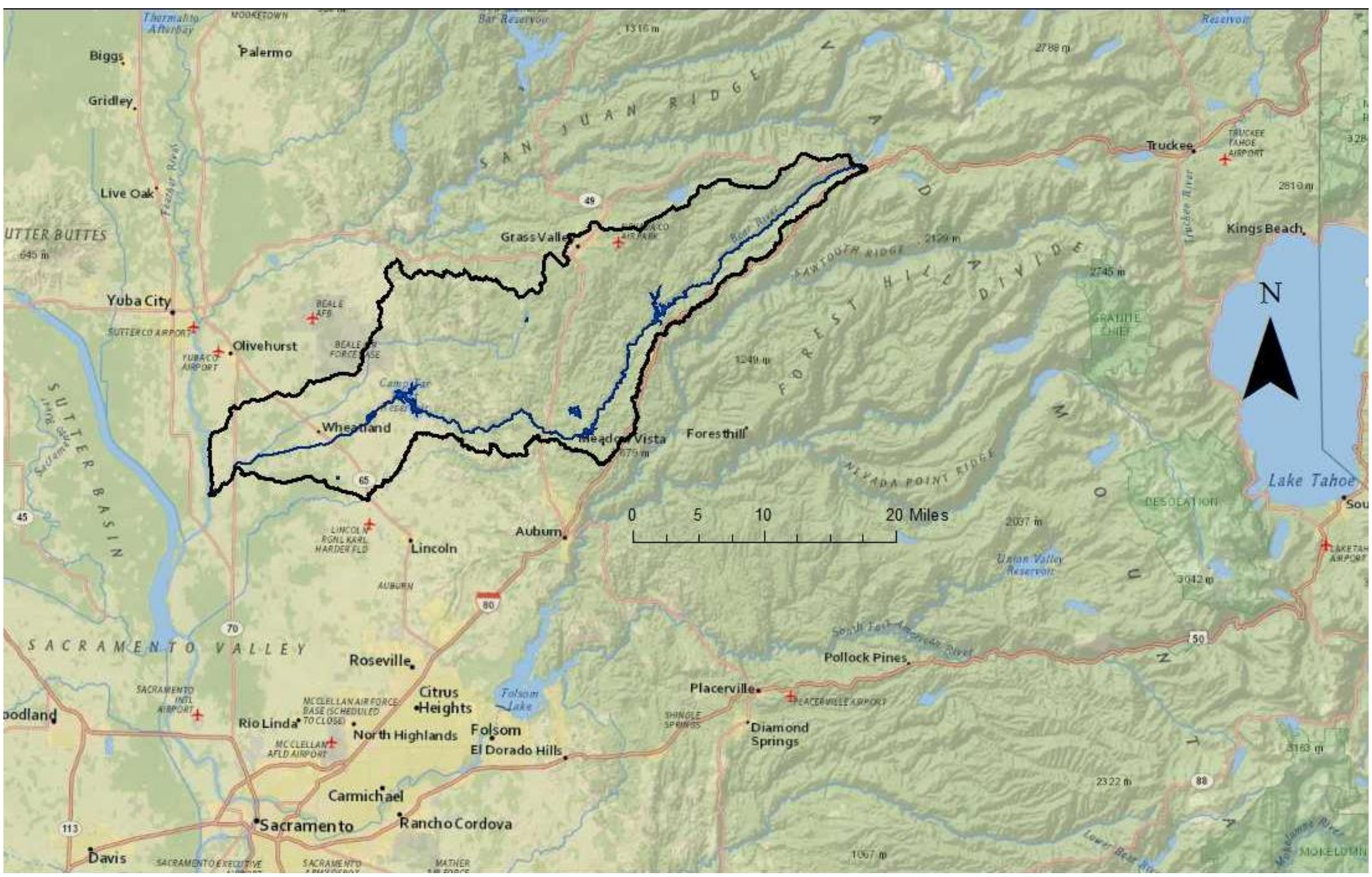
Bear River Watershed

Disturbance Inventory and Existing Conditions Assessment 2016

Sierra Streams Institute



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March 31, 2016

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I. Acknowledgements

This study is the beginning of a restoration planning process for the Bear River Watershed, the culmination of decades of study by the researchers cited in our reference list, the fruit of collaboration with the stakeholders listed on the preceding pages, and the result of months of dedicated work by the Sierra Streams Institute team. The Bear River Watershed restoration planning process began with the inspiration of Sierra Streams' executive director Joanne Hild to expand the organization's successful work as Friends of Deer Creek into this additional watershed much in need of coordinated study and restoration. Jane Sellen wrote the grant proposal that resulted in Bureau of Reclamation WaterSMART funding to put this inspiration into action. With Joanne's guidance, Jane also began the process of coordinating stakeholders as the first project manager under the grant. With her, Julia Berkey co-led the first several months of relationship building and data gathering with stakeholders, before the two moved out of the region. Kristen Hein Strohm joined the team as the new project manager at that time, and continued the process of stakeholder engagement with facilitator Julie Leimbach and Carmen Fraser. Kristen also researched and wrote several portions of this study, and provided guidance for the remaining authors of this document. The initial document structure was inspired by the 2003 Bear Watershed Disturbance Inventory developed by Fraser Shilling and Evan Girvetz, which we also cited frequently in this study. Alexandra Lincoln and Leah Campbell are the primary authors of this substantial work, supplying thoughtful and thorough analyses throughout all major sections of the document. Their work was substantially supported by Carmen Fraser in the Human Community and Land Use section, Denise Della Santina in the terrestrial Biological Resources section, Justin Wood in the Hydrology section, and Peter Burnes in the Fisheries sections. Sheli Meylor skillfully analyzed the available Benthic Macroinvertebrate data and authored the section on these species as ecosystem indicators of water quality. The Bear Watershed Stakeholder Group's diverse range of local knowledge and subject-area expertise was invaluable to gathering many of the source documents upon which our analyses were based, identifying high-priority questions about watershed conditions for us to address, and reviewing draft versions of the document. The authorship team also reviewed each other's sections for accuracy, and Jennifer Langdon supplied a further layer of document quality assurance with her skillful review. Leah Campbell provided the final document formatting. Irene Hoiby and Tom Hawes graciously managed the Bureau of Reclamation grant, while Lisa Frankel and Jim Primrose kept the finances in check on our end. Sierra Streams Institute is abundantly grateful to the many volunteers and donors who have supported our work over the years. We look forward to continued collaboration as we begin the next phase of restoration planning for this vital watershed. Thank you all!

II. Introduction

The Bear River Watershed, on the western slopes of the northern Sierra Nevada, is one of the most impacted, and simultaneously least-studied, watersheds in the state. It is home to a diversity of plant, wildlife, and human communities, and has a complex history of development and anthropogenic impact. This report seeks to provide a narrative of the existing conditions and an inventory of the current and historical disturbances in the watershed. It was produced using the input of a variety of stakeholders and is modeled on a previous Disturbance Inventory produced in 2003 (Shilling and Girvetz, 2003). It is the first step in producing a long-term restoration plan and was made possible by the generous support of the Bureau of Reclamation.

Below, in Table 1, is a timeline of major disturbances and important historical events related to the Bear River Watershed. More information on individual events and the larger context of those events can be found in below throughout the Disturbance Inventory. The fires included in the timeline are only those that burned more than 5,000 acres.

***Table 1*. Timeline of important events and major disturbances in Bear Watershed**

1849	California Gold Rush begins at Sutter's Mill in American River watershed
1852	Construction of the Bear River Canal
1853	Hydraulic mining used for first time, just outside Nevada City
1865	Transcontinental railroad completed, leading to large-scale development
1877	Peak production of Coast Range mercury mining
1884	Sawyer Decision imposes laws regulating downstream debris from hydraulic mining
1893	Caminetti Act passed to regulate hydraulic mining and create California Debris Commission
1902	Construction of the Alta Powerhouse, which remains oldest functioning hydroelectric plant in the state
1911	Nisenan Rancheria granted tribal lands outside of Nevada City
1917	Unnamed fire on Greenhorn Creek (6270 acres)
1928	Van Giesen Dam constructed (85 ft tall) to form Lake Combie
1942	Construction of Beale Air Force Base
1943	California Water Code enacted
1958	Nisenan Rancheria land revoked by federal order
1963	FERC licenses issued to NID and PG&E for Yuba-Bear and Drum-Spaulding Hydroelectric Projects
1963	Camp Far West Dam (185 ft tall) constructed as part of State Water Project

1965	Rollins Reservoir Dam constructed (242 ft tall)
1970	California Environmental Quality Act enacted
1972	Federal Clean Water Act (CWA) enacted
1973	Federal Endangered Species Act enacted
1981	FERC license issued to SSWD for Camp Far West Hydroelectric Project
1982	NID receives amendment to license to construct Rollins Reservoir
1988	49'er fire on Dry Creek (36,343 acres)
1994	Bear River below Camp Far West 303(d) listed for diazinon under the CWA
2010	Bear River below Camp Far West 303(d) listed for chlorpyrifos under the CWA
2013	FERC license for Yuba-Bear and Drum-Spaulding Hydroelectric Projects expired

Indicators of Watershed Health

In 2010, a team of regional experts convened to assess the condition of the subwatersheds of the Sacramento River Basin, as part of the EPA's Healthy Watersheds Initiative. The result was the The Sacramento River Basin Report Card and Technical Report (Aalto *et al*. 2010), which assigned a score of 0-100 to individual subwatersheds for 16 indicators of both natural and human processes. Scores are not available for every watershed for every indicator and **lower scores suggest greater instability or stress, while higher scores indicate relative health**, More information on sources of data, how individual scores were calculated, and how indicators were selected can be found in the report.

Table 2 shows the scores calculated for the Upper and Lower Bear subwatersheds for each of the 16 indicators, as well as the Watershed Assessment Framework (WAF) attribute of each indicator. The WAF comes from the 2006 California Watershed Action Plan. The Report Card divides the entire Bear Watershed into Upper and Lower based on USGS-defined subwatersheds. The Upper Bear includes the Upper and Middle Bear subwatersheds and the Wolf Creek watershed. The Lower Bear includes the Lower Bear subwatershed and the Dry Creek watershed. The Middle and Lower Bear subwatersheds are divided at Camp Far West Reservoir. A map of these subwatersheds can be found in Figure 1. Text explanations of each of the 16 indicators follow the table, as well as a brief description, taken from the report, of each of these watersheds. N/A refers to those sites where there were insufficient data available to calculate a score.

Table 2. **Sacramento River Report Card indicator scores for Bear Watershed**

Indicator	Watershed Assessment Framework Attribute	Upper Bear	Lower Bear
Periphyton Cover and Biomass	Biotic Condition	n/a	n/a
Surface Water Temperature	Physical/ Chemical	79	82
Mercury in Fish Tissue	Physical/ Chemical	0	41
Flow Patterns and Alteration	Hydrology/ Geomorphology	60	41
Bird Species Diversity	Biotic Condition	100	100
Proportion of Watershed as Agricultural/Urban	Landscape Condition	88	82
BMI Community Structure (total taxa richness)	Biotic Condition	44	n/a
Fish Community Diversity	Biotic Condition	51	n/a
Aquatic Habitat Barriers	Hydrology/ Geomorphology	67	79
Terrestrial Habitat Fragmentation	Landscape Condition	14	2
Carbon Stock and Sequestration	Ecological Processes	91	93
Nitrogen Load/Cycling	Ecological Processes	n/a	98
Fire Frequency	Natural Disturbance	0	4
Flooding and Floodplain Access	Natural Disturbance	n/a	38
Pesticide Application and Organic Agriculture	Social Condition	100	62
School Lunch Program Enrollment	Economic Condition	70	61

The **cover and biomass of periphyton**, which is both benthic algae and submerged vascular plants, are considered good indicators of water quality and pollution because of periphyton's important role as the base of the food web. Excessive algae growth is a water quality concern because it can deplete the system of nutrients and have negative impacts of dissolved oxygen (DO) levels, carbon production, pH, and nutrient cycling, thus impacting species in higher trophic levels. Scores for this indicator were calculated using the percent cover and dry weight of algae. A score of zero implies 100% cover while a score of 100 corresponds to 35% cover. Because of a lack of data on percent cover and biomass measurements in both the Upper and Lower Bear watersheds, scores were not available for this indicator.

Changes in **surface water temperature** can have important impacts on aquatic ecology by changing biotic community structure and facilitating the invasion of exotic species. Non-seasonal variations in water temperature are primarily caused by water diversions for human consumption and riparian land use. In this region, maximum water temperature is particularly important given the patterns of water withdrawals and diversions for human use, as well as the fragility of salmonid fish communities, which are highly dependent on the availability of cool water habitat. Scores for this indicator were calculated for each watershed using the maximum seven-day average daily maximum temperature (7DADM) for each year and each subwatershed. A score of 100 corresponds to a system that meets the EPA's guidelines of maximum 7DADM temperatures below 18°C in order to sustain salmonid populations. A score of 0 is given to a system with maximum 7DADM temperatures of 25°C, the lethal point for juvenile Chinook salmon. The Upper Bear watershed had a score of 79, while the Lower Bear had a score of 82, for this indicator, which is considered good. The Upper Bear showed a positive trend in water temperature, while the Lower Bear illustrated a negative trend; however, the authors stress that there were insufficient data available for these watersheds in this area to be very confident of this trend.

Mercury contamination is a serious water quality issue given the potentially toxic effects of mercury on humans and wildlife and its propensity to bioaccumulate as it moves up the food web. It is also of particular concern in this region because of the extensive mining history and the quantities of mercury used in gold recovery throughout the 19th and early 20th century. Available data suggest that sources of methylmercury, the toxic biologically available form of mercury, other than the consumption of contaminated fish were negligible and thus scores were based on the concentrations of methylmercury found in fish tissue compared to the EPA methylmercury water quality criterion. While the Lower Bear had a score of 41, the second highest of all subwatersheds in the basin, the Upper Bear, because of its extensive gold mining history, had a score of zero and thus some of the highest concentrations in the basin.

Hydrologic alteration, a measure of how current flow patterns compare to the natural flow regime, is an important indicator of the extent of human disturbance on a watershed. The flow regime can have important impacts on riparian and aquatic communities by altering the transport of sediment and nutrients, the establishment of invasive species, and soil composition. Hydrologic alteration is caused by human infrastructure, such as dams, weirs and paved surfaces, as well as erosion and losses of vegetation cover. While the Upper Bear had a score of 60, one of highest of any subwatershed, the Lower Bear had a score of 41, which makes it one of the most highly altered subwatersheds in the basin, primarily due to extensive water management that has changed the timing of extreme flow events.

Bird species diversity is an important, and visible, indicator of watershed biodiversity and can be affected by degradation of habitat and changes in land use, such as development, deforestation and conversion to agriculture. In order to quantify species diversity, the Report Card considered changes in species richness over time for each subwatershed at a community level. Both the Upper and Lower Bear had scores of 100 for this indicator, suggesting that there was no decline in bird species richness over the past ten years.

The proportion of **land in a watershed classified as agricultural and urban** is a valuable indicator of human disturbance of the landscape because of the impacts of these land uses on ecological function. Conversion of land changes sediment and nutrient loading in aquatic systems can increase rates of runoff and the transport of pollutants into waterways, and can lead to the fragmentation and destruction of productive habitat. Non-agricultural, rural land use can also strongly affect natural processes and is thus also quantified using housing unit density. The foothills and mountain regions tend to have high scores because of the low proportion of urban or agricultural land and the low population densities. The Upper and Lower Bear were both classified as intermediate to relatively good for this indicator, with scores of 88 and 82, respectively. The score for the Lower Bear was unsurprisingly lower because of the increase in agriculture as one approaches the valley.

The monitoring of **freshwater benthic macroinvertebrate** (BMI) communities provides an indicator of the ability of a watershed to support biological communities and the integrity of those communities. BMIs are widespread, easy to collect and identify, relatively sedentary, and often highly sensitive to pollution so they are ideal species to monitor to assess overall biological health of a watershed over the long term. The Report Card uses total taxa richness and the richness of the Ephemeroptera (EPT) taxa, whose populations are a good proxy for pollution, in order to calculate watershed scores for this indicator. While there was insufficient data to calculate a score for the Lower Bear, the Upper Bear was given a score of 44 for total taxa richness and 37 for EPT taxa richness, both of which are on the lower end of subwatersheds in the basin.

The abundance and **diversity of fish** is an effective indicator of watershed health because fish can provide an integrated measure of aquatic condition due to their mobility, higher trophic level, and relatively long-life. Fish diversity can be affected by habitat degradation, changes in sediment and nutrient transport, increases in stream temperature, and competition with non-native species. To calculate scores, the authors considered both the proportion of species collected that were native and the percentage of native species expected, which is a measure of species richness observed compared to what is expected based on data from the larger region. A score of 100 indicates that all species observed were native and that every species expected was found in the watershed. The Upper Bear watershed had a score of 51, which was intermediate within the larger basin suggesting declines in certain native species or increases in non-native species populations. There were no data available in the Lower Bear watershed.

The abundance and permeability of **aquatic habitat barriers**, which includes man-made structures like dams and weirs, is used an indicator of the connectivity of aquatic habitat. Disruptions in the waterway can change the natural flow regime, prevent the movement of aquatic species, and affect the transport of sediments. Scores are calculated considering the number of barriers per linear kilometer of river, and do not consider the nature of the barriers and whether they are partial or complete barriers. While the Lower Bear had a score of 79, which is one of the highest of any subwatershed, the Upper Bear had a score of only 67, which was the lowest of all subwatersheds in the basin. This is likely due to extent of anthropogenic water management in this watershed and the high density of diversions and canals.

Terrestrial habitat fragmentation provides an indicator of landscape condition. Fragmentation can cause disruptions in natural chemical, hydrological and geomorphological processes, thus reducing the resiliency and integrity of the larger system. Fragmentation also has important implications for terrestrial and aquatic species by altering habitat quality and connectivity. Changes in land use for human activity are the most visible and direct cause of fragmentation. Scores were calculated using effective mesh size, which considers the probability that two points chosen randomly in a region will be connected. The lower the effective mesh size, the more fragmented the landscape. The Lower Bear had a score of only two for this indicator, which was the lowest of any subwatershed in the basin and corresponds to an effective mesh size of only 1210 acres. The Upper Bear had a score of only 14, which was also one of the lower scores in the basin.

The **carbon stock and sequestration** indicator considers the rates of carbon sequestration and net primary productivity, which are both primarily controlled by forest cover, to assess both present and future watershed condition. Most of the data used to investigate these processes come from remote sensing and vegetation plot data. This indicator is important for understanding long-term environmental change and the climate change mitigation potential of regional forests. The scores for the Upper and Lower Bear watersheds for this indicator were both quite high, at 91 and 93, respectively, which was typical across the entire basin.

Understanding the processes of **nitrogen loading and cycling** in a watershed is important for determining the rate of primary productivity, food web dynamics and overall ecological functioning because of the role of nitrogen in biological processes. Human disturbance often leads to an overabundance of nutrients like nitrogen, often from agriculture, which can decrease biological diversity and lead to harmful algae blooms and toxically low values of DO. Nitrogen is thus, one of the significant forms of pollution in aquatic environments. For the Report Card, the target for good condition, a score of 100, corresponds to a Total Kjeldahl Nitrogen (TKN, ammonia and organic nitrogen) concentration of 0.1mg/L, while a score of zero corresponds to a concentration of 1mg/L TKN. There was not enough information to calculate a score for the Upper Bear. The Lower Bear watershed received a score of 98 for this indicator, the second highest score in the basin, which suggests that nitrogen is not a significant source of pollution.

Fire frequency is an indicator of both human disturbance to the forest landscape and larger climactic patterns. It can be affected by disease pressure, drought, fire management practices, logging, and climate cycles like El Niño. Changing conditions can affect both the frequency of fires as well as their intensity. To calculate a score for this indicator, the authors used the fire return interval, which compares the observed fire frequency over the last 100 years to the expected fire frequency using vegetation data. Lower scores reflect a current fire regime that differs dramatically from natural and historical patterns. The fire regime of the Upper and Lower Bear clearly has diverged dramatically from historical conditions, given the low scores of only zero and four, respectively, assigned for this indicator.

The **flooding** regime, as with fire frequency, is an important indicator of how current conditions differ from historical and natural patterns; it also has important implications for hydrological and geomorphological processes. Similarly, floodplain access is an indicator of how well a watershed can handle a flood, which also has effects on the composition and quality of riparian vegetation. Given the importance of riparian habitat and the floodplain region, the flooding regime and floodplain access are important measures of the health of a watershed and the potential impacts of flooding on human communities. Floodplains on most inhabited rivers have been greatly modified by human development and flood control structures like levees. Data were insufficient to calculate a score for most of the subwatersheds in the basin. While there were insufficient data available for the Upper Bear, the Lower Bear received a score of only 38 for this indicator, likely due to the abundance of agricultural land on the floodplain in this watershed.

Pesticide use and the presence of organic agriculture are important indicators of wildlife-friendly agricultural practices and the social condition of a watershed. Pesticide use affects biological communities and human health, and reflects the impact of economic demand on agricultural practices. In this way, this indicator reflects the relationship between economic and ecological health of the watershed. The report assumes that no pesticide use is the best possible condition and thus equates this with a score of 100. While the Upper Bear received a score of 100 for this indicator, with no significant change over time, the Lower Bear received a score of only 62, with not enough data available to determine the trend over time. This low score is not surprising given the intensity of agriculture in this watershed.

Enrollment of children in school lunch programs is a valuable measure of poverty levels and income inequity, which has impacts on life expectancy, well-being and academic performance. Logging, mining and agriculture, some of the largest job providers in the region, are notoriously unstable industries, while, in recent years, there has been an increase in ex-urban migration. All of these factors control rates of poverty. For the Report Card, 0% enrollment in school lunch programs was considered a good target, corresponding to a score of 100. The score for all intermediate watersheds was calculated as 100 minus the percentage of children enrolled. The Upper and Lower Bear watersheds received relatively high scores for this indicator, receiving scores of 70 and 61, respectively, suggesting relatively lower levels of poverty in these watersheds, based on the assumptions made by this report.

III. Inventory

III.A. Hydrologic and Geologic Setting

III.A.1. Area and delineation of watersheds

There are five Hydrologic Unit Code (HUC)-10 subwatersheds within the Bear River watershed: Wolf Creek, Dry Creek and the upper, middle and lower sections of the Bear River (Figure 1). The largest subwatershed is the Dry Creek watershed at approximately 73,143 acres. The total watershed area is almost 303,500 acres. Watershed boundary data was acquired through the Watershed Boundary Dataset (WBD) of The National Map, operated jointly by the US Geological Survey (USGS) and the Environmental Protection Agency (EPA). The WBD represents drainage basins as enclosed areas at eight different HUC categories. The Bear River Watershed has the HUC-8 code, 18020126. It has five HUC-10 subwatersheds, and 12 HUC-12 subwatersheds.

III.A.2. Stream mileage and density

Data on the hydrography of the Bear River watershed, shown in Figure 2, are taken from the National Hydrography Dataset (NHD) of The National Map. The NHD contains spatial information on rivers, streams, canals, lakes, ponds, coastlines, dams and stream gauges across the US. The NHD includes 6.5 million lakes and ponds and 7.5 million miles of streams and river across the US. Work to produce a high-resolution (1:24,000 scale) map for the coterminous US began in 2002 and was completed in 2007. Information on the standards and definitions used in the NHD can be found at http://nationalmap.gov/standards/pdf/NHD0799.PDF. In Figure 2, the 'Pipe' designation includes both pipes and artificial waterway connectors, while the 'Canal' designation includes canals, artificial ditches and aqueducts. 'Streams' refer to both intermittent and perennial streams.

The main stem of the Bear River is approximately 75 miles long. The total stream mileage is approximately 960 miles. This includes intermittent and perennial streams, but not artificial canals, which total 284 miles, or ephemeral streams, which are located primarily in the upper watershed and remain poorly mapped. The most up-to-date data estimates total stream distance of ephemeral streams to be at least 280 miles. There are also at least 40 miles of artificial pipes and connectors, used primarily for irrigation and water diversions. In addition, the watershed includes 3,138 acres of lakes, ponds and reservoirs, not including intermittent water bodies, the largest of which by area is Rollins Reservoir.

