CLIMATE CHANGE VULNERABILITY ASSESSMENT
BUTTE COUNTY
CLIMATE ACTION PLAN UPDATE

Prepared for:

Butte County

Development Services

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Contents

Executive summary

In 2015, Governor Schwarzenegger signed Senate Bill (SB) 379, which states that local governments need to address climate adaptation and resiliency's in their general plan's safety element by 2022. The first step in meeting this requirement is to conduct a Climate Change Vulnerability Assessment to identify the risks that climate change poses to the local jurisdiction and the geographic regions most at risk from climate change. SB 379 requires the following information to be included in the Vulnerability Assessment:

(I) Information from the Internet-based Cal-Adapt tool.
(II) Information from the most recent version of the California Adaptation Planning Guide.
(III) Information from local agencies on the types of assets, resources, and populations that will be sensitive to various climate change exposures.
(IV) Information from local agencies on their current ability to deal with the impacts of climate change.
(V) Historical data on natural events and hazards, including locally prepared maps of areas subject to previous risk, areas that are vulnerable, and sites that have been repeatedly damaged.
(VI) Existing and planned development in identified at-risk areas, including structures, roads, utilities, and essential public facilities.
(VII) Federal, state, regional, and local agencies with responsibility for the protection of public health and safety and the environment, including special districts and local offices of emergency services.

Climate change is currently impacting Butte County and it is projected to get worse in the coming years. Butte County Planning staff saw an immediate need to meet SB 379 to ensure that our community can adapt and build resilience to the changing climate.

This Vulnerability Assessment provides a qualitative analysis on how climate change might impact the Butte County throughout the century. Direct impacts of climate change to the County is the increase in average temperature and changes in annual precipitation. Secondary impacts include: Increased frequency, intensity, and duration of extreme heat days and heat waves/events, increased flooding increased wildfire, and loss of snowpack and decreased water supplies. Over the long term, these changes create the potential for a wide variety of secondary consequences, including human health and safety risks, economic disruptions, shifts in ecosystem function and habitat qualities, and difficulties with provision of public services (California Natural Resources Agency [CNRA] 2012). See appendices, future climate projections for the Butte County.

The biggest climate change threats to the Butte County is the increase in extreme heat events as well as the increase in wildfire events. The County's roadways, infrastructure in flood zones, disadvantaged communities, agriculture sector and sensitive species habitat are among the most vulnerable to climate change impacts. Disaster recovery efforts require extreme measures and commitment to the development of healthy, organized responses to chaotic situations. Every region has a unique need. If a jurisdiction is not in synch with current regulation it may not only miss opportunities for state and federal funding but it may leave that jurisdiction more vulnerable to the threats of climate change induced natural disasters. County staff intends to use this assessment as a guide bolstering the County's adaptive capacity to respond to these impacts. This Vulnerability Assessment provides a qualitative analysis on how climate change might impact the Butte County throughout the century and where our greatest risks lie.

1 Introduction

Climate change is a global phenomenon that, over the long term, will cause a wide variety of impacts on human health and safety, economic vitality, water supply, ecosystem function, and the provision of basic services (California Natural Resources Agency [CNRA] 2012). Locally in the Butte County (the County) region, as well as throughout California, climate change is already affecting and will continue to affect the physical environment.

The California Adaptation Planning Guide (APG), developed by California Office of Emergency Services (CalOES) and CNRA, helps communities throughout California plan for and adapt to the impacts of climate change. The APG includes a nine-step process, which allows communities to assess their specific climate vulnerabilities and provides strategies for communities to reduce climate-related risks and prepare for current and future impacts of climate change.

This vulnerability assessment provides an overview of the primary and secondary threats associated with climate change, and identifies the ones most likely to affect Butte County. The findings of the vulnerability assessment will be used to develop climate adaptation strategies that address these threats, which will be updated in The Butte County General Plan, meeting SB 379 requirements.

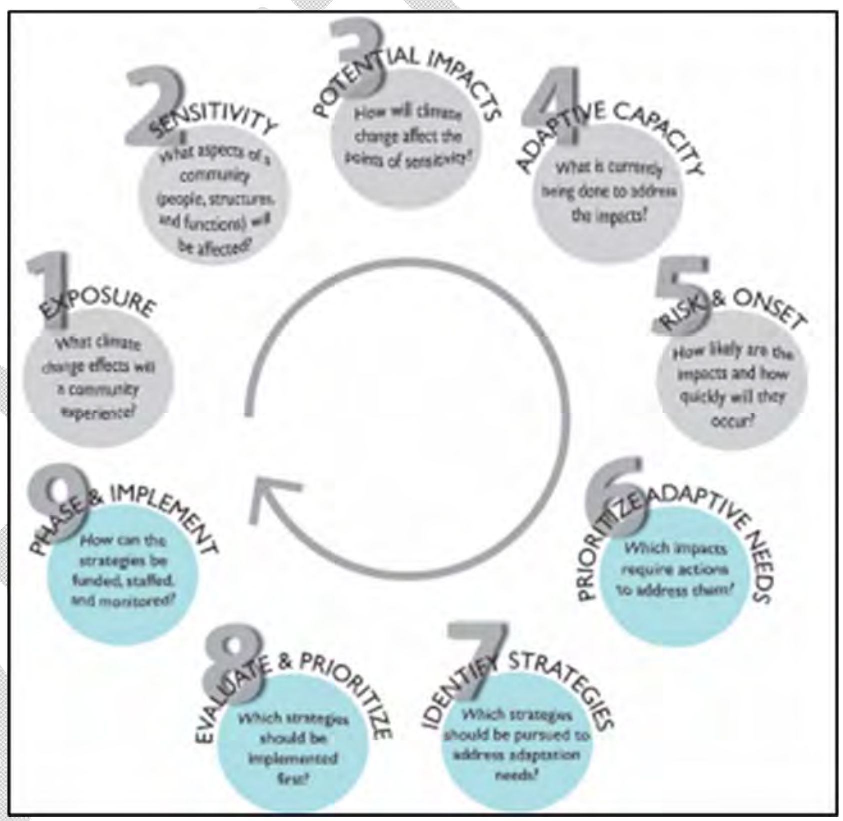

Figure 1: Adaptive Planning Guide (APG) Vulnerability Assessment Steps

The first five steps in the APG (see **Figure 1**) result in a Vulnerability Assessment, which is an evaluation of a community's level of exposure to climate-related impacts and an analysis of how these impacts will affect a community's population, functions, and structures. The last four steps of the process use the information gathered in the Vulnerability Assessment to develop adaptation strategies and measures to help the community prepare for, respond to, and adapt to local climate change impacts.

A vulnerability assessment is intended to answer the following questions:

1. **Exposure:** what climate change effects will a community experience?

2. **Sensitivity:** what aspects of a community (i.e., function, structures, and populations) will be affected?
3. **Potential Impacts:** how will climate change affect the points of sensitivity?
4. **Adaptive Capacity:** what is currently being done to address the impacts?
5. **Risk and Onset:** how likely are the impacts and how quickly will they occur?

The second phase of the APG process is adaptation strategy development. The vulnerability assessment phase helps communities understand climate change impacts so that they can prepare effective climate adaptation strategies to increase resilience to climate change. Development of climate adaptation strategies will be included in the County's General Plan. The final four steps in the APG help communities create their adaptation strategies:

6. **Prioritize Adaptive Needs:** setting priorities for adaptation needs.
7. **Identify Strategies:** identifying strategies to address adaptation needs.
8. **Evaluate and prioritize:** evaluating and setting priorities for implementation of strategies.
9. **Phase and Implementation:** establishing a phasing and implementation plan.

This assessment only covers steps 1-5. Steps 6-9, adaptation strategies, will be developed by Butte County Development Services at a later date.

Based on data provided by The International Panel on Climate Change (IPCC) and research conducted by the State of California and its partner agencies and organizations, the effects of climate change are already occurring and will continue to occur in Butte County. These effects are identified and analyzed further below.

1.1 Butte County

Located in Northern California, unincorporated Butte County has an area of approximately 1,680 square miles within the northeastern end of the Sacramento Valley, extending east into the northern Sierra Nevada foothills. Butte County is a predominantly rural area; urban land makes up less than 5% of the total county area. Weather is generally temperate and warm, with average lows dropping just below 40 degrees Fahrenheit and summer highs ranging over 90 degrees Fahrenheit. (Butte County. 2007. General Plan Setting & Trends Report Public Draft)

Homes and businesses are dispersed throughout the unincorporated county, resulting in transportation activity that is typical for a rural unincorporated county. Given the distribution of homes, businesses, and daily activities, driving in personal vehicles is common.

Agriculture is a strong and growing sector of the Butte County economy and occupied about 500,000 acres of unincorporated county land in 2012. According to the Agricultural Commissioner's office, Butte County's gross 2016 agricultural production totaled $705,211,786. (County 2016 Crop Report.) Walnuts, almonds, and rice crops were among the highest-value crop types grown in Butte County. Generally, agricultural activity has been shifting from field crops to higher-value nut crops that typically require less water and fertilizer. See figure 3, a map of Butte County agriculture land use.

The primary crops grown in Butte County are rice and orchards, with rice averaging approximately 103,000 acres and orchards averaging approximately 93,000 acres Almonds (38,000 acres), walnuts (34,000 acres), and prunes (11,000 acres) are the primary orchard crops, with decreases in almond and prune acreage over time offset by increases in walnuts and, to a lesser extent, other trees and vines (e.g., olives, peaches and nectarines, kiwis, pistachios, pears, and cherries). Other than orchards and rice, crops include pasture and alfalfa (13,000 acres), grain (4,000 acres), and miscellaneous field and annual crops (5,000 acres). Acreages for grain and other crops have decreased substantially over time, while pasture and alfalfa acreage has increased. On average, 16,500 acres were idle annually (Butte County Department of Water and Resources Conservation, 2016).

The Butte County Climate Action Plan (2014), included a section (Chapter 5) entitled, Adapting to a Changing Climate, which includes several adaptation and resiliency measures, as well as government resiliency measures. The Butte CAP recognizes that adaptation policy development is an iterative process that incorporates a range of inputs (Figure 2).

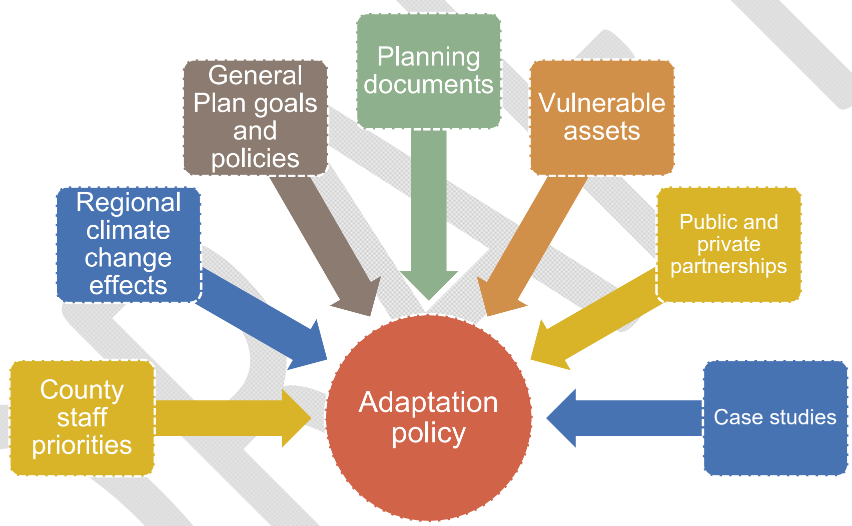

Figure 2: Climate Adaptation Development (Butte County Climate Action Plan, 2014)

This vulnerability assessment builds upon the initial efforts provided by the Butte County CAP to develop adaptation policy that will ultimately be incorporated into the Butte County General Plan.

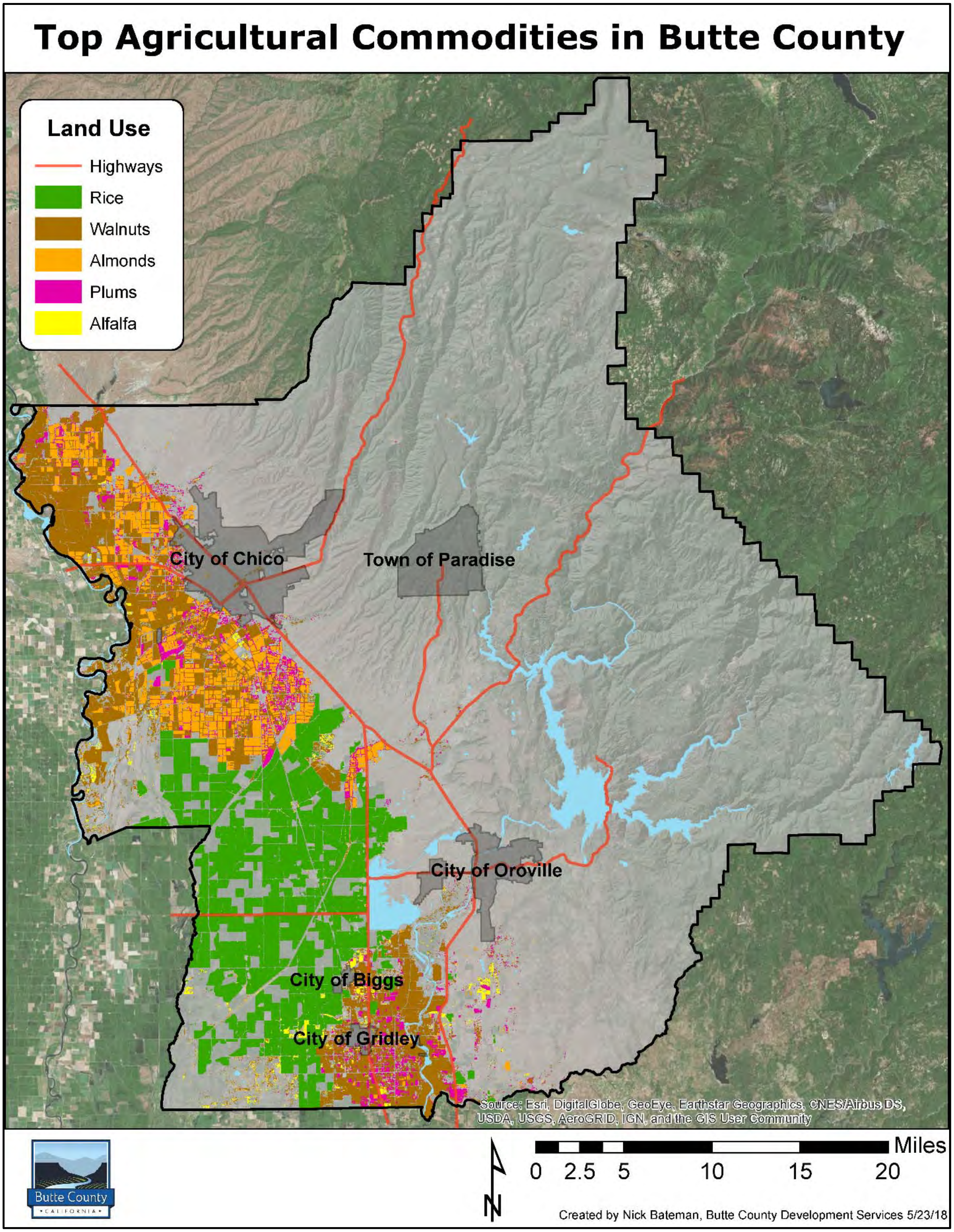

Figure 3: Agriculture Land-Use in Butte County

1.2 Cal-Adapt

As directed by the State's Adaptive Planning Guide (APG), the first step in adaptation planning is conducting a climate change vulnerability assessment utilizing Cal-Adapt. Cal-Adapt is a web-based climate change scenario planning tool developed by the California Energy Commission (CEC) and the University of California, Berkeley Geospatial Innovation Facility. The data available on this site offers a view of how climate change might affect California at the local level. Here users can work with visualization tools, access data, and participate in community sharing to contribute their own knowledge. Cal-Adapt's development is a key recommendation of the 2009 California Climate Adaptation Strategy (Cal-Adapt, 2017).

In order to accurately represent the variability of weather patterns, Cal-Adapt includes four different Global Climate Models (GCM's); Warm/Dry, Cool/ Wet, Average, and Complement models. These climate projections have been downscaled from global climate models from the Program for Climate Model Diagnosis and Intercomparing (CMIP5) archive, using the Localized Constructed Analogs (LOCA) statistical technique developed by Scripps Institution of Oceanography. LOCA is a statistical downscaling technique that uses history to add improved fine-scale detail to global climate models (Cal-Adapt, 2017). The Cal-Adapt charts used in Section 3 Sensitivity and Potential Impacts, you will see four colored lines which correspond to a different model. The red line represents the Warm/Dry model which shows the average future climate projection during a warm/ dry year. The blue line represents the Cool/Wet Model which shows the average future projection during a cool/wet year. The yellow line represented the Average Model which shows the average future climate projection for our typical California Mediterranean climate. The purple line represents the complement model which shows the projection that is most unlike the first 3 for the best coverage of different possibilities

For the purposes of this assessment, climate change effects are characterized for two milestone years: midcentury (2050) and end of the century (2090). This data was gathered under the Butte County Boundary scenario. Data for 2050 was found by using data on the timeline from 2040-2060. Data for 2090 was found by using data on the timeline from 2080-2099.

Historical data is used to set the baseline for describing the degree of change occurring by these two future dates. Cal-Adapt downscales global climate simulation model data to local and regional resolution under two emissions scenarios: The Representative Concentration Pathways scenarios (RCP) 8.5 scenario represents a higher, future global greenhouse gas (GHG) emissions scenario, and the RCP 4.5 scenario represents a lower future GHG emissions scenario. Which scenario most closely resembles actual future conditions depends on the effectiveness of programs implemented to reduce GHG emissions. While there has been progressing on GHG emissions reduction and significant national, regional and local efforts, overall human cause CO 2 emissions have continued to rise at a rate that is anticipated to have major consequences worldwide (IPCC 2014). Because the degree of effectiveness of implemented programs is not yet known, results from both the low and high emissions scenarios are considered in this vulnerability assessment and distinguished, where possible.

"Over the long term, these [climate change] impacts create the potential for a wide variety of consequences, including human health and safety risks, economic disruptions, diminished water supply, shifts in ecosystem function and habitat qualities, as well as difficulties with the provision of basic services such as utilities"

2 Exposure

The first step in the vulnerability assessment is to identify the climate changes predicted for Butte County. Based on the Cal-Adapt projections, direct impacts to Butte County include changes in average temperature and annual precipitation. Secondary impacts include an increase in flooding events and increased frequency of heat events, wildfire risk, and changes in snowpack (California Natural Resources Agency (CNRA) 2012:16-17).

Direct Impacts:

1. Increase in average temperature
2. Changes in annual precipitation

Secondary Impacts:

1. Increased frequency, intensity, and duration of extreme heat days and heat waves/events
2. Increased flooding
3. Increased wildfire
4. Loss of snowpack and decreased water supplies

Over the long term, these impacts create the potential for a wide variety of consequences, including human health and safety risks, economic disruptions, diminished water supply, shifts in ecosystem function and habitat qualities, as well as difficulties with the provision of basic services such as utilities (California Natural Resources Agency [CNRA] 2012a:3). Climate change is already affecting and will continue to alter the physical environment throughout the Central Valley and Butte County; however, the specific implications of climate change effects vary with differing physical, social, and economic characteristics of the County. For this reason, it is important to identify the projected severity of climate change impacts on Butte County and ways the County can reduce its vulnerability to them. Communities that begin to plan now will have the best options for adapting to climate change and increasing their resilience (CNRA 2012a:4).

Cal-Adapt data describing each of the direct and secondary impacts for Butte County are summarized in the sections below.

2.1 Increased Temperatures

According to CNRA, downscaling of global climate simulation model data suggest that average temperatures in California are projected to increase 2.7 °F above 2000 averages by 2050 and, depending on emissions levels, 4.1-8.6°F by 2100 (CNRA 2012b:2).

Annual average temperatures in Butte County are projected to increase steadily. Butte County's historical average temperature, based on data from 1961 to 1990, is 71.1 °F (Cal-Adapt, 2017). Under the low emissions scenario, Butte County's average temperature will rise from 71.1°F to 75.5°F by 2050 and to 77°F by 2090 (Cal-Adapt, 2017) (See Figure 4). Under the high emissions scenario, Butte County is projected to have an average temperature of 76.4 °F by 2050. By 2090, it's projected that Butte County's annual average temperature will be 80.7°F (Cal-Adapt, 2017) (See Figure 5).

Butte County's annual average low temperature (minimum temperature), based on historical data from 1961 to 1990, is 44.6 °F. The annual average low temperature using the low emissions scenario is projected to be at 48.6°F by 2050 and 50.0 °F by 2090 (Cal-Adapt, 2017). The annual average low temperature under the high-emissions scenario is projected to increase to 49.6 °F by 2050 and to 53.9 °F by 2090 (Cal-Adapt 2018 (Cal-Adapt, 2017).

