discharge data (2016-2017)
	Respiratory disease	Chronic lower respiratory disease-related health incidents per 100,000 (age adjusted)	Southern Nevada Health District, Nevada death certificate data (2013-2017); Nevada hospital discharge data (2016-2017)

[6] Among those consulted were researchers at the UNLV School of Public Health and public health professionals at the Southern Nevada Health District.

[7] This date range was selected because it was a contemporary heatwave that included the hottest day recorded at the McCarran Airport Weather Station since 2014 and occurs concurrently with ACS survey estimates used in this study.

Index & spatial analysis summary

After variables were identified for each of the 18 indicators, data was collected, processed, and prepared for analysis. Each variable was then mapped.

To overcome differences in the variables' spatial units of measurement (e.g., zip code, block group, census tract, or pixel resolution), which do not allow for direct comparison, the data was disaggregated into a uniform grid using the U.S. National Grid (USNG). Doing so divided the urbanized region into 129,100 1,000-square-meter cells, each with a disaggregated estimate of the 18 variables.

To improve disaggregated estimates, population-based data was clipped to residential parcels[8] since they refer to data centered around places of residence. This also prevented areas of vacant land, right-of-way, and commercial development from being identified as highly vulnerable areas, as the purpose of the study was to identify areas where people were most vulnerable to extreme heat.

Next, a statistical regression was performed to determine the relative importance of each variable's inclusion in successfully predicting heat-related health outcomes in the region.

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[8] With the exception of the unsheltered homeless population counts

Photo source: CNN

Photo source: Mike Blake/Rueters

Photo source: John Locher/AP

This allowed for variables to be weighted when forming the extreme heat vulnerability index.
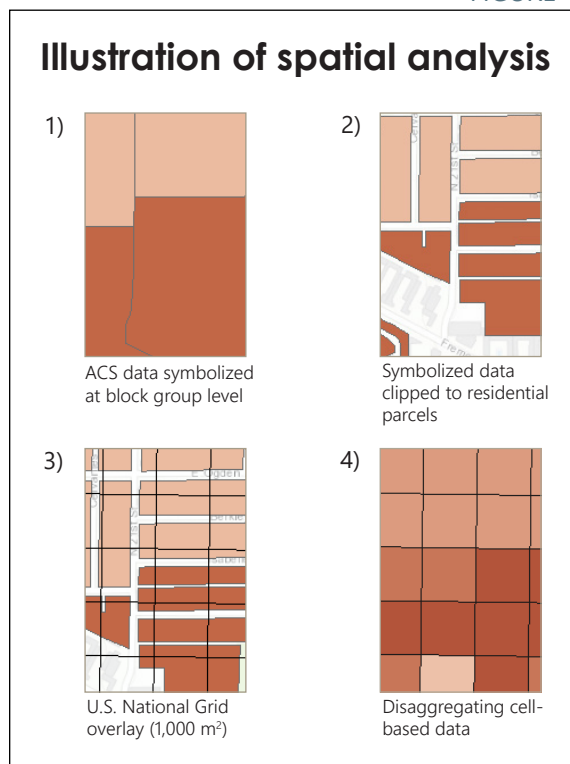
To account for differing units of measurement, each variable was normalized using min-max scaling[9]. Additional scaling was done before each component's weighted score was summed and scaled a final time to create a composite extreme heat vulnerability index

The index results were then mapped, producing a grid cell-based visualization of the results. Next, the spatial results were generalized for both aesthetic and data sensitivity[10] purposes. The results, which are included on the following pages, were then published to an ArcGIS Server to create an interactive web-based map application. Demographic data was added to the web-based map to provide additional neighborhood-level context for users.

See Appendix B for additional detail on the spatial anaylsis methodology.

Illustration of spatial analysis

1) ACS data symbolized at block group level

2) Symbolized data clipped to residential parcels

3) U.S. National Grid overlay (1,000 m²)

4) Disaggregating cell-based data

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[9] Min-max scaling performs a linear transformation on original data, rescaling the range of features to between 0 and 1. For this analysis, a value of 0 was assigned to the grid cell with the minimum variable value in the region and a value of 1 to the grid cell with the maximum value. Remaining cells were transformed to a decimal value between 0 and 1 based on their original value.

[10] Sharing health-related data and demographic characteristics at micro-scale geographies comes with privacy and confidentiality concerns.
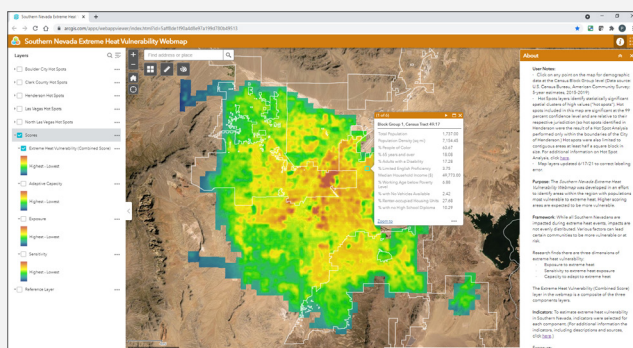
The interactive Southern Nevada Extreme Heat Vulnerability Map is available at https:arcg.is/0mi1n9

RESULTS

The Southern Nevada Extreme Heat Vulnerability Map (see Figure 5) visualizes the spatial distribution of extreme heat vulnerability among the region's population. Red areas in the composite map below represent those with populations most vulnerable to extreme heat, according to the analysis. In the three component maps (see Figures 6-8), red areas represent those with populations most vulnerable to each respective component.

It is important to note that this analysis measured relative vulnerability to extreme heat, not absolute vulnerability. So it should not be inferred that there is little or no vulnerability in areas at the opposite end of the spectrum, just that there are lower levels of vulnerability relative to other areas of the region.

FIGURE 5

EXTREME HEAT VULNERABILITY

Highest

Lowest

N

EXPOSURE

SENSITIVITY
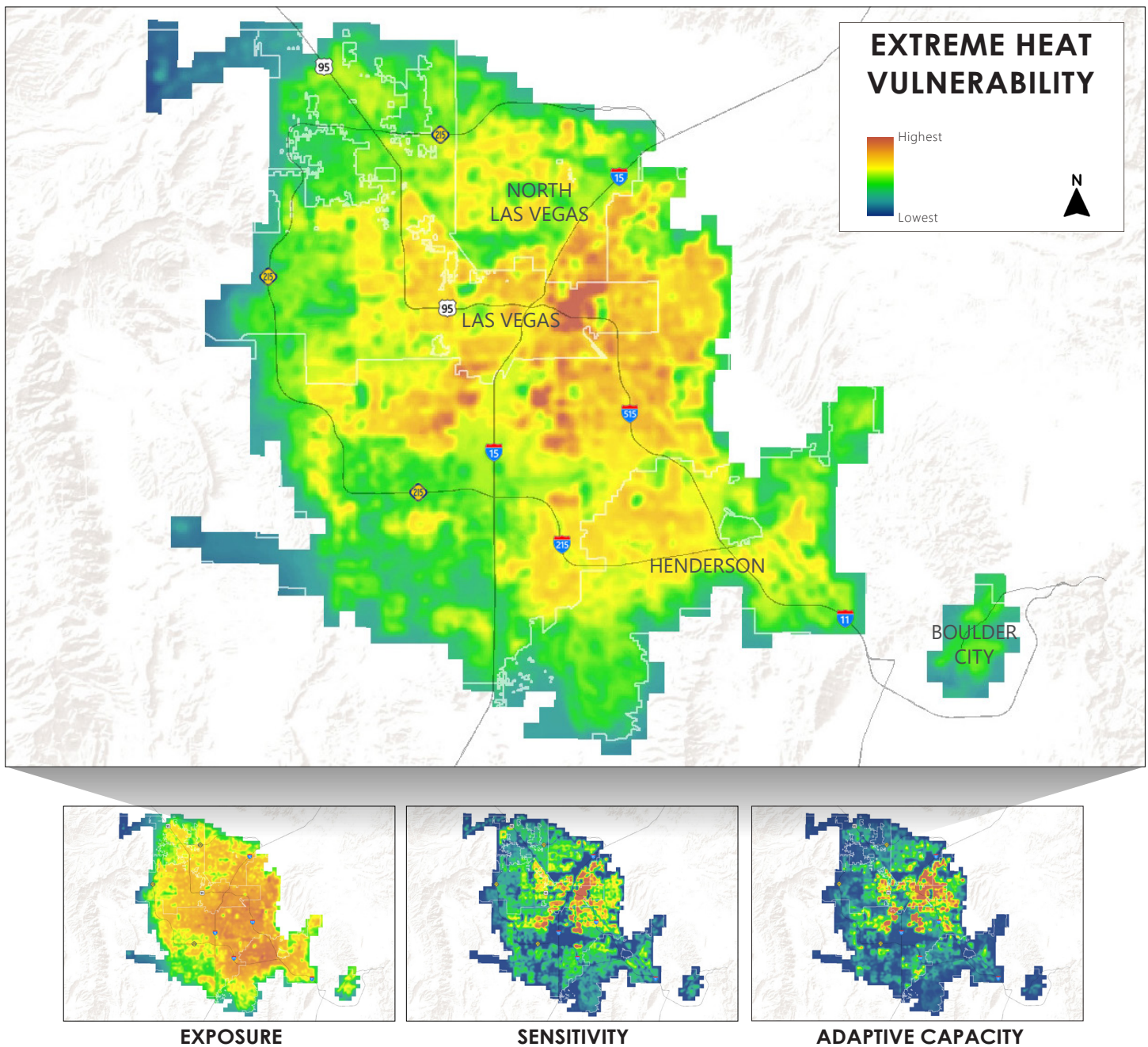
ADAPTIVE CAPACITY

Exposure

The spatial distribution of EXPOSURE factors (see Figure 5) is more evenly dispersed across the region than the SENSITIVITY and ADAPTIVE CAPACITY components. However, EXPOSURE is more intense in the eastern half of the valley, and is closely correlated with the region's elevation, the most influential variable in this set, according to the analysis. Elevation drops by as much as 2,000 feet from west to east in developed area of the region, resulting in naturally higher temperatures in the valley's east side[11], especially east of the I-515 freeway.

The difference in daytime and nighttime land surface temperature was the next strongest variable in the EXPOSURE set. Its influence can largely been seen in two areas: It's largely responsible for the Summerlin South area's relatively high score compared to neighboring areas, and it also contributes to the dark orange area in central Henderson. However, it is worth noting that while both Summerlin South and central Henderson cool less overnight than much of the urbanized region, the former is naturally cooler due, in large part, to its higher elevation.

Sensitivity

Populations most sensitive to extreme heat in Southern Nevada are concentrated in the region's urban core – largely in and around downtown Las Vegas, downtown North Las Vegas, and the resort corridor. The most influential SENSITIVITY indicators based on the analysis were the three related
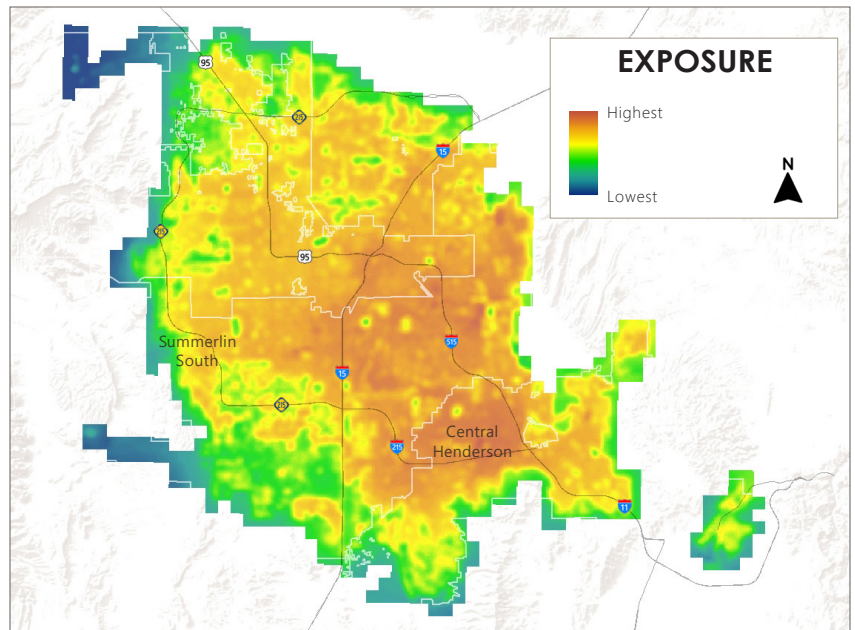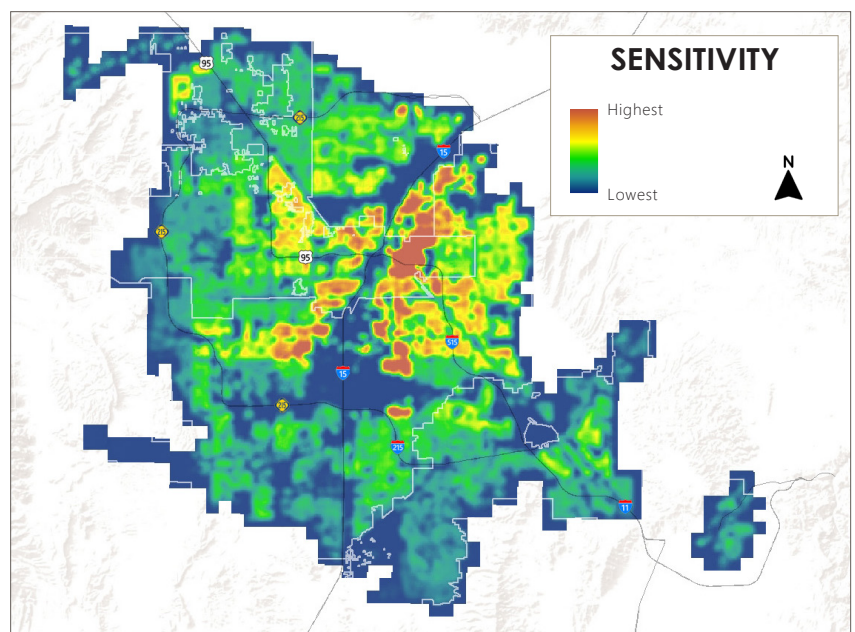
FIGURE 6

FIGURE 7

[11] On average, the temperature drops 3.57°F for every 1,000-foot increase in elevation in the Las Vegas region, according to the National Weather Service's Las Vegas office. This means there can be a difference of up to 10°F from one side of the valley to the other.

to health: Heart disease, diabetes, and chronic lower respiratory disease. The prevalence of each, not surprisingly, is highest in the same areas.

