County of San Bernardino

Climate Change Vulnerability Assessment

REPORT USE, INTENT, AND LIMITATIONS

This report was prepared to inform the preparation of the Countywide Plan. This report is not intended to be continuously updated and may contain out-of-date material and information. This report reflects data collected in 2017 as part of due diligence and issue identification.

This report is not intended to be comprehensive and does not address all issues that were or could have been considered and discussed during the preparation of the Countywide Plan. Additionally, many other materials (reports, data, etc.) were used in the preparation of the Countywide Plan. This report is not intended to be a compendium of all reference materials.

This report may be used to understand some of the issues considered and discussed during the preparation of the Countywide Plan, but should not be used as the sole reference for data or as confirmation of intended or desired policy direction. Final policy direction was subject to change based on additional input from the general public, stakeholders, and decision makers during regional outreach meetings, public review of the environmental impact report, and public adoption hearings.

Data and analysis as of February 2018
Updated with outreach summary in November 2018

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This vulnerability assessment looks at the susceptibility of people, facilities and structures, services, and ecosystems in San Bernardino County to the hazardous conditions that may be created or made worse as a result of climate change. This includes identifying the climate-related hazards in the area and how they may change, the damage that these hazards may cause, and the ability of people and assets to effectively resist or recover from these hazards. San Bernardino County's vulnerability assessment was prepared in accordance with state guidelines, primarily the *California Adaptation Planning Guide*.

The PlaceWorks team determined which hazardous conditions may affect which people and assets in San Bernardino County. This assessment evaluates six hazards: extreme temperatures, drought, floods, pests and diseases, severe weather, and wildfires. Also assessed in this report are 76 different populations and assets (16 populations, 29 facility and infrastructure types, 10 services, and 21 ecosystems and natural services). The PlaceWorks team then used existing countywide reports, spatial data, scholarly research, and other scientific and governmental reports to assess hazards impacts and the extent to which people and assets are able to resist or adapt to them. The PlaceWorks team combined these results to assign a measure of vulnerability to each population and asset for each hazard condition, with V1 being the least vulnerable and V5 the most vulnerable.

This assessment found seven major climate vulnerabilities in San Bernardino County:

1. Homeless persons and people who work outdoors are highly vulnerable to extreme heat because they are more exposed to outdoor conditions than other people They are also more vulnerable to floods, pests and diseases, and severe weather. To a lesser extent, people who live in mobile homes may be similarly affected.
2. Persons with medical challenges (e.g., senior citizens, persons with disabilities, and persons with existing medical conditions) face higher vulnerabilities from extreme heat, floods, pests and diseases, and wildfires. These individuals often have difficulty evacuating hazardous situations and may be more susceptible to harm due to existing medical conditions such as cardiovascular weaknesses or a compromised immune system.
3. Persons with low income levels, undocumented persons, and individuals without access to vehicles or communication often have very limited ability to retrofit their homes against hazard conditions and take other preparatory steps due to limited resources. These limitations can also make it difficult for these individuals to evacuate or effectively recover from disasters. Undocumented persons face heightened challenges because they may be less willing to work with government agencies to receive assistance.
4. Agricultural and recreational facilities are major economic drivers in San Bernardino County, but the viability of these operations could be harmed by the effects of climate change,

particularly by drought. Less water could make it more challenging to grow crops or raise livestock and could make it harder for recreational lakes or ski resorts to attract visitors. Agricultural operations are also susceptible to pest and disease infestations.

5. Utility services, in particular electricity and water/wastewater, are vulnerable to some of the effects of climate change. Electrical lines may be damaged or destroyed by severe weather, particularly wind, which could result in a loss of critical electrical services for some communities. Water and wastewater services can become less reliable during drought conditions, which are especially threatening to rural areas with limited water supplies.
6. Many of the ecosystems in San Bernardino County are highly susceptible to drought, pest and disease outbreaks, and wildfires. Ecosystems that are not adapted to these hazard events may have challenges thriving in a changed climate, and in some cases, may become extinct in the region.
7. Groundwater basins, which supply many of the water systems in San Bernardino County, are vulnerable to drought conditions and other changes in precipitation patterns. Over time, climate change can lead to lower groundwater levels in these basins, threatening the water supply of urban and rural communities.

Table EX 1 summarizes the issues and discussion items related to climate change vulnerability in San Bernardino County.

Table EX 1 Climate Vulnerability Issues and Discussion Items

Category	Issues	Discussion Items
Building and infrastructure systems	Rural areas often lack redundant infrastructure, increasing the risk of a single failure causing widespread service outages.	Is it feasible for the County to identify and add redundant or backup systems so that County services can remain operational if a single failure occurs? Is there an opportunity for non-County agencies partner to engage?
	Many key components of infrastructure networks cross into hazard-prone areas and may be exposed to highly damaging conditions.	What are the options to harden vulnerable infrastructure, particularly above-ground facilities and those in hazard-prone areas, to better resist the effects of climate-related hazards?
	Buildings in and adjacent to flood and wildfire hazard areas face an increased threat from a potential increase in hazard frequency and intensity.	What resources are available to conduct or facilitate education and retrofit programs to increase resilience to these hazard types? How should the County explore long-term strategies to remove the most vulnerable or impacted structures from the areas where the risk is highest?
Vulnerable populations	Mobility challenges, including physical disabilities and lack of access to transportation, can seriously hinder evacuations.	How can the County partner and collaborate with local transit providers and community groups to ensure that there is a sufficient supply of properly equipped vehicles to assist with evacuation?
	Social isolation, especially in rural areas, can be a major barrier to people taking steps to prepare for hazards or receiving timely and accurate information. Senior citizens who live alone may be more vulnerable than other potentially socially isolated populations.	What are the opportunities to foster formal and informal support networks throughout the county, with an emphasis on rural areas? Who would be involved?

Table EX 1 Climate Vulnerability Issues and Discussion Items

Category	Issues	Discussion Items
	Lower income persons may lack financial resources or access to information to make retrofits to structurally vulnerable homes.	Are there existing or anticipated awareness campaigns and financing mechanisms for the County to support or promote that would make homes less vulnerable to natural hazards? Are there are other mechanisms for the County to support resiliency retrofits?
	Persons who are outdoors for lengthy periods of time, including homeless persons and those who work outdoors, face a higher risk of harm.	What does it mean for the County to make shelters available during times of dangerous outdoor conditions, and ensure that persons who are outdoors for extended periods of time have access to supplies and materials that help protect their health and safety?
Economic and service concerns	Long-term climate changes may make some economic activities less feasible or impractical.	Are there existing networks or partnerships available to engage business groups and other County partners and assess long-term climate impacts on local economic activities? Is it feasible to evaluate ways to eventually transition land used for unproductive economic activities to more resilient options?
	Water supplies used by many providers in San Bernardino County are vulnerable to disruption by drought.	What are the opportunities to diversify water supplies and promote extensive water conservation and efficiency?
	Many of the existing ecosystems in San Bernardino County may shrink in size or be no longer viable by the end of the 21st century.	What are the short and long-term disruptions to ecosystem services and how are those disruptions likely to affect outdoor recreation activities and habitat conservation plans? How should we prepare for changing local ecosystems?
Understanding and coordination	Detailed, down-scaled projections of changes to climate-related hazards are not readily available for some hazard types.	How can the County improve its understanding of local changes to climate-related hazards? What information and resources need to be maintained to better the understanding of changing climate? Are there new opportunities for partnerships with local and regional universities and other research institutions?
	Due to the emerging nature of climate adaptation planning best practices, the County of San Bernardino's climate vulnerability strategy may differ from those of incorporated cities and surrounding jurisdictions.	Can we leverage existing regional coordination related to energy and climate action activities to develop and promote unified climate adaptation approaches and strategies?

These results and the other outcomes of the vulnerability assessment will be used to develop policies for the County Policy Plan to improve community resiliency, reduce the harm caused by climate-related hazard conditions, and demonstrate compliance with new statutory requirements established by Senate Bill 379.

Executive Summary

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1. Introduction

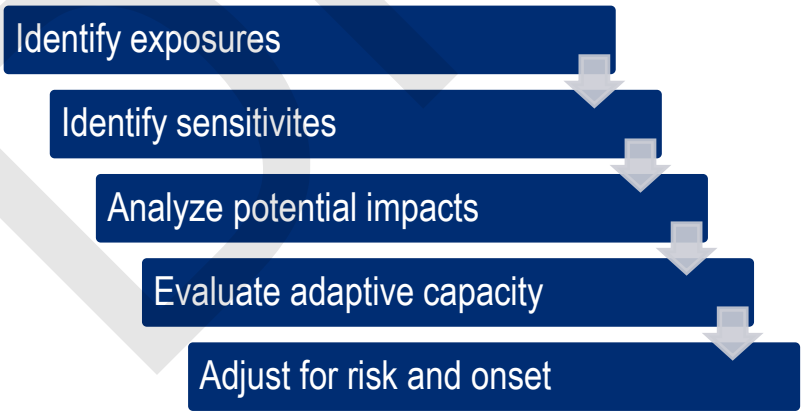
This vulnerability assessment analyzes the susceptibility of San Bernardino County to climate-related hazard events. It identifies the climate-related hazards in the area and how they are expected to change, the damage that these hazards may cause, and how severe the threat is to the community. The outcomes of the vulnerability assessment will guide development of adaptation strategies, which will help make the community more resilient to these hazards.

This vulnerability assessment stems from the County's desire to proactively identify hazard conditions and opportunities to build resilience and protect the health, safety, and overall well-being of community members, including residents, employees, business owners, and visitors. It also complies with Senate Bill 379, which requires that a jurisdiction's general plan address the risks posed by climate change.

> *The Safety Element shall be reviewed and updated as necessary to address climate adaptation and resiliency strategies. This review…shall include a vulnerability assessment that identifies the risks that climate change poses to the local jurisdictions and the geographic areas at risk from climate change impacts.*
>
> —California Government Code Section 65302 (g)(4)(A)(i)

1.1 METHODS AND PROCESS

In accordance with Senate Bill 379 and best practices, this vulnerability assessment follows the method and process recommended in the *California Adaptation Planning Guide* (CNRA and Cal EMA 2012), which provides state-level guidance to regional and local governments addressing the effects of climate change. The *Adaptation Planning Guide* outlines a five-step process for conducting a vulnerability assessment.



- Identify exposures: Assess which effects of climate change will affect the community.
- Identify sensitivities: Determine the key components of the community, including populations, structures, and functions, that are potentially susceptible to each effect of climate change.
- Analyze potential impacts: Look at how the effects of climate change will affect the community's populations, structures, and functions.
- Evaluate adaptive capacity: Determine the community's current ability (e.g., with existing laws, resources, and practices) to prepare for and recover from projected impacts.
- Risk and onset: Adjust the assessment of potential impacts to account for uncertainty, timing, and adaptive capacity (CNRA and Cal EMA 2012). Note: In this vulnerability assessment, this step was performed as part of the initial impact assessment, not as a stand-alone step in the process.

A list of key terms associated with the process and other components of the vulnerability assessment are in **Appendix B**.

1.2 DATA SOURCES

The vulnerability assessment must be firmly grounded in the best available science and data to be the most useful to the County and community members. The PlaceWorks team assembled data from a variety of credible sources to prepare this analysis and support its conclusions.

1.3 DRAFT COUNTYWIDE PLAN REPORTS

As part of the ongoing Countywide Plan process, a number of related background reports were prepared in advance or concurrently with this vulnerability assessment. Although these reports did not primarily address the hazards created by climate change, they provide a detailed assessment of current conditions in San Bernardino County and, in some cases, a discussion of how these conditions are expected to change. The PlaceWorks team considered several of these reports, including:

- Biological Resources Existing Conditions Report (2016)
- Regional Services Report (2017)
- Safety Background Report (2017)
- Transportation Existing Conditions Report (2017)
- Water, Wastewater, and Hydrology Existing Conditions Report (2017)

1.4 OTHER LOCAL PLANS AND REPORTS

When appropriate, the PlaceWorks team obtained and reviewed plans and reports that were not prepared as part of the Countywide Plan but discuss relevant issues. These documents provide useful information about current and projected conditions in San Bernardino County, including quantitative and qualitative discussions. The PlaceWorks team reviewed:

- San Bernardino County Community Indicators Report (2015)
- San Bernardino County Multi-jurisdictional Hazard Mitigation Plan (2016–2017 Update)

1.5 SPATIAL DATA

The PlaceWorks team collected spatial data that show the current locations of various populations, facilities, infrastructure, and ecosystems as well as current and future hazard conditions, including areas of increased hazard risk (e.g., flood zones) and projections of future climate conditions. In many instances, the PlaceWorks team used spatial data previously supplied by County staff for use in the Countywide Plan. Where these data were insufficient, the PlaceWorks team relied on verified data from state agencies, universities, and other sources.

1.6 SCHOLARLY RESEARCH

To conduct the vulnerability assessment, the PlaceWorks team relied heavily on an extensive body of scientific research that discusses how climate change may affect people, facilities, and other assets. Much of this research did not specifically evaluate San Bernardino County or included San Bernardino County as part of a larger area (e.g., California as a whole). In these instances, the PlaceWorks team only used data that are applicable and relevant to conditions in San Bernardino County.

Much of the scholarly research comes from a variety of different sources and is peer reviewed to ensure credibility. Some is sponsored as part of a government agency publication, such as studies from the Centers for Disease Control or California Department of Fish and Wildlife. Some research is sourced from peer-reviewed scientific journals, including The Proceedings of the National Academy of Sciences and Environmental Health. The PlaceWorks team also relied on academic institution websites and publications that may not necessarily be peer reviewed, but are managed by scientific experts and can generally be trusted. Where necessary, the PlaceWorks team referenced articles from local and national sources to support and expand upon the information from scientific publications.

1.7 STATE AND FEDERAL DATA

The PlaceWorks team relied on multiple sources of data from state and federal agencies. Data included published reports, datasets, and scientific studies. One of the key state and federal sources of data was Cal-Adapt (CES 2017), a web-based tool developed by the California Energy Commission that shows historical climate-related data and projects how the climate is expected to change in future years. The

PlaceWorks team used the most recent version of Cal-Adapt (in beta as of June 2017), which provides more updated and precise data than the previous version.

The PlaceWorks team also relied on the US Census Bureau as the primary source for demographic information. The Census Bureau provides data counts every 10 years as well as annual estimates through the American Community Survey (US Census Bureau 2015). The PlaceWorks team primarily used the most recent estimates from the American Community Survey, which were calculated in 2015 and are more up to date than the last census count in 2010.

1.8 SUMMARY OF PUBLIC OUTREACH

This section summarizes the public outreach that included opportunities to comment on climate adaptation and resiliency topics. Table 1-1 summarizes input related to climate hazards received during outreach activities conducted between October 2015 and November 2018. This is not an exhaustive list of all topics covered during the extensive public outreach effort for the Countywide Plan.

Table 1 Climate Hazard Issues Identified in Public Outreach, 2015–2018

Issues Identified by the Community	Valley	Mountain	North Desert	East Desert
Lack of access to medical services	X	X	X	X
Limitation or cap on emissions or other pollutants	X	X	X	X
Improved technology that can reduce pollution	X	X	X	X
Poor housing conditions	X		X	X
Long response times for emergency services		X	X	X
Drinking water quality / pollution			X	X
Groundwater contamination			X	X
Sewage sludge and impacts on water quality			X	
Existing and future access to water	X	X	X	X
Extreme weather (response and protection)	X	X	X	X
High fire hazards		X		X
Poor road conditions/maintenance	X	X	X	
Fugitive dust emissions and impacts on air quality			X	X
Viability of agriculture (water, pests, etc.)	X	X		
Decreasing snowpack		X		

Engaging residents in a county as large and diverse as San Bernardino required a robust effort to reach residents, agencies, and other stakeholders who live, work, or serve one or more of the county's communities.

The County initiated outreach in late 2015 with a focus on individual community planning areas. Between 2015 and 2017, the County engaged over 2,100 individuals from over 80 unincorporated communities throughout the county's four regions. The outreach consisted of over 70 meetings in over 30 different locations, along with in-person and online surveys (total of 910 survey responses).

The public meetings were designed to engage residents in a workshop setting to identify problems and potential solutions to address specific issues unique to each community planning area. Attendees were given a presentation and materials on the overall Countywide Plan effort, including new topics like climate adaptation and resiliency. Specific questions asked of the community (in person and through the surveys), included the following:

- What areas are there for improvement in the community?
- What internal or external factors or resources could be opportunities for your community?
- What are threats to your community?
- What outside factors outside of the control of the community could threaten your community?

The second phase of public meetings took place in 2017 and 2018 through two rounds of 17 regional meetings in 13 different locations throughout the county's four regions. Over 600 individuals attended these meetings, including representatives from over 50 agencies and organizations associated with federal, state, regional, and local services and interests. The first round of regional meeting was designed to engage residents, agencies, service, providers, advocacy groups, and other stakeholders to identify and discuss issues that are unique to specific communities or regions or are countywide. Common climate hazard and resiliency issues discussed included utilities like water supply, adequate infrastructure like roads and sewer, as well as emergency response capabilities. The second round of regional meetings presented draft policy recommendations based on input received and as directed by state law.

With over 100 communities spread across 20,000 square miles, the County anticipated that attendance at public meetings would not be feasible for many community members. To maximize input and access to information, the County posted all of the meeting material online (countywideplan.com/cp) in advance of public meetings (with summary information and electronic versions of surveys posted after the meetings). An individual webpage was dedicated for each community planning area (e.g., www.countywideplan.com/bloomington) so that community members could focus on information and provide input specific to their area of interest. Numerous agencies, advisory entities, advocacy groups, and other organizations participated in person or online.

The County also maintained email addresses for each community (e.g., bakercp@lus.sbcounty.gov) and provided an online submission form (no email required) for people to submit comments and questions. Over the span of the three-year outreach effort, the project website was used by over 13,000 unique visitors (excluding County and consultant usage), with the County receiving hundreds of comments and questions through the email addresses and online submission forms (anonymous if desired). A portion of these comments and questions addressed matters related to climate hazards and resiliency.

1. Introduction

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2. Exposures

Exposures, as defined by the California Adaptation Planning Guide, are the changes to climate conditions that are expected in the community.

2.1 EXPOSURE CONSIDERATIONS

There are a few key considerations to keep in mind to best understand the nature of exposures. First, forecasts of future climate conditions, as with any forecast of future conditions, have some degree of uncertainty. Climate change is caused by an increase in the levels of greenhouse gases (GHGs) such as carbon dioxide (CO_2) in the earth's atmosphere. The specific nature of the change depends in large part on the volume and timing of GHG emissions released. GHG emissions patterns are in turn affected by a number of factors, including population size, personal behavior, economy activity, and government policies. Because of this, forecasts often present multiple scenarios, each one based on different changes to these factors. The forecasts used in this vulnerability assessment cover a reasonable range of future climate conditions, but future changes could occur outside of these ranges. The changes described in this assessment generally lie at the higher end of the range of probable conditions and assume a comparatively higher level of GHG emissions.

Second, it is helpful to understand that "weather" and "climate" refer to different things. "Weather" is short term—a description of the conditions at a particular location at a particular time. "Climate" is a long-term average of conditions. For example, the maximum temperature in Joshua Tree on any given day may be below 60 degrees or above 110 degrees. However, on average, the maximum temperature in Joshua Tree over the course of the year is approximately 80 degrees (WRCC 2016). The daily maximum temperatures are weather and are difficult to accurately project beyond a few days. The annual average maximum temperature is climate and can usually be projected with a fairly high amount of certainty for decades. Because climate is an average, it is important to remember that it does not state with certainty whether an event will happen or not, only the general likelihood of it. For example, climate forecasts for San Bernardino County say that days with a temperature below freezing will become less frequent. If days with below-freezing temperatures do occur, this does not invalidate the forecast as long as the long-term average is that such days are less frequent than they used to be.

Third, all data on future climate conditions are modeled and therefore have a scale. Models project changes within a defined geographic area, such as a region, state, or even continent. Making projections for very small scales, such as individual neighborhood blocks, is not feasible. As a result, projections from these models are extrapolated down to a small scale in order to be more useful for local planning (a process called downscaling). The models used to generate the forecasts in this vulnerability assessment produced results at the statewide level, which scientists downscaled to specific locations in San Bernardino County. The downscaling allows these models to project climate

conditions for individual areas of approximately 14 square miles (CEC 2017); however, within these individual blocks, there will still be some variation of specific conditions.

2.2 SELECTED EXPOSURES

Based on the review of data collected as part of the vulnerability assessment, the PlaceWorks team identified six climate change–related exposures for San Bernardino County:

- Drought
- Extreme heat
- Flooding
- Pests and diseases
- Severe weather
- Wildfire

Table 2 shows which exposures are likely in each area of the county.

Table 2 Exposure by Area

Exposure	Valley	Mountain	Desert
Drought	Yes	Yes	Yes
Extreme heat	Yes	Yes	Yes
Flooding	Yes	Yes (limited)	Yes
Pests and diseases	Yes	Yes	Yes
Severe weather	Yes	Yes	Yes
Wildfire	Yes (limited)	Yes	Yes (limited)

2.3 DROUGHT

There are numerous water providers in the unincorporated areas of San Bernardino County, including city departments, special districts, and private companies. Additionally, many customers in more rural and isolated parts of the county obtain their water from individual wells. Most of the water supplied in the county is from local groundwater basins, and approximately 15 percent is purchased from the Metropolitan Water District. Purchased water comes from the rivers of the northern Sierra Nevada and is delivered through the State Water Project. Some communities near lakes and rivers can obtain water directly from these water bodies.

Droughts are expected to become more frequent and potentially more severe in California because climate change is expected to cause an overall decline in precipitation. Scientists estimate that the valley regions will see 2 to 4 inches of decline in annual precipitation by 2050, and up to 6 inches less

precipitation annually by 2100. By the end of the century, the mountain regions may see approximately 8 inches less precipitation. The desert regions of the county are not expected to see measureable changes in precipitation levels, although these areas have very little precipitation currently (CNRA and Cal EMA 2012).

Precipitation levels in the northern Sierra Nevada are expected to decline by 3 to 5 inches by 2050 and more than 10 inches by 2100. Additionally, climate change is expected to affect the amount of accumulated snow (snowpack) in high mountains. Typically, the snowpack melts during warmer months and contributes to water supplies during California's dry season. Warmer temperatures are expected to cause less precipitation to fall as snow, decreasing the snowpack. In the northern Sierra Nevada, snowpack levels are projected to fall by over 60 percent by 2090. Warmer temperatures are also projected to cause accumulated snow to melt faster, making less snow available later in the dry season. All of these factors are expected to make less water available from the State Water Project, making drought conditions more likely (CNRA and Cal EMA 2012).

2.4 EXTREME HEAT

Extreme heat events occur when temperatures significantly exceed normal conditions.[1] The threshold for what is considered extreme heat varies widely. In areas with hot climates, such as Baker, an extreme heat day is one where the maximum temperature exceeds 115.5 degrees. However, in Wrightwood, where the climate is much cooler, the extreme heat threshold is 82.9 degrees. Heat waves, a closely associated event, occur when there are five or more consecutive extreme heat days.

Climate change is expected to increase overall temperatures globally, which is forecast to translate to more frequent and more intense heat waves. This can result in substantial health and safety risks, especially among senior citizens, children, outdoor workers, and persons with existing health conditions. Extreme heat can also damage mechanical and electrical equipment, harming buildings and facilities, and cause agricultural crops to wilt and die. Some aircraft may be unable to take off or land in very high temperatures (Atherton 2017). Even in areas with mild temperatures, where an extreme heat event may be less than 90 degrees, these events can be dangerous because community members are not used to these temperatures.

As temperatures get warmer, it is likely that extreme heat events will increase as well. **Figure 1** and **Figure 2** show the anticipated increase in average maximum temperatures in San Bernardino County for the years 2070 to 2099. **Figure 1** shows the average annual maximum temperature for this time period. Although the mountain regions are expected to have an average temperature of at least 60 degrees, average temperatures in the desert may reach above 95. **Figure 2** shows the change in average temperatures for 2070 to 2099, compared to the years 1961 to 1990. The average increase in the region is approximately 7.7 degrees, although some parts of San Bernardino County may see increases close

[1] There is no universal definition of extreme heat. Cal-Adapt defines an extreme heat event as a day between April and October when the maximum temperature is hotter than 98 percent of maximum temperatures for that day between 1961 and 1990 (CEC 2017).

to 9 degrees. All areas are expected to see an increase of at least 6.5 degrees. **Table 3** shows the anticipated levels of extreme heat in different parts of the county.