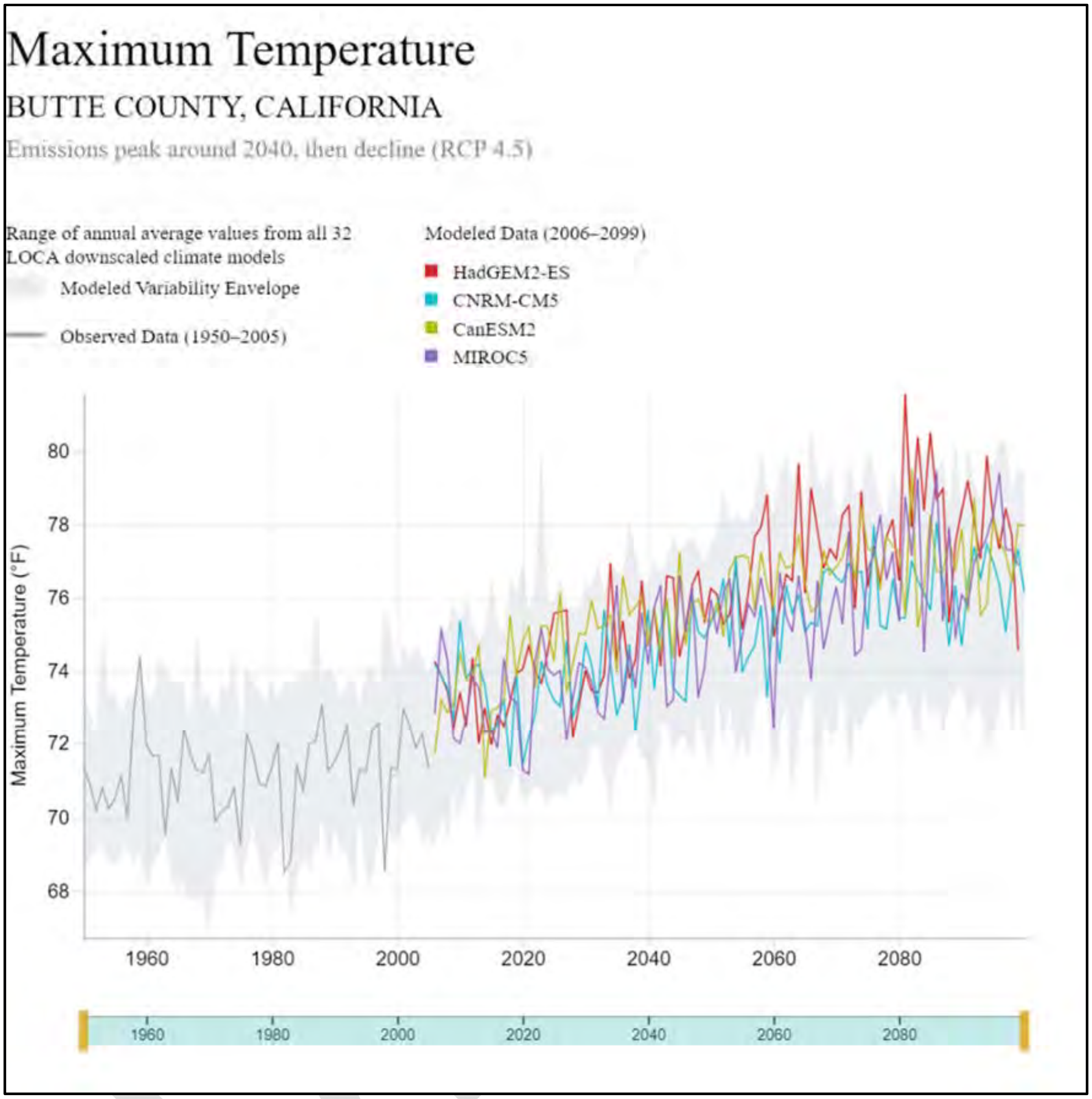

Figure 4: This chart shows annual averages of observed and projected Maximum Temperature values for the selected area on map under the RCP 4.5 scenario. The gray line (1950 – 2005) is observed data. The colored lines (2006 – 2100) are projections from 4LOCA downs

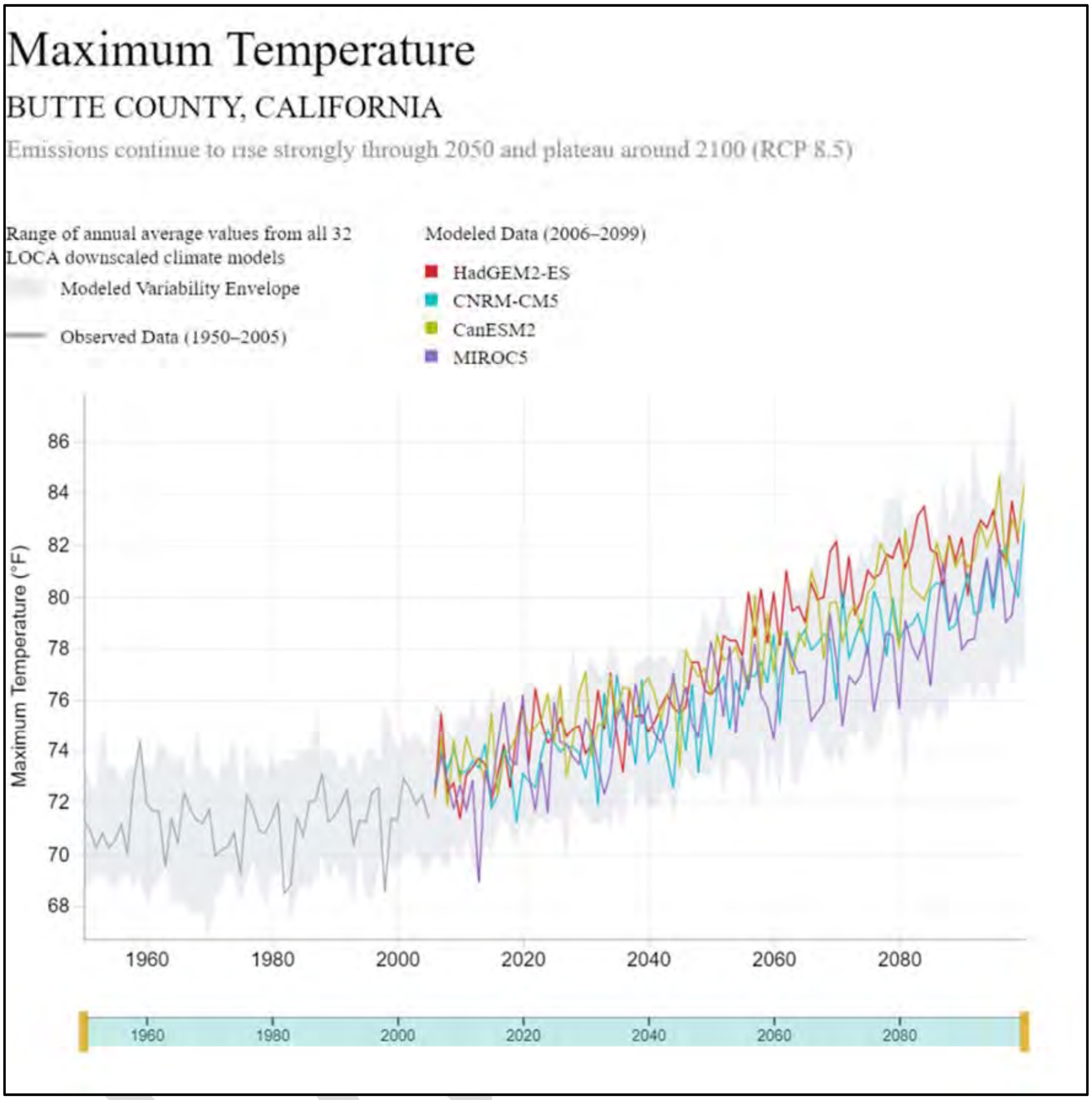

Figure 5: This chart shows annual averages of observed and projected Maximum Temperature values for the selected area on map under the RCP 8.5 scenario. The gray line (1950 – 2005) is observed data. The colored lines (2006 – 2100) are projections from 4LOCA down

2.2 Extreme Heat

Increased average temperatures are expected to lead to secondary climate change impacts, including increases in the frequency, intensity, and duration of extreme heat days and multi-day heat waves in California. Using Cal-Adapt's Extreme Heat tool, historical data from Butte County was used to project the change in frequency of extreme heat days, warm nights, and heat waves for the low- and high-emissions scenarios in 2050 and 2100. Cal Adapt's historical data and future climate projections are discussed below.

Cal-Adapt defines the extreme heat day threshold for Butte County as 100.2°F or higher. Butte County has a historical average of four extreme heat days a year. Climate change is already increasing the number of extreme heat days in Butte County substantially. Butte County experienced an average of 11 extreme heat days per year from 2010 to 2016 (Cal-Adapt, 2017), including 26 extreme heat days in 2015. Under the low emissions scenario; Butte County is expected to experience 22 extreme heat days by 2050 and 33 a year by 2090 (Cal-Adapt, 2017) (See Figure 6). Under the high-emissions scenario, Cal-Adapt predicts that Butte County will experience 29 extreme heat days per year in 2050 and 59 days per year by 2090 (Cal-Adapt, 2017) (See Figure 7).

When extreme temperatures are experienced over a period of five or more days, they are known as heat waves in some definitions, or heat events in others. The U.S. Environmental Protection Agency and Centers for Disease Control define extreme heat events as "periods of summertime weather that are substantially hotter and/or more humid than typical for a given location at that time of year."

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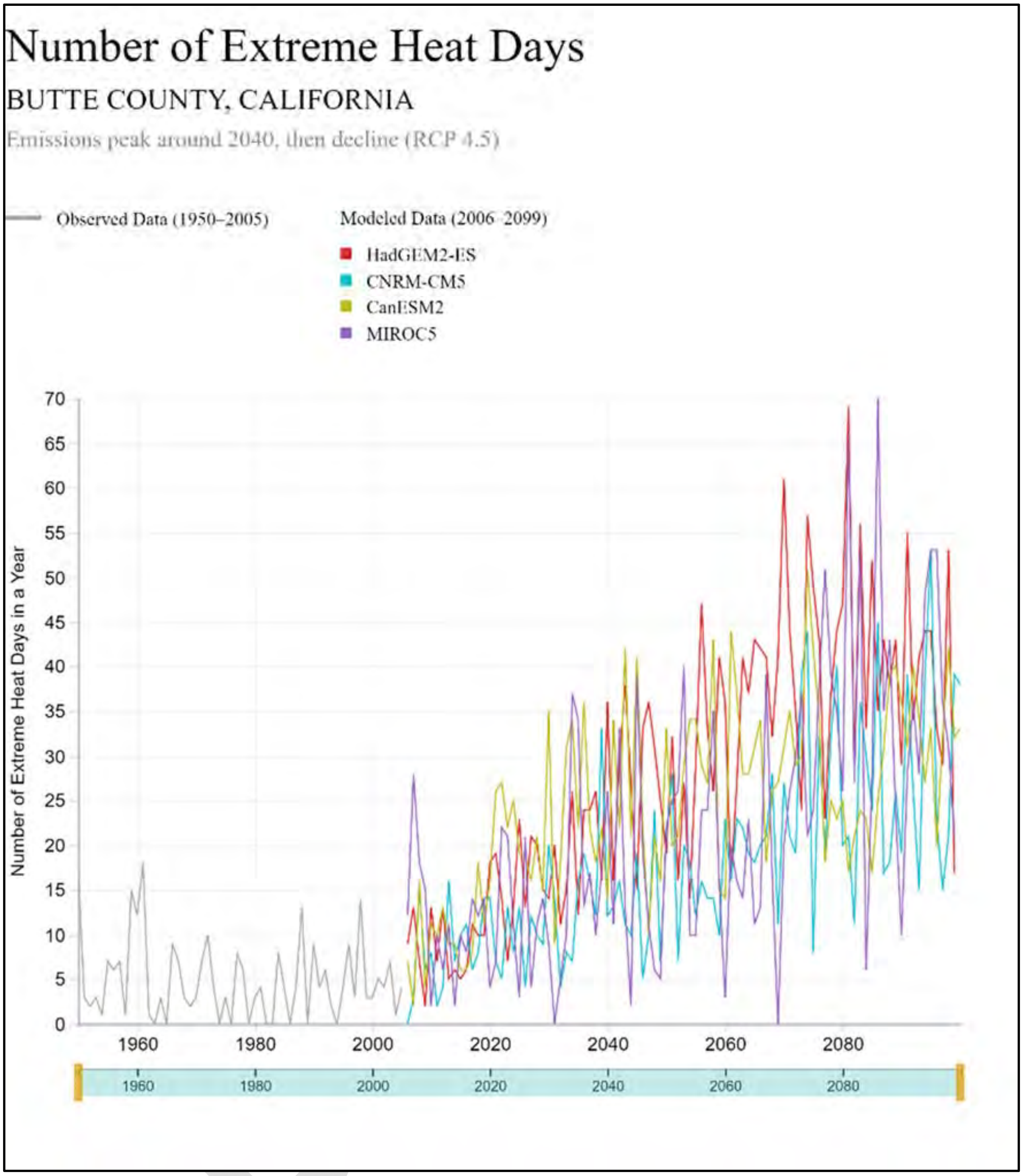

Figure 6: This chart shows number of Extreme Heat days in a year for the selected location on map under the RCP 4.5 scenario. An Extreme Heat day is defined as a day in April through October when the Maximum Temperature exceeds the location's Extreme Heat Threshold, which is calculated as the 98th percentile of historical maximum temperatures between April 1 and October 31 based on observed daily temperature data from 1961–1990). The gray line (1950–2005) is observed data. The colored lines (2006–2100) are projections from 10 LOCA downscaled climate models selected for California. (Cal-Adapt, 2018)

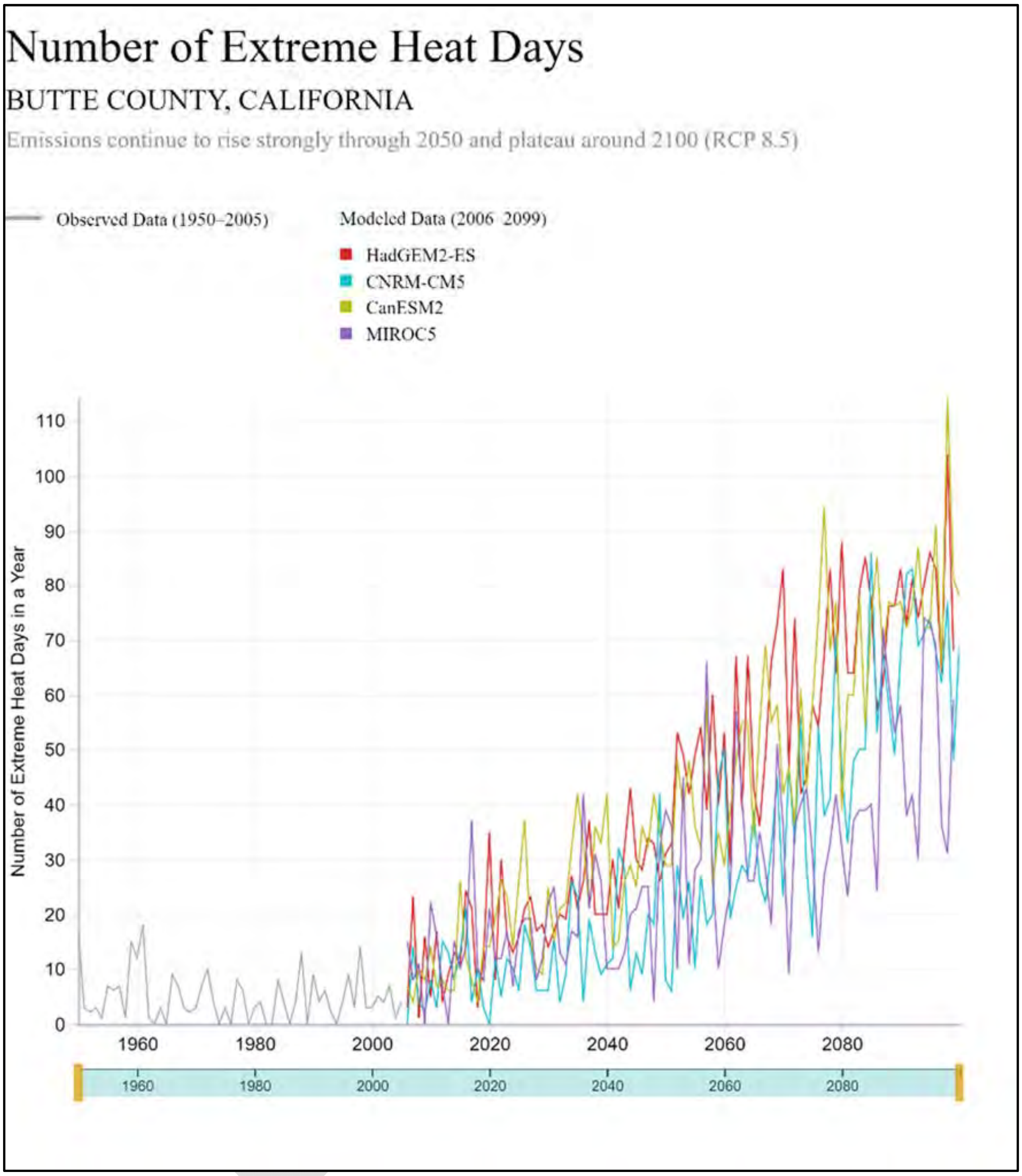

Figure 7: This chart shows number of Extreme Heat days in a year for the selected location on map under the RCP 8.5 scenario. An Extreme Heat day is defined as a day in April through October when the Maximum Temperature exceeds the location's Extreme Heat Threshold, which is calculated as the 98th percentile of historical maximum temperatures between April 1 and October 31 based on observed daily temperature data from 1961–1990). The gray line (1950–2005) is observed data. The colored lines (2006–2100) are projections from 10 LOCA downscaled climate models selected for California. (Cal-Adapt, 2018)

"Depending on location, precipitation events may increase or decrease in intensity and frequency. They are also notoriously difficult to predict. Reduced precipitation could lead to a higher risk of drought, while increased precipitation could cause flooding and soil erosion."

2.3 Changes in Precipitation Patterns

Global climate change will affect physical processes and conditions beyond average temperatures. For example, historic precipitation patterns could be altered. Rainfall and the winter snowpack in the Sierra Nevada mountain range provide significant surface water flows and groundwater recharge as water drains through the County. Depending on location, precipitation events may increase or decrease in intensity and frequency. They are also notoriously difficult to predict (Cal-Adapt, 2017). Reduced precipitation could lead to a higher risk of drought, while increased precipitation could cause flooding and soil erosion (CNRA 2014:25). See figure 8 for Butte County's historical annual precipitation levels.

While Cal-Adapt's projections show minimal changes in total annual precipitation in California, even slight changes could have a dramatic effect on California's ecosystems, which are conditioned to historic precipitation levels (CNRA 2012). It's anticipated that climate change may lead to an increase in the frequency and intensity of storms, resulting from increased precipitation and harsh flooding's. According to future climate projections, it is also anticipated to result in more prolonged periods of drought (Cal-Adapt, 2017). This dichotomy makes analyzing the impacts of precipitation difficult, as there will likely be even greater variability between extreme wet years and periods of drought than what already exists in California's mostly Mediterranean climate.

Cal-Adapt provides a historical annual average rate of precipitation of about 41.9 inches for Butte County. Overall precipitation in Butte County is expected to increase over the course of the century. Under the low emissions scenario, precipitation is expected to increase from 41.9 inches to 46 inches by 2050 and to 45.1 inches by 2090 (Cal-Adapt, 2017) (See Figure 9). Under the high emission scenario, it is predicted that Butte County will see an increase from 41.9 inches to 46.8 inches in 2050 and an increase to 49.9 inches in 2100 (Cal-Adapt, 2017) (See Figure 10).