These health conditions are particularly sensitive to extreme heat. Higher temperatures can increase heat rate and blood pressure, which negatively impact individuals with cardiovascular issues and diabetes (Peters et al. 2020). And because extreme heat can worsen air quality, particularly in dry climates, it can exacerbate asthma and other respiratory conditions (Tibbetts 2015).

Adaptive Capacity

Populations least able to adapt to or cope with the impacts of extreme heat in the region are primarily concentrated in the valley's urban core and east side. The three most influential ADAPTIVE CAPACITY indicators, based on the analysis, are educational attainment, race, and homelessness.

Research finds that low levels of educational attainment can be a barrier to accessing weather forecasts and extreme weather advisories and warnings (Muttarak et al. 2014), which can allow individuals to appropriately prepare for and respond to weather-related hazards. Low levels of educational attainment are also highly correlated with lack of financial resources, which can limit the ability of households to cope with extreme heat. Adequately weatherizing a home or running air conditioning for extended periods, for example, can be cost prohibitive for low-income households.

Studies also find that non-white populations are disproportionately impacted by extreme heat in the U.S., due in large part to decades of discriminatory housing and

land use policies (Benz et al. 2021; Hoffman et al. 2020).

Unsheltered homeless populations often lack many of the critical resources needed to prepare for and endure extreme heat. In Maricopa County, Arizona, data compiled by the public health department show that homeless individuals represent a fast-growing share of heat-related deaths (Flavelle et al. 2019).
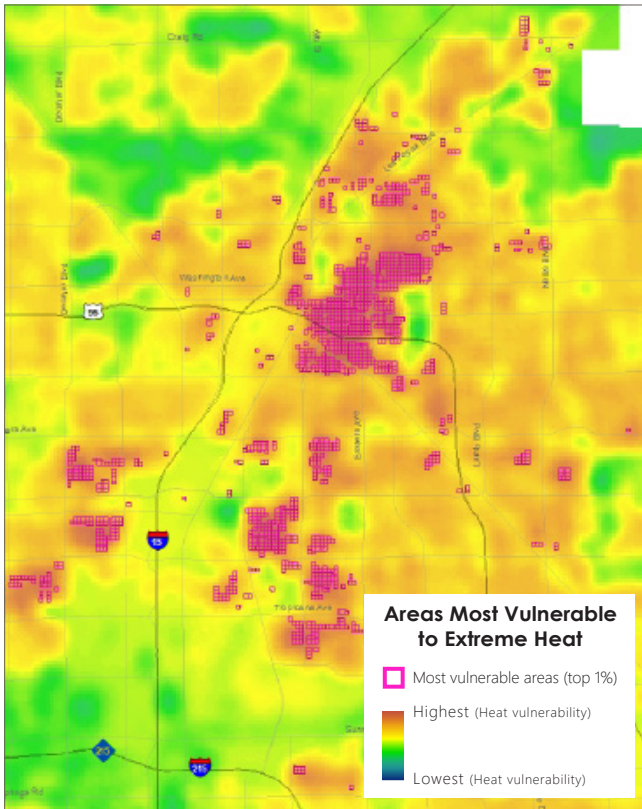
FIGURE 8
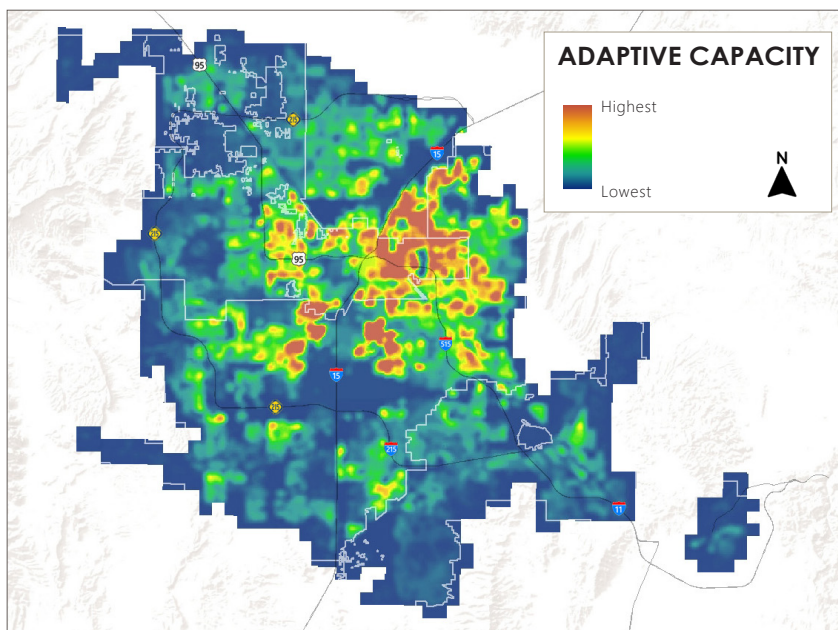
Extreme heat vulnerability

Even to an untrained eye, it's clear that heat vulnerability is highest among populations in the central and eastern valley. And the data bears this out. The majority of the highest-scoring 1 percent of grid cells (i.e., areas with populations most vulnerable to extreme heat) are located in and around the region's urban core and the east side (see Figure 9). These areas include many of the region's older neighborhoods. The populations in these areas are typically more racially and ethnically diverse than other parts of the region, and more economically challenged. And because these areas are also at lower elevations than much of the western half of the urbanized region, they experience naturally higher temperatures.

FIGURE 9

Areas Most Vulnerable to Extreme Heat

☐ Most vulnerable areas (top 1%)

Highest (Heat vulnerability)

Lowest (Heat vulnerability)

The highest scoring 1 percent of cells (i.e., areas with populations the most vulnerable to extreme heat) in the region highlighted in pink.

In total, an estimated 115,000 people live in the highly vulnerable areas highlighted in Figure 9. A full 80 percent are people of color – more than half identify as Hispanic/Latinx, 17 percent as Black/African American, and 6 percent as Asian. Approximately 25 percent of residents are 50 or older, and nearly 20 percent of residents in these areas live alone. The average median income among households is $31,000, and nearly one-in-five people of working age live below the poverty level.

See the Neighborhood Profiles insert between pages 12 and 13 of this report for neighborhood-level context on four areas within the region found to be particularly vulnerable to extreme heat.

Southern Nevada
**Extreme Heat Vulnerability Analysis**

NEIGHBORHOOD PROFILES

Henderson | Las Vegas | North Las Vegas | Uninc. Clark County

RTC

Neighborhood Profiles

As part of the SOUTHERN NEVADA EXTREME HEAT VULNERABILITY ANALYSIS, neighborhood profiles were completed to highlight vulnerable areas that were found to exist within the region's urban core. Four study areas were profiled – one each in the cities of Henderson, Las Vegas, and North Las Vegas, and one in unincorporated Clark County (see map below).

The profiles are intended to provide neighborhood-level context to the SOUTHERN NEVADA EXTREME HEAT VULNERABILITY ANALYSIS, which is regional in nature. Each profile includes existing conditions, demographic data, and a discussion of each study area within the context of extreme heat vulnerability.
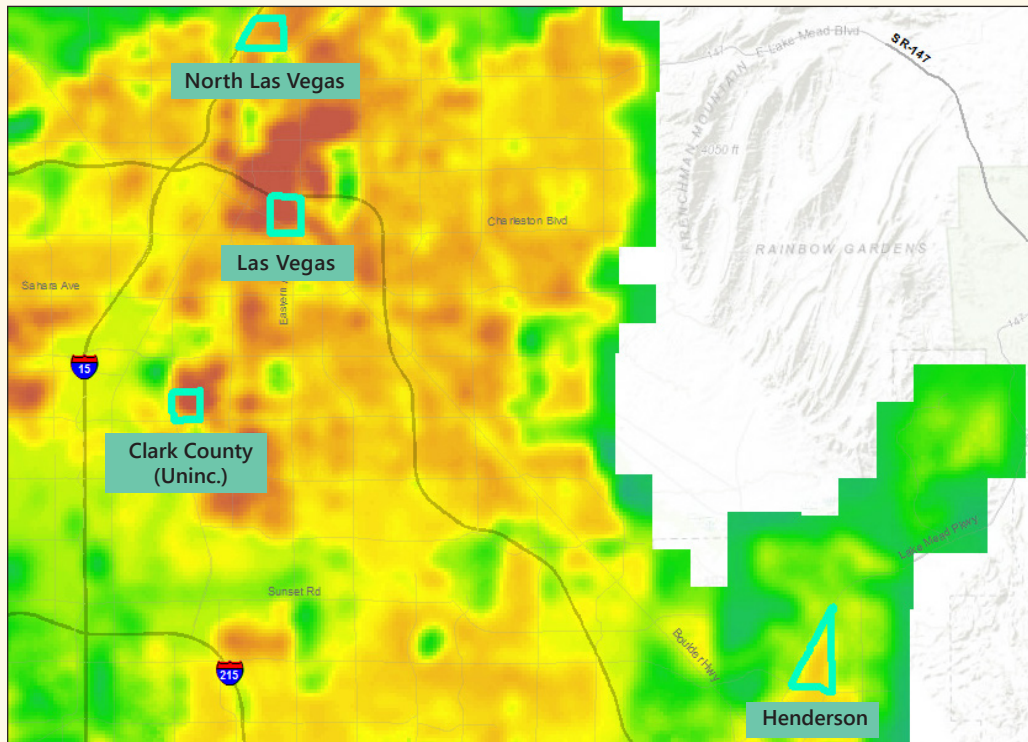
When choosing neighborhoods to profile, two primary factors were prioritized. First, consideration was given to high-scoring areas – the four study areas are among the highest-scoring (i.e., most vulnerable to extreme heat) in their respective jurisdictions. And second, areas were strategically chosen to highlight a range conditions – from the built environment to the makeup of the population – that contribute to higher levels of extreme heat vulnerability. As such, while the observations and insights offered in each profile are specific to the respective neighborhood, they may also be applicable to other areas in the region where characteristics are similar.

The neighborhood profiles were constructed through a variety of research methods, including reviewing local maps and planning documents, informal site visits, and discussions with local planning departments. Review the Summary of Analysis on the following page for an explanation of how high-scoring areas were determined. High scores referenced throughout this section are negative in nature – higher-scoring areas have greater vulnerability to extreme heat.

See the STRATEGIES FOR ADDRESSING EXTREME HEAT section of the SOUTHERN NEVADA EXTREME HEAT VULNERABILITY ANALYSIS for strategies and best practices that could be considered and further explored in these and other high-scoring areas in the region.

Summary of Analysis

To identify areas in Southern Nevada where populations are most vulnerable to extreme heat, extensive data and spatial analysis was completed, built around the three components heat vulnerability:

- **Exposure to extreme heat** – Weather patterns, and both the natural and built environments can influence levels of exposure to extreme heat.

- **Sensitivity to extreme heat** – Demographic, physiological, and health factors may predispose individuals to greater risk to extreme heat.

- **Adaptive capacity** – The ability to prepare for or cope with extreme heat impacts, whether through economic, political, or social resources.

Indicators for each component were selected based on existing research and input from local experts.

EXTREME HEAT VULNERABILITY INDICATORS		
EXPOSURE	**SENSITIVITY**	**ADAPTIVE CAPACITY**
• Temperature • Vegetation • Developed land • Elevation • Air conditioning • Mobile homes	• Older adults (50+) • Isolated seniors • Diabetes • Heart disease • Respiratory illness	• Disability • Educational attainment • Limited English • Poverty • Race (non-white) • Unsheltered homeless • Vehicleless households

Creating a vulnerability ranking based on the data above required overcoming differences in each variables' spatial and numerical units of measurement.

To place each variable in a common spatial unit, the data was disaggregated into a uniform grid using the U.S. National Grid (USNG). Doing so divided the urbanized region into 129,100 100-square-meter cells, each with a disaggregated estimate of the 18 variables. These grid cell values were subsequently scaled to remove units of measurement from each variable.

Before aggregating each set of variables, a statistical regression was performed. As an output, the regressions quantitatively describe the relative importance of each variable's inclusion in successfully predicting the rate of heat-related health outcomes.

Additional scaling was done before each component's weighted score was summed and scaled a final time to form a combined score.

See the DATA & METHODS section, as well as Appendix B, of the SOUTHERN NEVADA EXTREME HEAT VULNERABILITY ANALYSIS report for additional methodology details and analysis results.

CITY OF HENDERSON Neighborhood Profile

Overview of Area

The Henderson study area is located at the northernmost point of the Valley View neighborhood in East Henderson, one of the oldest parts of the city. Like much of East Henderson, the area is economically challenged, demonstrated by its location within both an Opportunity Zone and USDA-defined food desert.

The study area is comprised mostly of low-density residential development, including single-family houses and mobile homes. A cluster of higher-density multifamily complexes, including a Southern Nevada Regional Housing Authority property, is located along Warm Springs Road. The rest of the southern portion of the area (south of Meyers Ave.) is largely made up of ranch-style homes built around 1980. Nearly all of the remaining 100 acres of residential development (north of Meyers Ave.) is mobile/manufactured homes, much of which was built in the mid-1960s. The residents in this portion of the study area tend to be older and Caucasian, as well as more likely to have a disability and have lower incomes compared to the rest of the study area's population. Commercial development in the area is located along Lake Mead Pkwy. Businesses range from a Wildfire Casino and health/rehabilitation center to gas stations and convenience stores.

Infrastructure in the study area appears to be well maintained. The roadways and sidewalks are in good condition. Pedestrian improvements and bike facility enhancements – including a separated bike path along Pueblo Blvd. – were recently completed along several streets running through the area. One defining feature of the built environment in the study area is a concrete stormwater drainage channel that runs along Pueblo Blvd. that limits connectivity. Between Warms Springs Rd. and the northernmost point of the study area, there is only one pedestrian access point to cross the fenced-in channel to the east.