Table 3 Extreme Heat Projections for Selected Locations

Community	Extreme Heat Threshold (degrees Fahrenheit)	Number of Extreme Heat Days (2070–2099)	
		Low Emissions	High Emissions
Valley communities			
Bloomington	103.9	30	47
Mentone	100.8	32	49
Muscoy	103.9	31	49
Mountain communities			
Big Bear City	84.3	43	66
Lake Arrowhead	91.1	31	50
Wrightwood	82.9	36	55
Desert communities			
Baker	115.5	24	42
Joshua Tree	104.4	34	56
Silver Lakes	106.1	38	60

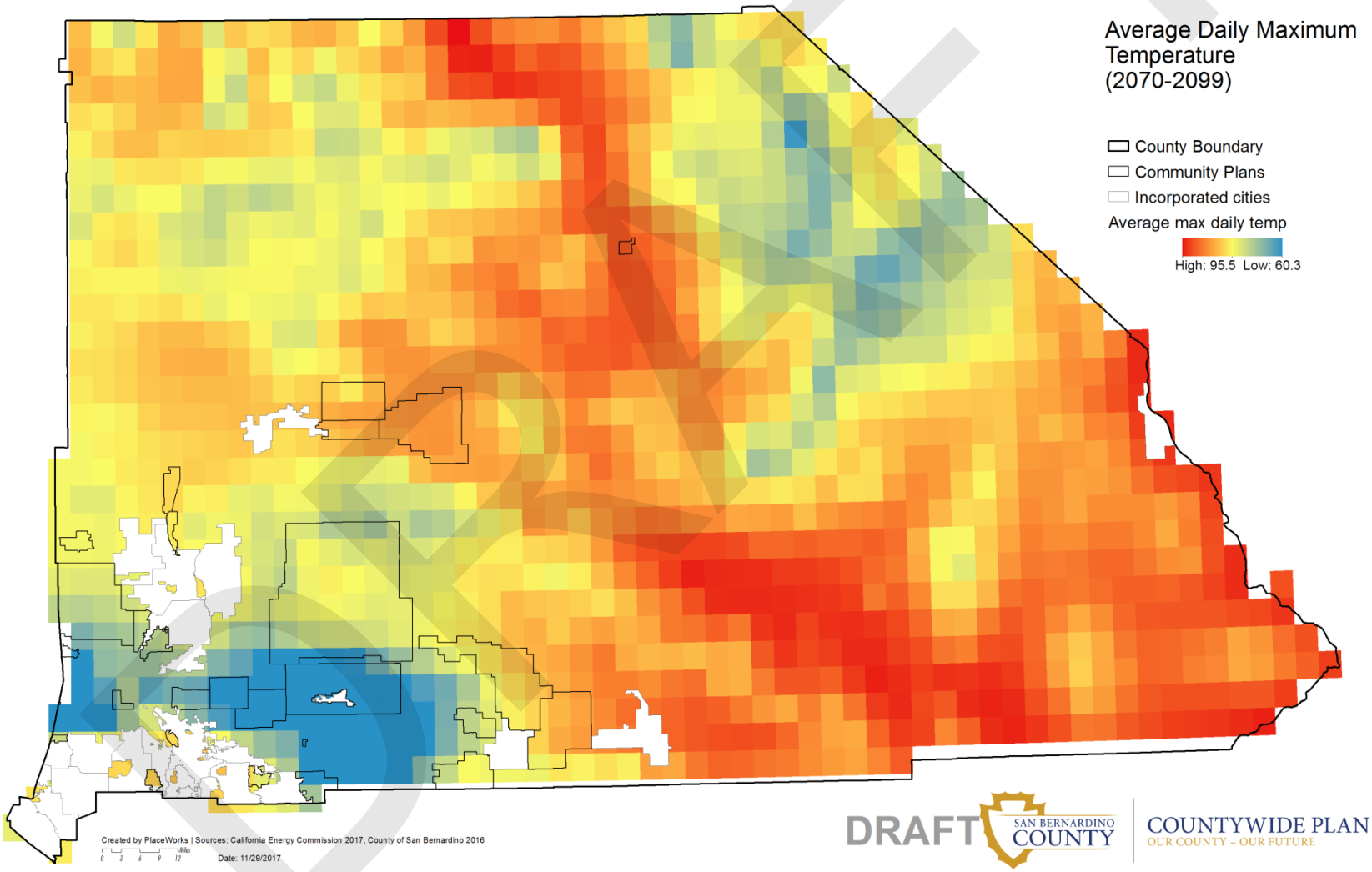
Notes: Under current conditions, there are an average of four extreme heat days per year.
Projections are an average of HadGEM2-ES, CanESM2, CNRM-CM5, and MIROC5 climate models. These four models are most commonly used by state agencies for climate projections.

2.5 FLOODING

In San Bernardino County, flooding is predominantly a risk in flood hazard zones, although floods may occur outside of these areas. Floods that disrupt regional infrastructure, such as roadways or energy networks, can cause significant disruptions outside of flood areas.

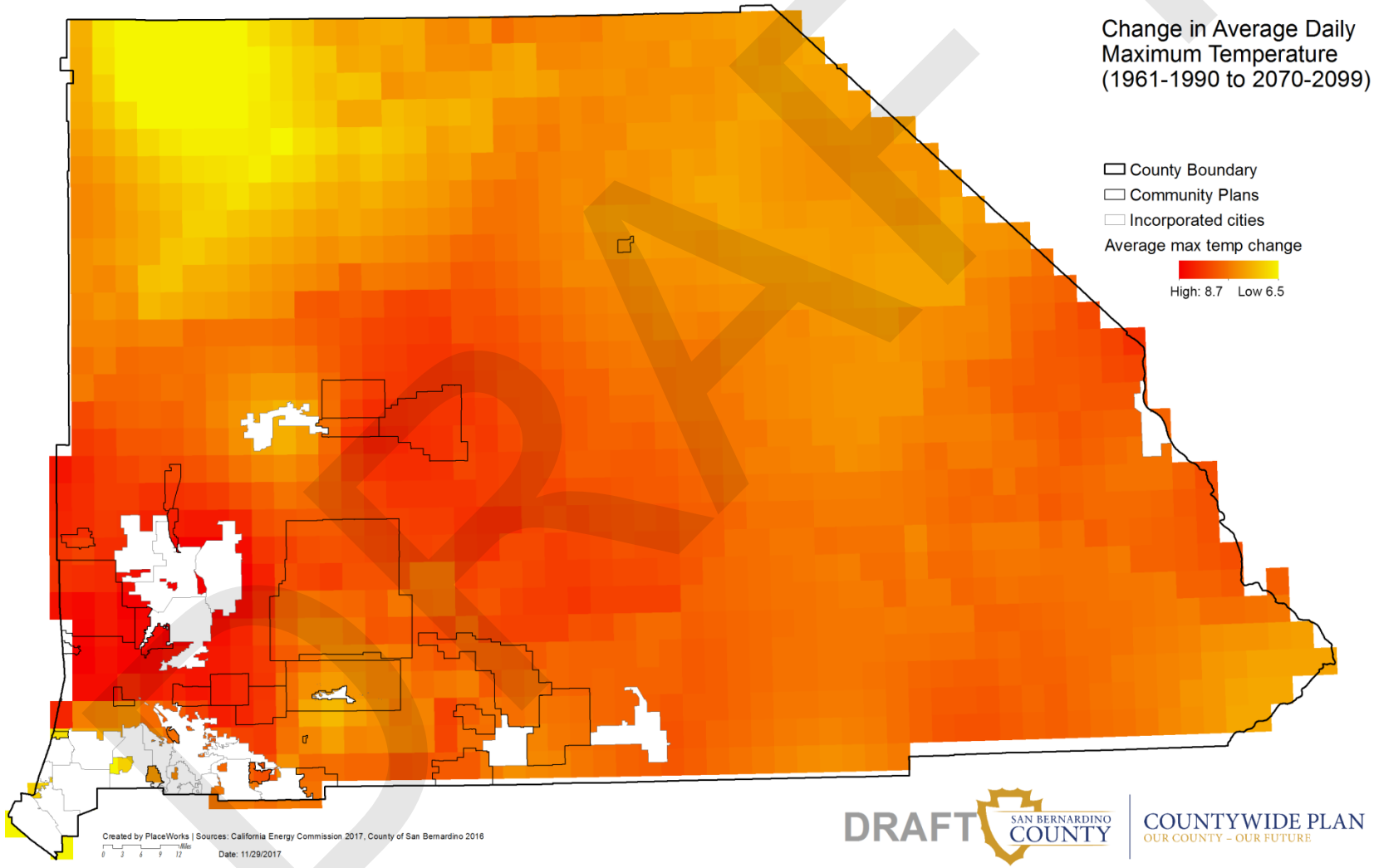
Although overall precipitation levels are expected to decline, storms will not necessarily become weaker or less frequent. Climate change may actually increase flood events. This is in large part due to expected changes to "atmospheric rivers," narrow bands of very moist air that act as pathways for intense storm systems. Although there are typically only a few atmospheric river storms each year, they are responsible for as much as 50 percent of California's rain (Rogers 2014) and up to 80 percent of the flood events in the state (Dettinger and Ingram 2013). Southern California is expected to see approximately the same number of atmospheric river storms by 2100 as a result of climate change, but each atmospheric river storm is expected to be 10 to 20 percent more intense (Oskin 2014). This increases the risk that any given storm will result in a flood event. Flood events will also continue to result from nonatmospheric river storms, but these flood events are expected to remain the minority. Warmer temperatures are also expected to cause more precipitation to fall as rain rather than snow, and to cause any accumulated snow to melt faster, exacerbating flood condition.

Figure 1 Average Daily Maximum Temperature



2. Exposures

Figure 2 Change in Average Daily Maximum Temperature



There are three mapped flood zones in San Bernardino County. A 100-year flood zone has a 1 percent (one in 100) chance of a flood in any given year, and a 500-year flood zone has a 0.2 percent (one in 500) chance of a flood per year.[2] A third type of flood zone, known as a flood awareness zone, identifies areas outside of the 100-year flood zone for which there is still an elevated risk of flood events.[3] If the risk of flooding increases as expected, it is likely that these zones will expand. For example, areas outside of the 100-year flood zone could become part of it as flood events become more common. It is also possible for areas outside of these defined areas to flood, particularly during especially severe events.

The vulnerability assessment also considers dam failure hazard zones. A dam failure occurs when a dam loses some or all of its ability to hold back water, releasing the water behind the dam and causing a fast-moving flood. The greatest risk is to people and structures closest to the dam, who will bear the brunt of the released water before it has a chance to slow down or absorb into the ground. Dam failures can have many different causes, including if intense storms cause heavy precipitation that erodes part of the dam. The dam failure zones overlap somewhat with other flood hazard zones.

Figure 3 shows the flood-prone areas in San Bernardino County.

2.6 PESTS AND DISEASES

As climate change brings warmer temperatures, conditions in San Bernardino County may become more supportive of pest animals and disease-causing organisms (pathogens). For example, some species of pest or pathogens, such as mosquitos, may be able to stay active for longer before they are killed by cold weather. The changing climate may allow pests or pathogens that are used to warmer or drier climates to migrate into the county, bringing new diseases or pest infestations. Climate change can also put stress on people, plants, and animals, making them more susceptible to pests and diseases.

Pests and diseases can cause a number of impacts to the community. They create significant health risks for community members, particularly for young children, senior citizens, and persons with weakened immune systems who are less able to resist them. They can damage or destroy agricultural products, both crops and livestock, creating economic hardships for farmers and ranchers. Wild plants and animals may be affected, which may not only harm the well-being of local ecosystems but may reduce outdoor recreation and tourism activities. Pest infestations and disease outbreaks can damage public and private landscaped areas. Overall quality of life may also decline if there are significant numbers of pest animals present, even if there are no substantive health impacts.

[2] These are averages, not firm cycles. A 100-year or 500-year flood event is not one that only occurs every 100 or 500 years, respectively. It is possible to have multiple 100-year or 500-year flood events closer together, even in the same year.

[3] There is some overlap between the 500-year flood zone and the flood awareness zone. However, there are also areas that lie within one or the other, but not both.

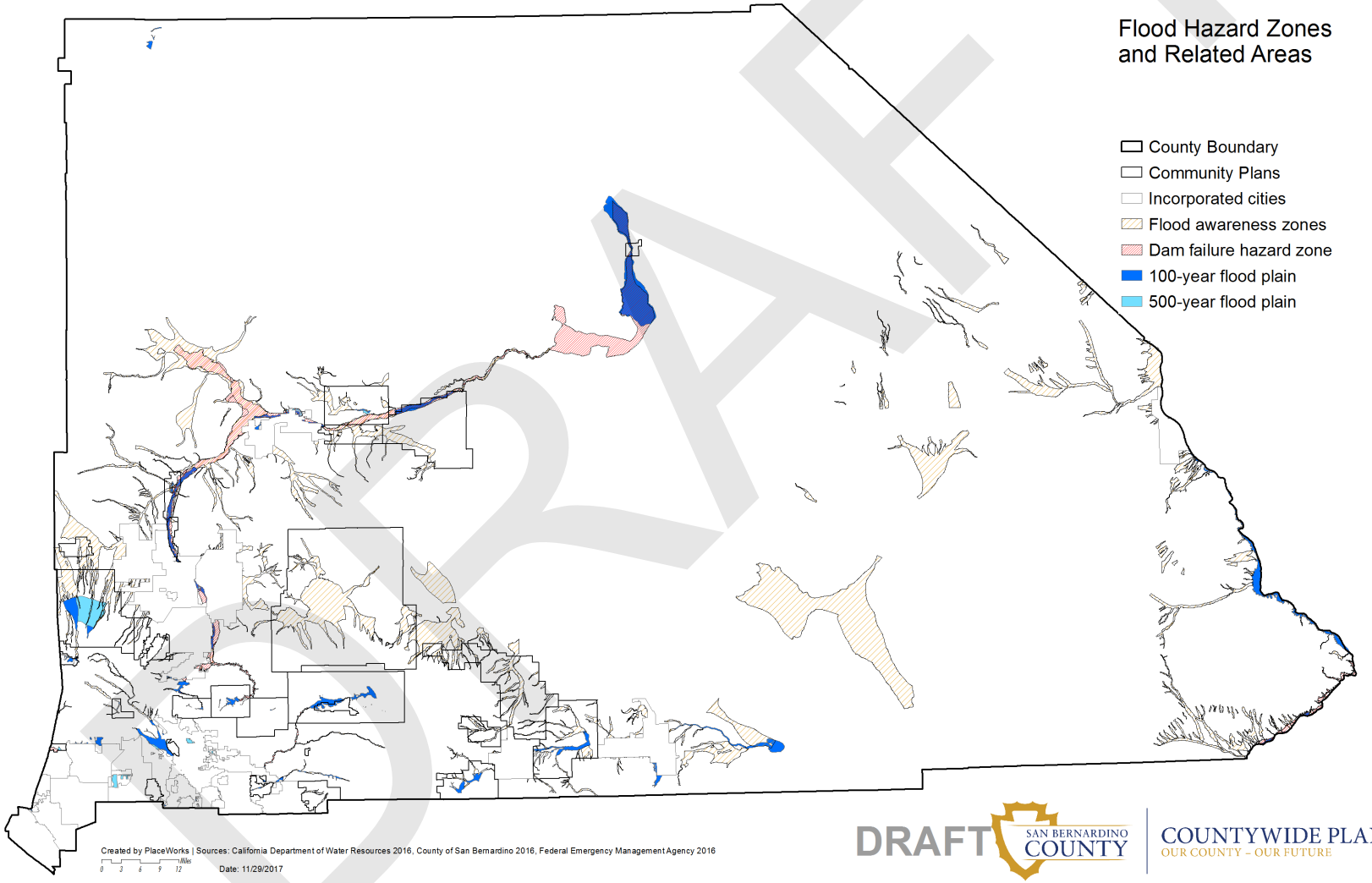
2.7 SEVERE WEATHER

Severe weather is a broad category for various exposures not effectively covered by other categories. It includes severe wind, thunderstorms, hail, and tornadoes. It is not certain how climate change will affect severe weather in San Bernardino County, although it is possible that increases in the number of intense storms could also increase the number of severe weather events. High wind events are likely the exposure of greatest concern, as they are more common and can cause property damage, destruction or disruption of infrastructure networks, and even injury and death in particularly extreme cases. Hail can also cause property damage and injury, although it is less frequent. Thunderstorms by themselves are not particularly damaging, although lightning strikes may start wildfires. Tornadoes can be very destructive, but they are rare in San Bernardino County.

2.8 WILDFIRE

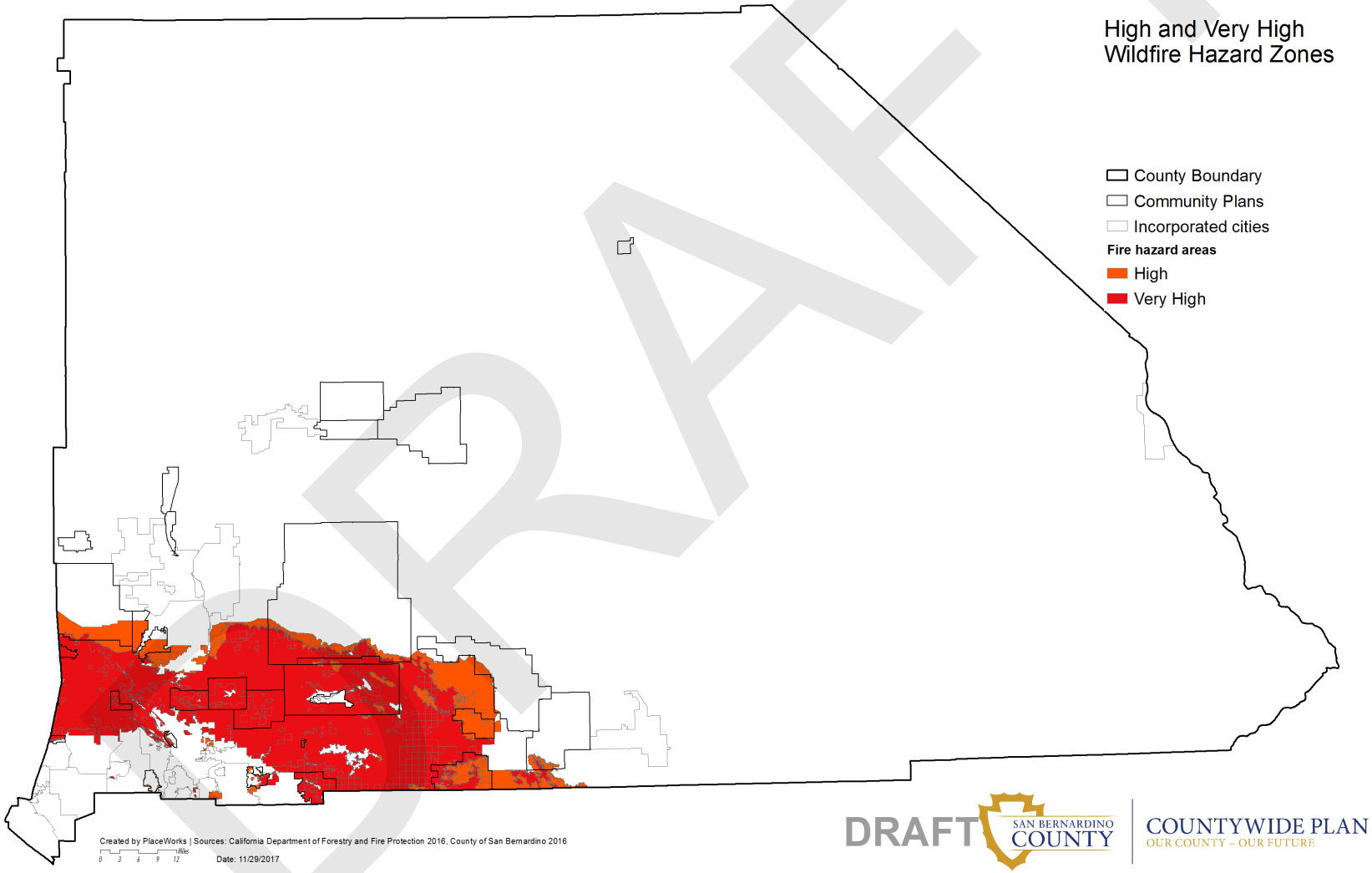
As temperatures increase and precipitation levels decline, it is expected that wildfires will be more frequent and of greater intensity. Additionally, individual fires are expected to be larger. The mountain region of the county faces the greatest risk, although the valley region may also see wildfires outside of the urban boundaries. Wildfires are not generally a problem in most of the desert region due to a lack of vegetation, although there may be wildfires in limited areas. In addition to threatening people, ecosystems, and structures in at-risk areas (as well as the services that depend on these structures), wildfires can impact regional air quality. Infrastructure damaged by wildfires may also result in widespread service disruptions. **Figure 4** shows the areas of high and very high wildfire risk.

Figure 3 Flood Hazard Zones and Related Areas



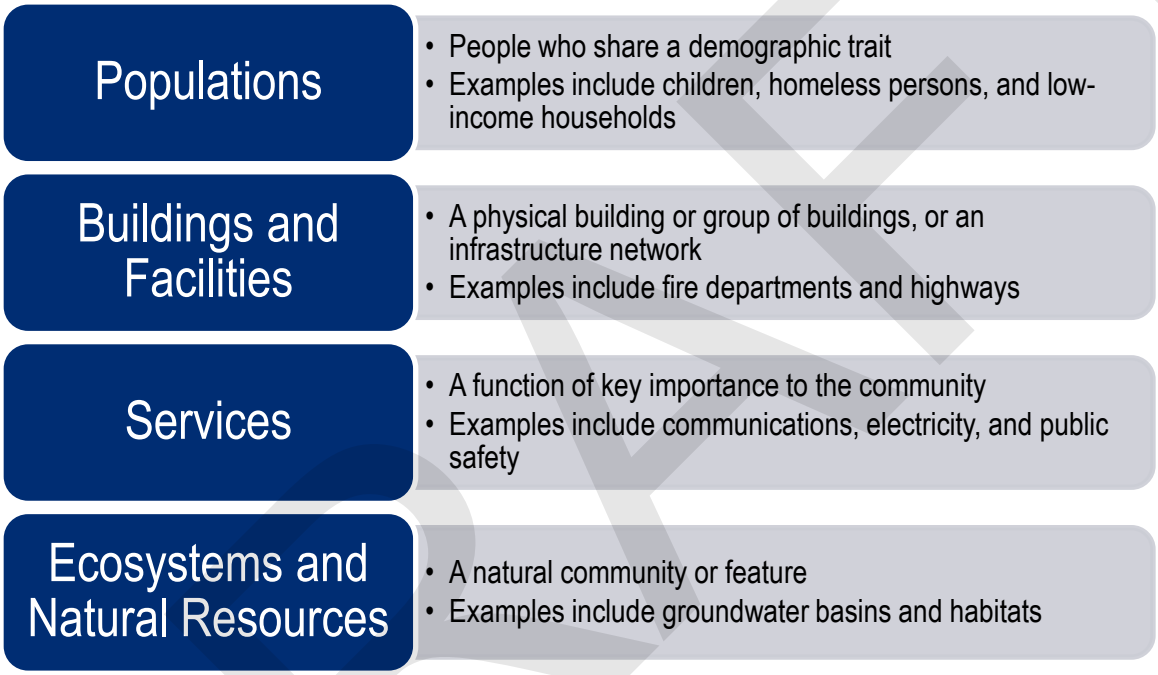
2. Exposures

Figure 4 High and Very High Wildfire Hazard Zones



3. Sensitivities

Sensitivities are the populations and assets in the community that can be affected by climate change. The Adaptation Planning Guide provides an initial list of sensitivities, which the PlaceWorks team has refined to be more appropriate for San Bernardino County. This vulnerability assessment has four categories of sensitivities.



3.1 SELECTED SENSITIVITIES

The vulnerability assessment looked at the sensitivities described below under each category. Note that not all sensitivities were analyzed for each exposure, as some exposures are not likely to be uniquely vulnerable to a particular hazard type (e.g., young children are not uniquely affected by flood events).

3.2 POPULATIONS

Children less than 10: According to the most recent census estimates, approximately 40,340 children under the age of 10 live in the unincorporated areas of San Bernardino County. Young children are also more likely than adults to face health complications from extreme heat and may also be at more risk from some pests and diseases.

3. Sensitivities

Homeless persons: San Bernardino County's 2017 homeless count identified 66 homeless persons in the unincorporated areas, although some persons may move between incorporated and unincorporated communities. The highest populations were reported in Crestline and Joshua Tree. Homeless persons are regularly exposed to the elements and often have very few or no resources, making them highly vulnerable to climate change–related effects.

Households in poverty: The Census Bureau estimates that approximately 55, 990 persons live in poverty in the unincorporated areas of San Bernardino County. Households in poverty often face extreme financial hardships, which can limit their means to resist hazard events or require them to live in more vulnerable areas. **Figure 5** shows the concentrations of households in poverty.