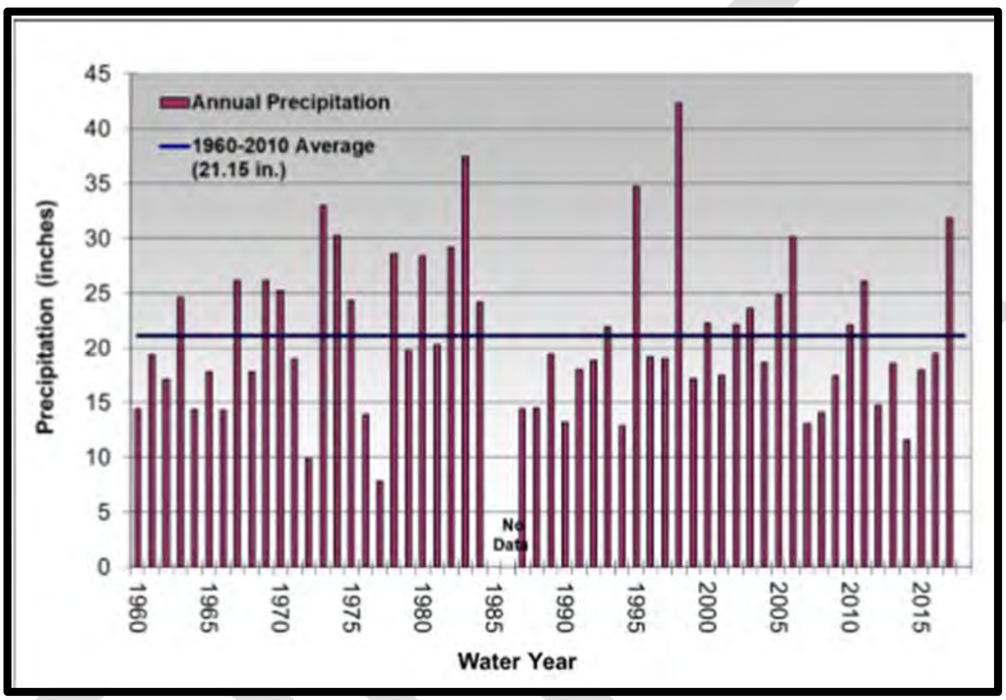

Figure 8: Historical Precipitation Patterns for Butte County. Butte County Water Inventory and Analysis, 2016

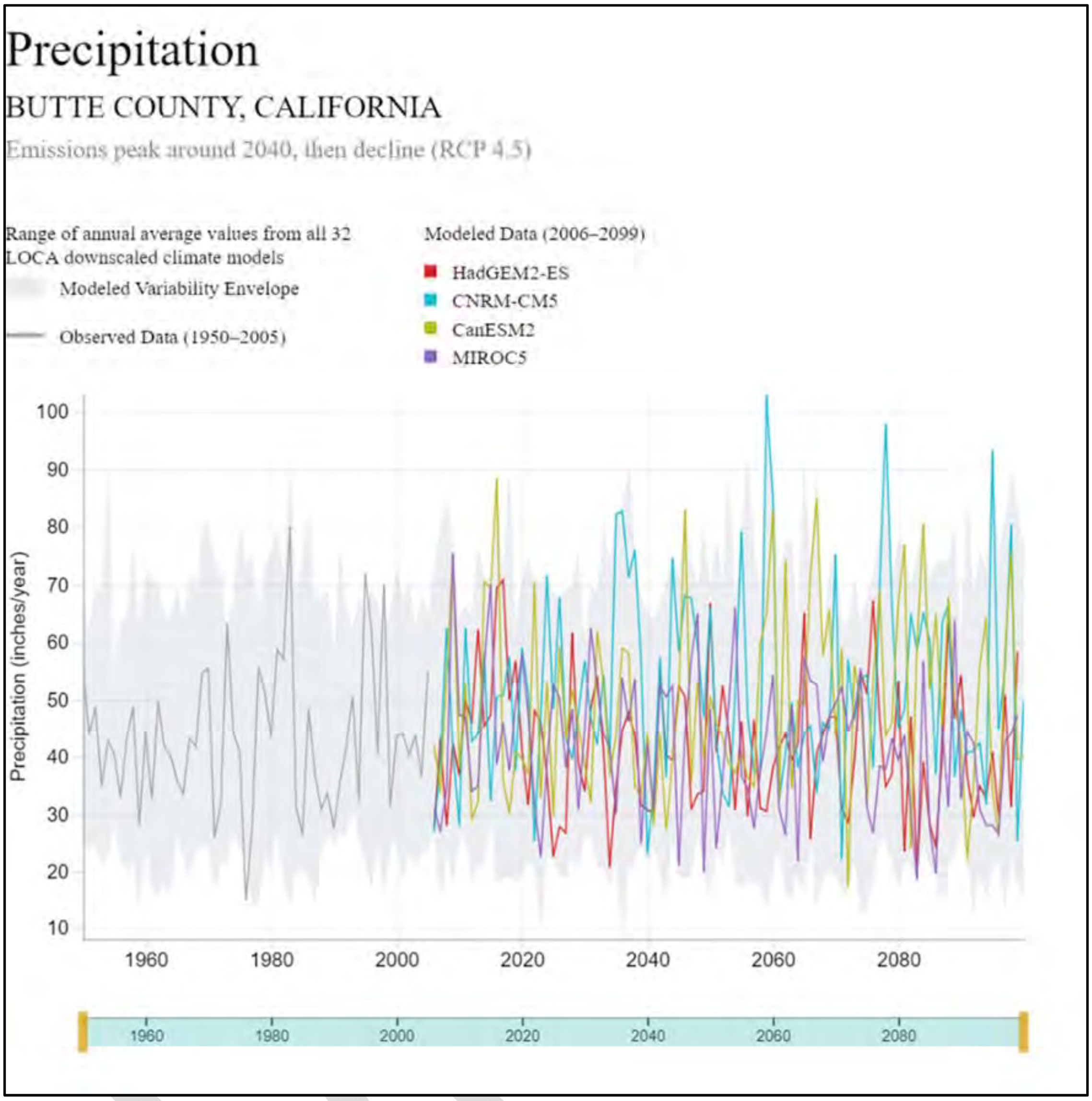

Figure 9: This chart shows annual averages of observed and projected Precipitation values for the selected area on map under the RCP 4.5 scenario. The gray line (1950 – 2005) is observed data. The colored lines (2006 – 2100) are projections from 4 LOCA downscaled climate models selected for California. The light gray band in the background shows the least and highest annual average values from all 32 LOCA downscaled climate models. (Cal-Adapt, 2018)

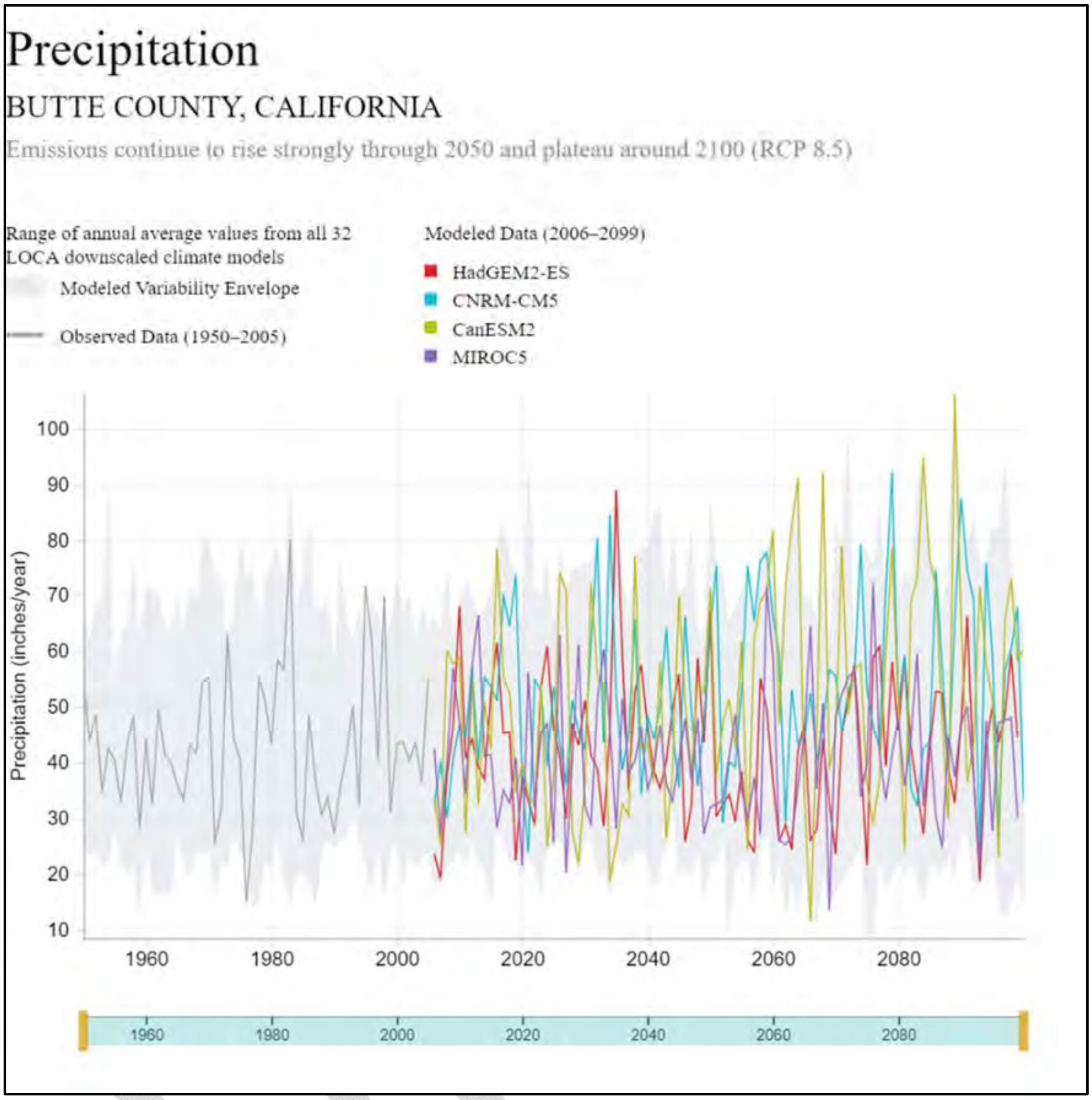

Figure 10: This chart shows annual averages of observed and projected Precipitation values for the selected area on map under the RCP 8.5 scenario. The gray line (1950 – 2005) is observed data. The colored lines (2006 – 2100) are projections from 4 LOCA downscaled climate models selected for California. The light gray band in the background shows the least and highest annual average values from all 32 LOCA downscaled climate models. (Cal-Adapt, 2018)

2.4 Increased Storm and Flooding Events

Climate change is predicted to alter the frequency, intensity, and duration of extreme storm events, with sustained periods of heavy precipitation and increased rainfall. The precipitation that will fall may have more intense characteristics, such as high volume of rain falling over a shorter period of time and stronger, more destructive wind patterns. These storms may produce higher volumes of runoff and contribute to an increased risk of flooding. These projected changes could lead to increased flood magnitude and flooding frequency (IPCC 2001). Several factors determine the severity of floods, including rainfall intensity, duration, and localized drainage characteristics. Flash floods occur when a large amount of rain falls over a brief period of time. Currently, the County experiences localized flooding in several areas of the community.

"The precipitation that will fall may have more intense characteristics, such as high volume of rain falling over a shorter period of time and stronger, more destructive wind patterns."

When the Sacramento River and Feather River reach their peak capacity, Big Chico Creek and the other tributaries that flow into these river systems cannot discharge at a normal rate. These conditions can cause tributaries to overflow and flood.

Butte County is susceptible to various types of flood events: riverine, flash, and localized storm water flooding (Butte County Local Hazard Mitigation Plan, 2013). Butte County includes numerous watersheds as well as several watersheds that drain into Butte County from surrounding counties. The County has assessed its flooding hazards as part of the Butte County Local Hazard Mitigation Plan (LHMP). According to the LHMP, the following are the principal areas subject to flooding in Butte County:

- Butte Creek
- Little Chico Creek
- Little Chico Creek Diversion
- Mud Creek
- Ruddy Creek and Ruddy Creek Tributary
- Sycamore Creek
- Wyman Ravine and Tributaries
- Comanche Creek

In addition to the streams listed above, flooding in Rock Creek and Keefer Slough, located north of Chico, and regularly occurs. These floods inundated State Routes 99 and 32 and several county roadways, as well as impacting extensive residential and agricultural areas in and around the North Chico area and the unincorporated community of Nord. The Dry Creek-Cherokee Canal poses a flood risk to the Richvale area, including rice research grounds and, rice storage and chemical storage facilities (Source: Butte County General Plan, Year).

Factors that directly affect the amount of flood runoff include precipitation quantity, intensity and distribution, the amount of soil moisture, seasonal variations in vegetation, snow depth in headwater regimes, and impermeability of developed surfaces, development patterns, building and infrastructure material choices and project designs. The placement and integrity of existing levees, as well as reservoir operation for flood control, are also important factors. Intense storms may overwhelm local waterways, as well as threaten the integrity of flood control structures (Butte County Local Hazard Mitigation Plan, 2013)

Butte County is also susceptible to localized stormwater flooding, where stormwater runoff exceeds the rate of drainage. Stormwater flooding occurs during periods of severe weather and unusually high amounts of rainfall, and where stormwater infrastructure is physically impaired or inadequate. This kind of flooding event typically occurs in urbanized areas with expanses of impervious surfaces.

During a large flooding event, some areas of the County may be vulnerable to levee and dam failure. Dam and levee failure-related flooding would vary in the planning area depending on which structure fails and the nature and extent of the failure and associated flooding. This flooding presents a threat to life and property, including buildings, their contents, and their use. Large flood events can affect lifeline utilities (e.g., water, sewerage, and power), transportation, jobs, tourism, the environment, agricultural industry, and the local and regional economies. (Butte County Local Hazard Mitigation Plan, 2013)

Butte County is home to Lake Oroville. Releases from Lake Oroville flow into the Feather River before joining with the Sacramento River. Eventually, the water flows into the Sacramento-San Joaquin Delta where the State Water Project's California Aqueduct diverts freshwater to the San Joaquin Valley for irrigation as well as contributing it to municipal and industrial water supplies to Southern California. Lake Oroville is a critical component of supplying water locally and throughout the state.

In February of 2017, a record high rainfall event took place in Butte County. An infrastructure error caused significant damage to Oroville Dam’s main spillway led to reduced releases and resulted in Lake Oroville reaching its maximum capacity. The emergency spillway was activated for the first time since its construction. Due to the potential infrastructure failure of the emergency spillway, 188,000 people in the region were evacuated. Southern Butte County experienced flooding during this event, temporarily displacing many families. Most of this flooding was a result of infrastructure failure rather than the Dam’s inability to hold that much water. Climate change is expected to cause more frequent, extreme rainfall events such as the one that occurred in February of 2017. If an event like this happened again, Southern Butte County residents could be at risk of flooding.

2.5 Snowpack

Changes in weather patterns resulting from increases in global average temperature could result in a decreased proportion and the total amount of precipitation falling as snow. This phenomenon is predicted to result in an overall reduction of snowpack in the Sierra Nevada. Based upon historical data and modeling, under the low- and high-emissions scenarios, the California Department of Water Resources (DWR) projects that the Sierra Nevada snowpack will decrease by 25-40 percent from its average of 28 inches of water content by 2050 and decrease 48 percent to 65 percent by 2100 (Department of Water Resources 2008, Department of Water Resources, 2013).

For this assessment, data from the North-Eastern Sierra Nevada Region was analyzed. This region encompasses areas within Butte County watersheds. The historic average snow water equivalent, a common measurement of snowpack, for the North-Eastern Sierra Nevada Region is 1.4 inches (Cal-Adapt, 2017). Under the low emissions scenario, CAL-Adapt predicts the snow water equivalent to be at 0.5 inches by 2050 and 0.4 inches feet by 2100 (Cal-Adapt, 2017) (See Figure 11). Under the high emission scenario, by 2050 the average snow water equivalent will be 0.3 inches and 0.1 inches by 2100 (Cal-Adapt, 2017) (See Figure 12).

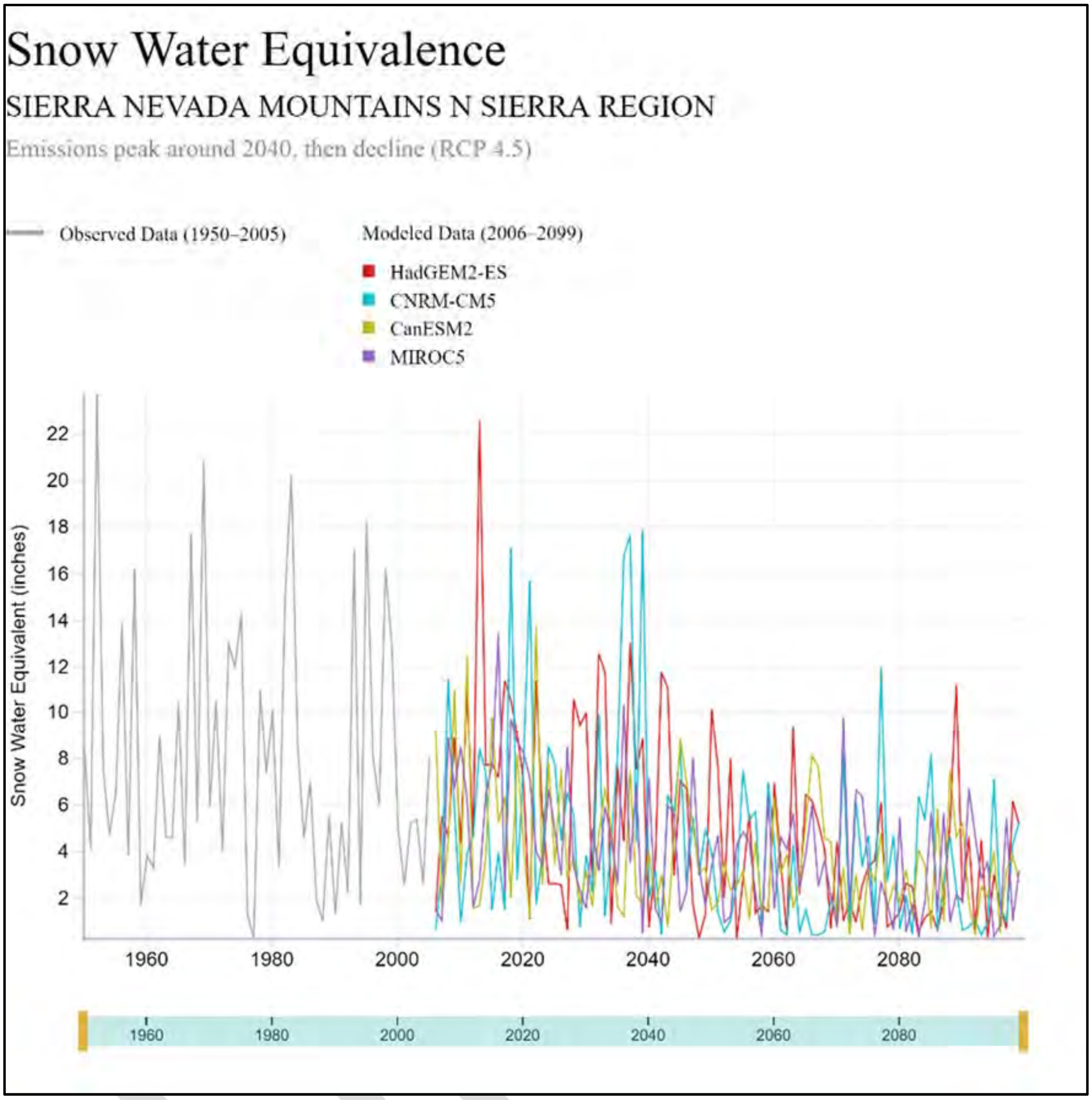

Figure 11: This chart shows monthly averages of projected Snow Water Equivalent values for the selected area on map under the RCP 4.5 scenario. The colored lines (2006 – 2100) are projections from 4 LOCA downscaled climate models selected for California. These models have been selected by California state agencies as priority models for research contributing to California's Fourth Climate Change Assessment. (Cal-Adapt, 2018)

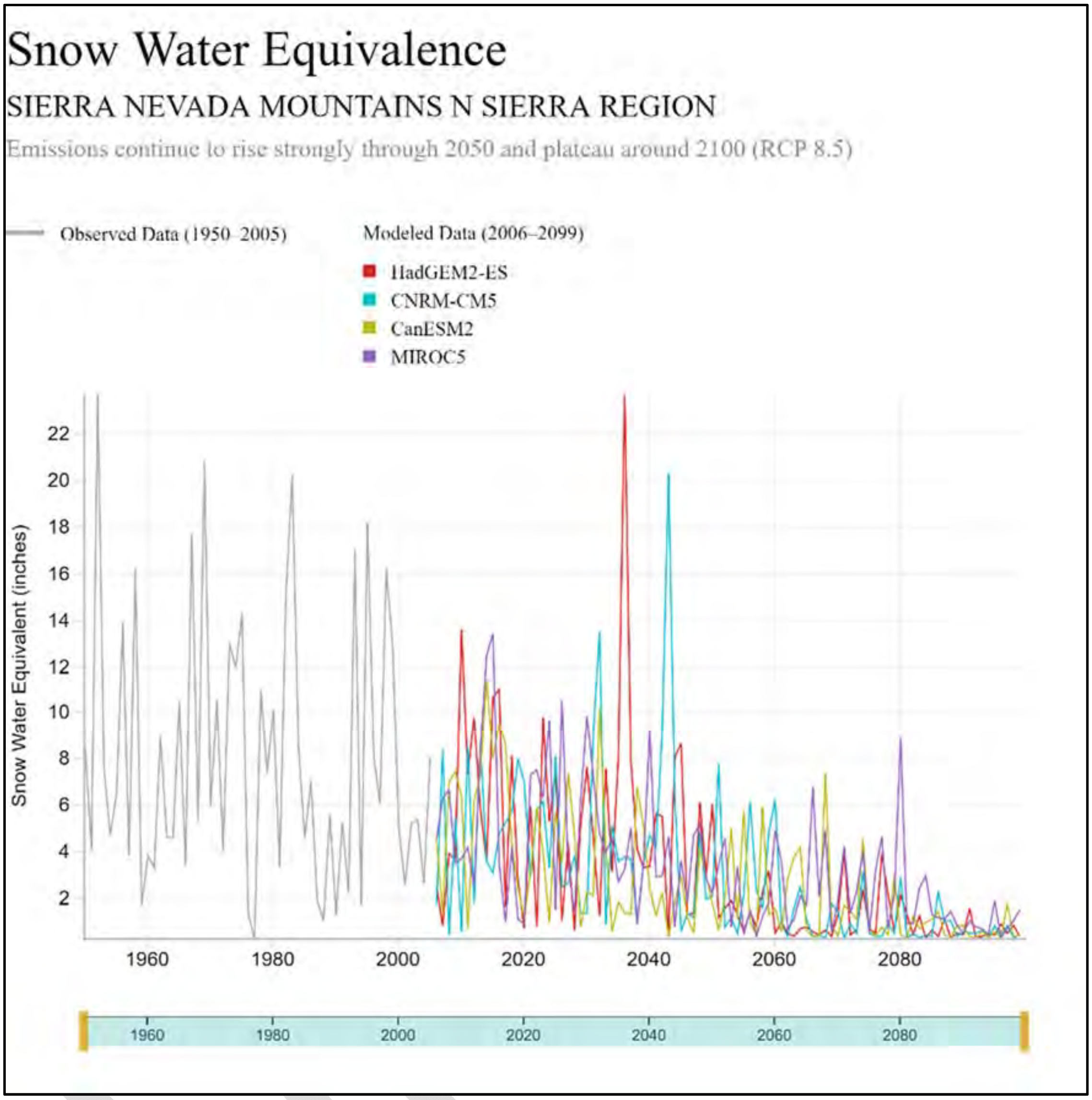

Figure 12: This chart shows monthly averages of projected Snow Water Equivalent values for the selected area on map under the RCP 8.5 scenario. The colored lines (2006 – 2100) are projections from 4 LOCA downscaled climate models selected for California. These models have been selected by California state agencies as priority models for research contributing to California's Fourth Climate Change Assessment. (Cal-Adapt, 2018)

2.6 Surface Water

Water districts, irrigators, private well owners and municipal utilities in Butte County rely on snowmelt, originating in the Sierra Nevada, as well as precipitation as a key source of surface water. The Feather River, Big Chico Creek, Little Chico Creek as well as many other creeks and streams provide municipal, agricultural, domestic, aquatic habitat and recreational water uses for the county. The flow-regimes of these rivers and streams depend on spring and summer snowmelt originating from the Sierra Nevada, runoff from precipitation as well as groundwater flows. The ability of snowpack to retain water and release it gradually is fundamental to water supply planning in the County and throughout the watersheds of the Sierra Nevada.

