BUTTE COUNTY CLIMATE CHANGE VULNERABILITY ASSESSMENT

Prepared for:

Butte County
Development Services

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Acronyms/Abbreviations

Acronym/Abbreviation	Meaning
°F	degrees Fahrenheit
AB	Assembly Bill
APG	*California Adaptation Planning Guide*
BCAQMD	Butte County Air Quality Management District
CalOES	California Governor's Office of Emergency Services
CAL FIRE	California Department of Forestry and Fire Protection
CAP	Climate Action Plan
CEC	California Energy Commission
FEMA	Federal Emergency Management Agency
GHG	greenhouse gas
GSA	Groundwater Sustainability Agency
GSP	groundwater sustainability plan
IPCC	Intergovernmental Panel on Climate Change
LHMP	Local Hazard Mitigation Plan
OEM	Office of Emergency Management
PSPS	Public Safety Power Shutoff
RCP	Representative Concentration Pathway
SB	Senate Bill
SGMA	Sustainable Groundwater Management Act
WUI	wildland-urban interface

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Executive Summary

In 2015, Senate Bill (SB) 379 was signed into law, establishing California Government Code Section 65302(g)(4), which states that local governments need to address climate adaptation and resilience in General Plan Safety Elements upon the next revision of a local hazard mitigation plan, or before 2022. The first step in meeting this requirement is conducting a Climate Change Vulnerability Assessment to identify the risks that climate change poses to a local jurisdiction and the populations and assets at highest risk from climate change. California Government Code Section 65302(g)(4) requires the following information to be included in the Climate Change 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, including contributing to major wildfires, and is projected to lead to more severe conditions in the future. Butte County Development Services staff saw an immediate need to meet SB 379 to ensure that the community could adapt and build resilience to the changing climate.

This Climate Change Vulnerability Assessment provides a qualitative analysis on how climate change may impact Butte County throughout the twenty-first century. Direct climate stressors in the county include an increase in average temperature and changes in annual precipitation patterns. Secondary climate stressors, or hazards, include agricultural pests and diseases, drought, extreme heat, human health hazards, severe wind, severe storms, and wildfire. Appendix A shows future climate projections for Butte County and Appendix B shows the full results of the Climate Change Vulnerability Assessment. Appendix C is a glossary identifying key terms used in the Climate Change Vulnerability Assessment.

Climate change hazards that create the highest vulnerabilities in Butte County include wildfire due to the heavily forested areas of eastern Butte County and limited access roads, followed by severe storms, severe wind, and extreme heat. The County's frontline populations, energy and water infrastructure, agricultural economic drivers, and conifer forest ecosystems are among the most vulnerable to climate change hazards. As part of the General Plan Update process, this Climate Change Vulnerability Assessment will directly inform the goals, policies, and actions of the Health and Safety Element of the General Plan to help create a more resilient Butte County.

1. Introduction

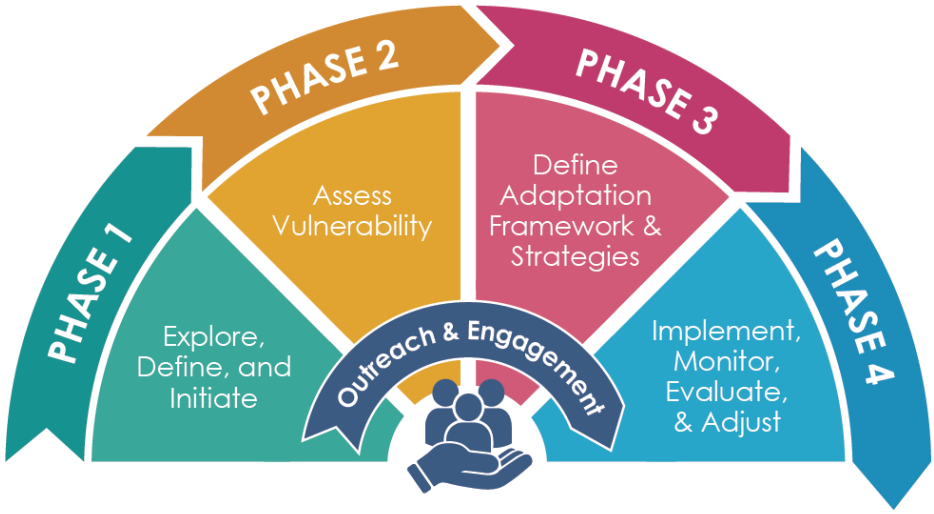
Climate change is a long-term change in the average meteorological conditions in an area. Currently, the global climate is changing due to an increase in greenhouse gas (GHG) emissions that trap heat near the Earth's surface. While some levels of these gases are necessary to maintain a comfortable temperature on Earth, an increased concentration of these gases from human activity traps additional heat, changing Earth's climate system in several ways. These effects can lead to an increase in frequency and intensity of climate change hazards, which, according to the *California Adaptation Planning Guide* (APG), have the potential to cause fatalities, injuries, property and infrastructure damage, interruption of business, and other types of harm or loss. These hazards can include agricultural pests and diseases, severe storms, wildfires, extreme heat, and drought conditions, among others. This Climate Change Vulnerability Assessment provides an overview of the primary and secondary climate stressors associated with climate change and identifies the hazards most likely to affect Butte County. The findings of the Climate Change Vulnerability Assessment will be used to develop climate adaptation strategies that address these vulnerabilities and inform the update to the Butte County General Plan Health and Safety Element, meeting California Government Code Section 65302(g) requirements, as amended by SB 379.

Other important updates to Section 65302(g) of the California Government Code related to Safety Elements, climate change, and resiliency and addressed in the Butte County General Plan Update include SB 1035 and SB 99. SB 1035 builds on previous legislation and requires local governments to review and update as needed their Safety Element during an update to their Housing Element or Local Hazard Mitigation Plan (LHMP) (or no less than every eight years). Any revisions should include updated information related to flood hazards, fire hazards, and climate adaptation and resilience. SB 99 established Section 65302(g)(5) of the California Government Code and requires jurisdictions to review and update the Safety Element to include information identifying residential developments in hazard areas that do not have at least two emergency evacuation routes. This vulnerability assessment, along with the update to the Safety Element, will help Butte County meet the state's requirements, in addition to increasing consistency with the LHMP.

1.1. Climate Change Vulnerability Assessment Method

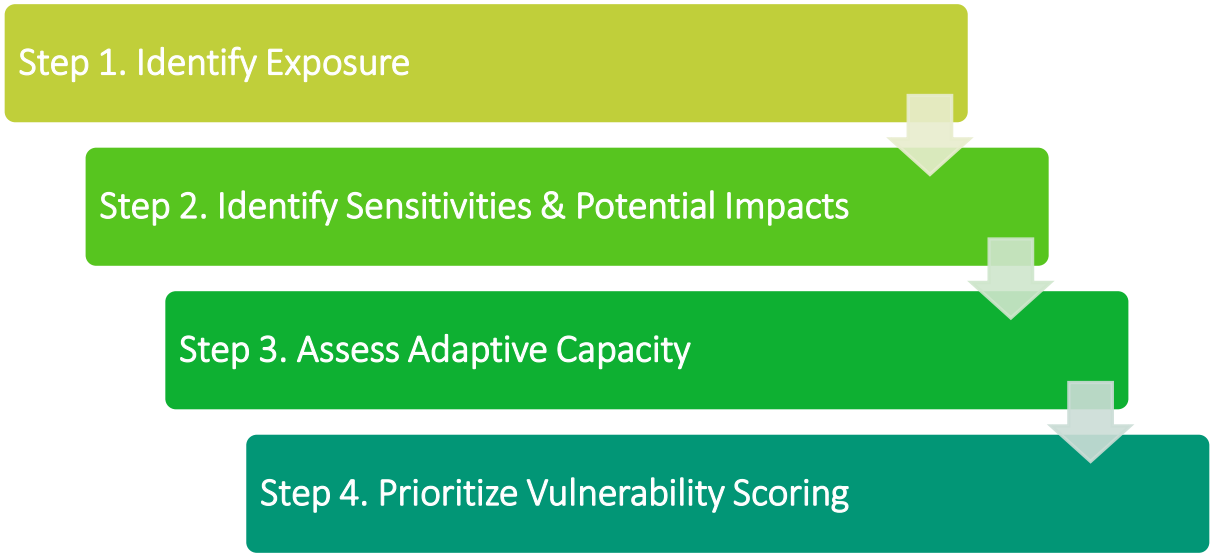
The APG, developed by the California Governor's Office of Emergency Services (CalOES), helps communities throughout California plan for and adapt to the impacts of climate change. The APG includes a four-phase process, shown in Figure 1, which allows jurisdictions to assess specific climate vulnerabilities and provides strategies to reduce climate-related risks and prepare for current and future impacts of climate change.

Figure 1. California Adaptation Planning Guide Process



The first two phases in the APG (see **Figure 1**) result in a vulnerability assessment, which is an evaluation of climate change hazard impacts to populations and assets and the adaptive capacity of these populations and assets to prepare for, respond to, and recover from climate change hazards. The last two phases 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 vulnerabilities, which is not included as part of this assessment. The second phase, Assess Vulnerability, is the focus of this report. This phase includes a four-step process: (1) characterizing the County's exposure to current and projected climate hazards; (2) identifying potential sensitivities and potential impacts to County populations and assets; (3) evaluating the current ability of the populations and assets to cope with climate impacts, also referred to as its adaptive capacity; and (4) identifying priority vulnerabilities based on systematic scoring. These steps are shown in **Figure 2**.

Figure 2. California Adaptation Planning Guide Vulnerability Assessment Method



Step 1: Identify Exposure. The goal of this step is to characterize the County's exposure to current and projected climate change hazards. Many projections of climate change hazards rely on multiple scenarios that reflect different levels of how global GHG emissions and atmospheric GHG concentrations may change over time. The Intergovernmental Panel on Climate Change (IPCC), an organization that represents the global scientific consensus about climate change, has identified four climate scenarios, also called Representative Concentration Pathways (RCPs), that can be used to project future conditions. RCPs are labeled with different numbers (e.g., RCP 2.6, RCP 6) that refer to the increase in the amount of energy that reaches each square meter of Earth's surface under that scenario. The four RCPs are:

- **RCP 2.6:** Under this scenario, global GHG emissions peak around 2020 and then decline quickly.
- **RCP 4.5:** Under this scenario, global GHG emissions peak around 2040 and then decline.
- **RCP 6:** Global emissions continue to rise until the middle of the century.
- **RCP 8.5:** Global emissions continue to increase at least until the end of the century.

The Cal-Adapt database, which provides California-specific climate change hazard projections, uses RCP 4.5 for a low emissions scenario and RCP 8.5 for a high emissions scenario. The Governor's Office of Planning and Research *Planning and Investing for a Resilient California* document and the APG recommend using RCP 8.5 for analyses considering impacts through 2050, as there are minimal differences between emission scenarios for the first half of the century. The APG also recommends using RCP 8.5 for late-century projections, for a more conservative and risk-adverse approach. The County used the RCP 8.5 GHG emission scenario results provided by the Cal-Adapt database and other resources for this assessment.

The first step of this Climate Change Vulnerability Assessment was to confirm which of the hazards are expected to take place at the local level in Butte County. The County identified seven climate change hazards for this assessment, listed here and discussed in more detail in Section 3.

1. Agricultural Pests and Diseases
2. Drought
3. Extreme Heat
4. Human Health Hazards
5. Severe Wind
6. Severe Storms
7. Wildfire

The climate change hazard data was derived from up-to-date information, including the Cal-Adapt database, the APG, the *California 4th Climate Change Assessment,* the California Geological Survey, the Federal Emergency Management Agency (FEMA), the California Department of Forestry and Fire Protection (CAL FIRE), and the Butte County 2019 LHMP.

Step 2. Identify Sensitivities and Potential Impacts. This step included evaluating past and potential future climate change impacts to community populations and assets. The County first identified a list of populations and assets to include in the assessment with the following five categories:

> **Sensitivity:** The level to which a species, natural system, or community, government, etc., would be affected by changing climate conditions.
>
> *Source: California Adaptation Planning Guide*

1. Populations: People that experience a heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to adapt to or recover from climate impacts.
2. Infrastructure and Buildings: Structures that provide various services to Butte County community members and visitors.
3. Economic Drivers: Economic sectors and activities that make significant contributions to the Butte County economy.
4. Ecosystems and Natural Resources: Types of wild and natural lands within the County boundary.
5. Key Services: Important functions to community members provided by government agencies and private companies.

This list included 16 populations, 26 infrastructure and building types, 10 economic drivers, 7 ecosystems and natural resources, and 8 key services. Once this list was confirmed, the County looked at which hazards are likely to affect which populations and assets, because not all hazards would affect all populations or assets. For example, human health hazards are likely to impact most populations, but it would not physically affect parks and open space or school buildings. The outcome of this step was a matrix that identified whether a population or asset is likely to be exposed to a hazard. If a population or asset has the potential to be affected directly or indirectly by a hazard, a "yes" was indicated in the appropriate box. Direct impacts affect buildings and infrastructure, health or populations, or immediate operations of economic drivers or community services, and they can lead to indirect impacts on the broader system or community, including populations or asset types in a different category. For example, severe wind can *directly* damage electrical transmission lines causing power outages, which can *indirectly* impact persons with chronic illnesses who depend on the electricity for life support systems. Therefore, both electrical transmission lines and persons with chronic illnesses were marked as "yes" for being affected by severe wind and would be evaluated in the assessment.

> **Exposure:** The presence of people, infrastructure, natural systems, and economic, cultural, and social resources in areas that are subject to harm.
>
> **Impact:** The effects (especially the negative effects) of a hazard or other conditions associated with climate change.
>
> *Source: California Adaptation Planning Guide*

After the applicability review, the County evaluated potential impacts to the applicable populations and community assets. To identify how great the impacts of each relevant hazard are on the populations and community assets, the County considered a number of different questions that helped ensure the assessment broadly covered a range of potential harm. Examples of these questions include:

- Could the hazards cause injury or damage?
- Is there a risk of behavioral or mental harm, loss of economic activity, or other nonphysical effects?
- How many people or community assets could be harmed both directly and indirectly?
- How long would the impacts persist?

- Is there a substantial chance of death or widespread destruction?

Based on the results of the impact assessment, the County ranked each population and asset low, medium, or high for each relevant hazard. Impact is considered a negative quality, and therefore a higher impact score means that there is a higher potential for harm to a population or asset. A lower impact score means that there is a lower potential for harm to a population or asset. Table 1 provides more detail about what each score means.

Table 1. Rubric for Impact Scoring

Impact Score	Meaning (People and Ecosystems)	Meaning (Buildings, Infrastructure, Services, and Economic Drivers)
Low Impact	Community members may not notice any change. If noticed, effect would be minor with only occasional disruptions.	Damage, interruption in service, or impacts on the local economy is small or intermittent enough to mostly go unnoticed. If noticed, effects are only minor.
Medium Impact	There is a marked impact to the community. Quality of life may decline. Impacts may be chronic, and at times substantial.	Damage, service interruptions, and other impacts are clearly evident. Impacts may be chronic and occasionally substantial.
High Impact	The well-being of the community declines significantly. The community's current lifestyle and behavior may no longer be possible. There is a severe risk of widespread injury or death to people, or of significant or total ecosystem loss.	Buildings, infrastructure, and services often or always cannot function as intended or needed to meet community demand. Large sections of the economy experience major hardships or are not feasible.

Step 3. Assess Adaptive Capacity. Adaptive capacity is the ability of populations and community assets to prepare for, respond to, and recover from the impacts of climate change. Each population and asset were evaluated for adaptive capacity by considering the following questions:

1. Are there existing programs, policies, or funding to provide assistance?
2. Are there barriers that limit response of recovery? Are these barriers, financial limitations, political challenges, lack of access to technology or other resources?
3. Do alternatives exist in or near Butte County that community members can use?