The study area's lack of open space further draws attention to the connectivity barrier the channel presents, as it limits many residents from easily accessing Hayley Hendricks Park located just east of channel. The 20-acre park includes large natural grass fields, mature trees, shaded playground equipment, a splash pad, and covered picnic areas. On the opposite side of the study, west of Lake Mead Pkwy., area are two newly-built parks in the Cadence master planned community. Cadence Central Park features abundant green space along with covered picnic areas and a 2.5-acre pond, while Desert

Study area
- **Boundaries**: Lake Mead Pkwy., Pueblo Blvd., Warm Spring Rd.
- **Zip code**: 89015
- **Census tract**: 54.21
- **Sq. miles**: 0.46 | **Acres**: 295

Heat Vulnerability Scores
Study area averages
- **COMPOSITE**: >80th percentile
- **Exposure**: >80th percentile
- **Sensitivity**: >75th percentile
- **Adaptive Capacity**: >80th pctl

Pulse Park features a playground, picnic areas, dog park and shade structures. However, with limited crosswalks and six lanes of fast-moving traffic on Lake Mead, accessing either of these parks by means other than automobile, especially from the residential parts of the study area, can be challenging.

Extreme Heat Vulnerability

Residents in the study area are among the most vulnerable to extreme heat in Henderson. Driven largely by high EXPOSURE and ADAPTIVE CAPACITY scores, the area includes 10 of the top 100 highest-scoring cells in the city. Additionally, the study area is located in the 89015 zip code, which is among the top seven zip codes in the region for heat-related deaths (from 2009-2018) and hospitalizations (from 2016-2018) per capita, according to Southern Nevada Health District (SNHD) data.

Exposure. The area's average EXPOSURE score is in the 80th percentile in the region. Due to its lower elevation, temperatures are hotter in East Henderson than most other parts of the valley. The study area also features little vegetated land cover, limiting natural cooling and shade provided by trees and green space. Although there are large community parks in the near vicinity, access is limited by

Demographic Snapshot

Study area estimates (County-level estimates in parentheses for comparison)

Population: 3,365
Households: 1,097
Age
- **Median**: 48 years old (37)
- **65 and over**: 21% (15%)

Race/ethnicity
- **Asian**: 3% (10%)
- **Black/Afr. American**: 10% (12%)
- **Hispanic/Latinx**: 19% (31%)
- **White**: 69% (60%)

Language
- **Limited English proficiency**: 4% (7%)
- **Spanish-speaking households**: 15% (31%)

Education
- **Bachelor's degree or higher**: 10% (25%)
- **Less than a high school diploma**: 18% (14%)

Income
- **Median household**: $36,600 ($59,300)
- **Individual below poverty**: 35% (14%)

Transportation
- **Households without a vehicle**: 21% (8%)
- **Take public transportation to work**: 16% (3%)

Housing
- **Detached single-family homes**: 36% (59%)
- **Mobile homes**: 20% (3%)
- **Renter-occupied housing**: 53% (46%)
- **Renter-burdened households**: 78% (52%)
- **65 and older living alone**: 10% (9%)

U.S. Census Bureau, American Community Survey, 5-year estimates (2015-2019)

infrastructure barriers previously noted.

The area's concentration of mobile home units also contributes to its high average EXPOSURE score. Data finds that mobile homes are less likely to be weatherized or have central air conditioning, which can increase exposure levels of inhabitants. Assessor's records indicate that roughly 32 percent of the mobiles homes in study area don't have air conditioning, 15 times higher than the overall regional rate.

Sensitivity. While the study area's average SENSITIVITY score is in the 75th percentile regionally, it's among the highest in Henderson. The median age of the area's residents, 48, is nearly 11 years older than that of the region, and East Henderson residents also have higher rates of health conditions that can be exacerbated during extreme heat events. The 89015 zip code ranks in the top 20 percent of all zip codes in the county for health issues stemming from chronic lower respiratory disease and diabetes per capita, according to health district data.

Adaptive Capacity. Similar to its SENSITIVITY score, the study area's average ADAPTIVE CAPACITY score is among the highest in Henderson. Median household incomes in the study area are among the lowest in Henderson and nearly $23,000 less than that of the region. And a third of the study area's population had an income below the poverty level. Incomes are lowest among residents in the cluster of multifamily housing along Warm Springs Rd. and manufactured housing north of Meyers Rd.

Approximately 25 percent of area residents identify as having a disability, twice that of the region as a whole. One-in-five households in the study area do not have access to a vehicle, leaving them more likely to rely on forms of transportation that subject them to greater levels of direct exposure to extreme heat, such as walking, bicycling, or taking public transit.

A flood channel that runs parallel to Pueblo Blvd. limits connectivity in the study area. A lone pedestrian crossing provides access east to Hayley Hendricks Park.

CITY OF LAS VEGAS Neighborhood Profile

Overview of Area

Located on the city's east side approximately a mile from the core of Downtown Las Vegas, the Las Vegas study area is among the oldest neighborhoods in the region. While the border between the Downtown Las Vegas and East Las Vegas planning areas run through the study area, its population and general character more closely align with the latter. Like much of East Las Vegas, the study area's population is predominantly comprised of communities of color (especially Hispanic/Latinx), and it features an older housing stock with a variety of housing types. In addition to the demographic and built environment similarities, the area also grapples with many of the same challenges that face East Las Vegas, including a high poverty rate, limited open space, environmental justice issues, and historical disinvestment.

The study area is among the most economically challenged in the region. At just over $20,000, its median household income is a third of the region's and among the lowest in Clark County. Nearly 40 percent of area residents are below the poverty level, and two-thirds of households are housing cost burdened. While both Downtown Las Vegas and East Las Vegas have been the focus of redevelopment efforts, recent private investment has been concentrated downtown and has yet to consistently make its way to the east side. However, new economic initiatives by the city aim to enhance workforce development in East Las Vegas and capitalize on training centers in the district, according to the newly adopted City of Las Vegas 2050 Master Plan[1].

Most of the real estate in the study area consists of older residential development with a range of housing types, much of which is naturally occurring affordable housing. The majority of the northern half of the study area is ranch-style single family homes built in the 1950s. A cluster of small multiplexes and low-rise apartments of a similar vintage is located along and around Stewart Ave. Housing in the southern half of the study area varies considerably, both in terms of type and affordability. The southwestern quadrant includes several higher density low-rise apartment complexes, along with a cluster of contemporary loft-style townhomes. The southeastern quadrant consists of low-rise apartments, including a 50-unit emergency housing complex targeted to low-income veterans. Fremont Street also features several single-story converted motels whose rooms are now small rental units.
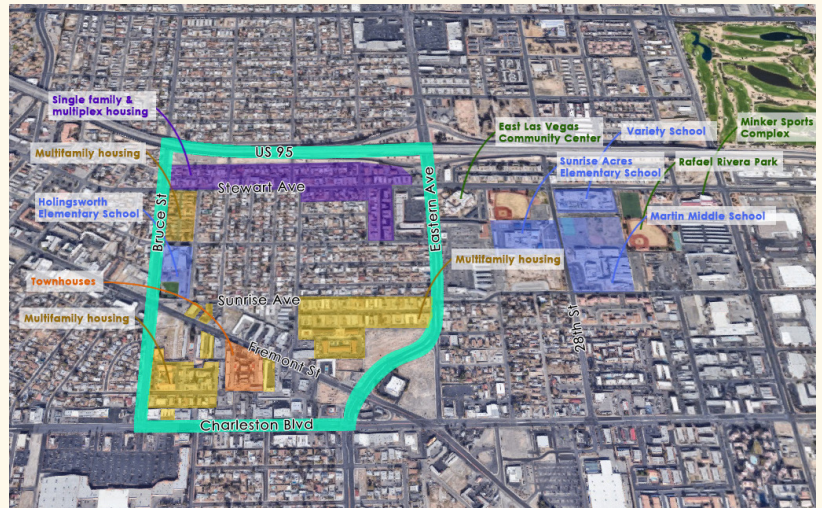
Study area
- **Boundaries**: Bruce Street, I-515, Eastern Ave., Charleston Blvd.
- **Zip code**: 89101
- **Census tract**: 5.21
- **Sq. miles**: 0.3 | **Acres**: 190

Heat Vulnerability Scores
Study area averages
- **COMPOSITE**: >99th percentile
- **Exposure**: >80th percentile
- **Sensitivity**: >99th percentile
- **Adaptive Capacity**: >95th pctl

Given the high share of multifamily housing in the study area, it's of little surprise that the majority of residents are renters – though the extent to which may be somewhat surprising: 90 percent of residential units are inhabited by renters, though single-family homes make up more than a quarter of all housing units.

Commercial development is largely concentrated in the southern half of the study area. Strip malls populated with small local businesses are prevalent along Charleston Blvd., while Fremont Street features a mix of commercial development ranging from budget motels, auto parts stores, and a self-storage location. Businesses in the area's northern half are mostly confined to a strip mall along Eastern Ave. at the corner of Stewart Ave.

Infrastructure in the study area is a bit of a mixed bag. Streets and sidewalks are in relatively good condition, though small stretches of sidewalk are incomplete along several residential streets. Connectivity is generally good given the minimal cul-de-sacs and block walls, however the pedestrian network, while better than many areas in the region, suffers somewhat from longer block lengths. Residential units vary in condition, though many of the multifamily and multiplex properties appear poorly maintained. As is the case with most of downtown and East Las Vegas, designated green space in the study area is lacking. However, a public park, community center, and recreation center are all less than a one mile walk

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[1] Adopted in the summer of 2021, the 2050 Master Plan establishes a new vision for a livable and sustainable Las Vegas and addresses a variety of issues and challenges – including population growth, public health, drought, recreation, housing, and economic diversification – in a manner that aim to provide residents equitable access to services, education and jobs. It also addresses climate hazards like extreme heat, urban forestry, and establishes a layered complete street network throughout the city.

for nearly all residents in the study area, and along with nearby schools, could be valuable assets for helping address extreme heat impacts in the area.

Many of the residential properties feature mature trees. However, city planners worry that many of the trees in East Las Vegas may soon be in need of replacement due to their age, heat stress, and maintenance needs. As part of the city's downtown master plan and new form-based code, new requirements for trees were included, and shade trees have been planted along Fremont Street in accordance with the new standards. And the 2050 Master Plan prioritizes increasing the tree canopy in East Las Vegas to combat ozone and extreme heat.

Concerns about trees nearing the end of their lifecycle and the lack of parks and open space are illustrative of environmental justice concerns that face much of the city's east side. The portion of I-515 that runs through East Las Vegas is among the most heavily congested roadway segments in the region, resulting in higher levels of noise and air pollution for the surrounding community. In fact, East Las Vegas has among the highest concentrations of ozone in the city, according to the city. There are concerns that a potential freeway expansion project on I-515 could further exacerbate environmental justice issues.

Extreme Heat Vulnerability

Residents in the study area are among the most vulnerable to extreme heat in Southern Nevada. Six of the top 50 highest-scoring cells in region are in the study area – all of which are south of Sunrise Ave. The 89101 zip code, in which the study area is located, has experienced among the most heat-related deaths (from 2009-2018) and hospitalizations (from 2016-2018) in the region, according to Southern Nevada Health District (SNHD) records. While all three of its average component scores are relatively high, its Sensitivity and Adaptive Capacity scores are the primarily drivers of its overall extreme heat vulnerability, with both above the 95th percentile.

Exposure. The study area's average Exposure score puts it in the 70th percentile in the region. Due to its lower elevation, temperatures are naturally hotter in the study area than much of the western half of the urbanized region. While the majority of the study area consists

of developed land, it does feature a fair amount of vegetated land cover. Many of the homes in the study area feature mature trees and lawns, while the multifamily developments, include fairly dense tree coverage. The parks and schools in and around the area also include natural green space and trees, which provide cooling and shade. The area's Exposure score is also helped by the fact that nearly all residential units have air conditioning, according to Assessor's records.

Sensitivity. The study area's average Sensitivity score is in the 99th percentile, putting it among the highest in Southern Nevada. It includes 10 of top 100 highest scoring Sensitivity cells in the valley. The area's high scores are largely a product of the high rates of health conditions that are particularly sensitive to extreme heat. The 89101 zips code leads the region in diabetes-related deaths per capita, and has among the highest rates of heart and chronic respiratory diseases, according to SNHD data.

Adaptive Capacity. The study area's average Adaptive Capacity score is also among the highest in the region. Five of the top 250 highest-scoring cells in this category are located in the southern half of the study area. The median household income of residents is among the lowest in the region, and the poverty rate is more than 2.5 times that of the region. This extreme lack of financial resources likely limits the ability of residents to sufficiently cope with extreme heat. Weatherizing a home or running air conditioning for long periods, for example, can be cost prohibitive for low-income households. Additionally, nearly half of households in the study area don't have a vehicle, making them more reliant on transportation modes that subject them to heat.

The low rates of education attainment and high rates of non-English speaking households further contribute to the area's high Adaptive Capacity score. Research points to both factors potentially serving as barriers to accessing public information related to extreme heat, such as warnings and advisories. The study area also features a much higher proportion of communities of color than the region as a whole. Studies find that communities of color in the U.S. are disproportionately impacted by extreme heat due in large part to decades of discriminatory housing and land use policies.

# CITY NORTH LAS VEGAS Neighborhood Profile

Overview of Area

Located just north of the heart of downtown North Las Vegas, the North Las Vegas study area, like much of its immediate surroundings, is economically challenged. The median household income of the area is nearly half that of the region's, and 40 percent of its residents are below the poverty level. While downtown North Las Vegas has seen new investment and redevelopment in recent years, much of it has been concentrated in commercial corridors and conditions in the adjacent neighborhoods have been slow to change.

The study area is a working-class neighborhood made up largely of Hispanic/Latinx families with children. Nearly two-thirds of the population identify as Hispanic/Latinx and almost half of the area's 900 households have children. A quarter of the study area population is younger than 10. The study area features a much higher proportion of communities of color than the region as a whole – specifically Hispanic/Latinx and Black/African American residents.