Figure 13 shows the principal entry points to Butte County for surface water and the major channels, natural and modified, by which water flows through the County (Butte County Department of Water and Resources Conservation, 2016). The principal waterways originating outside the County are:

- The Sacramento River
- The Feather River. The North, Middle and South Forks originate outside the County and, together with the West Branch, supply water to Lake Oroville with a portion of flow routed through the Thermalito Forebay and Afterbay facilities to generate hydropower and deliver irrigation water supply, with the remaining water returning to the Feather River.
- Big Chico Creek
- Butte Creek
- Pine Creek

Runoff and groundwater flows within the County contribute to the flows in the above waterways and also to those originating within the County. These waterways represent the major streams and water supply and drainage features in the County and include:

- **Natural Waterways**
    - The West Branch of the Feather River. The West Branch joins the forks originating outside the County and supplies water to Lake Oroville and then to Thermalito Forebay and Afterbay. Diversions are additionally made by PG&E to Butte Creek.
    - Little Chico Creek
    - Rock Creek
    - Dry Creek
    - Little Dry Creek
    - Clear Creek
    - Angel Slough
    - Wyandotte Creek
    - Honcut Creek
- **Supply Canals**
    - Western Main Canal

- Western Lateral 374
- Richvale Main Canal
- Sutter Butte Canal
- Minderman Canal
- Biggs-West Gridley Main Canal

- **Flood Control Channels**
  - Cherokee Canal
  - Lindo Channel (Sandy Gulch)
  - Sycamore Bypass Channel

Water is distributed from Thermalito Afterbay to canals serving multiple users including Western Canal Water District and the Joint Districts. The Joint Districts include Richvale Irrigation District, Biggs-West Gridley Water District, Butte Water District, and Sutter Extension Water District.

Water from the west branch of the Feather River is diverted to the Toadtown Canal for power generation by PG&E, where it also provides cold water for fish. The Butte Canal carries Toadtown Canal and Butte Creek water to the De Sabla power plant forebay. Hydropower is also generated at several other locations. Operations at these sites affect the timing of water releases. At Lake Oroville, Thermalito, Toadtown, and De Sabla Centerville, water for power generation is transferred from the Feather River watershed to the Butte Creek watershed. (Butte County Department of Water and Resources Conservation, 2016)

Average monthly flows for the Sacramento River are greatest between January and March, reflecting runoff from precipitation on the valley floor, planned reservoir releases, and reservoir spillage in some years. Flows are sustained through July or August and even into November, as water is released from storage in Lake Shasta. In contrast, unimpaired Feather River flows and flows from Butte Creek and Big Chico Creek are greatest between approximately February and May, as a result of runoff from snowmelt. These flows decrease greatly between May and July once the snow has melted. If the snowpack melts earlier, it could affect Feather River, Sacramento River, Butte Creek, Big Chico Creek, and other local creeks and stream that support the spring and winter Chinook salmon runs.

Butte County has entered into several contracts with the State Water Project in order to get rights to the water coming from Lake Oroville. Water rights settlement agreements were executed with the Joint Water District Boards (555,000 acre-feet) and Western Canal Water District (295,000 acre-feet) to settle protests over the construction of State Water Project facilities in Oroville. Under these agreements, the DWR provides the districts with a water supply from Lake Oroville in exchange for the districts exercising their individual water rights (Butte County Department of Water and Resources Conservation, 2016). Climate change may increase our variability between wet and dry months, it’s expected that the county will experience drought-like conditions (Butte County Department of Water and Resources Conservation, 2016).

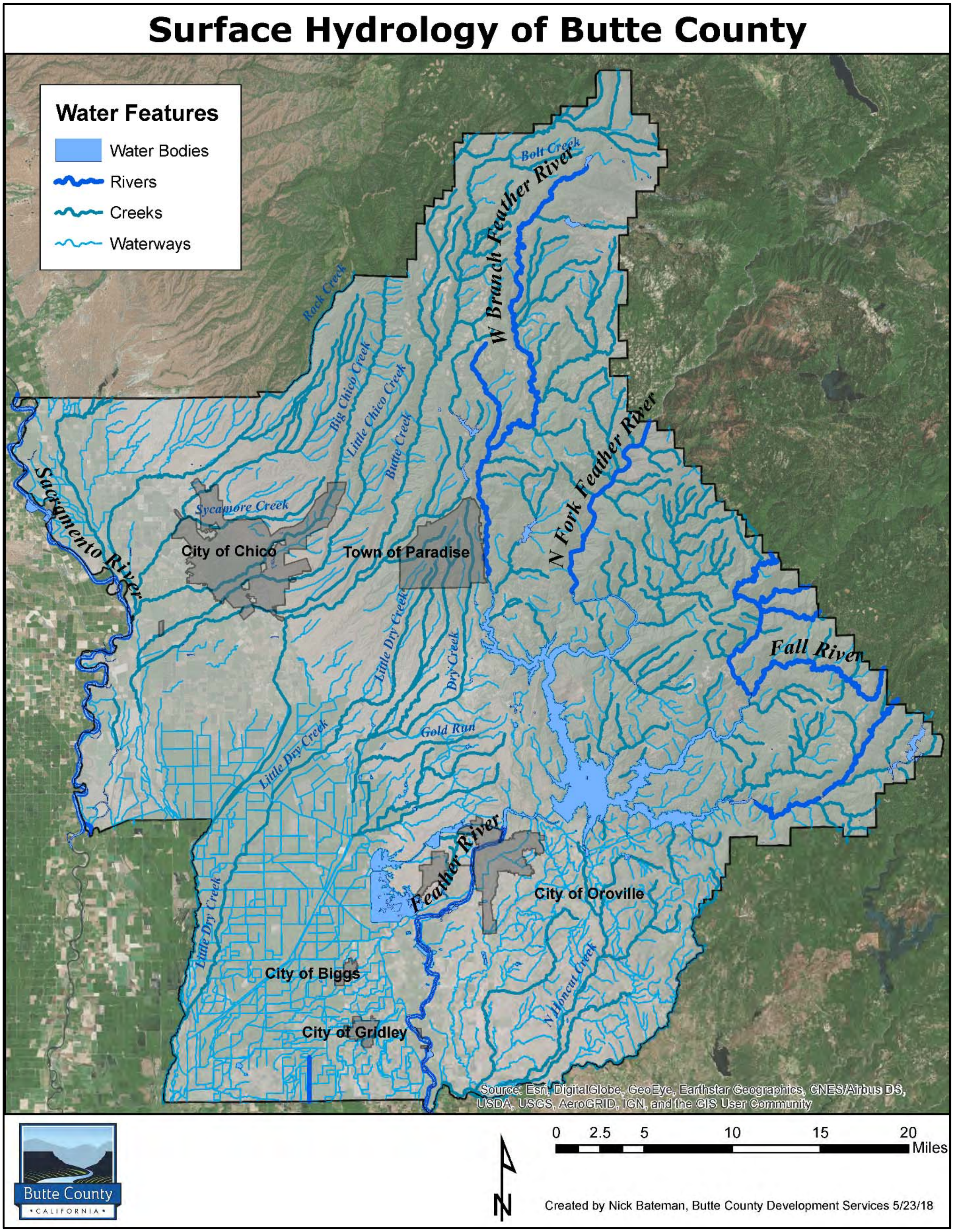

Figure 13: Surface water hydrology for Butte County.

2.7 Groundwater

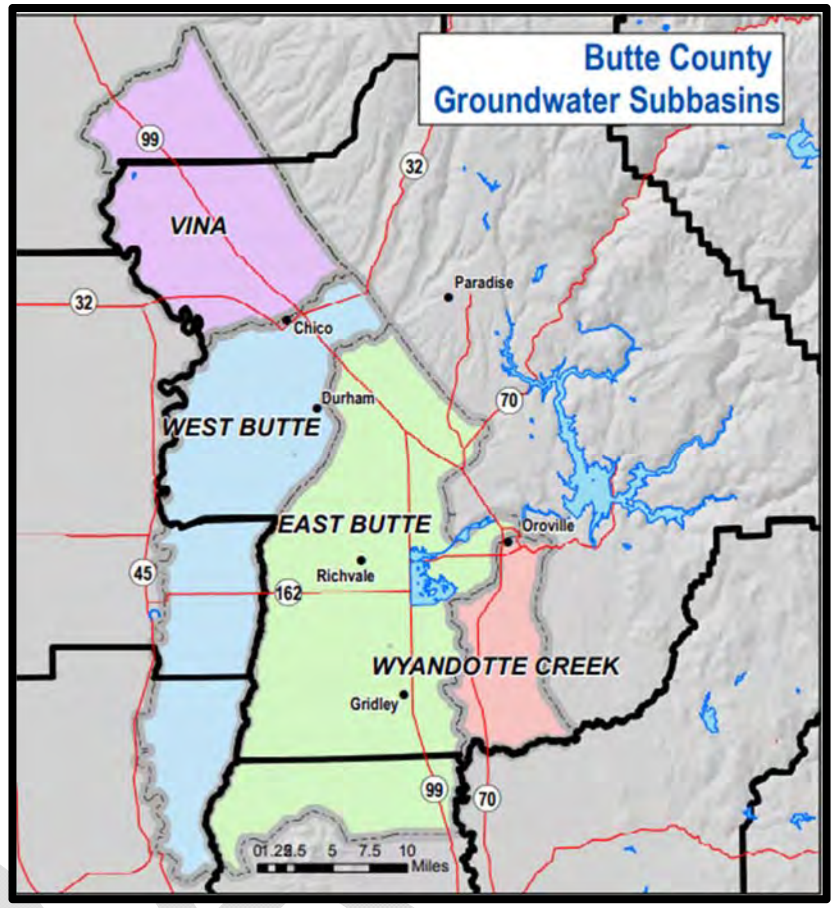

Figure 14: Butte County Groundwater Subbasins. Butte County Water Inventory and Analysis, 2016.

Groundwater is directly linked to surface water in the County and snowmelt in the Sierra Nevada; therefore, increased average temperatures and changes in the timing, and amounts. Precipitation in the form of rain and snow could affect local aquifer recharge for groundwater supplies (Sacramento County 2011a). Butte County's overlays a portion of the Sacramento Valley Groundwater Basin and is comprised of four Subbasins: Vina Subbasin, West Butte Subbasin, East Butte Subbasin and the Wyandotte Creek Subbasin (See Figure 14). While there is no single source of groundwater recharge, according to the Isotope Recharge Study conducted by Butte County Department of Water and Resources Conservation, different parts of the basin are recharged from one or more of the following sources:

- Rainfall on the Lower Foothills (North and East Areas, intermediate and deep zones);
- Creeks (North Area shallow wells)
- Rivers (North Area shallow zones)
- Irrigation water (South Area)
- Local rainfall on the Valley Floor (East Area shallow and South Area)

Groundwater use typically increases during years characterized as dry and critical water years. If too much groundwater is pumped, Land subsidence can occur. Land subsidence is a gradual settling or sudden sinking of the Earth's surface, owing to subsurface movement of earth materials, often caused by groundwater or oil extraction. To date, no land subsidence has been recorded in Butte County. Butte County will prevent or limit groundwater subsidence through an ordinance that was passed in 1996 calling for groundwater conservation. Groundwater level declines have been observed in some areas of the County over recent years and are likely driven by drought conditions leading to reduced deep percolation (potential recharge) and increased groundwater pumping (Butte County Department of Water and Resources Conservation, 2018). Due to increased uncertainty in the amount and timing of water availability and the stress placed on aquifers during droughts, Butte County may face increased challenges in managing groundwater supplies to meet adequately meet future demands.

The primary climate variable affecting water conditions in the County is inter-annual differences in precipitation and snowfall. Variability from year-to -year impacts both the availability of surface water to meet demands and the amount of pumping required to meet crop irrigation requirements. In the future, temperatures are likely to increase as a result of climate change, resulting in less snowpack in the Feather River watershed as well as earlier runoff. These changes will make existing surface water supplies less reliable, increasing the need to rely on groundwater to meet demands.

Butte County is currently addressing groundwater conservation throughout the county. The Sustainable Groundwater Management Act (SGMA) went into effect in January 2015. One of the key principles of SGMA is that each groundwater basin has unique characteristics and challenges; therefore, groundwater is best managed at the local level, and local agencies should have the tools they need to sustainably manage their resources (Butte County Department of Water and Resources Conservation, 2016). To avoid state intervention, groundwater sustainability agencies were formed before June, 2017 and implemented groundwater sustainability plans that will bring the basin into sustainability in 20 years. The components of groundwater sustainability plans (GSPs) are subject to regulations adopted by the Department of Water Resources. A water budget with potential use of a groundwater model is a required component of a GSP. GSP's are important as they are a currently solutions to managing groundwater for sustainability and will help to ensure that we are not over drafting any of our basins.

2.8 Increased Wildfires

Rising temperatures combined with changes in precipitation patterns and reduced vegetation moisture content can lead to a secondary climate impact: an increase in the frequency and intensity of wildfires. Changes in precipitation patterns and increased temperatures associated with climate change will alter the distribution and character of natural vegetation and associated moisture content of plants and soils (CNRA 2012b:11). Increased temperatures will increase the rate of evapotranspiration in plants, resulting in a greater presence of dry fuels in forests creating a higher potential for wildfires (CNRA 2012b).

Increased wildfire activity across the western United States in recent decades has contributed to widespread forest mortality, carbon emissions, periods of degraded air quality, and substantial fire suppression expenditures. Although numerous factors aided the recent rise in fire activity, observed warming and drying have significantly increased fire-season fuel aridity, fostering a more favorable fire environment across forested systems. On October 11, 2016, the Proceedings of the National Academy of Sciences reported that human-caused climate change has contributed to over half of the documented increases in fuel aridity since the 1970s and doubled the cumulative forest fire area since 1984. This analysis suggests that human-caused climate change will continue to contribute to the potential for western U.S. forest fire activity where fuels are abundant.

> *"Generally, the fire season extends from early spring to late fall. With climate change, Butte County's fire season may now extend further into the winter months."*

According to the Butte County 2013 Local Hazard Mitigation Plan (LHMP), wildfire and urban wildfire are an ongoing concern for the County. Generally, the fire season extends from early spring to late fall. With climate change, Butte County's fire season may now extend further into the winter months. Fire conditions arise from a combination of weather, topography, wind patterns, accumulation of vegetation, and low-moisture content in the air. Wildland fire hazards (open space, rangeland, chaparral, and forested areas) exist in approximately 70% of Butte County.

Urban wildfires often occur in areas where development has expanded into rural areas. Currently, many homes (See figure 23) within the County are located in the wildland- urban interface (WUI), which is characterized by zones of transition between wildland and developed areas and often includes heavy fuel loads that increase wildfire risk. See Figure 17 for a look at Butte Counties Wildfire Severity Zone.

Using Cal-Adapt's wildfire tool, the historic yearly average of area burned for Butte County is at 5,627.08 acers per year. Under the low emissions scenario, it's predicted that the mean burned area will rise to 7,363.25 acres by 2050 and to 9,595.6 hectares by 2090 (Cal-Adapt, 2017) (See Figure 15). Under the high-emissions scenario, fire risk is projected to rise to 8,434.44 acers by 2050 and to 1,4960.75 acres by 2090 (Cal-Adapt, 2017) (See Figure 16).

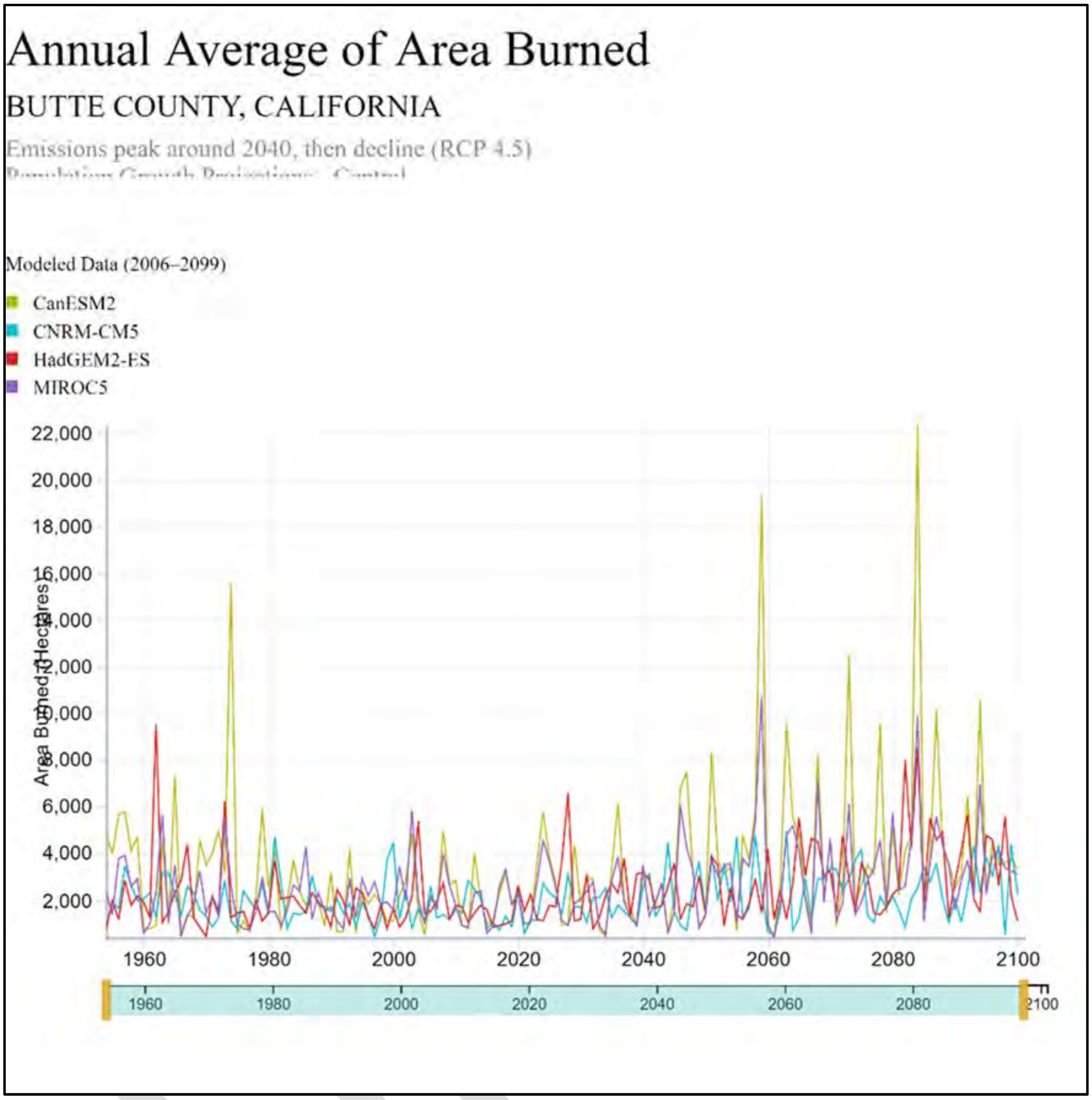

Figure 15: This chart shows modeled annual averages of area burned for the selected area on map under the RCP 4.5 scenario. These models have been selected by California state agencies as priority models for research contributing to California's Fourth Climate Change Assessment. (Cal-Adapt,2018**)**