Figure 1. HUC-10 (Hydrologic Unit Code) Subwatershed Boundaries

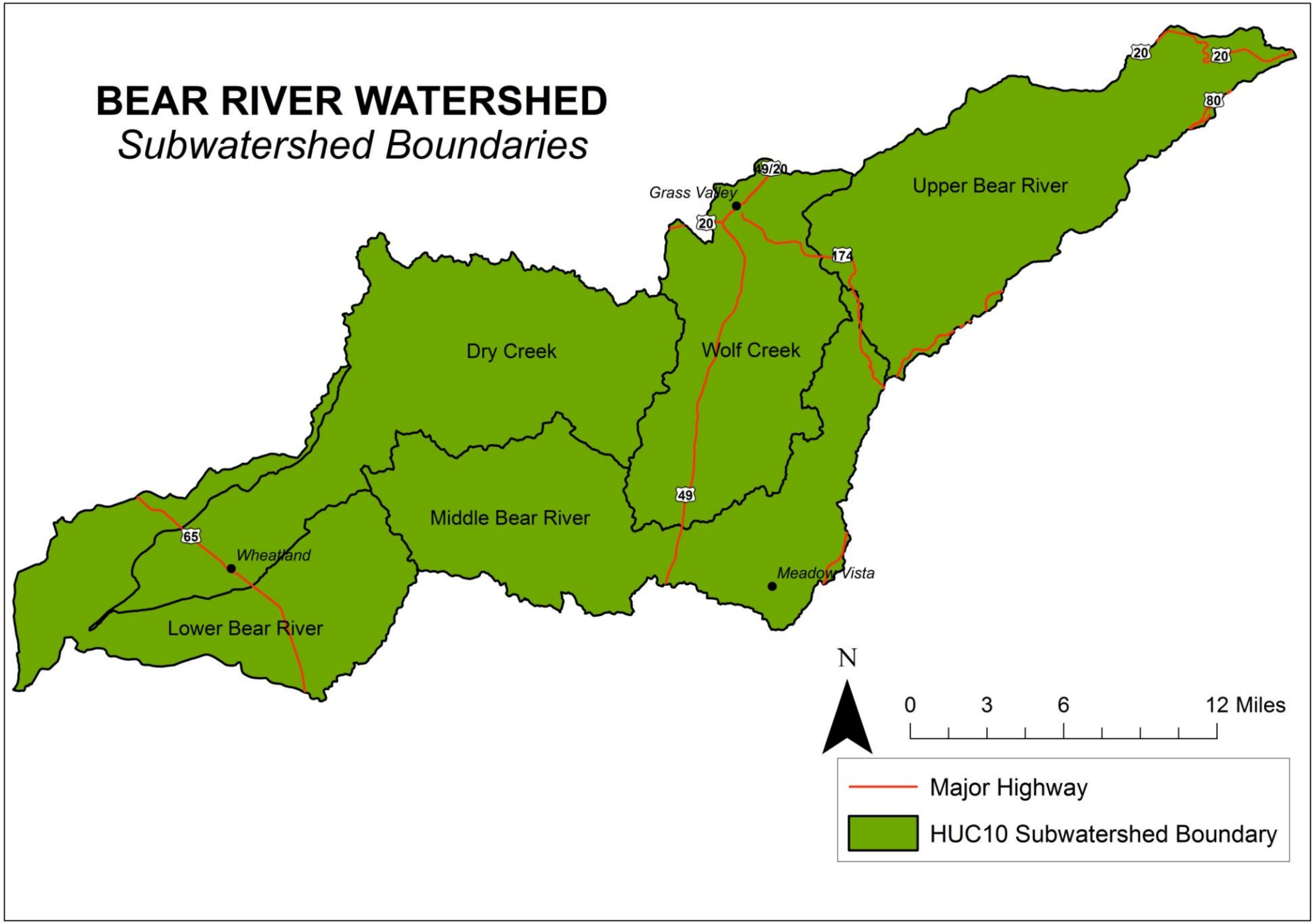
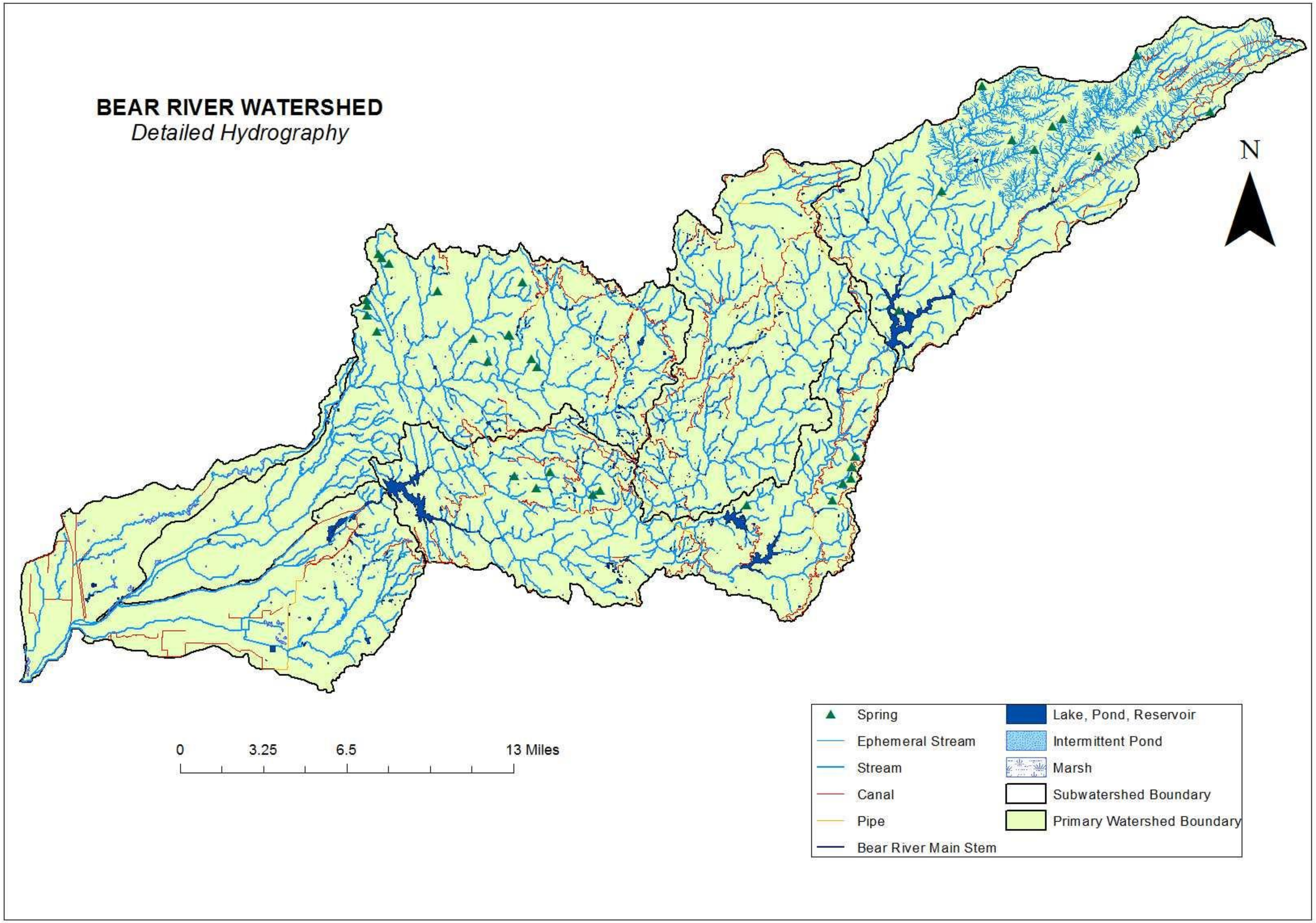


Figure 2. Bear River Watershed Hydrography



There are also 39 recognized springs in the watershed, which are defined by the USGS as places where water seeps naturally from the ground. More information on the extent and size of wetlands presented in Figure 2 can be found in Section A.5: Wetlands.

Stream density (calculated using only intermittent and perennial streams and not canals or ephemeral streams) is highly variable, though greatest in the upper Bear subwatershed. Density ranges from 0-0.75 miles of stream per 100-acres of area.

III.A.3. Flows

III.A.3a. Hydrologic and Climate Monitoring

There are 49 hydrologic and climate monitoring stations within the Bear River watershed, as illustrated in Figure 3. Available information on the dates of activity, operator, and location, as well as the type of data collected, at each station is presented in Table 3. The Internet location of all of publicly available online data for each station is presented in Table 4. Most of this information is available through the National Water Inventory System, the California Data Exchange Center, or the National Weather Service. These stations are operated by a variety of agencies, including Pacific Gas and Electric Company (PG&E), the California Department of Water Resources (DWR), Nevada Irrigation District, and the National Oceanographic and Atmospheric Administration (NOAA). The type of data collected also varies, with the majority of stations collecting information on climate and flow (discharge or river stage). NOAA operates most of the climate stations through the National Weather Service, while the US Geological Survey (USGS) controls the majority of the flow gauges in the watershed. Most monitoring stations in the watershed are located on the main stem of the Bear River. Our knowledge of the watershed would be immeasurably enhanced by greater instrumental coverage, particularly in the northern half of the watershed in the Dry Creek subwatershed.

There are fourteen stations in the watershed dedicated to collecting weather and climate information, all of which were active as of the end of 2015. Some of them began collecting data as early as 1940 and, between all of the stations, there is good spatial-distribution with station elevation ranging from 26 to 3400 ft. In addition, two stations, operated by the USGS and PG&E, respectively, collect both flow and climate data, both of which are still active. The USGS station at Dry Creek began collecting climate and flow data as far back as 1946. Four stations in the watershed are dedicated to measuring storage volume and reservoir water elevation, operated by NID and the USGS. The USGS station at Rollins, which stretches back to 1964, is maintained by NID under USGS supervision. There is not accurate GPS data available for the New Camp Far West Reservoir station and, as such, it is not mapped in Figure 3. In addition, there are also two stations, operated by PG&E and DWR, that collect both flow and storage data, both of which are still active. There are also three stations where data and details on the type of information collected are not readily available; one may need to contact state agencies to acquire data from these stations.

The majority of stations in the watershed are flow gauges. These stations are colored in Figure 3 by their operational status. In addition to the four active stations that collect climate or storage data in addition to flow data, there are 24 stations that are dedicated to collecting data on river stage and discharge. Fifteen of these stations are still actively collecting data, though for some of the USGS sites there is a delay of some months between data acquisition and public availability due to quality control procedures. Nine of the stations are no longer active as of the end of 2015, though most still have at least ten years of available data. For those that are recently inactive, specifically Wolf Creek (11423150) and Combined Drum 1 and 2 (11414196), there is no indication of whether they are permanently or temporarily shut down. Nine of the flow stations also have data on water quality. This only includes those sites with multiple years of water quality data, rather than one or two samples. In all, there are 28 stations with available flow data, with gauges at both ends of the watershed, which will allow quantification of discharge through the entire watershed. For information on the statistical hydrological analysis that is possible with this data see Helsel and Hirsch (2002).

***Table 3*: Descriptions of hydrological and climate monitoring stations**

NOAA: National Oceanic and Atmospheric Agency
NWS: National Weather Service
NWIS: National Water Information System
CDEC: California Data Exchange Center
NID: Nevada Irrigation District
PG&E: Pacific Gas and Electric Company
YCWA: Yuba County Water Agency
DWR: California Department of Water Resources
USGS: US Geological Survey

ID	Name	Type	Elevation	Operator	Start	End	Active?
BEV	South Canal of Bear	Flow, Storage	1980	PG&E	1978	Present	Active
BRE	Bear, Rollins	Flow, Climate	1945	PG&E	1998	Present	Active
BRF	Dry-Bear Confluence	NA	NA	YCWA	NA	NA	NA
CFW	Bear, Camp Far West	Flow, Storage	250	DWR	1963	Present	Active

ID	Name	Type	Elevation	Operator	Start	End	Active?
CMB	Lake Combie	Storage	1600	NID	1984	Present	Active
DPH	Drum Power House	Climate	3400	PG&E	1999	Present	Active
RLL	Rollins	Storage	2171	NID	1964	Present	Active
SRT	Secret Town	Climate	2720	Cal Fire	1995	Present	Active
BPG	Bear, Pleasant Grove	Flow	75	DWR	2005	Present	Active
NWS1	Wheatland 0.1ENE	Climate	26	NOAA	2011	Present	Active
NWS2	Grass Valley No 2	Climate	732	NOAA	1966	Present	Active
NWS3	Blue Canyon Airport	Climate	1608	NOAA	1940	Present	Active
NWS4	Grass Valley 8.3SSE	Climate	665	NOAA	1998	Present	Active
NWS5	Colfax 3.3SW	Climate	644	NOAA	2014	Present	Active
NWS6	Colfax 3.1SW	Climate	633	NOAA	2009	Present	Active
NWS7	Grass Valley 5S	Climate	705	NOAA	2008	Present	Active
NWS8	Alta Sierra 0.4WSW	Climate	702	NOAA	2008	Present	Active
NWS9	Alta Sierra 1.4SSW	Climate	627	NOAA	2009	Present	Active
NWS10	Alta Sierra 2.3WSW	Climate	511	NOAA	2009	Present	Active
NWS11	Grass Valley 2.7SW	Climate	711	NOAA	2012	Present	Active
NWS12	Grass Valley 4.2SE	Climate	849	NOAA	2012	Present	Active
11424000	Bear, near Wheatland	Flow, Water Quality	72	USGS	1929	Present	Active
11424500	Dry Cr, near Wheatland	Flow, Climate	63	USGS	1946	Present	Active
11421723	Alta Forebay at Baxter	NA	NA	USGS	NA	NA	NA
11421730	Bear below Boardman Div	NA	NA	USGS	NA	NA	NA
11423800	Bear below Camp Far West	Flow	120	USGS	1989	2015	Active
11414194	Drum 1 near Blue Canyon	Flow	NA	USGS	1981	2015	Active
11414195	Drum 2 near Blue Canyon	Flow	NA	USGS	1981	2015	Active
11414196	Combined Drum 1,2	Flow	3390	USGS	1981	2013	Inactive
11421710	Bear, near Emigrant Gap	Flow	4550	USGS	1978	2015	Active
11421720	Boardman Canyon, near Emigrant Gap	Flow	NA	USGS	1964	1986	Inactive
11421725	Alta Powerhouse	Flow	NA	USGS	1981	2015	Active
11421750	Dutch Flat Powerhouse	Flow	NA	USGS	1964	2015	Active
11421760	Dutch Flat 2 Flume, near Blue Canyon	Flow	NA	USGS	1965	2015	Active
11421780	Chicago Park Flume, near Dutch Flat	Flow	NA	USGS	1965	2015	Active
11421790	Bear, below Dutch Flat Afterbay	Flow, Water Quality	2560	USGS	1965	2015	Active

ID	Name	Type	Elevation	Operator	Start	End	Active?
11421800	Rollins, near Colfax	Storage	NA	USGS	1964	2015	Active
11421900	Rollins Powerhouse	Flow	NA	USGS	1980	2015	Active
11422000	Bear R Canyon, near Colfax	Flow, Water Quality	1960	USGS	1911	2015	Active
11422500	Bear, below Rollins Colfax, near Colfax	Flow, Water Quality	1996	USGS	1912	2015	Active
11423000	Bear, near Auburn	Flow, Water Quality	1230	USGS	1940	1967	Inactive
11423500	Bear, van Trent	Flow	180	USGS	1904	1927	Inactive
38571412 1330701	Bear, Berry Rd near E Nicolaus	Flow, Water Quality	43	USGS	2001	2003	Inactive
11421770	Bear, below Drum Afterbay	Flow	3320	USGS	1966	2015	Active
11423050	Magnolia Creek, Auburn	Flow	NA	USGS	1962	1973	Inactive
11423150	Wolf Creek, near Wolf	Flow, Water Quality	NA	USGS	2002	2015	Inactive
11423700	New Camp Far West near Wheatland	Storage	NA	USGS	1966	1983	Inactive
39102312 0541301	Bear, below Steephollow, near Chicago Park	Flow, Water Quality	2180	USGS	2000	2003	Inactive
39111612 0562501	Greenhorn Creek at You Bet Rd, Nevada City	Flow, Water Quality	2200	USGS	2000	2006	Inactive

***Table 4*: Internet location of flow and climate monitoring data**

ID	Data Source	Web Link
BEV	CDEC	http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=BEV
BRE	CDEC	http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=BRE
BRF	CDEC	NA
CFW	CDEC	http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=CFW
CMB	CDEC	http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=CMB
DPH	CDEC	http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=DPH
RLL	CDEC	http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=RLL
SRT	CDEC	http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=SRT
BPG	CDEC	http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=BPG

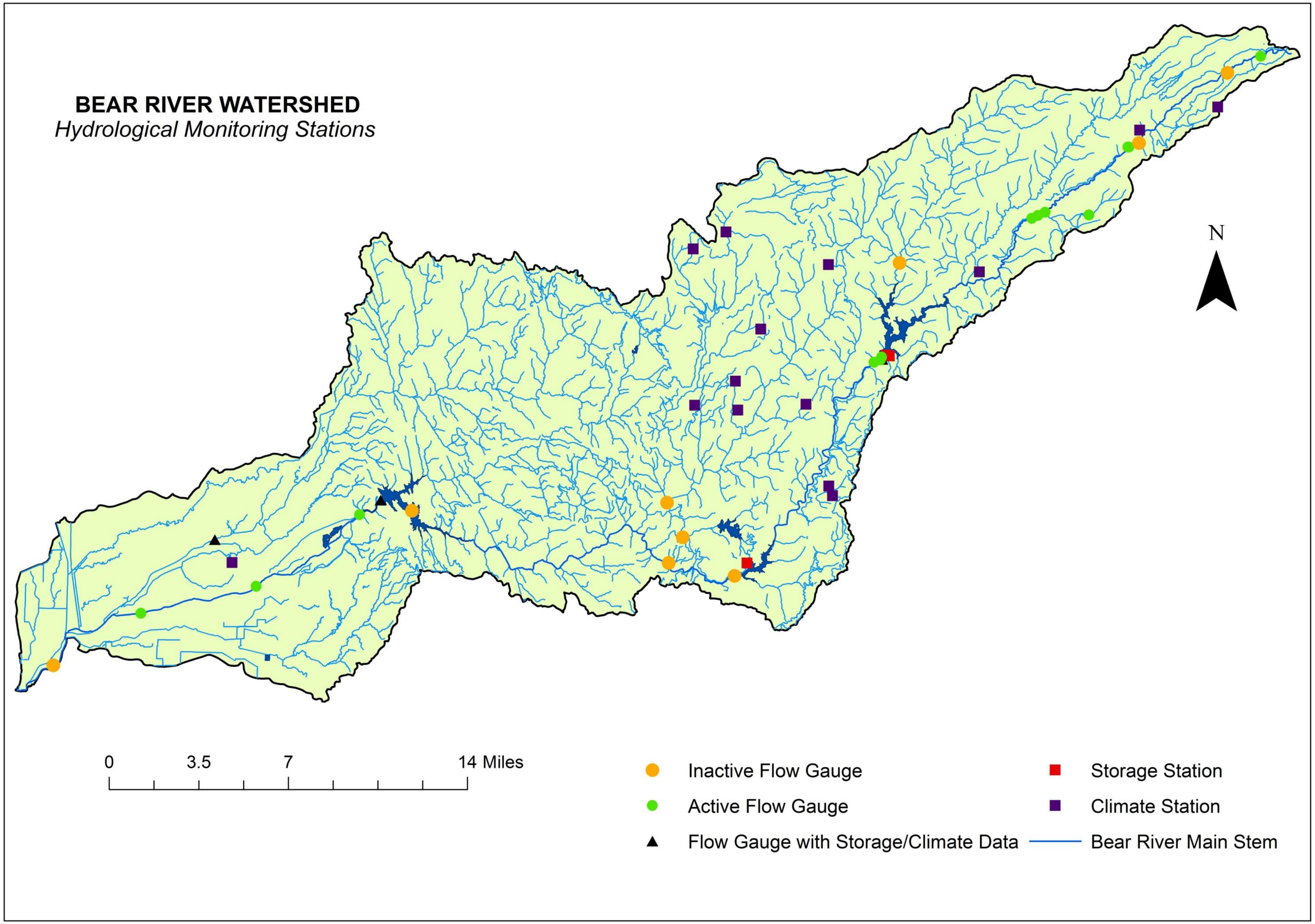
ID	Data Source	Web Link
NWS1	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CAYB0004/detail
NWS2	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/ANNUAL/stations/COOP:043573/detail
NWS3	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/ANNUAL/stations/COOP:040897/detail
NWS4	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CANV0042/detail
NWS5	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CAPC0028/detail
NWS6	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CAPC0011/detail
NWS7	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CANV0006/detail
NWS8	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CANV0016/detail
NWS9	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CANV0023/detail
NWS10	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CANV0011/detail
NWS11	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CANV0036/detail
NWS12	NWS	http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CANV0034/detail
11424000	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11424000
11424500	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11424500
11421723	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421723
11421730	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421730
11423800	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11423800
11414194	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11414194
11414195	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11414195
11414196	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11414196
11421710	NWIS (also Dreamflows)	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421710
11421720	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421720
11421725	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421725
11421750	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421750
11421760	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421760
11421780	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421780
11421790	NWIS (also Dreamflows)	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421790
11421800	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421800
11421900	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421900

ID	Data Source	Web Link
11422000	NWIS (also Dreamflows)	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11422000
11422500	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11422500
11423000	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11423000
11423500	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11423500
385714121330701	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=385714121330701
11421770	NWIS (also Dreamflows)	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11421770
11423050	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11423050
11423150	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11423150
11423700	NWIS	http://waterdata.usgs.gov/nwis/inventory/?site_no=11423700&agency_cd=USGS&amp
391023120541301	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=391023120541301
391116120562501	NWIS	http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=391116120562501

**also Dreamflows* refers to those stations where real-time flow data can be acquired through the Dreamflows website (http://www.dreamflows.com/flows.php?page=prod&zone=canv&form=norm&mark=All)

The network of flow gauges within the Bear watershed is crucial for fully understanding and quantifying the complex hydrology of the watershed, which is one of the most regulated and managed in the Sierra Nevada. Flow patterns in the Bear are typical of the foothill watersheds with high winter and spring flows and low summer and fall flows; however, this natural pattern has been highly altered by a series of diversions and reservoirs along the length of the river (Sacramento River Watershed Program, 2016). Other factors that have caused hydrologic alteration on the watershed include the presence of weirs, paved surfaces, and road crossings and historic land use changes that have contributed to changes in vegetation cover, soil composition and runoff, and loss of floodplain connectivity (Aalto et al., 2010). More information on the impacts and evidence of hydrological alteration in the Bear watershed can be found in Section C.4: Water Management.

Figure 3. Hydrologic and Climate Monitoring Stations



The hydrological monitoring stations in the watershed are also important for understanding the availability of water and the ability of water providers to meet consumptive demand and usage in the watershed. The EPA's EnviroAtlas GIS Database provides estimates of the water use, in gallons per day, for domestic, agricultural and industrial uses in the 12 HUC-12 subwatersheds of the Bear. Estimates were calculated using 2005 Water Use Data by county from the USGS. Information on the population, irrigation acreage and locations of industrial facilities were used to distribute water use across counties. Table 5 summarizes the EPA estimates. Magnolia Creek includes Meadow Vista and Colfax, which explains the high domestic and industrial use. Similarly, Rattlesnake Creek encompasses Grass Valley, and Grasshopper Slough includes Wheatland, which explains the high domestic use. Agricultural use dominates in the Lower Bear subwatershed. For these estimates, domestic use includes all indoor and outdoor domestic or residential water uses, including water for drinking, bathing, cleaning, landscaping and primary residence pools. For agricultural irrigation and industrial uses, the estimates include self-supplied surface and groundwater as well as water supplied by water providers (EPA, 2016a).

***Table 5*. EPA-Estimated Categorized Water Use by Subwatershed (gallons/day)**

Subwatershed	Domestic	Agricultural	Industrial
UPPER BEAR			
Greenhorn	869,353	0	77,440
Steephollow	9,232	0	not available
Little Bear	326,416	0	7,287
WOLF CREEK			
Rattlesnake	5,140,302	0	631,104
South Wolf	1,599,922	0	98,012
MIDDLE BEAR			
Magnolia	2,864,770	0	122,699
Camp Far West	334,937	1,872	8,148
DRY CREEK			
Vineyard	199,939	0	2,678
Indian Springs	456,318	0	38,022
Grasshopper Slough	1,022,939	39,548,980	4,083
LOWER BEAR			
Best Slough	1,201,814	60,238,297	4,310
Yankee Slough	317,054	45,844,810	44,239

III.A.3b. Groundwater

Groundwater is an important natural resource that helps to sustain California's economy and provide drinking water to millions of people throughout the state. Groundwater supplies about 38% of California's agricultural and urban water needs in average water years, and 46% or more of the need in dry and critically dry years such as water years 2013-2015 (Department of Water Resources, 1998; Department of Water Resources, 2016). In addition, there are many areas throughout California where groundwater satisfies all of the water supply needs (Department of Water Resources, 1998; Department of Water Resources, 2016). Given the importance of groundwater for meeting California's water demand and the need for resource managers to have information for making effective management decisions, the California Department of Water Resources (DWR) and other agencies conduct research and report information on groundwater in California.