Households overpaying for housing: Households that spend at least 30 percent of their income on housing are said to be overpaying. This can restrict households' financial means, meaning that they are less able to prepare for hazard events or recover effectively. There are approximately 36,230 households overpaying for housing in the unincorporated areas of San Bernardino County. Renters are more likely to overpay.

Individuals with existing medical conditions: Existing medical conditions are chronic illnesses or other conditions that require regular medication, procedures, medical devices, or other medical assistance. Such individuals are more likely to have disabilities and may be economically stressed, making them even more vulnerable. Some medical conditions may make a person more directly susceptible to hazardous conditions.

Individuals without access to lifelines: Lifelines include means of travel and communication, including personal vehicles (particularly in rural areas), telephones, and televisions. Persons without these lifelines are often socially isolated, which can make it harder for them to receive information or obtain goods and services. Social isolation can also decrease a person's mental well-being, further increasing their vulnerability.

Linguistically isolated households: There are approximately 4,430 households in San Bernardino County that are linguistically isolated, according to estimates from the US Census Bureau. In these households, no one over the age of 13 speaks English only or speaks a language other than English and speaks English "very well." In approximately 82 percent of linguistically isolated households, Spanish is the primary language spoken. Linguistically isolated households may have difficulty understanding information about how to prepare for climate-related hazard events, how to respond to such events as they happen, and how to effectively recover.

Low-income households: According to the California Department of Housing and Community Development, a family of four with an income of less than $53,600 annually is considered low-income. There are approximately 46,840 households in the unincorporated areas making less than $50,000, which is half of all households in the unincorporated areas. Such households may be unable to prepare for or recover from climate-related hazards due to less financial means.

Outdoor workers: Outdoor workers include workers in construction, agriculture, landscaping, outdoor recreation, and others. These persons are more exposed to the natural elements and so are more likely to be harmed by harsh climate-related conditions.

Overcrowded households: The US Census Bureau estimates that approximately 7,590 households are overcrowded in the unincorporated areas of San Bernardino County, and 1,950 households are severely overcrowded. An overcrowded household has more than one person per room (all rooms, not only bedrooms), and severely overcrowded households have at least one and a half persons per room. Overcrowded housing units are less likely to be well maintained, which puts them at increased risk from climate-related hazards. Overcrowded households are also more likely to experience financial stress, which can limit their ability to prepare for, respond to, and recover from hazardous events.

Persons in a mobile home: There are approximately 8,080 mobile homes in the unincorporated areas of San Bernardino County according to Census Bureau estimates, making up approximately 9 percent of housing units in the unincorporated area. Mobile homes are more physical susceptible to damage from hazard types, increasing the risk to people who live in them. Persons living in mobile homes are also more likely to have lower income, which limits their ability to prepare for and respond to climate-related events.

Persons with disabilities: The US Census Bureau estimates that approximately 28,030 households in the unincorporated areas of San Bernardino County have at least one person with a disability. This is approximately 30 percent of all households in the unincorporated area. Persons with disabilities may have difficulty caring for themselves and often have reduced mobility. This can make it challenging for them to adequately prepare for, respond to, and recover from climate-related hazard events, particularly if they have limited access to support networks, both formal (such as organized assistance programs) and informal (such as friends and family). **Figure 6** shows the percentage of households that have at least one person with a disability.

Renters: People who rent typically have lower income levels than people who own their homes, which could limit their ability to adapt to climate-related hazards. They also have less control over their homes, which limits their means to make preventative retrofits and can make it harder to find replacement housing if their homes are damaged or destroyed. The US Census Bureau estimates that there are approximately 31,260 rental households in the unincorporated areas of San Bernardino County, or approximately 34 percent of all households.

Senior citizens: There are approximately 36,850 persons at least 65 years of age in the unincorporated areas of San Bernardino County, according to the US Census Bureau. Senior citizens are more likely to face a range of challenges that place them at increased vulnerability from climate-related hazards, including reduced mobility, physical or mental disabilities, and lower income levels. **Figure 7** shows the percentage of the population that is seniors.

Senior citizens living alone: According to US Census Bureau estimates, approximately 8,520 senior citizens in the unincorporated areas of San Bernardino County, or approximately 23 percent of all

senior citizens, live by themselves. Senior citizens living alone face the same challenges as other senior citizens, including greater likelihood of disabilities or existing medical conditions, potentially limited income, greater risk of mobility challenges, and higher susceptibility to extreme heat and some illnesses. Seniors living alone have a greater vulnerability, because there is no one else in the house to provide assistance if needed. Seniors living alone are also more likely to be socially isolated.

Undocumented persons: Undocumented persons are those who do not have legal documentation to live or work in the United States, such as a passport, visa, or proof of permanent residency (a "green card"). These persons often have low income levels and may live in substandard housing, leading to high vulnerabilities. Their lack of official status also makes them more likely to face abuse or to have their rights ignored, further increasing their vulnerability. Additionally, undocumented persons may deliberately isolate themselves from government agencies or formal support networks due to a lack of trust, which can make effective communication difficult. Although there is no official count of undocumented persons, estimates from 2013 suggest that there are approximately 118,000 undocumented persons in San Bernardino County (PPIC 2017).

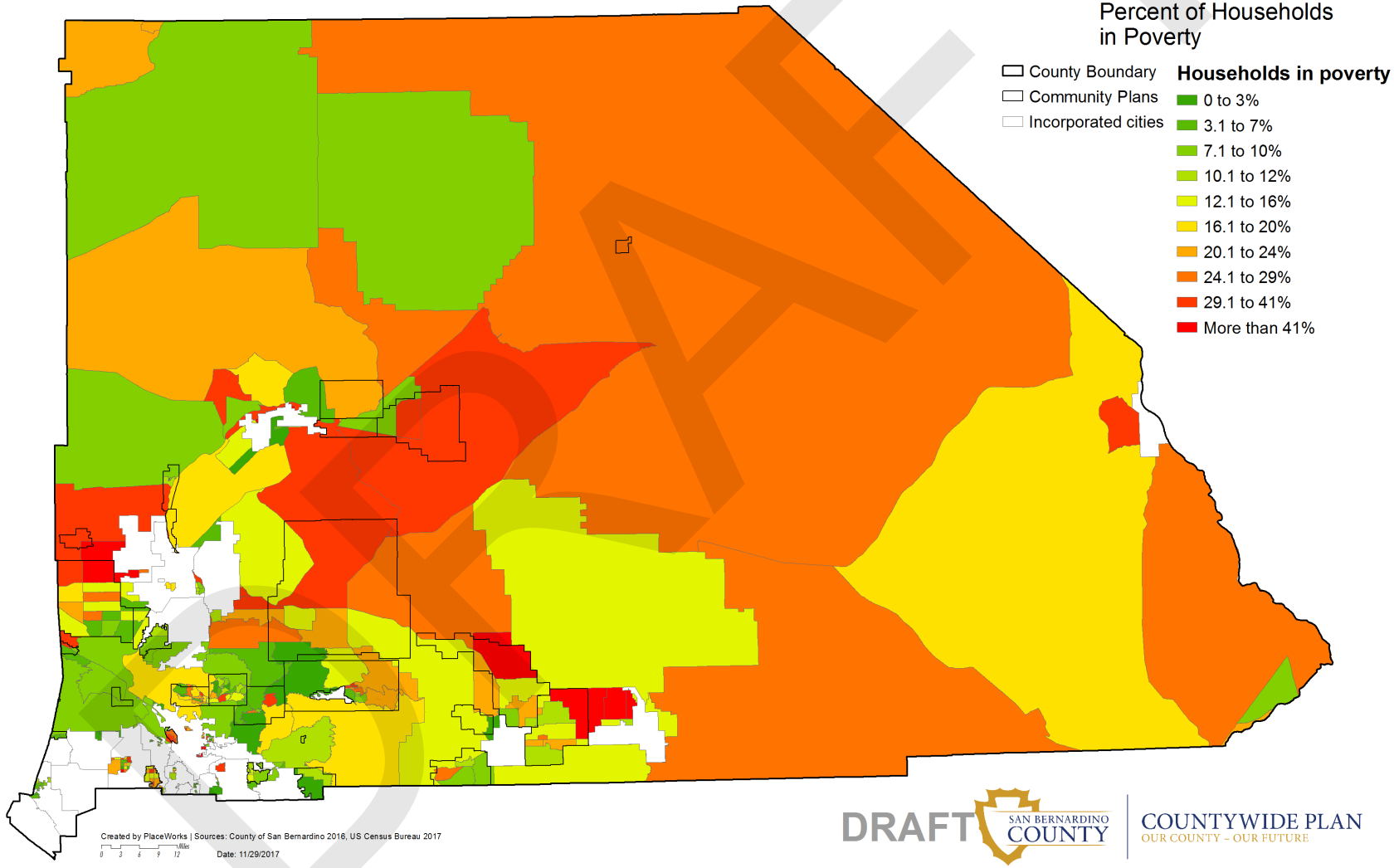
3.3 BUILDINGS AND FACILITIES

Adult residential care centers: These facilities provide long-term care to adults with special needs who are unable to take care of themselves. Residents of these facilities often have physical or mental disabilities, chronic health conditions, or other challenges that can make them highly vulnerable to climate change–related hazards. There are 56 such facilities in the unincorporated areas of the County.

Agricultural lands: Agricultural lands include farms, pastures, orchards, horse ranches, poultry operations, vineyards, nurseries, and other lands used for growing crops or raising livestock. Most agricultural land in the unincorporated area is in Daggett and other areas around Barstow, in the Lucerne Valley, and in Mentone. Climate-related hazards can physical damage crops or facilities or make it harder for crops to grow. There are approximately 45,530 acres of agricultural land in the unincorporated areas. **Figure 8** shows agricultural areas in San Bernardino County.

Airports: Excluding unnamed landing strips and facilities on military installations, there are 17 currently operating airports and landing strips in the unincorporated areas of San Bernardino County. (Airports typically have facilities to support flight operations, and airstrips lack such facilities and are often little more than a runway.) No airports in the unincorporated area provide commercial air liner service. Damage to airports can interrupt flight operations, which may interfere with rescue and recovery operations, especially in more remote areas.

Figure 5 Percentage of Households in Poverty



3. Sensitivities

Figure 6 Households with Disabled Persons

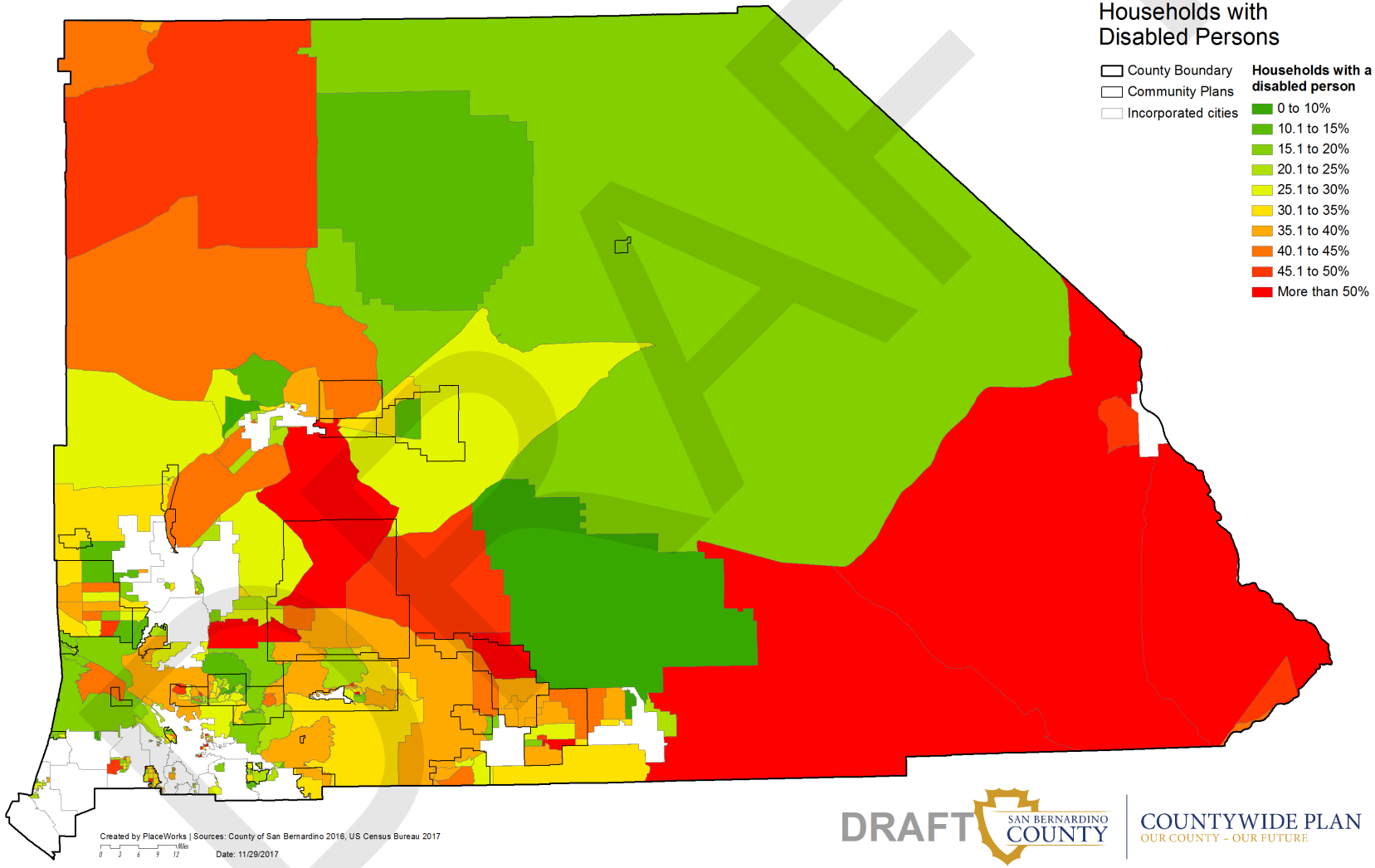
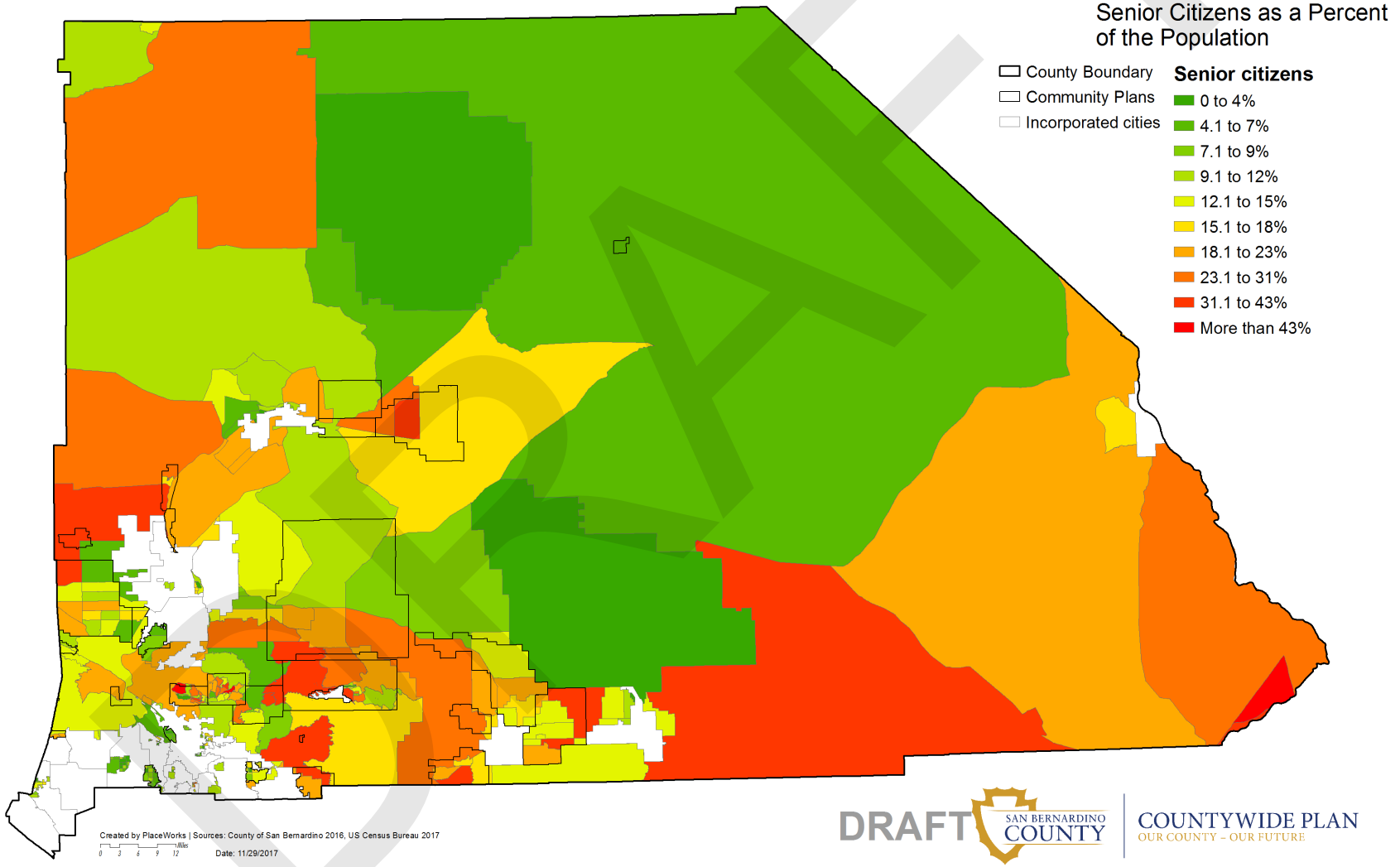
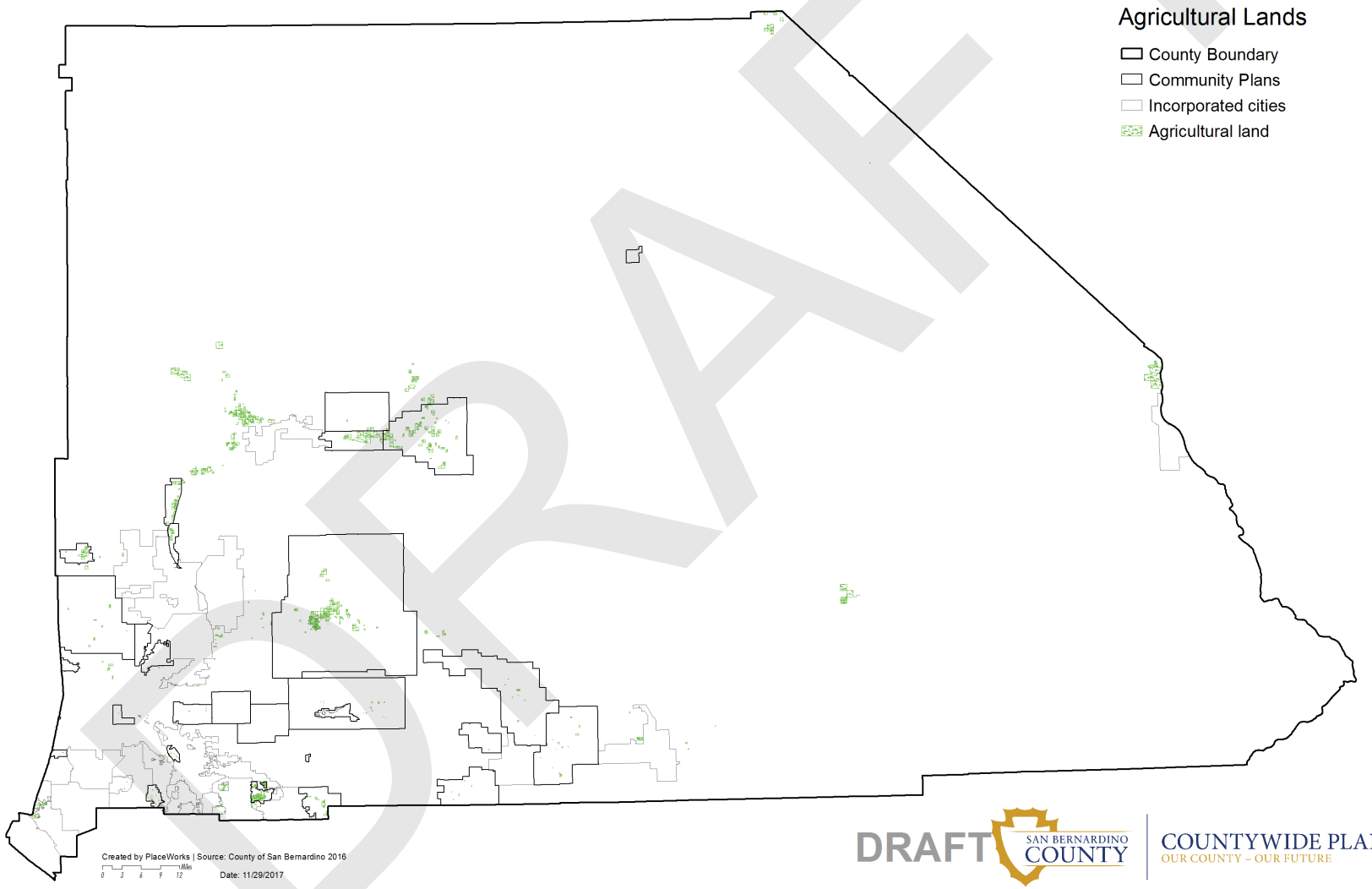


Figure 7 Senior Citizens as a Percentage of the Population



3. Sensitivities

Figure 8 Agricultural Lands



Bridges: This category consists of roadway bridges over permanent or seasonal bodies of water, including over washes in the desert that are dry except during intense rainstorms. If bridges are damaged or destroyed, it can cause substantial traffic disruption, affecting regular commutes and daily activities as well as urgent activities such as emergency response. In some rural areas, detouring around a bridge can add hours to a trip. There are 192 road bridges in the unincorporated areas of San Bernardino County, of which 137 are considered structurally deficient.

Buildings in dam inundation areas: Buildings in dam inundation areas face a high risk of damage or destruction if the dam fails, particularly buildings close to the dam. Since dam inundation areas often include low-lying riverbeds and surrounding floodplains, these buildings also often face an elevated flood risk.

Buildings in flood hazard areas: Buildings in flood hazard areas include those in the marked 100 and 500-year floodplains as well as those in flood awareness zones. Such buildings face an increased risk of being damaged or destroyed by a flood event. Flooding may also affect buildings outside of these zones.

Buildings in wildfire hazard areas: Buildings in high or very high wildfire hazard zones are at risk of being damaged or destroyed by wildfire, particularly if they lack wildfire-resistant design features and landscaping. Buildings outside of wildfire hazard areas may also be harmed by a large fire.

Communication facilities: Communication facilities include media (e.g., radio and television) transmitters, cell-phone towers, and related support structures. If these facilities are damaged or lose power, they may be unable to send and receive signals, causing communication outages. While this may be an annoyance or inconvenience in some cases, loss of communication services used for emergency response, community notification, or other vital functions can have serious consequences. There are 147 identified communication facilities in the unincorporated area of San Bernardino County.

Dams: Dams in the unincorporated areas of San Bernardino County are used for flood control, water supplies, hydroelectricity, and recreation. They vary widely in size, with the largest (Seven Oaks Dam along the Santa Ana River) standing 550 feet tall and capable of holding back 145,600 acre-feet (47.4 billion gallons) of water (DWR 2017). Damage to these facilities can cause potentially catastrophic flooding downstream, along with a loss of whatever services the dam provides. There are 24 dams in the unincorporated area.

Electrical substations: Substations convert high-voltage electricity from power plants to lower voltages that can be used by electrical customers such as homes and businesses. They are key parts of the electrical grid, and any damage to substations can result in power outages. There are 74 substations in the unincorporated areas of San Bernardino County.

Electrical transmission and distribution lines: Transmission lines carry electricity from power plants to local communities, and distribution lines connect individual buildings to the electrical grid. Collectively, they provide electrical service to San Bernardino County community members, and any

damage to them can cause power outages, particularly in more rural areas where redundant power lines are not always available.

Foster homes: Foster homes provide homes to minors without permanent guardians, many of whom are waiting to be adopted. Residents of foster homes have often had difficult lives, and these facilities provide a vital safety net for children with no other options for shelter. Like other buildings, these facilities can be damaged by a variety of climate-related hazards, which can reduce their capacity or impose additional difficulties on residents. There are two foster facilities in the unincorporated areas.

Government offices: Government offices are facilities that are important for county government administration. These include County administrative buildings, courthouses, and similar structures. If these offices are damaged or inaccessible, key County government functions could be partly or completely interrupted. Although most of these facilities are in incorporated communities, eight are in the unincorporated areas. **Figure 9** shows the location of government offices in the unincorporated areas.