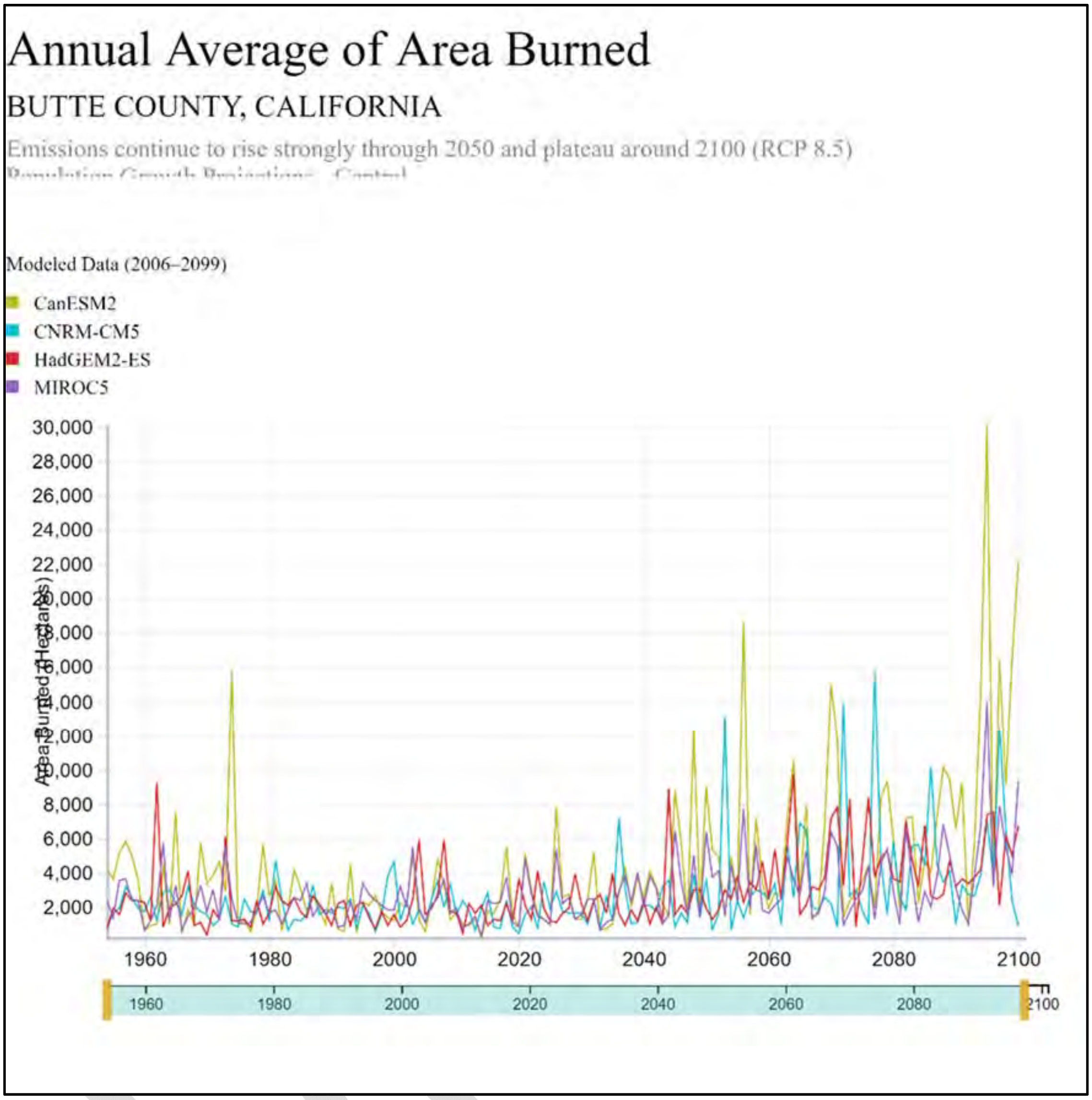

Figure 16: This chart shows modeled annual averages of area burned for the selected area on map under the RCP 8.5 scenario. These models have been selected by California state agencies as priority models for research contributing to California's Fourth Climate Change Assessment. (Cal-Adapt,2018)

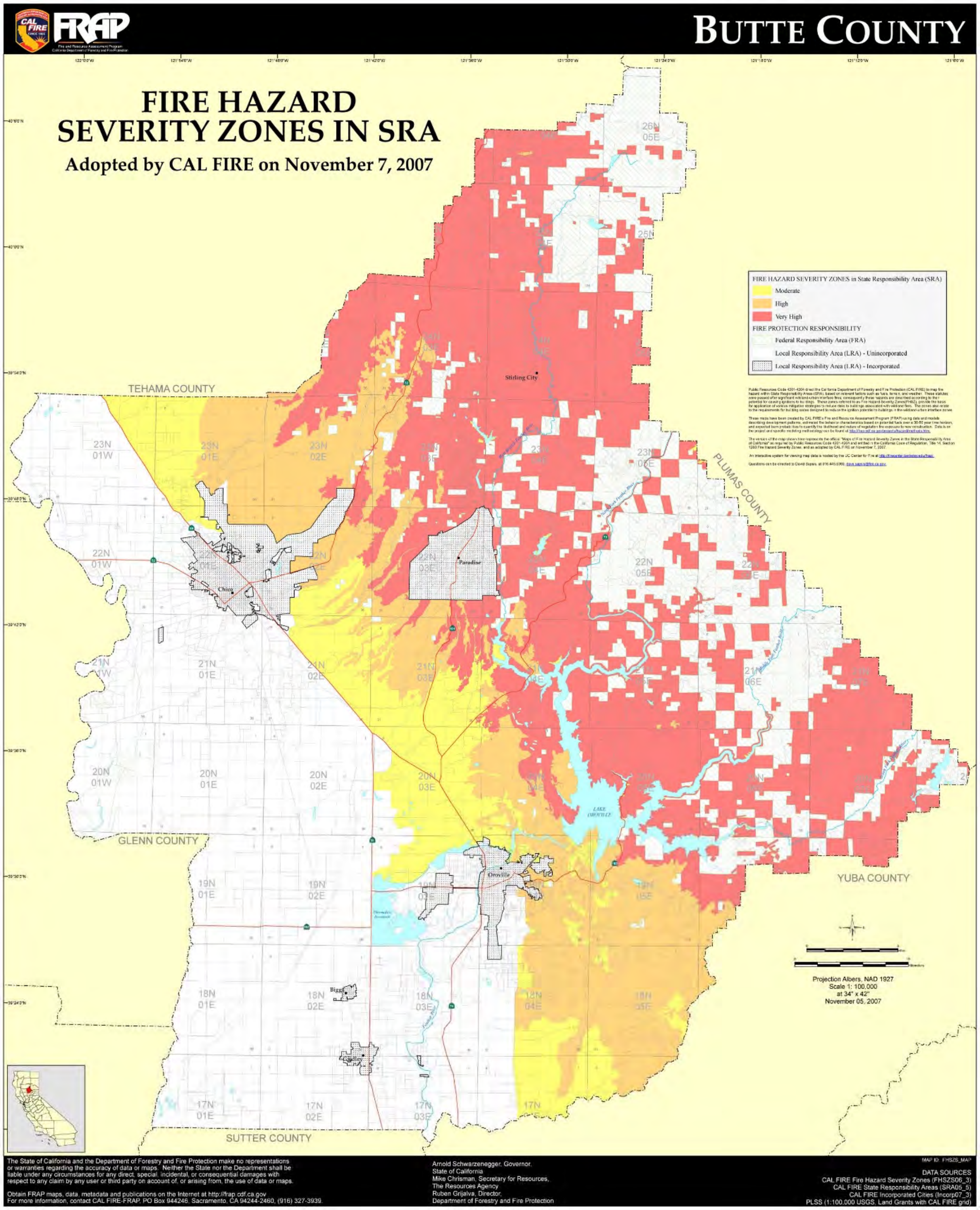

Figure 17: Butte County Wildfire Severity Zone, Map from Cal Fire

3 Sensitivity and Potential Impacts

The APG recommends that a vulnerability assessment be composed of five discrete steps; however, the next two steps in the vulnerability assessment are closely related and are thus discussed together. The second step in the vulnerability assessment involves conducting a systematic evaluation to identify populations, functions, and structures that may be affected in Butte County by projected exposures to climate change impacts and their degree of sensitivity.

The sensitivity checklist is organized into three main categories: Population, Functions, and Structures. The categories are described in more detail below. For the purposes of this analysis, functions, and Structures are grouped together for each:

Populations: Includes both the general human population and segments of the population that are most likely to be sensitive or vulnerable to climate change impacts. This applies, particularly to non-English speaking, disadvantaged communities and elderly populations who may require special response assistance or special medical care after a climate-influenced disaster, and disadvantaged communities.

Functions: Includes facilities that are essential to the health and welfare of the whole population and are especially important following climate-influenced natural hazards. These facilities include hospitals, medical facilities, police and fire stations, emergency operations centers, evacuation shelters, and schools. Transportation systems, such as airways (e.g., airports and highways), bridges, tunnels, roadways, railways (e.g., tracks, tunnels, bridges, and rail yards), and waterways (e.g., canals, seaports, harbors, and piers) are also important to consider. Lifeline utility systems such as potable water, wastewater, fuel, natural gas, electric power, and communications are also critical for public health and safety. Functions also include other economic systems such as agriculture, recreation, and tourism, as well as natural resources within a community, including various plants and animal species and their habitat.

Structures: Includes the structures of essential facilities noted above such as residential and commercial infrastructure, institutions (i.e., schools, churches, hospitals, prisons, etc.), recreational facilities, transportation infrastructure, parks, dikes and levees, and water and wastewater treatment infrastructure. It also includes facilities, where damage would have large environmental, economic, or public safety considerations (e.g., nuclear power plants, dams, and military installations).

"This assessment is not meant to be exhaustive and prescriptive but is rather intended to provide a high-level view of potential impacts that could occur as a result of identified climate change exposures."

Given that climate change exposures at the local scale are inherently uncertain, the APG recommends that communities conduct a qualitative assessment that describes the potential impacts based on the exposure of a given community (CNRA 2012a). This assessment is not meant to be exhaustive and prescriptive but is rather intended to provide a high-level view of potential impacts that could occur as a result of identified climate change exposures. Further evaluation and research would be needed to more precisely identify points of sensitivity and potential impacts, including specific facilities, structures, and areas of concern.

3.1 Increased Temperature

Based on the high- and low-emissions scenarios, annual average temperatures in Butte County are projected to rise 4 to 7 ºF by 21. Increased temperatures can lead to secondary climate change impacts including increases in the frequency, intensity, and duration of extreme heat events in Chico.

Populations

The projected rise in temperature will have severe impacts on human health. Cases of heat-related illnesses such as nausea, dizziness, stroke, dehydration, and heat exhaustion are expected to rise. As identified in the Climate Change Effects section above, Butte County is projected to experience four times as many days above 103 degrees (Extreme Heat Day), which will increase cases of heat-related illnesses, as well as exacerbate pre-existing medical conditions. Higher temperatures will also mean greater instances of record high minimum temperatures. When there is not a significant drop in temperature overnight (at least 20 degrees Fahrenheit) the human body continues to behave in distress—high blood pressure, elevated heart rate—overtaxing the body.

With longer heat waves, Butte County medical centers are likely to see an increase in patients admitted for care related to prolonged heat exposure. According to the Climate Change and Health Profile Report Butte County, from 2005-2010 there was an annual average of 41 heat-related emergency room visits. This number is projected to increase and may become a concern for Butte County medical centers with the increase of heat-related illness. (Maizlish Neil ET all, 2017) Disadvantaged and vulnerable individuals will suffer the greatest impacts as temperature and the number of extreme heat events increases. Children and the elderly, who collectively make up 37% of the Butte County population, are among the most vulnerable to heat-related illnesses (U.S Census Bureau, 2015).

The disadvantaged communities of Butte County are likely to face greater challenges in dealing with extreme heat. Populations that are socially and economically vulnerable often bear the disproportionate burden of climate effects. People in low-income areas, some of which are communities of color; people with existing health issues, such as chronic diseases and mental health conditions; young children and the elderly; people experiencing homelessness; outdoor workers, including farmworkers; immigrants; some tribal nations; and socially or linguistically isolated people are most vulnerable to the impacts of climate change. Many do not turn on or even own air conditioning, because they cannot afford to pay the utility bill. Low-income populations usually live in aging buildings, with poor insulation and ventilation, leading to higher costs associated with air conditioning. Currently, 21.9% of Butte County residents are living in poverty (U.S Census Bureau, 2015). These people often live in communities where residents are less likely to have air conditioning to cool homes or shade from trees in their neighborhoods, more likely to experience infrastructure limitations, more likely to have one or more chronic medical conditions, and less likely to own cars that can provide mobility to avoid deleterious climate effects. See figure 18 & 19 for a look at future temperature projections and disadvantaged communities

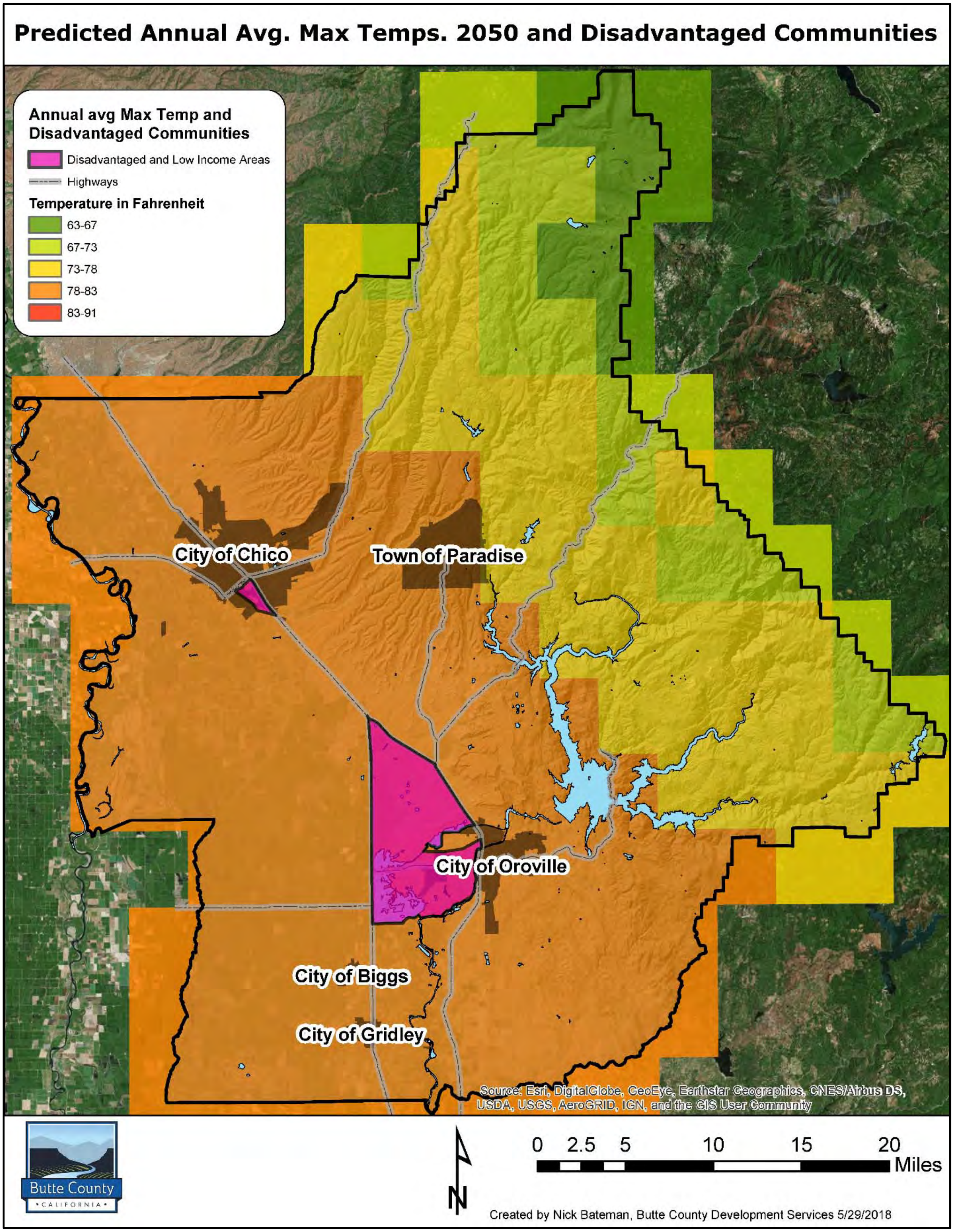

Figure 18: Predicted Annual Average for 2050 under the RCP 8.5 scenario in relation to disadvantaged communities.

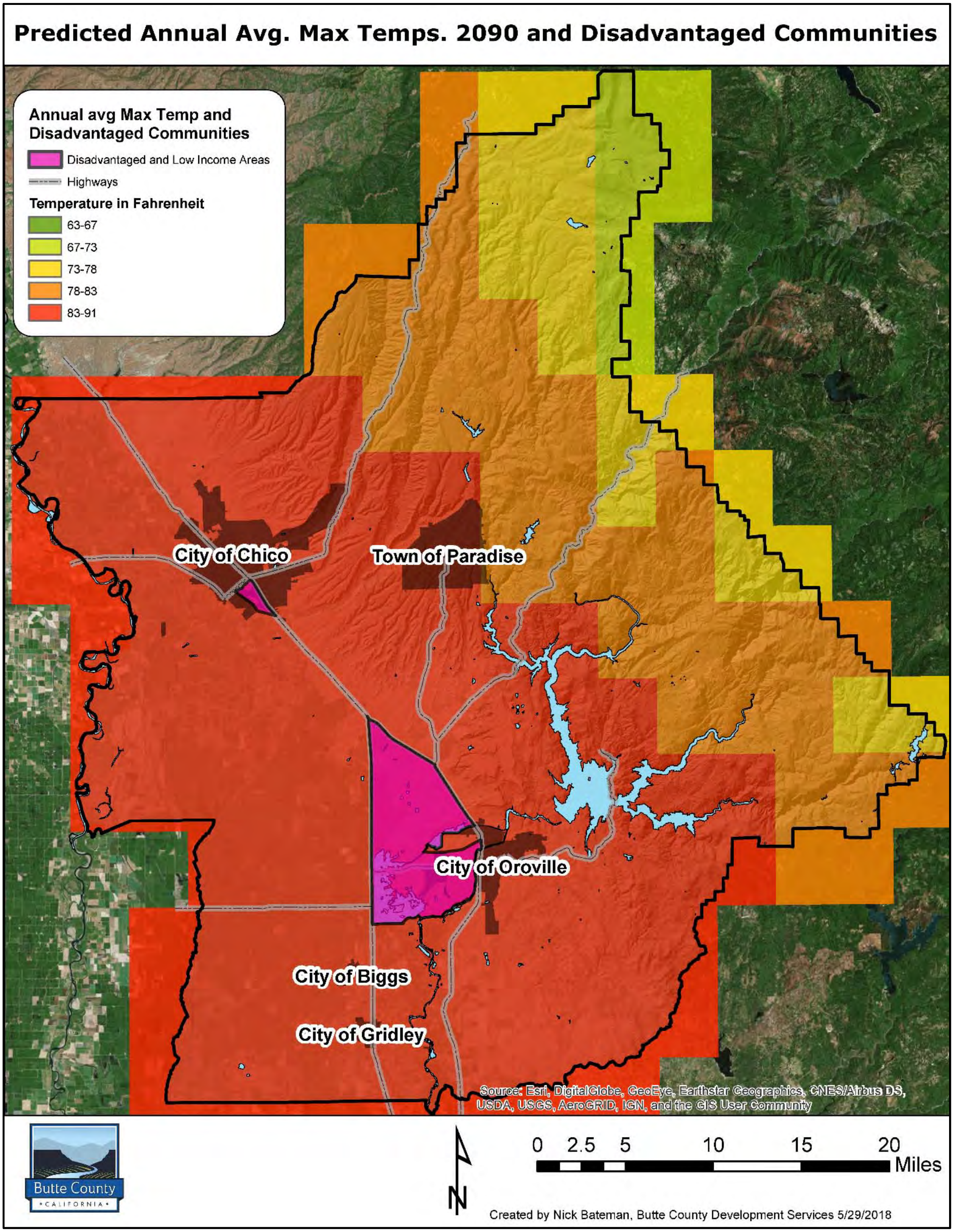

Figure 19: Predicted Annual Average for 2090 under the RCP 8.5 scenario in relation to disadvantaged communities.