Real estate in the study area consists mostly of residential development, including single family houses, small multiplexes, and low-rise apartments. Nearly all of the multifamily rental properties are located along the study area's western boundary along Donna Street. Most of the apartments were built in the 1960s and 70s, with the exception of a 144-unit complex located in the southwest corner of the study area, which was built in the 90s. The remaining residential development consists of single-family housing. The subdivisions north of Cartier Ave. consist mostly of ranch-style houses built around 1970. The southeast quadrant of the study area includes a mix of ranch-style houses and small, 2- to 5-unit multiplexes.

While there are no commercial businesses within the boundaries of the study area, it is adjacent to downtown North Las Vegas, which has been the focus of both local and state redevelopment efforts. Directly south of the study area is a Smith's Food & Drug and the Maya Cinemas development. North Las Vegas City Hall & Library is also less than three-quarters of a mile from most points in the study area. Though businesses don't exist in the study area, it is home to several churches and schools, which have the potential to serve as valuable community resources for addressing extreme heat impacts, in addition to the nearby civic resources in downtown.

Infrastructure in the study area appears to be in fairly good condition. Streets and sidewalks look to be well maintained, especially along the study area's main thoroughfares. Connectivity throughout the study area
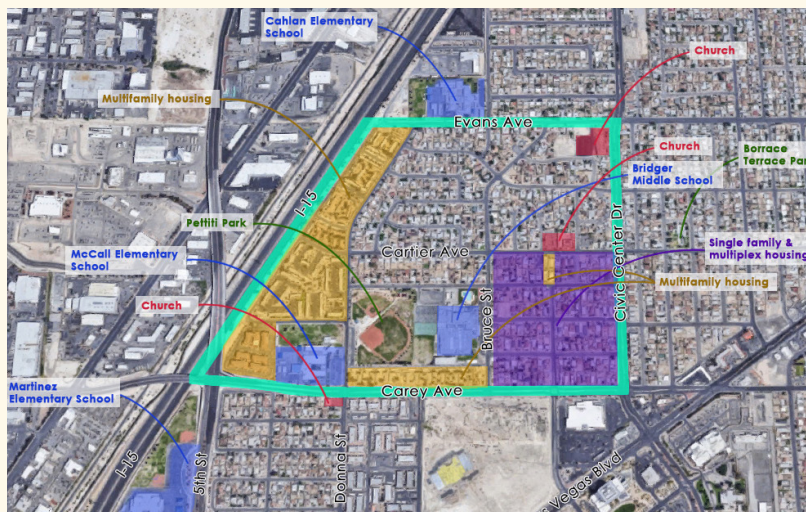
Study area

- **Boundaries**: I-15, Evans Ave., Civic Center Dr., Carey Ave.
- **Zip code**: 89030
- **Census tract**: 44.02
- **Sq. miles**: 0.3 | **Acres**: 190

Heat Vulnerability Scores
Study area averages

- **COMPOSITE**: >95th percentile
- **Exposure**: >70th percentile
- **Sensitivity**: >90th percentile
- **Adaptive Capacity**: >95th pctl

and to neighborhoods to the north, east, and south is relatively good. The block walls and cul-de-sacs that impede connectivity in so many neighborhoods across the valley are fairly limited in the study area. I-15, which serves as the area's western boundary, is an obvious infrastructure challenge. In addition to the negative health and environmental outcomes associated with living near a freeway, it also limits connectivity to the west. Study area residents do have access to several parks and natural open space areas. Each of the four schools in and around the area have green space, though shade trees are somewhat limited. Pettitti Park offers grass fields and shaded picnic areas within the study area. And Boris Terrace Park, located just outside the study area on Cartier Ave., also offers both natural and artificial shade elements. The city is heavily investing in infrastructure improvements in downtown North Las Vegas. New pedestrian and bicycle amenities have been added in recent years, and many of the primary arterial streets also slated for improvements over the next several years.

Extreme Heat Vulnerability

Residents in the study area are among the most vulnerable to extreme heat in the valley. Ten of the top 100 highest-scoring cells in the city are in the study area and are also among the top 1 percent of cells

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<u>Demographic Snapshot</u>
Study area estimates (County-level estimates in parentheses for comparison)

Population: 3,503
Households: 928
Age
- **Median**: 27 years old (37)
- **65 and over**: 37% (15%)

Race/ethnicity
- **Asian**: 0% (10%)
- **Black/Afr. American**: 23% (12%)
- **Hispanic/Latinx**: 66% (31%)
- **White**: 55% (60%)

Language
- **Limited English proficiency**: 19% (7%)
- **Spanish-speaking households**: 41% (31%)

Education
- **Bachelor's degree or higher**: 5% (25%)
- **Less than a high school diploma**: 41% (14%)

Income
- **Median household**: $28,800 ($59,300)
- **Individual below poverty**: 41% (14%)

Transportation
- **Households without a vehicle**: 19% (8%)
- **Take public transportation to work**: 2% (3%)

Housing
- **Detached single-family homes**: 37% (59%)
- **Mobile homes**: 0% (3%)
- **Renter-occupied housing**: 71% (46%)
- **Renter-burdened households**: 58% (52%)
- **65 and older living alone**: 8% (9%)

U.S. Census Bureau, American Community Survey, 5-year estimates (2015-2019)

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in the entire region. The 89030 zip code, in which the study area is located, has experienced among the most heat-related deaths (from 2009-2018) and hospitalizations (from 2016-2018) in the entire region, according to Southern Nevada Health District (SNHD) records.

While all three of the study area's average component scores are relatively high, its Adaptive Capacity and Sensitivity scores are primarily responsible for its overall extreme heat vulnerability, with both in the 90th percentile in their respective categories.

Exposure. The study area's average EXPOSURE score puts it in the 70th percentile in the region. Due to its lower elevation, temperatures are naturally hotter in the study area than much of the western portions of the urbanized region. While the majority of the study area consists of developed land, it does feature a fair amount of vegetated land cover. Many of the homes in the study area feature mature trees and lawns, while the multifamily developments, particularly along Donna Street north of Cartier Ave., include fairly dense tree coverage. The parks and schools in and around the study area also include natural green space and trees, which provide natural cooling and shade. The area's EXPOSURE score is also helped by the fact that nearly all of its residential units have central air

conditioning, according to Assessor's records. Two multiplexes in the southeast quadrant, with a total of 6 units between them, are the lone exceptions.

Sensitivity. Driven largely by the high rates of health conditions that are particularly sensitive to extreme heat, the study area's SENSITIVITY scores are among the highest in the North Las Vegas. Although study area residents are much younger than the region as a whole – the median age is 27, 10 years less than the region's – heart disease, chronic lower respiratory conditions, and diabetes are all prevalent in the area. In fact, 89030 ranks among the top 5 zip codes in the region for diabetes-related deaths and hospitalizations per capita and top 10 for heart disease, according to SNHD data.

Adaptive Capacity. The study area's average ADAPTIVE CAPACITY score is in the 97th percentile, putting it among the highest in the valley. In fact, the study area includes six of top 500 highest-scoring cells in the region in this category. Like many of the neighborhoods around downtown North Las Vegas, the study area is economically challenged. Poverty rates are nearly three times the regional rate, and the median household income of study area residents is half that of the region's. This lack of financial resources could limit residents' ability to sufficiently prepare for and cope with extreme heat events. Adequately weatherizing a home or running air conditioning for extended periods, for example, can be cost prohibitive for low-income households.

The low rates of education attainment and high rates of non-English speaking households further contribute to the study area's high ADAPTIVE CAPACITY score. Research points to both factors potentially serving as barriers to accessing and comprehending public information related to extreme heat, such as warnings and advisories. The study area also features a much higher proportion of communities of color than the region as a whole – specifically Hispanic/Latinx and Black/African American residents. Studies find that communities of color, across all income levels, are disproportionately impacted by extreme heat.

The multifamily developments in the study area, particularly along Donna Street north of Cartier Ave., feature a fairly dense tree canopy.

CLARK COUNTY (Uninc.) Neighborhood Profile

Overview of Area

Located in the unincorporated town of Paradise, the Clark County study area is situated between several regional landmarks: It's just northwest of the University of Nevada-Las Vegas (UNLV) main campus, approximately a mile east of the Las Vegas Strip, and less than a mile south of the Las Vegas Convention Center. Its proximity to the Strip and the commercial development along the Maryland Parkway corridor made the area attractive to working class households in the 1960s and 70s. However, beginning in the 90s, the area began to fall into decline, and over the past few decades, has been one of the more economically challenged neighborhoods in the urban core. The median household income of the study is nearly half that of the region's, and nearly a third of its residents are below the poverty level.

Much of the study area consists of low-rise multifamily units – both walk-up apartments and small multiplexes – several of which are low-cost weekly rentals. Siegel Suites has a strong presence in the area, with three residential properties, as well as a commercial office building. Nearly all of the multifamily units were built between 1962 and 1976, and many of them – especially in the interior of the study area – show their age. Some of the residential properties, particularly those along Flamingo Rd. and University Center Dr., are marketed as off-campus student apartments. The study area's adjoining census tracts to the north and east have similar residential characteristics.

Commercial development in the area is concentrated along Flamingo and Paradise roads, as well as along Twain Ave. west of Palos Verde Street. Businesses along Flamingo and Paradise include a mix of national hotel chains and freestanding restaurants capitalizing on the area's proximity to the resort corridor, as well as strip mall developments largely populated with smaller restaurants. Commercial development along Twain Ave. is very different, consisting mostly of strip malls with small local businesses catering to area residents.

The built environment in the study area is a somewhat inconsistent. Residential units are in varying condition – some properties appear well maintained, while others show obvious wear and tear. Street and sidewalk conditions also vary. Infrastructure on and along main thoroughfares is in relatively good condition, while cracked streets and sidewalks are abundant in the study area's interior. A large unpaved drainage channel, approximately a quarter mile in length and more than 80 feet wide (see Fig. 2), is a prominent feature in the study area's southeast quadrant. In addition to limiting connectivity, it has been used as an encampment for the unsheltered homeless. Connectivity throughout the

Study area
- **Boundaries**: Paradise Rd., Twain Ave., University Center Dr., Flamingo Rd.
- **Zip code**: 89119
- **Census tract**: 24.05
- **Sq. miles**: 0.21 | **Acres**: 137

Heat Vulnerability Scores
Study area averages
- **COMPOSITE**: >95th percentile
- **Exposure**: >95th percentile
- **Sensitivity**: >90th percentile
- **Adaptive Capacity**: >95th pctl

study area is generally poor. Cul-de-sacs in residential areas, the aforementioned flood channel, and walled-off and fenced-in properties serve as impediments.

While some residential properties feature mature trees and landscaping, asphalt is the predominant landcover in the study area. Large parking lots behind the study area's commercial development, especially along Paradise, feature little to no vegetation. Patches of raw undeveloped land also exist throughout the area. Dedicated open space is nonexistent within the study area, though a park and recreation center are both less than a mile's walk from most residential units.

The makeup of study area residents differs in several key ways from the region as a whole. Nearly 60 percent of study area residents identify as Hispanic/Latinx, nearly twice the regional rate. Half of study area households are Spanish-speaking, compared to a third of households in the valley. And close to 60 percent of study area residents are between the ages of 25-59, compared to 48 percent for the region.

Extreme Heat Vulnerability

Residents in the study area are among the most vulnerable to extreme heat in the entire region. Three of the top 50 and 14 of the top 200 highest-scoring cells in the region are in this study area. And all three of its

Demographic Snapshot
Study area estimates (County-level estimates in parentheses for comparison)

Population: 4,089
Households: 1,901
Age
- **Median**: 38 years old (37)
- **65 and over**: 10% (15%)

Race/ethnicity
- **Asian**: 1% (10%)
- **Black/Afr. American**: 12% (12%)
- **Hispanic/Latinx**: 57% (31%)
- **White**: 40% (60%)

Language
- **Limited English proficiency**: 26% (7%)
- **Spanish-speaking households**: 47% (31%)

Education
- **Bachelor's degree or higher**: 6% (25%)
- **Less than a high school diploma**: 39% (14%)

Income
- **Median household**: $30,700 ($59,300)
- **Individual below poverty**: 29% (14%)

Transportation
- **Households without a vehicle**: 48% (8%)
- **Take public transportation to work**: 24% (3%)

Housing
- **Detached single-family homes**: 1% (59%)
- **Mobile homes**: 0% (3%)
- **Renter-occupied housing**: 97% (46%)
- **Renter-burdened households**: 55% (52%)
- **65 and older living alone**: 13% (9%)

U.S. Census Bureau, American Community Survey, 5-year estimates (2015-2019)

component scores – Exposure, Adaptive Capacity, and Sensitivity – are in the 90th percentile in their respective category. Recent data supports these research findings: The 89119 zip code, in which the study area is located, is among the top 10 in the region for heat-related deaths (from 2009-2018) per capita and top 5 for heat-related hospitalizations (from 2016-2018) per capita, according to Southern Nevada Health District (SNHD) records.

Exposure. The study area's average Exposure score puts it in the 90th percentile in the region. Due to its lower elevation, temperatures are naturally hotter in the study area than much of the western half of the region. Additionally, the study area's residents don't experience as much nighttime relief from daytime temperatures as other parts of the region, which suggests the urban heat island effect is at play. The study area's lack of vegetated land cover also contributes to its high average Exposure score. While several properties do have mature trees, many are palm trees, which don't offer the levels of natural cooling or shade that other varieties provide due to their low leaf area. The majority of the study area is developed land, including large parking lots, paved roads, and residential and commercial buildings.

On the plus side, all of the parcels within the study area have central air conditioning. And a public park and community center are both less than a mile's walk from nearly all residential units in the area.

Sensitivity. The study area includes three of the top 500 highest scoring Sensitivity cells in the region. While study area residents don't differ much in terms of age from the region as a whole, they do have higher rates of health conditions that are sensitive to extreme heat conditions. The 89119 zip code ranks in the top 20

percent in the county for heart disease and diabetes per capita and the top 25 percent in chronic lower respiratory disease, according to SNHD data.