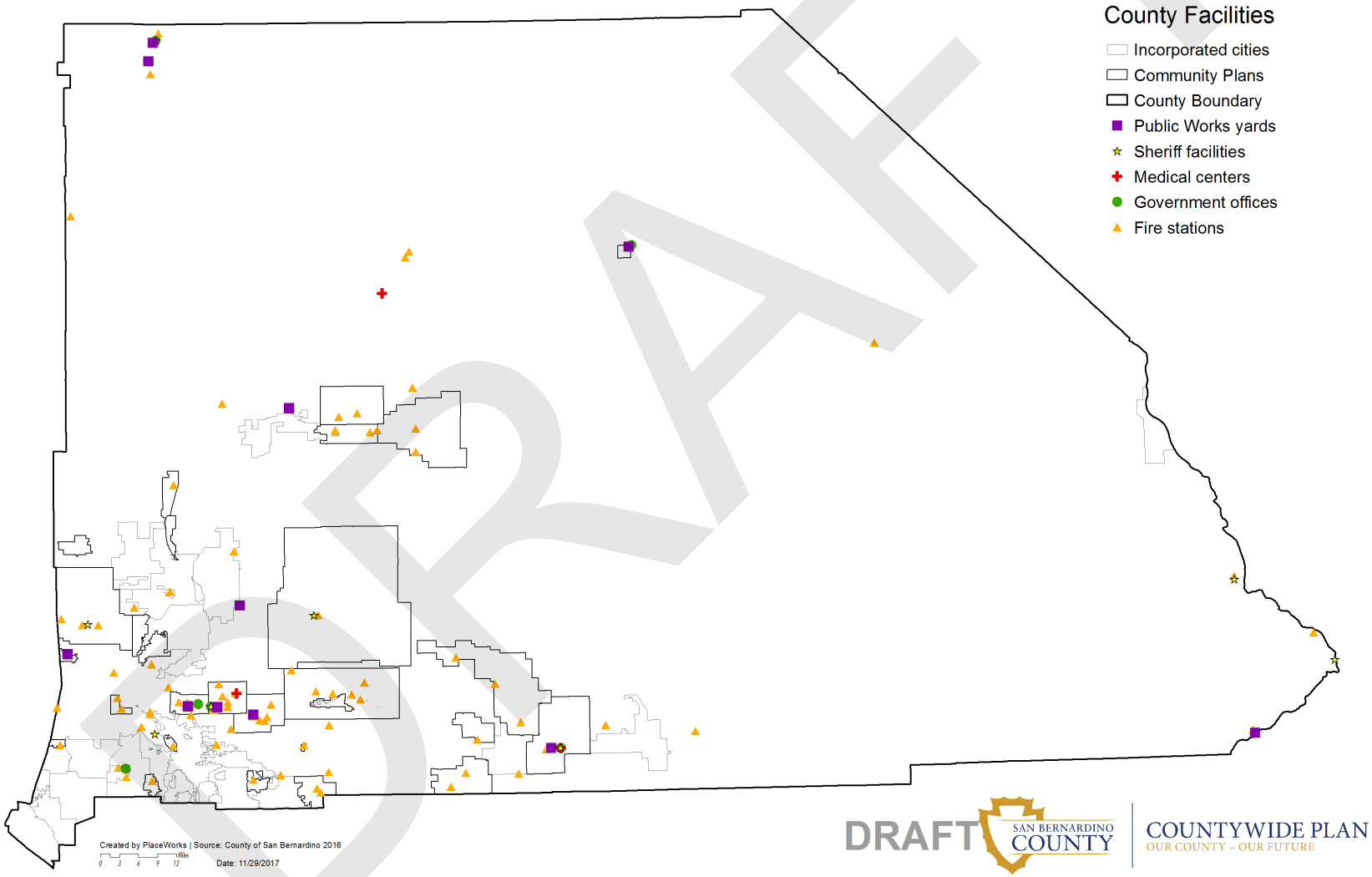
Libraries: In addition to supplying community members with books and other media, libraries serve as key community meeting spaces, provide Internet access, and can be used as assembly points or shelters during emergency events. If climate-related hazards damage library buildings or make it difficult to operate libraries, these functions may be curtailed. There are 10 County library facilities in the unincorporated areas.

Medical facilities: Medical facilities, such as hospitals, are critical for County residents. These provide vital medical services, which can be particularly important during climate-related hazards or other disasters. If such facilities are damaged or cannot operate, medical services can be strained. There are two main medical facilities in the unincorporated areas: Mountains Community Hospital in Lake Arrowhead and the High Desert Medical Center (a third hospital is in Fort Irwin, on military land beyond County control). **Figure 9** shows the location of medical facilities in the unincorporated areas.

Military facilities: Military facilities in the unincorporated area are the Marine Corps Air Ground Combat Center Twentynine Palms, Fort Irwin, the Marine Corps Logistics Base Barstow, and parts of Naval Air Weapons Station China Lake and Edwards Air Force Base. While these facilities are not under County control, they are major employment centers that could provide shelter and serve as assembly points and staging areas during a disaster event.

Natural gas facilities: Natural gas facilities are responsible for ensuring a safe and reliable supply of natural gas to homes and business, which use it for space and water heating, cooking, clothes drying, and industrial purposes. These facilities help store natural gas and keep it moving through pipelines at safe and efficient pressures. Any damage to these facilities may affect natural gas delivery or result in a natural gas leak, which poses a risk of explosion and fire. There are seven natural gas facilities identified in the unincorporated area of San Bernardino County that affect the supply of natural gas to customers throughout California.

Figure 9 County of San Bernardino Facilities



3. Sensitivities

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Old homes: Old homes are those constructed before 1970, prior to the adoption of modern building codes. While some of these homes have been renovated, others that have not been improved may be more likely to be damaged or destroyed during a hazard event. Older homes may also lack modern temperature controls and weatherization to help keep the indoors comfortable during extreme temperatures. The US Census Bureau estimates that approximately 54,540 homes were constructed before 1970 in the unincorporated areas of San Bernardino County, approximately 40 percent of all homes in the unincorporated area.

Parks and open space: Community parks can serve as key meeting places and/or staging areas in times of need. They are also important to a high quality of life in the community and support improved public health. There are 56 community parks in the unincorporated areas of San Bernardino County.

Power plants: Power plants generate the electricity used by residents, businesses, and other customers across California. Although San Bernardino County is not necessarily supplied with electricity entirely from local power plants, damage to power plants that causes them to shut down or curtail generation could put stress on the local electrical grid.

Private recreational sites: Private recreational sites include privately owned reservoirs, ski resorts, and other recreational facilities. Many of these facilities rely on certain climate conditions, such as a minimum amount of annual precipitation, to remain viable and in business. If these conditions are at risk of being unmet as a result of climate change, these facilities may be unable to operate, potentially causing financial hardships for community members who work there.

Public housing: Public housing consists of homes owned by public agencies to provide housing, often to people who are lower-income or otherwise disadvantaged. Many residents of public housing may be unable to find adequate housing elsewhere, and so any damage that makes public housing buildings unlivable can create significant hardships for residents.

Public protected land: Most of San Bernardino County's total land area is owned by local, regional, state, and federal land management agencies and is protected to various standards for public access and recreation, natural conservation, and other benefits. Of the approximately 18,100 square miles of unincorporated area in San Bernardino County, 13,120 square miles are public protected land. Damage to the natural ecosystems of this land could harm the regional economy and local quality of life. **Figure 10** shows public protected land in San Bernardino County.

Public safety buildings: Public safety buildings are sheriff's facilities and fire stations that provide law enforcement and fire protection services in the unincorporated area. If these facilities are damaged or otherwise inoperable, it could affect the ability of the San Bernardino County and fire agencies to provide these important services. There are 9 sheriff's facilities and 87 active fire protection facilities in the unincorporated area (a further 9 are inactive). **Figure 9**, above, shows the location of these facilities in the unincorporated area.

3. Sensitivities

Public Works corporation yards: Corporation yards are County facilities that are used to maintain roads and other County-owned public works. These facilities store and repair vehicles and equipment, serve as an operating base for many Public Works staff, and provide other functions as needed. If they are damaged or cannot be used, it may affect the ability of Public Works staff to conduct repair and maintenance work. There are 10 corporation yards in the unincorporated area. **Figure 9**, above, shows the location of these facilities in the unincorporated area.

Railways: Railways provide commuter rail (valley areas only), long-distance passenger rail, and freight service within San Bernardino County and to other communities. If railways are damaged, services can be interrupted, with potentially substantial impacts to the local economy. There are approximately 744 miles of railway in the unincorporated areas of San Bernardino County. **Figure 11** shows railways in the unincorporated area.

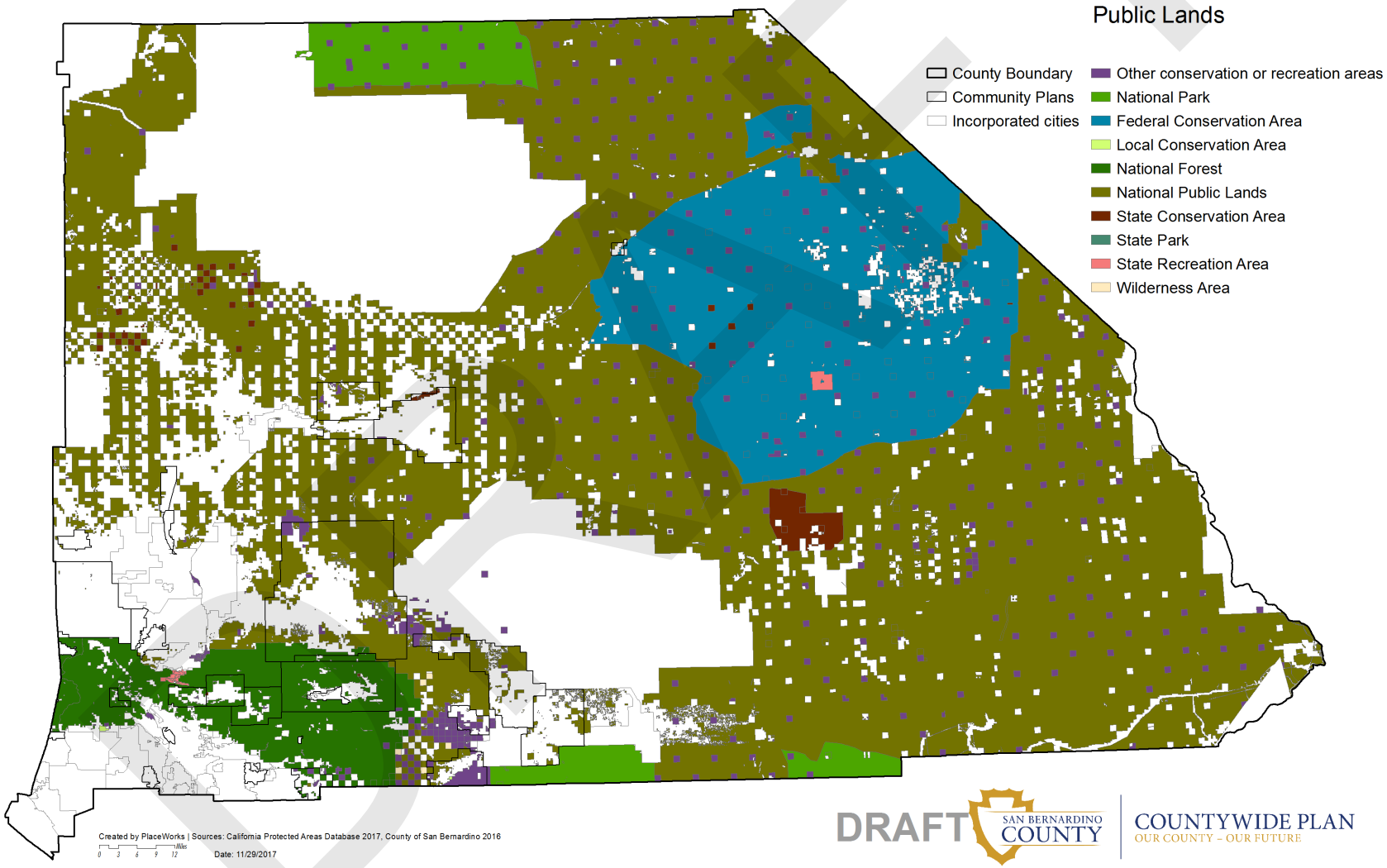
Schools and child care centers: In addition to elementary, junior high, and high schools, this category includes adult schools, colleges and universities, continuing education facilities, and special education centers. It also includes child care centers, which provide care and basic educational services to very young children. Beyond providing education, schools and child care centers can also act as community meeting points, staging grounds, and temporary shelters. These functions may all be constrained by climate-related hazard events. There are 124 schools and 73 child care centers in the unincorporated area (not including closed schools).

Senior care centers: These facilities provide long-term residences to senior citizens who require assisted living. They can vary widely in size, style, and types of care provided, but all provide critical shelter and assistance. Damage to these facilities can deprive senior citizens of these vital services, and may require complex evacuation efforts to effectively relocate residents. There are 35 senior care centers in the unincorporated area.

State highways: State highways are designated roadways managed by the California Department of Transportation (Caltrans), including roadways that are part of the Interstate Highway System, and provide high-speed connections between communities. If they are impassable or if capacity is constrained, this affects commuting, freight shipping, and key services that involve vehicles (e.g., emergency response). There are approximately 1,250 miles of state highway in the unincorporated area. **Figure 11**, above, shows state highways in the unincorporated area.

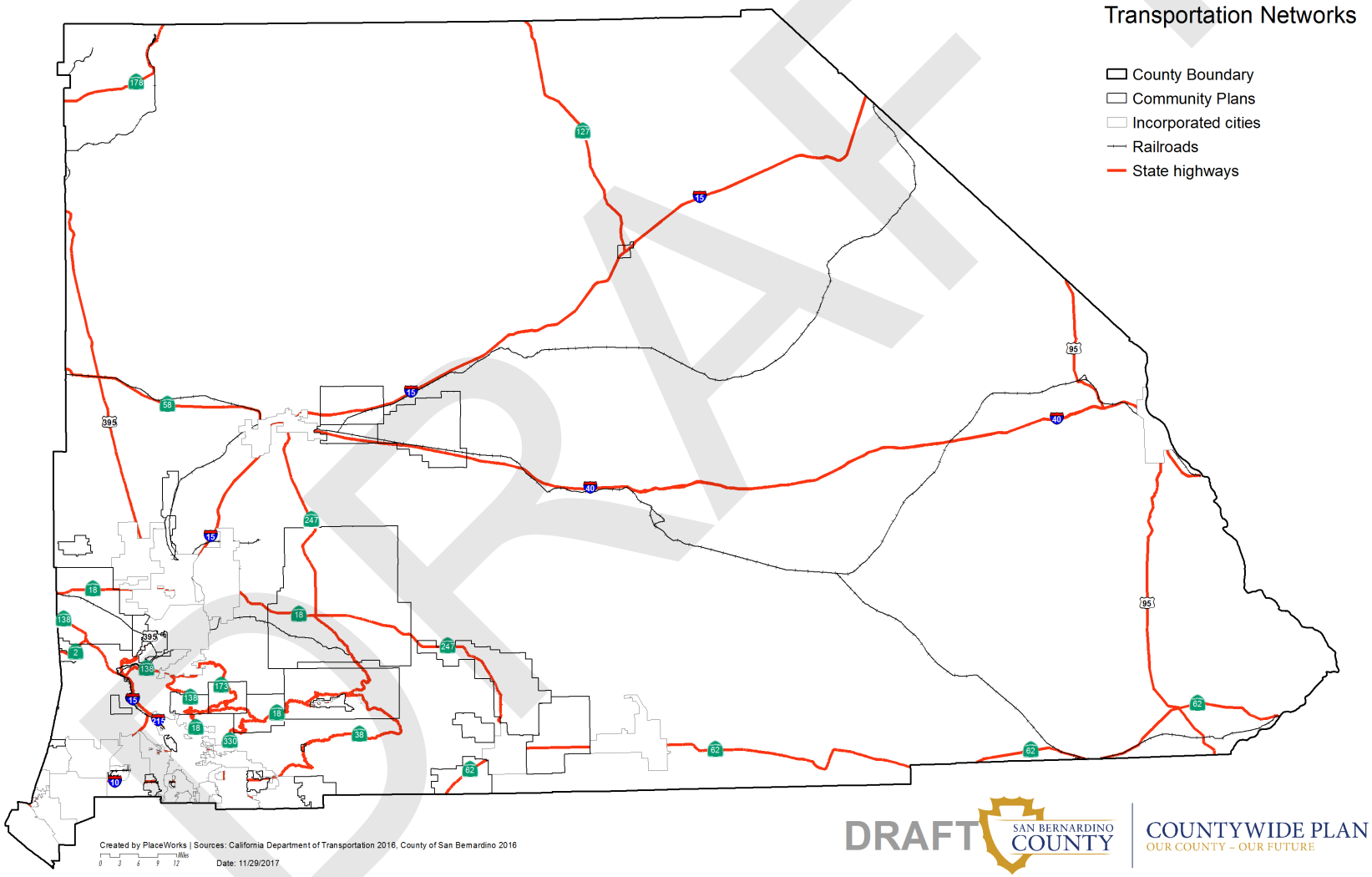
Water and wastewater infrastructure: Water and wastewater infrastructure includes water and sewer pipes, treatment facilities, groundwater wells, reservoirs, and pump stations. Together, these facilities provide community members with clean water and efficient wastewater removal and treatment. If these facilities are damaged or destroyed, services may degrade or (in extreme cases) no longer be provided, with potentially serious health implications.

Figure 10 Public Lands in San Bernardino County



3. Sensitivities

Figure 11 Transportation Networks



3.4 SERVICES

Communications: Communication services include phones (cellular and landline), television, radio, and Internet. These services allow people to learn about the nature of hazard events, including how to prepare for them and how they may be affected by such events. Communication services also enable people to check up on each other (particularly important for persons with disabilities, senior citizens, and others who are more likely to be isolated) and request help if needed. If these services are interrupted during a hazard event, individuals may be less aware of what is happening and less able to get help if they need it.

Electricity: Electrical service can be extremely important to run air conditioners during extreme heat events, to rapidly communicate evacuation warnings, to operate medically necessary devices, to provide heating to approximately 16 percent of the houses in the unincorporated area, and for other functions that have significant effects on peoples' health and well-being. Electrical services can be disrupted by physical damage to the grid or by overloading the grid. Loss of this service can result in widespread inconvenience and potentially more serious impacts.

Emergency response: Emergency response services include law enforcement, fire, and emergency medical service traveling to a location to protect peoples' health and safety. While these services are necessary at all times, they are particularly important during hazardous situations, when there is a greater threat to health and safety. Disruption to emergency response service can occur when demand for these services exceeds the capacity of service providers (an important consideration during hazard events, when emergency responders may be in very high demand), or when damage to roads or buildings physically prevents emergency providers from reaching those in need. Emergency response service disruptions can increase the risk of harm to peoples' health and safety.

Government administration: Local government administrative functions are diverse—keeping vital records, issuing permits, maintaining tax and property data, overseeing construction and repair, maintaining public infrastructure, and many others. Damage of administrative facilities or loss of key services (e.g., electricity) to these facilities can disrupt administrative functions, which can delay important activities necessary for hazard preparation, response, and recovery. Such activities can include mobilizing agency staff during hazard events, tracking response expenses for disaster relief aid purposes, and issuing permits for reconstruction.

Health services: Health services include emergency medical response, treatment of chronically ill persons, nonemergency medical services, and assisted living or in-home medical care. Such services are necessary at all times, but especially during and after hazard events, when there is a greater threat to peoples' health. Health services can be disrupted by damage to health-related facilities, a loss of vital supplies or resources, or widespread damage to transportation networks that prevent health care providers from reaching patients. Loss or reductions of these services can lead to increased mortality and morbidity.

Natural gas: Natural gas provides heat to approximately 61 percent of houses in the unincorporated area of San Bernardino County and is also widely used for other functions. A loss of natural gas service can be dangerous during cold weather, when persons without another source of heat may suffer cold-related health complications.

Public safety: Public safety functions, such as law enforcement and fire protection, are necessary at all times, but particularly so during hazard events. Public safety staff respond to reports of crime or other safety concerns, provide rescue services, direct traffic and coordinate evacuations, and check on people to ensure their safety. These vital functions can be less effective or disrupted entirely if public safety providers are unable to meet service demands, which can have widespread ramifications for health and safety in the community.

Water delivery and wastewater treatment: Delivering clean water and removing and treating wastewater, are integral functions to protect public health. Without these services, communities run the risk of diseases from water-borne pathogens, dehydration, and other complications resulting from a decline in hygiene. These services can be disrupted even if the infrastructure systems that provide these services are undamaged (for example, if a significant drought reduces water supplies).

3.5 ECOSYSTEMS AND NATURAL RESOURCES

American Southwest riparian forest and woodland: This ecosystem is found in warm desert areas near rivers or other sources of water (e.g., an oasis), usually at lower elevations. Species of cottonwood, sycamore, palm, and willow are among the trees that make up this ecosystem. This habitat type can be found near the Cajon Pass, along the Mojave River, and at various scattered locations in desert and foothill areas.

Big sagebrush scrub: This ecosystem is found in valleys and lower slopes in dry areas, and is dominated by various species of shrubs and herbaceous plants. It can be found in the mountains surrounding the Lucerne Valley, around Phelan/Piñon Hills, on some mountains in the Mojave National Preserve, and in the Kingston Range in the County's extreme northeastern corner.

California foothill and valley forest and woodlands: This habitat type covers a wide variety of different plant types, including many types of oaks, pines, cypress, firs, and junipers. In San Bernardino County, this habitat type is found along rivers and in scattered locations, mostly throughout the valley and mountain regions, although a few patches of this ecosystem can be found in the Morongo Valley and along the banks of the Mojave River.

California grasslands and flowerfields: This habitat type includes both native and nonnative annual and perennial grass species, including many types of wildflower, and is usually found in valleys and lower foothills. It covers large sections of the valley region, as well as areas in the San Bernardino Mountains and the western half of the County's desert region.

Chaparral: Chaparral habitats are composed of various evergreen shrubs, including manzanita, ceanothus, toyon, and many others. They are common throughout California and consist of many different plant communities, each with different temperature and precipitation preferences. This habitat type covers large areas of the San Bernardino Mountains and is also found in isolated patches in the valley region and in Joshua Tree National Park.

Coastal sage scrub: Unlike the evergreen plants in chaparral habitat, the plants of the coastal sage scrub ecosystem are deciduous. This habitat type is made up of small shrubs, often found in the lower reaches of California's coastal mountains and hills. Common species include California sage, purple sage, and black sage. In San Bernardino County, this ecosystem is mostly found along slopes in the valley region, although there are isolated patches in the Cajon Pass and various locations in the mountain region.

Desert wash woodland and scrub: This habitat type is made up of trees and large shrubs that have adapted to the very hot conditions of the Colorado Desert. Acacia, ironwood, smoke tree, and desert lavender are among the common plant species of this ecosystem. It is widely found in washes throughout the desert region of San Bernardino County (in both the Colorado Desert as well as the colder and higher-elevation Mojave Desert), the northern reaches of the valley region, and in some dry valley areas of the mountain region.

Freshwater marsh: Freshwater marsh habitats have standing water during most or all of the year. Common plants in this ecosystem include cattails, bulrushes, reeds, and floating plants such as water lilies and duckweed. In San Bernardino County, it is found along the Santa Ana River and in Summit Valley along the Mojave River

Great Basin piñyon-juniper woodland: This habitat consists of various species of piñon and juniper trees, along with sagebrush and other shrubs. It is commonly found along mountains in cooler, dry areas. In San Bernardino County, this ecosystem is found along the north side of the San Bernardino Mountains, in the mountains of the Mojave National Preserve, and in the Kingston Range in the extreme northeastern part of the county.

Great Basin upland scrub: This habitat type is found in cooler desert environments and includes various shrubs and grasses. Common species include blackbrush, bitterbrush, rabbitbrush, and mountain mahogany. In San Bernardino County it is found along the northern side of the San Bernardino Mountains, in the mountains around the El Mirage and Lucerne valleys, and in isolated mountain locations in the northern half of the county.

Groundwater basins: Groundwater basins are the underground areas where groundwater is stored, or where there is sufficient capacity for groundwater. In many parts of San Bernardino County, especially in the desert, groundwater basins supply most or all of the water delivered through community water systems. If more water is taken out of the groundwater basin than into the basin (through natural processes or through intentional human activity), the basin becomes overdrawn and cannot be used.

3. Sensitivities

There are numerous groundwater basins in San Bernardino County, underlying most of the county's area except for the high desert peaks and large sections of the San Bernardino Mountains.