Currently, 1,983 people are considered to be homeless in Butte County (Housing Tools, 2017). Homeless populations are especially vulnerable to heat-related illnesses in periods of excessively high heat, as refuge from high temperatures may not be accessible.

Higher temperatures also worsen air quality through increases in air pollution, such as from ozone formation and particulate matter generation (e.g., from wildfire smoke), which pose a health hazard, especially to vulnerable populations. Children, elderly, and persons with pre-existing chronic diseases are particularly susceptible to the respiratory and cardiovascular effects of air pollution.

The majority of agriculture laborers in Butte County work in orchards and rice fields. The harvest of walnuts and almonds takes place in late summer and early autumn when the highest annual temperatures occur. Cal-Adapt estimates that 34 extreme heat days will occur in Butte County, on average, by 2050. These days will occur during the harvest season, exposing farm workers to extreme temperatures and intense sun. Farmworkers in row crop fields will be the most exposed and vulnerable because they work under the open sun, with no shade. Farmworkers in the orchards and rice fields have a slightly lower exposure because most harvesting is done with machinery, and the workers are provided some shade by the orchard trees or within a tractor or harvesting machinery. Health risks such as heat stroke and dehydration are likely to occur, and could potentially lead to disability. Extreme heat events can also lead to a reduction of productivity, which could have economic impacts on farms and consumers.

Increases in temperature can have a severe impact on our biological resources and ecological functions. Water temperature will generally increase in streams, lakes, and reservoirs as air temperature rises. This tends to lead to lower levels of dissolved oxygen in the water, resulting in more stress on the fish, insects, crustaceans and other aquatic animals that rely on oxygen. An increase in temperature will decrease food availability resulting in loss of habitat for many species. See figures 20 & 21 for a map of projected temperature increases in relation to endangered and threatened species.

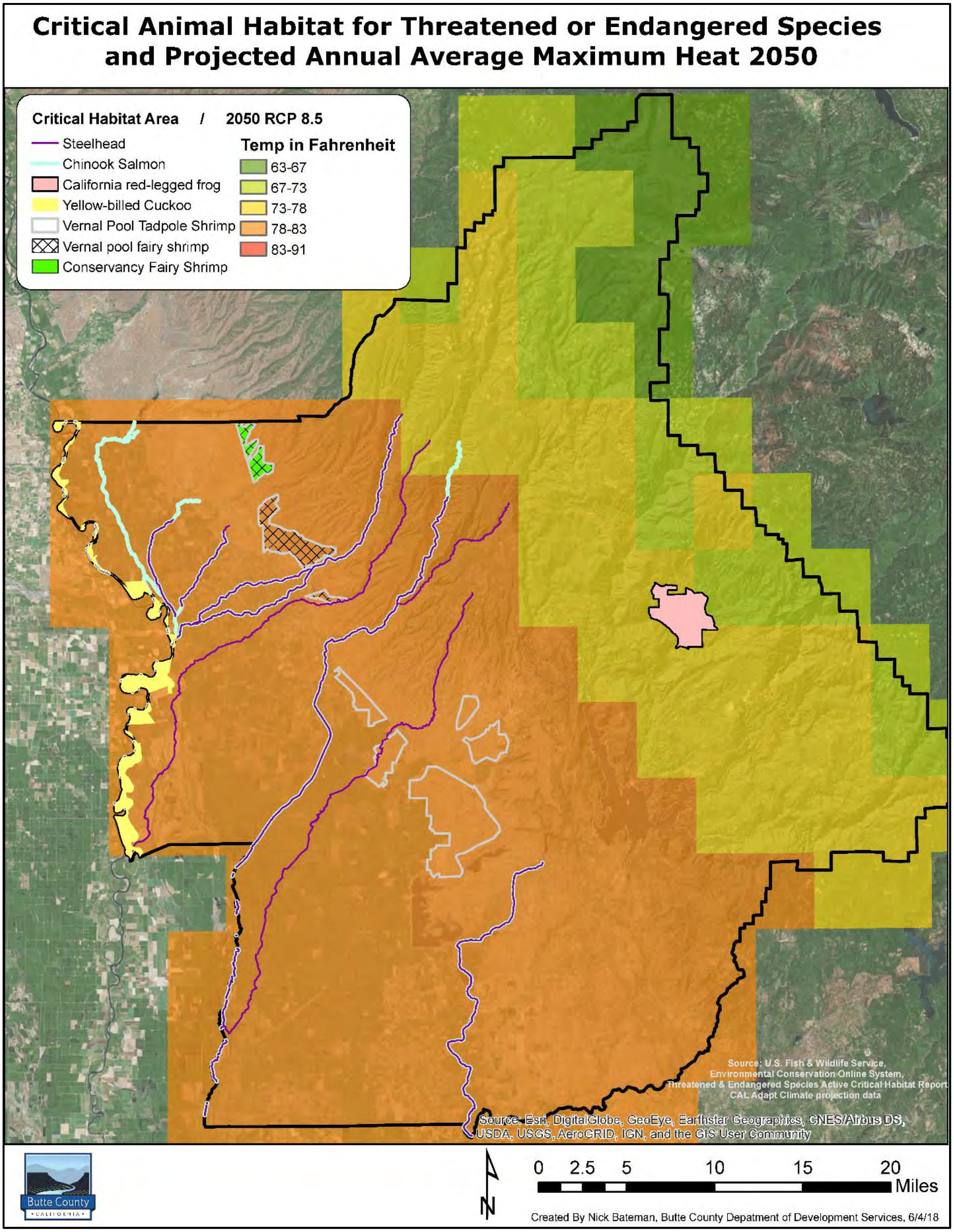

Figure 20: Map of predicted annual temperature average in 2050 under the RCP 8.5 scenario in relation to Critical habitats in Butte County

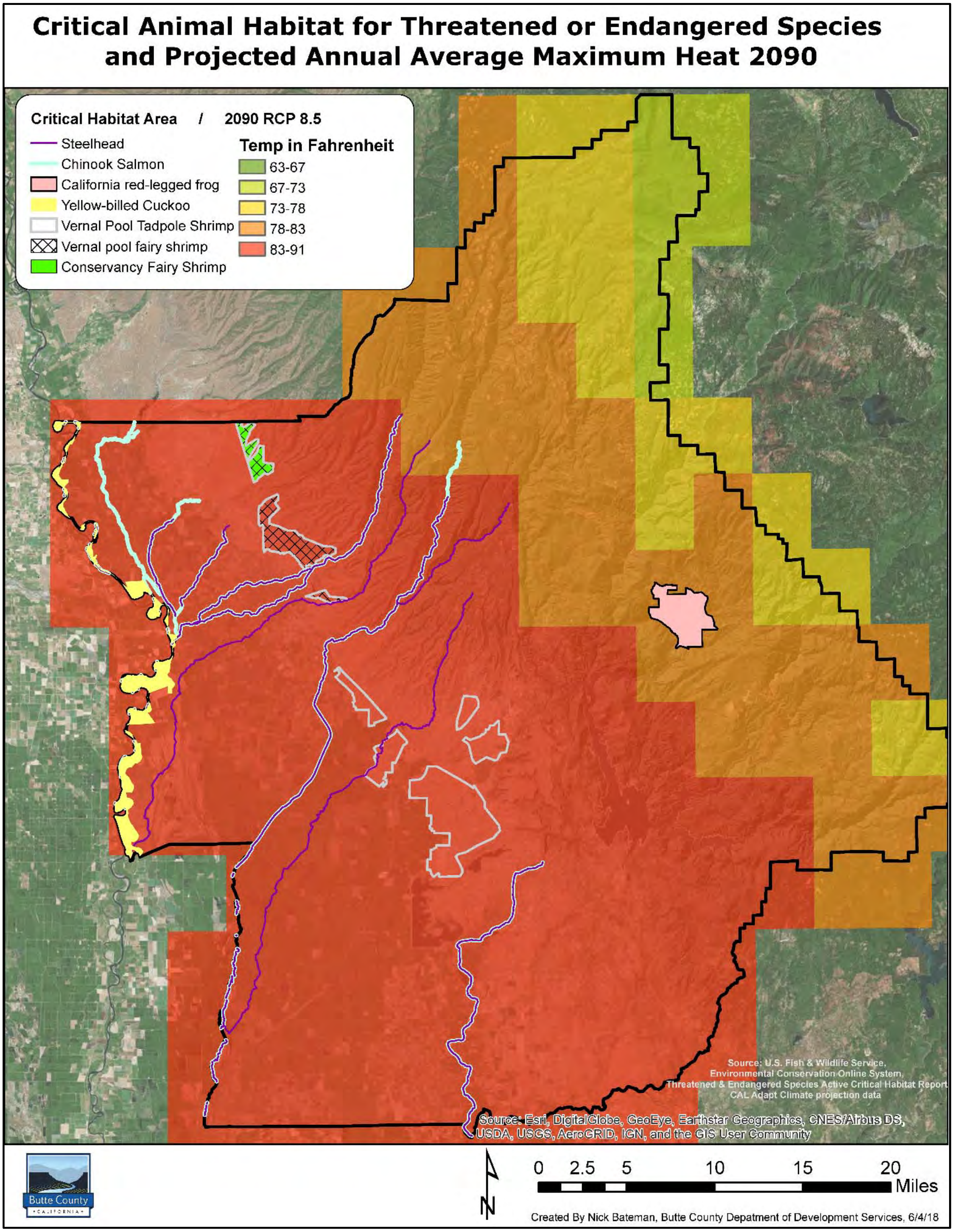

Figure 21: Map of predicted annual temperature average in 2090 under the RCP 8.5 scenario in relation to Critical habitats in Butte County

Calflora, a website that hosts information on wild California plants, lists about 35 species that are rare, native, or edaphically inclined to serpentine soils in Butte County. Many of these plants will be outcompeted by invasive species and are prone to disease. Virus vectors such as aphids, soil-borne fungi, and "weeds" (non-native invasive plants); can quickly spread the disease to heat-stressed natives. Plants that cannot disperse fast enough or those with longer life cycles, such as perennials and trees, might fail to survive under these new stressful conditions.

There are about 153 invasive plant species in Butte County alone (CalFlora, 2017). Invasive species often flourish where native species struggle. Faster development of non-perennial crops results in a shorter life cycle resulting in smaller plants, shorter reproductive duration, and lower yield potential. Temperatures extremes that occur at critical times during development can significantly impact plant productivity.

Tree mortality has been an ongoing problem for the Sierra Nevada mountain ranges. Dead trees can fuel larger more damaging wildfires which can have a long-term impact on our water, air, wildlife, recreation and climate. Bark beetles are common pests of conifers (such as pines) and some attack broadleaf trees. Bark beetles consume the inner bark (the phloem-cambial region) of twigs, branches, or trunks of trees and shrubs. Bark beetles frequently attack trees weakened by drought, disease, injuries, or other factors that may stress the tree. Bark beetles can contribute to the decline and eventual death of trees; however, only a few aggressive species are known to be the sole cause of tree mortality.

Functions and Structures

With the increase in average temperature, Butte County will see an impact on infrastructure and utility services. Infrastructure, such as roads, railroads, and bridges will need to be improved to withstand extreme heat conditions. Roads exposed to continued heat spells can experience cracks and pavement rutting, causing dangerous conditions for all active transportation modes. Bridges experience expansion and contraction as temperature changes throughout the day. This impacts the way that bridge expansion joints function and absorbs movement over time. Butte County has railroad lines running through many small communities. The rail line's power system may experience thermal expansion, which can cause loss of tension which can lead to reduced speeds will impact public safety and mobility by increasing the need for road maintenance and road closures (Maizlish Neil Et all, 2017).

"Utility Services will also be impacted. High temperatures decrease power transmission line efficiency while summer air conditioning use increases electricity demand. This can lead to more power outages and blackouts. This could put public health and safety at risk with limited ways to stay cool during these times"

Utility Services will also be impacted. High temperatures decrease power transmission line efficiency while summer air conditioning use increases electricity demand. This can lead to more power outages and blackouts. This could put public health and safety at risk with limited ways to stay cool during these times

(Maizlish Neil Et all, 2017). Limited or no access to air conditioning during heat events can be fatal to our vulnerable populations.

Quality of life could also be affected by heat-related power outages. Loss of electricity reduces the ability to cool inside areas, which could affect people ability to seek refuge from the heat. Foodservice and grocery stores could see economic losses from food spoilage due to loss of refrigeration caused by power outages. The ability to communicate via the Internet, cell towers and landline could also be affected. Internet outages due to high heat can have a negative impact on local business economy who rely on internet to run business systems and communication.

Butte County is well known for its variety of outdoor activities. Our spring and summer months are often filled with people hiking, swimming, and attending outdoor community events such as farmers markets. As an increase in extreme heat events occurs, outdoor recreation will become less desirable. Recreational users will become more vulnerable to heat-related illness, which could be exacerbated by physically demanding exercise. Reduced outdoor activity has the potential to affect revenue for business and parks in the outdoor recreation industry. Increase in temperature and extreme heat could also affect people's quality of life, as getting outside and exercising is no longer an option. This could also lead to negative health impacts such as obesity, weight gain, and anxiety.

"Changes in growing season conditions could cause variations in crop quality and yield. Plant and wildlife distributions may also be affected by changes in temperature, competition from colonizing species, regional hydrology, and other climate-related effects."

Butte County agriculture productivity is vulnerable to increase in average temperature. The majority Butte County's commodities are walnut, almond and prune orchards as well as rice farms. According to the 2016 Water Inventory Analysis, the County contains around 430,000 acres of plant crops. Out of these plant crops, around 90,000 acres produces nuts and around 95,000 acres produces rice. These two types of farming practices make up almost half of the designated agricultural lands. Increases in temperature could impact overall crop production. Nut trees such as walnuts require chilling hours during winter. "Chilling hours" can be defined as the cumulative number of hours below 45 degrees Fahrenheit (Tapan B. Pathak ET all, 2018). Almonds require around 400-700 chilling hours while walnuts range from 400-1500 chilling hours each winter (Tapan B. Pathak ET all, 2018). Increases in average temp will directly reduce the number of chilling hours experienced by nut crops. Fewer chilling hours has the potential to reduce yields and therefore profits,

Changes in growing season conditions could cause variations in crop quality and yield. Plant and wildlife distributions may also be affected by changes in temperature, competition from colonizing species, regional hydrology, and other climate-related effects. These shifts could also increase the ability of disease vectors (organisms that transmit diseases, such as mosquitoes) to survive or thrive in areas that were previously uninhabitable (City of Oroville Community Climate Action Plan, 2015).

The increase in summer temperatures will also impact livestock and dairy production negatively, as well as their supply of forage crops. When dairy cows become overheated or stressed their milk production decreases.

Prolonged periods of high heat will increase the rate of evapotranspiration in plants and reduce the moisture content of soils, increasing water demand for irrigation and landscaping. Additionally, extreme heat waves will exacerbate the rate of evaporation in surface waters, resulting in the loss of valuable water resources.

Open grasslands, vernal pools, riparian forests, woodlands of all types, and wetlands (emergent and managed) are all vulnerable to climate change. Many of these areas are biologically rich in species and can be easily be affected by changes in the number of extreme heat days, heat waves, and overall increased temperatures. Vernal pools may not recover from such heat. Organisms who live in vernal pools depend upon a balance of snow, precipitation, and evaporation for conditions that that all them to survive each year. Too much water and the vernal pool will become a home to fish that will eliminate the vernal pool organisms. Too dry and many organisms won't be able to complete their larval stages.

The woodlands and savanna ecosystems of Butte County are part of the California Floristic Province, a globally recognized conservation hotspot. They are also the most at risk from the effects of climate change. In California, oak woodland and savanna is one of the most biologically diverse communities, providing habitat for approximately 2,000 plant, 5,000 insects, 80 amphibian and reptile, 160 bird, and 80 mammal species. This high biodiversity is partly due to the availability of acorns, providing critically important food for many wildlife species.

3.2 Changes in Precipitation, Increase in Flooding, Decrease in Groundwater, and Decrease in Snowpack

Climate change will not only lead to an increase in frequency and intensity of storms, meaning more water in the form of rain and flash flood but it's also predicted we will see more prolonged periods of drought which can lead to water shortages and decreases in our groundwater levels. This dichotomy makes analyzing the impacts of precipitation difficult because not only will Butte County see more rainfall at times but also drought conditions**.**

"Climate change will not only lead to an increase in frequency and intensity of storms, meaning more water in the form of rain and flash flood but it's also predicted we will see more prolonged periods of drought which can lead to water shortages and decreases in our groundwater levels. This dichotomy makes analyzing the impacts of precipitation difficult because not only will Butte County see more rainfall at times but also drought conditions"

Surface and groundwater supplies in Chico area already being affected by climate change. Changes in precipitation, reduced snowpack, and more frequent droughts are likely to increase the demand on groundwater sources, risking overdraft, ground subsidence, and decreased water quality (California Department of Water Resources Climate Change Basics, 2018). As a result, Butte county water users could face challenges in finding adequate supplies to meet their demands. Water users could face shortages in normal or dry years if demand continues to increase.

In this section, we will be discussing both drought and flooding impacts on Butte County.

Populations

Flooding will most adversely affect populations living in 100-, 200-, and 500-year floodplains (Butte County, 2013). All County residents living in flood zones will be adversely affected if a flood event occurs; however, flooding-related impacts will likely disproportionately affect populations considered socially vulnerable. Social vulnerability is defined by using including age, race, health, income, and quality of the built environment. Low-income status is considered the largest contributor to social vulnerability; therefore, low-income households are likely to be disproportionately affected by a disaster such as flooding (Burton and Cutter 2008). Low-income populations generally suffer higher mortality rates and their homes sustain greater damage due to the housing stock and location. Further, low-income households may not be able to afford structural upgrades or flood insurance to mitigate the effects of flooding associated with dam failure or levee collapse (Burton and Cutter 2008). Low-income households may also lack transportation and other resources to respond to or evacuate during a flood event.

Race, income, ethnicity, and immigration status are also drivers of flood-related social vulnerability. These factors may impose cultural and language barriers that may affect pre-disaster mitigation and access to post-disaster resources for recovery. Further, physically and mentally disabled individuals may not have the capacity to adequately respond to or evacuate during a flood event. Additionally, populations with limited mobility (e.g., dependent on public transportation, without a vehicle) are also considered more vulnerable to flood events because their ability to use sandbags or to evacuate is reduced. Educational status also contributes to the social vulnerability of a population. Lower education typically coincides with poverty, overcrowding, unemployment, income inequality, and marginalization (Rafut et. al 2015).

Floodwaters from large storms can interact with sources of pollution and distribute hazardous pollutants locally and regionally. The resulting water contamination may lead to human health impacts as well as the degradation of ecosystems. Flood water intrusion also has the potential to damage infrastructure and cause mold infestation, which can affect indoor air quality. This may also lead to a large economic impact to the county and county residents as well as leave people displaced.

More persistent drought conditions coupled with reduced flows of fresh water and increased water demands will likely affect the quantity and quality of water supplies. When flows decrease, water temperature increases, leading to harmful bacteria and algal blooms. Butte County recently experienced some of these in the summer of 2017; people and animals were advised to stay out of waters in Table Mountain Ecological Reserve due to toxic blue algal blooms in the water.

"As mentioned earlier, climate change will also potentially result in more periods of drought. Less precipitation and snowpack in the headwater region means Butte County may face a decrease in surface water availability."

As mentioned earlier, climate change will also potentially result in more periods of drought. Less precipitation and snowpack in the headwater region means Butte County may face a decrease in surface water availability. A reduction in surface water availability can result in an increased dependence on groundwater supplies. It is generally understood that groundwater use goes up when surface water flows are curtailed (Butte County Department of Water and Resources Conservation, 2016). Many of California's groundwater basins are already over drafted, with groundwater use exceeding the rate of recharge. An overdraft can lead to land subsidence, a gradual settling or sudden sinking of the earth's surface. While there is no evidence of land subsidence occurring in Butte County (Butte County Department of Water and Resources Conservation, 2018), under the predicted future climate conditions we, could begin to see subsidence occurring. The effects of subsidence could impact houses and other structures, transportation infrastructure, water well casings, and the elevation and gradient of stream channels, drains, and other water transport structures (Butte County Department of Water and Resources Conservation, 2016).

Those who rely on domestic and agricultural wells may face challenges in meeting water demands if rates of groundwater recharge decline (CalBRACE, 2015). Butte County faced critical drought conditions in 2015 (Butte County Department of Water and Resources Conservation, 2016). Those extreme drought patterns are predicted to become statistically normal for Butte County.

Drought conditions can support the spread of vector-borne illness. Coupled with higher temperatures, reduced levels of precipitation restrict flows in underground and above-ground pipes used for water and wastewater diversion. This can result in unseen, stagnant pools of water that provide conditions for the breeding of mosquitoes and other vector carrying insects and arthropods, particularly in urban areas. An increase in the populations of these organisms may result in the spread of mosquito-borne illnesses, such as dengue fever, West Nile virus, and Zika virus. Vulnerable populations that are susceptible to these diseases include the elderly and people with compromised immune systems or chronic illness (Maizlish Neil ET all, 2017).