Adaptive Capacity. The study area's average Adaptive Capacity score is 16 times higher than the region's. The area's northeast quadrant was found to have among the highest Adaptive Capacity scores in the region. In general, study area residents have less financial resources than most in the region, which limits their ability to prepare for and cope with the negative impacts of extreme heat to the same extent as others in the region. The median household income in the study area is nearly $30,000 less than that of the region, and its poverty rate is twice as high. The study area also has a fairly consistent presence of unsheltered homeless individuals, ranking in the top five percent of census tracts in the region, according to county data. Approximately half of area households don't have a vehicle – six times higher than the regional rate – and a quarter rely on public transportation to get to work.

The low rates of education attainment and high rates of non-English speaking households further contribute to the study area's high Adaptive Capacity score. Research points to both factors potentially serving as barriers to accessing public information related to extreme heat, such as warnings and advisories.

A drainage channel that runs through the southwest quadrant of the study area not only limits connectivity, but is also frequently the site of small homeless encampments.

DISCUSSION

Research application

Identifying the geographic distribution of populations that are particularly vulnerable to extreme heat is an important element of reducing adverse health outcomes associated with extreme heat and a warming climate. Understanding where the populations most vulnerable to extreme heat exist can help local government agencies and service providers prevent negative health outcomes by targeting resources in priority areas.

The results of the spatial analysis, for instance, can help guide the location of cooling stations throughout the region. Furthermore, by utilizing the component maps, the analysis can also inform the types of strategies that might be appropriate or most effective in reducing vulnerability in specific areas. For example, in an area where vulnerability is driven largely by exposure factors, interventions aimed at heat mitigation – such as cool infrastructure and additional vegetation and green space – could be considered. See the Strategies for Addressing Extreme Heat section of this report for a survey of interventions and best practices for addressing extreme heat from across the country.

Limitations

While the maps produced as the result of this analysis offer a clear and easily interpretable illustration of the distributions of extreme heat vulnerability factors, this analysis is best viewed as preliminary, pointing to areas where additional investigation is warranted. This study is not intended to provide a complete picture of the strengths and vulnerabilities of the

region's residents, or of the capacity of service networks to meet the most pressing needs of the community during an extreme heat crisis. No single assessment can quantify all the important aspects that contribute to extreme heat vulnerability, but this approach offers a clarifying picture.

As with any approach to assessment that relies on indicators and variables that act as proxies – in this case, for heat vulnerability – there is some subjectivity involved with regard to the selection and weighting of variables, as well as with spatial transformations. And data constraints, including availability and access, also serve as a complicating factor. As such, the findings presented in this report should be used in conjunction with contextual knowledge, other datasets and research, and wider discussion with relevant stakeholders. It should also be noted that this research should only be interpreted within the context of extreme heat vulnerability. Any attempt to broaden its applicability to related or unrelated subject matters is inadvisable.

Opportunities for continued study

The approach taken in this study can be considered an important early step toward the development of resources that can help stakeholders better understand heat vulnerability in the region and where resources could be allocated to help save lives. However, continued analysis and regional collaboration is recommended to more comprehensively understand and address the threat of extreme heat across Southern Nevada.

As with any study, data limitations could be further explored and addressed. New or more precise data could result in methodological refinement and potentially yield more accurate estimates. For instance, greater access to and examination of health data, which is generally restricted due to privacy concerns, could yield important insight into demographic and socio-economic factors and their relation to heat-related health outcomes. And a more thorough study of temperature data could replace the land surface temperature dataset used in this study, which represents a specific locally occurring heatwave[11].

Recent focus in Southern Nevada on climate change provides a unique opportunity to magnify the significance of extreme heat and its health implications for the region. This

analysis should be used in conjunction with existing efforts, including ongoing heat-related studies, to explore and implement interventions – from new policies, programs, and activities – that could result in lives being saved and a more sustainable community. The

Photo source: Michael Quine/Las Vegas-Review Journal

region is renowned for the innovative and aggressive measures it has taken in the interest of water conservation; a similar approach is certainly worth considering given the expectation of rising temperatures in the near future.

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[11] The Land Surface Temperature dataset used in this study is composed of the average values of clear-sky land surface temperatures from June 18 – 25, 2017. This range was selected because it was a contemporary heatwave that included the hottest day recorded at the McCarran Airport Weather Station since 2014 and occurs concurrent with ACS estimates. While this data was visually compared with other local heatwaves and satellite imagery of surface temperature to assess its applicability – little variation was found – a more scientific approach is certainly recommended for future study.

ADDRESSING EXTREME HEAT

Cities and regions across the globe have taken steps in recent years aimed at cooling temperatures and protecting residents from heat's negative impacts. This section includes a survey of strategies and best practices that have been explored and implemented.

The actions presented in this section should not be seen as a complete or exhaustive inventory of interventions, but as a broad sampling of strategies that could be considered and further explored in Southern Nevada. Included strategies are limited to those deemed appropriate or feasible for the region. Green roofs, for example, are not included because they are generally water intensive, which would present a challenge given the valley's limited water resources.

Included actions are sorted into four categories:

- Mitigation – Strategies aimed at temperature reduction

- Adaptation – Strategies aimed at helping people adapt to or cope with extreme heat

- Education & Outreach – Strategies aimed at raising awareness, improving social cohesion, and building capacity of residents and stakeholders

- Planning & Policy – Strategies aimed at creating or shifting policies to address extreme heat and environmental injustice

Each action noted below is accompanied by a brief description, as well as examples of where they have been implemented. Additionally, a qualitative assessment of how well each strategy addresses each component of heat vulnerability is included. Several actions are called out in greater detail.

For more case studies related to heat mitigation, adaptation, and policy, see ULI's "Scorched" report.

WATTS SERENITY PARK

For decades, 1.13 acres of land on Monitor Avenue in the Watts neighborhood of Los Angeles lay vacant, overgrown with weeds and strewn with garbage and broken glass. When plans for a housing development fell through, the prospect of giving local children and their parents a safe place to meet and play motivated neighbors to step forward and support the creation of a community park.

Local residents actively participated in the park planning process. At a series of community workshops, they suggested special features and refined initial input into a coherent concept for the entire park. When Watts Serenity Park opened it 2015, it included features residents prioritized most: The final design includes play equipment for kids, an exercise area for adults, and a skate park.

The park also includes shaded picnic areas, natural green space and trees, and light-colored pavement, all of which combat the urban heat island effect. On sunny days, much of the infrastructure in urban areas — from asphalt roads and dark shingles on rooftops to blacktop on basketball courts — traps heat and drives up the temperature. That's why cities are often so much hotter than surrounding rural areas.

Photo source: Breen Engineering & EPT Design

(Above) Watts Serenity Park.

(Left) Watts residents in the vacant lot that became Watts Serenity Park.

Photo source: Trust for Public Land

ACTION	DESCRIPTION	EXAMPLES OF IMPLEMENTATION	HEAT VULNERABILITY DIMENSIONS ADDRESSED	
MITIGATION				
Cool infrastructure	Altering or constructing city surfaces (i.e., pavements, roofs, and walls) with coatings and seals that reflect solar energy can help combat the urban heat island effect in the right conditions. Conventional dark pavements, like asphalt, absorb 80-95 percent of sunlight. Cool roofs can be as much as 50 degrees cooler than a standard roof on a hot summer day.	City of Phoenix's Cool Pavement Pilot Program (2020); State of California's Cool Roof requirement	Adaptive Capacity Exposure Sensitivity	◔ ● ○
Parks & open space	Parks and open spaces can help reduce surrounding air temperatures, creating "cool park islands," when vegetation and other impermeable surfaces are adequately incorporated. They can also provide outdoor refuge and help improve air quality.	WATTS SERENITY PARK (LOS ANGELES); Tulsa's Gathering Place Park (Tulsa, Okla.)	Adaptive Capacity Exposure Sensitivity	◐ ● ◐
Shade structures	Shade sails, awnings and other artificial canopies can be installed on buildings or incorporated into landscape design to enhance comfort and reduce the impact of extreme heat. Studies find that shade can lower temperatures in excess of 20°F in certain conditions.	SKYSONG (ASU SCOTTSDALE INNOVATION CENTER); Sundance Square Plaza (Fort Worth, Tex.)	Adaptive Capacity Exposure Sensitivity	◔ ● ○
Tree canopy expansion	Trees are one of the best and cheapest ways to combat the impacts of heat in urban areas. Healthy tree canopies provide shade and water transpiration that can mitigate the heat island effect, as well as improve air quality.	Cincinnati's urban forestry program; Trees for Tucson program; Baltimore's TreeBaltimore program; Greening of Detroit's tree-planting program	Adaptive Capacity Exposure Sensitivity	◐ ● ◐
Urban design	The geometry and design of cities and neighborhoods can play an important role in cooling. For instance, linear parks and green corridors help to enhance the movement of air through a city, and varied building forms can promote ventilation and the release of trapped heat.	Edison Eastlake housing development (Phoenix); SKYSONG (ASU SCOTTSDALE INNOVATION CENTER)	Adaptive Capacity Exposure Sensitivity	○ ● ○
ADAPTATION				
Climate-adapted bus shelters	Transit shelters can be designed and/or retrofitted with technology and cooling elements – such as air conditioning, hydration stations, and enhanced canopy designs – that provide a safer and more comfortable experience for transit riders.	Dubai's fully air-conditioned transit shelters; JCDecaux's Natural Cooling bus shelter; UTS's Climate Adapted People Shelters	Adaptive Capacity Exposure Sensitivity	● ◐ ○
Cooling appliance distribution	Distribution of appliances like fans and air conditioning units can provide needed relief from high temperatures to low-income households and populations most vulnerable to heat.	Philadelphia's Beat the Heat initiative; City of Chelsea, Mass.; Society of St. Vincent de Paul - Cincinnati's (SVDP) heat relief assistance	Adaptive Capacity Exposure Sensitivity	● ◐ ○
Cooling centers	Cooling centers are generally air conditioned public spaces, often community centers and libraries, that provide respite from heat. Locating cooling centers in areas of high vulnerability can reduce heat-related morbidity and mortality.	Maricopa County's Heat Relief Network, which includes cooling centers, hydration stations, and emergency heat relief stations operated by a nonprofit partner	Adaptive Capacity Exposure Sensitivity	◐ ● ○
Energy assistance (targeted)	For low-income households, energy bills as a portion of income are three times higher than for the average customer. Energy assistance programs make energy bills more affordable generally through direct financial assistance (e.g., bill discounts, lower rates, etc.). Targeted assistance for areas of high vulnerability could contribute to a reduction in heat-related illness and death.	State of Utah's Home Energy Assistance Target (HEAT) program	Adaptive Capacity Exposure Sensitivity	● ◐ ○

Microtransit	Microtransit services and small-scale circulators can limit exposure to heat in areas with high pedestrian activity. For instance, in areas with high transit ridership, microtransit can offer connections to and from public transit stops. And in dense urban environments, circulators can provide convenient access to popular destinations.	King County Metro Microtransit (Washington); Las Vegas Downtown Loop; Charm City Circulator (Downtown Baltimore);	Adaptive Capacity ● Exposure ○ Sensitivity ○	
Mobile cooling stations	Air conditioned vehicles, such as public transit buses, can be deployed during heat waves or power outages to serve as mobile cooling stations, especially is areas with high vulnerability.	Austin, Tex. (Capital Metro); New York City (MTA)	Adaptive Capacity ● Exposure ○ Sensitivity ○	
Water features	Spray showers and splash pads are recreation areas with water-spraying jets or nozzles with minimal standing water. Generally incorporated into parks and community centers, they provide relief from heat and recreation opportunities, especially for children.	Grand Park (Los Angeles); Henderson Multigenerational Center (Henderson, Nev.); Sundance Square Plaza (Fort Worth, Tex.); City of Capetown's spray parks (South Africa)	Adaptive Capacity ● Exposure ◐ Sensitivity ○	
Weatherization assistance (targeted)	Increasing the energy efficiency of housing through weatherization programs can reduce energy costs. Typical weatherization measures include: Insulation, air sealing, solar screens, replacing inefficient heating and cooling systems, etc. Targeting assistance in areas with populations most vulnerable to heat could reduce negative heat-related health outcomes		Adaptive Capacity ● Exposure ◐ Sensitivity ○	

OUTREACH & EDUCATION

Culturally-specific engagement	Communication and outreach methods should be tailored to target communities and be appropriate for the reading level, age range, and ethnic or cultural background of the audience. Information should be shared in multiple languages. Partnering with local community organizations can help remove barriers and enhance understanding and retention of messaging.	Los Angeles Department of Transportation	Adaptive Capacity ◐ Exposure ○ Sensitivity ◔	
First responder and caregiver training and education	Educating first responders and caregivers (especially those who care for vulnerable populations) on the health risks associated with extreme heat and the signs of heat-related illness can help ensure proper assessment and aid is administered. For instance, in treating hyperthermia, moving a person off of hot surfaces, like asphalt, can help lower body temperature.	New York City's climate-risk training for home health aids (as part of Cool Neighborhoods NYC)	Adaptive Capacity ◕ Exposure ○ Sensitivity ●	

SKYSONG (ASU SCOTTSDALE INNOVATION CENTER)

Located in Scottsdale, Ariz., a desert city just east of Phoenix, SkySong is a 1.2-million-square-foot mixed-use project that prioritized sustainable design and heat mitigation features to help attract and retain tenants and improve the city's resiliency. SkySong includes commercial office space, Arizona State University's SkySong incubator, retail shops and restaurants, luxury apartments, a hotel, and an urban park. The center is a hub for academic and private entrepreneurship that has revived a previously declining neighborhood.

Photo source: Experience Scottsdale

The SkySong shade structure has become one of Scottsdale's most recognized icons.

SkySong features a heat-conscious site layout organized in four quadrants, centered around a 150-foot-tall shade structure covering a central plaza. The development is oriented around shaded and landscaped pedestrian scale boulevards with public gathering places and open spaces, water features and bike paths. SkySong's heat-conscious landscaping and design help ensure its outdoor amenity spaces can be enjoyed year-round. Additionally, all of the site's buildings are LEED Silver certified and have achieved Energy Star certification.