In 1975 DWR released Bulletin 118-75, *California's Ground Water*, which provided an inventory of 461 identified groundwater basins, subbasins, and areas of potential groundwater storage in California (Department of Water Resources, 2003). In 1980 DWR released Bulletin 118-80, *Ground Water Basins in California*, which updated groundwater basin boundaries to identify 447 groundwater basins, subbasins, and areas of potential groundwater storage in California (Department of Water Resources, 2003). Bulletin 118-80 also identified 11 groundwater basins with critical overdraft conditions (Department of Water Resources, 2003; Department of Water Resources, 2016). In 2003 DWR updated Bulletin 118, *California's Ground Water*, to provide tools to assist agencies with sustainable groundwater management. In addition, the 2003 update to Bulletin 118 identified 515 alluvial groundwater basins and subbasins in California, and provided technical information and maps for each (Department of Water Resources, 2003; Department of Water Resources, 2016). An additional update to *California's Ground Water* was published in April 2015, to provide updated information for the California Water Plan Update (Department of Water Resources, 2015).

In 2009, the California Water Code was amended to require a statewide program to monitor groundwater levels in California's basins and to make the data available to the public. To satisfy the amendment requirements, DWR established the California Statewide Groundwater Elevation Monitoring (CASGEM) program, with the goal of increasing collaboration between DWR and local water agencies to accomplish regular monitoring in each of California's 515 identified alluvial groundwater basins (Department of Water Resources, 2016). In 2014, the Sustainable Groundwater Management Act (SGMA) was approved. The SGMA follows in the footsteps of other legislation, including AB 3030 (Groundwater Management Act of 1992), SB 1938 (2002 modifications to the Groundwater

Management Act), and AB 359 (2011 modifications to the Groundwater Management Act), aimed at improving management of California's groundwater resources. The SGMA directed local agencies to develop groundwater sustainability plans that would be tailored to their local economic and environmental needs (Department of Water Resources, 2016).

Bear River Groundwater

The Bear River watershed is located within the Sacramento River Hydrologic Region and is part of the Sacramento Valley groundwater basin (Figure 4; Department of Water Resources, 2003). The western, lowest-elevation portions of the Bear River watershed overlie two alluvial groundwater subbasins identified by DWR: the South Yuba (Basin #: 5-21.61) and the North American (Basin #: 5-21.64) subbasins (Figure 5). The Sutter sub-basin (Basin #: 5-21.62) is located just west of the Bear River watershed, running north-south along the Feather River (Figure 5). Studies have estimated the groundwater storage capacity of the South Yuba and North American sub-basins to be approximately 1,090,000 and 4,100,000 acre-feet respectively (Department of Water Resources, 2003). To establish efficient and effective monitoring of California's groundwater basins, DWR prioritized groundwater basins into High, Medium, Low, or Very Low priority categories, based on the need for additional groundwater elevation monitoring (Department of Water Resources, 2016). Prioritization for each basin was based on a number of variables including population, population growth, the number of public supply and total groundwater wells, irrigated acreage, groundwater reliance, impacts, and other information available to DWR. Based on the CASGEM Basin Prioritization, 127 out of 515, or 25%, of groundwater basins and sub-basins were scored as High and Medium priority. These basins account for 96% of the annual groundwater pumping in California and supply 88% of the population that lives over groundwater basins (Department of Water Resources, 2016). The South Yuba sub-basin was categorized as a Medium priority, and the North American sub-basin was categorized as a High priority for additional groundwater elevation monitoring (Figure 6).

DWR works collaboratively with federal, state, and local agencies and entities to implement aspects of the CASGEM program, including groundwater elevation monitoring in High and Medium priority basins. In the Bear River watershed, three primary Monitoring Entities have been established, including Yuba County Water Agency (YCWA) in the South Yuba groundwater sub-basin, and South Sutter Water District and the Western Placer County Group in the North American groundwater sub-basin. These Monitoring Entities have established Groundwater Management Plans, under SB 1938, within the groundwater sub-basins that the Bear River watershed overlies. Copies of existing Groundwater Management Plans can be accessed at:

http://www.water.ca.gov/groundwater/groundwater_management/GWM_Plans_inCA.cfm.

The YCWA Groundwater Management Plan characterized groundwater trends and elevations at wells throughout the South Yuba sub-basin, including at three wells within the Bear River watershed. At the wells within the Bear River watershed, groundwater levels have generally remained stable or increased since 1980 (YCWA, 2010). Groundwater generally flows from east to west within the South Yuba sub-basin (YCWA, 2010). In the spring of 2010, groundwater elevations within the South Yuba sub-basin portion of the Bear River watershed ranged from 140 feet above mean sea level in the eastern portion to less than 30 feet above mean sea level near the western edge of the subbasin, with these conditions representative of groundwater elevations during the previous decade (YCWA, 2010). The Western Placer County Groundwater Management Plan characterized groundwater trends and elevations at wells throughout the North American sub-basin, including at six wells within the Bear River watershed (MWH, 2007). At the wells within the Bear River watershed, groundwater levels have remained constant or slightly increased since the 1980s (MWH, 2007). Sites with a long-term record dating to the 1940s or 1950s show similar trends of stable or increased groundwater elevations over time (MWH, 2007). In the spring of 2006, groundwater elevations within the North American sub-basin portion of the Bear River watershed ranged from about 90 feet above mean sea level in the eastern portion near Camp Far West reservoir to approximately 20 feet above mean sea level in the western portion near the Feather River confluence (MWH, 2007). The South Sutter Water District (SSWD) Groundwater Management Plan characterized groundwater trends and elevations at wells within the SSWD boundaries in the North American sub-basin, including at two wells within the Bear River watershed (SSWD, 2009). At the wells within the Bear River watershed, groundwater levels have generally increased since 1980, with groundwater elevations ranging from about 60 feet above mean sea level in the eastern portion of SSWD boundaries near the Bear River to around 30 feet above mean sea level near the Feather River (SSWD, 2009).

Using the CASGEM and California Water Data Library databases developed by DWR, a total of 687 groundwater wells were identified with GPS coordinates that are located within the two groundwater sub-basins as of March 2016. Out of the 687 total wells, 108 groundwater wells were identified with GPS coordinates located within the footprint of the Bear River watershed (Figure 7). Data for these wells, including well hydrographs, can be accessed and downloaded through the California Water Data Library (http://www.water.ca.gov/waterdatalibrary/) or through the CASGEM Online System Public Portal (http://www.water.ca.gov/groundwater/casgem/online_system.cfm). In addition to data from DWR, groundwater data is also available from the United States

Geological Survey (http://waterdata.usgs.gov/ca/nwis/gw/). The majority of the USGS groundwater elevation sites within the Bear River watershed are either inactive or consist of very few data points, and therefore cannot be used to evaluate recent or long-term groundwater trends.

In 2014, DWR released the *Summary of Recent, Historical, and Estimated Potential for Future Land Subsidence in California* (Department of Water Resources, 2014a). The report analyzed groundwater elevation data from CASGEM and the Water Data Library through May 2014 to compare historical low spring groundwater elevations between 1900-1998 against recent low spring groundwater elevations between 2008-2014 (Department of Water Resources, 2014a). A total of 13 groundwater wells were evaluated in the Bear River watershed, with 85% (11/13) of the groundwater wells exhibiting recent groundwater elevations above the historical spring low and 15% (2/13) of the groundwater wells exhibiting recent groundwater elevations near the historical spring low (Figure 8). No groundwater wells in the Bear River watershed were characterized as below the historical low, although there are groundwater wells within the sub-basins that underlie the Bear River watershed that are below the historical low, particularly south of the western portion of the watershed in the North American groundwater sub-basin. Groundwater levels observed during the recent drought between spring 2013 and 2014 showed more variability within the Bear River watershed, with wells generally exhibiting groundwater decreases of between 2.5 to 10 feet elevation or showing a change of +/- 2.5 feet (Department of Water Resources, 2014b).

In 2014, the Governor signed the Sustainable Groundwater Management Act (SGMA). SGMA requires that in basins which are designated as High or Medium priority, local public agencies and Groundwater Sustainability Agencies (GSA) develop and implement groundwater sustainability plans (Department of Water Resources, 2016). Within the Bear River watershed, the Yuba County Water Agency has applied to become a GSA for the South Yuba groundwater subbasin. As of March 2016 DWR indicates that no agency has applied to be a GSA in the Bear River watershed portion of the North American groundwater subbasin; however, the Sacramento Groundwater Authority has applied to be a GSA at the southern end of the North American groundwater subbasin, south of the Bear River watershed.

Figure 4. Sacramento River Hydrologic Region and Sacramento Valley Groundwater Basin (Department of Water Resources, 2015)
*The Bear River watershed is located in sub-basins 5-21.61 and 5-21.64.

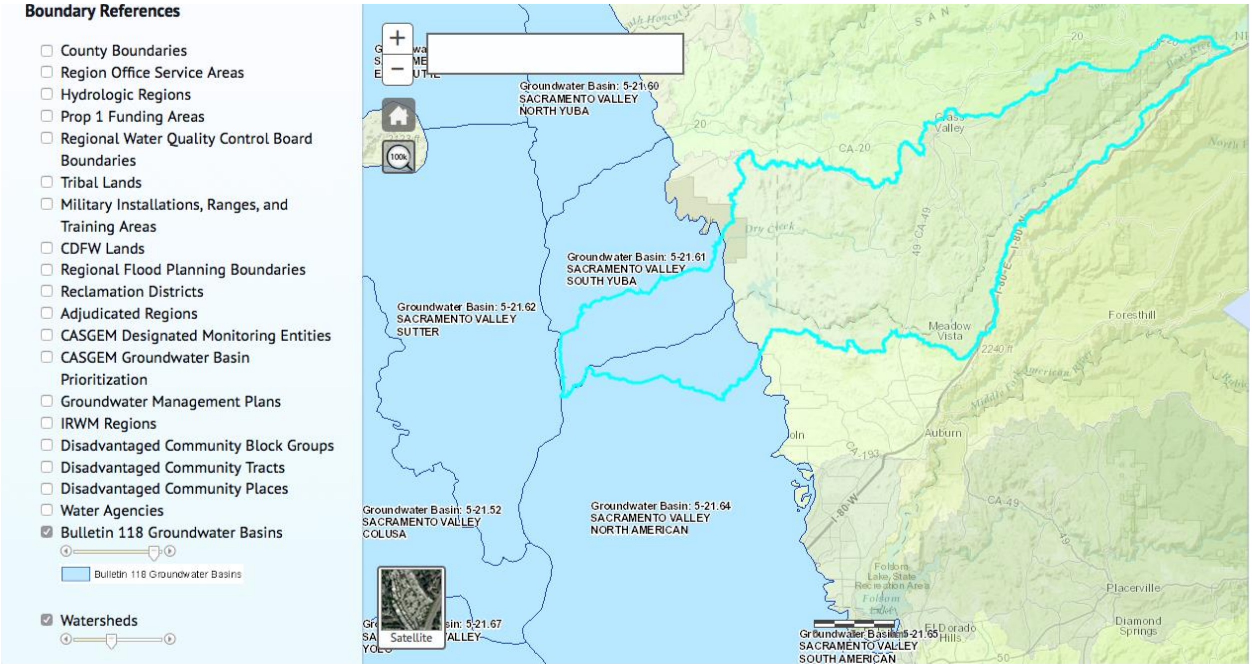


Figure 5. Bulletin 118 Groundwater Basins and Subbasins
(https://gis.water.ca.gov/app/boundaries/)

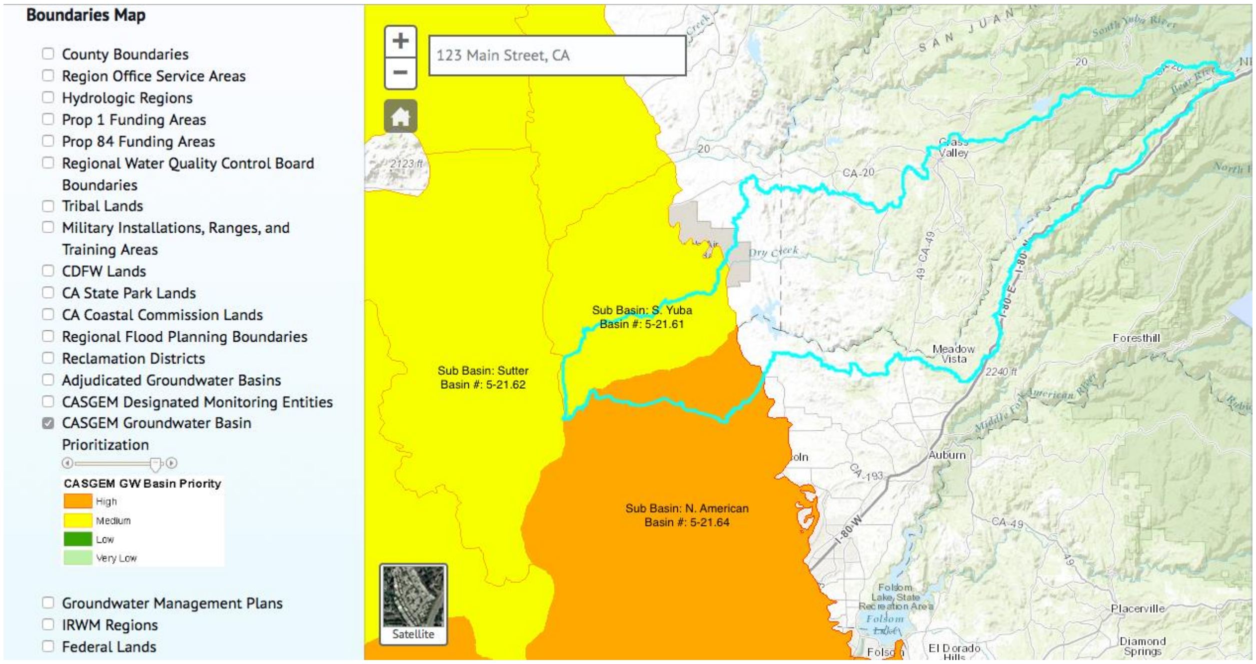


Figure 6. CASGEM Groundwater Basin Priority
(https://gis.water.ca.gov/app/boundaries/)

Figure 7. Groundwater Extraction Well Locations

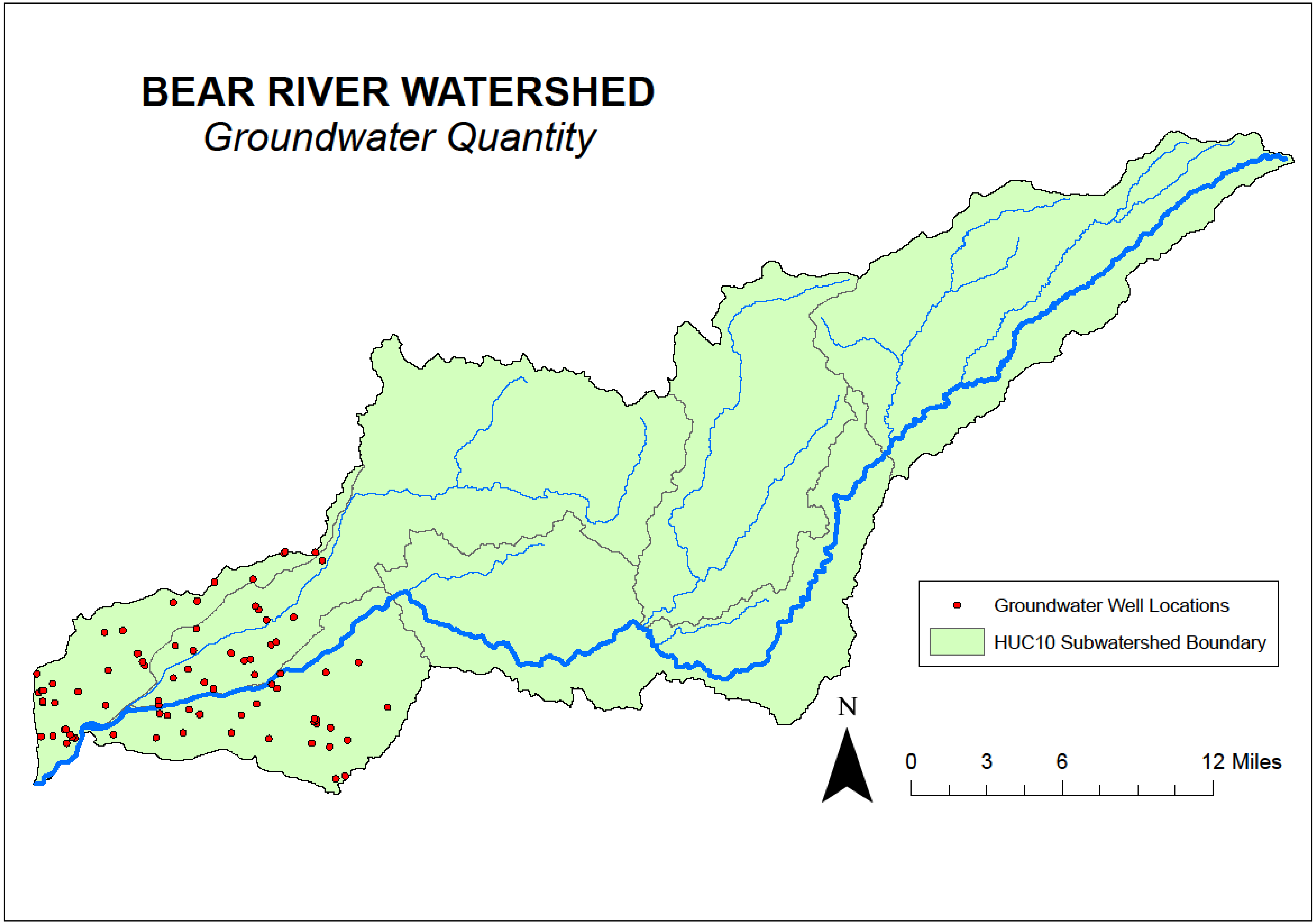
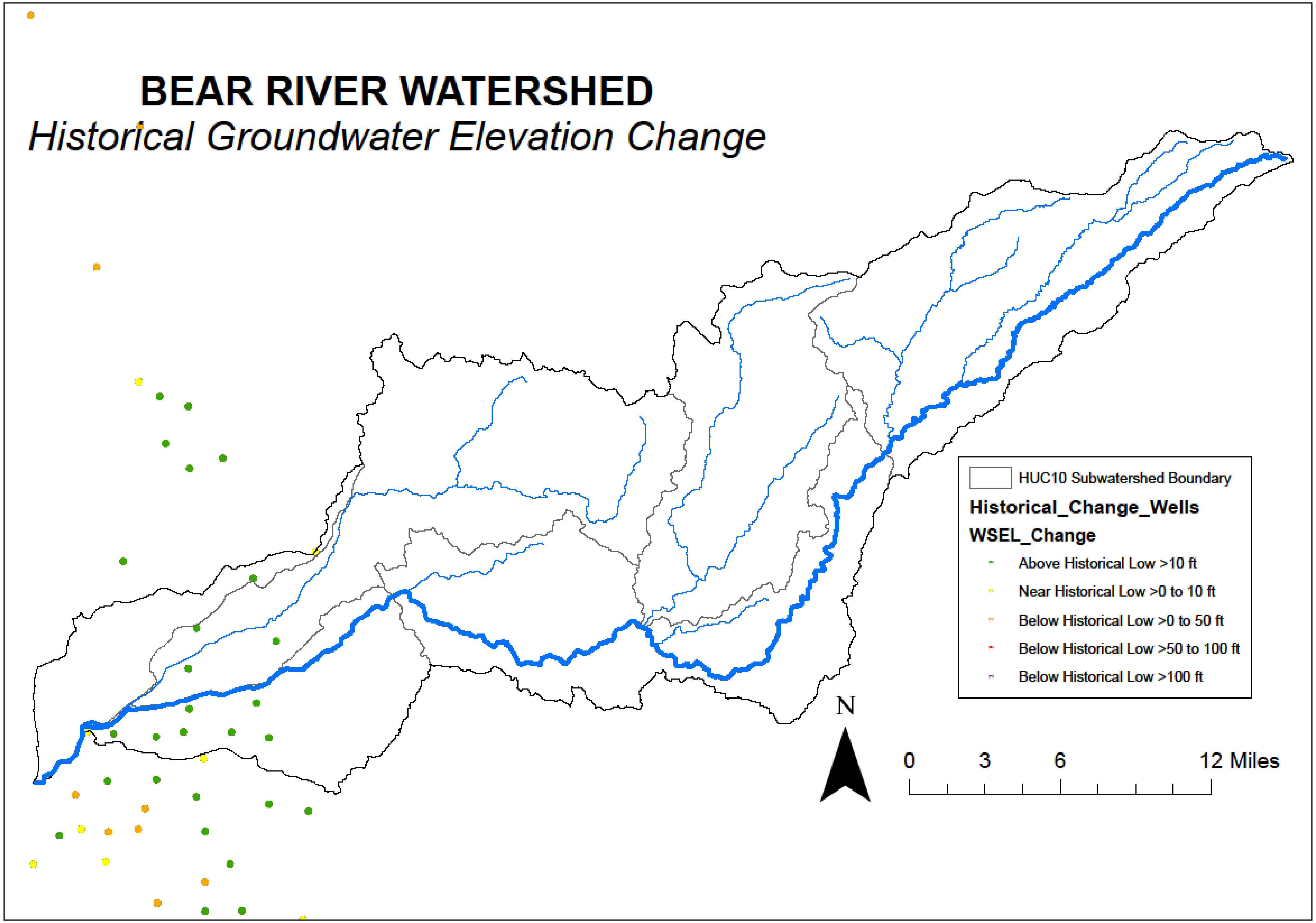


Figure 8. Historical Groundwater Elevation Change



III.A.4. Water quality

III.A.4a. Surface Water Quality

Surface water in the Bear River is crucial for a range of consumptive and non-consumptive uses. Maintaining high surface water quality has important socioeconomic benefits, in addition to the more obvious human and ecological health needs. Beyond municipal and domestic water supply, surface waters from the Bear and its tributaries are also used for agriculture (irrigation and stock watering), power generation, and recreation. Recreational activities range from those with direct contact with water, such as swimming, fishing, and rafting, to those not directly in water including riverside hiking and hunting. Surface waters also provide wildlife habitat, essential warm and cold freshwater habitat for non-anadromous fish, and potential migration and spawning habitat for striped bass/sturgeon/shad/salmon/steelhead (CRWQCB 2010). It is, thus, of economic, agricultural, recreational, and ecological interest to maintain high surface water quality.

Because of impairment to surface water quality, however, there are multiple reaches within the watershed currently that are 303(d) listed under the Clean Water Act, at varying stages of Total Daily Maximum Load (TMDL) development. This includes 21 miles of the lower Bear River, below Camp Far West Reservoir, listed for mercury, copper, and pesticide-use; 23 miles of Wolf Creek and 2 miles of French Ravine, listed for fecal coliform; and all three major reservoirs, Camp Far West, Rollins, and Lake Combie, listed for mercury (California Water Board, 2016). More information on the 303(d) listing and TMDL development process, as well as pesticide use in the watershed, can be found in Section C.5c: Pesticides and Agricultural Impacts. In addition, more information on mercury contamination can be found in Section C.5a: Mine Lands and Mercury.

Multiple surface water quality metrics were monitored by the Nevada County Resource Conservation District (NCRCD) at various sites in the Bear watershed from 2001-2002 and 2005-2007. In addition, several Dry Creek sites in the Bear Watershed were monitored by Sierra Streams Institute (SSI) in 2014 on behalf of Friends of Spenceville (FOS). Beale Air Force Base has also offered valuable water quality data on Dry Creek that may not be integrated into this section due to time constraints, but will be considered in the restoration plan. Monitored water quality parameters included temperature, pH, conductivity, dissolved oxygen, turbidity, nutrients (NH_4, NO_3, PO_4), and bacteria (total coliform and *E. coli*). Not all metrics were measured during all months within the 2001-2002, 2005-2007, and 2014 time periods. Figure 9 shows the location of each monitoring site in the watershed, and Table 6 lists which sites were monitored at which times.