Lacustrine habitats: Lacustrine habitat refers to freshwater lakes and ponds. It includes the part of the habitat that is permanently underwater as well as areas around the edges that may be underwater at some times of the year. These habitats lack trees and shrubs, although such plants may be found at the edge of lacustrine habitats. In San Bernardino County, lacustrine ecosystems consist largely of the lakes in the mountain region, including Big Bear Lake, Lake Arrowhead, Silverwood Lake, Lake Gregory, and Baldwin Lake.

Mojave and Sonoran desert scrub: This ecosystem is found on slopes and flatlands in desert areas with very hot summers and winters that are not too cold. Creosote bushes, Joshua trees, saguaro, brittlebush, and various other shrubs and perennial grasses are common species in this ecosystem. This habitat type is the most common in San Bernardino County and covers most of the desert, except along desert washes, dry lake valleys, and in some mountainous areas. There are also isolated stands along hillsides in parts of the mountain and valley regions.

Montane chaparral: Montane chaparral ecosystems are found in mountainous, cooler areas, often in the same locations as conifer forests such as pine and fir. As with other chaparral environments, various species of plants such as ceanothus and manzanitas are common. It is widespread throughout the mountain areas of San Bernardino County

Nonnative forest and woodlands: This habitat type is primarily eucalyptus, but also includes some species of acadia, South American pepper trees, myoporum, and others. These trees are common in urban areas, but are also found in isolated parts of the valley region outside of urban development.

North coastal mixed evergreen and montane conifer forests: This forest ecosystem is widespread in cool and wet mountainous areas, although it can also tolerate somewhat warmer and drier conditions. It is made up of a wide variety of trees, including Douglas fir, maple, various pine species, red alder, and many others. It is common throughout the mountain regions of San Bernardino County.

North coastal riparian and montane riparian forest and woodland: This habitat type is found along rivers and streams in mountainous environments, usually in relatively cool and wet locations. It includes species of cottonwood, alder, willow, and ash trees, along with some conifers such as fir, spruce, and pine. In San Bernardino County it is mostly limited to areas around the rivers and streams of the mountain region, although there are a few patches along riparian areas in the hills surrounding the Morongo Valley.

Shadscale-saltbrush scrub: This ecosystem is made up of various shrubs, including shadscale, allscale, and four-wing saltbrush. It is typically found in cooler desert environments at higher elevations, although it can tolerate a range of conditions. In San Bernardino County is it found widely throughout the western desert region as well as in a few places in the eastern desert.

Sparsely vegetated desert dunes: This habitat type is found on sand dunes throughout the desert region. The amount of vegetation often varies based on local rainfall. Common plant species include big galleta, sand verbenas, and various species of panicgrass.

Subalpine aspen forests and pine woodlands: This forest ecosystem is found in cold, fairly high elevation areas. As the name implies, several species of pine and aspen dominate this habitat type. It is found in the highest elevations of the mountain region in San Bernardino County, including near San Bernardino, San Gorgonio, and Sugarloaf mountains.

Wet mountain meadow: This ecosystem is found in valleys and low-lying mountain areas. Unlike marshlands or wetlands, it is not permanently wet, although standing water or saturated soil is common for most of the year. Numerous plant species are common, including mountain thistle, cocklebur, and several sedges. It is found in a few limited locations of the mountain region, particularly near Big Bear and Baldwin Lakes and in the Holcomb Valley.

Figure 12 shows the ecosystems in the unincorporated areas of San Bernardino County.

3.6 SOCIAL VULNERABILITY INDEX

The vulnerability assessment looks at individual populations and other sensitivities. To supplement this analysis, the PlaceWorks team also created a social vulnerability index (SoVI), which shows where the largest shares of socially vulnerable persons live in San Bernardino County. The PlaceWorks team created the SoVI through a 5-step process.

Step 1: The PlaceWorks team identified several populations that are likely to be socially vulnerable and downloaded data from the US Census Bureau at the census-block-group level for each of these groups. These populations are listed here. Those in bold are also analyzed as individual population sensitivities in the vulnerability assessment.

- Adults who have not completed high school or equivalent (e.g., GED)
- Children less than 10
- Ethnic minorities[4]
- Female-headed households
- Households in poverty
- Households overpaying for housing
- Households without a car
- Linguistically isolated households
- Low-income households
- Native Americans [5]

[4] Persons who do not identify as non-Hispanic/Latino white.

3. Sensitivities

- Overcrowded households
- Persons in a mobile home
- Persons living in group quarters (e.g., dormitories, health institutions, prisons)
- Persons with disabilities
- Renters
- Senior citizens
- Senior citizens living alone

Step 2: The PlaceWorks team calculated the proportion of each indicator for each block group relative to the entire population (e.g., the percentage of all households that are low-income households).

Step 3: The PlaceWorks team ranked each indicator for each block group into percentiles, from 0 to 100, and assigned a comparable score of 0 to 10. For example, the block groups that had a greater proportion of low-income households than 90 percent of all block groups received a score of 9.0.

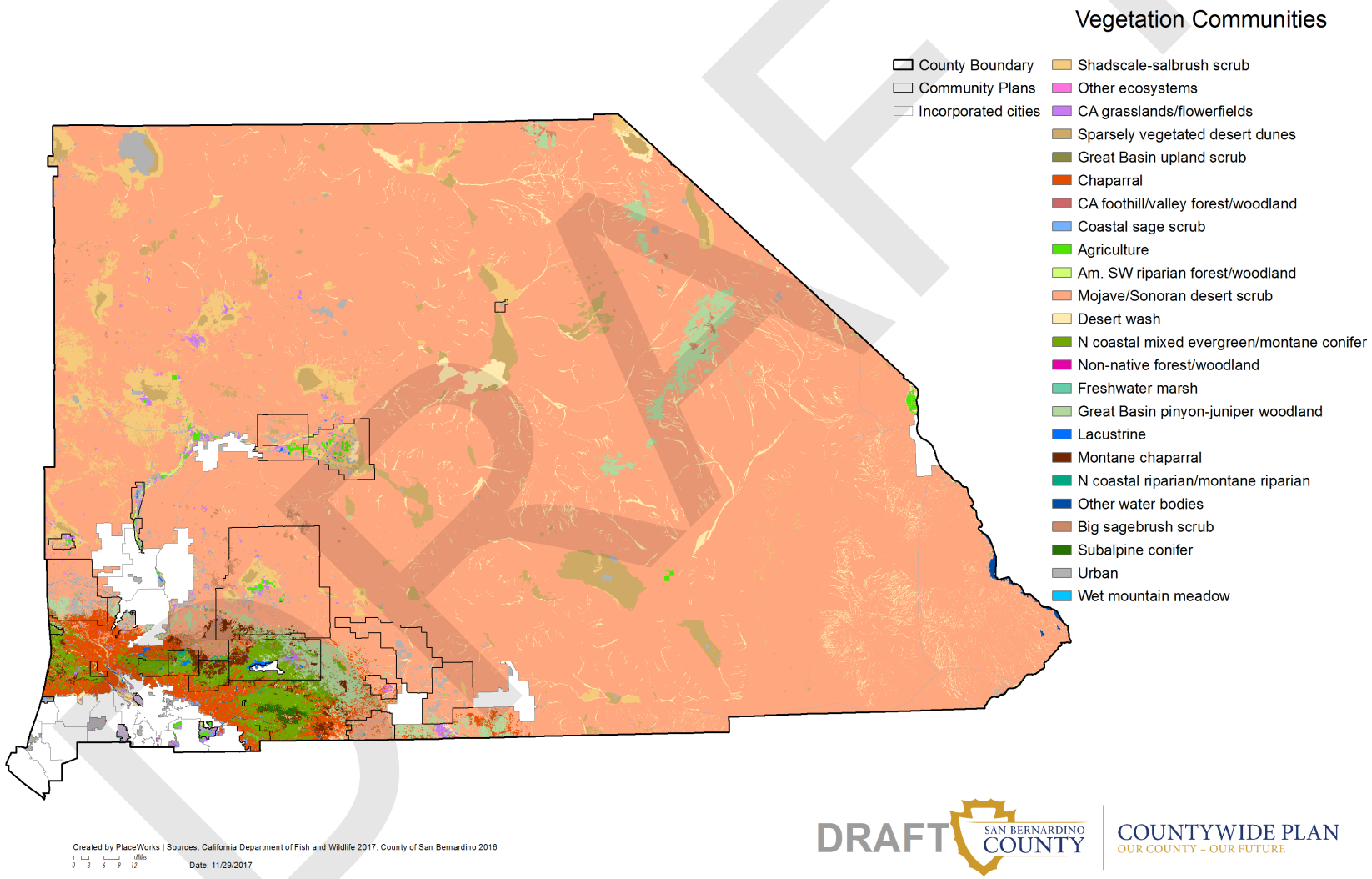
Step 4: The PlaceWorks team added up the scores for each indicator in each block group, creating an overall score of social vulnerability for every block group. Since each of the 17 indicators has a possible score between 0 and 10, the possible score for each block group ranges from 0 (if the score for all 17 indicators is 0) to 170 (if the score for all 17 indicators is 10).

Step 5: The PlaceWorks team ranked each combined score by percentiles, from 0 to 100, and assigned a comparable ranked score. For example, block groups that have a higher social vulnerability score than 50 percent of all block groups received a ranked score of 50. The higher the ranked score, the more socially vulnerable the block group.

Figure 13 shows the combined social vulnerability in San Bernardino County.

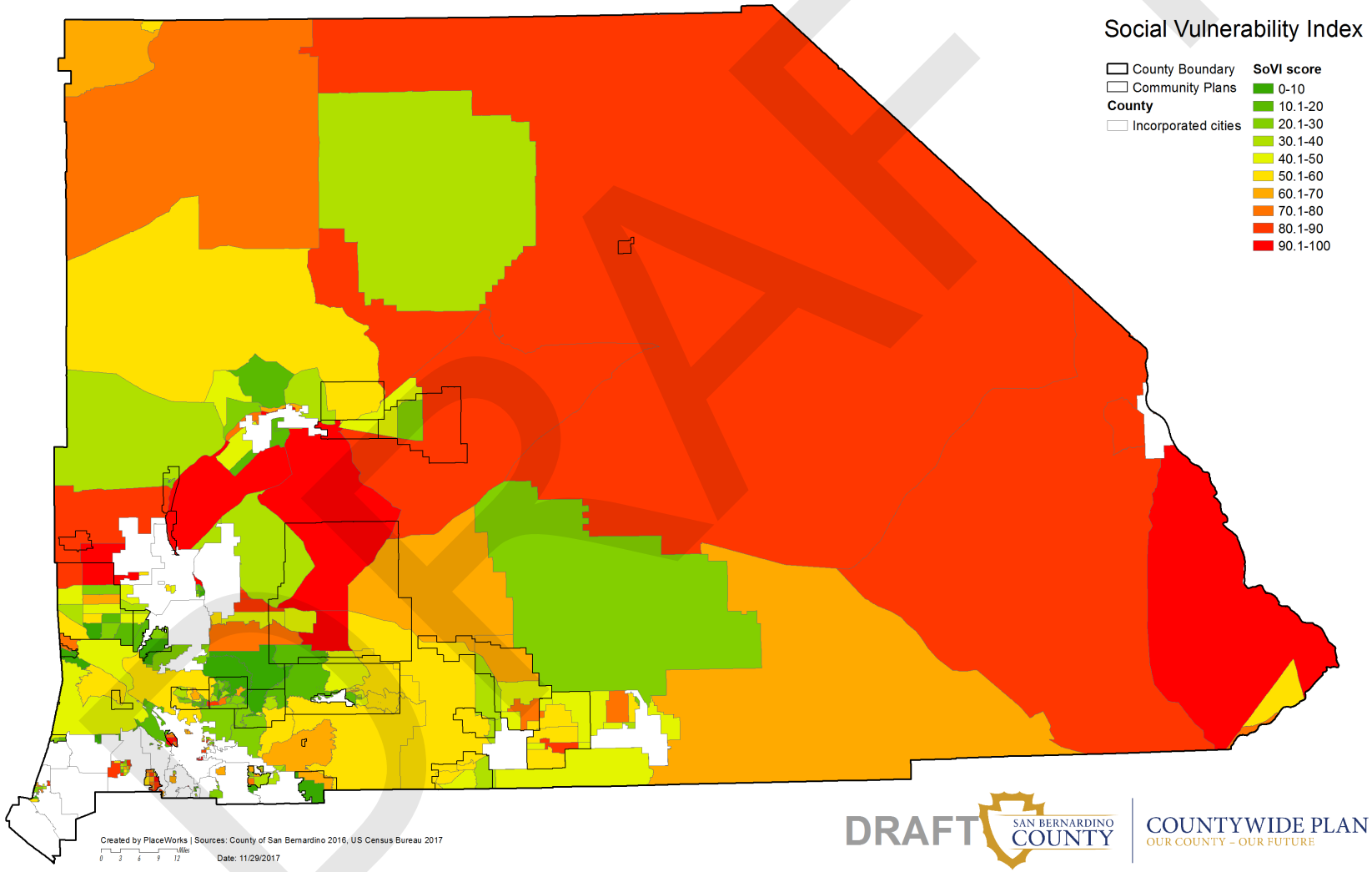
[5] Persons identifying partially or entirely as Native American/American Indian.

Figure 12 Vegetation Communities



3. Sensitivities

Figure 13 Social Vulnerability



3.7 IMPACT AND ADAPTIVE CAPACITY

Two factors affect how vulnerable a sensitivity is to an exposure: impact and adaptive capacity. The combination of these two factors produces an overall vulnerability score.

3.8 IMPACT

Impact is a measurement of how severe the effects of the exposure are to the sensitivity. The greater the harm to the sensitivity, the higher the impact. When assessing the impact for populations, the PlaceWorks team considered questions such as:

- How severe are the hardships faced by the population? Is there a risk of mortality/morbidity, property damage, or degradation of quality of life?
- How many people could be affected?
- How long would the effects last? Would they diminish in severity over time?

For assets such as buildings and infrastructure, services, and ecosystems, the PlaceWorks team considered a similar set of questions, including:

- How much damage can the asset take before its integrity or ability to provide service is damaged?
- How important is the asset to the overall well-being of the community? How many people rely on the asset?
- What is the risk to the population if the asset is degraded?

The PlaceWorks team ranked each sensitivity on a five-point scale, from IM0 (minimal impact) to IM4 (severe impact). The following rubric outlines the general meaning of each score:

3. Sensitivities

Impact Score	Criteria (Population and Ecosystem sensitivities)	Criteria (Land Use/Structure and Service sensitivities)
IM0	The impacts are minimal. Community members may not notice any difference.	The impacts are minimal. Service disruptions, if any, are mild and/or intermittent enough to largely escape notice.
IM1	Community members notice minor impacts. There may be mild, occasional disruptions to some behaviors or actions.	Community members notice minor impacts. There may be mild disruption to services or performance on occasion.
IM2	There is a marked impact on the community. Impacts may be chronically evident, with occasional moments of increased severity. Overall quality of life may decline.	Impacts are evident to community members and are likely to be chronic, with occasional substantial reductions in service quality.
IM3	There is a substantial drop in the well-being of the affected communities. Current lifestyles and behaviors may not be viable.	The sensitivity's functionality is likely to be chronically and substantially limited. The asset may be frequently or always unable to meet community needs.
IM4	There is a severe risk of injury or death of community members. In the case of ecosystems, the community may be destroyed.	The asset can no longer perform its functions as intended. Physical sensitivities may face serious risk of destruction.

3.9 ADAPTIVE CAPACITY

Adaptive capacity is a measurement of how effectively the sensitivity can respond to the exposure using existing resources. The easier, more efficient, and more complete the response and recovery are, the higher the adaptive capacity. When assessing adaptive capacity for populations, the PlaceWorks team considered questions such as:

- Are there barriers in place, such as financial limitations, political challenges, or access to technology, that limit an effective response and recovery?
- What alternatives exist to reduce or eliminate the hardships caused by the exposure?
- Are there existing programs or policies to provide assistance? Do members of the population have access to these programs or policies?

For assets such as buildings and infrastructure, services, and ecosystems, the PlaceWorks team considered a similar set of questions, including:

- What barriers, if any, may delay or complicate response and recovery activities?
- Are there alternatives that the community can use while the asset is being repaired or replaced?
- Are programs or policies in place to support response and recovery activities? Do these programs or policies support complete recovery or only partial?

The PlaceWorks team ranked each sensitivity on a five-point scale from AC4 (very high adaptive capacity) to AC0 (no adaptive capacity). The following rubric outlines the meaning of each score:

Adaptive Capacity Score	Criteria
AC4	The sensitivities can adapt with little or no effort. Quality of life remains unchanged and may even improve.
AC3	Adaptive solutions are feasible for most or all sensitivities, although some sensitivities may face occasional or small-scale challenges.
AC2	Solutions are available, but may not always be feasible. Many sensitivities are likely to face sizeable difficulties in adapting.
AC1	Adaptive solutions are available, but are expensive, technologically difficult, or politically unpopular.
AC0	There are no feasible methods of adapting currently available.

3.10 VULNERABILITY SCORE

The combination of each sensitivity's impact and adaptive capacity score results in a vulnerability score, ranging from V1 (low vulnerability) to V5 (high vulnerability). A low impact and high adaptive capacity score results in a low vulnerability score, and a high impact and low adaptive capacity score results in a high vulnerability score. The matrix below shows how different impact and adaptive capacity scores translate to vulnerability scores.

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

3. Sensitivities

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4. Results

This section discusses the key outcomes of the vulnerability assessment.

4.1 PRIORITY RESULTS

Several sensitivities score at least a V4 (medium-high vulnerability) for at least one of the six exposures. These sensitivities should be considered higher priorities for climate adaptation strategies.

4.1.1 POPULATIONS

Homeless persons: Homeless persons are more exposed to events such as severe weather, extreme heat, and floods. Therefore, they are much more prone to the physical impacts of these events, which can include threats to health as well as the risk of physical injury (e.g., from debris during high wind events). The lack of shelter, difficulty obtaining supplies (e.g., water during extreme heat), and little to no access to medical care often results in a low adaptive capacity. Homeless persons face V5 vulnerabilities for extreme heat and severe weather and V4 vulnerabilities for pests and diseases.

Households in poverty: The poverty threshold in the United States for a family of four is approximately $24,000, less than half of the median income for a similarly sized family in San Bernardino County. Households in poverty face extreme financial pressures that expose them to greater threats from hazards and minimize their ability to appropriately respond. Households in poverty often live in substandard housing that may be more easily damaged, and often cannot afford home retrofits or equipment purchases to reduce their vulnerability. They are at risk of additional financial hardships if hazard events make it difficult to reach work. There are many programs available to help persons in poverty, although these programs are rarely able to erase their elevated vulnerability. Households in poverty face V5 vulnerabilities for extreme heat and drought and V4 vulnerabilities for floods and wildfires. **Figures 14**, **15**, and **16** show where households in poverty are most at risk from extreme heat, floods, and wildfires.

Individuals with existing medical conditions: Individuals with existing chronic health conditions may have health issues that can be exacerbated by extreme events, such as heat waves or the smoke from wildfires. These individual are also often dependent on medical devices or medication and may have mobility challenges, which can make it difficult to evacuate. These persons frequently rely on formal and informal support networks for assistance, which can be challenging in rural areas. Individuals with existing medical conditions face V5 vulnerabilities for extreme heat, flooding, and wildfires. They face V4 vulnerabilities for pests and diseases.

Individuals without access to lifelines: A lack of lifelines, such as transportation and communication, can have severe consequences. These individuals may be unaware of pending emergency situations or information about how they can prepare. Without access to transportation,

taking actions to prepare can be difficult. These individuals may also be unable to evacuate if necessary. Support networks (formal and informal) can help, but may not always be sufficient. Persons in rural areas or other isolated locations may face elevated hardships. Individuals without access to lifelines face V5 vulnerabilities from extreme heat and wildfires and V4 vulnerabilities from flooding.

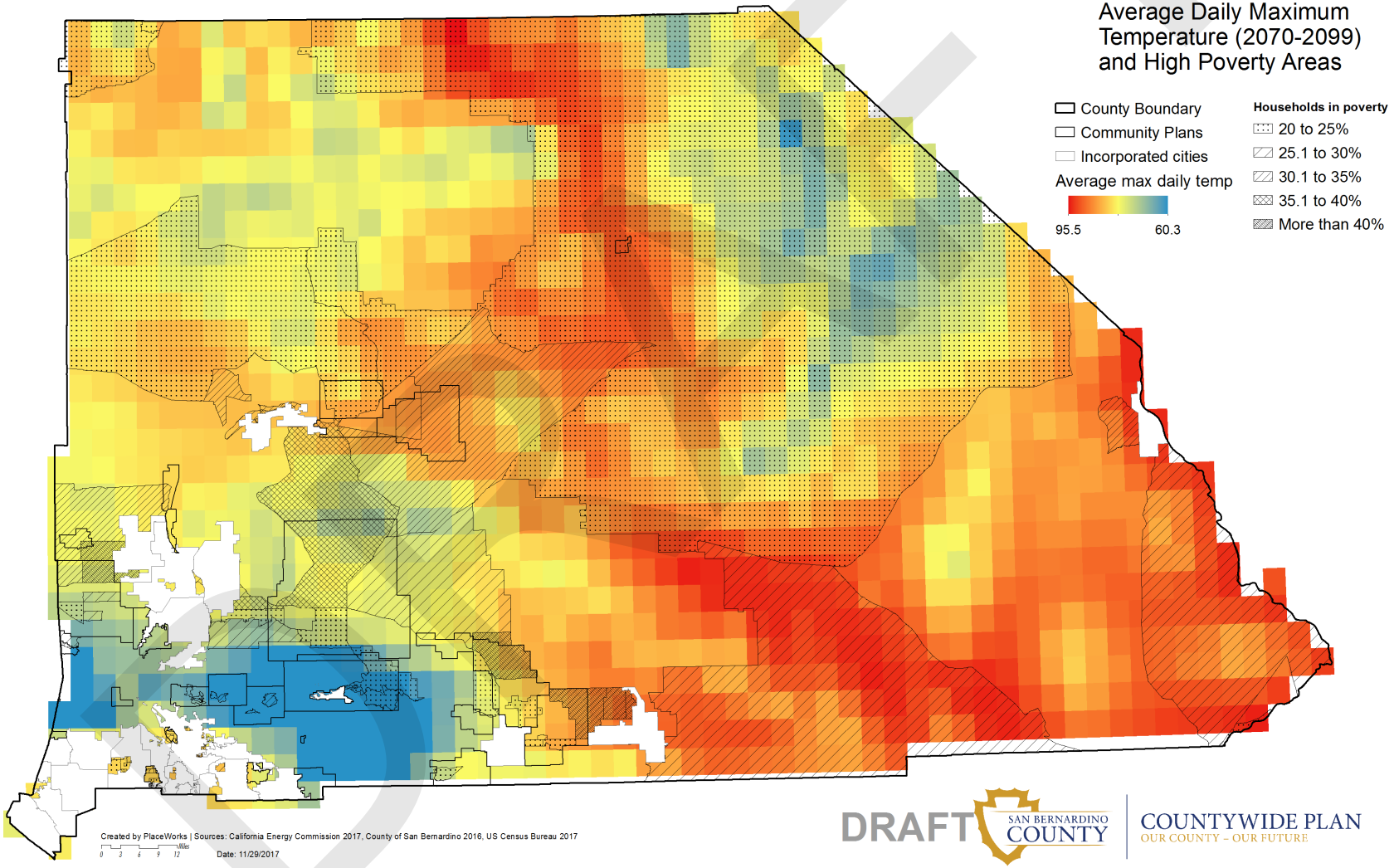
Low-income households: In San Bernardino County, a four-person family making less than $53,600 is considered low income. These households may live in substandard housing that is more easily damaged or is not protected against extreme events, and they may have difficulty affording retrofits or other preventative actions. Financial assistance and other forms of support networks are often available for low-income households, but hardships typically remain. Low-income households face V4 vulnerabilities from drought.

Outdoor workers: Outdoor workers are exposed to extreme conditions more than most other people. They also often perform intensive labor, which can increase physical stress and make them more vulnerable to hardships. These individuals may be unable to work during some extreme conditions, which can create economic challenges for them and their families. Although protections from extreme conditions are often available, some employers may not provide outdoor workers with these protections, and workers may not always choose to use them. Outdoor workers face V5 vulnerabilities from extreme heat and V4 vulnerabilities from severe weather.

Persons in a mobile home: Mobile homes are more likely to be damaged by intense weather conditions, such as hail or high winds. Persons living in a mobile home often have lower income levels, which can make it difficult to harden their homes against these extreme events. Persons in a mobile home face V4 vulnerabilities from severe weather.