Landlord outreach	Because many of the households most vulnerable to heat live in rental units, they are unable to take advantage of weatherization and energy efficiency upgrade programs without landlord authorization. Educating and working with landlords in priority areas could result benefits to both tenants and landlords.		Adaptive Capacity Exposure Sensitivity	◐ ○ ○
Phone-a-neighbor program	Social cohesion is a critical but difficult-to-measure component of heat vulnerability. Establishing neighborhood-level check-in programs, like creating phone trees, can help prevent heat-related illness and death, especially among vulnerable populations, like seniors who live alone.	AARP's Create the Good project; BE A BUDDY NYC (NEW YORK CITY)	Adaptive Capacity Exposure Sensitivity	◐ ○ ◐
Public health campaigns	Because certain conditions (e.g., diabetes, heart disease, and respiratory illness) are particularly sensitive to extreme heat, public health campaigns that educate communities on potential risk factors and encourage them to adopt healthier behaviors could help reduce heat-related health incidents.	Oklahoma City's "This City is Going on a Diet" initiative; Get Healthy Clark County initiatives (Southern Nevada Health District)	Adaptive Capacity Exposure Sensitivity	○ ○ ●

PLANNING & POLICY

Climate action planning	Climate action plans are comprehensive frameworks for measuring, planning, and reducing greenhouse gas emissions and other climate impacts. They often include actions that can be taken to help meet those goals.	Tempe's Climate Action Plan (Tempe, Ariz.); Riverside's Climate Action Plan (Riverside, Calif.); San Diego's Climate Action Plan	Adaptive Capacity Exposure Sensitivity	◐ ◐ ○
Designated personnel	Cities and community organizations across the country have been hiring staff specifically tasked with tackling extreme heat. Common responsibilities include engaging with neighborhoods, coordinating efforts between stakeholders, and conducting research and data analysis to help inform local plans and policies.	City of Philadelphia's Heat Team	Adaptive Capacity Exposure Sensitivity	◐ ○ ◕
Heat relief plans	Community-driven neighborhood heat-relief plans can not only result in mitigation of negative extreme heat impacts, but have also shown to improve social cohesion and civic engagement.	COOL NEIGHBORHOODS NYC (NEW YORK CITY); Philadelphia's Community Heat Relief Plan	Adaptive Capacity Exposure Sensitivity	◐ ● ◕
Temperature reduction goals	Cities can establish targets to help drive and communicate action as part of a heat strategy. Targets are typically linked to a heat mitigation approach.	Sustainable City pLAn 2019 (Los Angeles).	Adaptive Capacity Exposure Sensitivity	◕ ● ○

COOL NEIGHBORHOODS NYC/BE A BUDDY NYC

New York City Mayor de Blasio launched Cool Neighborhoods NYC in June 2017 to minimize the effects of extreme heat on the city by implementing projects such as cool roofs, city-wide tree plantings, and climate risk training for home health aides. The comprehensive resilience program aims to reduce heat-related health impacts by lowering temperatures in heat-vulnerable neighborhoods and strengthening social networks.

As part of "Cool Neighborhoods NYC," the city launched Be a Buddy NYC to create a community-led preparedness model that promotes social cohesion. The program aims to address heat-related health impacts by enhancing the response capacity, climate preparedness and communication tools of local community-based organizations, while increasing neighborhood volunteerism through the creation of buddy systems.

Photo source: Edwin Torress/NYC Mayoral Photography Office
A resident checks on a neighbor as part of the Be a Buddy NYC program.

Through the program, city staff work with neighborhoods to foster buddy systems between social service and community organizations, volunteers, and vulnerable New Yorkers, to be deployed during emergencies to conduct telephone and, if necessary, door-to-door and building level checks on vulnerable individuals.

REFERENCES

Aminipouri, M., Knudby, A., and Ho, H.C. (2016). "Using multiple disparate data sources to map heat vulnerability: Vancouver case study." *The Canadian Geographer*, 60: 356-368. https://doi.org/10.1111/cag.12282

Bandala, E.R., Kebede, K., Jonsson, N., Murray R., Green, D., Meija J.F., and Martinez-Austria, P.F. (2019). "Extreme heat and mortality rates in Las Vegas, Nevada: inter-annual variations and thresholds." *International Journal of Environmental Science and Technology*, 16: 7175-7186. https://doi.org/10.1007/s13762-019-02357-9

Benz, S.A. and Burney, J.A. (2021). "Widespread race and class disparities in surface urban heat extremes across the United States." *Earth's Future*, 9(7). https://doi.org/10.1029/2021EF002016

City of Cambridge, Massachusetts (2015). "Vulnerable Population Ranking Memorandum" [Memorandum]

Climate Central (2019). "American Warming: The Fastest-Warming Cities and States in the U.S."

Flavelle, C., and Popovich, N. (2019). "Heat Deaths Jump in Southwest United States, Puzzling Officials." *The New York Times*. Aug. 26, 2019; Updated May 31, 2021. https://www.nytimes.com/2019/08/26/climate/heat-deaths-jump-in-southwest-united-states-puzzling-officials.html

Graham, D., Vanos, J., Kenny, N., and Brown, R. (2016). "The relationship between neighbourhood tree canopy cover and heat-related ambulance calls during extreme heat events in Toronto, Canada." *Urban Forestry & Urban Greening*, 20: 180-186. http://dx.doi.org/10.1016/j.ufug.2016.08.005 Retrieved from https://escholarship.org/uc/item/53v4h0ph

Hoffman, J., Shandas, V., and Pendleton, N. (2020). "The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas." *Climate*, 8(1): 12-26. https://doi.org/10.3390/cli8010012

Jones, B., O'Neill, B.C., McDaniel, L., McGinnis, S.A., Mearns, L.O., and Tebaldi, C. (2015). "Future population exposure to US heat extremes". *Nature Climate Change*, 5: 652-655. https://doi.org/10.1038/nclimate2631

Muttarak, R. and Lutz, W. (2014). "Is education a key to reducing vulnerability to natural disasters and hence unavoidable climate change?" *Ecology and Society*, 19(1): 42-49. http://dx.doi.org/10.5751/ES-06476-190142

Peters, A. and Schneider, A. (2021). "Cardiovascular risks of climate change." *Nature Reviews Cardiology*, 18: 1-2. https://doi.org/10.1038/s41569-020-00473-5

Reid, C.E., O'Neill, K.S., Gronlund, C.J., Brines, S.J., Brown, D.G., Diez-Roux, A.V., and Schwartz, J. (2009). "Mapping community determinants of heat vulnerability." *Environmental Health Perspectives*, 117(11): 1730–-1736. https://ehp.niehs.nih.gov/doi/10.1289/ehp.0900683

Seneviratne, S.I., Nicholls, N., Easterling, D., Goodess, C.M., Kanae, S., Kossin, J., Luo, Y., Marengo, J., McInnes, K., Rahimi, M., Reichstein, M., Sorteberg, A., Vera, C., and Zhang, X. (2012). "Changes in climate extremes and their impacts on the natural physical environment." In: "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC)*. Cambridge University Press, Cambridge, UK, and New York, NY, USA. 109-230.

San Francisco Department of Public Health (2013). "Climate and health: An assessment of San Francisco's vulnerability to extreme heat events." San Francisco, CA: San Francisco Department of Public Health.

Sherman, A. (2020). "The Heat is On." *Planning Magazine*. 86(8): 18-25.

Tibbetts, J. (2015). "Air quality and climate change: a delicate balance." *Environmental Health Perspectives*, 123(6) A148-153. (2015). https://doi.org/10.1289/ehp.123-A148

Burgess, K., and Foster, E. (2019) "Scorched: Extreme Heat and Real Estate." Washington D.C.: Urban Land Institute.

U.S. Environmental Protection Agency (2006; Updated 2016). "Excessive Heat Events Guidebook."

Vaidyanathan, A., Malilay, J., Schramm, P., and Saha, S. (2020). "Heat-Related Deaths – United States, 2004–2018." *Morbidity and Mortality Weekly Report*, 69:729–734. http://dx.doi.org/10.15585/mmwr.mm6924a1

Appendix A
Indicators

Southern Nevada Extreme Heat Vulnerability Analysis indicators

Selected indicators act as proxies to understanding the complex, interconnected nature of extreme heat vulnerability, and provide an initial approach for discerning the critical indicators that may be associated with greater relative impact and longer recovery times. Our preliminary list of indicators, organized around the three dimensions of heat vulnerability – exposure, sensitivity, and adaptive capacity – are presented below.

EXPOSURE TO EXTREME HEAT – Weather patterns, as well as both the natural and built environments can influence levels of exposure to extreme heat. The following indicators help identify areas in Southern Nevada that are expected to have the greatest exposure to extreme heat.

- Land surface temperature – While Southern Nevada's desert climate is among the hottest in the country, certain areas within the region experience hotter temperatures due to a variety of factors, including elevation, proximity to bodies of water, and the urban heat island effect.

- Vegetated land cover – Vegetation, such as trees and shrubs, can be a natural source of shade and facilitate evaporation, which results in a cooling effect. Therefore, neighborhoods with more vegetated land cover are less exposed to extreme heat. Vegetation can also improve air quality – by absorbing carbon dioxide, producing oxygen, and trapping and filtering other pollutants – which is negatively impacted during extreme heat events.

- Developed land – Developed land replaces natural land and vegetation cover with impervious surfaces (such as paved roads, parking lots, and buildings) that retain heat and take longer to cool than natural surfaces. These surfaces have been shown to be strongly related to increased surface temperatures and a contributor to urban heat islands.

- Elevation – While most of Southern Nevada experiences extreme heat conditions given the region's climate, its geography can impact the extent to which impacts are felt. Temperatures are hotter in areas of lower elevation. The temperature drops 3.6 degrees for every 1,000-foot increase in elevation, on average, according to the National Weather Service Forecast Office in Las Vegas. This means there can be a difference of approximately 7-10 degrees from one side of the valley to the other.

- Air conditioning – Because most of the health impacts of extreme heat occur indoors, air conditioning is an important indicator. Air conditioning is among the most impactful ways to limit the effects of exposure to extreme heat conditions. Several studies, including an analysis of a 1995 Chicago heat wave, have demonstrated that access to air conditioning greatly reduced the risk of heat-related mortality.

- Mobile homes – Mobile and manufactured homes are approximately 20% less likely to have central air conditioning than other types of housing units in Las Vegas. Additionally, mobile homes can be more isolated than other housing types, limiting the adaptive capacity of their inhabitants. In Maricopa County, Arizona (which includes Phoenix), 27.5% of heat-related deaths occurred among mobile home residents, though they only make up 5% of the region's population.

ADAPTIVE CAPACITY – The ability to prepare for or cope with extreme heat impacts, whether through economic, political, or social resources. The following indicators help identify areas in Southern Nevada where populations are expected to have the least capacity to adapt to extreme heat.

- Disability – Populations with a mobility or cognitive disability may require significant support during extreme heat events, including transportation and specialized care.

- Education attainment – The percentage of the population without a high school education is among the socioeconomic indicators associated with increased heat stress, mortality from high temperatures, and increased risk of heat-related morbidity. Studies have also found correlation

between education level and access to and understanding of weather forecasts and warnings, as well as the technologies used to access weather information.

- Language – Households with limited English proficiency or a language may have a more difficult time becoming aware of or understanding public information relating to extreme heat events that hasn't been appropriately translated. While non-English populations may have strong social networks, language may be a barrier to accessing emergency or response services.

- Poverty – Individuals below the poverty level have fewer resources, which reduces their ability to prevent, cope with, and adapt to climate change impacts. This population is more likely to reside in housing that may lack adaptive features, such as insulation or air conditioning, or may be less likely to use available air conditioning because of the cost. They are also more likely to live in neighborhoods that lack important amenities like grocery stores and safe open space.

- Race – Non-white populations have consistently been found to have been disproportionately impacted by extreme heat. This disparity is not just a function of racial and ethnic income inequality, as they occur across income levels. The difference in impacts has been attributed to current and historical systemic inequities in economic, political, and cultural power.

- Unsheltered homeless – Unsheltered homeless populations are among the most exposed and the most vulnerable during extreme heat events. This population lacks many of the key resources needed to prepare for and endure extreme heat events. In Maricopa County, Arizona (which includes Phoenix), data compiled by the public health department show that the homeless represent a fast-growing share of heat-related deaths.

- Vehicleless households – Households without access to a vehicle may have a more difficult time accessing appropriately cooled locations and other important mitigation resources. Additionally, walking, bicycling, or utilizing public transportation during extreme heat events increases heat exposure.

SENSITIVITY TO EXTREME HEAT – Demographic, physiological, and health factors that may predispose individuals to greater risk from exposure during extreme heat events. The following indicators help identify areas in Southern Nevada that are expected to have population with the greatest sensitivity to extreme heat.

- Adults age 50+ – Older adults are among the most vulnerable to the health impacts of extreme heat. This population is more likely to have chronic physical or cognitive health conditions, and are at greater risk of dehydration due to a reduced sense of thirst. A recent paper published by a Desert Research Institute (DRI) researcher found that 76 percent of those who died from heat-related causes in Southern Nevada between 2007 and 2016 were older than 50.

- Isolated older adults – Adults 65 and older who live alone are more likely to have limited ability to access adequately cooled locations during extreme heat events due to physical limitations, lack of social support, and lack of transportation. An analysis of the deadly 1995 Chicago heat wave found that social isolation increased risk for heat-related morbidity and mortality. This risk was compounded for those who were bedridden or elderly, among other factors.

- Diabetes – Populations with diabetes are particularly vulnerable to extreme heat. Higher temperatures can negatively impact glucose metabolism, and diabetes also affects the body's ability to regulate body temperature. Diabetes medications can also cause dehydration. Additionally, hospital admissions for cardiovascular disease (such as hypertension, high cholesterol, and obesity), which are commonly associated with diabetes, often increase during extreme heat events.

- Heart disease – Intense heat adds strain on the heart that can be dangerous for those with cardiovascular issues. Higher temperatures increases heart rate and blood

pressure, and significantly impact on those with preexisting hypertension caused by cardiovascular problems. Extreme heat can also lead to increased resistance to blood flow, making it harder for the heart to pump. Additionally, some medications prescribed to patients with heart conditions can reduce the ability to cool off in the heat. A study of heat-related deaths in Southern Nevada found that almost all deaths of those over the age of 50 (which made up 76 percent of heat-related deaths in the region) were described as being related to heart disease.