Functions and Structures

Climate change is likely to lead to increases in the frequency, intensity, and duration of extreme storm events. Extreme storms include unexpected, unusual, unpredictable, severe or unseasonal weather; weather at the extremes of the historical distribution. Further, increases in annual temperature may result in earlier and more rapid melting of the Sierra Nevada snowpack, which could lead to an increase in the flow rate of surface waters in Butte County. These projected changes could place more pressure on Butte County by creating a higher risk of damage to land, buildings, roads, and crops.

Butte County is susceptible to various types of flood events: riverine, flash, and localized storm-water flooding. Riverine flooding can occur anytime from November through April (Butte County, 2013). Riverine flooding generally occurs as result of prolonged rainfall, or rainfall combined with Sierra snowmelt and/or already saturated soils from previous rain events. Factors that directly affect the amount of flood runoff include precipitation amount, intensity and distribution; soil moisture, seasonal variation in vegetation that aids in absorbing water and percolating water back into the ground, snow depth in the head waters, and impermeability of surfaces. The placement and integrity of existing levees and reservoir operation for flood control are also important factors. Intense storms may overwhelm local waterways, as well as threaten the integrity of flood control structures.

Localized flooding already poses a threat to Butte County roadways, especially near the Sacramento and Feather Rivers. This was discussed further in the Increased Storm and flooding Section. Increased precipitation may exacerbate this issue, blocking access to commuters, affecting road infrastructure, home infrastructure and could lead to school closers.

Flooding events may disrupt communications, energy transmission, public services, and transportation systems by damaging infrastructure. Flood events can also cause considerable property damage as well as structural damage, through erosion and an increased risk of mudslides

Increased flooding could lead to degradation of flood control infrastructures such as dikes and levees. Oroville Dam is a good example of infrastructure failure.

During high flow events, bridges over waterways are particularly vulnerable to damage and blockage due to high-velocity water and debris. Bridge collapses pose a risk to life and can cause damage to property and structures. Collapsed bridges may also disrupt transportation routes.

The relatively minimal reported damages and loss of life attributed to flooding over the past 25 years in Butte County indicates that the current land use management practices have proven effective. However, increasing development and population growth will require disciplined land use management practices to ensure that the urbanization of land protected by levees does not occur and is not allowed to exacerbate the effects of flooding in other areas (Butte County Flood Mitigation Plan, 2006).

Several issues cause drainage problems that lead to flooding in Butte County's watersheds. Ditches and stormwater systems are needed to convey stormwater away from developed areas; however, in some areas, the topography prevents surface water from draining quickly to a ditch, stream, or storm drain. Typically, stormwater systems are designed to handle storm runoff for events smaller than the 100 year event, such as a 10-year event. Older stormwater systems were typically designed to convey the 10 year storm or less may become inadequate as additional watershed development and associated runoff increases. Stormwater systems, ditches, and other waterways can be blocked by debris, resulting in ponding, which may flood adjacent areas. Many roads not present in the FEMA-designated floodplains have undergone damage in the past, due to flooding. The Butte County Storm Drainage criteria have not been updated to account for existing, excess, flows and future conditions (Butte County Flood Mitigation Plan, 2006)

A reduction in surface water availability can result in an increased dependence on groundwater supplies. Groundwater level declines have been observed in some areas of the County over recent years, and are likely driven mainly by drought conditions leading to reduced deep percolation (potential recharge) and increased groundwater pumping. (Butte County Department of Water and Resources Conservation, 2016) As a result of intensified groundwater use during recent drought periods, many of California's groundwater basins are already over drafted, with groundwater use exceeding the rate of groundwater recharge. None of Butte County's groundwater basins are critically over drafted as of now, but the predicted climate impacts could place more strain on these basins.

Water supplies for agricultural irrigation could decrease and become more variable with the risk of flooding expected to increase over time. As discussed above, the timing of runoff and precipitation events may cause reservoirs to reach their capacity, which would result in dams releasing water to minimize flood risk. Balancing inflows and outflows for flood protection could result in reduced water security for irrigation in the later, drier months of the year (CNRA 2014). Additionally, as climate change warms the weather, agricultural demand for water could intensify because, during extreme heat conditions, water evaporates faster and plants require more water to stay cool (CNRA 2014). These combined effects will result in future water insecurity for agriculture and may necessitate changes in agricultural practices, water use, and water sources.

Increases or decreases in precipitation could have an effect on plant life in the Butte County area. If plant life is decimated there may be numerous consequences that can lead to a steeper loss of biodiversity. Moisture can impact both host plants and pathogens in many ways. Some pathogens such as apple scab, late blight, and several vegetable root pathogens are more likely to infect plants with increased moisture content. Other pathogens like the powdery mildew species tend to thrive under conditions with lower (but not low) moisture. Drought conditions are also expected to lead to an increased frequency of tree pathogens due to indirect effects on host physiology.

More persistent drought conditions coupled with reduced flows of fresh-water and increased water demands will likely lead to increased water temperature in streams, lakes, and reservoirs. Higher water temperatures tend to lead to lower levels of dissolved oxygen in the water, resulting in more stress on fish, insects, crustaceans and other aquatic animals that rely on it. Butte Creek, Big Chico Creek, Feather River and the Sacramento River support Chinook salmon and are used for winter and spring-runs. They also support many other federally and state protected fish and wildlife species. Changes in water temperature will eventually cause waterways to be unable to support various life stages of protected fish in these areas. Many stream and rivers have already become unviable for salmon to spawn in, such as parts of Big Chico Creek located in Upper Bidwell Park. Under the new climate scenarios, salmon and many other aquatic species may not be able to use these channels located in Butte County to thrive.

3.3 Wildfire

Increased temperatures, changes in precipitation patterns, and reduced moisture content in vegetation during dry years are expected to increase the severity of wildland fire within and beyond the boundaries of the County. With a potential increase ranging between 4-7.5 °F by 2100, grasslands in the County and surrounding area will lose moisture content. Additionally, as higher temperatures begin to last for longer periods of time, dead fuels of a wider diameter (e.g., twigs and sticks) will also become drier and contribute to increased wildfire intensity in the County. These conditions are predicted to lead to an increase in the total area burned by grassland fire, especially in the foothill areas in the eastern portion of the County, of which a section is designated a moderate Fire Hazard Severity Zone by the California Department of Forestry and Fire Protection (CAL FIRE)

Climate change is also expected to subject forests outside the County to increased stress due to drought, disease, invasive species, and insect pests. These stressors are likely to make these forests more vulnerable to catastrophic fire (Westerling 2008). An increased rate and intensity of wildfire in the coniferous forests of the Sierra Nevada could adversely impact the populations, functions, and structures within County.

Populations

Increased wildfire activity may occur on the wildland urban interfaces around Butte County due to changes in the climate. Urban wildfires often occur in areas where development has expanded into rural areas. The wildland-urban interface (WUI) is defined as the areas where community development has expanded into the foothills and mountainous areas, prone to wildfire. The WUI describes those communities that are mixed in with grass, brush and timbered covered lands (wildland). These are areas where wildland fire once burned only vegetation but now burns homes as well. The WUI for Butte County consists of the communities at risk as well as the area around the communities that pose a fire threat.

There are two types of WUI environments. The first is the true urban interface where development abruptly meets wildland. The town of Paradise, Magalia and the community of Paradise Pines are examples of high-density housing meeting wildland in Butte County. The second WUI environment is referred to as the wildland-urban intermix. Wildland urban intermix communities are rural, low-density communities where homes are intermixed in wildland areas. In Butte County, the communities of Cohasset, Forest Ranch, Concow, Yankee Hill, Berry Creek and Forbestown are considered to be urban-wildland intermix areas.

- Yankee Hill: Pop. 333
- Berry Creek: Pop. 1,424
- Forbestown: Pop. 320
- Concow: Pop. 710
- Forest Ranch: Pop. 1,184
- Cohasset: Pop. 847
- Magalia: Pop. 11,310

WUI communities are difficult to defend because they sprawl over large geographical areas with wildland fuels throughout. These attributes make emergency access, structure protection, and fire control difficult as fires are relatively uninhibited in these communities. Human development of wildland areas has made it much more difficult to protect life and property during a wildland fire. This home construction has created a new fuel load within the wildland and shifted firefighting tactics from preventative to life safety and structure protection. (Butte County Community Wildfire Protection Plan, 2015).

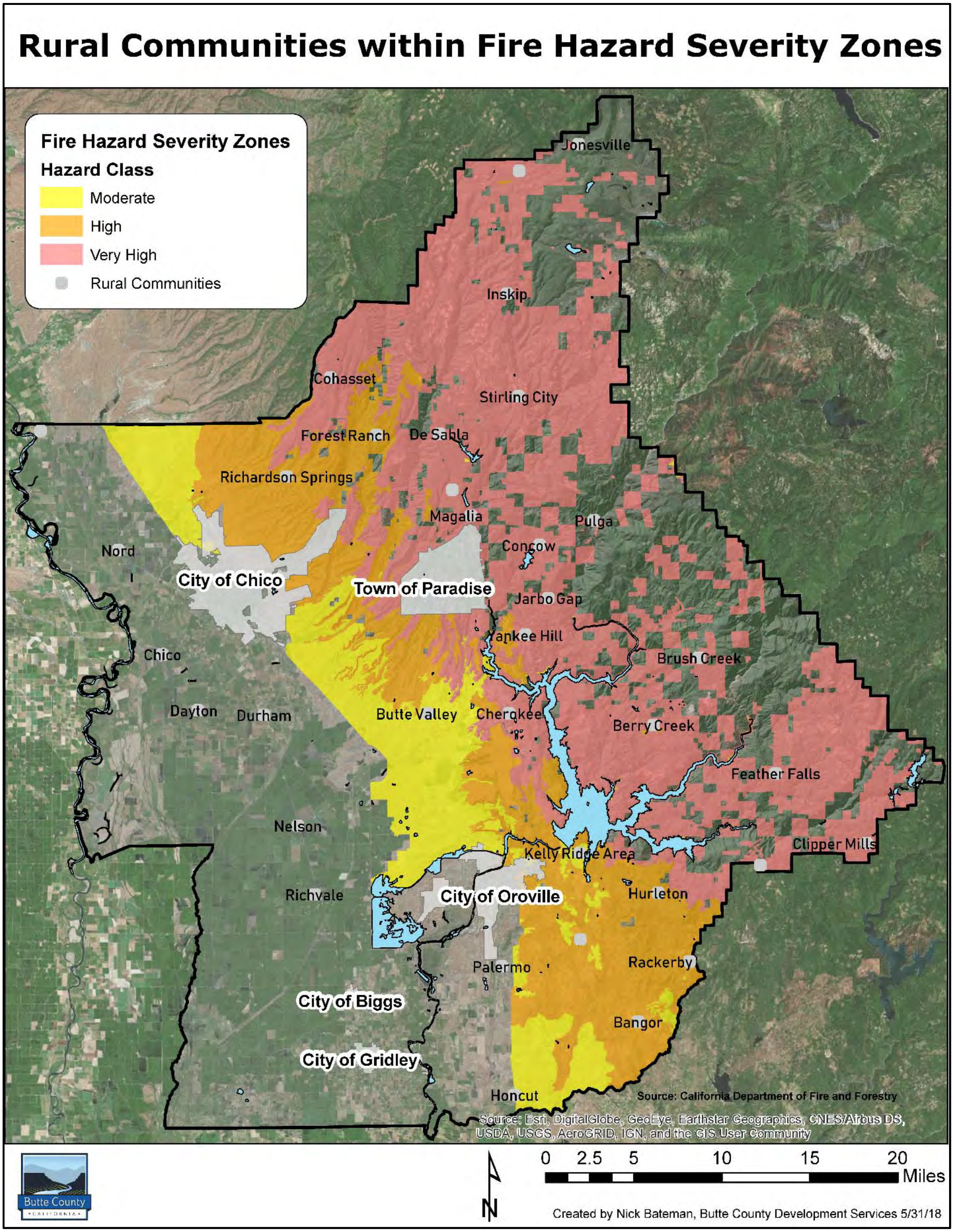

Figure 22: Rural communities living in wildfire severity zones

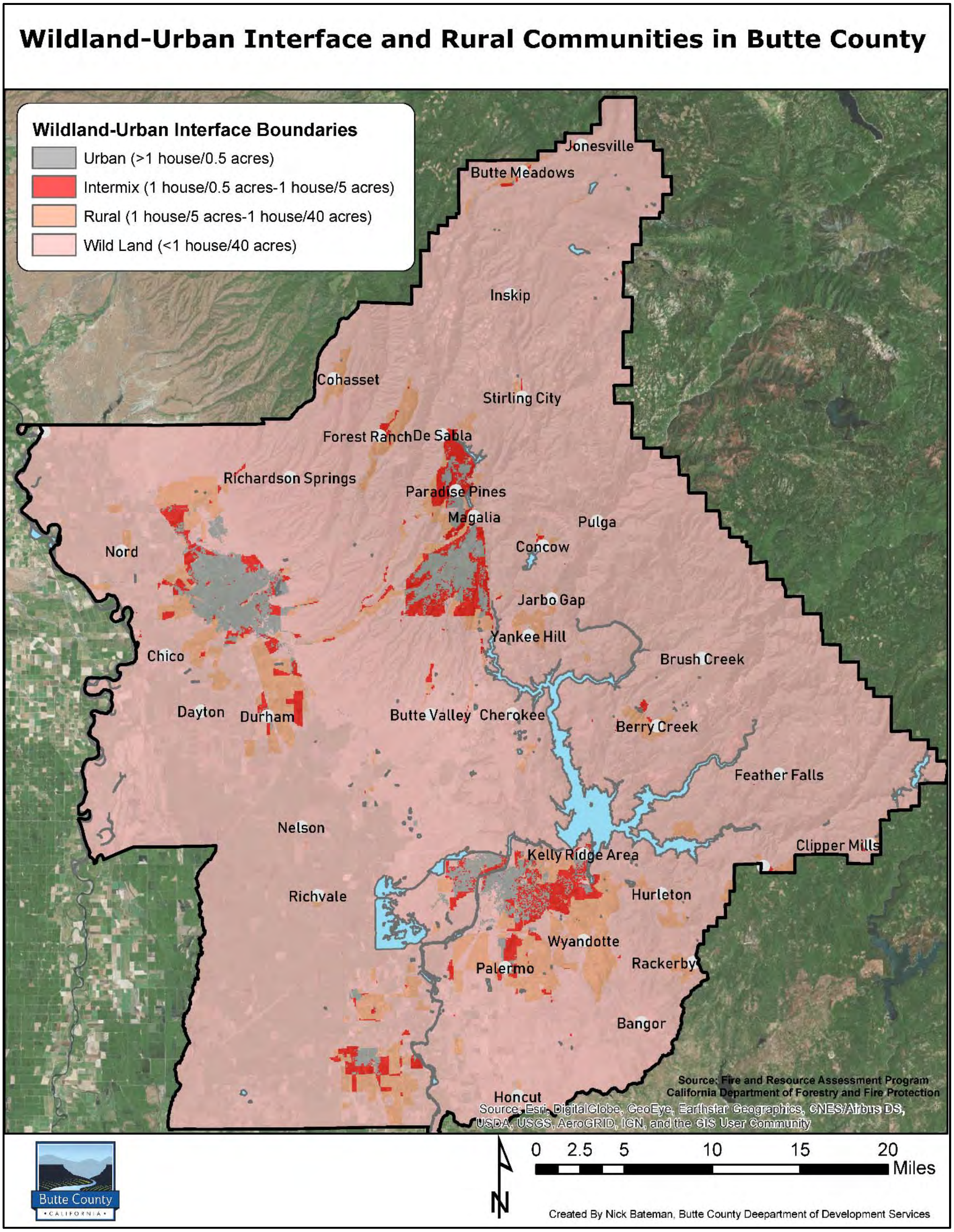

Figure 23: Wildland Urban Interface areas in Butte County.

In addition to an increased threat to human safety, the increased frequency of wildfire may result in the release of harmful air pollutants into the atmosphere, which can affect the respiratory health of residents across a broad geographical scope. Particulate matter, PM 2.5 (soot and smoke), carbon monoxide, nitrogen oxides, and other pollutants are emitted during the burning of vegetation, and can cause acute and chronic cardiovascular and respiratory illness, especially in vulnerable populations such as the elderly, children, agricultural and outdoor workers, and those suffering from pre-existing cardiovascular or respiratory conditions. Census data (Sourced from American Fact Finder) reports that 23.1% of Butte County's population is over 60 years of age. Another 11.4% are between 5 and 14 years of age.

Butte County is filled with many creeks, streams, lakes, reservoirs, etc. With more frequent and intense wildfires, there is a high probability that sedimentation within fish-bearing waters will increase. Nutrients and temperatures within the water will change and woody debris will become more prominent in the environment. Ultimately, this will negatively affect the overall health of the water and the fisheries themselves.

Loss of species such as deer and salmon due to climate change can impact Butte County's fishing and hunting industry, which can, in turn, have negative impacts on our conservation efforts and funding.

The risk of wildfire may threaten deer migration and habitats. Herds may be temporarily forced out of their migration patterns and most likely move north to adjust for loss in habitat and food. This could cause deer to move into developed or populated areas. Traits that commonly make a species vulnerable to climate change include limited dispersal abilities, slow reproductive rates, specialized habitat and dietary requirements, restricted distribution and rarity, and narrow physiological tolerances, while potentially vulnerable habitats include montane habitats, savannahs, and grasslands.

Functions and Structures

The characteristics of the Sierra Nevada contribute to the region's susceptibility to wildland fires. Fire activity in the Sierra Nevada region may damage the water and energy infrastructure upon which Butte County relies.

Wildfire can cause direct and indirect damage to electrical infrastructure. Direct exposure to fire can sever transmission lines, and heat and smoke can affect transmission capacity. Furthermore, because of historical forest management trends over the past century, increased temperatures, and more frequent drought, California wildfires are characteristically hotter and more intense as compared to naturally occurring fire regimes.

Forest health in Butte County and the economic vitality that these forests provide are likely to be impacted by increased wildfire. Forestry is over a $16 million-a-year economic sector in Butte County (Butte County Sustainable Forestry Brochure). Without the combination of ample rainfall, long growing seasons, and deep soils, forests in Butte County will be unable to maintain the productivity for our current and future needs. However, high severity fires, which are likely in the upcoming decades, can undo a substantial amount of this carbon storage in a very short period of time. Carbon emissions will continue over a few decades as the trees killed by fire begin to decay.

4 Adaptive Capacity

The next step in the Vulnerability Assessment process is to evaluate the adaptive capacity of the populations, functions, and structures as identified in Steps 2 and 3 to address climate change. Step 4 involves determining a community's current ability to address the points of sensitivity and impacts associated with climate change. Review of the County's existing local policies, plans, programs, resources, or institutions provides a good snapshot of the County's ability to adapt to climate change and reduce vulnerability. Based on this information, adaptive capacity for a city can be rated high, medium, or low. High adaptive capacity indicates that sufficient measures are already in place to address the points of sensitivity and impacts associated with climate change, while a low rating indicates a community is unprepared (CNRA 2012).

The adaptive capacity of Butte County's response to projected climate change impacts is analyzed below, based on identified exposure where possible. It is important to note that this review of local climate adaptation-related work offers an initial, high-level perspective on the issue and is not all-inclusive nor site specific. As more specific facilities, structures, and areas are identified in the future, additional review of adaptive capacity would be valuable.

On a planning level, the County addresses current and future impacts related to existing natural hazards, as evidenced by the County's Local Hazard Mitigation Plan (LHMP) most recently updated in December 2013. The 2013 LHMP identifies current hazard risks and mitigation strategies for climate change, flooding, levee failure, drought/water shortage, severe weather, and wildfires (Butte County, 2013).

Furthermore, the County's Climate Action Plan, adopted in 2014, contains policies aimed at reducing local contributions to global climate change and encourages sustainable building practices, efficient use of resources (i.e., water, land, and energy), and ecological stewardship. The County's Climate Action Plan also addresses climate adaptation and resiliency. Chapter 5 of the Climate Action Plan lays out several actions that should be taken to adapt the changing climate. Example actions include, establishing cooling centers during heat waves, promoting energy efficiency and renewable energy to reduce peak load demand and developing low-impact development standards to reduce storm water runoff and increase groundwater demand.

Butte County Office of Emergency Management (OEM) website contains a variety of resources for disaster preparedness. Evacuation plans and routes, standards for defensible spaces, disaster supplies kit check lists, heatwave precautions, drought assistance, and flood after fire information are some of the resources provided by Butte County OEM.

Disaster recovery efforts require extreme measure and commitment to the development of healthy, organized responses to chaotic situations. Every region has a unique need. If a jurisdiction is not in synch with current regulation it may not only miss opportunities for state and federal funding but leave that jurisdiction more vulnerable to the threats of climate change induced natural disasters. The County is conducting this assessment to find where its vulnerabilities lie and to be able to address them by incorporating adaptation strategies emergency plans and into the General Plan.

In addition to planning efforts, other climate adaptation-related work is ongoing in Butte County. These efforts are discussed below.

4.1 Adaptive Efforts Related to Increase Temperature

The Butte County Office of Emergency Services provides Butte County with information on how to stay safe during periods of extreme heat through the CodeRED application. CodeRED is a web-based critical communication solution that enables local public safety personnel to notify residents and businesses by telephone, text message, email, and social media of time-sensitive information, emergencies, or urgent notifications. The system can reach hundreds of thousands of individuals in minutes to ensure information such as evacuation notices, missing persons, inclement weather advisories, and more are quickly shared. Only authorized officials have access to send alerts using the CodeRED system.