Figure 9. Surface Water Quality and Macroinvertebrate Monitoring Stations

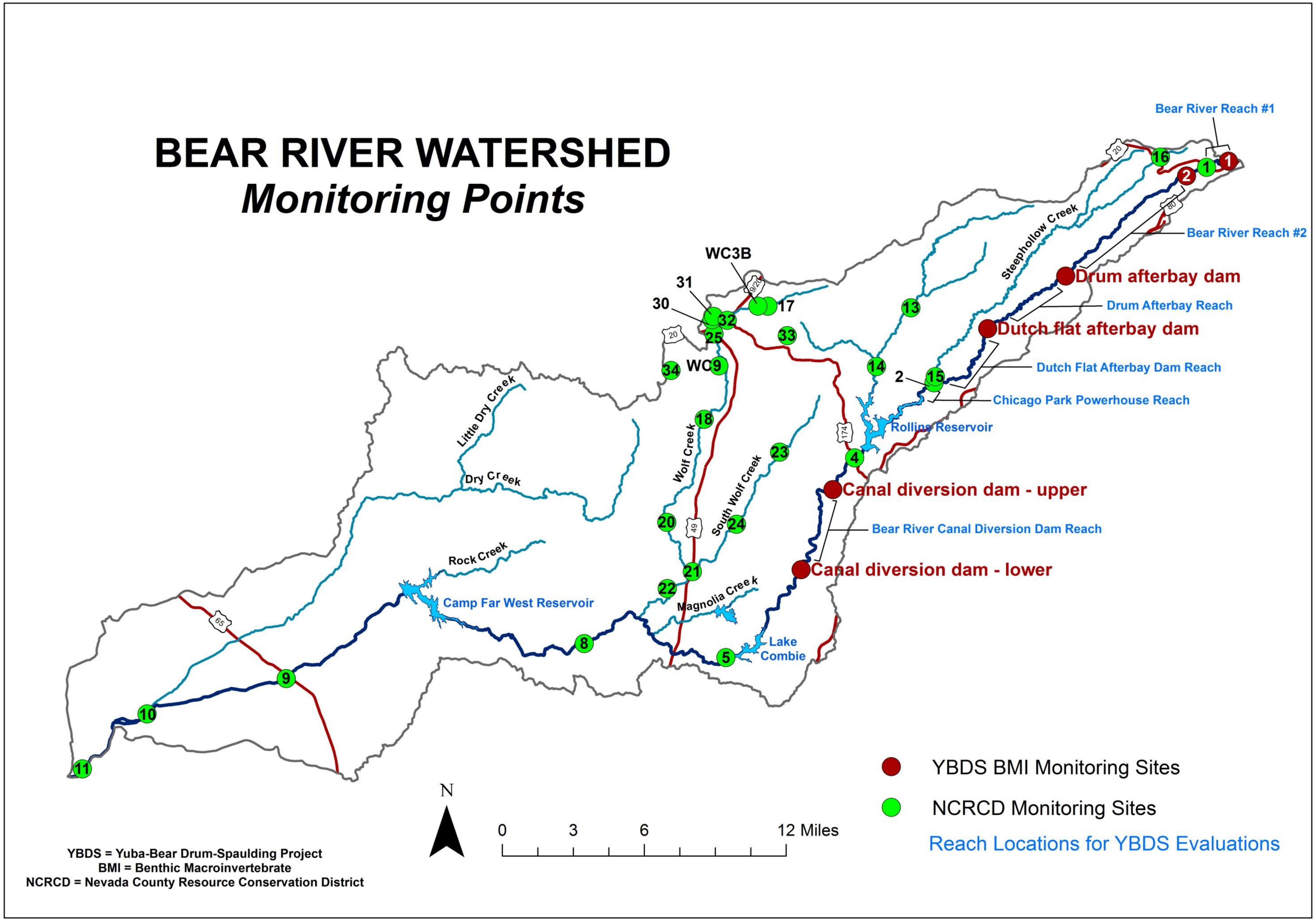


Table 6. **Sites monitored for surface water quality**

Site	Location	2001-02	2005-07	2014
1	Bear River at Highway 20	X	X	
2	Bear River above Steephollow Creek	X		
4	Bear River at Highway 174	X		
5	Bear River below Lake Combie	X		
8	Bear River above Camp Far West Reservoir (below Wolf Creek)	X	X	
9	Bear River at Highway 65	X		
10	Bear River above Dry Creek	X		
11	Bear River above Feather River	X		
13	Greenhorn Creek at Red Dog Road	X		
14	Greenhorn Creek at You Bet Road	X		
15	Steephollow Creek above Bear River	X		
16	Steephollow Creek at Highway 20	X		
17	Loma Rica - upstream of Brunswick at Idaho-Maryland		X	
18	Wolf Creek at Old Auburn Road	X		
20	Wolf Creek at Lime Kiln Road	X		
21	South Wolf Creek at Highway 49	X		
22	Wolf Creek at Wolf Road	X	Bacteria only	
23	South Wolf Creek at Dog Bar Road	X		
24	South Wolf Creek at Lode Star Drive	X		
25	Wolf Creek at North Star Mine Museum	X	X	
30	Peabody Creek at Pond		X	
31	Peabody Creek at Walsh Street		X	
32	South Fork of Wolf Creek at Hennessy		X	
33	South Fork of Wolf Creek at Wood Rose		X	
34	French Ravine 1 at McCourtney Road		X	
35*	French Ravine 2 at Hidden Valley		X	
41*	Peabody Creek West Fork, by new homes		Bacteria only	
42*	Peabody Creek East Fork, behind homes		Bacteria only	
WC #3B	Olympia Creek at Idaho-Maryland x Brunswick		Bacteria only	
WC #9	Wolf Creek above Allison Ranch Road		Bacteria only	
LWC*	Little Wolf Creek at Garden Bar Road		Nutrients & Bacteria	
Linden Ave.*	Small Stream on Linden Ave. GV		Nutrients & Bacteria	
BR_Gaut*	Bear River at Gautier Rd		X	
FOS #1*	Dry Creek – Above Fairy Falls			X

Site	Location	2001-02	2005-07	2014
FOS #2*	Dry Creek – Below Fairy Falls			X
FOS #3*	Dry Creek – Upstream from mine site			X
FOS #4*	Little Dry Creek above mine site			X
FOS #5*	Little Dry Creek below mine site			X
FOS #6*	Dry Creek – Downstream of mine site			X
FOS #7*	Dry Creek – Below rope swing swimming hole			X
FOS #8*	Dry Creek – Below Waldo Bridge			X

*No GPS Coordinates and not illustrated in Figure 9

Benthic Macroinvertebrate Indicators of Water Quality

Benthic macroinvertebrates (insects and similar organisms that spend all or a portion of their life cycle within the substrate at the bottom of rivers and creeks) are powerful indicators of stream health, both from a water quality standpoint and a physical habitat standpoint. Data on these diverse animals have been collected throughout the Bear Watershed along with direct water quality data. The results of these studies are discussed further in Section B.5: Aquatic Macroinvertebrate Species.

Monitored Parameters

Table 7, on the following page, summarizes the results of past water quality monitoring in the Bear River Watershed. This table defines the water quality objective threshold values set by the EPA and the California Regional Water Quality Control Boards (CRWQCB), and lists the number of times (if any) each monitoring site failed to meet these federal and state water quality objectives. The text following the table interprets these results by describing the ecological context of each monitoring parameter, stating the environmental and public health significance of each parameter's threshold value, and listing additional details from the monitoring data.

Table 7. **Number of months each site was outside EPA and/or CRWQCB threshold water quality objectives***

Metric	Water Quality Objective	Site No.	Total No. Months Outside Threshold	Total No. Months Sampled	No. Months Sampled 2001-2002	No. Months Sampled 2005-2007	No. Months Sampled 2014
Fecal Coliform	<200/100ml	4	**1**	**12**	12	--	--
		10	**1**	**9**	9	--	--
		11	**2**	**12**	12	--	--
		18	**2**	**8**	8	--	--
		20	**1**	**8**	8	--	--
		21	**2**	**11**	11	--	--
		22	**3**	**12**	12	--	--
		23	**5**	**9**	9	--	--
		24	**1**	**6**	6	--	--
		25	**1**	**20**	11	9	--
		30	**1**	**12**	--	12	--
		31	**1**	**11**	--	11	--
		34	**1**	**5**	--	5	--
		42	**1**	**1**	--	1	--
		WC #9	**2**	**2**	--	2	--
Nutrients	<0.1ppm PO4, <0.45ppm NH4, <10ppm NO3	1	**3**	**41**	12	29	--
		2	**1**	**12**	12	--	--
		5	**2**	**12**	12	--	--
		8	**3**	**32**	12	20	--
		13	**1**	**8**	8	--	--
		14	**1**	**8**	8	--	--
		15	**1**	**12**	12	--	--
		17	**4**	**45**	--	45	--
		18	**1**	**8**	8	--	--
		20	**2**	**8**	8	--	--
		22	**3**	**12**	12	--	--
		25	**7**	**48**	12	36	--
		30	**6**	**9**	--	9	--
		31	**6**	**10**	--	10	--
		32	**4**	**19**	--	19	--
		33	**5**	**18**	--	18	--

Metric	Water Quality Objective	Site No.	Total No. Months Outside Threshold	Total No. Months Sampled	No. Months Sampled 2001-2002	No. Months Sampled 2005-2007	No. Months Sampled 2014
		4	**2**	**12**	12	--	--
		5	**2**	**12**	12	--	--
		8	**3**	**31**	12	19	--
		9	**3**	**12**	12	--	--
		10	**2**	**12**	12	--	--
		11	**8**	**12**	12	--	--
		13	**1**	**7**	7	--	--
		17	**2**	**47**	--	47	--
Turbidity	<10NTU	20	**1**	**8**	8	--	--
		21	**2**	**12**	12	--	--
		22	**2**	**12**	12	--	--
		25	**8**	**56**	12	44	--
		30	**4**	**12**	--	12	--
		31	**1**	**12**	--	12	--
		32	**3**	**20**	--	20	--
		34	**4**	**20**	--	20	--
		35	**3**	**23**	--	23	--
		1	**2**	**41**	12	29	--
		5	**1**	**12**	12	--	--
		8	**1**	**29**	11	18	--
		9	**1**	**12**	12	--	--
		13	**2**	**9**	9	--	--
		14	**1**	**8**	8	--	--
		16	**2**	**9**	9	--	--
pH	6.5-8.5	17	**8**	**47**	--	47	--
		25	**1**	**55**	12	43	--
		30	**2**	**12**	--	12	--
		31	**3**	**11**	--	11	--
		32	**4**	**17**	--	17	--
		33	**14**	**20**	--	20	--
		34	**2**	**19**	--	19	--
		BR_Gaut	**1**	**2**	--	2	--

Metric	Water Quality Objective	Site No.	Total No. Months Outside Threshold	Total No. Months Sampled	No. Months Sampled 2001-2002	No. Months Sampled 2005-2007	No. Months Sampled 2014
Dissolved Oxygen (DO)	>85%, >7mg/L	1	**31**	**41**	12	29	--
		2	**1**	**12**	12	--	--
		4	**1**	**12**	12	--	--
		5	**1**	**12**	12	--	--
		8	**1**	**30**	12	18	--
		10	**1**	**11**	11		
		11	**7**	**12**	12	--	--
		13	**4**	**8**	8	--	--
		14	**1**	**8**	8	--	--
		15	**6**	**12**	12	--	--
		16	**9**	**9**	9	--	--
		17	**9**	**47**	--	47	--
		18	**3**	**8**	8	--	--
		20	**2**	**9**	9	--	--
		21	**6**	**12**	12	--	--
		22	**4**	**12**	12	--	--
		23	**2**	**10**	10	--	--
		24	**2**	**7**	7	--	--
		25	**10**	**55**	12	37	--
		30	**2**	**12**	--	12	--
		31	**6**	**12**	--	12	--
		32	**9**	**19**	--	19	--
		33	**19**	**22**	--	22	--
		34	**17**	**20**	--	20	--
		35	**12**	**23**	--	23	--
		FOS #3**	**1**	**9**	--	--	9
		FOS #4**	**1**	**10**	--	--	10
		FOS #5**	**1**	**9**	--	--	9
		FOS #8**	**1**	**10**	--	--	10

Metric	Water Quality Objective	Site No.	Total No. Months Outside Threshold	Total No. Months Sampled	No. Months Sampled 2001-2002	No. Months Sampled 2005-2007	No. Months Sampled 2014
Conductivity	<150 uS/cm	8	**4**	**30**	12	18	--
		9	**1**	**12**	12	--	--
		10	**5**	**12**	12	--	--
		11	**6**	**12**	12	--	--
		18	**1**	**8**	8	--	--
		20	**1**	**9**	9	--	--
		21	**1**	**12**	12	--	--
		22	**3**	**12**	12	--	--
		25	**16**	**54**	12	42	--
		32	**14**	**18**	--	18	--
		35	**2**	**23**	--	23	--
		FOS #1	**7**	**8**	--	--	8
		FOS #2	**8**	**8**	--	--	8
		FOS #3	**9**	**10**	--	--	10
		FOS #4	**6**	**10**	--	--	10
		FOS #5	**6**	**10**	--	--	10
		FOS #6	**7**	**10**	--	--	10
		FOS #7	**7**	**10**	--	--	10
		FOS #8	**8**	**10**	--	--	10

*If sites were tested but never had values outside of threshold ranges, they are not included in this table.
**DO% was not tested at FOS sites. DO mg/L was tested instead.

Bacteria

Surface water almost always contains some degree of bacterial contamination, due to exposure to animals, humans, aquatic life, etc. Bacteria are microscopic single-celled organisms that function as decomposers in a waterway, breaking down plant and animal remains. Bacteria live on the surface of water, in the water column, in sediment, on detritus, and in and on the bodies of plants and animals. Bacteria serve as food for other organisms; they also are involved in many chemical reactions within the water. While bacteria normally inhabit waterways as an integral part of the food web, human activities may introduce pathogenic bacteria into the system. The greatest public health concern is the introduction of fecal waste from humans or warm-blooded animals. Sources of fecal bacterial contamination include faulty wastewater treatment plants, livestock, sanitary landfills, failing septic systems, fecal waste from pets and wildlife, storm water runoff, and sewage spills. Elevated levels of pathogenic bacteria can cause health problems, cloudy water, unpleasant odors, and an increased oxygen demand.

Coliforms are a group of mostly friendly bacteria which are readily found in soil, decaying vegetation, animal feces, and raw surface water. They are commonly used as "indicator organisms" in water microbiological analyses. They are common and generally not harmful.

E.coli or *Escherichia coli* is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. The presence of *E.coli* in water is a strong indication of recent sewage or animal contamination. Sewage may contain many types of disease-causing organisms. During rainfalls, snow melts or other types of precipitation, *E.coli* may be washed into waterbodies. *E.coli* O157:H7 is one example of a harmful strain of bacterium that produces a powerful toxin and can cause severe illness. Many other *E.coli* strains are harmless and live in the intestines of healthy humans and animals.

Water quality objectives outlined by the California Regional Water Quality Control Board (CRWQCB) for the Sacramento River basin dictate that fecal coliform should not exceed a geometric mean of 200/100 ml (CRWQCB, 2010). The following sites were above the recommended threshold for fecal coliform:

- Site 4 (Bear River at Hwy 174) in Dec 2001
- Site 10 (Bear River above Dry Creek) in Oct 2002
- Site 11 (Bear River above Feather River) in Feb and Oct 2002
- Site 18 (Wolf Creek at Old Auburn Road) in July and Aug 2002
- Site 20 (Wolf Creek at Lime Kiln Road) in June 2002
- Site 21 (South Wolf Creek at Hwy 49) in Feb and June 2002
- Site 22 (Wolf Creek at Wolf Road) in Dec 2001 and Feb and Sept 2002
- Site 23 (South Wolf Creek at Dog Bar Road) from May-Aug and Oct 2002
- Site 24 (South Wolf Creek at Lode Star Drive) in June 2002
- Site 25 (Wolf Creek at North Star Mine Museum) in Sept 2006
- Site 30 (Peabody Creek at Pond) in June 2006
- Site 31 (Peabody Creek at Walsh Street) in June 2006

- Site 34 (French Ravine 1 at McCourtney Road) in Sept 2006
- Site 42 (Peabody Creek East Fork, behind homes) in Oct 2005
- WC #9 (Wolf Creek above Allison Ranch Road) in Oct and Nov 2005.

Note: bacteria samples were not taken consistently in 2005-2007 and were not taken in 2014 data.

Dissolved Oxygen (DO)

Dissolved oxygen is molecular oxygen (oxygen gas, O_2) dissolved in water. Although all water molecules contain oxygen atoms, this oxygen is chemically part of the water molecule and not available as oxygen the aquatic organisms need for “breathing.” Rapidly moving water tends to contain a lot of dissolved oxygen, while stagnant water contains little. Dissolved oxygen in water is obtained by atmospheric re-aeration and photosynthetic activities of aquatic plants. Dissolved oxygen is then used by the organisms living in the creek for their metabolic activities. Altitude affects dissolved oxygen because water holds less oxygen at higher altitudes. By taking this measurement monthly, we see the various DO readings at different conditions throughout the Bear River Watershed and can use this information to measure overall stream health.

The CRWQCB water quality objective for dissolved oxygen is above 85% and 7.0 mg/l (CRWQCB, 2010). Fish die-offs begin to occur at less than 7.0 mg/l. The following sites did not meet one or both of these objectives:

- Site 1 (Bear River at Highway 20) from Dec 2001-Nov 2002, Nov 2003-May 2004, Jan/Mar/Apr 2005, Sept 2005 -May 2007 (<85%)
- Site 2 (Bear River above Steephollow Creek) in Sept 2002 (<85%)
- Site 4 (Bear River at Highway 174) in Sept 2002 (<85%)
- Site 8 (Bear River above Camp Far West Reservoir) in Nov 2002 (<85%)
- Site 11 (Bear River above Feather River) in June and Aug 2002 (<7.0mg/l) and Dec 2001-Jan 2002, June-Sept 2002, and Nov 2002 (<85%)
- Site 13 (Greenhorn Creek at Red Dog Road) in May-June 2002, Sept and Nov 2002 (<85%)
- Site 14 (Greenhorn Creek at You Bet Road) in June 2002 (<85% and <7.0mg/l)
- Site 15 (Steephollow Creek above Bear River) from June-Nov 2002 (<85%)

- Site 16 (Steephollow Creek at Highway 20) in July and Aug 2002 (<7.0mg/l) and Dec 2001-Nov 2002 (<85%)
- Site 17 (Loma Rica - upstream of Brunswick at Idaho-Maryland) in Feb 2006 (<7.0 mg/l), Sept 2003, Nov 2004, Feb/Mar/Sept/Dec 2006, June-Aug 2007 (<85%)
- Site 18 (Wolf Creek at Old Auburn Road) in June and Oct 2002 (<85%)
- Site 20 (Wolf Creek at Lime Kiln Road) in Aug and Sept 2002 (<85%)
- Site 21 (South Wolf Creek at Highway 49) from June-Nov 2002 (<85%)
- Site 22 (Wolf Creek at Wolf Road) from July-Oct 2002 (<85%)
- Site 23 (South Wolf Creek at Dog Bar Road) in Sept 2002 (<7.0 mg/l and <85%) and Nov 2002 (<85%)
- Site 24 (South Wolf Creek at Lode Star Drive) in July 2002 (<7.0 mg/l and <85%) and Oct 2002 (<85%)
- Site 25 (Wolf Creek at North Star Mine Museum) in Jan/June/Oct 2002, Oct/Nov 2003, July 2004, Feb/Mar 2006, May 2007 (<85%), Feb 2006 (<7.0 mg/l)
- Site 30 (Peabody Creek at Pond) in July 2005 (<85%), Jan-Feb 2006 (<7.0 mg/l)
- Site 31 (Peabody Creek at Walsh Street) in Apr/July/Aug/Oct 2005, Feb/Mar 2006 (<85%), and Dec 2005, Feb 2006 (<7.0 mg/l)
- Site 32 (South Fork of Wolf Creek at Hennessy) in Jan/Nov/Dec 2005, Mar/May 2007 (<85%) and Jan/Mar 2007 (<7.0 mg/l)
- Site 33 (South Fork of Wolf Creek at Wood Rose) in Feb-Aug/Oct-Dec 2005, Mar 2006, Aug 2006-Aug 2007 (<85%), and July/Aug/Dec 2005, Aug 2006, May/July/Aug 2007 (<7.0 mg/l)
- Site 34 (French Ravine 1 at McCourtney Road) in Feb/Apr/July 2006-Aug 2007 (<85%), and Feb/July/Aug-Nov 2006, Mar/May/June/Aug 2007 (<7.0 mg/l)
- Site 35 (French Ravine 2 at Hidden Valley) in Oct/Nov 2005, July/Sept/Oct/Nov 2006, Feb/May/June/Aug 2007 (<85%)
- FOS #3 July 2014 (<7.0 mg/l)
- FOS #4 in Aug 2014 (<7.0 mg/l)
- FOS #5 in Aug 2014 (<7.0 mg/l)

- FOS #8 in July 2014 (<7.0 mg/l).

Note: Friends of Spenceville (FOS) sites on Dry Creek were not measured for DO%; they were instead measured for DO mg/L.

Nutrients

Nutrients, such as nitrogen and phosphorus, are essential for plant and animal growth and nourishment, but an overabundance of certain nutrients in water can cause a number of adverse ecological and health effects. Excess nitrogen and phosphorus can cause the overstimulation of growth of aquatic plants and algae. Excessive growth of these organisms can use up dissolved oxygen as they decompose and block light to deeper waters. Lake and reservoir eutrophication can also occur, which produces unsightly algae scums on the water surface and can cause fish kills due to oxygen depletion.

Nitrogen is abundant naturally in the environment but can be introduced through sewage and fertilizers. Phosphorus is a common constituent of agricultural fertilizers, manure, and organic wastes in sewage and industrial effluent. In fresh water ecosystems, phosphorus is often the limiting nutrient; therefore, excess phosphorus inputs can have detrimental effects.

The CRWQCB basin objectives documentation warns against elevated levels of nitrogen and phosphorus, however specific threshold values are not given (CRWQCB, 2010). The US EPA has set a threshold value of 10,000 ug/L (10 ppm) for acceptable levels of nitrogen for fish consumption, and a threshold of 0.1 mg/L of total phosphorus in cold freshwater habitats for fish spawning (USEPA, 1986; USEPA, 1988). Acceptable levels of ammonium vary with water pH and temperature, with the lowest threshold of 0.45 mg/L at the extremes of 16°C and pH 8.5 (USEPA, 1986). The reporting limit for phosphate laboratory analysis in the 2001 to 2002 monitoring time period was initially 0.2 ppm, but changed to 0.1 ppm in October 2002 due to laboratory equipment upgrades. As a result, it is not clear whether phosphate levels were above the 0.1 mg/L recommendation before October 2002; however, values over 0.2 ppm are noted below. From 2005-2007, only field measurements of phosphate were taken, with a reporting limit of 1 ppm. Again, only values over this threshold were reported as elevated.

The following sites have experienced elevated nutrient levels:

- Site 1 (Bear River at Highway 20) in Jan 2002 (>0.45 ppm NH_4), Aug 2002 and Sept 2005 (>0.1 ppm PO_4)
- Site 2 (Bear River above Steephollow Creek) in July 2002 (>0.45 ppm NH_4)

- Site 5 (Bear River below Lake Combie) in Dec 2001 and Aug 2002 (>0.1 PO_4)
- Site 8 (Bear River above Camp Far West Reservoir) in Oct 2002 and Mar 2007 (>0.45 ppm NH_4) and July 2005 (>0.1 ppm PO_4)
- Site 13 (Greenhorn Creek at Red Dog Road) in Aug 2002 (>0.1 ppm PO_4)
- Site 14 (Greenhorn Creek at You Bet Road) in June 2002 (>0.45 ppm NH_4)
- Site 15 (Steephollow Creek above Bear River) in Jan 2002 (>0.45 ppm NH_4)
- Site 17 (Loma Rica - upstream of Brunswick at Idaho-Maryland) in Apr/July/Aug 2005 and June 2006 (>0.45 ppm NH_4)
- Site 18 (Wolf Creek at Old Auburn Road) in Aug 2002 (>0.1 ppm PO_4)
- Site 20 (Wolf Creek at Lime Kiln Road) in July 2002 (>0.45 ppm NH_4) and Aug 2002 (>0.1 ppm PO_4)
- Site 22 (Wolf Creek at Wolf Road) in Oct 2002 (>0.45 ppm NH_4), Dec 2001 and Aug 2002 (>0.1 ppm PO_4)
- Site 25 (Wolf Creek at North Star Mine Museum) in Aug 2002, Jan/Feb 2005, Nov 2006, and Jan 2007 (>0.1 ppm PO_4), May/Oct 2005 (>0.45 ppm NH_4)
- Site 30 (Peabody Creek at Pond) in Apr/July/Sept 2005 (>0.45 ppm NH_4), Sept 2005 (>10 ppm NO_3), Jan/Feb/Apr/Dec 2005 (>0.1 ppm PO_4)
- Site 31 (Peabody Creek at Walsh Street) in Apr/July/Sept/Oct 2005 (>0.45 ppm NH_4), Sept 2005 (>10 ppm NO_3), Feb/Apr 2005 and June 2006 (>0.1 ppm PO_4)
- Site 32 (South Fork of Wolf Creek at Hennessy) in Nov 2005 and Jan 2006 (>0.45 ppm NH_4), May/Nov 2005, Jan 2006 and Jan 2007 (>0.1 ppm PO_4)
- Site 33 (South Fork of Wolf Creek at Wood Rose) in Dec 2006 (>0.45 ppm NH_4), Nov 2005, Dec 2006, Jan 2007 (>0.1 ppm PO_4).

pH

The pH value is very important for various organisms living in the creek and many have adapted to living in water with a specific pH range. Changes in pH can greatly affect these organisms and can cause death, which is especially true for certain aquatic macroinvertebrates and fish fry and eggs. pH is a measure of the acidity or basicity of a solution or, in other words, the concentration of hydrogen ions (H+) or hydroxide ions (OH-). pH is measured on a logarithmic scale and typically ranges from 0 to 14, though values outside of this range are possible. Therefore a drop in 1.0 pH unit is equivalent to a 10-fold increase in acidity. Pure water is considered to be neutral when there is an equal amount of acidic and alkaline molecules and will have a reading of 7.0 at 25^{o}C. Solutions with a pH value less than 7.0 are said to be acidic, and values above 7.0 are said to be basic or alkaline.