- Respiratory disease – Because extreme heat events are associated with poor air quality and increases in ozone pollution, individuals with chronic lower respiratory disease (CLRD) – a group of conditions that affect the lungs – can be particularly vulnerable. CLRD includes conditions such as COPD, emphysema, asthma, pulmonary hypertension, and certain lung diseases, among others.

Appendix B
Spatial Analysis Details

Index & spatial analysis

Prior to analysis, some considerations were taken into account for data collection. A principal consideration was an operational definition of extreme heat events. Based on a literature review of other extreme heat studies and given the relatively extreme climate of the Mojave Desert, the following parameters were followed: Greater than or equal to eight consecutive days of greater than 75 degrees Fahrenheit minimum temperatures, and greater than 105 degrees Fahrenheit maximum temperatures. In addition, an effort was made to ensure that the data in the analysis was collected in a time period contemporaneous with 5-year American Community Survey (ACS) estimates derived between the dates of January 1, 2014 and December 31, 2018. Lastly, satellite data had to have been incidentally collected during a qualifying extreme heat event with little cloud cover. With these qualitative and temporal limitations taken into consideration, a 10-day extreme heat event occurring June 18 through June 27, 2017 was an ideal representative candidate of an extreme heat event in Southern Nevada. At the time of analysis, this time period included the hottest date recorded at the McCarran Airport Weather Station since 2014, and the hottest minimum and maximum temperatures recorded in Clark County recorded by Oregon State University's Parameter-elevation Regressions on Independent Slopes Model (PRISM). Fortuitously, NASA's MODIS satellites happened to capture 8-day temperature averages during this time frame that could be made ingestible into commonly-used GIS applications through the use of the HDF-EOS to GeoTIFF Conversion Tool.
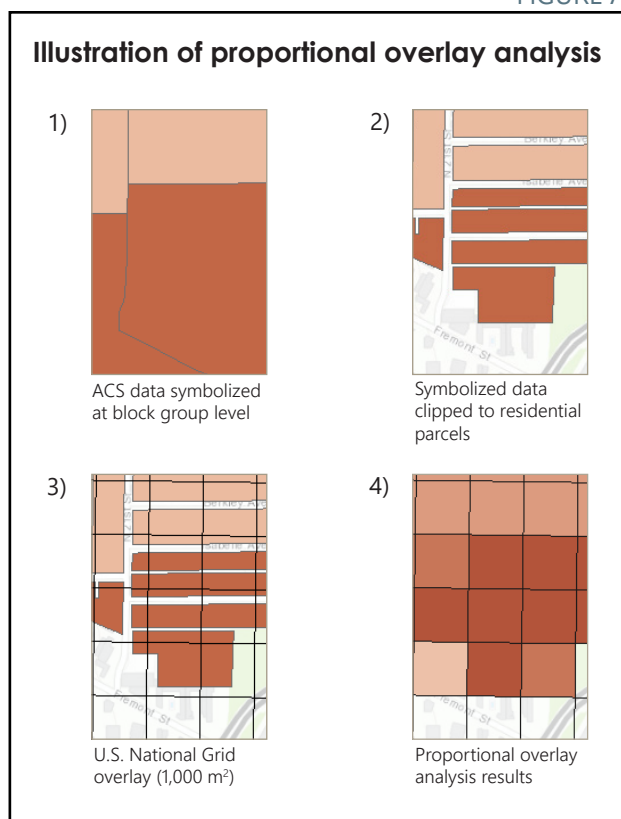
Having tracked down an appropriate temperature-specific indicator, the remaining indicators were fairly straight forward to collect, process, and prepare for analysis. To overcome differences in the variables' spatial units of measurement (e.g., zip code, block group, census tract, or pixel resolution), which do not allow for direct comparison, the data was disaggregated

into a uniform grid using the U.S. National Grid (USNG). Doing so divided the urbanized region into 129,100 1,000-square-meter cells, each with a disaggregated estimate of the 18 variables.

The method of disaggregation applied depended on the data format of each variable. Non-population based data (e.g., land surface temperature and elevation) was disaggregated by calculating a zonal statistic of the pixels falling within each cell or the pixel value present at the center of each grid cell. Population-based and parcel-specific data (e.g., demographic and health variables) was disaggregated by calculating a proportional overlay, which derives a value for each cell based on the percentage of area each cell spatially overlaps the underlying data (see Figure A).

To improve proportion overlay estimates, population-based data was clipped to residential parcels[i] since they refer to data

Illustration of proportional overlay analysis

1) ACS data symbolized at block group level

2) Symbolized data clipped to residential parcels

3) U.S. National Grid overlay (1,000 m²)

4) Proportional overlay analysis results

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[i] With the exception of the unsheltered homeless population counts

centered around places of residence. This also prevented areas of vacant land, right-of-way, and commercial development from being identified as highly vulnerable areas, as the purpose of the study was to identify areas where people are most vulnerable to extreme heat.

With the disaggregation complete, the study grid was prepared for an analysis of relationships between the variables using a Forest-Based Regression statistical technique. Three regressions were calculated using each framework component's grouping of variables against reported rates of heat-related health outcomes (i.e., hospitalizations and deaths). As an output, the regressions quantitatively describe the relative importance of each variable's inclusion in successful prediction equations.

When forming the index, these percentages of variable importance within each framework component (see Figure B) was

Variable weights based on regression analysis

EXPOSURE

Elevation	0.268
Land surface temperature	0.212
Vegetated land cover	0.207
Developed land	0.140
No air conditioning	0.094
Mobile homes	0.078

ADAPTIVE CAPACITY

Educational attainment	0.189
Race (non-white population)	0.183
Unsheltered homeless	0.151
Disability Poverty	0.135
Language (limited English proficiency)	0.130
Poverty	0.125
Vehicleless households	0.086

SENSITIVITY

Heart disease	0.289
Respiratory disease	0.251
Diabetes	0.230
Older adults	0.130
Isolated older adults	0.100

the basis for weighing certain variables more heavily than others. Weights were applied within framework components, but not between them. This approach avoided de-emphasizing any of the three components of heat vulnerability framework.

While varying units of measurement between variables do not preclude regression analysis, they are a barrier to forming an index score. To eliminate units of measurement, every variable was normalized using min-max scaling[ii]. Having applied this transformation, the weighted sum of all the variables within each framework component for each cell were calculated, and the weighted sum was rescaled once more, due to the fact that some components having more variables than the others. The normalized grand totals for each framework component were then aggregated, with equal weighting, then rescaled a final time to create a composite extreme heat vulnerability index.

After the extreme heat vulnerability index was finalized, it was then mapped, producing a grid cell-based visualization of the results. While the grid had been useful for regression, its 100-meter granularity presented both cartographic and data sensitivity concerns[iii] In an attempt to abate these concerns without data loss, the results were processed first within spatial statistics tools and then visually generalized using inverse distance weighting.

To identify statistically significant spatial clusters of high index values, hot spot analyses were performed on selections of cells lying within each municipality's boundary. This form of analysis provides confidence that clusters of cells with high index scores perceived (or not perceived)

[ii] Min-max scaling performs a linear transformation on original data, rescaling the range of features to between 0 and 1. For this analysis, a value of 0 was assigned to the grid cell with the minimum variable value in the region and a value of 1 to the grid cell with the maximum value. Remaining cells were transformed to a decimal value between 0 and 1 based on their original value.

[iii] Sharing health-related data and demographic characteristics at micro-scale geographies comes with privacy and confidentiality concerns.

on the regional map are not the result of random chance or symbological limitations. To address data sensitivity concerns, hot spot boundaries were simplified in shape or otherwise removed from the map if their area were smaller than half a city block. See Figure C for hot spot analysis results.

FIGURE C
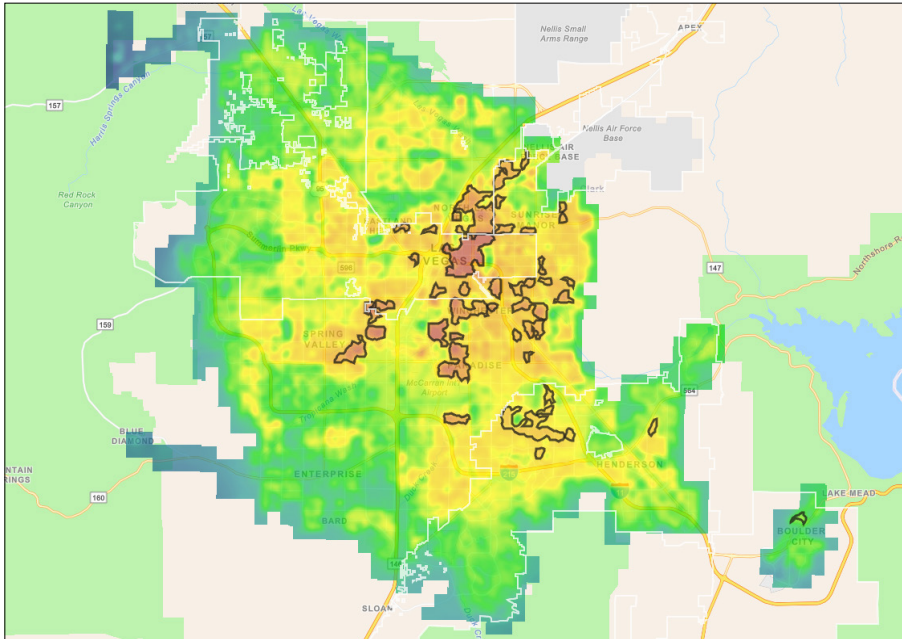
Areas identified by the hot spot analyses outlined in black on the map above. Hot spots included in this map are significant at the 99 percent confidence level and are relative to their respective jurisdiction (so hot spots identified in Henderson were the result of a Hot Spot Analysis performed only within the boundaries of the City of Henderson.)

Having preserved the underlying data through statistical summary within hot spots, the vulnerability index scores could be generalized by interpolating index values between cell centroids using an inverse distance weighting (closer cell values are given more weight than distant cell values) technique. The interpolated values shown on the map are the weighted mean of the index values of each cell's nearest 48 neighbors within the grid. The outputs of the hot spot analyses and weighted distance averages were then published to an ArcGIS Server to create an interactive web-based map application. Demographic data was added to the web-based map to provide additional neighborhood-level context for users.

Appendix C
Project Factsheets
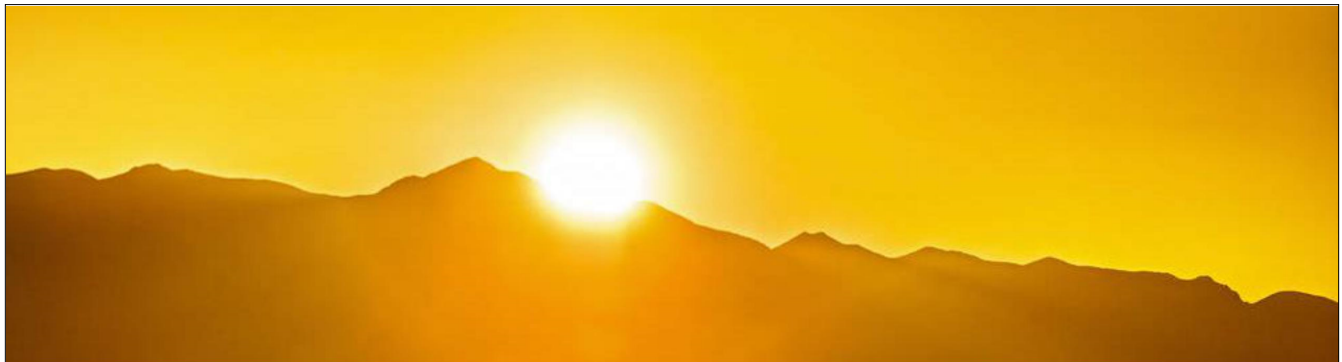
RTC REGIONAL PLANNING PROJECT FACTsheet

EXTREME HEAT VULNERABILITY

Southern Nevada has been identified as one of the fastest warming regions in the U.S., and recent research indicates a substantial risk of heat-related deaths from an increasing number of extreme heat events in the valley.

Despite the history of adverse health impacts associated with extreme heat in our region, experts hold that many of these outcomes are preventable. Reducing future adverse outcomes will require developing effective and coordinated responses, as well as improving the awareness of public health officials and the general public about the health risks associated with extreme heat. This is especially critical in areas with high concentrations of those most vulnerable during extreme heat events.

WHAT WE'RE DOING:

- Identifying local demographic and environmental factors that increase vulnerability to extreme heat
- Analyzing relevant data to pinpoint areas in Southern Nevada with high concentrations of at-risk populations
- Identifying targeted responses and interventions that could help save lives during extreme heat events

WHAT DOES THE SNS REGIONAL PLAN SAY ABOUT THIS ISSUE?
The SNS Regional Plan provides a few recommendations for mitigating the negative impacts of our region's high temperatures, including:

Include shade and other design features in transit stops that provide relief from extreme heat

Invest in streetscape amenities that provide respite from the heat in neighborhoods with higher transit ridership and pedestrian rates

Encourage new development to incorporate design features that mitigate heat impacts

568

Heat-related deaths in Southern Nevada between 2009 and 2018 [1]

104°F

Average daytime high during summer months in Southern Nevada between 2015 and 2019 [2]

23

Excessive heat warnings issued in Southern Nevada between 2015 and 2019 [3]

84

Days exceeding 100°F in Southern Nevada in 2019 [4]

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IT'S GETTING HOTTER IN SOUTHERN NEVADA

Southern Nevada is the fastest warming region in the U.S., with temperatures increasing more than 5°F since 1970, according to recent research. The number of days exceeding 100°F has also been on the rise in recent decades, as shown in the chart below.