Persons with disabilities: Persons with disabilities face challenges with preparing their homes for hazard events or evacuating if necessary. Disabled persons are more likely to need assistance from other persons or from medical devices, putting them at greater risk if they are unable to obtain this assistance during emergency situations. These individuals are also more likely to have limited financial resources, which can further constrain their ability to prepare and recover. Persons with disabilities face V5 vulnerabilities from extreme heat and flooding and V4 vulnerabilities from wildfires. **Figures 17**, **18**, and **19** show where persons with disabilities face the greatest risk from extreme heat, flooding, and wildfires.

Figure 14 Average Daily Maximum Temperature (2070–2099) and High Poverty Areas



4. Results

Figure 15 Flood Hazard Zones and High Poverty Areas

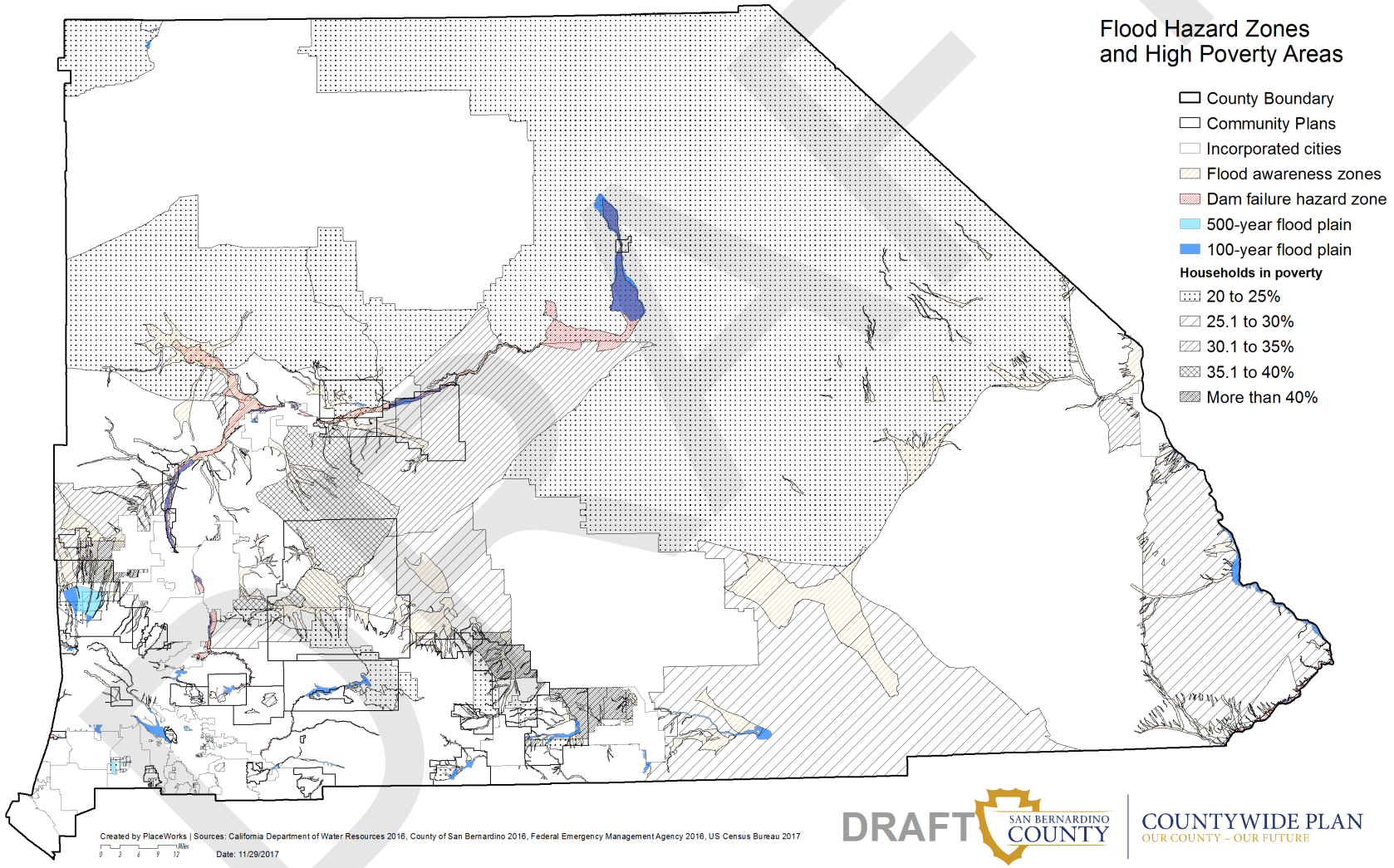
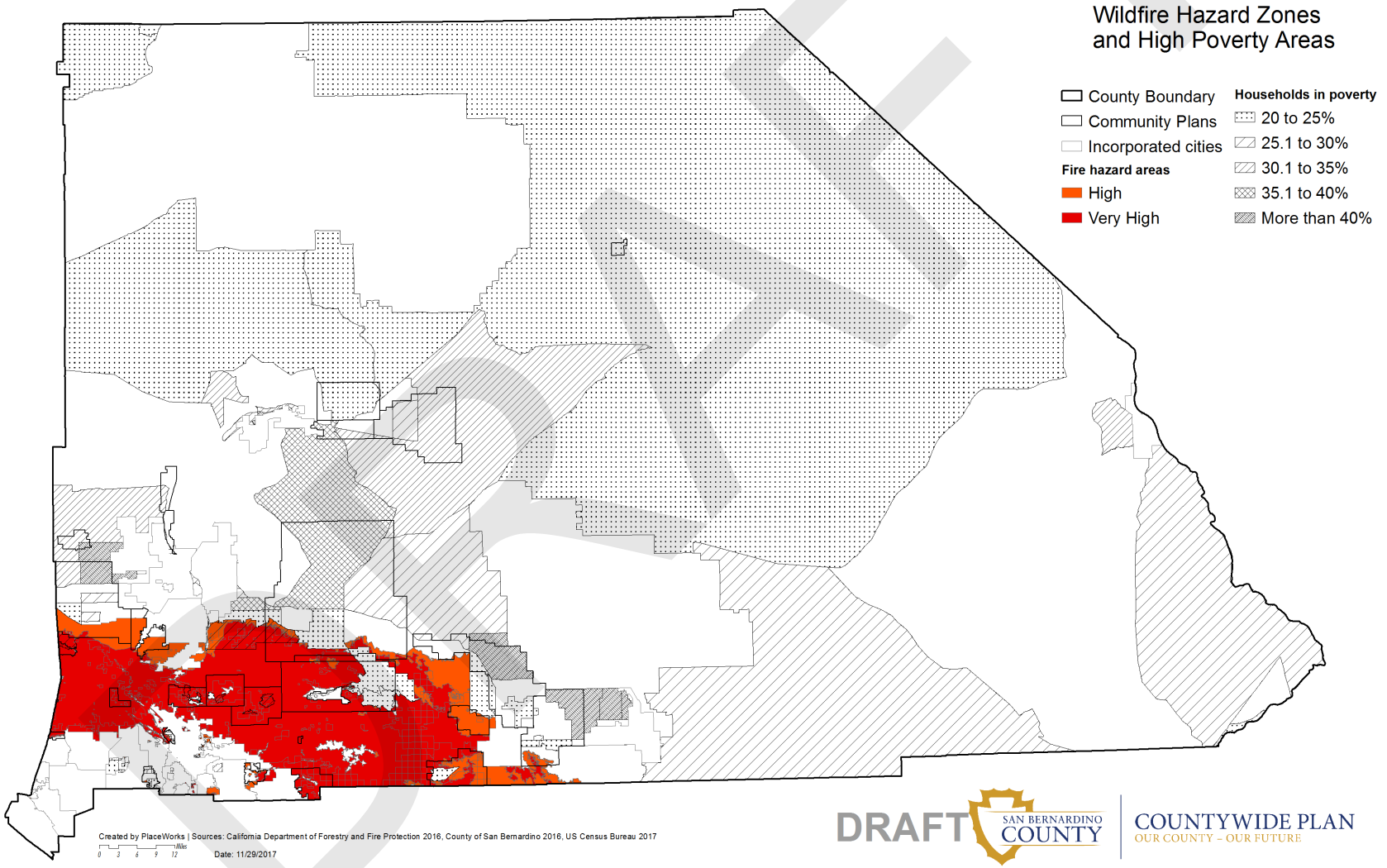


Figure 16 Wildfire Hazard Zones and High Poverty Areas



4. Results

Figure 17 Average Daily Maximum Temperature (2070–2099) and Senior Citizens

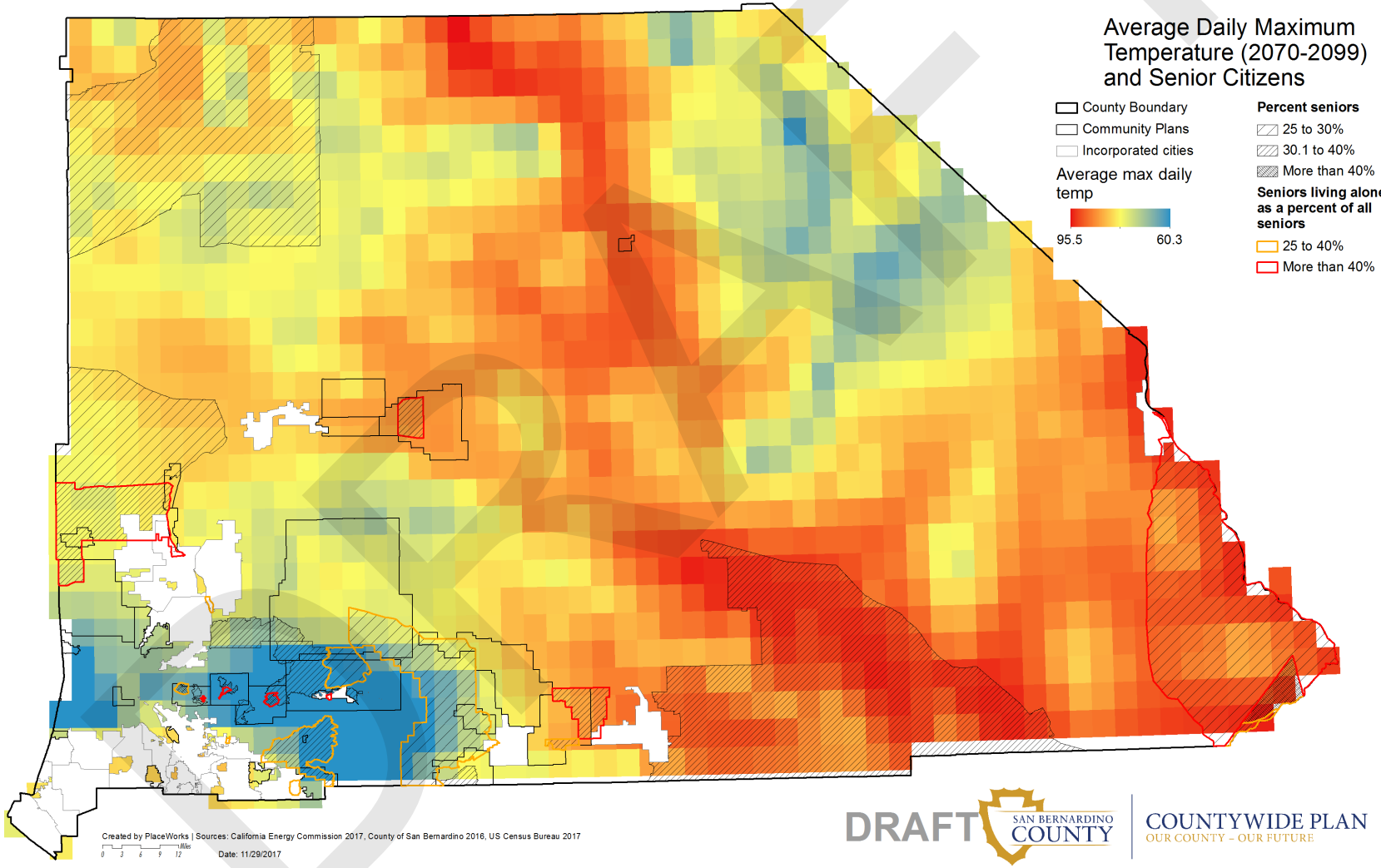
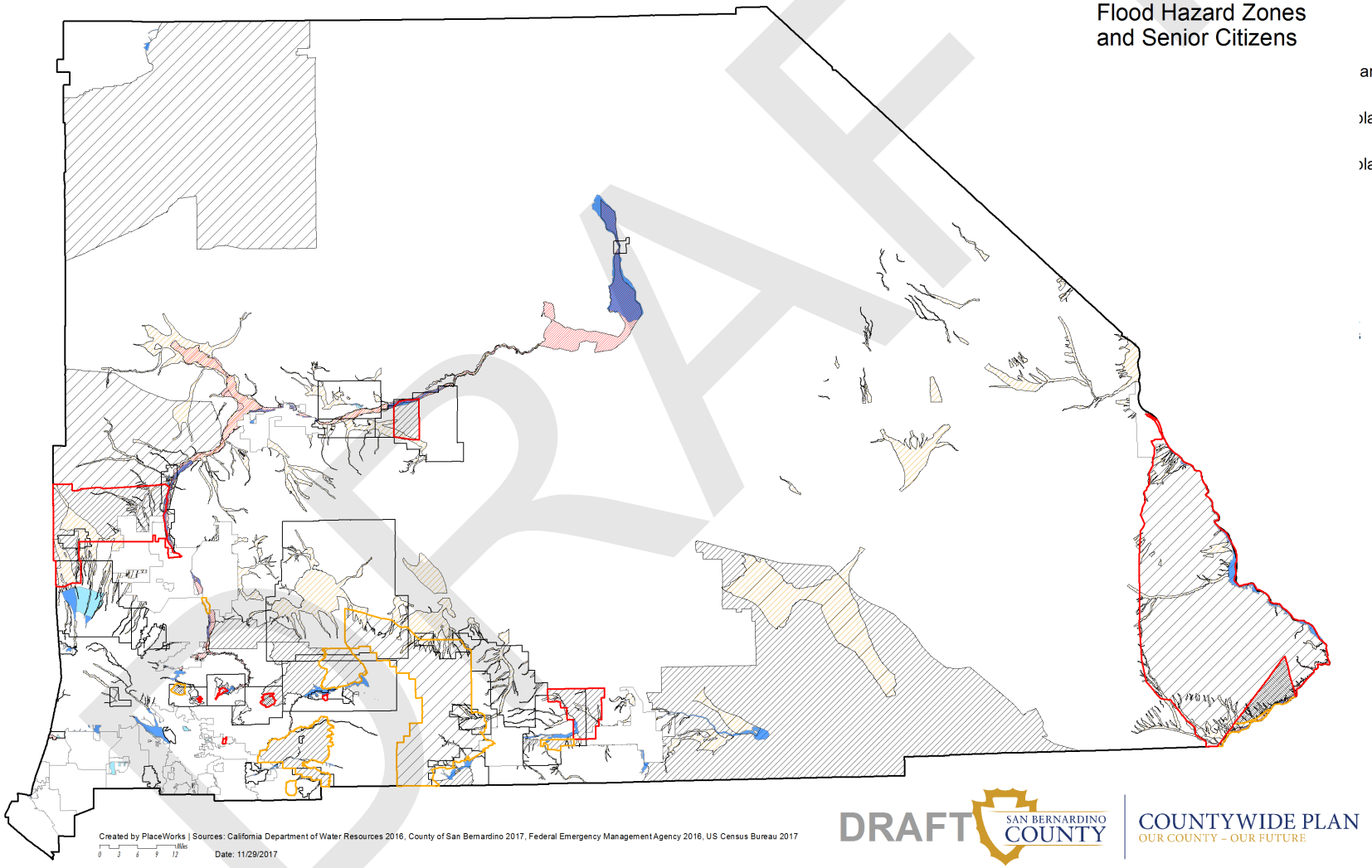
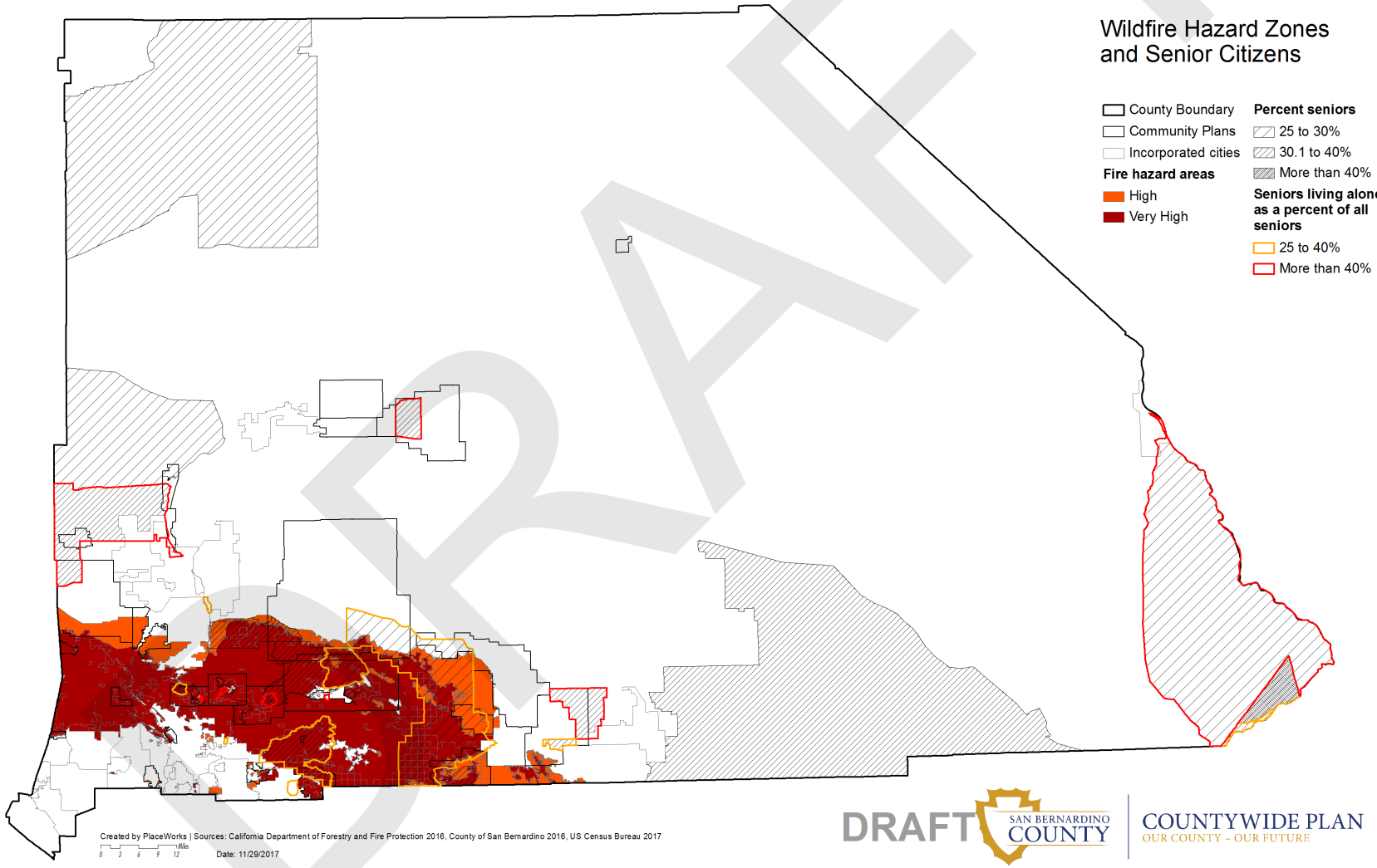


Figure 18 Flood Hazard Zones and Senior Citizens



4. Results

Figure 19 Wildfire Hazard Zones and Senior Citizens



Senior citizens: Events such as extreme heat and some diseases are more harmful to senior citizens than other persons, placing seniors at increased risk of health effects. Seniors typically have lower levels of mobility, making it difficult to take protective action or to evacuate. There are many support networks available to help seniors, but these services are not always available to meet all needs. Senior citizens face V5 vulnerabilities from extreme heat and V4 vulnerabilities from wildfires. **Figures 20**, **21**, and **22** show where senior citizens face the greatest risk from extreme heat, flooding, and wildfires.

Senior citizens living alone: Senior citizens living alone face the same challenges as other senior citizens. They are highly vulnerable to the health impacts of emergency events and are often unable to make appropriate preparations or to evacuate if the situation calls for it. Senior citizens living alone often depend entirely on formal and informal support networks for assistance, and so can face extreme challenges if these support networks are disrupted or unavailable. Senior citizens living alone face V5 vulnerabilities from extreme heat and wildfires and V4 vulnerabilities from floods and pests and diseases. **Figures 20**, **21**, and **22** shows where senior citizens living alone reside relative to areas that face the greatest risk from extreme heat, flooding, and wildfires.

Undocumented persons: Undocumented persons are often unable to obtain decent-paying jobs, which can lead to significant financial stress. They may be unable to afford adequate housing, make necessary repairs, or take other preparatory actions, all of which can increase the likelihood of their homes being damaged by extreme events. Many work in outdoor or other jobs that require intense physical labor, increasing the risk of exposure. Their undocumented status may make it difficult to obtain funds to assist with recovery, and many undocumented persons may be distrustful of formal support networks associated with government agencies. Undocumented persons face V5 vulnerabilities from drought and V4 vulnerabilities from pests and diseases.

4.2 BUILDINGS AND FACILITIES

Agricultural lands: Agricultural lands can be highly susceptible to changes in weather and climate conditions. Some severe events may directly damage crops and livestock, or wash away productive topsoil needed for growing. Crops and livestock may be less productive under some chronic conditions, and the cost of livestock feed can increase if feedstocks are damaged. These changes can cause an increase in pest and disease outbreaks, which can injure or kill plants and animals and cause a reduction in yield. Resistant varieties of crops and livestock are available, but they may not always be feasible. There are strategies to harden agricultural activities against some types of climate-related hazards, but some can be expensive or not suitable. Agricultural lands face V5 vulnerabilities from drought and V4 vulnerabilities from pests and diseases.

Buildings in flood hazard areas: Buildings in flood hazard areas face substantial risks of being damaged or destroyed by flooding. Smaller buildings constructed with lighter materials, such as single-family homes, may face greater risks. Buildings can be designed or retrofitted to be more resilient, although these retrofits may not always be affordable. Flood insurance is available for people in flood-prone areas. Buildings in flood hazard areas face V4 vulnerabilities from flooding.

Buildings in wildfire hazard areas: Buildings in wildfire hazard areas are more likely to be exposed to wildfires and suffer damage as a result. There are protective strategies that are usually available to property owners to reduce risks, although they may not be sufficient to minimize the risk. Buildings in wildfire hazard areas face V4 vulnerabilities from drought and wildfire.

Electrical transmission and distribution lines: This infrastructure can face moderate damage from various extreme events. Some events can cause power lines to snap and poles to fall down, and the associated equipment can be damaged by extreme heat. Hardening power lines against hazard events may be possible, but is not always economically feasible, particularly given the amount of infrastructure that must be protected. Electrical transmission and distribution lines face V4 vulnerability from severe weather.