> Adaptive Capacity: The "combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities."
>
> *Source: California Adaptation Planning Guide*

Based on the results of the adaptive capacity assessment, the County ranked each population or asset as low, medium, or high adaptive capacity. Adaptive capacity is considered a positive attribute, so a higher adaptive capacity score will mean that a population or asset may be more adaptable to the hazard. A lower adaptive capacity score means that a population or asset may have a harder time adjusting to the changing conditions. Table 2 provides more detail about what each score means.

Table 2. Rubric for Adaptive Capacity Scoring

Adaptive Capacity Score	Meaning
Low Adaptive Capacity	Adaptive solutions are available, but they are expensive, technologically difficult, and/or politically unpopular. Alternatives may not exist that can provide similar services. Some assets may not have feasible means to adapt.
Medium Adaptive Capacity	Some adaptation methods are available, but not always feasible. Adapting may create significant challenges for some sensitivities. Some alternatives exist within the jurisdiction area that can provide similar services.
High Adaptive Capacity	Adaptation solutions are feasible for most or all sensitivities. There may be occasional or small-scale challenges to implementing adaptation methods, but populations and assets can adapt with little or no effort. Many alternatives exist in the area that can provide similar services.

Step 4. Prioritize Vulnerability Scoring. The County used the impact and adaptive capacity scores for each population and asset for each relevant hazard to determine the vulnerability score. The vulnerability score reflects how susceptible a population or asset is to harm from a particular hazard. Vulnerability is assessed on a scale of low, medium, and high. Low vulnerability does not mean that the population or asset will be unaffected by climate change, but that the effects are likely to be less substantial. The matrix in Table 3 shows how impact and adaptive capacity scores combine and translate into a vulnerability score. For example, extreme heat would create a high impact on energy delivery services by damaging electrical infrastructure and potentially exceeding the available electrical supply as mechanical failures, heat damage, and high demand for electricity from cooling equipment, can disrupt service. Adaptive capacity is low because many County residents need to use more electricity on extreme heat days to keep cool and because retrofitting electrical equipment can be expensive. Therefore, energy delivery services have a high vulnerability to extreme heat.

> **Vulnerability:** The degree to which natural, built, and human systems are susceptible "…to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt."
>
> *Source: California Adaptation Planning Guide*

Table 3. Vulnerability Scoring Matrix

	Low Impact	Medium Impact	High Impact
Low Adaptive Capacity	Medium	High	High
Medium Adaptive Capacity	Low	Medium	High
High Adaptive Capacity	Low	Low	Medium

1.2. Butte County Community Profile

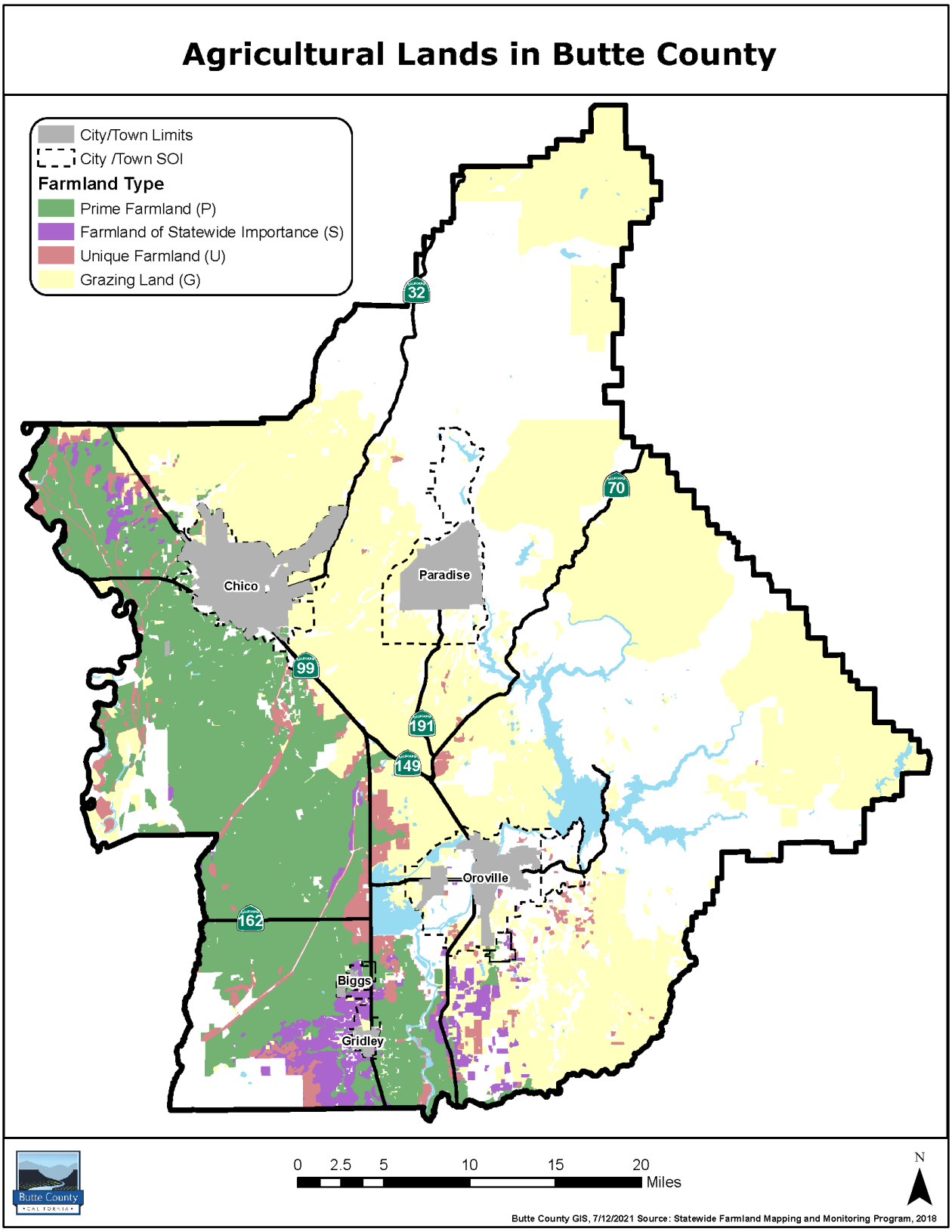
Located in Northern California, unincorporated Butte County has an area of approximately 1,680 square miles within the northeastern end of the Sacramento Valley extending east into the northern Sierra Nevada foothills. Butte County is a predominantly rural area; urban land makes up less than 5 percent of the total county area. Weather is generally temperate and warm, with hot, dry summers and cold, wet winters. The historic average minimum annual temperature is 44.6 degrees Fahrenheit (°F) and historic average maximum annual temperature is 71°F (Cal-Adapt 2018).

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. Several unincorporated communities in eastern Butte County are located on single access and rural roadways.

Agriculture is a strong and growing sector of the Butte County economy and according to the 2019 *Butte County Crop & Livestock Report*, agriculture occupied about 425,000 acres of county land in 2019. Butte County's gross 2019 agricultural production totaled $688,369,916. Walnuts, almonds, and rice crops are 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. Figure 3 shows agricultural lands within Butte County.

The primary crops grown in Butte County are rice, fruits, and nuts, with rice crops covering approximately 96,772 acres and fruit and nut orchards covering approximately 108,113 acres. Almonds (39,205 acres), walnuts (56,312 acres), and prunes (7,100 acres) are the primary orchard crops. Decreases in prune acreage and, to a lesser extent, other trees and vines (e.g., olives, peaches and nectarines, kiwis, pistachios, pears, and cherries) has been offset by increases in walnuts. Other agricultural activities include alfalfa crops (727 acres) and raising cattle (with pasture covering 207,000 acres). Acreages for grain and other crops have decreased substantially over time, while pasture and alfalfa acreage has increased. Approximately 16,000 head of cattle and sheep support the livestock industry, and 68,484,000 board feet of timber was harvested in 2019 (Butte County Department of Agriculture, Weights, and Measures 2019).

Figure 3. Agricultural Lands in Butte County



1.3. Water Resources

The following sections describe the water resources providing water to domestic and agricultural users locally, and to the rest of the state through Lake Oroville and the State Water Project.

1.3.1. 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, and 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 state.

Figure 4 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 Butte 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 within the County also contributes to the flows in these waterways. These waterways represent the major streams, water supply, and drainage features in the county, including:

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 the Pacific Gas and Electric Company (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.

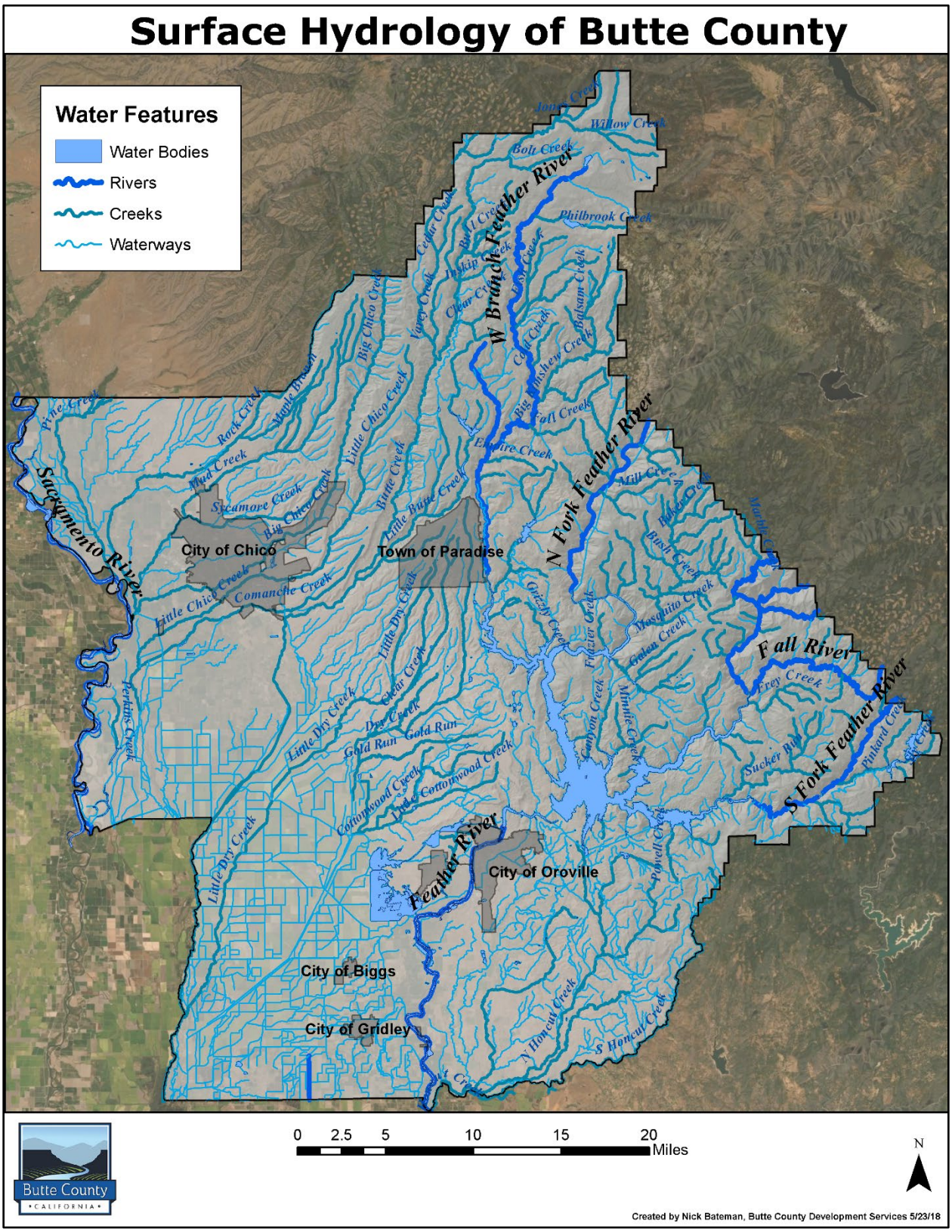
Water from the west branch of the Feather River is diverted to the Toadtown Canal for power generation by PG&E, where it also provides cold water for fish. The Butte Canal carries Toadtown Canal and Butte Creek water to the De Sabla power plant forebay. Hydropower is also generated at several other locations. 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 highest 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 flows from the Feather River, Butte Creek, and Big Chico Creek are highest 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 streams that support the spring and winter Chinook salmon runs.

Local agencies in Butte County have entered into several contracts with the Department of Water Resources to retain their water rights which they held prior to the construction of Oroville Dam. 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 California Department of Water Resources provides the districts with water supply from Lake Oroville in exchange for the districts' individual water rights (Butte County Department of Water and Resources Conservation 2016). The delivery of water under these agreements may be curtailed if inflows into Lake Oroville do not meet specific targets by April 1st of each year. Under these circumstances, the Department of Water Resource could curtail water deliveries by no more than 50% in any one year and no more than 100% over a seven-year period.

Climate change may increase the variability between wet and dry months and the county will likely experience drought-like conditions, reducing overall water supply (Butte County Department of Water and Resources Conservation 2016). Climate change projections in the draft Butte Subbasin Groundwater Sustainability Plan assumes an increase in the frequency of curtailments over the next twenty years. Groundwater Sustainability Plans are being prepared pursuant to the Sustainable Groundwater Management Act and are described in the Groundwater Section.

Figure 4: Surface Water Hydrology in Butte County



1.3.2. Groundwater

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 of precipitation in the form of rain and snow could affect local aquifer recharge for groundwater supplies (DWR 2019). Butte County overlays a portion of the Sacramento Valley Groundwater Basin and is made up of three subbasins: Vina Subbasin, Butte Subbasin, and the Wyandotte Creek Subbasin (see **Figure 5**). While there is no single source of groundwater recharge, according to the studies (e.g., Lower Tuscan Aquifer Study, Isotope Recharge Study) conducted by the Butte County Department of Water and Resource Conservation, different parts of the basin are recharged from one or more of the following sources:

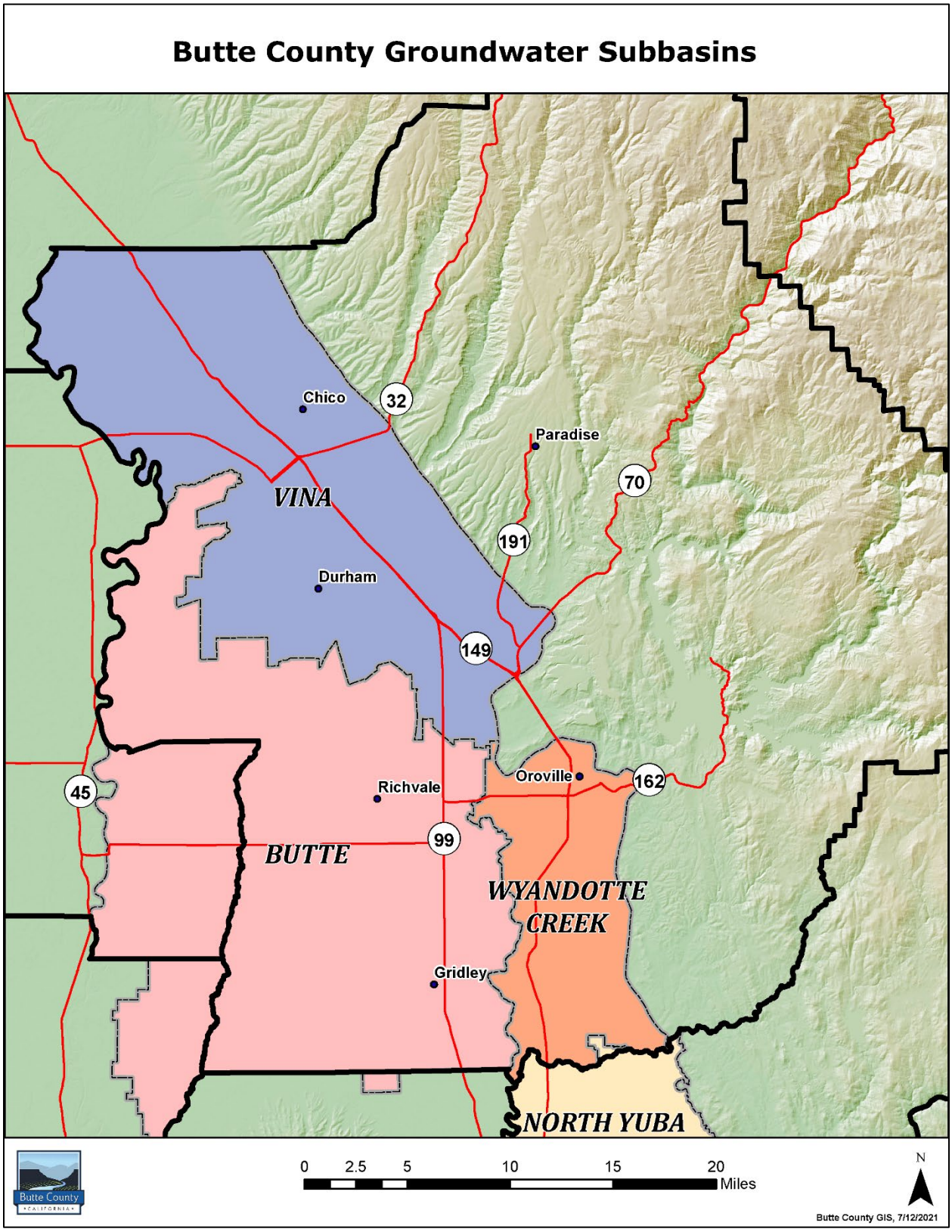
- Rainfall on the Lower Foothills
- Creeks
- Rivers
- Irrigation water
- Local rainfall on the Valley Floor

Butte County monitors groundwater conditions under the Groundwater Conservation Ordinance passed in 1996. The Ordinance requires that the County monitor groundwater levels, saltwater intrusion, and land subsidence quarterly. An annual groundwater status report is presented to the Butte County Board of Supervisors. Groundwater use typically increases during years characterized as dry and critical water years, or droughts. The most significant concern about increased groundwater use is the lowering of groundwater levels in the Vina and Wyandotte subbasins of the Sacramento Valley groundwater basin. Drought conditions exacerbate groundwater level declines due to reduced percolation (potential recharge) and increased groundwater pumping (Butte County Department of Water and Resources Conservation 2018). Under the Sustainable Groundwater Management Act, the groundwater sustainability plans for the three subbasins in Butte County will implement projects and actions to ensure that groundwater conditions will operate within a sustainable yield to avoid undesirable results for groundwater users.