Days per year (chart, 1990–2019)

Legend: Days exceeding 100°F — Decadal average
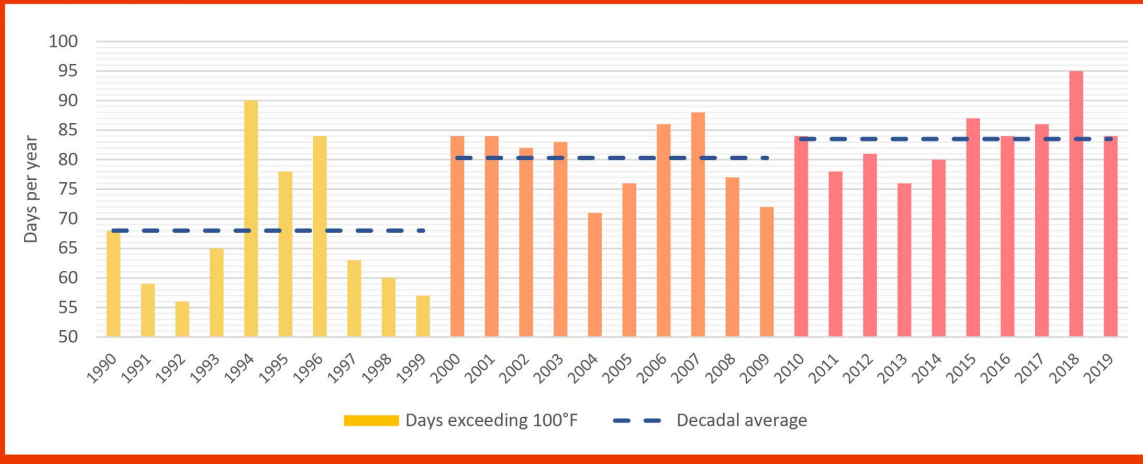
Data source: National Weather Service, Las Vegas Office

ASPECTS OF EXTREME HEAT VULNERABILITY

While all Southern Nevadans are impacted during extreme heat events, impacts are not evenly distributed. Certain communities in our region will be particularly affected based on:

- **LEVEL OF EXPOSURE** – Weather patterns, and both the natural and built environments can influence levels of exposure to extreme heat

- **SENSITIVITY TO EXPOSURE** – Demographic, physiological, and health factors may predispose individuals to greater risk during extreme heat events

- **ADAPTIVE CAPACITY** – The ability to prepare for or cope with high temperatures – whether through economic, political, or social resources – plays an important role in extreme heat vulnerability

HEALTH CONDITIONS, especially diabetes and heart disease, can be greatly exacerbated by extreme heat events. High temperatures can also negatively impact glucose metabolism.

AMBIENT TEMPERATURE above 90°F can be dangerous to the human body.

DEVELOPED LAND retains heat and takes longer to cool, and can create urban heat islands.

OLDER ADULTS, especially those who are socially isolated, are among the most vulnerable during extreme heat events.

DEMOGRAPHIC FACTORS – such as race, income, language, education level, and disability – can impact vulnerability to extreme heat.

VEHICLELESS HOUSEHOLDS may have a more difficult time accessing cooled locations and other mitigation resources. And walking, bicycling, or utilizing public transit can increase exposure.

UNSHELTERED HOMELESS lack many of the resources needed to prepare for and endure extreme heat, and are among the most exposed and vulnerable.

VEGETATED LANDCOVER can be a source of shade and facilitates evaporation, which results in a cooling effect.

Data sources:
[1] Southern Nevada Health District, Office of Epidemiology and Disease Surveillance
[2,3,4] National Weather Service, Las Vegas Office

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RTC REGIONAL PLANNING PROJECT FACTSheet
EXTREME HEAT VULNERABILITY

Southern Nevada has among the hottest climates in the U.S. and is also one of the fastest-warming regions in the country[1]. And recent research predicts the region, and the southwestern United States generally, to experience a significant increase in the frequency and intensity of extreme heat events in the coming decades[2].

Increasing temperatures in the region are associated with and contribute to a host of negative impacts – from poorer air quality to added wear and tear on infrastructure. But, most importantly, studies have found a clear link between increasing temperatures and heat-related deaths and hospitalizations[3].

Despite the history of adverse health impacts associated with extreme heat in our region, experts hold that many of these outcomes are preventable. Reducing future adverse outcomes require developing effective and coordinated responses, as well as improving the awareness of public health officials and the general public about the health risks associated with extreme heat. This is especially critical in areas with populations most vulnerable during extreme heat events.
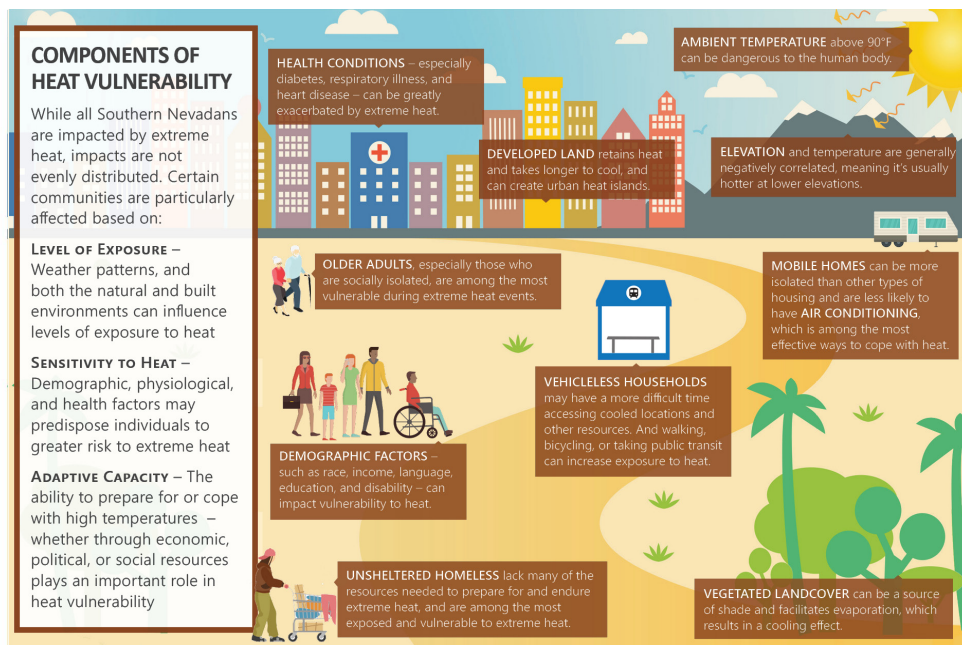
568
Heat-related deaths in Southern Nevada between 2009 and 2018[4]

104°F
Average daytime high during summer months in Southern Nevada between 2015 and 2019[5]

23
Excessive heat warnings issued in Southern Nevada between 2015 and 2019[6]

84
Days of at least 100°F in Southern Nevada in 2019, including 10 days of at least 110°F[7]

115
Estimated days of at least 100°F in Southern Nevada by 2070[8]

COMPONENTS OF HEAT VULNERABILITY

While all Southern Nevadans are impacted by extreme heat, impacts are not evenly distributed. Certain communities are particularly affected based on:

LEVEL OF EXPOSURE – Weather patterns, and both the natural and built environments can influence levels of exposure to heat

SENSITIVITY TO HEAT – Demographic, physiological, and health factors may predispose individuals to greater risk to extreme heat

ADAPTIVE CAPACITY – The ability to prepare for or cope with high temperatures – whether through economic, political, or social resources plays an important role in heat vulnerability

HEALTH CONDITIONS – especially diabetes, respiratory illness, and heart disease – can be greatly exacerbated by extreme heat.

AMBIENT TEMPERATURE above 90°F can be dangerous to the human body.

DEVELOPED LAND retains heat and takes longer to cool, and can create urban heat islands.

ELEVATION and temperature are generally negatively correlated, meaning it's usually hotter at lower elevations.

OLDER ADULTS, especially those who are socially isolated, are among the most vulnerable during extreme heat events.

MOBILE HOMES can be more isolated than other types of housing and are less likely to have **AIR CONDITIONING**, which is among the most effective ways to cope with heat.

DEMOGRAPHIC FACTORS – such as race, income, language, education, and disability – can impact vulnerability to heat.

VEHICLELESS HOUSEHOLDS may have a more difficult time accessing cooled locations and other resources. And walking, bicycling, or taking public transit can increase exposure to heat.

UNSHELTERED HOMELESS lack many of the resources needed to prepare for and endure extreme heat, and are among the most exposed and vulnerable to extreme heat.

VEGETATED LANDCOVER can be a source of shade and facilitates evaporation, which results in a cooling effect.

For more information, visit www.rtcsnv.com/extremeheat

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Southern Nevada Extreme Heat Vulnerability

The Southern Nevada Extreme Heat Vulnerability Map visualizes the spatial distribution of extreme heat vulnerability among the region's population, and is a composite of the three component maps to the left (MAPS 1-3). Red areas in the composite map represent those with populations most vulnerable to extreme heat. In the component maps, red areas represent those with populations most vulnerable to each respective component. The map was produced as part of an analysis and report that can be found at https://rtcsnv.com/extremeheat.
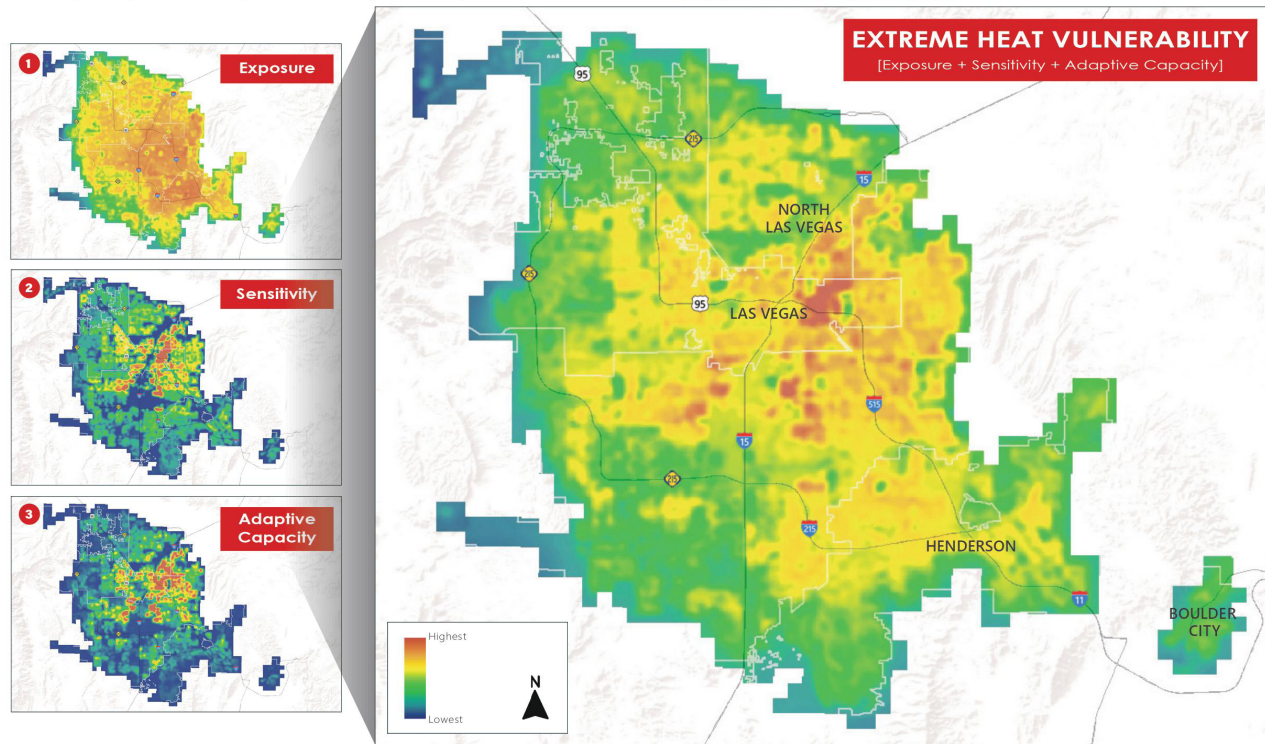
Note: This analysis measured relative vulnerability to extreme heat, not absolute vulnerability. So it should not be inferred that there is little or no heat vulnerability in areas at the lower end of the spectrum (blue areas on the map), just that there are lower levels of heat vulnerability relative to other areas of the region.

EXTREME HEAT VULNERABILITY. The areas in Southern Nevada with populations most vulnerable to extreme heat are largely concentrated in and around the region's urban core and east side. These areas include many of the region's older neighborhoods. The populations in these areas are typically more racially and ethnically diverse and economically challenged than other parts of the region. And because these areas are also at lower elevations than much of the western half of the valley, they experience naturally higher temperatures.

❶ *Exposure.* The spatial distribution of *EXPOSURE* factors is more evenly dispersed across the region than the *SENSITIVITY* and *ADAPTIVE CAPACITY* components. However, *EXPOSURE* is more intense in the eastern half of the valley, and is closely correlated with the region's elevation. Elevation in the valley drops by more than 2,500 feet from west to east, resulting in naturally higher temperatures in the east side, especially east of the I-515 freeway.

❷ *Sensitivity.* Populations most sensitive to extreme heat are located in the region's urban core – largely in and around downtown Las Vegas, downtown North Las Vegas, and the resort corridor. The most influential *SENSITIVITY* indicators are related to health: Heart disease, diabetes, and respiratory disease. These conditions are particularly sensitive to extreme heat.

❸ *Adaptive Capacity.* Populations least able to adapt to extreme heat are primarily concentrated in the valley's urban core and east side. The three most influential *ADAPTIVE CAPACITY* indicators are education, race, and homelessness. Low levels of educational attainment are correlated with lack of financial resources and can be a barrier to accessing weather warnings, which allow individuals to prepare for weather-related hazards. Non-white populations are disproportionately impacted by heat in the U.S. due to decades of redlining and other discriminatory practices. And homeless populations often lack many of the resources needed to prepare for and cope with extreme heat.

See the **"Southern Nevada Extreme Heat Vulnerability Analysis" report** for strategies and best practices for addressing extreme heat vulnerability

Data sources:
[1] Climate Central (2019). "American Warming: The Fastest Warming Cities and States in the U.S."
[2] Jones, B. et al (2015). "Future population exposure climate change." *Ecology and Society*, 19(1): 42-49
[3] Bandala, E. at al (2019). "Extreme heat and mortality rates in Las Vegas, Nevada: inter-annual variations and thresholds." *International Journal of Environmental Science and Technology*, 16: 7175-7186
[4] Southern Nevada Health District, Office of Epidemiology and Disease Surveillance
[5 & 7] National Weather Service, Las Vegas Office
[?] Resilient Analytics (2020). "Heat Impacts on Infrastructure & Personnel: A SNWA Case Study." Southern Nevada Water Authority

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