Butte County participates in several Property Assessed Clean Energy (PACE) financing programs. PACE programs help homeowners finance home energy and water efficiency upgrades and save money on energy and water bills through special financing options. By enabling homeowners to retrofit their homes and install upgrades, this program helps to build adaptive capacity by increasing home comfort and mitigating higher energy costs associated with increasing temperatures and extreme heat events and heat waves. It should be noted that PACE programs are only available to homeowners and cannot be used by renters or occupants of multi-family housing.

Urban greening and urban forestry in the County are supported by numerous organizations and agencies. Urban forestry involves the planting of trees to mitigate these impacts. Trees provide shade for homes, roadways, parking lots, and provide relief during periods of extreme heat. Further, ground-level ozone produced from excessive heat can be filtered by certain tree species, which improves local air quality (Nowak 2002). Tree coverage also reduces energy demand.

Given its climate and location, Butte County and its residents will be vulnerable to the adverse effects of elevated temperatures as a result of climate change. As discussed previously in Section 2.1 Increased Temperature, the populations most likely to be endangered by extreme heat events are seniors, infants and children, persons with pre-existing respiratory and cardiovascular illness, persons with dementia, outdoor workers, non-English speaking persons, persons with low incomes and limited mobility, and the homeless. To adapt to a hotter climate, these populations may require assistance from a variety of sources, including local government, non-profits, and privately-owned businesses and organizations.

Adaptive capacity can be improved by informing and assisting individuals through proactive engagement in programs and services designed to mitigate the burdens and risks of high heat and heat events. Butte County Department of Public Health provides information and education regarding methods to stay safe during extreme heat; however, the responsibility to use these methods ultimately lies with the individual.

Further, the adaptive capacity of these populations can be increased through involvement in community programs to improve resiliency during periods of extreme heat. Individuals who own poorly-insulated housing may work with organizations receiving grants and financial assistance to improve the efficiency of their homes for those who qualify based on income. They may also participate in the PACE program to finance energy efficiency, renewable energy, and water conservation upgrades to their homes.

Persons dependent on others (e.g., infants and children) or isolated persons (e.g., seniors, transportation limited) may not have the capacity to adapt to living in extreme heat. Persons dependent on caretakers rely on these individuals to provide a safe environment from the effects of high heat. Further, seniors living alone, those with dementia or mental illness, the homeless, or persons without a reliable form of transportation and/or access to transit services may not have the resources to mitigate against heat, and are susceptible to heat-related illness such as heat exhaustion, heat stroke, or death.

To adapt to climate change-related periods of high heat, Butte County Department of Public Health will need to continue to provide education regarding the risks of excessive heat available on the Department of Public Health website and elsewhere. The County should also work to identify provide cooling centers for disadvantaged, vulnerable, and homeless populations. The cooling centers should be located in areas where disadvantaged populations can easily access the facilities.

As discussed in Section 3.1, transportation infrastructure (e.g., roads, bridges, sidewalks) can be damaged by extreme heat events. Damage due to climate change would place additional strain on already limited financial resources. Further, existing efforts to maintain and enhance the urban forest canopy may provide some increase in shading throughout the County, mitigating portions of transportation-related surfaces (e.g., asphalt) from excessive sun exposure. However, planting of shade trees alone may not be enough to fully mitigate potential damage from increased temperatures and extreme heat. The use of cool pavements and higher-albedo impervious materials on various surfaces should be investigated.

Butte County agriculture sector is extremely vulnerable to the increase in average temperature. Agriculture is a large driver of Butte County's economy and also among the most vulnerable to climate change. Butte County should work with U.C Cooperative extensions, the Agriculture commissioner's office and farmers to conduct more research on the impacts of climate change to agriculture. More research should be conducted on how farmers can adapt to the changing climate. Potentially exploring new crop or covert to different varieties of crops that thrive in warmer climate. By conducting this research, Butte County will increase its adaptive capacity for the increase of temperature on agriculture functions.

Adaptive Capacity Ranking for Increase in Temperature: Low/Medium

Butte County's population has a higher chance of heat-related illness and will require more extensive efforts to combat adverse heat effects. Efforts of the programs discussed above provide the county with appreciable resources to reduce temperature-related climate change effects. However, given that residents of Butte County experience heat-related illness at present, the County needs to invest more to improve its adaptive capacity as compared to other regions with cooler climates. Therefore, Butte County is given an adaptive capacity ranking of low/medium for increased temperatures.

4.2 Adaptive Efforts Related to Changes in Precipitation Patterns

Efforts occurring in Butte County to adapt to or reduce the impacts of changes in precipitation patterns are summarized below:

Butte County's Department of Water and Resource Conservation implements programs to protect Butte County's water resources. The priorities of the Department come from the 2005 Butte County Integrated Water Resource Plan some of which include: Administering Water Resource Management Programs, Ground Water Conservation Ordinance, Ground Water Management Plan (AB 3030 Plan), Drought Management Plan, Coordination Regional Watershed Management Plan and more.

The Department also oversees the Sustainable Ground Water Management Act. This program seeks to actively monitor groundwater levels and increase groundwater recharge throughout the region. SGMA went into effect in January 2016 and is California's new comprehensive statewide groundwater management law designed to provide for local management of groundwater resources. The Department is currently working on developing groundwater management plans that are tailored to the resources and needs of their communities that meet the requirements of SGMA and must be adopted by 2022. These plans will provide a buffer against drought and climate change, and contribute to reliable water supplies regardless of weather patterns. California depends on groundwater for a major portion of its annual water supply, and sustainable groundwater management is essential to a reliable and resilient water system.

Butte County and other Groundwater Sustainability Agencies (GSAs) have been working with stakeholders to evaluate the feasibility of artificially recharging the groundwater in the Vina and West Butte subbasins to help ensure groundwater sustainability by 2042. One option would be to use the City of Chico's treated wastewater that now is discharged into the Sacramento River as a potential direct or indirect source of groundwater recharge.

General Plan 2030 contains policies and actions designed to promote groundwater recharge and minimize impervious land cover. Policy W-P3.3 protects groundwater recharge and groundwater quality in new development projects. Action W-A3.1 directs the County to seek funding for and conduct comprehensive, countywide mapping of water resources and groundwater recharge areas, and Action W-A3.2 directs the County to develop standards to preserve groundwater recharge and protect groundwater quality (Butte County Draft EIR, 2010).

In addition, the County is implementing the State required Low Impact Development (LID) program. Butte County Plan General Water Resources Element Policy W-P.1, indicates that where appropriate, new development shall be Low Impact Development (LID) that minimizes impervious area, minimizes runoff and pollution and incorporates best management practices. The General Plan also directs the development of standards to determine where Low Impact Development techniques are appropriate. Most recently, the North Butte County Public Works Maintenance Facility utilized pervious concrete for the facility's parking lot.

The County approved the Butte Creek Canyon Overlay Zone, which implements Low Impact Development strategies to reduce impacts to the watershed, and enhance groundwater recharge, such as limits to impervious surfaces, erosion and sediment control plans for construction, and various other measures.

The County should consider installing impervious pavement in parking lots to capture rainwater and percolate back into the ground. The County should continue to install bioswales was it is appropriated to mitigate stormwater flows and recharge groundwater. Bioswales are landscape elements designed to concentrate or remove debris and pollution out of surface water. They consist of swaled drainage course with gently sloped sides and filled with vegetation. Bioswales are also beneficial in groundwater recharge and are great stormwater mitigation tools.

Drought impacts are wide-reaching and may be economic, environmental, and/or societal. The most significant impacts associated with drought in the planning area are those related to water intensive activities such as agriculture, wildfire protection, municipal usage, commerce, tourism, recreation, and wildlife preservation. Also, during a drought, allocations go down and water costs increase, which results in reduced water availability. Voluntary conservation measures are a normal and ongoing part of system operations and actively implemented during extended droughts. A reduction of electric power generation and water quality deterioration are also potential problems. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding and erosion (Butte County, 2013).

Butte County has several programs in place to conserve municipal water supply. Butte County citizens can engage in rebate programs provided by Cal-Water and other water purveyors and PG&E to improve the water efficiency of home appliances and replace water-demanding landscapes. Further, PACE financing programs can also help homeowners finance upgrades to their homes and landscapes to improve water efficiency along with energy efficiency. Deployment of these efforts can help to lower Butte County's overall municipal water usage thereby helping ensure that Butte County residents continue to have a reliable source of potable water in the face of future dry years. Additionally, through Cal-Water, citizens can report wasteful water usage.

The primary water source within the county is surface water (55 percent), followed by groundwater (31 percent) and surface water reuse (14 percent). The majority of the surface water supply used by Butte County residents and businesses originates in the Feather River watershed, accumulates in Lake Oroville, and is primarily used for agriculture locally (Integrated Water Resources Plan (IWRP), 2004). During drought years, county residents may face water shortages and strict reductions. If more residence begin to rely on groundwater, subsidence may occur. Agriculture operations who rely on surface water may experience water shortages which can impact crop production during drought years. Farmers should look into low flow irrigation methods to conserve water.

Further, groundwater in Butte County is regulated by Butte County Department of Water and Resources Conservation. The in-process Sustainable Groundwater Management Plans will further inform and adopt policies and actions that will provide a buffer against drought and climate change, and contribute to reliable water supplies. With the potential for precipitation patterns to become more erratic and less predictable, groundwater may become a more significant resource for County residents currently relying on surface water resources. To function in drier years, groundwater resources must be reliable and quantity and quality.

Adaptive capacity will be improved once SGMA begins to implement ground water recharge throughout the county. Capturing storm water and early snowmelt and getting that water back into the water table will ensure Butte County residents will have adequate water during droughts and help to mitigate any subsidence that could occur. Butte County may want to look into places long term water restrictions to ensure that water is not wasted as drought may be more prevalent in the future.,

Adaptive Capacity Ranking for Changes in Precipitation Patterns: Medium

Water conservation programs are helping to reduce water usage in the County, but there are still vulnerabilities to water supply issues due to drought, changing surface water flow regimes, increased pressure on groundwater supplies, and other factors. Butte County may face challenges in providing sufficient water supplies in the future due to climate change effects, coupled with an increasing population and water demand. Butte county and other water purveyors will need to continue to explore additional options to address projected long-term changes in water availability through advanced conservation approaches, more integrated supply management of both surface and groundwater (i.e., conjunctive use), greater water recycling, and other means. The adaptive capacity ranking for changes to precipitation patterns and water supply is medium.

4.3 Adaptive Efforts Related to Increased Flooding

Efforts occurring in Butte County to adapt to or reduce the impacts of flooding are summarized below:

Butte County Office of Emergency Services coordinates the overall countywide response to large-scale incidents and disasters through their website and CodeRED system. There is information on flood evacuation plans for flood zones in southern Butte County and contains strategies to ensure evacuations are handled smoothly.

General Plan 2030 includes policies that protect people and property from flooding. As discussed in Sections D.1.f and D.1.g, Health and Safety Element Policies HS-P2.4 and HS-P2.5 protect people and property from flood risks within the 100-year flood hazard zone and ensure that development within this area will not impede or redirect flood flows. As discussed in Section D.1.c, Policies HS-P3.1 through HS-P3.4 work to prevent and reduce flooding. In addition, Policy HS-P2.1 supports the efforts of regional, State and federal agencies to improve flood management facilities along the Sacramento River, and Policy HS-P2.2 supports the efforts of private landowners and public agencies to maintain existing flood management facilities (Butte County Draft EIR, 2010).

Floods can occur as a result of extreme precipitation, whereby water levels of drainage ways, such as streams, creeks and rivers, are overwhelmed by the stormwater runoff, exceed banks, and inundate the surrounding area. There are a number of levees in Butte County that provide various levels of protection for the citizens and property in the county from flooding hazards. There are also dams that serve as water storage features in the county and surrounding areas (Butte County Draft EIR, 2010).

Butte County contains areas currently designated as 100-year flood zones, and the General Plan 2030 land use map allows occupied development within these flood hazard areas. However, General Plan 2030 includes policies designed to prevent flooding of occupied developments. Specifically, Health and Safety Element Policy HS-P2.4 prohibits development on lands within the 100-year flood zone, as identified on the most current available maps from FEMA, unless the applicant meets criteria that FEMA has set out demonstrating development will not cause a danger to life or property (Butte County Draft EIR, 2010).

The Urban Level of Flood Protection Criteria was developed in response to the requirements from the Central Valley Flood Protection Act of 2008, enacted by SB 5. Urban level of flood protection; means the level of protection necessary to withstand a 200-year flood in any given year. The criteria were developed by DWR as a systematic approach to assist affected cities and counties within the Sacramento-San Joaquin Valley in making findings related to an urban level of flood protection before approving certain land-use decisions. In response to the passage of SB 5, Butte County adopted the Flood Hazard Prevention Ordinance requires the Department of Development Services to review all applications for new construction or subdivisions in flood hazard areas and requires that the lowest floor of any new construction or substantial improvement in FEMA-designated Flood Zones be elevated 1 foot or more above the regulatory flood elevation. Also, applicants must show that development within the floodplain will not raise the existing flood level in a manner that adversely affects any neighboring property.

Residents living in areas at high-risk for inundation from levee or dam failure have limited adaptive capacity to deal with flooding. Structural improvements to modify or elevate homes and other structures, as well as the purchase of flood insurance, can reduce the financial burden of recovering from flooding; however, these options are not universally acquirable. Low-income, mobility-challenged, and physically or linguistically isolated persons are particularly vulnerable. Localized and tributary flooding may also impact those living in close proximity to creeks and streams, as well as areas with constrained infrastructure (e.g., old, undersized infrastructure) that could back up when capacity is reached. The County continues to undertake projects to upgrade drainage infrastructure, however, residents need to be aware if they live in flood-prone areas and make necessary accommodations in advance when access to their homes or businesses may be inaccessible.

Butte County has a number of levees constructed by both private individuals and government agencies. Many of these are aging and may need repair and maintenance in order to adequately control flood flows. County staff should conduct an assessment on these flood control systems and begin maintenance to increase adaptability (Butte County Draft EIR, 2010).

Although General Plan 2030 policies and actions discussed above would reduce potential impacts related to flooding as a result of levee failure, they do not eliminate the risks to people and property from flooding. In addition, recently-adopted policies by FEMA would de-certify a number of levees in Butte County, which indicates that larger areas of Butte County are subject to levee inundation than realized under previous policies. Given the number of levees in Butte County, and the fact that most are owned or maintained by private individuals or other public agencies, it is not feasible for the County to completely address maintenance and improvements to all levees to the extent necessary to eliminate risks from levee failure. The impact is therefore considered significant and unavoidable (Butte County Draft EIR, 2010).

Adaptive Capacity Ranking for Flooding: Low

While levees and structures have been built to protect the County residents from catastrophic flooding, this infrastructure was constructed for protection from design floods based on the historic flow regimes of the County's creeks and streams. Increases in the rate or changes in the timing of snowmelt associated with rising temperatures in the Sierra Nevada along with changes in the intensity of storm events may result in an exceedance of the capacity of dams and levees and would increase Butte County's vulnerability to major flood events. The County should invest in maintaining and bolstering flood-related infrastructure as it experiences greater pressures from modified meteorology and flow regimes change. The County will have to continue to invest in mitigation to prevent flooding to provide its residents with a moderate level of flood protection.

4.4 Adaptive Efforts Related to Increased Wildfires

Efforts occurring in Chico to adapt to or reduce the impacts of wildfire are summarized below:

Butte County Office of Emergency Services coordinates the overall countywide response to large-scale incidents and disasters through their website and CodeRED system. There are wildfire evacuation plans for each town and city in the county and contains strategies to ensure evacuations are handled smoothly.

Butte County has adopted the 2016 California Fire Code, which includes provisions to help prevent the accumulation of combustible vegetation or rubbish that can be found to create fire hazards and potentially impact the health, safety, and general welfare of the public. Provisions include ensuring that defensible spaces, which are adjacent to each side of a building or structure, are cleared of all brush, flammable vegetation, or combustible growth (Butte County Draft EIR, 2010).

Damage to infrastructure development in Butte County must comply with the 2016 California Fire Code, which includes standards to reduce the safety risks associated with fire. This includes the incorporation of 100 feet of defensible space, which limits the proximity of combustible vegetation to new structures. Further, low- income residents living in aged buildings lacking the financial ability to either relocate to a safer, more modern building or upgrade their existing residence are at higher risk for fire-related injury. Further, the 2013 LHMP recognizes wildfire as a potential hazard and contains strategies to mitigate impacts.

Policy HS-P11.4 in the Butte County General Plan requires that new development meet current fire safe ordinance standards for adequate emergency water flow, emergency vehicle access, signage, evacuation routes, fuel management, defensible space, fire safe building construction, and wildfire preparedness, which would help to reduce the wildfire impacts on new development. Furthermore, Action HSA11.1 directs the County to complete roadside fuel reduction projects to reduce wildfire risk, increase visibility, and maintain safe evacuation routes, which would help to reduce wildfire hazards (Butte County Draft EIR, 2010).

In addition, Health and Safety Goal HS-12 and its associated policies and actions seek to protect people and property from wildland and urban fires. Specifically, Policy HS-P12.1 maintains regulations regarding vegetation clearance around structures, and Policy HS-P12.3 requires the use of fire resistant landscaping and fuel breaks in residential areas. In addition, Policy HSP12.2 requires fuel breaks along the edge of developing areas in High and Very High Fire Hazard Severity Zones, and Policy HS-P12.4 requires all developments in wildland urban interface areas in High or Very High Fire Hazard Severity Zones to provide, at a minimum, small-scale water systems for fire protection (Butte County Draft EIR, 2010).

The County's Wildfire Mitigation Action Plan will help to reduce damage and prevent injury from wildfire through wildfire mitigations, including a fuel reduction program, a weed abatement program, construction codes requiring the use of fire resistant building materials in new construction, and improvements to the water supply and hydrant system. Additionally, the Butte County Community Wildfire Protection Plan of 2005 will mitigate impacts associated with wildfire in developed areas through evaluation and assessment of proposed structures, implementation of mitigation measures associated with construction, and education programs for private landowners and public agencies (Butte County Draft EIR, 2010).

The Butte County Fire Safe Council provides the portions of Butte County within its jurisdiction with a plan to combat the effects of wildland fire. The Butte County Fire Safe Council serves to protect both people and structures from fire-related damage and provides useful strategies to create an environment that is not conducive to ignition and spreading. Chico residents living in the foothills and around Upper Bidwell Park may wish to utilize information developed by the Butte Fire Safe Council

Butte County Air Quality Management District (BCAQMD) takes actions to reduce exposure to harmful pollutants related to wildfire (e.g., PM) by implementing no-burn days during periods of poor air quality. BCAQMD also provides resources to educate the public on the status of air quality on a daily basis, provides alerts on poor air quality days, and provides educational material on the health effects of air pollution.

Adaptive Capacity Ranking for Wildfire: Low/Medium

Wildland fire is an ongoing concern for the Butte County Planning Area. Wildland fire hazards (open space, rangeland, chaparral, and forested areas) exist in varying degrees over approximately 70% of Butte County. The threat of wildfire and potential losses constantly increase as human development and population increase in the wildland urban interface area in the County. This results in a highly likely rating of future occurrence according to the Butte County LHMP. Wildfire occurring beyond the County borders will likely affect the welfare and health of the Butte County citizens (such as smoke-influenced air quality degradation). The county currently has many policies in place to mitigate wildfire however climate change is projected to exacerbate current risk due to increased temperatures and changes in precipitation patterns. The adaptive capacity for risks associated with wildfire is considered low/medium.

5 Risk and Onset

Impact	**Risk Certainty Rating**	**Onset Timeframe**
Increased Temperature	High	Current
Increased Frequency of Extreme Heat Days	High	Current
Increased Frequency of Heat Waves	High	Current Near-term
Changes to Precipitation Patterns	Medium	Mid Term
Increase Wildfire Risk	High	Current
Increased Flooding	Medium	Mid Term

- Current: Impacts currently (2017-2020)
- Near-term: 2020-2040
- Mid-term:2040-2070
- Long-term: 2070-2100

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Appendices

Low Emission	Historical Average 1961-1990	2050 2040-2060	2090 2070-2099
Temperature	71.1°F	75.5°F	77°F
Extreme Heat Days above 103.9	4.3	22	33
Precipitation	41.9"	46.0"	47.3"
Snow Pack Sierra Nevada Mountains (North Sierra Region)	7.9"	3.6"	2.6"
Wildfire Low pop scenario	2,309.8 hectares	2,979.8 hectares	3,594.5 hectares

High Emission	Historical Average 1961-1990	2050 2040-2060	2090 2070-2099
Temperature	71.1°F	76.4°F	79.7°F
Extreme Heat Days above 103.9	4.3	29	55
Precipitation	41.9"	46.8"	50.9"
Snow Pack Sierra Nevada Mountains (North Sierra Region)	7.9"	3.0"	.07"
Wildfire Low pop scenario	2,309.8 hectares	3,413 hectares	6,054.4 hectares