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 through the Sustainable Groundwater Management Act (SGMA), which 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 these agencies are currently implementing groundwater sustainability plans (GSPs) that will bring the basin into sustainability in the next 20 years. The components of GSPs are subject to regulations adopted by the California Department of Water Resources. A water budget with potential use of a groundwater model is a required component of a GSP. GSPs establish the sustainable yield of the basin and identify regulatory and non-regulatory actions that will be taken to achieve sustainability by 2042.

Figure 5. Butte County Groundwater Subbasins



1.4. Cal-Adapt and Climate Change Projections

As directed by the APG, data needed to prepare the vulnerability assessment is available through several sources, with Cal-Adapt being one of the main sources. 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 website offers a view of how climate change will likely affect Butte County at the local level. Climate projections included in this Climate Change Vulnerability Assessment include an average of four models representing Warm/Drier (HadGEM2-ES), Cooler/Wetter (CNRM-CM5), Average (CanESM2), and Complement (MIROC5) models. Cal-Adapt provides projections using two RCPs, RCP 4.5 and RCP 8.5, which project different possible future GHG emission scenarios. This Climate Change Vulnerability Assessment uses the recommended RCP 8.5 scenario in the APG, which represents a business-as-usual, sometimes called a "worst-case," scenario.

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 downloaded from Cal-Adapt using the Butte County boundary. Projections for 2050 include an average of the years 2040 to 2060, and projections for 2090 include an average of the years 2070 to 2099. Historic data includes an average of the years 1961 to 1990.

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. Populations and Assets

Populations and assets are the people, infrastructure, services, and economic drivers in Butte County that can be affected by climate change. The Climate Change Vulnerability Assessment looks at how each population and community asset has been and will continue to be affected by each of the climate change hazards discussed in Section 3. The APG provides a general list of populations and assets, which Butte County refined and used to develop five distinct asset categories: (1) populations, (2) buildings and infrastructure, (3) economic drivers, (4) ecosystems and natural resources, and (5) key services. The following sections describe the populations and assets included in each of the five categories.

2.1. Populations

The Climate Change Vulnerability Assessment evaluated 19 populations that may be disproportionately harmed by climate change hazards. These populations have financial, age, mobility, health, or other characteristics that make them more vulnerable to hazardous events. Butte County gathered data for many populations listed from the 2021 *Settings and Trends Report*, the California Native American Heritage Commission, the Healthy Places Index, and the 2019 Point-in-Time Count for Butte County. The following populations were included in the Climate Change Vulnerability Assessment:

- Children
- Cost-burdened households
- Households in poverty
- Immigrant communities
- Linguistically isolated persons
- Low-income households
- Low-resourced ethnic minorities
- Overcrowded households
- Outdoor workers
- Persons experiencing homelessness
- Indigenous peoples and tribal nations
- Persons living in mobile homes
- Communities on single access roads
- Persons with disabilities and/or chronic illnesses
- Persons without access to lifelines
- Renters
- Seniors
- Seniors living alone
- Students

2.2. Buildings and Infrastructure

The Climate Change Vulnerability Assessment assessed the vulnerability of 26 different types of buildings and infrastructure in the County. These infrastructure categories help daily activities, economic drivers, community services, and emergency response events. Several of these assets support the transportation network, energy delivery, water and wastewater services, and recreation and tourism activities. The infrastructure section of the Climate Change Vulnerability Assessment focuses on the physical effects of climate change hazards on infrastructure itself instead of the services or economic activity they provide. The County derived information on buildings and infrastructure from local, state, and federal agencies. The following building and infrastructure assets were included in the Climate Change Vulnerability Assessment:

- Airports
- Bridges and tunnels
- Communication facilities
- Community centers and libraries
- Dams

- Electrical transmission infrastructure (substations and power lines)
- Emergency operation buildings
- Evacuation and cooling centers
- Flood control infrastructure (levees, dikes, etc.)
- Government administrative facilities
- Hazardous materials sites
- Hiking and biking trails
- Homes and residential structures
- Hospitals and medical facilities
- Major roads and highways
- Natural gas pipelines
- Parks and open space
- Power plants
- Public safety buildings
- Railways
- Schools
- Single access, rural, and minor roads
- Solid waste facilities and landfills
- Transit facilities
- Water and wastewater infrastructure
- Waterway infrastructure

2.3. Economic Drivers

The Climate Change Vulnerability Assessment evaluated the vulnerability of 10 distinct economic drivers in Butte County. These economic assets include three separate agricultural-based sectors, major employment industries, and recreation and tourism on regional, state, and federal lands. The County obtained information on economic drivers from the 2019 *Butte County Crop Report* and the 2019 to 2020 *Butte County Comprehensive Annual Financial Report*. The following economic driver assets were included in the Climate Change Vulnerability Assessment:

- Agriculture
- Construction
- Education
- Healthcare
- Livestock
- Manufacturing
- Regional recreation and tourism
- Rice-growing areas
- State and federal land recreation and tourism
- Timber production

2.4. Ecosystems and Natural Resources

There are eight primary ecosystems in Butte County, although many can be subdivided into specific habitats. The Climate Change Vulnerability Assessment analyzes these seven ecosystems. The ecosystems and natural resources section of the vulnerability assessment focuses on the how the plants and wildlife in ecosystems are likely to be affected by climate change hazards and the current ability of these systems to adapt to changing conditions. The primary resource for this analysis is the 2021 *Settings and Trends Report*, Biological Resources chapter. The following ecosystems and natural resources were included in the Climate Change Vulnerability Assessment:

- Conifer forest
- Oak woodland
- Riparian woodland
- Chaparral
- Annual grassland
- Open water: reservoirs, ponds, drainages
- Wetlands
- Pacific Flyway

2.5. Key Services

The Climate Change Vulnerability Assessment assessed the vulnerability of eight different types of services in the county. These key service categories provide essential goods, utilities, and services to residents and visitors in the county. These services are provided by public and private agencies, as well as volunteer organizations. The key services section of the vulnerability assessment focuses on the actions and services provided in these categories instead of the physical buildings and infrastructure that support the services. The following key services were included in the Climate Change Vulnerability Assessment:

- Communication services
- Emergency medical response
- Energy delivery
- Vital goods delivery
- Government administration
- Public safety response
- Public transit access
- Water and wastewater

3. Hazards of Concern

The first step in the vulnerability assessment is to identify the climate change hazards projected for Butte County. Based on the Cal-Adapt projections and information obtained from the APG*;* the *California Fourth Climate Change Assessment*; the 2019 Butte County LHMP; and the 2021 *Setting and Trends Report,* "Hazards and Safety" chapter, direct climate stressors to Butte County include changes in air temperature and annual precipitation. Secondary climate stressors, also known as climate change hazards, include agriculture and forestry pests and diseases, drought, extreme heat, human health hazards, severe wind, severe storms, and wildfire. The Climate Change Vulnerability Assessment focuses on the climate change hazards, as shown in Table 4, as these will directly affect populations and assets within the County. The following sections describe the primary climate stressors and secondary climate change hazards likely to occur within Butte County.

Table 4. Primary and Secondary Climate Stressors in Butte County

Primary Climate Stressors	Secondary Climate Stressors
Increase in air temperature	Agriculture and forestry pests and diseases
	Extreme heat
	Human health hazards
	Wildfire
Changes in precipitation patterns	Drought
	Severe wind
	Severe storms (flooding and landslides)
	Wildfire

3.1. Primary Climate Stressors

3.1.1. Increase in Air Temperatures

Annual average air temperatures in Butte County are projected to rise substantially during the next century, compared to historic levels, as global temperatures continue to rise (Houlton 2018). This is measured through annual average minimum and maximum temperatures. Butte County's historical (1961 to 1990) average maximum temperature is 71°F (Cal-Adapt 2018). Butte County's average annual maximum temperature is projected increase to 76.4°F by 2050 and 80.1°F by 2090 (Cal-Adapt 2018).

Butte County's annual average minimum temperature is also projected to increase throughout the century. Historically, average annual minimum temperature was 44.6°F (Cal-Adapt 2018). The annual average minimum temperature is projected to increase to 49.5°F by 2050 and to 53.3°F by 2090 (Cal-Adapt 2018).

The increase in annual average temperatures is expected to create or worsen hazards throughout the County, such as agriculture and forestry pests and diseases, extreme heat, human health hazards, and wildfire. Increasing temperatures will increase evapotranspiration rates in plants, increasing the water demand for crops in the County. These secondary hazards are discussed in more detail in Section 3.2.

3.1.2. 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 range provides significant surface water flows and groundwater recharge as water drains through the County. While Cal-Adapt 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 (CalOES 2020). It is anticipated that climate change would lead to an increase in the frequency and intensity of storms, meaning more precipitation may fall in fewer storms throughout the year. This may also result in more frequent and prolonged periods of drought (Bedsworth et al. 2018).

According to Cal-Adapt, historical annual average precipitation was approximately 52.3 inches throughout Butte County. Precipitation is expected to vary over the course of the century, with an annual average of 47.2 inches by 2050 and an annual average of 50.8 inches by 2099 (Cal-Adapt 2018).

Changes in precipitation can directly and indirectly cause or worsen hazards in the County, such as drought, severe wind, severe storms, and wildfire. These secondary hazards are discussed in more detail in Section 3.2.

3.2. Secondary Climate Hazards

3.2.1. Agriculture and Forestry Pests and Diseases

According to the *2019 Butte County Crop Report*, agricultural production and timber harvesting had total gross production of over $688 million in 2019, with walnuts being the largest grossing crop. Agricultural and forestry pests and diseases can affect crop plants, forests, and livestock throughout Butte County. This hazard is measured by the occurrence of pests and diseases, which is likely to increase as higher temperatures allow for insects to reproduce more rapidly.

These pests and diseases, such as fruit flies (*Drosophila melanogaster*), Japanese beetles (*Popillia japonica)*, gypsy moth (*Lymantria dispar dispar*), glassy-winged sharpshooter (*Homalodisca vitripennis)*, Asian citrus psyllid (*Diaphorina citri*), European grapevine moths (*Lobesia botrana*), fir engraver beetle (*Scolytus ventralis*), white-fir sawfly (*Neodiprion*), fall webworm (*Hyphantria cunea*), black stain root disease, and heterobasidion root disease, can cause plants and animals to grow more slowly, damage them so that their products are less appealing and harder to sell, or even kill them (California Climate and Agricultural Network 2019). Many pests and organisms that carry diseases are most active during warmer months, so the threat of infection or infestation can be higher during this time of year. Temperatures are expected to get warmer earlier in the year and remain warmer until later in the year due to climate change, creating a wider activity window for pests and diseases.

3.2.2. Drought

A drought occurs when conditions are drier than normal for a long period of time, making less water available for people, agricultural uses, and ecosystems. Droughts are a regular occurrence in California and are measured by the timing and length of drought. However, in the past 50 years, there have been four major statewide droughts, plus smaller regional droughts (CalOES 2018). Due to changes in precipitation patterns discussed in Section 3.1.2, droughts will likely last longer and occur more frequently due to more variability in precipitation extremes. Baseflow in rivers and creeks is projected to decline significantly. Historic annual average baseflow in rivers and creeks in Butte County was 12.2 inches, which is projected to decrease to an annual average of 8.1 inches during a mid-century drought and an annual average of 7.4 inches during a late-century drought.

Changes in weather patterns resulting from increases in global average temperature could result in a decrease in the total amount of precipitation falling as snow, leading to a loss in snowpack. Projections show an overall reduction of snowpack in the Sierra Nevada (Cal-Adapt 2018). Based on historical data and climate projections, State studies indicate that the Sierra Nevada snowpack will decrease by more than a third from its historic average by 2050 and decrease 50 percent to 66 percent or more by 2100 (DWR 2008; Bedsworth et al. 2018 2013).

The historic average snow water equivalent, a common measurement of snowpack, for Butte County was 1.9 inches (Cal-Adapt 2018). By 2050, the average annual snow water equivalence is projected to be 0.5 inches and by 2100 the average annual snow water equivalence is projected to be 0.1 inches (Cal-Adapt 2018).

3.2.3. Extreme Heat

Extreme heat occurs when temperatures rise significantly above normal levels and is measured by the number of extreme heat events per year and heat wave duration. “Extreme heat” is a relative term—temperatures of 100°F are normal in locations like Palm Springs, but almost unprecedented in Truckee. An extreme heat day in Butte County is where temperatures reach at least 100.1°F (Cal-Adapt 2018). Although temperatures are typically lower at higher elevations in the county, it is still dangerous when temperatures are higher than usual for people and assets that are not accustomed to them and may not have the resources to cope with the warmer temperatures.

Butte County historically experiences an average of five extreme heat days a year. Climate change is already increasing the number of extreme heat days in Butte County substantially. Butte County is projected to experience an average of 29 extreme heat days per year by 2050 and 59 extreme heat days per year by 2090 (Cal-Adapt 2018).

High temperatures can also occur during the night, as temperatures may not cool off and provide relief from the heat. A warm night in Butte County is when temperatures exceed 64.8°F (Cal-Adapt 2018). Historically, Butte County experienced 4 warm nights per year, which is projected to increase to 33 warm nights per year by 2050 and 76 warm nights per year by 2090 (Cal-Adapt 2018).

When extreme temperatures are experienced over a period of four or more days, the State's Cal-Adapt database defines these as heat waves.

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, including 26 extreme heat days in 2015.

3.2.4. Human Health Hazards

Human health hazards are bacteria, viruses, parasites, and other organisms that can cause diseases and illness in people. Some of these diseases may only cause a mild inconvenience, but others are potentially life threatening. Examples include hantavirus pulmonary syndrome, Lyme disease, West Nile virus, and influenza, which can be debilitating or fatal for some of the population. These diseases are carried by animals such as mice and rats, ticks, and mosquitos, which are usually seen as pests even if they do not cause infections.