The pH of a body of water is affected by several factors. One of the most important factors is the bedrock and soil composition the water is exposed to. Some rock types such as limestone can, to an extent, neutralize acid, while others such as granite have virtually no effect on pH. Another factor that influences pH is the amount of plant growth and organic material within the stream. When this material decomposes carbon dioxide is released. The carbon dioxide combines with water to form carbonic acid, which is also produced when carbon dioxide dissolves into the water from the air. Although this is a weak acid, large amounts of it will lower the pH. There is also diurnal variation in pH values throughout the day. The majority of aquatic organisms prefer a pH range of 6.5-8.5. pH can also be an indicator for potential invasion of non-native aquatic species, such as zebra and quagga mussels. Researchers have generally used or recommend the use of pH limits between 6.5-7.5 and 9.0-9.5 to assess zebra mussels' potential distribution. (Cohen, 2008)

The pH values should fall between 6.5 and 8.5, according to the CRWQCB (CRWQCB, 2010). The following sites were outside of this range:

- Site 1 (Bear River at Highway 20) in Mar 2006 and Mar 2007 (<6.5)
- Site 5 (Bear River below Lake Combie) in June 2002 (<6.5)
- Site 8 (Bear River above Camp Far West Reservoir) in July 2006 (>8.5)
- Site 9 (Bear River at Highway 65) in Mar 2002 (>8.5)
- Site 13 (Greenhorn Creek at Red Dog Road) in Mar/May 2002 (<6.5)
- Site 14 (Greenhorn Creek at You Bet Road) in Mar 2002 (<6.5)
- Site 16 (Steephollow Creek at Highway 20) in Dec 2001 and June 2002 (<6.5)
- Site 17 (Loma Rica - upstream of Brunswick at Idaho-Maryland) in Mar/Oct 2003, Jan/Feb/Nov/Dec 2004, Apr 2005, Sept 2006, Jan 2007 (<6.5)
- Site 25 (Wolf Creek at North Star Mine Museum) in Nov 2003 (<6.5)
- Site 30 (Peabody Creek at Pond) in Apr 2005, Jan/June 2006 (<6.5)

- Site 31 (Peabody Creek at Walsh Street) in Feb/Apr 2005, June 2006 (<6.5)
- Site 32 (South Fork of Wolf Creek at Hennessy) in Aug/Sept 2005, Jan/Mar 2006 (<6.5)
- Site 33 (South Fork of Wolf Creek at Wood Rose) in Feb/May/July/Aug/Sept/Dec 2005, Jan-Apr/Sept/Dec 2006, Jan/Aug 2007 (<6.5)
- Site 34 (French Ravine 1 at McCourtney Road) in June/Nov 2006 (<6.5)
- BR_Gaut (Bear River at Gautier Rd) in Aug 2006 (<6.5).

Conductivity

Conductivity is the measure of the ability of water to pass an electrical current and is highly dependent on the amount of ions such as salt (sodium chloride) dissolved in the water. Specific conductivity is the term used for conductivity values that have been adjusted to 25^{o}C. Conductivity is affected by temperature: the warmer the water, the higher the conductivity. Pure water, such as distilled water, will have very low specific conductance whereas salt water will have a high reading.

The geology and rock composition of an area helps determine the chemistry of a watershed and the amount of types of available ions. Soil and rocks release ions into the waters that flow through or over them. Streams that run through areas with granitic bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionize when washed into water. Conversely, streams that run through areas with carbonate rocks, such as limestone, tend to have higher conductivity. Periods of high flow, such as during storms, may cause periods of high conductivity due to the flush of ions entering the streams.

Conductivity should not exceed 150 micromhos/cm (150 microsiemens) because salinity imbalances can make stream conditions unfavorable for a wide variety of species (CRWQCB, 2010). Sites above this value include

- Site 8 (Bear River above Camp Far West Reservoir) in Dec 2001, Nov 2002, Aug/Oct 2005; Site 9 (Bear River at Highway 65) in Dec 2001
- Site 10 (Bear River above Dry Creek) in Dec 2001 and Jan/July/Oct/Nov 2002
- Site 11 (Bear River above Feather River) in Dec 2001 and Jan/Aug-Nov 2002
- Site 18 (Wolf Creek at Old Auburn Road) in Nov 2002

- Site 20 (Wolf Creek at Lime Kiln Road) in Nov 2002
- Site 21 (South Wolf Creek at Highway 49) in Nov 2002
- Site 22 (Wolf Creek at Wolf Road) in Jan/Mar/Nov 2002
- Site 25 (Wolf Creek at North Star Mine Museum) in Jan/Nov 2002, Feb/Oct/Nov 2003, Jan/Oct/Dec 2004, Jan/Feb/Nov/Dec 2005, Mar/Nov/Dec 2006, Jan 2007
- Site 32 (South Fork of Wolf Creek at Hennessy) in Jan-Mar/May, Aug-Dec 2005, Sept/Nov/Dec 2006, Mar/May 2007
- Site 35 (French Ravine 2 at Hidden Valley) in Nov/Dec 2005
- FOS #1 in Jan/Apr-July/Sept/Dec 2014
- FOS #2 in Jan/Mar-July/Sept/Dec 2014
- FOS #3 in Jan/Mar-July/Sept/Nov/Dec 2014
- FOS #4 in Jan/Mar-May/Nov/Dec 2014
- FOS #5 in Jan/Mar/Apr/May/Nov/Dec 2014
- FOS #6 in Jan/Mar-June/Nov/Dec 2014
- FOS #7 in Jan/Mar-June/Nov/Dec 2014
- FOS #8 in Jan/Mar/Apr-July/Nov/Dec 2014.

In February 2016, New Zealand mud snails were discovered in the lower Yuba and lower Feather rivers. Research suggests that many waterways in the range of 25–200 micromhos/cm cannot support productive populations and that nuisance invasions may be most prevalent in waters above 200 micromhos/cm (Herbst et al., 2008). New Zealand mud snails can have significant impacts on stream ecosystems, and may consume a large fraction of available algae production and compete with and displace native invertebrates.

Turbidity

Turbidity is a measure of water clarity. Water clarity is affected by the presence of suspended and dissolved matter, such as clay, silt, finely divided organic matter, plankton, microscopic organisms, organic acids and dyes. Algae, suspended sediment, organic matter and some pollutants can obscure the water making it appear cloudy or muddy. Suspended particles diffuse sunlight and absorb heat, which can increase water temperature and reduce light availability for submerged aquatic vegetation and benthic (bottom-dwelling) macroinvertebrates. If the turbidity is caused by sediment, it can be an indicator of erosion, either natural or man-made. High sediment loads can clog the gills of fish. Once the sediment settles, it can foul gravel beds and smother fish eggs and benthic macroinvertebrates. The sediment can also carry pathogens, pollutants and nutrients. High turbidity often occurs during storms.

A clear objective for turbidity levels is difficult to determine, as the CRWQCB objectives rely on the natural turbidity of a waterway, which is currently undefined for the Bear River (CRWQCB, 2010). However, from previous experience in the region, a threshold of 10 NTU (Nephelometric Turbidity Unit) is likely appropriate; however, better understanding the natural seasonal variations in turbidity (i.e. typically higher turbidity in the rainy winter season) will be important in the future for setting more specific water quality objectives. With this value, the following sites displayed high turbidity

- Site 4 (Bear River at Highway 174) in Dec 2001, Feb 2002
- Site 5 (Bear River below Lake Combie) in Dec 2001 and Feb 2002
- Site 8 (Bear River above Camp Far West Reservoir) in Feb 2002, Jan/March 2004
- Site 9 (Bear River at Highway 65) in Feb 2002
- Site 10 (Bear River above Dry Creek) in Feb 2002 and July 2002
- Site 11 (Bear River above Feather River) in Dec 2001-Mar 2002, May-July/Sept 2002;
- Site 13 (Greenhorn Creek at Red Dog Road) in Aug 2002
- Site 17 (Loma Rica - upstream of Brunswick at Idaho-Maryland) in Jan/Feb 2004
- Site 20 (Wolf Creek at Lime Kiln Road) in Feb 2002
- Site 21 (South Wolf Creek at Highway 49) in Dec 2001 and Feb 2002
- Site 22 (Wolf Creek at Wolf Road) in Dec 2001 and Feb 2002
- Site 25 (Wolf Creek at North Star Mine Museum) in Dec 2001, Jan 2002, Jan/Feb 2004, July 2005, Jan/Mar/June 2006
- Site 30 (Peabody Creek at Pond) in July-Oct 2005
- Site 31 (Peabody Creek at Walsh Street) in Sept 2005
- Site 32 (South Fork of Wolf Creek at Hennessy) in May 2005, Mar 2006, Mar 2007;
- Site 34 (French Ravine 1 at McCourtney Road) in Feb/Nov/Dec 2006, Feb 2007

- Site 35 (French Ravine 2 at Hidden Valley) in Dec 2005, Mar/Dec 2006

Wolf Creek Community Alliance Monitoring

Wolf Creek Community Alliance (WCCA), a nonprofit creek stewardship organization based in Grass Valley, regularly monitors the physical and chemical conditions of sites across the Wolf Creek subwatershed. The sites monitored by WCCA between 2004 and 2012 are presented in Table 8. An overview of the results of WCCA's water quality monitoring is presented in Table 9. The thresholds set by WCCA are slightly different than those used by the Regional Water Quality Control Board, discussed above, because of the different conditions found in Wolf Creek, which is 303(d) listed for bacteria. More detailed information on the WCCA water quality results and methods can be found in WCCA, 2013.

Turbidity was measured across the sites of the WCCA 1,078 times. All sites had a mean turbidity below the approximate 10 NTU thresholds, but most sites experienced spikes in turbidity greater than the threshold, up to 100 NTU. According to WCCA, 67% of the spikes in turbidity occurred between December and March.

For conductivity, WCCA sets a threshold of 1000 microsiemens. Out of 1,204 records across all sites between 2004 and 2012, the maximum conductivity value recorded was less than 600microsiemens, below their threshold. However, the majority of sites were above the 150microsiemen threshold set by the Regional Water Quality Board. The highest conductivity measurements occurred during the winter. Values were very low in the summer along the stretch of the creek that conveys NID flows. The headwater sites and tributaries to Wolf Creek did not have the same seasonal variation.

For pH, WCCA had issues with instruments underreporting pH between the fall of 2005 and August 2009. WCCA has screened out data that it is confident was incorrect, but some of the data of poorer quality remains. Generally, the headwaters were more acidic and the majority of sites were below the WCCA threshold of 6.5, with the exception of sites 9.5 and 11, which were above the threshold of 8.5.

WCCA also measured for nutrients. Excess concentrations were not found for any nutrients except for phosphates. Phosphate sampling locations were targeted and, as such, phosphates were detected at every site tested.

***Table 8*. Wolf Creek Community Alliance Monitoring Sites**

Site No.	Location
1	Wolf Creek Headwaters
2	Wolf Creek at Loma Rica, above Brunswick
3	Wolf Creek above Olympic Creek

3.1	Olympic Creek, Brunswick
4	Wolf Creek Grass Valley Industrial Area
5	Wolf Creek below Industrial Area
6	South Fork at Empire Mine
6.1	South Fork Headwaters
7	Wolf Creek above WWTP
8	Wolf Creek at North Star
9	Wolf Creek at Allison Ranch
9.5	Wolf Creek head of Tarr Ditch
10	Wolf Creek below French Ravine
10.8	Wolf Creek upstream of Lime Kiln Crossing
11	Wolf Creek at Lime Kiln
12	Peabody Creek above Condon
13	Peabody Creek at Condon
14	South Wolf above Wolf
15	Wolf Creek above Bear River
25	South Wolf at Dog Bar
26	Salt Creek
27	South Wolf above Cherry Creek
28	Cherry Creek
30	French Ravine at Hidden Valley
32	French Ravine below horse farms
34	French Ravine upstream of McCourtney Rd

***Table 9*. Sites Outside of Water Quality Thresholds on Wolf Creek**

Metric	Water Quality Objective	Site	Number of Samples	Percent outside threshold
		1	14	7
		2	12	8
		3	14	7
		3.1	13	15
		6	19	16
		6.1	2	50
		8	31	23
		9	41	10
		12	11	45
E. coli	<256MPN	13	11	9
		14	14	29
		15	17	6
		25	2	50
		27	14	14
		28	12	8
		30	28	25
		32	12	42

Metric	Water Quality Objective	Site	Number of Samples	Percent outside threshold
		34	15	7
		FRD	1	100
DO	<7mg/L	2	44	2.3
		3.1	75	2.7
		6.1	39	23
		10	70	1.4
		10.8	64	1.6
		12	53	11
		13	58	3.4
		15	65	1.5
		27	54	13
		28	54	17
		30	18	5.6
		32	11	9.1
		34	15	47
pH	6.5-8.5	1	66	62
		2	38	16
		3	62	4.8
		5	62	10
		6	74	1.4
		6.1	35	71
		6.2	1	100
		8.01	1	100
		9.01	1	100
		9.5	12	8.3
		11	15	6.7
		12	45	38
		13	51	26
		15	61	1.6
		27	45	4.4
		28	46	22
		30	19	5.3
		32	12	8.3
		34	17	24
		Safeway Culvert	1	100

III.A.4b. Groundwater Quality

Groundwater is the largest store of freshwater on the planet, with approximately 94% of all freshwater residing underground. Groundwater is closely linked to ecosystem services, as many populations rely directly on aquifers for drinking water, and a significant proportion of the world’s agriculture depends on groundwater for irrigation (Bergkamp and Cross, 2006). In the hydrological cycle, groundwater functions to store and release water, sustaining river flows, purifying water, and controlling erosion and floods in the process. Aquifers hold ecological importance as well, with connections to multiple ecosystems such as terrestrial flora and fauna, river base flows, aquifer and cave ecosystems, wetlands, and estuarine ecosystems. Maintaining high groundwater quality is critical because contaminated groundwater discharge to streams can affect aquatic life and downstream users of water including for drinking or irrigation purposes (Bergkamp and Cross, 2006).

Several groundwater wells throughout the watershed have shown levels of chemical contaminants above the drinking water standard for public supply wells (State Water Resources Control Board, 2008). Figure 10 shows the approximate location of these wells based on data from the State Water Resources Control Board's Geotracker Groundwater Ambient Monitoring and Assessment (GAMA). Information on the precise sources of this contamination, if known, was not available, but will be crucial for restoration and remediation efforts. In the last ten years, 169 wells were found with elevated levels of at least one of the following contaminants, based on the thresholds presented in Table 10: (GAMA Geotracker, 2008).

***Table 10*. Groundwater Quality Contaminant Thresholds**

Indicator	Threshold
1,2 dichloroethane	0.5ug/L
1,2 dibromoethane	0.5ug/L
Arsenic	10ug/L
Benzene	1ug/L
Carbon-14	94.88 percentile
Cadmium	0.5UG/L
Chloride	500mg/L
Copper	1.3mg/L
Electrical conductivity	1600umHos/cm
Ethylbenzene	300ug/L
Iron	300ug/L
Lead	15ug/L
Manganese	50ug/L
Methyl-ter-butyl ether	5ug/L
Naphthalene	100ug/L
Nickel	100ug/L
Sodium	50mg/L
Sulfate	500mg/L
Tert-butyl alcohol	12ug/L
Tetrachloroethene	5ug/L
Thallium	2ug/L
Toluene	150ug/L

Indicator	Threshold
Trichloroethene	5ug/L
Total xylenes	1750ug/L

Subwatersheds with groundwater most likely to be heavily affected by contamination are Magnolia Creek, Best Slough, Grasshopper Slough, and Rattlesnake Creek-Wolf Creek. A summary of the number of wells per subwatershed with elevated levels of contaminants at some point in the past ten years is shown in Table 11. Magnolia Creek subwatershed had 15 wells in the past ten years with elevated levels of benzene, toluene, ethylbenzene, iron, manganese, methyl-tert-butyl ether, tert-butyl alcohol, and total xylenes. In the past three years, elevated levels of benzene, ethylbenzene, and methyl-tert-butyl ether have been found. In Best Slough subwatershed, four wells were found with elevated manganese since 2005, and seven others had elevated levels of manganese, electrical conductivity, sodium, chloride, benzene, total xylenes, ethyl benzene, toluene, arsenic, trichloroethene, tetrachloroethene, and 1,2 dichloroethane. In the past three years from 2013 to 2015, elevated TCE, benzene, arsenic, and manganese were found. In Grasshopper Slough subwatershed, five wells had elevated levels of either iron, sodium, trichloroethene, or methyl-tert-butyl ether in the past ten years, and 11 more had multiple chemical contaminants (sodium, iron, methyl-tert-butyl alcohol, xylene, tert-butyl alcohol, ethyl benzene, 1,2 dichloroethane, toluene, benzene, and trichloroethene). By far the most affected subwatershed is Rattlesnake Creek-Wolf Creek, with a total of 118 wells containing levels of contaminants above threshold levels. Benzene, manganese, methyl-tert- butyl ether, cadmium, 1,2 dichloroethane, ethyl benzene, iron, naphthalene, nickel, lead, tetrachloroethene, sulfate, tert-butyl alcohol, trichloroethene, and total xylenes were found in elevated concentrations in the subwatershed in the last decade.

Subwatersheds with a lesser degree of contamination include Indian Springs-Dry Creek (one well with elevated Carbon-14 in 2008), Little Bear Creek (one well with elevated iron and manganese in 2012 and 2015), Camp Far West Reservoir (one well with elevated iron in 2013), Vineyard Creek- Dry Creek (four wells with elevated levels of tetrachlorethene in 2014 and 2015), and Yankee Slough (two wells with elevated sodium in 2007 and 2009).

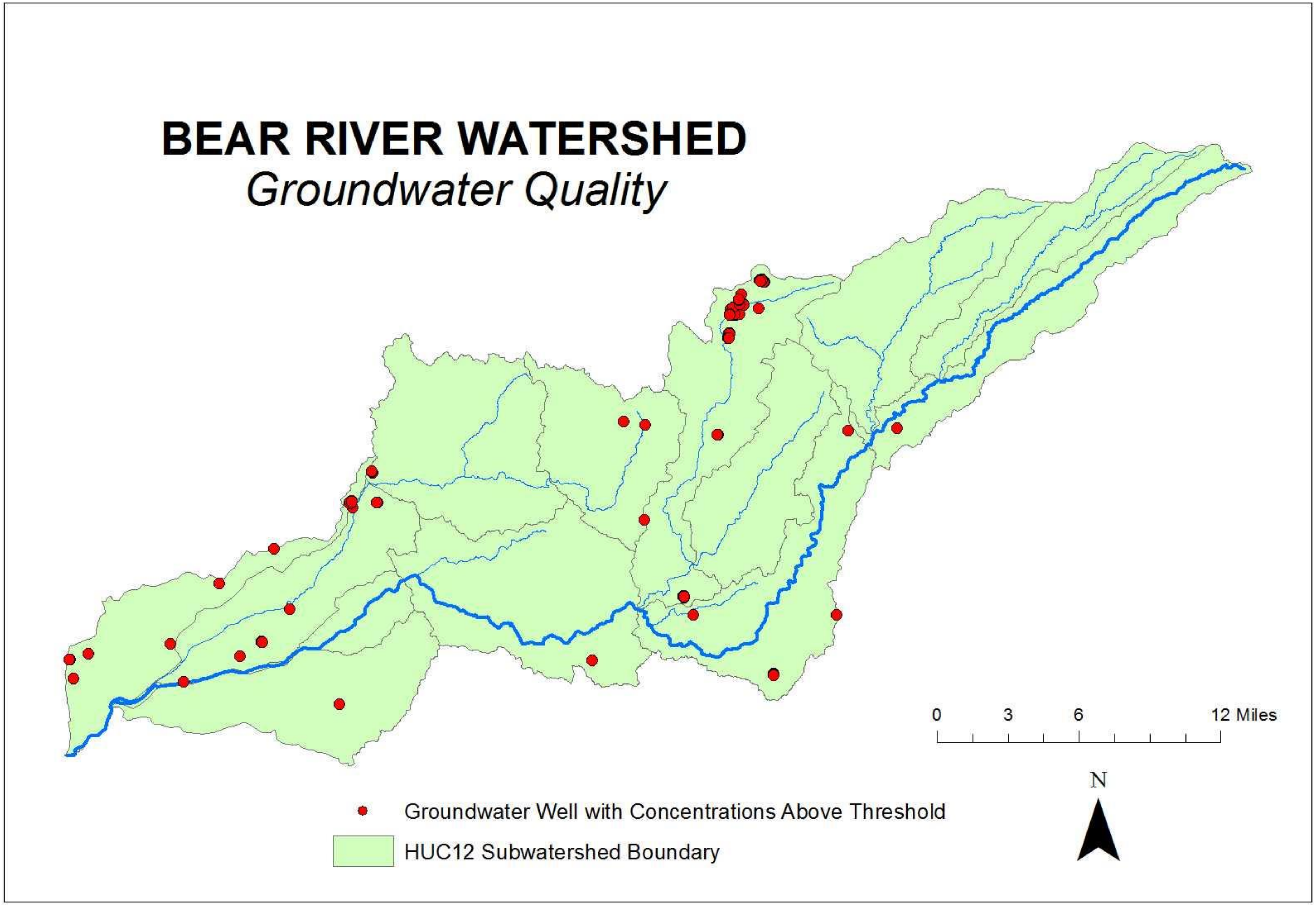
***Table 11*. Number of Groundwater Wells by Subwatershed with Elevated Contaminants**

Subwatershed	Number of Wells	Contaminants Detected
Magnolia Creek	15	Benzene, ethylbenzene, methyl-tert-butyl ether, toluene, iron, manganese, tert-butyl alcohol, total xylenes

Subwatershed	Number of Wells	Contaminants Detected
Best Slough	11	Manganese, electrical conductivity, sodium, chloride, benzene, total zylenes, ethyl benzene, toluene, arsenic, trichloroethen, tetrachloroethene, 1 2 dichloroethane
Grasshopper Slough	16	Iron, sodium, trichloroethene, methyl-tert-butyl ether, xylene, tert-butyl alcohol, ethyl benzene, 1 2 dichloroethane, toluene, benzene, trichloroethene
Rattlesnake Creek	118	Benzene, manganese, methyl-tert-butyl ether, cadmium, 1 2, dichloroethane, ethyl benzene, iron, naphthalene, nickel, lead, tetrachloroethene, sulfate, tert-butyl alcohol, trichlorethene, total xylenes
Indian Springs	1	Carbon-14
Little Bear Creek	1	Iron, Manganese
Camp Far West Reservoir	1	Iron
Vineyard Creek	4	Tetrachlorethene
Yankee Slough	2	Sodium

A shallow assessment of the Bear River is in progress and should be completed by March 2016 in time for development of the restoration plan. The study unit for the assessment will contain 75 wells in the watersheds of the Upper, Middle, and South Yuba Rivers and the Bear River, and the USGS plans to make a data series report, fact sheet, and scientific investigations report publicly available online (USGS, 2015).