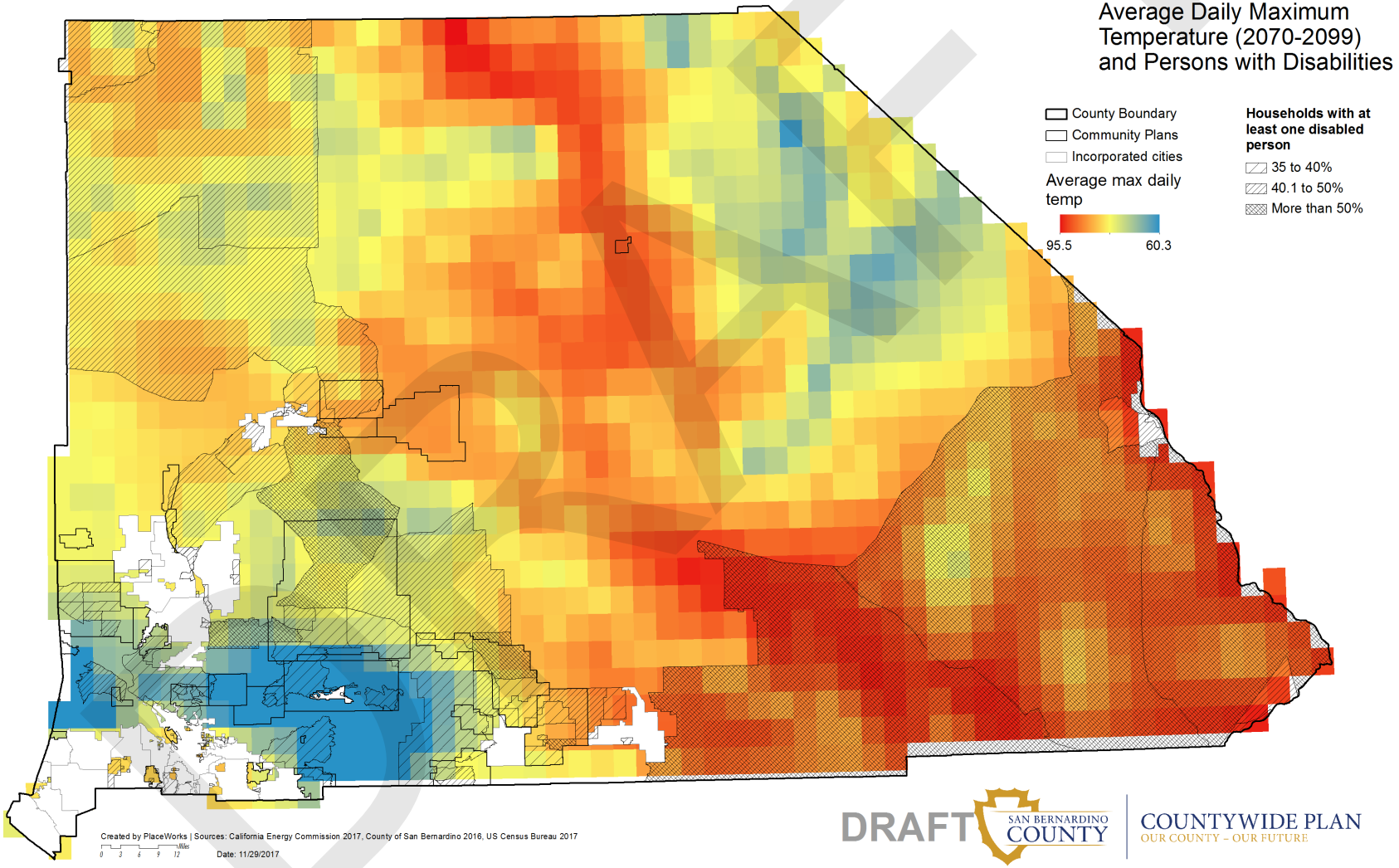
Private recreational sites: Private recreation facilities often depend on certain climate conditions to provide recreational opportunities (e.g., a ski resort depending on snow, or a private lake depending on rainfall). Changes to these conditions make it harder for such facilities to operate, decreasing business and causing economic harm to employees and other members of the community. Some businesses may be able to adapt (e.g., a ski resort using artificial snow), although this can be expensive and not suitable for all activities. Private recreational sites face V5 vulnerabilities from drought.

Public protected land: The ecosystems of public protected land have evolved to match the particular climate conditions in their area. These ecosystems may be unable to adapt if conditions change rapidly. There may be management strategies available to help public lands cope with changing conditions, but the size of the affected areas and limited resources make this infeasible. Public protected land faces V5 vulnerability from wildfires. **Figure 23** shows where public protected lands face the greatest risk from wildfires.

4.3 SERVICES

Electricity: Electrical service can be disrupted when high demand puts stress on the grid, increasing the risk of a key component failing and causing a power outage. Some severe events can directly damage or destroy power line components, causing a loss of service, and droughts can reduce generating capacity. Electrical facilities can be hardened against severe events in some cases, and energy conservation measures can reduce stress on the grid. There is a moderate amount of redundancy in the electrical grid, meaning that some damaged infrastructure can be bypassed, although this redundancy may not exist in more rural or isolated areas. Electrical services face a V4 vulnerability from extreme heat.

Figure 20 Average Daily Maximum Temperature (2070–2099) and Persons with Disabilities



4. Results

Figure 21 Flood Hazard Zone and Persons with Disabilities

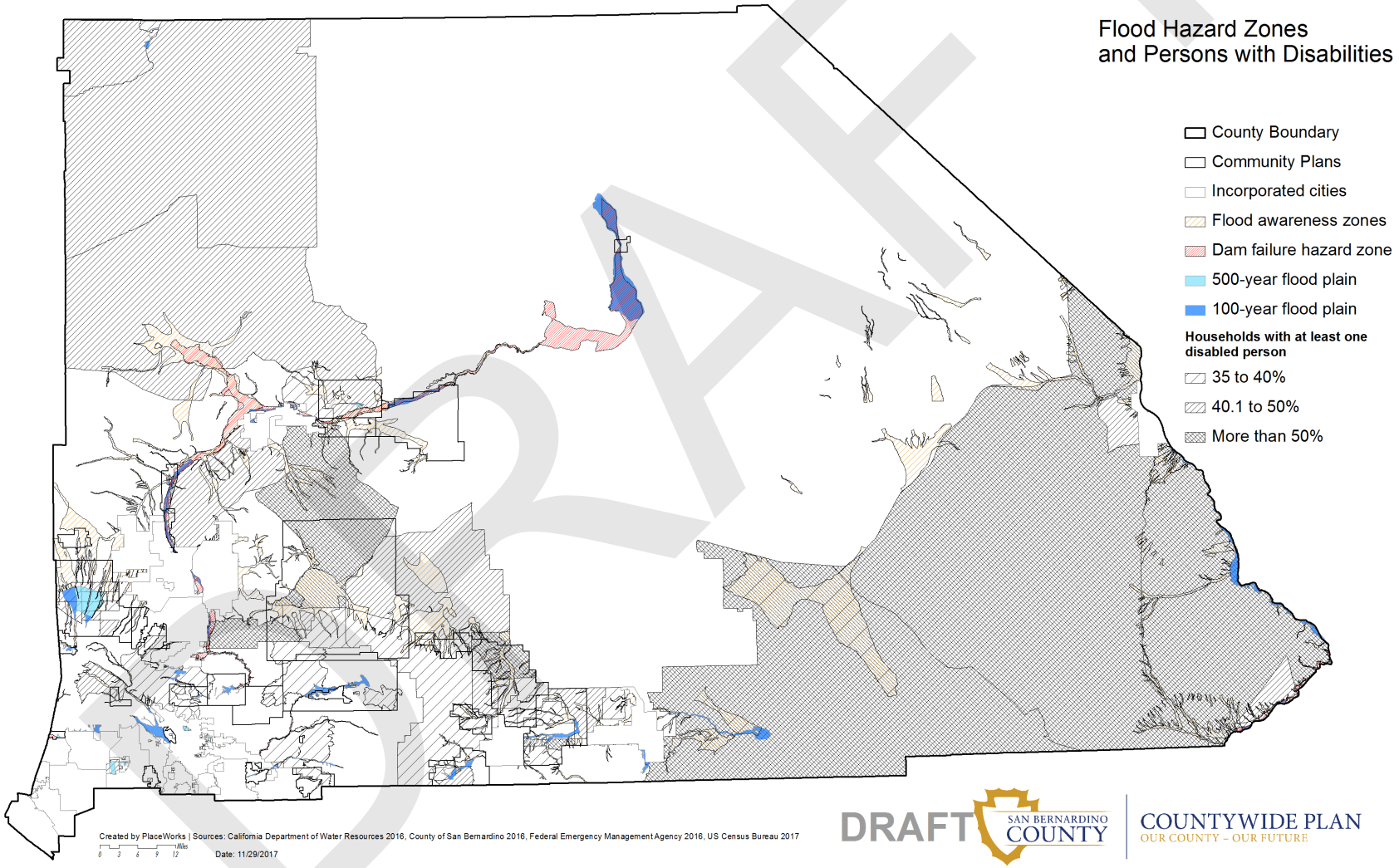


Figure 22 Wildfire Hazard Zones and Persons with Disabilities

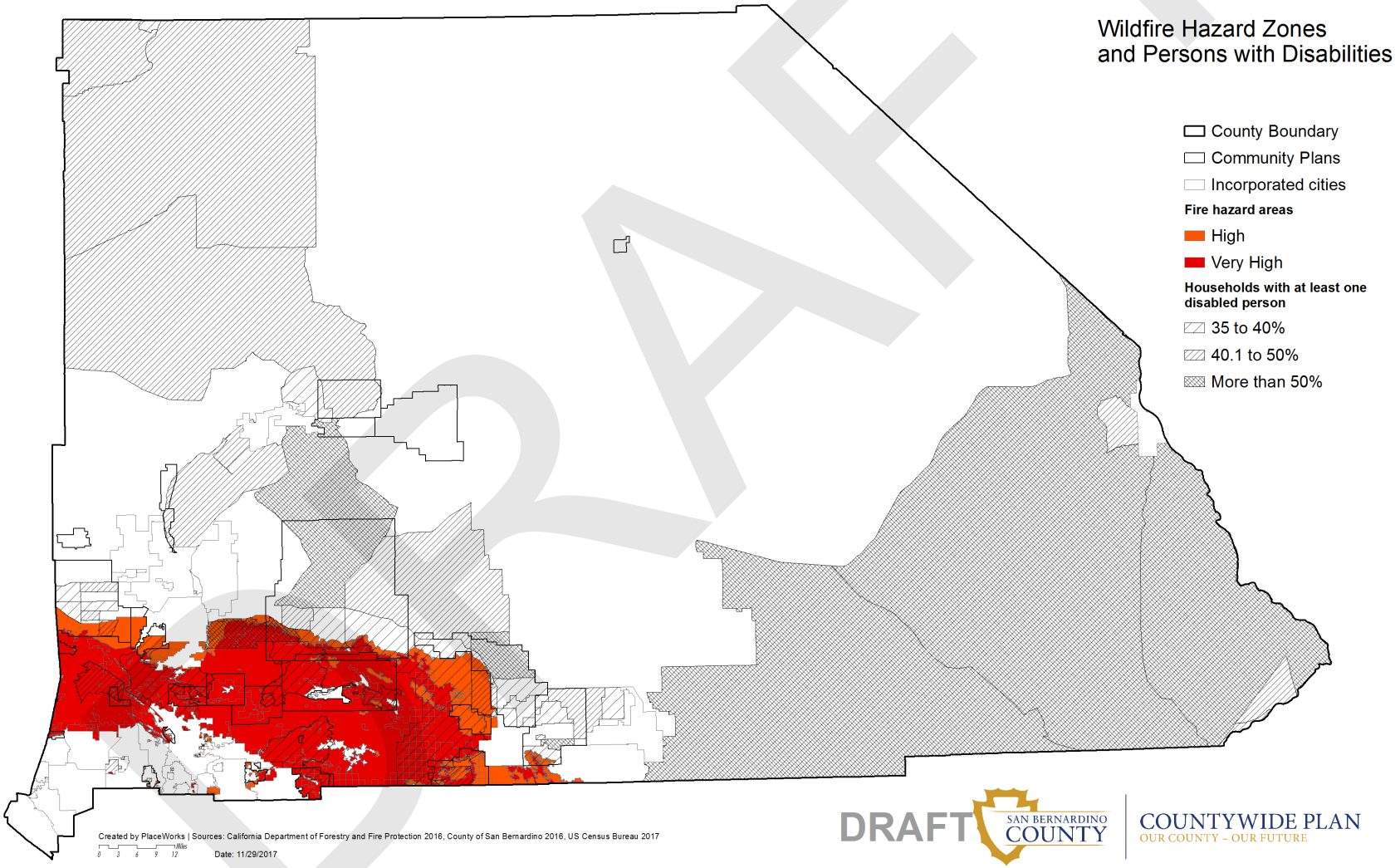


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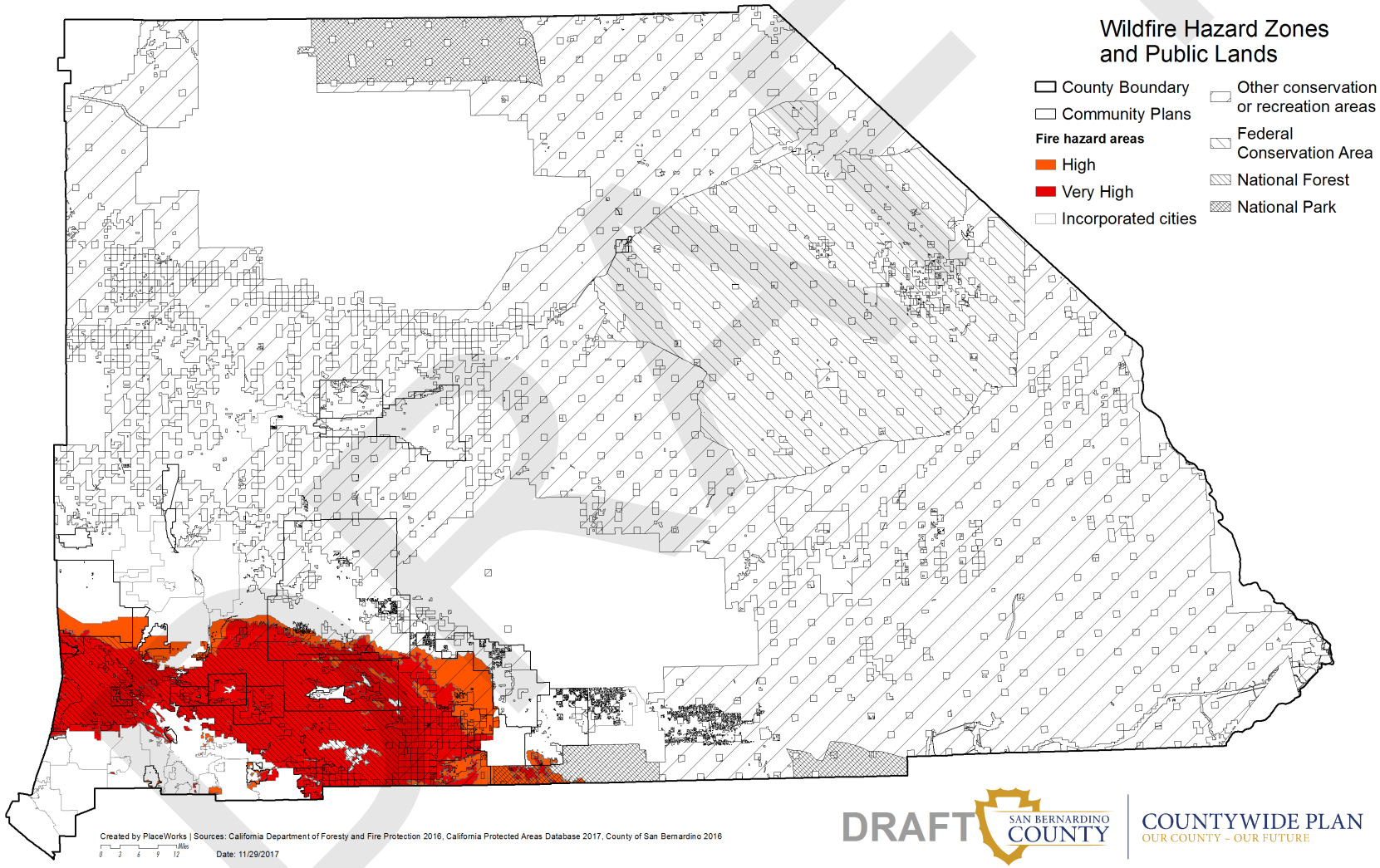
Figure 23 Wildfire Hazard Zones and Public Lands.



Health services: Health services can be stressed by extreme events if unexpectedly high demand for healthcare leads to an insufficient number of staff or resources. Some emergency events can block roads and cause traffic delays, which can affect ambulance response time. Emergency staffing and response plans can help health care providers prepare for such situations, although limitations on resources and physical capacity can still be a constraint. Health services face V4 vulnerability from extreme heat.

Water delivery and wastewater treatment: Water services rely on available water supplies from a variety of local and imported sources. These supplies can be disrupted due to changes in climate conditions, particularly when there is excessive demand or when supplies are not properly managed. Water conservation strategies can extend supplies, although only to a point. Some areas may experience water shortages, particularly properties with private wells, and alternative supplies may not be affordable. Hauled water from other sources, which can serve as an alternative supply, could be more difficult to obtain due to increased prices or lower availability. Less water results in less wastewater being generated, which can reduce the effectiveness of wastewater systems that are designed for a particular minimum volume. Water delivery and wastewater treatment services face V5 vulnerability from drought.

4.3.1 ECOSYSTEMS AND NATURAL RESOURCES

Big sagebrush scrub: Many common species in big sagebrush scrub ecosystems face a high risk of damage from wildfires because they burn very easily and do not often survive. These species also have slow growth rates and do not resprout, which makes recovery difficult. There is a risk that faster-growing invasive species can take over a burned area before sagebrush species are able to recover. Big sagebrush scrub faces a V5 vulnerability from wildfire. **Figure 24** shows the overlap between wildfire hazard zones and habitats that are vulnerable to wildfires.

California foothill and valley forest and woodlands: California foothill and valley forest and woodland species are somewhat adapted to many types of climate hazards and related events and can often survive without substantial damage. However, stresses from extreme events that occur more frequently or with greater severity can exceed these species' tolerance, creating a risk of widespread tree death. California foothill and valley forest and woodlands face V5 vulnerability from pests and diseases and V4 vulnerability from drought.

California grasslands and flowerfields: Many species in the California grasslands and flowerfields ecosystem are vulnerable to the effects of wildfires and often unable to survive intense flames. Many of these species also regrow slowly, which means that they can be crowded out of a burned area by fast-growing invasive species. California grasslands and flowerfields face V5 vulnerability from wildfires. **Figure 24** shows the overlap between wildfire hazard zones and habitats that are vulnerable to wildfires.

Coastal sage scrub: Coastal sage scrub species are adapted to extreme events such as droughts, which can occur regularly in the areas where the ecosystem is located. However projections indicate that

future conditions are likely to exceed these species' ability to adapt, reducing their ability to grow and reproduce. Coastal sage scrub faces V4 vulnerability from drought.

Freshwater marsh: Freshwater marsh species require wet soil to remain viable, and changes to climate conditions that reduce soil moisture can have widespread negative consequences. While some species can adapt to drier conditions, others are unlikely to remain viable, which could affect the overall integrity of the ecosystem. Freshwater marshes face V5 vulnerability from drought and V4 vulnerability from extreme heat. **Figure 25** shows the overlap between areas with projected high temperatures and habitats that are vulnerable to extreme heat.

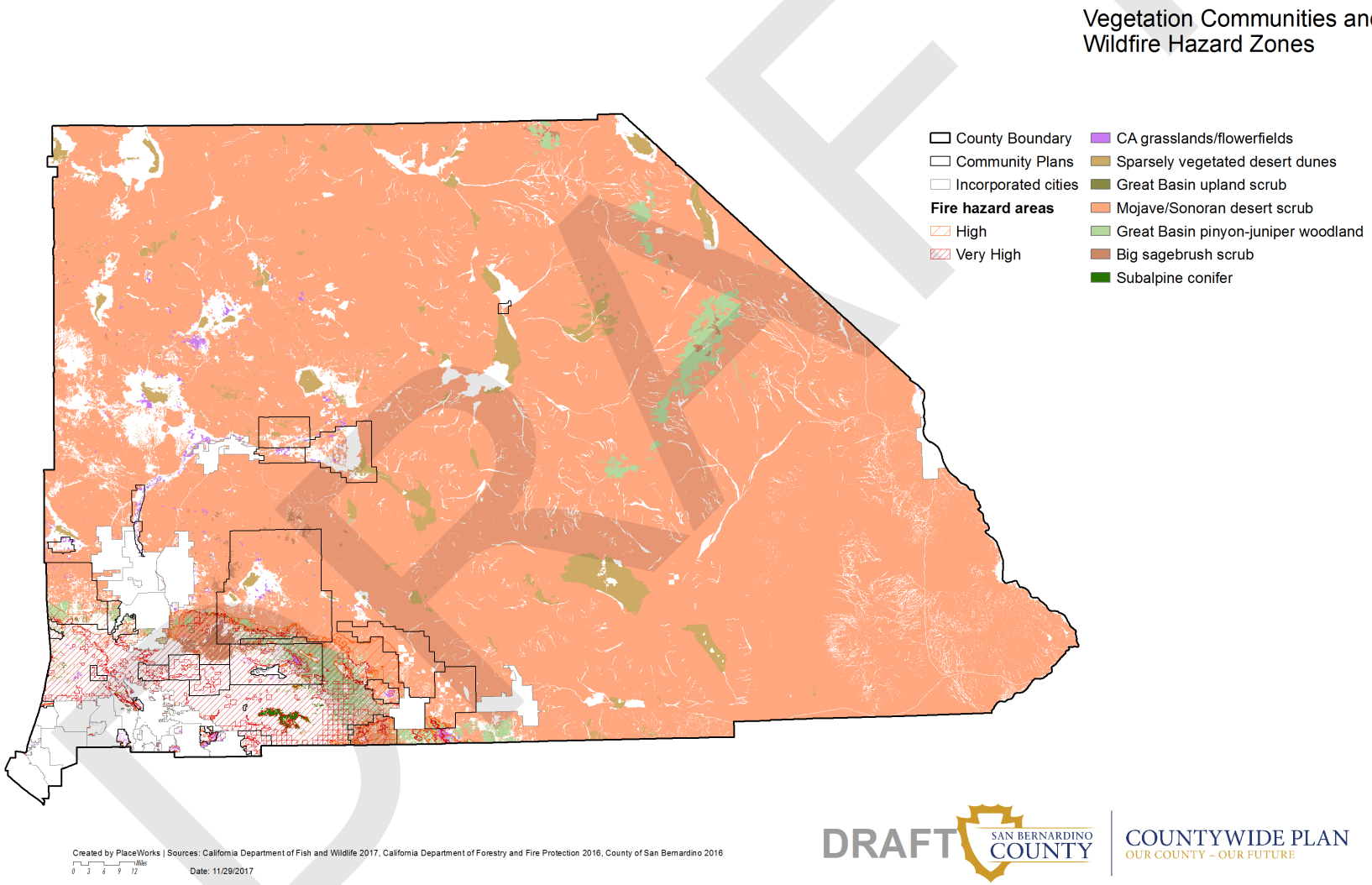
Groundwater basins: Groundwater basins build up over a very long time and so are buffered from normal variations in precipitation levels. However, substantial long-term decreases in precipitation can cause a chronic decline, particularly if the basin is not managed effectively. Groundwater meets the water demand in many parts of San Bernardino County, and alternatives are not always available if groundwater levels decrease due to precipitation or poor management strategies. Increases in the number of private wells and greater regional reliance on groundwater have put greater stress on regional groundwater resources. A number of groundwater basins in San Bernardino County are regulated through court adjudication, which can help to manage extraction and ensure the basin's sustainability. Groundwater basins face V4 vulnerabilities from drought.

Great Basin piñon-juniper woodland: The species in this habitat type are susceptible to various extreme events, especially wildfire. The plants are highly flammable, and their shapes allow for the easy spread of flames. Extreme events such as wildfires can damage fertility and seed longevity, making it harder for the ecosystem to recover. Great Basin piñon-juniper woodland faces V5 vulnerability from wildfires. **Figure 24** shows the overlap between wildfire hazard zones and habitats that are vulnerable to wildfires.

Great Basin upland scrub: Some species in the Great Basin upland scrub habitat can be harmed by extreme events, although impacts can vary widely. These species often grow and reproduce slowly, making it difficult for the habitat to recover if a hazard event has caused significant destruction. This ecosystem is also found in limited areas that could no longer be feasible under changing climate conditions. Great Basin upland scrub faces V5 vulnerability from wildfires and V4 vulnerability from extreme heat. **Figure 24** shows the overlap between wildfire hazard zones and habitats that are vulnerable to wildfires. **Figure 25** shows the overlap between areas with projected high temperatures and habitats that are vulnerable to extreme heat.