Similar to agriculture and forestry pests and diseases, changes in temperature and precipitation can increase the rates of infections because many of the animals that carry diseases are more active during warmer weather. Warmer temperatures earlier in the spring and later in the winter can cause these animals to be active for longer periods, increasing the time for the disease to be transmitted. Warmer temperatures and higher levels of rainfall lead to increased populations of animals such as mosquitos, rodents, and ticks, creating a greater risk of diseases carried by these animals.

3.2.5. Severe Wind

Severe wind in Butte County is defined as sustained wind speeds exceeding 40 miles per hour and lasting for one hour or longer, or winds of 58 miles per hour for any duration (Butte County 2019). These winds can occur seasonally or as part of a severe weather event, such as a thunderstorm. The entire county has historically been subject to severe winds, from high winds in the mountain areas of the County to tornadoes in the valley portion of the county. Severe wind or tornado events occur approximately every 3.3 years according to historic records (Butte County 2019). The climate science surrounding wind is less certain; however, the intensity of individual thunderstorm events is likely to increase throughout the century, which may bring stronger thunderstorm winds (Butte County 2019). Severe wind can damage or destroy buildings, knock over trees, damage power lines and electrical equipment, and exacerbate wildfire conditions, as seen during Butte County's 2018 Camp Fire (see Section 3.2.7).

3.2.6. Severe Storms

Climate change is projected to alter the frequency, intensity, and duration of severe storm events, with sustained periods of heavy precipitation and increased rainfall. Precipitation patterns may have more intense characteristics, such as a high volume of rain falling over a shorter period of time. 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 (Bedsworth et al. 2018). 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.

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.

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.

Butte County is susceptible to various types of flood events: riverine, flash, and localized stormwater flooding (Butte County 2019). 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 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 these streams, flooding in Rock Creek and Keefer Slough, located north of Chico, regularly occurs. These floods inundate State Route 99, State Route 32, and several county roadways, as well as impact 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 (Butte County 2010).

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 2019).

Heavy rainfall can also cause landslides in the mountain areas of the county. Hillsides commonly absorb water, which increases instability of the slope, leading to increased slope failure. Steep slopes made up of loose or fractured material are more likely to slide. In some cases, the hillsides can become so saturated that slope failures can result in a mudslide (a mixture of soil and water moving downslope). Landslides and mudslides can move fast enough to damage or destroy buildings or other structures in their path, block roads or railways, and injure or kill people caught in them.

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 2019).

Butte County is home to Lake Oroville, which releases water 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 in Southern California. Lake Oroville is a critical component of supplying water locally and throughout the state.

In February 2017, a record high rainfall event took place in Butte County. An infrastructure failure caused significant damage to Oroville Dam's main spillway, which 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 2017. If an event like this happened again, southern Butte County residents could be at risk of flooding.

Severe storms can also include severe winter weather, hail, and lightning. Severe winter weather includes blizzards, ice storms, and extreme cold. Blizzards and ice storms can damage buildings and other structures, knock over electricity lines and trees, and block roadways. Ice can form on roadways and paths, creating slippery conditions that make it difficult or even hazardous to get around, especially for visitors who may not be used to icy conditions. Very cold temperatures create a health risk for people who are exposed to them, including the possibility of trench foot, frostbite, or hypothermia. Hail can damage buildings and plants (and in extreme cases injure people), and lightning can spark fires, injure people, or cause fatalities.

3.2.7. Wildfire

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 alter the distribution and character of natural vegetation and associated moisture content of plants and soils (CNRA 2012b:11). Increased temperatures increase the rate of evapotranspiration in plants, resulting in a greater presence of dry fuels in forests and creating a higher potential for wildfires (CNRA 2012b).

In addition to property damage and loss of life, 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 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 climate change will continue to contribute to the potential for western U.S. forest fire activity where fuels are abundant. A description of the devastating 2018 Camp Fire and 2020 North Complex Fire can be found in the "Hazards and Safety" chapter of the 2021 *Butte County Setting and Trends Report*.

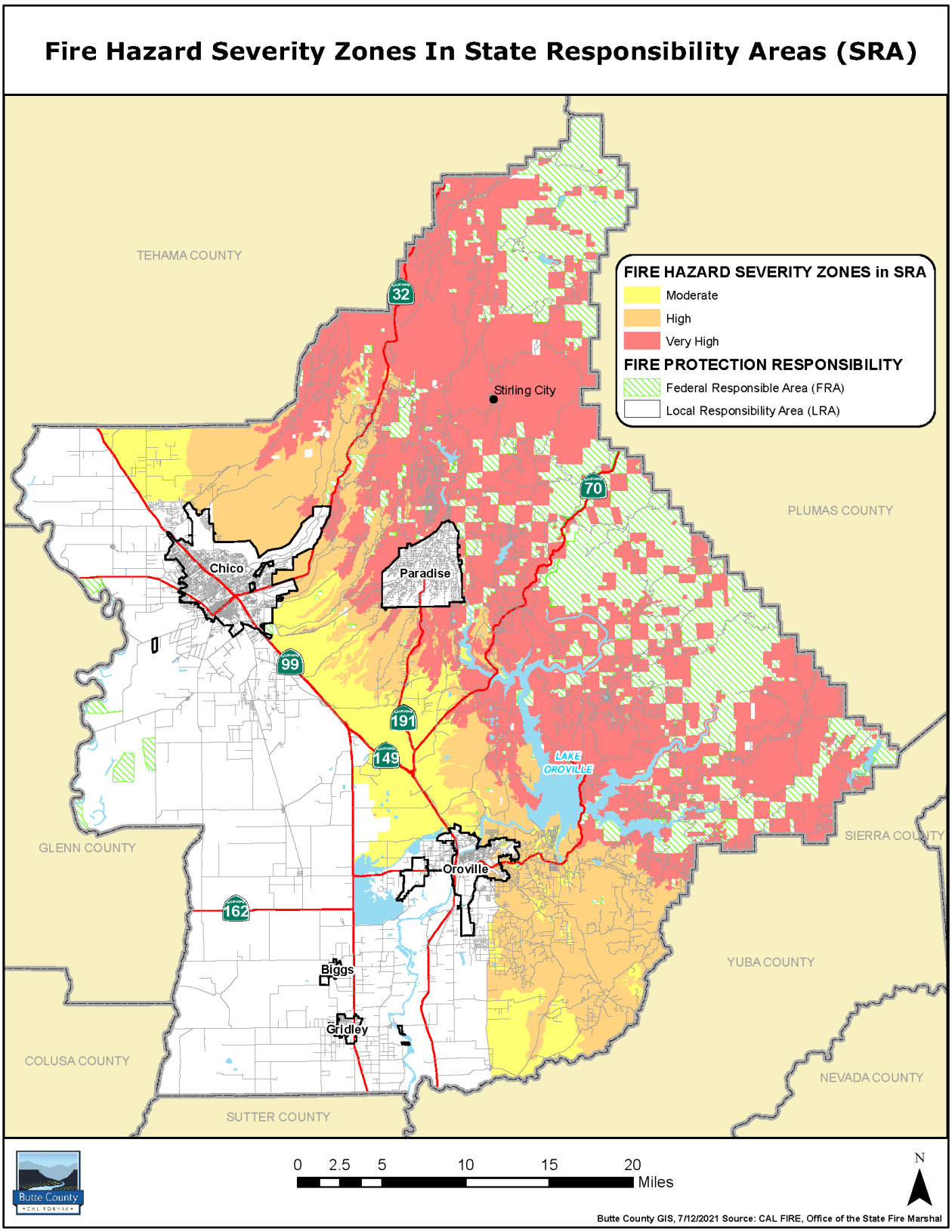
According to the Butte County 2019 LHMP, wildfire is an ongoing concern for the County. Generally, the fire season extends from early spring to late fall. With climate change, Butte County's fire season may now extend further into the winter months. Wildfire conditions arise from a combination of weather, 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 percent of Butte County.

Urban wildfires often occur in areas where development has expanded into rural areas. Currently, many homes 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 6 for a look at Butte County's Fire Severity Zones. Areas in eastern Butte County that appear empty but are surrounded by Very High Fire Hazard Severity Zones are mostly areas under federal jurisdiction.

The historic yearly average of area burned in Butte County was approximately 5,306 average annual acres per year, which is projected to increase to an annual average of 8,961 acres per year by 2050 and an annual average of 13,939 acres per year by 2099 (Cal-Adapt 2018).

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

Figure 6. Butte County Fire Hazard Severity Zones



4. Potential Impacts

Climate change hazards at the local and regional scale carry some uncertainty. Therefore, the Climate Change Vulnerability Assessment included a qualitative analysis that describes the potential impacts based on the hazards discussed in Chapter 3 (CNRA 2012a). This assessment provides a high-level overview of potential impacts that could occur as a result of identified climate change hazards. Further evaluation and research would be needed to identify vulnerabilities to specific properties, structures, or services. The following sections describe the general impacts of hazards on populations and assets within Butte County, which was used to conduct vulnerability scoring. The results of the vulnerability scoring are provided in Appendix B.

4.1. Agriculture and Forestry Pests and Diseases

Agriculture and forestry pests and diseases can affect all population and asset sectors in Butte County. These pests and diseases can cause plants and animals to grow more slowly, damage them so that their products are less appealing and harder to sell, or even kill them. Though there are treatment options for several agriculture and forestry diseases, some have no cure. The forests face particular harm from insects and other pests, diseases caused by bacterial or viruses, fungal infections, and other conditions that can affect the health of forest trees and plants. Specific pests and diseases include sudden oak death, fir engraver, white-fir sawfly, fall webworm, black stain root disease, and heterobasidion root disease (California Forest Pest Council 2019). Pest or disease infections can cause trees and other plants to grow more slowly, damage them so they are less able to function in an ecosystem, or kill them outright, which can impact the timber production industry. Forest and wilderness managers can cure or treat some pests or diseases or control their spread. However, in some cases, there is nothing that can be done.

In places where forests are a scenic and recreation attraction—and an important contributor to local quality of life—such as the conifer forests, forestry pests and diseases can cause significant economic harm. Dead trees or tree limbs may fall, especially during high winds and severe storms, and can damage or destroy buildings and structures, electrical transmission lines, homes, and other property. Falling trees or tree limbs may block roadways and cause injuries or even fatalities to community members and visitors. Blocked roadways can isolate communities located in the remote regions of the County. Dead trees and other plants can also create more fuel for wildfires.

In the agricultural sector, pests and diseases can affect the quality and viability of crops and livestock, which could become chronic as conditions continue to warm. Outdoor workers, immigrant communities, and low-resourced ethnic minorities could face economic hardship if they rely on this industry for work. It may be difficult for these populations to find alternative work if agricultural production declines.

4.2. Drought

More persistent drought conditions coupled with reduced flows of freshwater 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 in open water and wetland ecosystems. Butte County experienced harmful algae blooms 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 previously, climate change will likely 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 in overdraft conditions, with groundwater use exceeding the rate of recharge.

Those who rely on agricultural wells may face challenges in meeting water demands of crops and livestock as groundwater levels decline. The cost of meeting crop water demands will increase due to the need to extend groundwater pumps deeper or install new wells. The economic impact to agriculture is likely to harm both the agricultural operations and the outdoor workers employed by these operations (Butte County Public Health Department 2017). Those who have domestic wells may see their wells go dry, unless they drill further into the aquifer. Drilling can be expensive and may not be possible for those with financial burdens or limited resources. Households dependent on community water supplies could experience price hikes during drought conditions, and those without financial means may be unable to afford water prices. Drought could also cause statewide water supply issues, as the State Water Project relies on water from the Sacramento River and Feather River watersheds. Shallow domestic wells may not be able to reach lower groundwater levels during drought conditions and the State Water Resources Control Board may curtail surface water rights, negatively impacting Butte County agriculture.

Increases or decreases in precipitation could have an effect on ecosystems 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. This can lead to tree mortality, which can devastate the timber production industry. Harm to ecosystems and natural resources can also affect regional recreation and tourism, as fewer individuals may be interested in traveling to the area for regional, state, and federal land recreation and tourism if water levels drop too low or the scenic appearance of the county has changed.

More persistent drought conditions, coupled with reduced flows of freshwater 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. This can also affect the patterns and availability of suitable ecosystems for migratory birds along the Pacific Flyway. 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 streams and rivers have already become unviable for salmon to spawn in, such as parts of Big Chico Creek 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. Some ecosystems, such as wetlands, may shift to other ecosystems that require less water, such as grasslands and chaparral (Kershner 2014).

4.3. Extreme Heat

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, will likely rise, especially for those who do not have access to air conditioning, cool spaces, or shelter. Children, outdoor workers, financially burdened households, persons experiencing homelessness, and those who cannot easily regulate their body temperature face the greatest health impacts (OPR TAG 2018). 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°F), 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 for 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 illnesses (Maizlish Neil et al. 2017).

Disadvantaged communities in Butte County are likely to face greater challenges in dealing with extreme heat than others. 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 will likely be most affected by extreme heat. Many of these individuals may not have access to or be able to afford their own air conditioning. Low-income populations may live in older buildings with poor insulation and ventilation, leading to higher indoor air temperatures on warm days. These populations 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 have one or more chronic medical conditions, and less likely to own cars that can provide mobility to avoid deleterious climate effects.

As of 2019, there are 891 unsheltered persons experiencing homelessness in Butte County (Butte County CoC 2019). Homeless populations are especially vulnerable to heat-related illnesses in periods of excessively high heat, as refuge from high temperatures may not be accessible even if homeless shelters are available. 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 an annual average of 29 extreme heat days will occur in Butte County by 2050. These days will likely 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 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 and harvesting machinery. Health risks such as heat stroke and dehydration may occur and could potentially lead to disability.

Increases in temperature can have a severe impact on Butte County's 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 in open water and wetland ecosystems. An increase in temperature will decrease food availability, resulting in loss of habitat for many species, including migratory birds along the Pacific Flyway. In conifer forests, extreme heat can lead to heat stress, making them more susceptible to harm from forestry pests and diseases. It is also projected that scrublands or grasslands will expand into conifer forests under drier future scenarios

(Lenihan et al. 2003, 2008). See **Figure 7** and **Figure 8** for a map of projected temperature increases in relation to critical habitats.

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. Temperature extremes that occur at critical times during development can significantly impact plant productivity.

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 2015).

Extreme heat events can also harm agricultural crops and livestock, which could have economic impacts on farms and consumers. The majority of 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 425,000 acres of plant crops. Out of these plant crops, around 108,113 acres produce nuts and around 96,772 acres produce rice. These two types of farming practices make up almost half of the designated agricultural lands.

Butte County agriculture productivity is vulnerable to increases in average temperature. Nut trees, such as walnuts, require chilling hours during winter. "Chilling hours" can be defined as the cumulative number of hours below 45°F (Tapan B. Pathak et al. 2018). Almonds require between 400 and 700 chilling hours while walnuts range from 400 to 1,500 chilling hours each winter (Tapan B. Pathak et Al. 2018). Increases in average temperatures will directly reduce the number of chilling hours experienced by fruit and 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.

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.

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.