Figure 10. Groundwater Quality Monitoring Stations



III.A.5. Wetlands

Wetlands provide a number of important ecosystem services, including maintenance of biodiversity, water storage, flood mitigation, carbon sequestration and aesthetic value. Mapping of wetlands can be used to prioritize conservation and restoration areas to protect vulnerable wetland flora and fauna, as well as to survey the prevalence of amphibian disease such as chytrid and ranavirus. The distribution of wetlands throughout the watershed is shown in Figures 11 through 15, according to the U.S. Fish & Wildlife Service National Wetlands Inventory. Data is current as of October 1, 2015. Patches of wetland are generally small, ranging in size from less than a tenth of an acre to 787 acres (Rollins Reservoir), with the vast majority of all wetland areas (68.5%) measuring under 1 acre. The total area of 6,466 acres covered by wetlands within the Bear River watershed is broken down by wetland type as follows:

- 1,148 acres freshwater emergent wetland (including herbaceous marsh, fen, swale, and wet meadow; 17.8%)
- 1,013 acres freshwater forested or shrub wetland (forested swamp or wetland shrub bog or wetland; 15.7%)
- 832 acres freshwater ponds (12.9%)
- 2,630 acres lakes or reservoirs (40.7%)
- 800 acres of riverine wetland (12.4%)
- 43 acres of other wetland types (farmed wetland, saline seep, and miscellaneous wetland; 0.007%)

The Wetlands Inventory's objective is to produce reconnaissance level information on the location, type, and size of resources, and maps are prepared from the analysis of high altitude imagery. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground surveys of known and unknown locations, and assessments would give a true measure of presence and level of function for these critical habitats within the watershed.

In general, freshwater wetlands are considered one of the habitats more sensitive to climate change since change in precipitation, evaporation, and evapotranspiration are likely to affect groundwater levels; even minor fluctuations in water availability can affect the suitability of habitat for some wetland plants (Kutner and Morse, 1996). Mid-elevation areas (1500-3000 meters), which contain the bulk of montane meadows, will face many issues, such as decreasing snowpack (Null et al., 2010). Moreover, meadow systems will be particularly vulnerable to flashy water runoff events and increased sediment loads, particularly those already affected by channel and bank instability, incision, and decreased water tables, in effect turning wet meadows to dry meadows. Flash floods carrying heavy sediment loads and debris can tear away at unstable meadow stream channels, drastically increasing incision and erosion in single events, resulting in a continuous positive feedback of decreased ecological integrity (Viers et al., 2013). These effects could be further magnified in areas that have experienced forest fires, which are of increasing risk under climate change scenarios (Westerling & Bryant, 2008).

Wet meadows in the Sierra Nevada's have a long history of conifer encroachment, possibly as a result of fire suppression, change in hydrology, and soil compaction. Wet meadows have resulted in a shift from a graminoid/herbaceous community to one dominated by woody species, potentially diminishing a meadow's water holding capacity and its ability to provide critical ecosystem services (Viers et al., 2013).

In meadows with relatively high water tables, anaerobic soils and slowly decaying plant material cause soil carbon sequestration. When water tables are lowered as a result of management practices, meadow soils dry out and the carbon stored in the soil is rapidly decomposed and released into the atmosphere as CO2 (Norton et al., 2011). Sierra-wide research is being conducted to determine if meadow restoration sequesters sufficient carbon to allow California's carbon "cap and trade" marketplace to pay for meadow restoration (https://www.wildlife.ca.gov/Conservation/Wetlands-Restoration).

Sierra Nevada fens are a hotspot of biodiversity and sensitive flora. Disturbances to fen function can be divided into three main categories, direct physical damage to the fen surface, change to watershed inputs, and direct influence on vegetation growth. The most commonly reported impact is cattle use, which can have widely varying levels of effects in all three categories (Prichard et al., 1999). Fens should be identified and protected to every possible extent within the watershed. Fen areas should be assessed and rated on their Proper Functioning Condition, a qualitative method for assessing the condition of fen areas (Prichard et al., 1999), in order to assess current status and restoration priority of these critical habitats.

Vernal pools are covered by shallow water for variable periods from winter to spring, but may be completely dry for most of the summer and fall. These wetlands range in size from small puddles to shallow lakes and are usually found in a gently sloping plain of valley grassland. The unique environment of vernal pools provides habitat for numerous rare plants and animals that are able to survive and thrive in these harsh conditions. In addition, birds such as egrets, ducks, and hawks use vernal pools as a seasonal source of food and water. Vernal pools are a valuable and increasingly threatened ecosystem, often smaller than the bulldozer that threatens to destroy them. More than 90% of California's vernal pools have already been lost. Two rare plants found in the watershed’s vernal pools include *Downingia pusilla* and *Legenere limosa* (Witham et al., 1998).

Beale Air Force Base is the home of numerous highly sensitive vernal pool wetlands and their associated wildlife species. The base's Habitat Conservation and Management Plan (HCMP) identifies areas that are slated for future development. It defines what the base will do to mitigate for all wetlands that will be disturbed in these development areas in support of Beale's mission. At this point, all mitigation can be accommodated on the base's property. The mitigation consists of “conservation areas,” where preservation, management, and restoration of wetlands and wildlife habitat will occur. Conservation areas comprise 5,300 total acres, which is roughly 23 percent of the base's property. “Management areas” are those containing high-quality wetlands and threatened and endangered species habitat, but these wetlands are in areas identified for possible (but not likely) development in the future. These areas will be managed in the same way as the preservation areas, unless a special development project is identified for these areas. Also included in the HCMP are ”restoration areas” where the construction of approximately forty acres of vernal pools and other aquatic areas will occur. These regions previously supported the vegetation types that will be restored there, but they had been degraded and destroyed by past agricultural and military practices. Monitoring of vegetation composition and residual dry matter of biomass in vernal pools and grasslands is used to inform cattle grazing regimes on the Base. Sustainable grazing practices can positively affect vernal pool health by removing competing non-native grasses and forbs (Marty, 2005).

Figure 11. Wetlands in the Dry Creek Subwatershed

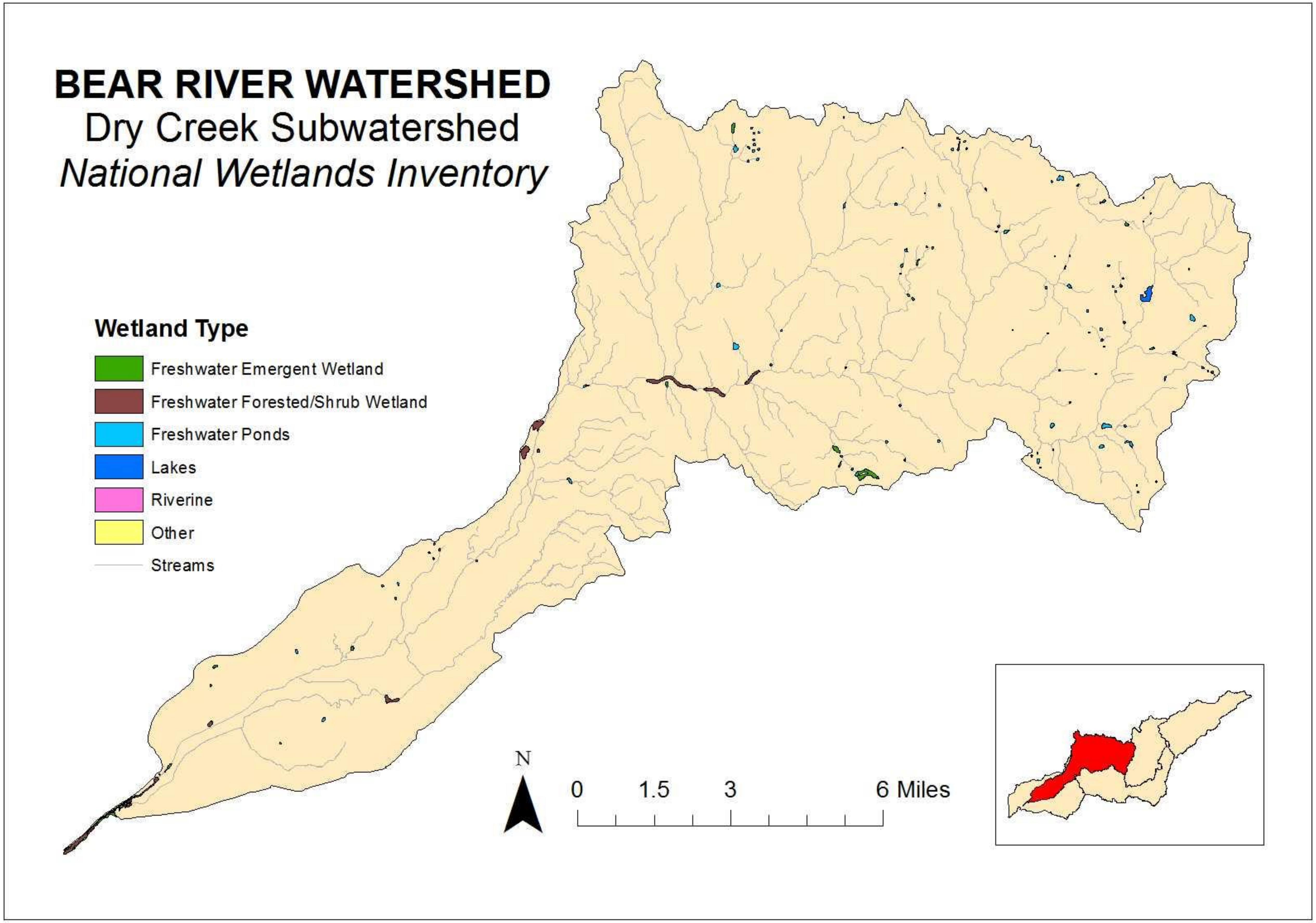


Figure 12. Wetlands in the Lower Bear Subwatershed

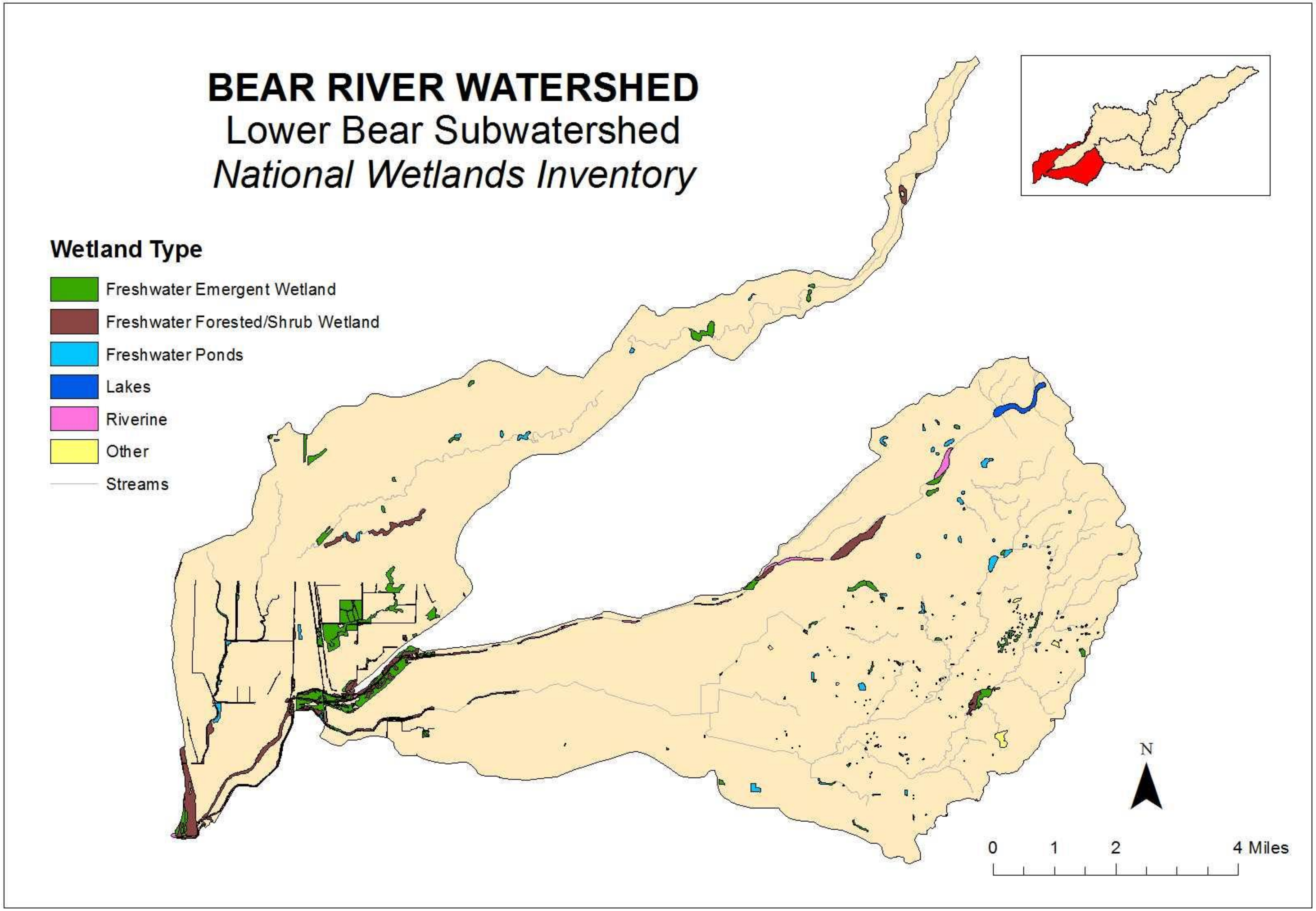


Figure 13. Wetlands in the Middle Bear Subwatershed

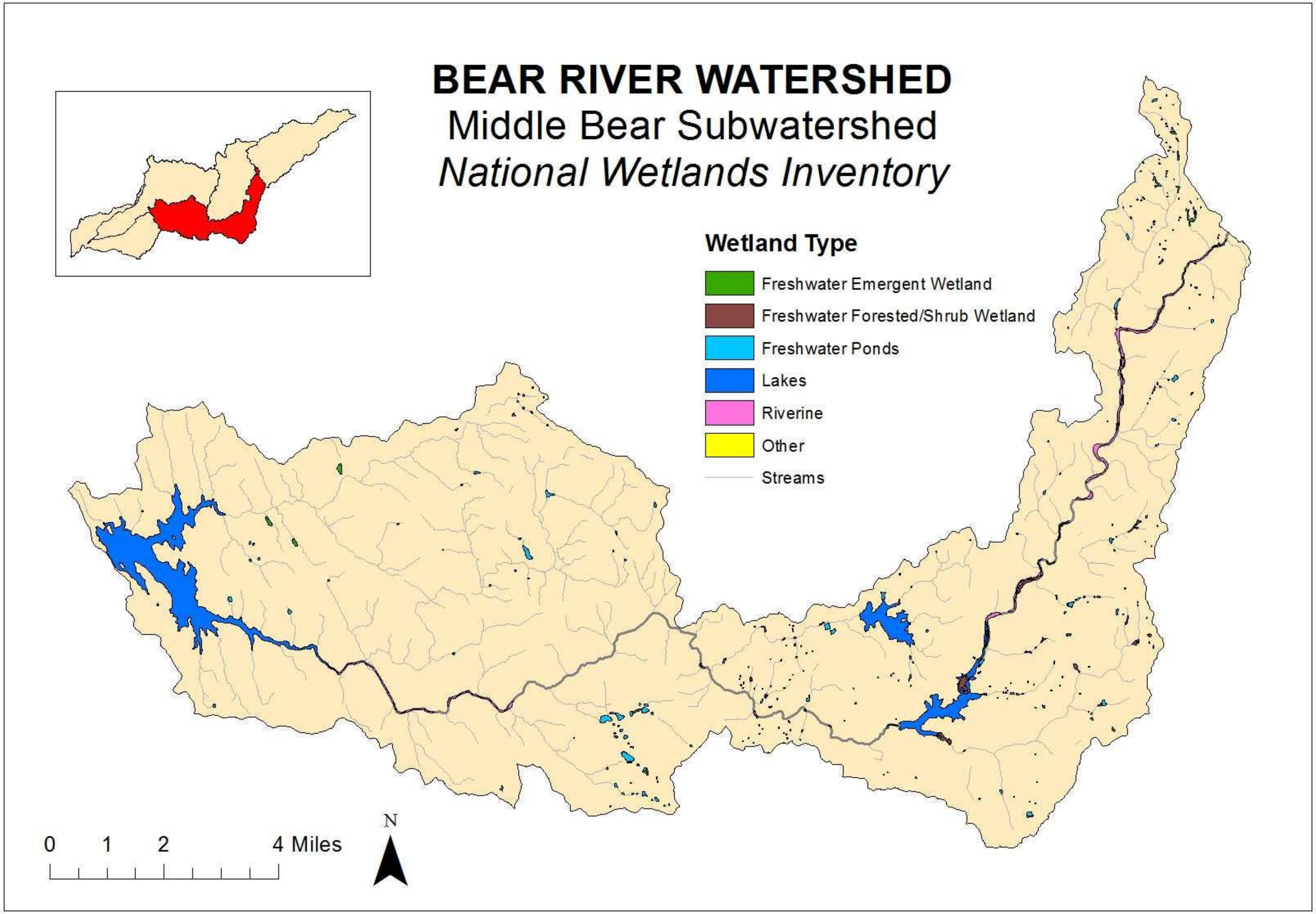


Figure 14. Wetlands in the Upper Bear Subwatershed

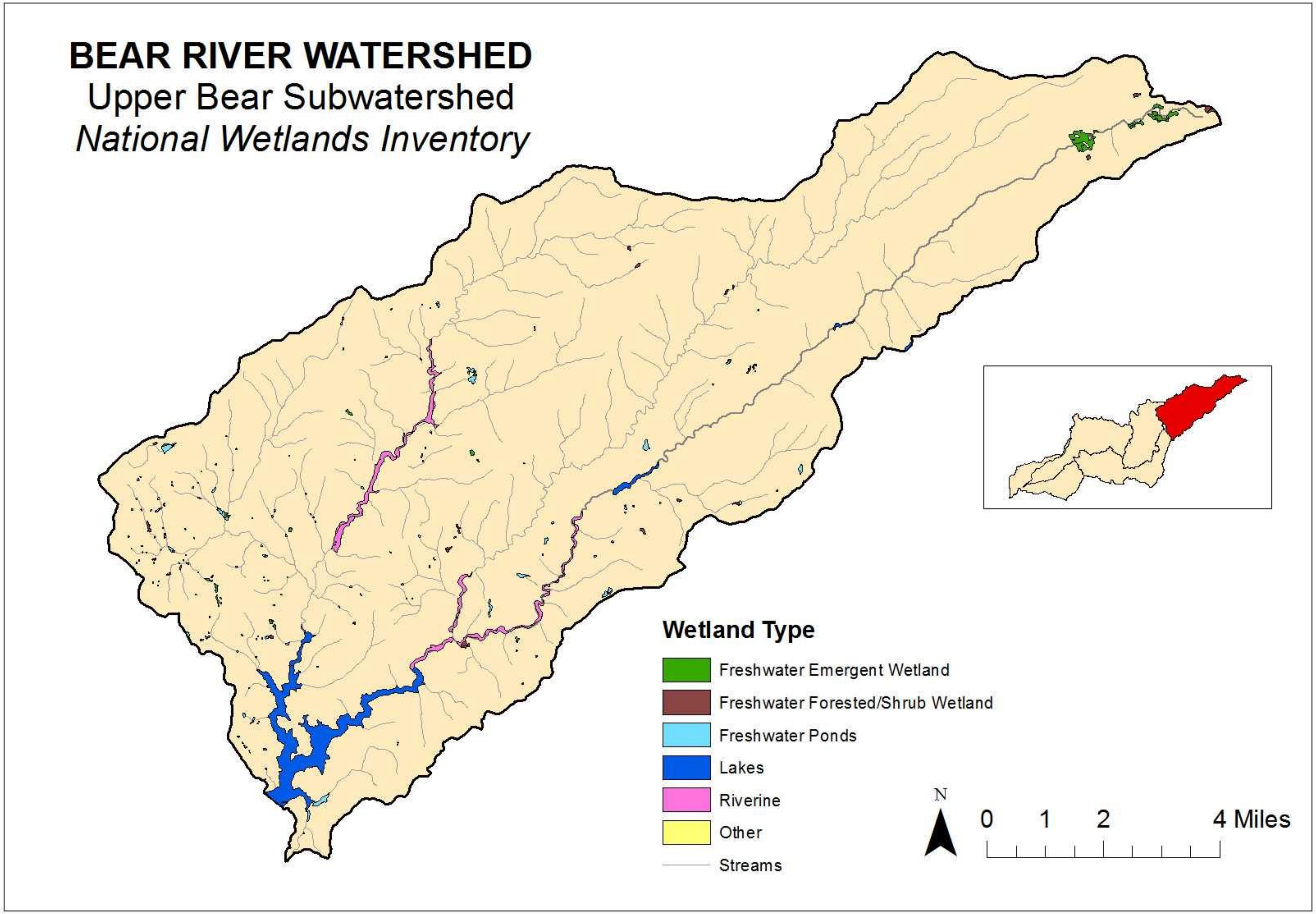
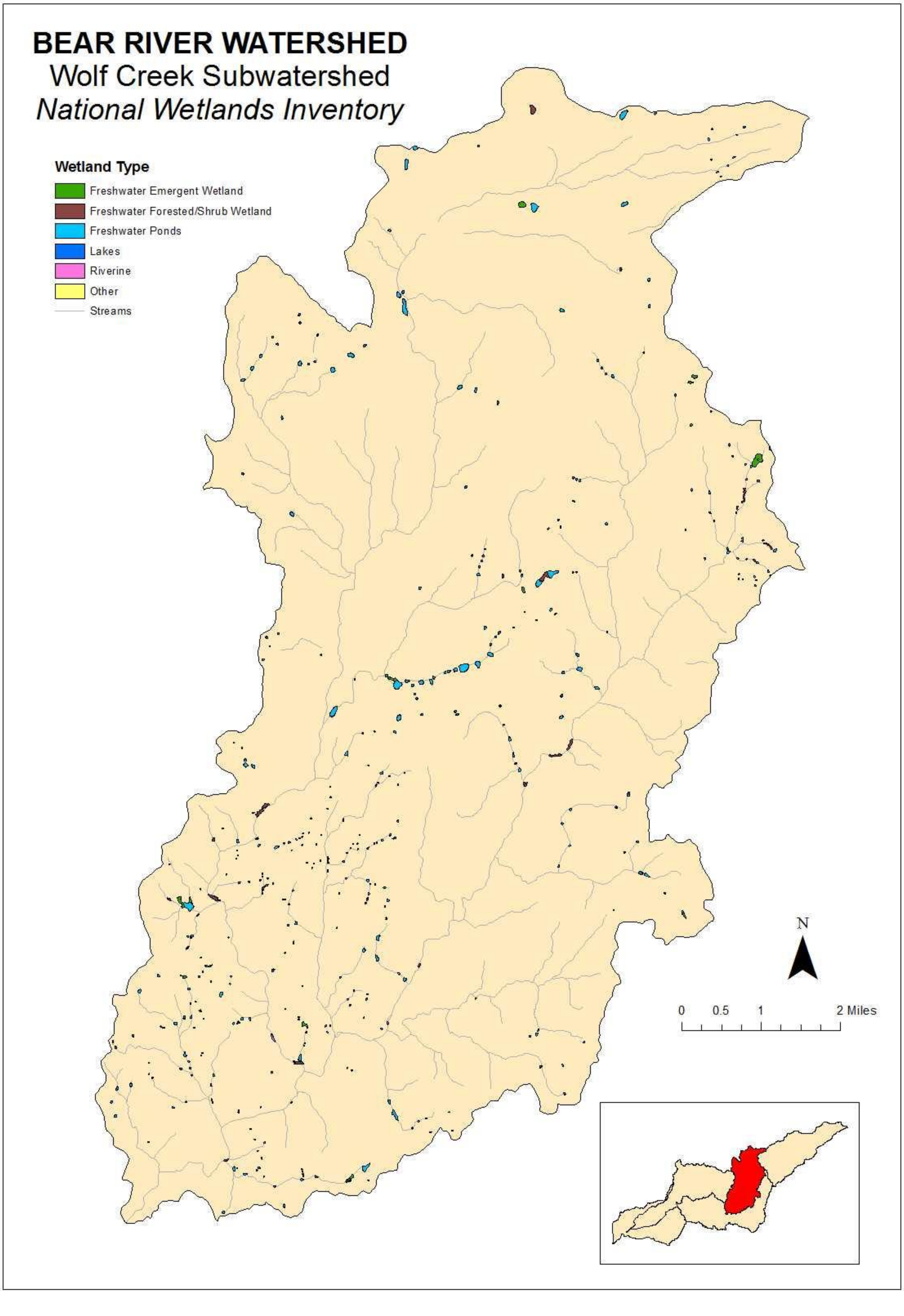


Figure 15. Wetlands in the Wolf Creek Subwatershed



III.A.6. Soils

The soil types and categories present in the Bear watershed, shown in Figure 16, illustrate the complex geology and biophysical processes at work in the watershed. Understanding the characteristics of particular soil types is important for restoration work as different types of soils affect habitat availability, erodibility, invasive species colonization and the potential for native plants. Many endemic and/or rare plant taxa are located exclusively on a specific soil or rock type, such as carbonate, serpentinite, basalt, or granite. Rare plants such as Stebbins' morning-glory, Pine Hill ceanothus, Pine Hill flannelbush, and Layne's butterweed , found in the American and Yuba watersheds, are associated only with gabrro serpentine soils. The status of these species in the Bear is unknown, and further survey and protection may assist in their survival. Identification of unique soil types known to have associated rare plants, coupled with on the ground plant surveys, would assist in identifying sites for protection and restoration, and add to a much needed plant inventory for the Bear.