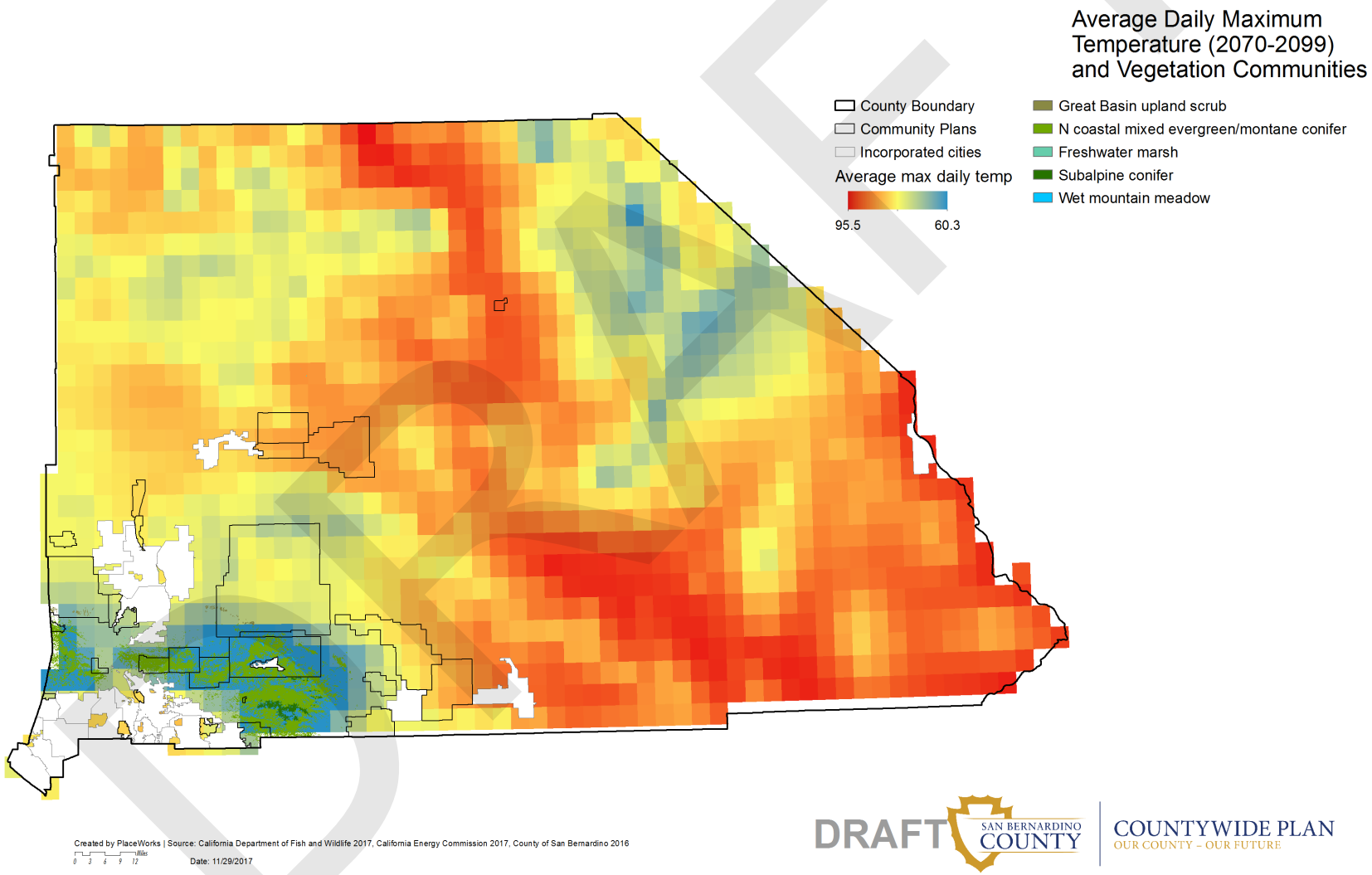
Mojave and Sonoran desert scrub: Mojave and Sonoran desert scrub is highly vulnerable to damage during wildfire events due to flammable resins and waxes in the plants' tissues. This means that they have little or no ability to adapt to wildfires. Although wildfires are fairly rare in desert environments, this ecosystem can be devastated by any that do happen. Mojave and Sonoran desert scrub faces V5 vulnerability from wildfires. **Figure 24** shows the overlap between wildfire hazard zones and habitats that are vulnerable to wildfires.

Figure 24 Vegetation Communities and Wildfire Hazard Zones



4. Results

Figure 25 Average Daily Maximum Temperature (2070–2099) and Vegetation Communities



North coastal mixed evergreen and montane conifer forests: This habitat type is made up of a diverse range of species, but many of these species can be harmed by extreme events. Impacts to the plants themselves are moderate, but the adaptive capacity in this ecosystem is very low because extreme events can significantly harm reproduction and damage the species' ability to grow and recover. Most or all of this ecosystem in San Bernardino County may be gone by the end of the 21st century. North coastal mixed evergreen and montane conifer forests face V5 vulnerability from drought and V4 vulnerability from extreme heat. **Figure 25** shows the overlap between areas with projected high temperatures and habitats that are vulnerable to extreme heat.

North coastal riparian and montane forest and woodland: North coastal riparian and montane forest and woodland habitats have middling tolerance for some types of extreme events such as droughts. There is a risk that the seeds of many species can be harmed, making them less fertile and therefore reducing the ability of the ecosystem to grow and recover. Changes to climate that make San Bernardino County hotter and drier mean that this ecosystem may not be present in the county by 2100. North coastal riparian and montane forest and woodland face V4 vulnerability from drought.

Sparsely vegetated desert dune: These habitats can face damage from wildfire events because many of the species are fairly flammable. Wildfires affect the fertility of plants in these ecosystems, preventing them from effectively growing and recovering after a fire. Although wildfires are rare in the habitats where these plants live, the effects can be significant. The sparsely vegetated desert dune environment faces V4 vulnerability from wildfires. **Figure 24** shows the overlap between wildfire hazard zones and habitats that are vulnerable to wildfires.

Subalpine aspen forests and pine woodlands: Subalpine aspen forests and pine woodlands are used to a cold climate with a moderate amount of precipitation. Changes to climate conditions can exceed the preferred living conditions for many species in this habitat, causing them to be stressed and reducing their growth. Stressed trees are also more susceptible to pests and diseases. These trees may be unable to survive outside of their preferred climate conditions, reducing the long-term viability of the ecosystem. It is possible that this habitat type may not be viable in San Bernardino County by the end of the 21st century. Subalpine aspen forest and pine woodlands face V5 vulnerability from extreme heat and pests and diseases and V4 vulnerability from drought and wildfire. **Figure 24** shows the overlap between wildfire hazard zones and habitats that are vulnerable to wildfires. **Figure 25** shows the overlap between areas with projected high temperatures and habitats that are vulnerable to extreme heat.

Wet mountain meadow: Wet mountain meadow ecosystems require saturated soil to thrive, and climate conditions that decrease the amount of water in the habitat can cause plants to become stressed or to die. These stresses also limit fertility and seed longevity, which prevents new plants from growing and therefore prevents the ecosystem from spreading. Hotter and drier conditions may mean that the climate in San Bernardino County can exceed the preferred range for these species, decreasing the likelihood that the ecosystem will survive. Wet mountain meadows face V5 vulnerability from

drought and V4 vulnerability from extreme heat. **Figure 25** shows the overlap between areas with projected high temperatures and habitats that are vulnerable to extreme heat.

4.4 ALL RESULTS

A table of the overall vulnerability for all exposures and sensitivities is in Appendix A.

4.5 KEY CONSIDERATIONS

This assessment reveals several sensitivities with high vulnerability—some are spatially defined and others occur countywide. The County, along with key partner organizations, can work to improve resiliency in San Bernardino County through development and implementation of policies and programs to address social and physical vulnerability. The County could also address vulnerabilities in additional areas that had a lower vulnerability score (V3 and lower, as shown in **Appendix A**), based on level of vulnerability, County priorities, available resources, and other factors. This section summarizes key issues—organized based on the types of challenges faced by the different sensitivities—for additional review and consideration during the outreach and policy development phases of the Countywide Plan.

Exposed persons: Homeless persons and people who work outside are more exposed to the elements, and by extension to natural hazards. Homeless persons have a very limited ability to seek shelter, and people who work outdoors may not be able to take shelter during working hours. Persons living in mobile homes are also somewhat exposed because their homes are generally more vulnerable than permanent structures. This is particularly dangerous during extreme heat events, although severe weather, pests and diseases, and flash floods can also be harmful. Exposure to natural hazards can create a substantial risk of avoidable injury, illness, and even death, which can stress emergency and medical response systems during disasters. Harm to people who work outside, such as agricultural and construction workers, can create economic hardships.

Where possible and feasible, the County can take steps to minimize or avoid exposure of exposed persons. Provision of homeless shelters and services for the chronically homeless and efforts to transition homeless persons to permanent housing can provide long-lasting reductions in exposure. Creating temporary shelters, such as during extreme heat or flooding events, can also help by minimizing exposure when the risk is greatest. The County can work with employers and social service providers to ensure that exposed persons have access to protective gear, such as water during heat waves and insect repellant during times when disease-carrying pests are most active. The County can also help people living in mobile homes by providing funding for retrofits, which can reduce the risk of damage to the structure and help protect residents. By reducing or removing exposure, the County can reduce the threat to human health and the resulting stress that health impacts can have on the regional economy and key services.

Persons with medical challenges: Persons with medical challenges include senior citizens, persons with disabilities, and persons with existing medical conditions. These people may be more physically vulnerable to some hazards (e.g., senior citizens have lower physical resistance to extreme heat) or may be less able to take care of themselves. Mobility challenges are also common. As a result, people with medical challenges face substantial threat from most natural hazards, especially extreme heat, floods, pests and diseases, and wildfires.

One of the most effective steps the County can take to improve resilience among persons with medical challenges is to build strong formal and informal support systems, working with community partners and health providers. These networks can provide paid staff and volunteers to assist the medically challenged with their daily needs and ensuring that they are prepared for natural hazards. When disasters do occur, support networks can provide emergency assistance, including helping with evacuations.

The County can facilitate financial and material assistance to help medically challenged people harden their homes against hazards—such as free or discounted air conditioners or grants or no-interest loans for weatherization or flood protection. The County could also make physical infrastructure and services more accessible to persons with medical challenges—especially during hazard events, when mobility may be even more constrained. This would not only reduce the threat to persons with medical challenges during hazard events, but improve overall quality of life.

Persons with operational challenges: Persons with operational challenges have heightened vulnerability because of their limited resources or societal status. They include persons in low-income households or households in poverty, persons without access to lifelines, and undocumented persons. These people have limited means to prepare for hazard situations because they lack financial resources or other necessities (e.g., good transportation). These limitations can also prevent persons with operational challenges from effectively recovering after a disaster. Undocumented persons face additional vulnerabilities, because they may avoid interacting with government authorities or other groups who could provide assistance. Any of the climate change–related hazards can harm the health and safety of persons with operational challenges, who make up a large segment of the county's population and may also cause indirect economic harm to the companies that employ them.

San Bernardino County can improve resiliency for persons with operational challenges by facilitating their access to additional resources. This can include direct assistance such as grants and low- or no-interest loans, or strengthening support networks with professional staff and volunteers who can assist them. Community outreach can also help reduce vulnerabilities among persons with operational challenges. The County can work with community agencies to better inform the operationally challenged about government assistance programs and other resources. By working to ensure that these individuals have access to the resources they need to prepare for or recover from emergency events, the County can help protect their health and safety, and by extension, the local economy and quality of life.

4. Results

Economic drivers: San Bernardino County has a diverse and growing economy, but climate change may threaten some types of economic activity. Agricultural lands and recreational facilities such as reservoirs/lakes and ski resorts are particularly vulnerable, especially to drought conditions. Without reliable water supplies, farmers and ranchers may be forced to turn to less reliable and/or more expensive sources of water, which could decrease the yield of crops or livestock. If they switch to more water-efficient but potentially less profitable operations, it could create economic hardship. Similarly, recreational facilities may be forced to spend more for alternative sources of water (not always be a viable option) or curtail their activities. Pests and diseases may also damage agricultural operations. Without effective adaptation, climate change could weaken the economy in San Bernardino County and substantially harm some communities.

The County can help reduce economic damage from drought and other climate change-related hazard conditions by increasing education and awareness. Working with industry groups and regional educational institutions, the County can distribute information about industry practices or new technologies that improve resiliency to climate change (for example, crop varieties that are more drought tolerant or better resist certain diseases). Improving sustainable practices on agricultural lands is a component of California's overall climate change strategy, and so the state may make available financial resources, such as grants or low- or no-interest loans, or other resources to make these types of improvements. However, operational changes may not be sufficient for all farmers, ranchers, or recreational facilities operators, particularly in the long-term. The County can take steps to allow property owners to transition their land to more viable uses through changes in local zoning. For example, ski resorts could add recreational facilities that are less affected by changes in climate conditions, such as mountain bike trails, zip lines, and rope courses. Such additional facilities can be phased in gradually to protect community character and existing operations, but property owners can still stay in business. This can help buffer the local economy from climate-related hardships.

Utilities: Utility lines and services, in particular electricity and water/wastewater, face increased challenges from climate-related hazard conditions. Electrical lines are vulnerable to severe weather, especially wind, and less reliable during extreme heat events. Similarly, water (and to a lesser degree wastewater) services can become less reliable during a prolonged and intense drought, such as the statewide 2012–2017 drought. Losing access to these services is not only frustrating to County residents and businesses, but can create a health risk (for example, the loss of power during extreme heat prevents the use of air conditioning, heightening the risk of heat-related illness).

Making utility lines and services more resilient to climate change–related hazards is a major step the County can take to protect the reliability of electrical and water/wastewater services. The undergrounding of electrical lines is expensive, but may be worthwhile for key power lines in wind-prone areas. The County can promote renewable energy and energy storage systems and support weatherization and energy-efficient appliances, all of which help to reduce stress on the electrical grid and decrease the risk of brownouts or blackouts. Programs that increase awareness and access to financial resources can support these efforts without harming quality of life or increasing costs. Although San Bernardino County is mostly out of drought conditions, the County can continue to

enforce strict water conservation standards to help prevent waste. The County can also work with water providers to support a diversity of water supplies, which improves resiliency by reducing dependence on a single source of water.

Ecosystems: Because of San Bernardino County's vast size and geographic diversity, it has a number of different ecosystems, which help drive the local economy and contribute to community characteristics and local quality of life. However, many of these ecosystems are vulnerable to climate change–related hazards, especially drought, wildfire, and pests and diseases, but it is very difficult for the County to take any substantial action to improve resiliency without dramatically altering their natural state. Also, many natural areas are under the control of state and federal agencies. However, the County can take some steps with these key partners to reduce the vulnerabilities of ecosystems.

One of the most important steps is supporting a natural fire regime, which allows occasional wildfires to burn themselves out naturally rather than suppressing all blazes. Naturally occurring fires help clear ecosystems of dead brush and other accumulated material, supporting a healthy environment that is better able to resist climate change–related hazards. The County can work to improve connectivity between natural areas so that animal species can migrate across a broader territory or move to new areas. In some cases, efforts to eradicate pest species or plant new flora may help to grow back an impacted ecosystem as long as the County and its partners take care to avoid inadvertently causing harm. Ultimately, the County should be prepared for a loss of some ecosystem types and a transition from one ecosystem to another in some areas, and should respond accordingly as needed to protect natural systems in any form.

Groundwater basins: San Bernardino County has a number of groundwater basins, particularly in the valley and desert regions, that are a major source of water for urban and rural areas. However, changes in drought and precipitation patterns may impair the replenishment of groundwater basins (a process called recharging), which can affect their long-term viability. If less groundwater is available, it affects water supplies for San Bernardino County, exacerbating drought-related shortages. Properties that rely exclusively on groundwater, such as sites with private wells, may face greater impacts

San Bernardino County and local water agencies can improve groundwater recharge and improve the long-term viability of groundwater basins despite climate change–related impacts. Most of the groundwater basins in the Valley and southwest Desert regions are already regulated through adjudication, and recently-adopted state law requires agencies to begin regulating groundwater basins that are not already under court supervision. The County and its partners can accelerate implementation of this law, in a manner consistent with community values and priorities. The County can promote permeable surfaces in new construction and renovations that allow water to percolate into the ground and recharge groundwater basins rather than running off into storm drains. Where possible, local water agencies that rely primarily on groundwater can diversify their water supplies, reducing groundwater demand. The County can also continue to promote strict water conservation measures to decrease overall water demand, including from groundwater basins. These steps can help groundwater basins to remain a useful and sustainable source of water for the community.

4. Results

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Appendix A. Complete Vulnerability Assessment Results

This table shows the vulnerability score for each sensitivity and hazard pairing. Vulnerability is measured on a scale ranging from V1 (low vulnerability) to V5 (high vulnerability). Pairings with no score have no special vulnerability considerations, although the hazard may still cause harm to the sensitivity.

Sensitivity	Extreme heat	Flooding	Drought	Pests and Diseases	Severe Weather	Wildfires
Populations						
Children less than 10 years old	V3	N/A	N/A	V3	N/A	N/A
Homeless persons	V5	V3	N/A	V4	V5	V3
Households in poverty	V5	V4	V5	V3	V3	V4
Individuals paying at least 30% of their income on housing	V3	V3	V3	V1	V1	V2
Individuals with existing medical conditions	V5	V5	N/A	V4	V3	V5
Individuals without access to lifelines	V5	V4	V2	V2	V3	V5
Low-income households	V3	V3	V4	V3	V2	V3
Outdoor workers	V5	V1	V3	V2	V4	V3
Persons in a mobile home	V2	V3	N/A	N/A	V4	V1
Persons in overcrowded housing	V3	V2	N/A	V2	V2	V1
Persons with disabilities	V5	V5	N/A	V2	V1	V4
Persons with limited English comprehension	V2	V2	V1	V1	V1	V1
Renters	V2	V3	V2	N/A	V1	V3
Senior citizens	V5	V3	N/A	V3	V1	V4
Senior citizens living alone	V5	V4	N/A	V4	V3	V5
Undocumented persons	V3	V3	V5	V4	V3	V2

Appendix A. Complete Vulnerability Assessment Results

Sensitivity	Extreme heat	Flooding	Drought	Pests and Diseases	Severe Weather	Wildfires
Buildings and facilities						
Adult residential care centers	V2	V3	N/A	N/A	V2	V1
Agricultural lands	N/A	V3	V5	V4	V3	V2
Airports	V2	V1	N/A	N/A	V3	V1
Bridges	V3	V4	N/A	N/A	V3	V1
Buildings in dam inundation areas	N/A	V3	N/A	N/A	V2	N/A
Buildings in flood hazard areas	N/A	V4	V2	N/A	V2	N/A
Buildings in wildfire hazard areas	V3	V3	V4	N/A	V3	V4
Communication facilities	V2	V1	N/A	N/A	V3	V3
Dams	N/A	V3	N/A	N/A	V1	N/A
Electrical substations	V2	V2	N/A	N/A	V2	V1
Electrical transmission and distribution lines	V3	V2	N/A	N/A	V4	V3
Foster homes	V2	V2	N/A	N/A	V1	V1
Government offices	V1	V1	N/A	N/A	V2	V1
Libraries	V2	V2	N/A	N/A	V2	V2
Medical facilities	V3	V2	N/A	N/A	V1	V1
Military facilities	V2	V1	N/A	N/A	V1	V1
Natural gas facilities	V1	V1	N/A	N/A	V2	V2
Old homes	V3	V3	N/A	V2	V3	V3
Parks/open space	V1	V2	V1	V1	V1	V3
Power plants	V3	V1	V1	N/A	V1	V1
Private recreational sites	N/A	V2	V5	N/A	V2	V3
Public housing	N/A	V3	N/A	N/A	V2	V2
Public protected land	N/A	V1	V1	V3	V1	V5
Public safety buildings	V2	V2	N/A	N/A	V1	V1

Appendix A. Complete Vulnerability Assessment Results

Sensitivity	Extreme heat	Flooding	Drought	Pests and Diseases	Severe Weather	Wildfires
Public Works corporation yards	V1	V1	N/A	N/A	V1	V2
Railways	V1	V2	N/A	N/A	V1	V1
Schools and child care centers	V3	V2	N/A	N/A	V2	V2
Senior care centers	V3	V2	N/A	N/A	V2	V3
State highways	V2	V3	N/A	N/A	V3	V1
Telecommunication systems	N/A	V1	N/A	N/A	V2	V2
Water and wastewater infrastructure	N/A	V3	V1	N/A	V1	V1
Services						
Communications	V2	V2	N/A	N/A	V1	V2
Electricity	V4	V3	V2	N/A	V3	V3
Emergency response	V3	V3	N/A	V1	V2	V2
Government administration	V1	V2	N/A	V1	V1	V2
Health services	V4	V3	N/A	V3	V2	V3
Natural gas	N/A	V3	N/A	N/A	V1	V1
Public safety	V2	V3	N/A	N/A	V1	V2
Water delivery and wastewater treatment	V1	V2	V5	N/A	V1	V1
Ecosystems and natural resources						
American Southwest riparian forest and woodland	V1	N/A	V3	V3	V1	V2
Big sagebrush scrub	V3	N/A	V3	V1	V1	V5
California foothill and valley forest and woodlands	V3	V2	V4	V5	V2	V1
California grasslands and flowerfields	V2	N/A	V3	V3	V1	V5
Chaparral	V2	N/A	V3	V2	V1	V3
Coastal sage scrub	N/A	N/A	V4	V2	V1	V3
Desert wash woodland and scrub	N/A	N/A	N/A	V2	V1	V3
Freshwater marsh	V4	V2	V5	V2	V2	V1

Appendix A. Complete Vulnerability Assessment Results

Sensitivity	Extreme heat	Flooding	Drought	Pests and Diseases	Severe Weather	Wildfires
Great Basin piñyon-juniper woodland	V3	N/A	V3	V3	V1	V5
Great Basin upland scrub	V4	N/A	V2	V1	V1	V5
Groundwater basins	V1	N/A	V4	N/A	N/A	N/A
Lacustrine	V3	N/A	V3	N/A	N/A	N/A
Mojave and Sonoran desert scrub	V1	N/A	N/A	V1	V1	V5
Montane chaparral	V2	N/A	V3	V3	V1	V2
Non-native forest and woodlands	V1	V2	V2	V3	V3	V1
North coastal mixed evergreen and montane conifer forests	V4	N/A	V5	V2	V2	V2
North coastal riparian and montane riparian forest and woodland	N/A	V2	V4	V3	V2	V1
Shadscale-saltbrush scrub	V2	N/A	V2	V1	V1	V3
Sparsely vegetated desert dune	N/A	N/A	V2	V1	V1	V4
Subalpine aspen forests and pine woodlands	V5	N/A	V4	V5	V3	V4
Wet mountain meadow	V4	V2	V5	V2	V1	V3

Appendix B: Key Terms

100-year flood. A flood that has a 1 percent (one in 100) chance of occurring in any given year (USGS 2016).

500-year flood. A flood that has a 0.2 percent (one in 500) chance of occurring in any given year (USGS 2016).

Adaptation. An adjustment in a system, in response to current or projected climate changes, that minimizes harm (CNRA and Cal EMA 2012).

Adaptive capacity. The ability of a sensitivity, under current conditions, to reduce the damage from an exposure (CNRA and Cal EMA 2012).

Asset. A nonhuman sensitivity, including physical structures, services and functions, and natural lands (CNRA and Cal EMA 2012).

Climate. The long-term average of meteorological conditions such as temperature, precipitation, and wind (IPCC 2012).

Climate change. A long-term change in climate conditions, either as a result of natural causes or human activities (IPCC 2012).

Distribution line. A utility line that transmits a resource from a central transmission line to individual users.

Downscaling. The process of determining small-scale (e.g., local or regional) information from a larger-scale set of data (IPCC 2012).

Drought. A period of unusually dry weather that causes an imbalance in the amount of water available (IPCC 2012).

Exposure. The effects of anticipated changes, such as a hazard, to climate conditions (CNRA and Cal EMA 2012).

Extreme heat. A period of unusually hot weather substantially above average conditions (IPCC 2012).

Groundwater. Water found underground in fractures and spaces in rocks and soil.

Hazard. A condition or event that can harm a sensitivity.

Impact. The effects, especially the negative effects, of a hazard (CNRA and Cal EMA 2012).

Lifeline. Basic necessities such as communication services and vehicles (CNRA and Cal EMA 2012).

Appendix B. Key Terms

Linguistic isolation. Having little or no ability to effectively communicate in the language or languages that are widely spoken in a community.

Model. A representation of the climate system (e.g., a virtual simulation of the climate system) used to study climate and simulate climate conditions (IPCC 2012).

Morbidity. Being diseased or unhealthy.

Mortality. Being dead.

Onset. The period of time in which an exposure begins (CNRA and Cal EMA 2012).

Overcrowding. As defined by the census, a condition in which there is more than one person living in a home for each room of that home (US Census Bureau 2007).

Pathogen. An organism or body, such as a bacteria or virus, that is responsible for causing a disease.

Resilience. The ability of a sensitivity to resist harm and effectively recover from hazards (CNRA and Cal EMA 2012).

Risk. The chance of a hazard event.

Sensitivity. A population or asset that may be affected by climate change (CNRA and Cal EMA 2012).

Severe weather. Any type of weather event that exceeds normal conditions, particularly an event that poses a threat to a sensitivity.

Snowpack. Accumulated snow in cold, high-elevation areas that melts and provides a source of water during warmer months.

Substation. An electrical facility that converts high-voltage electricity from power plants to a lower voltage for use by individual end-users.

Threat. The overall likelihood that a hazard will cause harm to a sensitivity.

Transmission line. A utility line that transmits a resource from a source (e.g., a power plant) to individual communities and neighborhoods for distribution.

Vulnerability. A weakness of a sensitivity that increases the risk of the sensitivity coming to harm.

Weather. The meteorological conditions (e.g., temperature, precipitation, and wind) at a specific location at a specific time.

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