Figure 7. Map of Predicted Annual Temperature Average in 2050 under the RCP 8.5 Scenario in Relation to Critical Habitats in Butte County

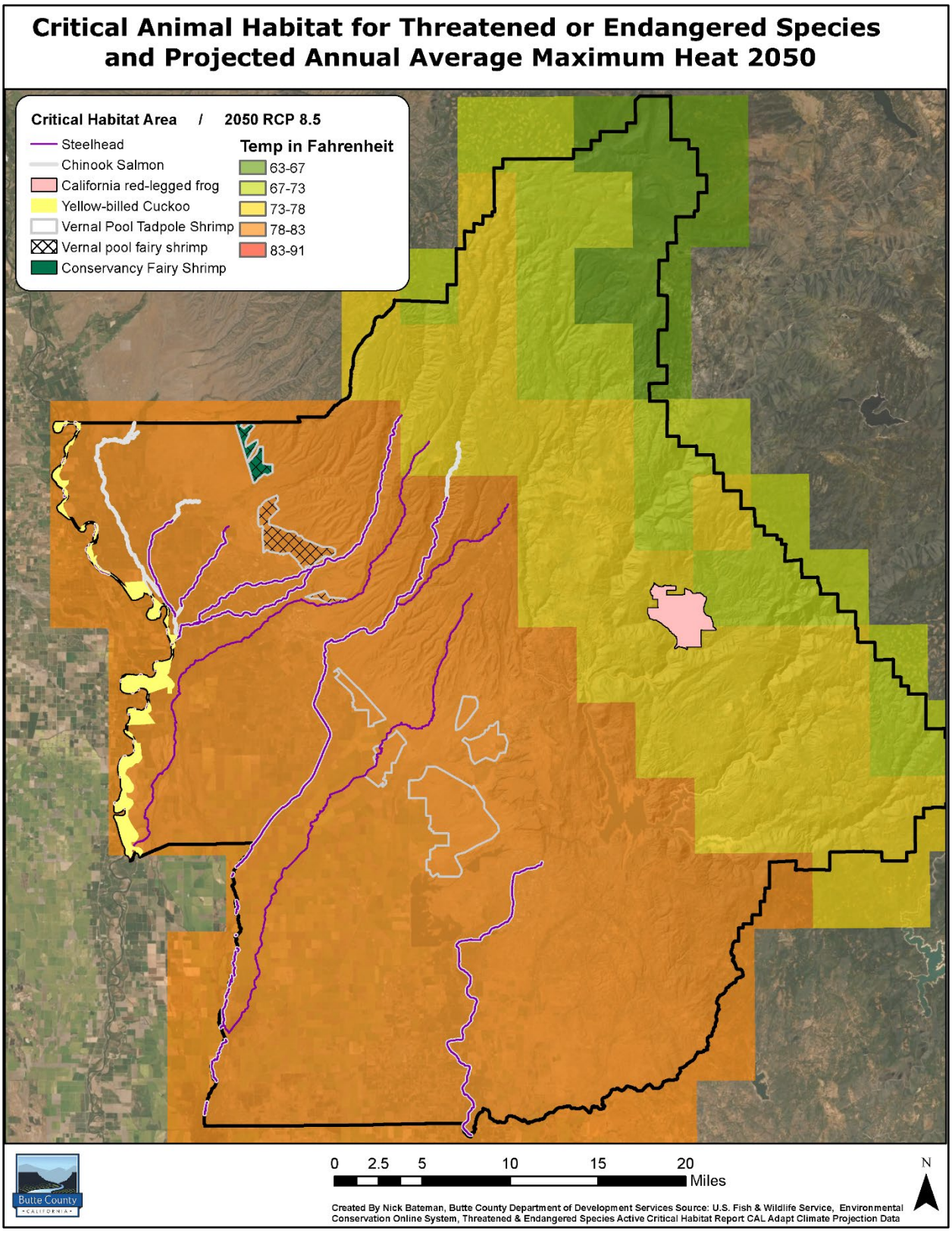
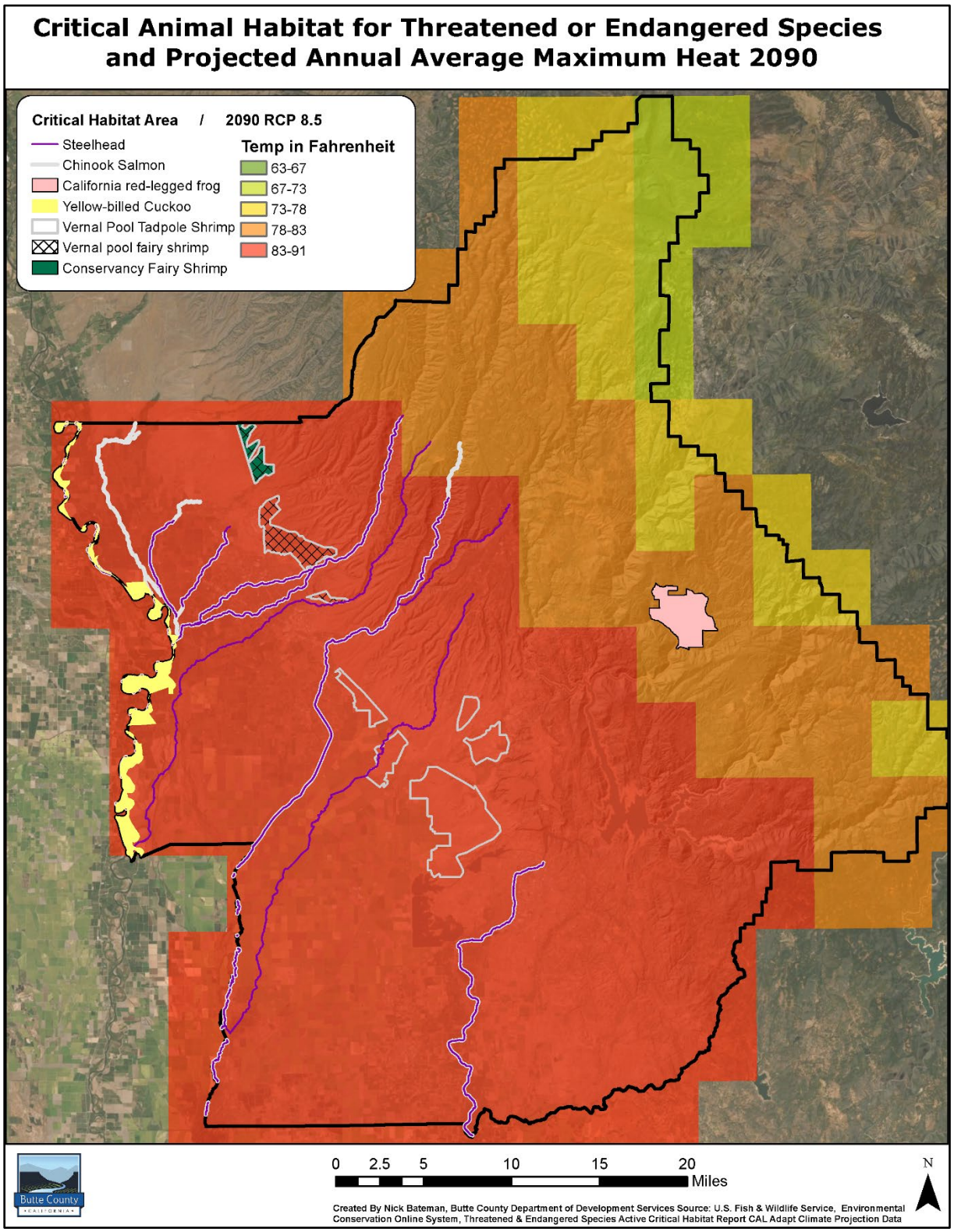


Figure 8. Map of Predicted Annual Temperature Average in 2090 Under the RCP 8.5 Scenario in Relation to Critical Habitats in Butte County



Extreme heat is also projected to impact infrastructure and utility services within Butte County. Infrastructure, such as roads, railroads, and bridges may bend and buckle in extreme heat conditions. Roads exposed to continued heat spells can experience cracks and pavement rutting, causing dangerous conditions for all 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 that will impact public safety and mobility by increasing the need for road maintenance and road closures (Maizlish Neil et Al. 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 and high winds could cause Public Safety Power Shutoffs. This could put public health and safety at risk with limited ways to stay cool during these times.

Utility services are likely to be impacted. High temperatures decrease the efficiency of power transmission lines while summer air conditioning use increases electricity demand. This can lead to more power outages and blackouts, leading to public health and safety risks if there are limited ways to stay cool during extreme heat events (Maizlish Neil et al. 2017). Limited or no access to air conditioning during heat events can be fatal for persons with chronic illnesses and seniors.

Quality of life could be affected by heat-related power outages. Loss of electricity reduces the ability to cool inside areas, which could affect people's ability to seek refuge from the heat. Food service 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 businesses who rely on internet to run business systems and communication.

Butte County is well known for its variety of outdoor activities. 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. Visitors participating in recreation activities could be doing physically demanding hiking, biking, or other recreation activities, increasing the potential for heat-related illness. Reduced outdoor activity has the potential to affect revenue for businesses in the outdoor recreation industry on regional, state, and federal lands. Increases in temperature and extreme heat days could also affect 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.

4.4. Human Health Hazards

Human health hazards primarily affect populations within Butte County; however, they can have indirect impacts on economic drivers and key services. Some human health hazards can cause a mild inconvenience, while others are potentially life threatening. Examples include hantavirus pulmonary syndrome, Lyme disease, West Nile virus, and influenza, which can be debilitating or fatal for some

people. Other hazards that affect human health include extreme heat (discussed in Section 4.3), poor air quality, and smoke created from wildfires in the region, which can cause additional risks or exacerbate existing cardiovascular and respiratory illnesses. Populations at highest risk for human health hazards are those that spend a disproportionate amount of time outside, such as children, outdoor workers, and persons experiencing homelessness; those with chronic illnesses or weakened immune systems; persons in overcrowded households that spread illnesses more easily; and financially burdened households that may not be able to seek medical attention. Pandemic-scale human health hazards can also harm several economic sectors within the county, as well as emergency medical response services.

4.5. Severe Wind

Severe wind can harm all population and asset sectors in Butte County. Severe wind can damage homes and essential infrastructure that can isolate households or communities. High-velocity winds increase the risk of sparking from electrical power lines. In recent years, this has caused PG&E to conduct Public Safety Power Shutoff (PSPS) events. This can affect those who rely on electricity to power life-support devices or refrigerate medicine and food, in addition to affecting communication services throughout the county. The uncertainty of PSPS events during severe wind can trigger stress and anxiety for residents and business owners. Severe wind can also cause trees and other debris to fly through the air, which can damage homes, other buildings, and infrastructure. Older buildings and infrastructure would likely be most affected by this, and those with financial burdens may be unable to repair structures and other infrastructure. If a roadway is blocked by downed trees or debris, communities on single-access roads could become isolated from the rest of the county.

Agriculture is the economic driver most likely to be affected by severe winds, as these winds can flatten crops and severely damage the agricultural economy (Motha 2011). Other economic activities may also be hindered, as high winds can create dangerous conditions for construction and visitors for recreation and tourism may be deterred from traveling to Butte County during severe wind events.

Ecosystems can also be harmed by severe winds, as diseases such as sudden oak death can spread more easily through high-velocity winds (Kershner 2014).

4.6. Severe Storms

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 is also predicted we will see more prolonged periods of drought, which can lead to water shortages and decreases in 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.

Severe storms will most adversely affect populations living in 100-, 200-, and 500-year floodplains in western Butte County (FEMA 2021). All County residents living in flood zones may be adversely affected if a flood event occurs; however, flooding-related impacts will likely disproportionately affect populations with financial burdens, those who spend a disproportionate amount of time outdoors, those who live in less-resilient structures, and persons with limited mobility. Households in poverty and low-income

households may suffer higher mortality rates and their homes may sustain greater damage due to the housing stock and location. Furthermore, 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). Financially burdened households or those with limited mobility 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 impacts. These factors may impose cultural and language barriers that may affect pre-disaster mitigation and access to post-disaster resources for recovery. Those with limited mobility and chronic illnesses may not have the capacity to adequately respond to or evacuate during a flood event. Educational status also contributes to the social vulnerability of a population. Lower education typically coincides with poverty, overcrowding, unemployment, income inequality, and marginalization (California Justice Working Group 2017), which are all factors that may increase vulnerability to climate-related hazards.

Floodwaters from heavy rainfall 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. Floodwater intrusion also has the potential to damage critical infrastructure, such as bridges, flood-control infrastructure, roadways, and cause mold and mildew to grow in homes and residential structures, which can affect indoor air quality. This may also lead to a large economic impact to the County and its residents as well as leave people displaced.

Localized flooding already poses a threat to Butte County roadways, especially near the Sacramento and Feather Rivers. Heavy rainfall will likely exacerbate this issue, blocking access to commuters, affecting road infrastructure, home infrastructure, and could lead to school closures. Flooding events may disrupt communications, energy transmission, public services, and transportation systems by damaging infrastructure. Flood events can 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 infrastructure, such as dikes and levees. 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 human 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 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 and 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 in the FEMA-designated floodplains have experienced flood damage in the past. The Butte County Storm Drainage criteria have not been updated to account for existing, excess flows and future conditions (Butte County 2006).

In addition to flooding, severe storms can cause landslides, which can block roadways, damage or destroy utility infrastructure, wash out hiking and biking trails, and harm the railway system. This can leave those living in communities on single-access roadways with few options for evacuating. Those with limited mobility may be unable to evacuate prior to a landslide event, further isolating them from the rest of the county. Landslides can also disrupt several key services that rely on the roadways and utility infrastructure, such as communication and energy delivery services, delivery of vital goods, and public transit access. Debris flows can also occur in wildfire burn scars, damaging structures, infrastructure, and economic sectors.

4.7. 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. 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 CAL FIRE. Climate change is also expected to subject forests 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, as seen in the 2018 Camp Fire and 2020 North Complex Fire (Westerling 2007). An increased rate and intensity of wildfire in the coniferous forests of the Sierra Nevada could adversely impact the populations, functions, and structures within the county.

Increased wildfire activity may occur on the WUIs around Butte County from drier conditions and development encroaching on wildland areas. The 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 Town of Paradise and community of Magalia and Paradise Pines are examples of high-density housing meeting wildland in Butte County. Development can also occur in the wildland-urban intermix, which are rural, low-density areas 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 urban-wildland intermix areas. 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 difficult to stop. Human development of wildland areas has made it much more difficult to protect life and property during a wildland fire. This home construction creates a new fuel load, which shifts firefighting operations from wildland to structural. Figure 9 and Figure 10 show rural communities in CAL FIRE-designated Fire Hazard Severity Zones and communities within the WUI. A full description of the impacts from the 2018 Camp Fire and 2020 North Complex Fire is provided in the Hazards and Safety chapter of the 2021 *Butte County Setting and Trends Report*.