Given the complexity of the soil survey in this watershed, it will be important to consult the soils map, in conjunction with maps of elevation and slope, for any future restoration. The data presented in Figure 16 was taken from the Web Soil Survey of the USDA. The legend of this map can be found on the page following the map. The data was gathered by the National Cooperative Soil Survey of the Natural Resources Conservation Service and provides the largest database of natural resource information in the world. Currently 95% of counties within the US are covered, including additional surveys on some tracts of public land by federal agencies.

According to the Web Soil Survey, there are 233 unique soil classifications in the watershed. Because each county has its own classification system for soil surveys, many of these categories overlap. For this reason, soil units were combined, as appropriate, and a watershed-wide labeling system was created with 190 unique units. Descriptions of the soil units of each label, as well as the Unit ID used by each county for that unit, can be found in Appendix A: List of Soil Classification Descriptions and County-Specific Unit IDs.

Across the watershed, the four largest soil units by area were Sj, JosMa1, AuRo1, and AuSo1. The Sj unit (ID 181 in Placer County, 158 in Sutter County and IDs 214 through 216 in Yuba County), is San Joaquin sandy loam soils, with slopes of 1-5 percent. The JosMa1 unit (JrE2 in Nevada County, JrE2nc in Tahoe National Forest, and 164 and 165 in Placer County) describes the Josephine-Mariposa complex, eroded, with slopes between 15 and 50 percent. AuRo1 (AxD in Nevada County and 117 in Placer County) is the Auburn-Rock outcrop complex, with slopes between 2 and 30 percent. AuSo1 (ID 110 in Yuba County), is the Auburn-Sobrante complex, with slopes between 8 and 15 percent. All four of these units cover areas of at least 11,000 acres each across the watershed.

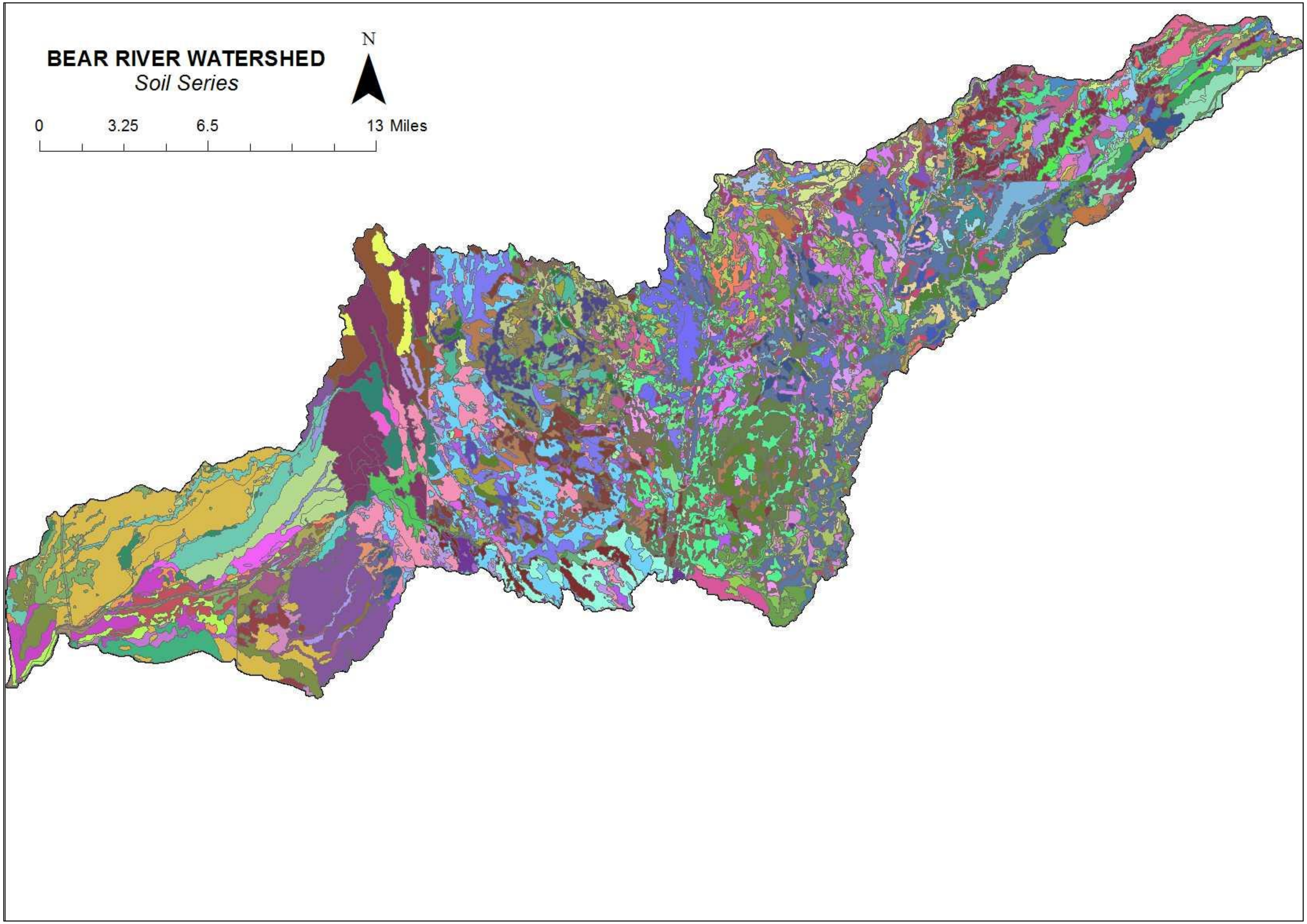
III.A.7. Topography

Understanding elevation is crucial for assessing what species of flora and fauna may be found throughout the watershed, as well as the potential movement of species up or down slope with climate change. It is also important for predicting flow patterns as the type of precipitation that falls at different elevations affects the timing and magnitude of flows. Similarly, understanding patterns in slope steepness helps to assess the risks from erosion and slope failure, which are important factors in the transport of contaminated sediments, the creation of aquatic habitat, downstream water quality, and even fire impact and recovery. Slope information is also critical for managing future construction and development.

Elevation contour data, in 50-100 m intervals, is taken from the USGS National Atlas Small Scale Datasets, which is current as of April 2014. The USGS no longer updates the Small Scale Datasets as they have begun integrating them into the larger National Map. Contour lines were clipped from data for the entire contiguous US, mapped at a millionth scale. The contour lines were then used to produce a map of elevation classes, shown in Figure 17, showing the rapid increase in elevation across the watershed. Steepness data come from a digital elevation model (DEM) produced from 100 ft-interval contour lines acquired from the Nevada and Placer County GIS offices. The tool used to create the DEM interpolates between the contour lines to determine slope, which may cause inaccuracies.

Over the course of the main stem of the Bear River, which is approximately 75 miles, the elevation of the watershed increases from close to sea level in the Central Valley to over 5000 ft. The banding of the elevation classes show the changes in elevation as one moves from the Central Valley into the foothills of the Sierra Nevada, with much of the watershed at 1000-3000 ft in elevation, which is below the snow line in a typical year. While the lower half of the watershed is characterized by relatively gentle slopes, the upper half of the watershed is characterized by steep-sided canyons, as seen in Figure 18, particularly at the headwaters of the Bear River and Steephollow Creek, one of its tributaries. In this upper watershed, these canyons have slopes over 70 degrees. In comparison, slopes in the lower watershed are typically less than 15 degrees. The Lower Bear subwatershed is characterized by slopes less than 5 degrees as the Bear River enters the Central Valley near its confluence with the Feather.

Figure 16. Map of Soil Classifications (legend on next page)



Soil Classifications

Ahw1	Au1	BoRo3	Com	HoC	IrRo	MaRo2	PuMcZ1	SecRo	Sob2
Ahw2	Au2	BoS1	ComFi	Hol1	JoCry	Mar	PuMcZ2	Sh	SobRo1
AhwRo1	Au3	BoS2	ComRa	Hol2	JoSiMa1	MayMa1	PuRoCry	Sha	SobRo2
AhwRo2	AuAr	CaRo	Con	HolS	JoSiMa2	MayMa2	PuRoZ1	Si1	SobTi
Ai1	AuArRo	Cap	CrCoh1	HolUr	Jos1	MayRo1	PuRoZ2	Si2	Tail
Ai2	AuRo1	ChaHo1	CrCoh2	Hor1	Jos2	MayRo2	Ra	Si3	TalCry1
Ai3	AuRo2	ChaHo2	CroMaCry	Hor2	Jos3	McC	ReRo	SiJo	TalCry2
AiC1	AuSo1	ChaHo3	CroMcCoh1	HorJoMa	JosC	McCS	Red	SiJoMa	Tis
AiC2	AuSo2	ChaRo	CroMcCoh2	HorR	JosMa1	McLedCr1	RedCor	SiRo	Tuj
Ala	AuSoRo1	ChaS	Cut	Hors	JosMa2	McLedCr2	Rice	SiS1	Wash
AllC	AuSoRo2	Coh1	Dam	HotMc	JosRo	McS	Ro	SiS2	Water
AllL	AuSoRo3	Coh2	DeRo	HuDe1	Kil	Me	RoAhw	Sie1	XFf
And	Aub	CohAiCr	Dig	HuDe2	Kim	Mus1	RoAu	Sie2	XH
AndSh	AubRo1	CohC1	DubRo	HuDeMa	LedMcRo1	Mus2	RoDe	SieRo1	XOf
Aq	AubRo2	CohC2	FiKa	HuDeRo1	LedMcRo2	MusRo	RoDub	SieRo2	XS
ArAu1	Bo1	CohMc1	Fl	HuDeRo2	MaG	Per	RoPuDe	Sj	Xcut
ArAu2	Bo2	CohMc2	Gr	HuyHor1	MaJo1	Pit	Rock	SjCom	Z1
ArG	BoRo1	Col1	Ho1	HuyHor2	MaJo2	PoNe1	Rub	Sn	Z2
ArRo	BoRo2	Col2	Ho2	IrC	MaRo1	PoNe2	RubRo	Sob1	ZPuCry

*See Appendix A for descriptions and county-specific Map Unit IDs corresponding to each soil classification

Figure 17. Elevation and Topography

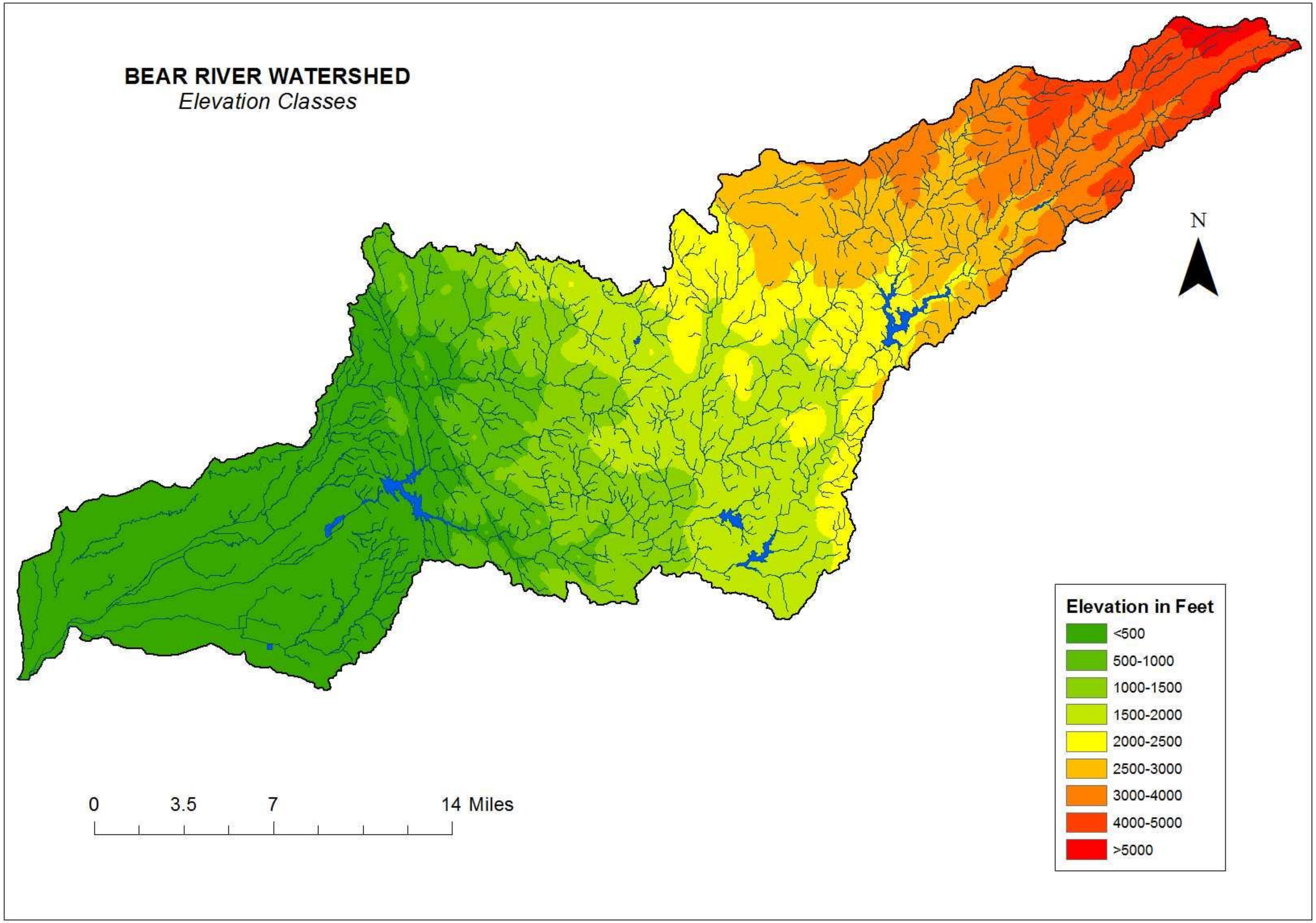
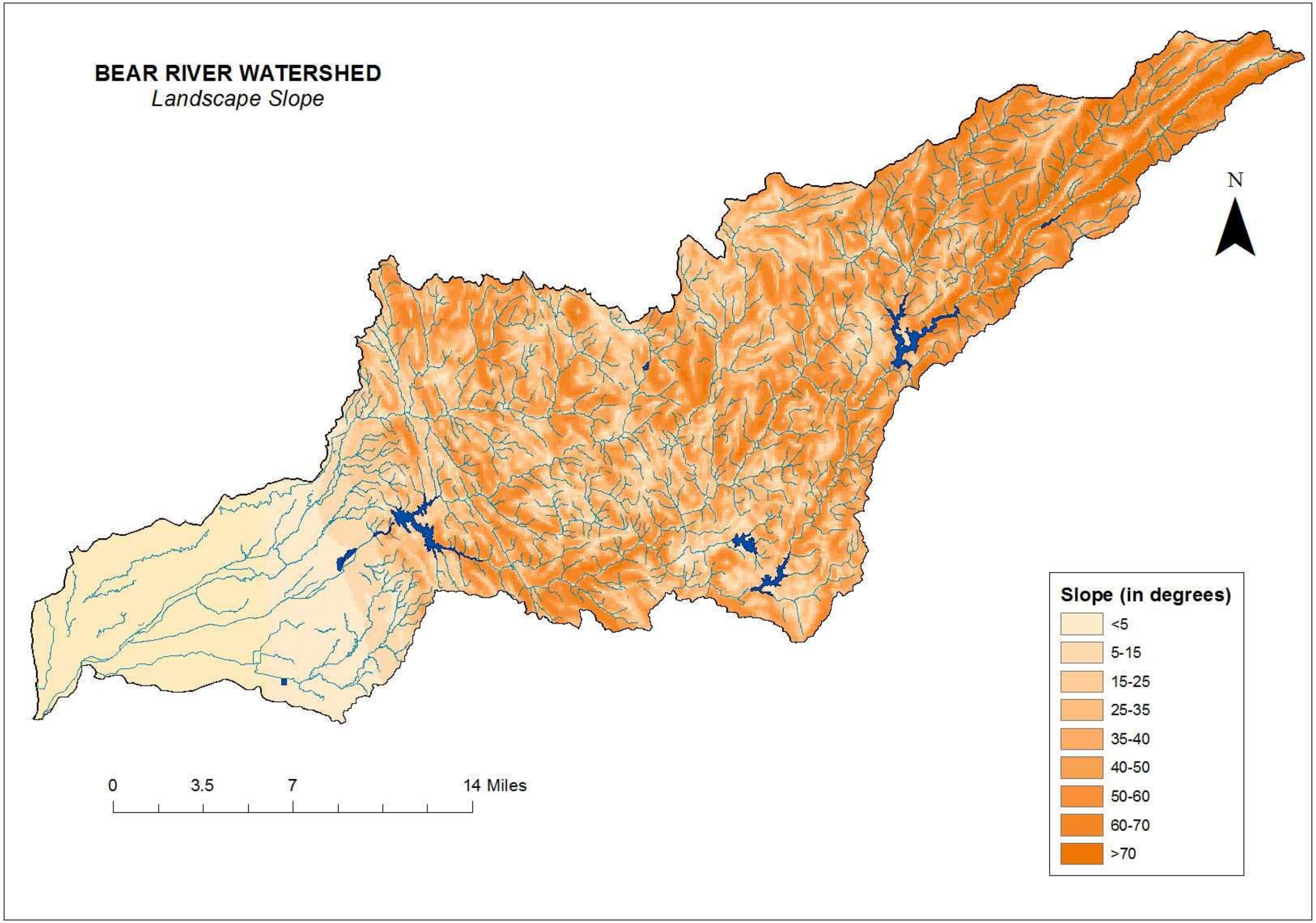


Figure 18. Slope Steepness



III.A.8. Fire history

Fire, ignited by lightning and Native Americans, was common in the Sierra Nevada prior to 20th century suppression efforts. Pre-settlement fire return intervals were generally less than 20 years throughout a broad zone extending from the foothills through the mixed conifer forests. In the 20th century, the areal extent of fire was greatly reduced (Stevens, 2014). This reduction in fire activity, coupled with the selective harvest of many large pines, produced forests which today are denser, with generally smaller trees, and have higher proportions of white fir and incense cedar than were present historically. These changes have almost certainly increased the levels of fuel, both on the forest floor and "ladder fuels"—small trees and brush which carry the fire into the forest canopy. Increases in fuel, coupled with efficient suppression of low and moderate intensity fires has led to an increase in general fire severity (Stevens, 2014). The number of large fires is also increasing: the average number of 900+ acre fires each year in the Sierra Nevada area has grown from three to seven since 1950. Between 1984 and 2010, there was a significant increase in the number of acres within a forest fire burning at high-intensity, from an average of 20% in mid-1980s to over 30% by 2010 and the trend is continuing upward (Miller, 2012).

Data from the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program (FRAP) indicates that 45 fires have occurred within the Bear River watershed in the last 15 years. This is more than twice as many fires than the number of fires occurring in any 20 year period since 1940. Of these, 22 fires have occurred in the last five years, ranging in size from 2 acres (the Thousand Oaks Fire in 2013) to 2300 acres (the Lowell Fire in 2015). Since 2002, the majority of fires were less than 100 acres in size, totaling an area of 6,082 acres. This figure may duplicate acreage that has experienced multiple fires within this timeframe, but is still remarkably smaller than acreage burned in prior periods. In comparison, a known 19,554 acres burned between the years 1910 and 1940; 15,860 acres burned from 1940 to 1959; 9,464 acres burned from 1960 to 1979; and 39,789 acres burned from 1980 to 1999 (most during the 49'er Fire of 1988 which burned 36,343 acres). All together, about 30% of the watershed, or 90,749 acres of the total 303,545 acres, has burned over the last century. A list of all known fires since 1910, including their acreage and cause, can be found in Table 12. A map of fire history is presented in Figure 19.

Fire affects watersheds in multiple ways, including through a short-term release of soil nitrogen followed by nitrogen deficiency, increased erosion and return periods of floods, altered vegetation structure, and increased stream temperatures (Dennis, 1989). Particularly relevant to watersheds in Gold Country, which are heavily impacted by mercury mine-waste, fire has been shown to increase methylmercury concentrations (Amirbahman et al., 2004). This is presumably associated with faster rates of microbial metabolism due to rapid nutrient cycling following fire, and suggests that mercury clean-up efforts may be most pressing in areas recently affected by fire.

The area encompassed by the Lowell Fire in 2015 along Steephollow Creek is likely to experience some of these impacts. The vegetation communities affected primarily consisted of ponderosa pine forest, as well as small sections of montane hardwood conifer, montane hardwood, Sierran mixed conifer, and mixed chaparral. When disturbed by fire, ponderosa pine communities are sometimes converted to mixed chaparral habitat, or in moister areas of higher site quality, to mixed conifer stands (CWHR, 1988). Secondary succession in disturbed montane hardwood conifer habitat consists of shrubs and trees regenerating together, with conifers maturing in 30-50 years, and broad-leaved trees maturing in 60-90 years (CWHR, 1988). Growth of hardwoods is particularly slow, especially canyon live oak.