Figure 9. Rural Communities Living in Wildfire Severity Zones

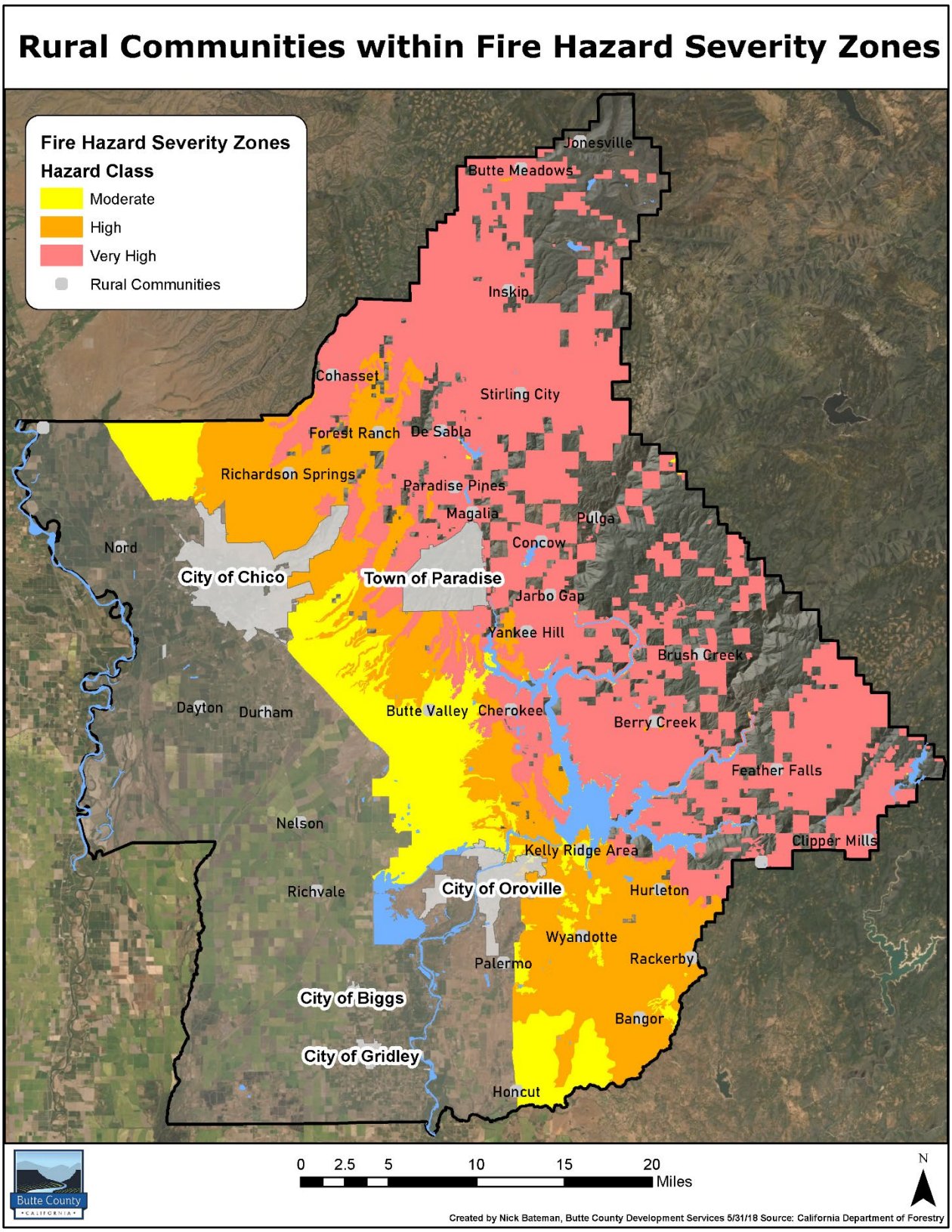
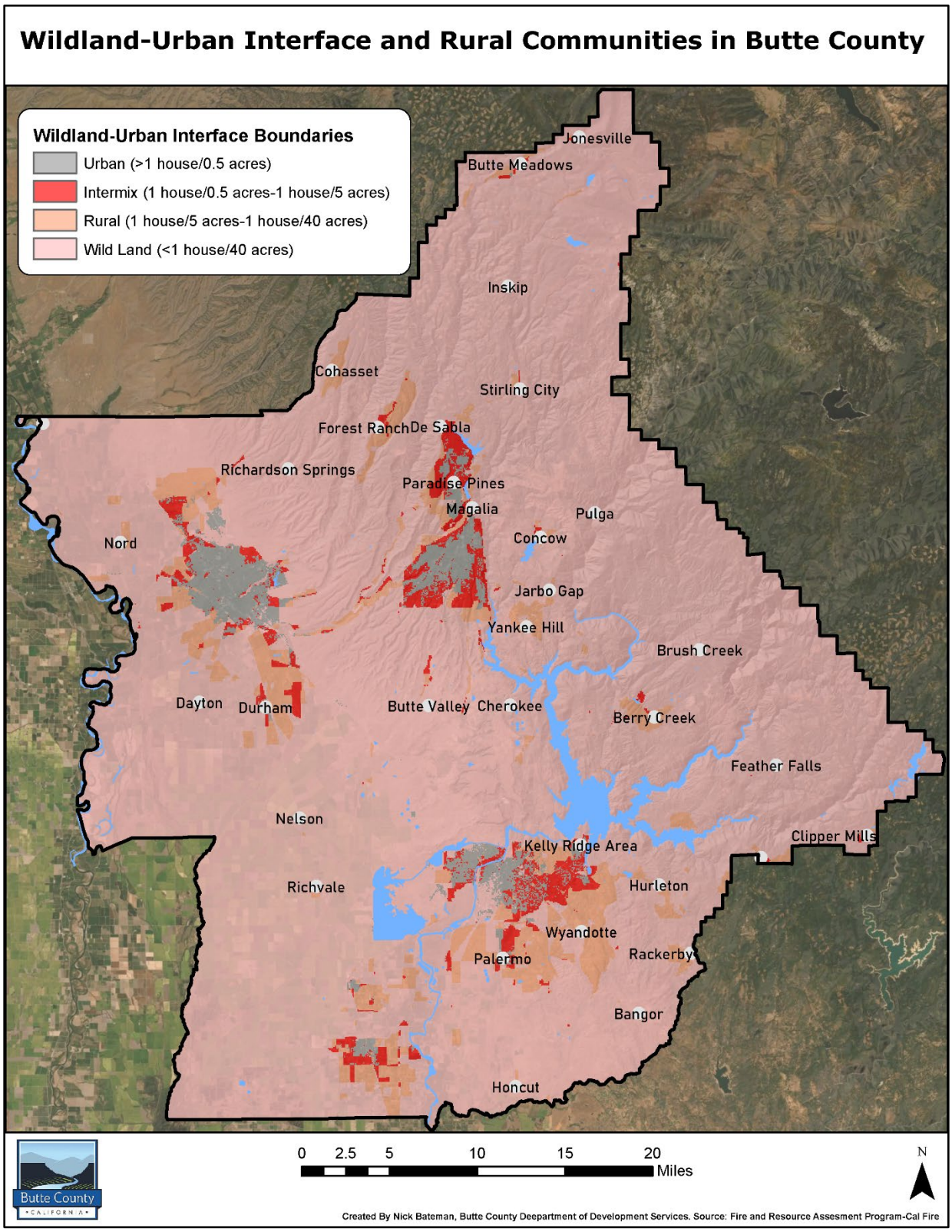


Figure 10. Wildland-Urban Interface Areas in Butte County



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 (including $PM_{2.5}$, which is 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.

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. This could affect the recreation and tourism industries that rely on healthy rivers and water sources. Loss of species such as deer and salmon from wildfires can impact Butte County's fishing and hunting industry, which can, in turn, have negative impacts on 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. Migratory bird patterns along the Pacific Flyway can also be disrupted by smoke and ash that fill the sky during wildfires.

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 decrease because of 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. High-intensity fires may also affect the ability of Butte County's forests and other natural lands to sequester carbon, as tree growth potentially becomes less productive and trees are burnt more regularly. Carbon sequestration is an emerging source of economic activity for forested areas in California and increases in wildfire may threaten this nascent industry.

5. Adaptive Capacity

The California APG defines adaptive capacity as the ability of a population, asset, or community to prepare for, respond to, and recover from climate change hazards based on current resources, tools, funding, policies, and programs. 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 specific population or asset rated high, medium, or low, as discussed in the Section 1.1.

A description of adaptive capacity of Butte County's populations and assets is provided in the following sections, based on identified hazard 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 analysis. 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 LHMP, most recently updated in December 2019. The 2019 LHMP identifies current hazard risks and mitigation strategies for climate change, flooding, levee failure, drought/water shortage, severe weather, and wildfires (Butte County 2019).

Furthermore, the County's Climate Action Plan (CAP), 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 CAP also addresses climate adaptation and resiliency. Chapter 5 of the CAP lays out several actions that should be taken to adapt to 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 stormwater runoff and increase groundwater demand. The County is currently preparing updates to the CAP and General Plan. These updates will include updates to adaptation goals, policies, and strategies that will be informed by this vulnerability assessment.

The 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 checklists, heatwave precautions, drought assistance, and flood after fire information are some of the resources provided by Butte County OEM.

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 sync 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 and emergency plans into the General Plan.

5.1. Agriculture and Forestry Pests and Diseases

Butte County's agriculture and timber production industries, persons who rely on these industries, and ecosystems surrounding these economic sectors will likely be harmed by an increase in agriculture and forestry pests and diseases. Pesticides can help crops and pastures resists pests and diseases; however, if pests and diseases quickly evolve, this may not be feasible for all crops. Agricultural owners and operators can work with the University of California Cooperative Extension to conduct more research on solutions to pests and diseases, or crop types that can more easily resist pest and diseases with less water and higher temperatures.

The timber production industry relies heavily on a healthy conifer forest ecosystem, which under normal conditions can resist pests and diseases. However, due to high temperatures and increased drought, the adaptive capacity of this ecosystem plummets and the forests have virtually no ability to resist pests and diseases, such as bark beetles. The timber industry may see additional challenges, as new market opportunities may shrink if forest resources are not available. Other tree ecosystems that can typically recover from pests and diseases, oak woodlands, and chaparral, may not be able to manage diseases such as sudden oak death (Kershner 2014). Other ecosystems may shift to other ecosystems that may be better suited for future conditions and disturbance regimes, such as grasslands (Kershner 2014). If forested ecosystems cannot recover, state and federal land recreation may decrease, as people may be deterred from traveling to the county.

The populations that rely on the agriculture and timber industries, such as immigrant populations and outdoor workers, may be able to transfer industries through educational opportunities. The Oroville Adult Education Program offers several programs for those living in or near the Cities of Chico and Oroville. However, due to potential fears of accessing government benefits and educational institutions, immigrant communities, low-resourced ethnic minorities, and outdoor workers may not seek these educational opportunities (Roos 2018).

The buildings and infrastructure damaged or blocked by diseases or dead trees can be repaired or retrofitted to prevent damage. Trees on single-access roadways can also be removed. However, these repairs, removals, and retrofits may take a considerable amount of time, and the facilities may not be useable until cleared and repaired. Mitigation action 46 of the Butte County LHMP may assist with this, as it is focused on hazard tree removal around infrastructure, specifically power lines; however, this project will require extensive funding to complete (Butte County 2019). Additional mitigation actions that may assist with agricultural pests and diseases include a marine and aquatic invasive species survey and surveillance project, foreign animal diseases rapid response quarantine program, and a Broom eradication project (Butte County 2019).

5.2. Drought

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, Groundwater Management Plan, Drought Management Plan, Coordination Regional Watershed Management Plan, and more.

The department also leads Butte County's involvement to implement the SGMA. 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. Butte County is a member agency in the Vina Groundwater Sustainability Agency and the Wyandotte Creek GSA. Butte County is a GSA fora

portion of the Butte subbasin. The GSAs are currently working on developing groundwater sustainability plans (GSP) for each subbasin. The GSPs must be adopted by 2022. The GSPs will ensure that groundwater extraction operates within the sustainable yield, accounting for future drought conditions, wet years, climate change, and future growth. The GSPs will provide a buffer against drought and contribute to reliable water supplies. However, SGMA recognized that drought conditions may result in impacts that cannot be avoided provided that the basin returns to its sustainable yield after the drought. 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 GSAs have been working with stakeholders to evaluate the feasibility of artificially recharging the groundwater in the Vina subbasin to 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. Other options under consideration are to promote recharging of winter flood water from streams and creeks, and water conservation.

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 2010).

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. Those who are financially burdened or may rely on water-dependent economic activities may not be able to prepare for or recover from water price hikes or disruptions to economic drivers. Voluntary conservation measures are a normal and ongoing part of system operations and are 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 2019).

Butte County has several programs in place to conserve domestic 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. Implementation of these efforts can help to lower Butte County's overall domestic 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.

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 (Butte County Department of Water and Resource Conservation 2005). During drought years, county residents may face water shortages from dry wells. Residents served by water purveyors may face strict restrictions on water supply and permitted uses.

Agriculture operations relying on surface water may experience water shortages that can impact crop production during drought years.

Butte County also has a Drought Preparedness Plan, which established a Drought Task Force, drought monitoring, and drought response and mitigation to ensure that water supply limitation are addressed during drought conditions. Adaptive capacity will also be improved once SGMA begins to implement groundwater recharge throughout the county. Capturing stormwater 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 the development of drought response rules in advance of a drought.

5.3. Extreme Heat

The Butte County Public Health Department provides Butte County community members with information on how to stay safe during periods of extreme heat through press releases and their webpage. However, linguistically isolated persons and those without access to internet may not be aware or able to look for these notifications.

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 increases insulation and air conditioning in homes, while reducing energy costs associated with 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 multifamily 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 (California Natural Resources Agency 2018). Tree canopy cover also reduces energy demand.

As discussed previously in Section 4.3, the populations most likely to be endangered by extreme heat events are those who spend a disproportionate amount of time outdoors, such as outdoor workers, children, and persons experiencing homelessness; seniors; persons with chronic illnesses; indigenous and tribal nations; linguistically isolated persons; and households in poverty and low-income households. Several cooling centers are available throughout the county for these individuals to seek relief from the heat. Persons in low-resourced ethnic minority communities or immigrant communities may not seek cooling centers or know about them because of immigration status or language barriers. For those with limited mobility or chronic illnesses, Butte Regional Transit does offer Dial-A-Ride and paratransit services, which seniors and other populations can use to seek relief from the heat.

Transportation infrastructure (e.g., roads, bridges, sidewalks) can also be damaged by extreme heat events. Damage from extreme heat conditions would place additional strain on already limited financial resources for maintenance and repair of county and state roads. Existing efforts to maintain and enhance the urban forest canopy may provide some increase in shading on local roads 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. Some roadways and rail lines may be managed by multiple agencies, which requires coordination that can extend the timeline for repairs and retrofits.

Other infrastructure that can be damaged by extreme heat includes electrical transmission lines. These transmission lines can be turned off during extreme heat events to reduce damage, and renewable energy, such as solar panels and wind turbines, can be installed to reduce electricity demands during the warmest part of the day. However, retrofits are expensive and may not be feasible for all structures. Turning off electricity lines can also be detrimental to critical facilities, residents who rely on electricity for life-support devices and refrigeration of medicines, and businesses in Butte County.

Butte County's agriculture sector will likely be highly affected by extreme heat. Agriculture owners and operators can work with the University of California Cooperative Extension and the Agriculture Commissioner's Office to conduct more research on crop types that can more easily resist damage from extreme heat days and warmer nights. By conducting this research, Butte County will increase its adaptive capacity for the increase of temperature on agriculture functions. Some industries, such as outdoor recreation and timber harvesting, may be less able to prepare for and recover from extreme heat, as visitors may be less likely to travel to the area during extreme heat days to participate in outdoor recreation and forests that support timber harvesting may be more susceptible to wildfires due to higher temperatures.

5.4. Human Health Hazards

As stated previously, households with financial burdens, overcrowded households, and populations that spend a disproportionate amount of time outdoors are most susceptible to human health hazards, in addition to the economic drivers they support and services they require. These populations may not be able to isolate if they have a contagious illness and may not have health insurance or financial means to seek medical attention. Persons working outdoors, persons experiencing homelessness, and others can wear protective clothing or bug spray to reduce exposure to vector-borne illnesses, but this may not be effective in all cases. Households with financial burdens may also not be able to take time off work to recover or seek medical attention, therefore worsening health outcomes.

Butte County does have a Mosquito and Vector Control District that can help mitigate the exposure to vector-borne illnesses, by removing ponding water and pests from specific areas. For those with limited mobility who need to seek medical attention, Butte Regional Transit offers paratransit and Dial-A-Ride services that can transport individuals to medical appointments. Even with these adaptive capacity measures, emergency medical response services may be overwhelmed by a human health hazard event. Strengthening medical supply chains and preparing emergency contingency plans for if and when human health hazards increase may take time and require extensive coordination.

5.5. Severe Wind

Butte County's adaptive capacity to severe wind events is similar to extreme heat and severe storms. For those whose homes may be impacted by severe wind, the County has low-cost PACE programs that homeowners can participate in to retrofit their homes to be more protected from severe wind events. Some populations may not feel safe participating in these programs because of immigration status or racial profiling towards low-resourced ethnic minorities (Roos 2018). For those who do not have permanent shelter during severe wind events, several homeless shelters are available throughout the county that can provide safety for these individuals or families.

Some populations, such as communities on single-access roads, persons with disabilities, and seniors, may become isolated during and after severe wind events. Communities on single-access roads can clear fallen trees and debris after a wind event, but this may take hours or days depending on the severity and remoteness of the community. Persons with disabilities and seniors may not be able to travel to find

shelter during extreme wind events. Butte Regional Transit's paratransit and Dial-A-Line services can help these individuals seek treatment following a severe wind event.

Severe wind may also cause PG&E to conduct PSPS events, which can harm both populations and economic drivers. The Butte County Disability Action Center does provide disaster preparedness and training programs and portable battery programs that may be able to assist persons with chronic illnesses and/or disabilities in the event of power loss. For energy delivery, electrical transmission lines can be undergrounded to reduce PSPS events; however, this can be expensive and may be difficult to do for larger transmission lines. Communication services may also be limited if the power is shut off, and there are few redundancies in communication infrastructure in the county, especially in remote mountain areas. Other infrastructure can be retrofitted to resist damage from severe wind or have trees trimmed to reduce damage from other debris carried by severe winds.

Some assets, such as crops flattened by high winds and oak woodlands decimated by sudden oak death, may be unable to recover from an increase in severe winds.

5.6. Severe Storms

Butte County Office of Emergency Management coordinates the overall countywide response to large-scale incidents and severe storm-related disasters through their Emergency Operations Center, which provides information and resources for agencies to coordinate disaster response efforts.

The County's website also provides information on flood evacuation plans for flood zones in southern Butte County that contains strategies to ensure evacuations are handled smoothly. For those with limited mobility or lack of access to transportation, Butte County has a Special Needs Awareness Program, established after the 2008 BTU lightning complex fire, which may be able to assist these individuals or families in evacuations during severe storm events.

General Plan 2030 includes policies that protect people and property from flooding that may be caused by severe storms. 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, and 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 2010).

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. However, the levee system is maintained by independent local levee and reclamation districts and overseen by the U.S. Army Corps of Engineers, California Department of Water Resources, and the Bureau of Reclamation, and would require extensive coordination to raise or extend levees. Many of these are aging and may need repair and maintenance to adequately control flood flows. There are also dams that serve as water storage features in the county and surrounding areas (Butte County 2010). However, in February 2017, an atmospheric river dropped heavy rainfall on the Feather River watershed, filling Oroville Dam more quickly than water could be released. Emergency evacuations occurred throughout Oroville and the communities south of the dam as the emergency spillway crumbled under the weight of the water being released from the dam.

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 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 the Department of Water Resources 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. This 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 by 1 foot or more above the regulatory flood elevation. In addition, 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. The County does participate in PACE financing programs, which can help populations with financial burdens increase the resiliency of their homes to severe storms and flooding.

Severe storms can also cause landslides in mountain areas of the county. Slope stabilization and increasing the capacity of drainage systems can help protect transportation, communication, and electrical infrastructure from damage by landslides. However, this can be difficult in remote areas of the county. Services such as energy delivery, vital good delivery, communication services, public transit access, and other utility services may be disrupted until infrastructure repairs can occur. Landslides may also affect timber harvesting, but they are required to have Timber Harvesting Plans to avoid harvesting trees in landslide-prone areas.

5.7. Wildfire

Butte County Office of Emergency Management coordinates the overall countywide response to large-scale incidents and disasters through their Emergency Operations Center, which provides information and resources for agencies to coordinate disaster response efforts.

There are wildfire evacuation plans for each town and city in the county on the Office of Emergency Management's website that contain strategies to ensure evacuations are handled smoothly and residents know where evacuation meeting points are located. However, those without internet access or linguistically isolated people may have difficulty receiving and acting on evacuation notices and emergency alerts. For those with limited mobility or lack of access to transportation, Butte County has a Special Needs Awareness Program, established after the 2008 BTU Lightning Complex Fire, which may be able to assist these individuals or families in evacuations during wildfires.

Butte County has adopted the 2019 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 2010). Damage to infrastructure development in Butte County must comply with the 2019 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. However, those with limited mobility, chronic illnesses, or lack of financial resources may be unable maintain defensible space around their homes, especially in heavily forested areas.

The 2019 LHMP provides several wildfire hazard mitigation strategies to increase adaptive capacity of county residents and infrastructure to wildfire. These include wildfire fuels reduction and maintenance on the Upper Ridge, Concow/Yankee Hill, Berry Creek, Butte Meadows, Cohasset, Forest Ranch, Feather Falls, and Forbestown. Other hazard-reduction strategies include eave vent replacement and education projects, fire-wise communities and education programs, chipper programs, residents assistance defensible space programs, hazardous tree removal, fuel load management through the Department of Water Resources, and the creation of refuge areas. Policy HS-P11.4 in the Butte County General Plan requires that new development meet current State regulations 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 HS-A11.1 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 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 WUI areas in High or Very High Fire Hazard Severity Zones to provide, at a minimum, small-scale water systems for fire protection (Butte County 2010).

The County's Wildfire Mitigation Action Plan aims 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 (CWPP) of 2015 will help 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. Additional projects completed, in progress, or proposed in the CWPP include fuel reduction, evacuation signage, education programs, defensible space assistance, prescribed burns, defensible space inspections, and general fire planning.

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. Specific programs include a chipper program, residents

assistance program, fire-safe home visits, wildfire education, and forest health and fuels reduction projects.

Butte County Air Quality Management District (BCAQMD) takes actions to reduce exposure to harmful pollutants related to wildfire (e.g., particulate matter) 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. Due to the heavily forested areas of the county and several communities living on single-access roads, the adaptive capacity of several populations and assets is still relatively low for wildfires. As seen in the 2018 Camp Fire and 2020 North Complex Fire, when several of these programs were already in place, people had difficulties evacuating, lost homes and businesses, and suffered economic loss due to these fires.

6. Conclusion

The impacts and adaptive capacity described create several key vulnerabilities within Butte County. The following sections describe the key findings of the Climate Change Vulnerability Assessment and provide recommended actions to increase adaptive capacity and reduce vulnerabilities to populations and assets throughout the county.

6.1. Key Findings

Out of the 71 populations and assets Butte County analyzed, 50 are highly vulnerable to at least one hazard condition. Wildfire is responsible for the highest vulnerability scores, followed by severe storms, severe wind, and extreme heat. The following list provides the key findings and critical vulnerabilities identified in the Climate Change Vulnerability Assessment:

- Populations and assets in the eastern portion of the county are most vulnerable to wildfires and populations in the western portion of the county are most vulnerable to severe storms.
- Outdoor workers and low-resourced ethnic minorities are the most vulnerable populations, and highly vulnerable to all climate change hazards.
- Electrical transmission infrastructure and energy delivery services are highly vulnerable to damage or PSPS events from extreme heat, severe wind, severe storms, and wildfire. Energy delivery services are a key supporting factor for everyday activities, economic drivers, and key services.
- Water and wastewater serving both the county and other areas of California can be disrupted from drought, severe wind, severe storms, and wildfire.
- Major roads, highways, and single-access roads can become impassable due to severe wind, severe storms, and wildfire, isolating populations in remote areas of the county and disrupting services to those areas.
- Recreation infrastructure and recreation on regional, state, and federal land can be disrupted by all climate change hazards.
- Agriculture is the most vulnerable economic driver in Butte County.
- Conifer forests and open water ecosystems are the most vulnerable ecosystems.

6.2. Recommendations

The resilience of these populations and assets can increase through the implementation of adaptation measures. Adaptation is the adjustment to natural and human systems, in response to actual or expected changes in climate conditions to reduce the harmful effects of actual or expected changes (Cal OES 2020).

Potential adaptation measures that could reduce vulnerability in Butte County, and some of which are planned items in the 2019 LHMP, include:

- Promoting the creation of community support networks to check on persons without access to lifelines, seniors living alone, and persons with disabilities during dangerous conditions.
- Collaborating with PG&E and other utility providers to underground electricity transmission lines.
- Increasing funding through grants or private organizations for fuel reduction and vegetation management projects for both neighborhoods and infrastructure.
- Continuing to provide residential assistance programs to help homeowners create and maintain defensible space and fuels management on their properties.
- Conducting structural retrofits for at-risk bridges and ensuring that these retrofits include protections against flooding and landslides.
- Expanding the chipper program throughout the county to help private homeowners dispose of trees near structures, supplementing existing cost-sharing programs.
- Working with farming organizations and the University of California Cooperative Extension to promote the availability of crop varieties that are more resilient to climate change while meeting market demand for yield and quality, as options become available.
- Continuing to work with state and federal land management agencies to support fuel and pest management activities.
- In coordination with local, state, and federal plant and wildlife management agencies and organizations, monitoring shifts in habitats, and preserving habitats where habitat migration may be needed.
- Working with local, state, and federal plant and wildlife management agencies and organizations to protect vulnerable habitat and improve ecosystem connectivity.
- Coordinating with utility providers to conduct regular evaluations and retrofits of energy transmission and delivery infrastructure.
- Incentivizing water conservation measures by establishing indoor plumbing retrofit and turf replacement programs.
- Support the implementation of Groundwater Sustainability Plans that take into consideration of the increased severity of droughts and climate change.
- Identifying equitably located resilience hubs in each community in the County to provide emergency assistance and information, cooling spaces on extreme heat days, and refuge for those who are unable to evacuate during hazardous conditions.

7. References

Bedsworth, Louise, Dan Cayan, Guido Franco, Leah Fisher, Sonya Ziaja. (California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission). 2018. *Statewide Summary Report*. *California's Fourth Climate Change Assessment*. Publication number: SUMCCCA4-2018-013.

Burton, Christopher and Susan L. Cutter. 2008. *Levee Failures and Social Vulnerability in the Sacramento-San Joaquin Delta Area, California*. Natural Hazards Review. Pp 136-149. https://www.researchgate.net/profile/Christopher_Burton3/publication/228756947_Levee_failures_and_social_vulnerability_in_the_Sacramento-San_Joaquin_Delta_area_California/links/00b4953c3a884f3878000000.pdf.

Butte County. 2006. *Butte County Flood Mitigation Plan*. 2006. http://www.buttecounty.net/Portals/19/ButteFMP_FINAL1-8-10.pdf.

Butte County. 2010. *Butte County General Plan Draft Environmental Impact Report*, https://www.buttecounty.net/Portals/10/Docs/GP2030/ButteCountyGP_PublicReview_EIR.pdf?ver=2019-07-25-160952-113.

Butte County. 2020. *Butte County Community Wildfire Protection Plan 2020-2025.* https://buttecounty.opennrm.org/wiki/10689.

Butte County. 2019. *Butte County 2019 Local Hazard Mitigation Plan*.

Butte County. 2021. *Settings and Trends Report.*

Butte County CoC (Butte Countywide Homeless Continuum of Care). 2019 Continuum of Care Homeless Assistance Programs Homeless Populations and Subpopulations, Conducted March 27, 2019. https://files.hudexchange.info/reports/published/CoC_PopSub_CoC_CA-519-2019_CA_2019.pdf.

Butte County Department of Agriculture, Weights, and Measures. 2019. *Butte County 2019 Crop Report*.

Butte County Department of Water and Resources Conservation. 2005. *Integrated Water Resources Plan*. May 2005.

Butte County Department of Water and Resources Conservation. 2016. *Butte County Water Inventory Analysis*. https://www.buttecounty.net/wrcdocs/Reports/I%26A/2016WI%26AFINAL.pdf.

Butte County Department of Water and Resources Conservation. 2017. *Stable Isotope Recharge Study Final Report*. https://www.buttecounty.net/wrcdocs/Reports/SpecialProjects/SIRS/SIRSFinalReport.pdf.

Butte County Department of Water and Resources Conservation. 2018a. *Evaluation of Restoration and Recharge within the Butte County Groundwater Basins*. https://www.buttecounty.net/wrcdocs/Reports/SpecialProjects/GWRecharge/Recharge_Eval.pdf.

Butte County Department of Water and Resources Conservation. 2018b. *Groundwater Status Report* (2017 Water Year). https://www.buttecounty.net/wrcdocs/Reports/GWStatusReports/2017/2017GSRCoverReport.pdf.

Butte County Public Health Department. 2017. *Butte County Community Health Assessment: 2015-2017*.

Cal-Adapt. 2018. "Annual Averages". https://cal-adapt.org/tools/annual-averages/.

CalFlora. 2017. Roy West. http://www.calflora.org/about-cf.html.

California Climate and Agricultural Network. 2019. Cultivating Climate Resilience in Farming: Ensuring California Farms and Ranches Thrive in the Face of Climate Change. https://calclimateag.org/wp-content/uploads/2019/07/Cultivating-Resilience-August-2019.pdf.

California Environmental Protection Agency. 2013 (October) *Preparing California for Extreme Heat.* http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf.

California Department of Forestry and Fire Protection. 2007. Fire Hazard Severity Zones in State Responsibility Areas: Butte County. https://osfm.fire.ca.gov/media/6652/fhszs_map4.pdf.

California Department of Food and Agriculture. 2013. Climate Change Consortium for Specialty Crops: Impacts and Strategies for Resilience. https://www.cdfa.ca.gov/oefi/climate/docs/CCC_Report.pdf.

California Department of Water Resources (DWR). 2020. *California's Groundwater Update 2020.* file:///C:/Users/jprotsman/Downloads/calgw2020_chapters1_6.pdf.

California DWR. 2008. *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*. https://cawaterlibrary.net/document/managing-an-uncertain-future-climate-change-adaptation-strategies-for-californias-water/.

California DWR. 2018. https://www.water.ca.gov/Water-Basics/Climate-Change-Basics

California DWR. 2019. Groundwater Basin Boundary Assessment Tool (BBAT). Last updated February 11, 2019. https://gis.water.ca.gov/app/bbat/.

California Forest Pest Council. 2019. 2018 California Forest Pests Conditions.

California Governor's Office of Emergency Services (CalOES). 2020. *California Adaptation Planning Guide*. June 2020.

California Natural Resources Agency (CNRA). 2012a. *California Adaptation Planning Guide.* http://resources.ca.gov/docs/climate/01APG_Planning_for_Adaptive_Communities.pdf.

CNRA. 2012b. Our Changing Climate 2012: Vulnerability and Adaptation to the Increasing Risk from Climate Change in California. https://ucanr.edu/sites/Jackson_Lab/files/155618.pdf.

CNRA. 2014. Safeguarding California: Reducing Climate Risk—An Update to the 2009 California Climate Adaptation Strategy. http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf.

CNRA. 2016. Safeguarding California: Implementation Action Plan. https://resources.ca.gov/CNRALegacyFiles/docs/climate/safeguarding/Safeguarding%20California-Implementation%20Action%20Plans.pdf.

CNRA. 2018. *Safeguarding California Plan: 2018 Update.* January 2018. https://resources.ca.gov/CNRALegacyFiles/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf.

California Governor's Office of Emergency Services (CalOES). 2018. 2018 State of California Multi-Hazard Mitigation Plan. https://www.caloes.ca.gov/HazardMitigationSite/Documents/002-2018%20SHMP_FINAL_ENTIRE%20PLAN.pdf.

CalOES. 2020. California Adaptation Planning Guide. June 2020. https://www.caloes.ca.gov/HazardMitigationSite/Documents/CA-Adaptation-Planning-Guide-FINAL-June-2020-Accessible.pdf.

California Justice Working Group. 2017. *Advancing Climate Justice in California: Guiding Principles and Recommendations for Policy and Funding Decisions*.

City of Oroville. 2015. *City of Oroville Community Climate Action Plan*. http://www.cityoforoville.org/home/showdocument?id=12191.

Federal Emergency Management Agency (FEMA). 2021. "Butte County." National Flood Hazard Layer Viewer. Accessed May 14, 2021. https://hazards-fema.maps.arcgis.com/apps/webappviewer/index.html?id=8b0adb51996444d4879338b5529aa9cd.

George, Holly; David Lile; Cheree Childers; Cindy Noble; Andrea Oilar; Katherine Haworth; Kristen Schmidt; Gabe Miller. "Upper Feather River Watershed (UFRW) Irrigation Discharge Management Program" (PDF). University of California. Archived from the original (PDF) on 12 June 2010. Retrieved 4 August 2010.

Houlton, Benjamin, Jay Lund. (University of California, Davis). 2018. Sacramento Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-002.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Fourth Assessment Report.* http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml.

IPCC. 2014. *Climate Change 2014 Synthesis Report.* http://www.ipcc.ch/report/ar5/wg1/.

Kershner, J.M., editor. 2014. A Climate Change Vulnerability Assessment for Focal Resources of the Sierra Nevada. Version 1.0. EcoAdapt, Bainbridge Island, WA.

Lenihan, J.M., D. Bachelet, R.P. Neilson, & R. Drapek. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. Clim. Change 87:215-230.

Lenihan, J.M., R. Drapek, D. Bachelet, & R.P. Neilson. 2003. Climate change effects on vegetation distribution, carbon, and fire in California. Ecological Applications 13(6):1667-1681.

Maizlish Neil, English Dorette, Chan Jacqueline, Dervin Kathy, English Paul, 'Climate Change and Health Profile Report Butte County' February 2017.

Motha, Ray. 2011. Chapter 30: The Impact of Extreme Weather Events on Agriculture in the United States.

OPR TAG. 2018. Executive Order B-30-15 Resiliency Guidebook Vulnerable Populations. http://opr.ca.gov/docs/20180312-Vulnerable_Communities_Descriptions.pdf.

Roos, Michelle. (E4 Strategic Solutions). 2018. Climate Justice Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-012.

Sacramento Area Council of Governments. 2015. Sacramento Region Transportation Climate Adaptation Plan. https://www.sacog.org/sites/main/files/file-attachments/2015_sacramento_region_transportation_climate_adaptation_plan_1.pdf?1601491789.

U.S. Census Bureau, 2015. Butte County Poverty Report. https://www.census.gov/quickfacts/fact/table/buttecountycalifornia/PST045217.

U.S. Department of Agriculture. 2011 (August). Social Vulnerability and Climate Change: Synthesis of Literature. http://www.fs.fed.us/pnw/pubs/pnw_gtr838.pdf.

Tapan B. Pathak, Mahesh L. Maskey, Jeffery A. Dahlberg, Faith Kearns, Khaled M. Bali and Daniele Zaccaria. 2018. Climate Change Trends and Impacts on California Agriculture: A Detailed Review.

Appendix A: Countywide Climate Change Projections

Climate Change Stressor	Historical Average 1961-1990	2050 – High Emission (RCP 8.5) 2040-2060	2090 – High Emission (RCP 8.5) 2070-2099
Maximum Average Annual Temperature	71.0°F	76.4° F	80.1°F
Minimum Average Annual Temperature	44.6°F	49.5°F	53.3°F
Annual Average Extreme Heat Days Threshold: 100.1°F	5 days	29 days	59 days
Annual Average Warm Nights Threshold: 64.8°F	4 nights	33 nights	76 nights
Annual Average Precipitation	52.3 inches	47.2 inches	50.8 inches
Annual Average Snowpack Level	1.9 inches	0.5 inches	.01 inches
Annual Average Wildfire Size	5,306 average annual acres per year	8,961 average annual acres per year	13,939 average annual acres per year
Source: California Energy Commission. 2018. "Climate Tools". https://cal-adapt.org/tools/.			

Appendix B: Climate Change Vulnerability Assessment Results Matrix

The Climate Change Vulnerability Assessment Results Matrix shows the detailed results of the vulnerability assessment, which are summarized in in Chapter 4 and Chapter 5 above. The vulnerability assessment evaluates how the populations and assets (people, buildings and structures, resources, etc.) in the unincorporated areas of Butte County are vulnerable to different types of emergencies and hazardous conditions that may be created or made worse because of climate change. The assessment follows the recommended process in the updated *California Adaptation Planning Guide*, as described in Section 1.1, above, which is the State of California's guidance for how local communities should conduct climate adaptation planning efforts, including vulnerability assessments. The vulnerability assessment relies on local, regional, and statewide datasets and studies to support the assessment.

The hazards, populations, and assets were first put into an applicability matrix to determine which hazards would affect which populations and assets. For example, bridge and tunnel infrastructure would likely be affected by wildfire but is not likely to be affected by human health hazards. For each relevant hazard and population or asset pairing, the team assessed the impact from the applicable hazard(s), and the County's adaptive capacity to the hazard. Impact refers to how substantial the effects of the hazard are on the population or asset, from a score of low (low impact) to high (severe impact). Adaptive capacity refers to the population's or asset's ability to resist and recover from damage given current programs and resources, from a score of low (low adaptive capacity) to high (high adaptive capacity).

The combination of the impact (IM) and adaptive capacity (AC) score determines the population's or asset's vulnerability to that hazard. A low impact and high adaptive capacity score lead to low vulnerability, while a high impact and low adaptive capacity score leads to a high vulnerability score. The vulnerability scores are:

- Low: Minimal to low vulnerability
- Medium: Moderate vulnerability
- High: High to severe vulnerability

Populations and Assets	Agriculture and Forestry Pests and Diseases	Drought	Extreme Heat	Human Health Hazards	Severe Wind	Severe Storms	Wildfire
Populations							
Children	-	-	High	Medium	Medium	High	High
Cost-burdened households	-	Low	Medium	Medium	Low	Medium	Medium
Households in poverty	-	High	High	High	High	High	High
Immigrant communities	High	Medium	High	High	High	High	High
Linguistically isolated persons	-	-	Medium	Medium	Medium	Medium	High
Low-income households	-	Low	Medium	Medium	Medium	Medium	High
Low-resourced ethnic minorities	High	High	High	High	High	High	High
Overcrowded households	-	-	Medium	High	Low	Medium	Medium
Outdoor workers	High	High	High	High	High	High	High
Persons experiencing homelessness	-	-	High	High	High	High	High
Indigenous peoples and tribal nations	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Persons living in mobile homes	-	-	High	Low	High	High	High
Communities on single access roads	Medium	-	Low	Low	High	High	High
Persons with disabilities and/or chronic illnesses	-	-	High	High	High	Medium	High
Persons without access to lifelines	-	-	Medium	Medium	Medium	Medium	Medium
Renters	-	-	Low	Low	Low	Medium	Medium
Seniors	-	-	High	High	Medium	High	High
Seniors living alone	-	-	High	High	High	High	High
Students	-	-	Low	Low	Low	Low	Low

Populations and Assets	Agriculture and Forestry Pests and Diseases	Drought	Extreme Heat	Human Health Hazards	Severe Wind	Severe Storms	Wildfire
Buildings and Infrastructure							
Airports	-	-	Low	-	Low	Low	Low
Bridges and tunnels	-	-	-	-	High	High	Medium
Communication facilities	-	-	Medium	-	High	Medium	Medium
Community centers and libraries	-	-	Medium	-	Medium	Medium	Medium
Dams	-	-	-	-	-	High	Low
Electrical transmission infrastructure (substations and power lines)	Low	-	High	-	High	High	High
Emergency operation buildings	-	-	Low	-	Low	Low	-
Evacuation and cooling centers	-	-	Medium	-	Medium	Medium	High
Flood control infrastructure (levees, dikes, etc.)	-	-	-	-	-	High	-
Government administrative facilities	-	-	Medium	-	Low	Low	-
Hazardous materials sites	-	-	-	-	-	Medium	Medium
Hiking and biking trails	Low	Low	-	-	Low	High	High
Homes and residential structures	High	-	Medium	-	High	High	High
Hospitals and medical facilities	-	-	Low	-	Low	Low	Low
Major roads and highways	Medium	-	Medium	-	-	High	High
Natural gas pipelines	-	-	-	-	-	Medium	Medium
Parks and open space	Low	Low	Medium	-	Low	Low	Medium
Power plants	-	-	Low	-	Medium	High	Medium
Public safety buildings	-	-	Low	-	Low	Medium	High

Populations and Assets	Agriculture and Forestry Pests and Diseases	Drought	Extreme Heat	Human Health Hazards	Severe Wind	Severe Storms	Wildfire
Railways	Low	-	High	-	-	High	High
Schools	-	-	Medium	-	Medium	Medium	High
Single access, rural, and minor roads	High	-	Medium	-	High	High	High
Solid waste facilities and landfills	-	-	-	-	Low	Low	Medium
Transit facilities	-	-	-	-	High	Medium	Low
Water and wastewater infrastructure	-	Low	-	-	-	Medium	High
Waterway infrastructure	-	Medium	-	-	-	Low	Low
Economic Drivers							
Agriculture	High	High	High	High	High	High	High
Construction	-	-	Medium	Medium	Medium	Medium	Medium
Education	-	-	-	Medium	Low	Low	Low
Healthcare	-	-	Low	Medium	Low	Low	Medium
Livestock	Medium	High	High	Low	Medium	Medium	High
Manufacturing	-	-	-	Low	Low	Low	Low
Regional recreation & tourism	Low	High	Medium	Medium	Medium	Medium	High
Rice-growing areas	Medium	High	Medium	High	Medium	High	Low
State and federal land recreation and tourism	High	High	High	Medium	Medium	Medium	High
Timber production	High	High	High	Medium	Low	High	Medium

Populations and Assets	Agriculture and Forestry Pests and Diseases	Drought	Extreme Heat	Human Health Hazards	Severe Wind	Severe Storms	Wildfire
Ecosystems and Natural Resources							
Conifer forest	High	High	High	-	Low	Low	High
Oak woodland	High	Low	Low	-	High	Low	Low
Riparian woodland	Medium	Medium	Medium	-	Medium	Medium	Medium
Chaparral	High	Medium	Low	-	Medium	Low	High
Annual grassland	Low	Medium	Low	-	Low	Low	Medium
Open water: reservoirs, ponds, drainages	Low	High	High	-	Low	High	High
Wetlands	Low	High	High	-	Low	Medium	Medium
Pacific Flyway	Low	High	High	-	Medium	Low	High
Key Services							
Communication services	Medium	-	Medium	-	High	High	Medium
Emergency medical response	Low	-	Medium	High	Low	Medium	Medium
Energy delivery	High	Low	High	-	High	High	High
Vital goods delivery	Medium	-	Low	Low	Low	High	Medium
Government administration	-	-	Low	Low	Low	Low	Low
Public safety response	Low	-	Low	Medium	Medium	Medium	High
Public transit access	Medium	-	High	Low	High	High	Medium
Water and wastewater	-	High	Medium	-	Low	High	High

Appendix C: Glossary

The Climate Change Vulnerability Assessment uses some terms specific to adaptation planning. The following identifies and defines key terms that will be used throughout the vulnerability assessment. For a more comprehensive list of terms commonly used in adaptation planning, consult the California Adaptation Planning Guide (https://www.caloes.ca.gov/climate).

List of Terms[i]

Adaptation: Making changes in response to current or future conditions (such as the increased frequency and intensity of climate-related hazards), usually to reduce harm and to take advantage of new opportunities.[ii, iii]

Adaptive Capacity: The "combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities."[iv]

Climate Change: A change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

Community Asset: A valued feature of a community that may be harmed by climate change. Community assets may include buildings, infrastructure, community services, ecosystems, and economic drivers. See also "*Populations and Assets*."

Disadvantaged Communities: Areas disproportionately affected by environmental pollution and other hazards that can lead to negative public health effects, exposure, or environmental degradation, or with concentrations of people that are of low income, high unemployment, low levels of homeownership, high rent burden, sensitive populations, or low levels of educational attainment.[v,vi]

Drought: When conditions are drier than normal for a long period of time, making less water available for people, agricultural uses, and ecosystems.

Economic Driver: Economic assets in Butte County, including three agricultural-based sectors, major employment industries, and recreation and tourism on regional, state, and federal lands.

Exposure: The presence of people, infrastructure, natural systems, and economic, cultural, and social resources in areas that are subject to harm.[vii]

Extreme Event: When a weather or climate variable exceeds the upper or lower thresholds of its observed range.[viii, ix]

Extreme Heat: When temperatures rise significantly above normal levels and is measured by the number of extreme heat events per year and heat wave duration. An extreme heat day in Butte County is where temperatures reach at least 100.1°F.

Frontline Population: Those disproportionately affected by climate change. See "*Vulnerable Populations.*"

Hazard: An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural losses, damage to the environment, interruption of business, or other types of harm or loss.[x]

Hazard Mitigation: Sustained action taken to reduce or eliminate the long-term risk to human life and property through actions that reduce hazard, exposure, and vulnerability.[xi]

Impact: The effects (especially the negative effects) of a hazard or other conditions associated with climate change.

Populations and Assets: Populations and assets are the people, infrastructure, services, and economic drivers in Butte County that can be affected by climate change.

Resilience: The capacity of any entity—an individual, a community, an organization, or a natural system—to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience. Community resilience is the ability of communities to withstand, recover, and to learn from past disasters to strengthen future response and recovery efforts.

Risk: The potential for damage or loss created by the interaction of hazards with assets such as buildings, infrastructure, or natural and cultural resources.

Sensitivity: The level to which a species, natural system, or community, government, etc., would be affected by changing climate conditions.[xii]

Susceptibility: A person or population's potential for vulnerability due to demographic, socioeconomic, and geolocation characteristics.

Vulnerability: Climate vulnerability describes the degree to which natural, built, and human systems are susceptible "…to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt."[xiii]

Vulnerability Assessment: An analysis of how a changing climate may harm a community and which elements—people, buildings and structures, resources, and other assets—are most vulnerable to its effects based on an assessment of exposure, sensitivity, the potential impact(s), and the community's adaptive capacity.

Vulnerable Populations: Vulnerable populations include, but are not limited to, elderly, children, agricultural and outdoor workers, and those suffering from pre-existing cardiovascular or respiratory conditions.[xiv, xv]

8. Endnotes

[i] California Governor's Office of Emergency Services, "California Adaptation Planning Guide", 2020.
[ii] Louise Bedsworth, Dan Cayan, Guido Franco, Leah Fisher, Sonya Ziaja, "Statewide Summary Report," in *California's Fourth Climate Change Assessment*, publication number: SUMCCCA4-2018-013, 2018.
[iii] California Natural Resource Agency, *Safeguarding California Plan: 2018 Update: California's Climate Adaptation Strategy*, 2018, http://resources.ca.gov/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf.
[iv] Intergovernmental Panel on Climate Change, "Annex II: Glossary," ed. K. J. Mach, S. Planton, and C. von Stechow, in *Climate Change 2014: Synthesis Report*, ed. Core Writing Team, R. K. Pachauri, and L. A. Meyer (Geneva, Switzerland: IPCC, 2014), p. 117–130, https://www.ipcc.ch/report/ar5/syr/.
[v] California Natural Resource Agency, *Safeguarding California Plan: 2018 Update: California's Climate Adaptation Strategy*, 2018, p. 231.
[vi] California Health and Safety Code, Division 26, Part 2, Chapter 4.1, "Greenhouse Gas Reduction Fund Investment Plan and Communities Revitalization Act," Section 39711.
[vii] Louise Bedsworth, Dan Cayan, Guido Franco, Leah Fisher, Sonya Ziaja, "Statewide Summary Report," in *California's Fourth Climate Change Assessment*, publication number: SUMCCCA4-2018-013, 2018.
[viii] California Natural Resource Agency, *Safeguarding California Plan: 2018 Update: California's Climate Adaptation Strategy*, 2018, p. 231.
[ix] International Panel on Climate Change, "Glossary of Terms," in Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, special report of Working Groups I and II of the IPCC, ed. C. B. Field et al. (Cambridge, UK, and New York: Cambridge University Press, 2012), p. 555–564, https://www.ipcc.ch/site/assets/uploads/2018/03/SREX_Full_Report-1.pdf.
[x] California Governor's Office of Emergency Services, *California State Hazard Mitigation Plan*, 2018, https://www.caloes.ca.gov/cal-oes-divisions/hazard-mitigation/hazard-mitigation-planning/state-hazard-mitigation-plan.
[xi] California Governor's Office of Emergency Services, *California State Hazard Mitigation Plan*, 2018.
[xii] California Natural Resource Agency, *Safeguarding California Plan: 2018 Update: California's Climate Adaptation Strategy*, 2018, p. 231.
[xiii] Neil Adger, "Vulnerability," *Global Environmental Change* 16 (2006): 268–281, https://www.geos.ed.ac.uk/~nabo/meetings/glthec/materials/simpson/GEC_sdarticle2.pdf.
[xiv] California Natural Resource Agency, *Safeguarding California Plan: 2018 Update: California's Climate Adaptation Strategy*, 2018, p. 231, http://resources.ca.gov/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf.
[xv] California Health and Safety Code, Division 112, Part 1, Chapter 1, "Organization of the State Department of Public Health," Section 131019.5.