***Table 12.* Fire history of the Bear watershed since 1910**

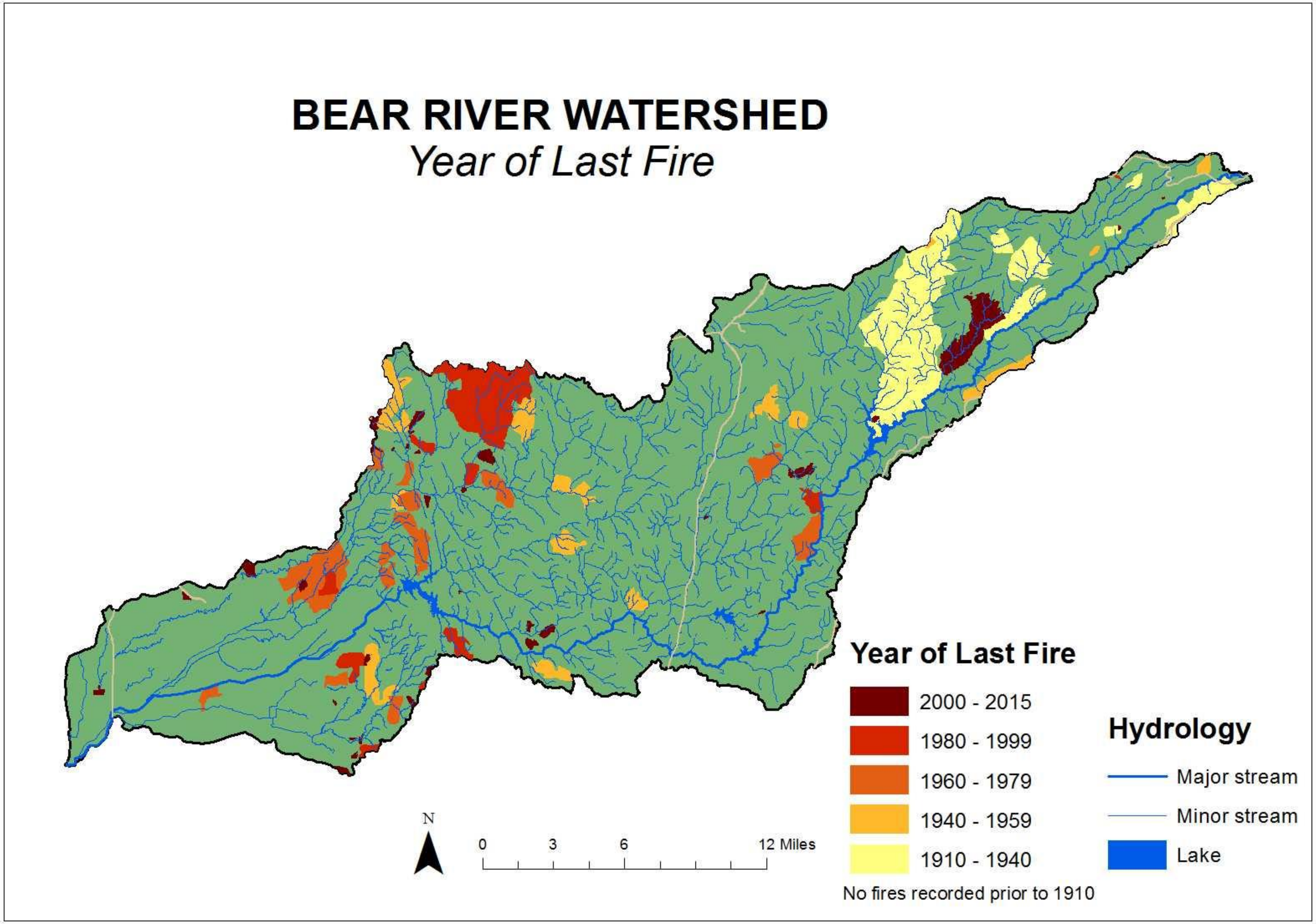
Year	Fire Name	Acres Burned	Cause	Watershed
1910		2852	Unknown	Greenhorn Creek
1911		425	Unknown	Greenhorn Creek
1916		1506	Unknown	Steephollow Creek
1916		3924	Unknown	Greenhorn/Clipper
1917		6270	Unknown	Greenhorn/Rollins Reservoir
1919		177	Unknown	Steephollow/Upper Bear above Rollins
1919		611	Unknown	Upper Bear above Rollins
1923		445	Unknown	Greenhorn Creek
1924		1401	Unknown	Steephollow/Upper Bear above Rollins
1924		1770	Unknown	Upper Bear above Rollins
1931		172	Unknown	Steephollow Creek
1943		323	Unknown	Upper Bear above Rollins
1944		60	Human	Greenhorn Creek
1949		67	Lightning	Upper Bear above Rollins
1950	BOBO	264	Unknown	Wolf Creek/Bear
1950	CAMP BEALE	669	Unknown	Dry Creek
1950	CAMP BEALE #2	4885	Unknown	Reeds/Dry
1951		6	Human	Greenhorn Creek
1951	CAMP BEALE #1	585	Unknown	Rock Creek
1951	RATTLESNAKE	585	Unknown	Wolf Creek
1951	WIZWELL	1049	Unknown	Lower Bear
1952	DENIZ	297	Unknown	Wolf Creek/Bear
1952	CAMP BEALE #2	799	Unknown	Reeds/Dry
1953	SUNSHINE VALLEY	336	Unknown	Wolf Creek
1953	CAMP BEALE #5	881	Unknown	Dry Creek

Year	Fire Name	Acres Burned	Cause	Watershed
1954	CAMP BEALE #1	509	Unknown	Dry Creek
1955	CAMP BEALE #7	445	Unknown	Dry Creek
1955	CAMP BEALE #3	1115	Unknown	Reeds/Dry
1958	LIGHTNING #6	551	Unknown	Bald Rock Mountain
1959	MADONNA #2	3164	Unknown	Upper Bear below Rollins
1960	NEWNAN LIGHTNING #9	739	Unknown	Wolf Creek
1961	MAYS	710	Unknown	Dry Creek
1961	BILDERBACK	925	Unknown	Upper Bear below Rollins
1961	CAPEHART	3302	Unknown	Lower Bear
1963	CAMP BEALE #29	501	Unknown	Reeds/Dry
1964	BREWER	293	Unknown	Lower Bear River
1964	BEALE #4	426	Unknown	Dry Creek
1967	CAPEHART	1063	Unknown	Dry/Camp Far West
1970	SHOCKLEY	285	Unknown	Lower Bear River
1970	JACINTO	385	Unknown	Lower Bear River
1970	CAMP FAR WEST	588	Unknown	Grasshopper Slough
1973	FISH & GAME #4	242	Unknown	Dry Creek
1979	ROADSIDE #88	299	Unknown	Reeds Creek
1979	ROADSIDE #70	2400	Unknown	Reeds Creek
1980	ROADSIDE #117	264	Unknown	Dry Creek
1980	R.S.#31	281	Unknown	Dry Creek
1980	LIGHTNING 1	336	Unknown	Lower Bear
1980	DOG BAR	347	Unknown	Upper Bear below Rollins
1981	BROWN	100+	Prescribed	Dry Creek Spenceville Area
1981	NADEIC	425	Miscellaneous	Lower Bear River
1981	PG&E #5	812	Equipment Use	Camp Far West
1982	BROWNING RANCH	121	Prescribed	Dry Creek
1982	NEIL ROBINSON	271	Prescribed	Dry Creek
1982	ANDRESSEN	439	Equipment Use	Lower Bear
1983	RONDONI	258	Prescribed	Wolf/Upper Bear below Rollins
1985	BALDWIN RANCH	171	Prescribed	Wooley/Lake of the Pines
1985	DOG BAR	186	Smoking	Upper Bear below Rollins
1986	ROADSIDE 82	143	Unknown	Yankee Slough/Coon
1986	BALDWIN RANCH	157	Prescribed	Lake of the Pines
1987	CONOUCK	183	Equipment Use	Lower Bear
1988	49'ER	36343	Debris or Human	Dry Creek
1989		25	Prescribed	Steephollow Creek
1998	READER RANCH	115	Prescribed	Dry Creek
1998	SMART	343	Arson	Reeds Creek
1998	BEALE ASSIST	1276	Smoking	Reeds Creek

Year	Fire Name	Acres Burned	Cause	Watershed
2002	HALCON	20	Equipment Use	Wolf Creek
2002	BLACK	216	Arson	Dry Creek
2003	VALLEY	52	Debris	Lower Bear
2003	GARDEN	61	Lightning	Middle Bear
2004	LOWELL	17	Debris	Upper Bear
2004	BEALE	434	Power Line	Dry Creek
2005	ZIEBRIGHT	8	Debris	Upper Bear
2005	GARDEN	110	Vehicle	Middle Bear
2006	ROLLINS	43	Playing with Fire	Upper Bear
2007	WALDO	16	Equipment Use	Dry Creek
2007	NADER	16	Unknown	Lower Bear
2007	SIXTY-FIVE 2	31	Unknown	Lower Bear
2007	SPENCEVILLE	31	Unknown	Dry Creek
2007	WALDO 2	39	Arson	Dry Creek
2007	VALLEY	70	Arson	Lower Bear
2007	JASPER	86	Equipment Use	Dry Creek
2007	GARDEN	146	Equipment Use	Middle Bear
2007	SOUTH BEALE	195	Railroad	Lower Bear
2008	SPENCEVILLE	14	Miscellaneous	Dry Creek
2008	RIFLE	19	Miscellaneous	Dry Creek
2008	RIOSA	80	Unknown	Lower Bear
2009	MAGNOLIA	21	Power Line	Middle Bear
2009	BEALE	281	Unknown	Dry Creek
2010	RIOSA Incident	17	Unknown	Lower Bear
2010	CHAMBERLIN Fire	22	Unknown	Lower Bear
2010	NADER2 Incident	34	Equipment Use	Lower Bear
2010	MEADOWLARK Incident	60	Playing with Fire	Lower Bear
2010	MORRISON Incident	82	Vehicle	Lower Bear
2011	CHALK FIRE	17	Escaped prescribed burn	Upper Bear
2011	WALDO	19	Unknown	Dry Creek
2011	SPENCEVILLE	66	Unknown	Dry Creek
2011	YEAGER INCIDENT	140	Vehicle	Dry Creek
2012	WALDO	23	Miscellaneous	Dry Creek
2012	COLUMBIA	83	Equipment Use	Lower Bear
2012	WALTZ	97	Equipment Use	Lower Bear
2013	THOUSAND OAKS	2	Equipment Use	Lower Bear
2013	MCDANIEL	9	Smoking	Dry Creek
2013	WALDO	23	Miscellaneous	Dry Creek
2013	SPENCEVILLE	66	Unknown	Dry Creek
2013	BEALE AFB GRASS VALLEY GA	255	Unknown	Lower Bear

Year	Fire Name	Acres Burned	Cause	Watershed
2014	PERIMERTER	10	Debris	Middle Bear
2014	HUTTO	49	Unknown	Dry Creek
2014	DOGBAR	248	Unknown	Wolf Creek
2014	APPLEGATE	459	Unknown	Middle Bear
2015	LOWELL	2294	Under Investigation	Steephollow Creek

Figure 19. Fire History Since 1910



III.B. Biotic Setting

III.B.1. Plant community distribution

The Bear watershed is composed of 26 vegetation communities. Much of the lower watershed is dominated by cropland, pasture, and grassland, while the majority of the mid-watershed consists of blue oak-foothill pine, montane hardwood and urban areas. The upper-watershed are made up of ponderosa pine, Sierran mixed conifer, and Douglas fir communities. The breakdown of plant community types is in shown in Table 13.

Table 13. **Vegetation communities and percent coverage in the Bear River Watershed**

Community Type	Percentage
TREE DOMINATED HABITATS	
Sierran Mixed Conifer	6.9%
Ponderosa Pine Forest	6.2%
Montane Hardwood-Conifer	4.4%
Montane Hardwood	10.3%
Blue Oak-Foothill Pine	0.43%
Blue Oak Woodland	16.5%
Blue Oak Woodland / Blue Oak-Foothill Pine	7.0%
Valley Oak Woodland	0.38%
Valley Foothill Riparian	0.51%
Douglas Fir	6.9%
White Fir	0.15%
Closed-cone Pine-Cypress	0.015%
Montane Riparian	0.023%
Valley Foothill Riparian	1.3%
SHRUB DOMINATED HABITATS	
Mixed Chaparral	1.7%
Montane Chaparral	0.28%
HERBACEOUS DOMINATED HABITATS	
Wet Meadows	0.048%
Fresh Emergent Wetlands	0.39%
Annual Grassland	15.1%
AQUATIC HABITATS	
Lacustrine/Riverine	0.68%
DEVELOPED HABITATS	
Cropland	18.1%
Evergreen Orchard	0.0013%
Pasture	1.1%
Urban	9.4%
NON-VEGETATED HABITATS	
Barren	0.66%

Figure 20 shows plant communities mapped by the California Department of Fish and Game (CDFG) in collaboration with the California Native Plant Society (CNPS) in 2008-2011 (lower watershed), and the US Forest Service (upper watershed). Using aerial information systems returning digital color images taken in 2005 and 2009, fine-scale vegetation maps (1-m resolution) of the northern foothills of the Sierra Nevada and the Central Valley were constructed. The CDFG/CNPS vegetation data was validated using an accuracy assessment in the field. Data in the lower watershed is incomplete, though prior vegetation maps included in Shilling's 2003 Disturbance Inventory suggest that the areas lacking data likely consist of cropland and annual grassland communities.

Tree Dominated Habitats

SIERRAN MIXED CONIFER

The Sierran mixed conifer habitat is an assemblage of white fir, Douglas-fir, ponderosa pine, sugar pine, incense-cedar, and California black oak. Stands form multilayered closed canopies with close to 100% cover. Shrubs are common in the understory, including deerbrush, Manzanita, rose, and mountain misery. Stand age is often varied due to historical burning and logging (CWHR, 1988). Soils supporting this habitat are varied, and include those derived from Mesozoic granitic, Paleozoic sedimentary and volcanic rocks, and Cenozoic volcanic rocks. Serpentine soils are found in the northern mixed conifer zone, which support endemic plants. Several hundred species of animals are supported by mixed conifer forest, including sensitive species such as the spotted owl (*Strix occidentalis*), fisher (*Martes pennanti*), and pine marten (*Martes caurina*). Endangered bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*) also use mixed conifer habitats. Forage for wildlife is provided by black oak acorns and berries from shrubs such as deerbrush, as well as a number of grasses and forbs (CWHR, 1988). Areas of Sierra mixed conifer are primarily found in the upper Bear watershed at higher elevations.

PONDEROSA PINE FOREST

Ponderosa pine habitat can vary from pure stands of ponderosa pine to a mixed stand of 50% ponderosa pine. Associated species include white fir, incense-cedar, Jeffrey pine, sugar pine, Douglas-fir, canyon live oak, California black oak, Pacific madrone, manzanita, ceanothus, mountain-misery, Pacific dogwood, hairy yerba-santa, bitter cherry, California buckthorn, poison-oak, and Sierra gooseberry. This habitat can serve as a transitional or migratory habitat for deer, and is an important nutritional source for deer. Deer migratory routes and holding zones, and riparian zones should receive special consideration during management planning. The Sierra Nevada red fox (*Vulpes vulpes necator*) also utilizes the Ponderosa pine forest (CWHR, 1988). Patches of ponderosa pine forest are found in the upper Bear watershed.

With the extreme drought and the last few years among the warmest ever recorded, landscape-level drought-stress has allowed native pine bark beetles to kill drought-weakened ponderosa pine trees throughout the Sierra Nevada, including the Bear and adjacent watersheds. Beetle populations have hit a critical threshold and trees have lost their ability to regulate beetle populations resulting in an epidemic. Placer County has followed the Governor's State Emergency Declaration in 2015 by declaring a local state of emergency due to ponderosa pine tree mortality throughout Placer County. Nevada County has seen similar mortality of ponderosa pine trees. The loss of so many trees, and more to be expected, will lead to vegetation changes in the ponderosa pine and other mixed conifer vegetation communities. With this large addition of dead fuel, these forests will become susceptible to high intensity forest fires.

MONTANE HARDWOOD-CONIFER

This community is common throughout the Bear watershed, with the exception of lower elevation annual grasslands and cropland. For an area to be considered montane hardwood-conifer at least a third of trees must be conifer and at least a third must be broad-leaved. Typically, broad-leaved trees are sclerophyllous evergreen, but may also be winter-deciduous. There is little understory underneath the dense canopy of montane hardwood-conifer except following a disturbance. California black oak, bigleaf maple, white alder, dogwood, Douglas-fir, incense-cedar, and ponderosa pine are common associate species. Montane hardwood-conifer is a geographically and biologically transitional habitat between coniferous forests and montane hardwood. Mature forests provide habitat for cavity nesting birds, and mast crops are an important food source for birds and mammals. Amphibians are found in the detrital layer in mesic areas (CWHR, 1988).

MONTANE HARDWOOD

Montane hardwood habitat patches are found throughout the mid-elevational areas of the Bear watershed. The structure of a montane hardwood habitat consists of a pronounced hardwood tree layer, a poorly developed shrub layer, and a sparse herbaceous layer. Typical associates include canyon live oak, Douglas-fir, Pacific madrone, California-laurel, California black oak, and foothill pine at mid- and lower elevations, and ponderosa pine, white fir, and Jeffery pine at higher elevations. Understory vegetation may include wood rose, Manzanita, poison-oak, currant, and Oregon-grape. This habitat type is very stable and includes a large number of species with long lifespans and slow growth. Fauna associated with montane hardwood areas are acorn disseminators including scrub and Steller's jays (*Aphelocoma californica* and *Cyanocitta stelleri*), acorn woodpeckers (*Melanerpes* *formicivorus*), and western gray squirrels (*Sciurus griseus*), as well as those using acorns as a major food source like wild turkey (*Meleagris gallopavo*), mountain quail (*Oreortyx pictus*), band-tailed pigeon (*Patagioenas fasciata*), California ground squirrel (*Spermophilus beecheyi*), dusky-footed woodrat (*Neotoma fuscipes*), and mule deer (*Odocoileus hemionus*). Additionally, the Mount Lyell salamander (*Hydromantes platycephalus*), ensatina (*Ensatina eschscholtzii*), western fence lizard (*Sceloporus occidentalis*), western rattlesnake (*Crotalus oreganus*), and California mountain kingsnake (*Lampropeltis zonata*) are found on the forest floor (CWHR, 1988).

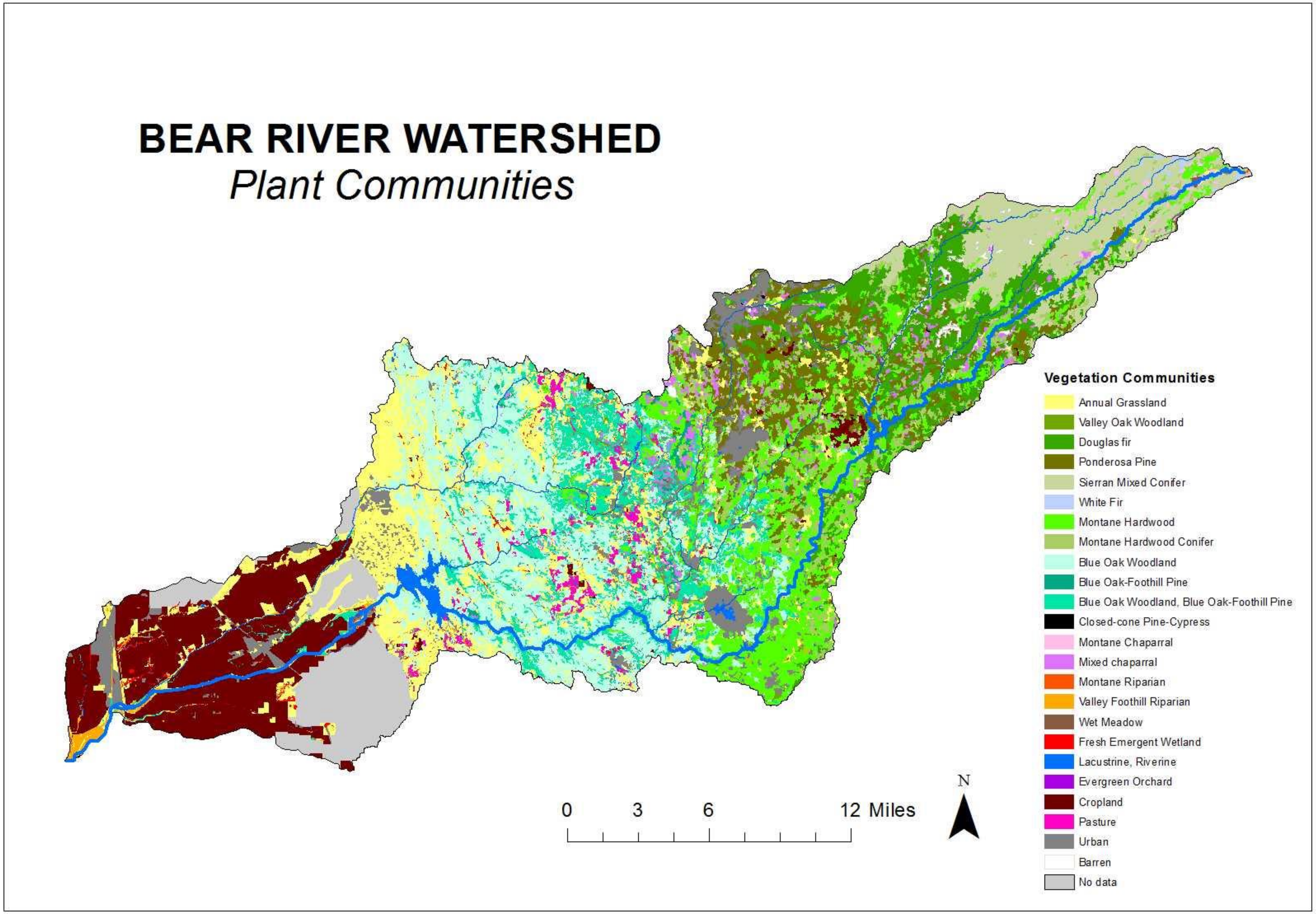
BLUE OAK-FOOTHILL PINE

Blue oak-foothill pine habitats occur across large areas of the watershed at mid-level elevations. The structure of blue oak-foothill pine habitats is diverse vertically and horizontally, with hardwoods, conifers, and shrubs. Relatively few snags and downed woody material are found. Blue oak dominates and, along with foothill pine, comprises the overstory of the habitat. Interior live oak and California buckeye are also prominent, and shrub species may include ceanothus spp., manzanita, coffeeberry, poison-oak, and California redbud. This habitat generally does not regenerate quickly because livestock and wildlife consume close to the entire acorn crop each year, and seedlings that do become established are eaten by deer. Mature blue oak-foothill pine provides optimal breeding habitat for 29 species of amphibians and reptiles, 79 species of birds, and 22 species of mammals in the western Sierra Nevada. Cavity-nesting birds use living oaks instead of snags (due to their infrequency) (CWHR, 1988).

BLUE OAK WOODLAND

As the name suggests, blue oaks dominate the blue oak woodland, comprising 85-100% of trees present. Common associates in the savanna-like stands are interior live oak, poison-oak, coffeeberry, buckbrush, redberry, California buckeye, manzanita, and annual grasses like brome grass, wild oats, foxtail, needlegrass, filaree, and fiddeneck. Similar to blue oak-foothill pine habitat, blue oak woodlands provide optimal breeding habitat for 29 species of amphibians and reptiles, 57 species of birds, and 10 species of mammals. While it is clear that many wildlife species utilize and benefit from the use of these oaks, further research into oak-wildlife relationships is needed before specific management recommendations can be made (CWHR, 1988). Within the Bear watershed, blue oak woodland is interspersed with blue oak-foothill pine, montane hardwood, and montane hardwood-conifer habitats.

Figure 20. Plant Community Types



VALLEY OAK WOODLAND

The canopies of this habitat are dominated nearly exclusively by valley oaks, with habitat structure varying from savanna-like to forest-like stands. When grazing is light or absent, a partial shrub layer of poison-oak, toyon, and coffeeberry may form. Tree associates may include California sycamore, interior live oak, and blue oak. Valley oak woodland provides food and cover for many species of wildlife, including birds and animals that use acorns and browse. In a study plot at Ancil Hoffman Park near Carmichael in Sacramento County in the 1970s, red-shouldered hawks (*Buteo lineatus*), European starlings (*Sturnus vulgaris*), California quail (*Callipepla californica*), plain titmouse (*Baeolophus inornatus*), scrub jay (*Aphelocoma californica*), rufous-sided towhee (*Pipilo erythrophthalmus*), Bewick's wren (*Thryomanes bewickii*), bushtits (*Psaltriparus minimus*), and acorn woodpeckers (*Melanerpes formicivorus*) were documented using valley oak habitat. Other studies have documented western gray squirrels (*Sciurus griseus*) and mule deer (*Odocoileus hemionus*) utilizing the food and shelter offered by valley oaks (CWHR, 1988). Valley oak woodland is found at mid-level elevations within the Bear watershed, alongside montane hardwood-conifer, montane hardwood, and blue oak woodland.

VALLEY FOOTHILL RIPARIAN

Valley foothill riparian areas typically contain winter deciduous trees that form a canopy cover of 20-80%. Lianas (wild grape) often comprise 30-50% of ground cover. Dominant species are cottonwood, California sycamore, valley oak, white alder, boxelder, Oregon ash, wild grape, wild rose, California blackberry, poison-oak, buttonbrush, and willows. Herbaceous vegetation (~1% of cover) includes sedges, rushes, grasses, miner's lettuce, Douglas sagewort, poison-hemlock, and hoary nettle. Due to rapid growth of cottonwoods, succession stages may proceed quickly, with shrubby riparian willow thickets lasting 15-20 years before cottonwoods shade them out. This habitat provides food, water, migration and dispersal corridors, escape, nesting, and thermal cover for many wildlife species. At least 50 permanent or transient amphibian and reptile species, 147 nesting or winter visitant bird species, and 55 mammal species are known to utilize valley foothill riparian areas (CWHR, 1988). Very few and small patches of valley foothill riparian are found within the Bear watershed, mainly at lower elevations within large patches of annual grassland and cropland

DOUGLAS-FIR

The structure of Douglas fir communities typically includes a dense lower story of broad-leaved evergreen trees (i.e. tanoak, Pacific madrone), with an open overstory of Douglas-fir. Wetter sites have a shrub layer (often 100% cover), while higher elevation sites will have a dense herb layer (often 100% cover). Snags and downed logs are a crucial structural component and increase in density with stand age. Depending on soil type, moisture, topography and disturbance, associated plant species may include canyon live oak, Pacific madrone, sugar pine, ponderosa pine, black oak, and Pacific yew. Shrub layers may be composed of Oregon-grape, California blackberry, dwarf rose, and poison-oak, while herb layers may include California honeysuckle, creeping snowberry, and bracken fern. . Bird species typical of this habitat include spotted owl, western flycatcher, chestnut-backed chickadee, vireos, hermit warbler, and varied thrush. Ensatina is the most abundant amphibian, and mammals include fisher, deer mouse, woodrats, voles, and shrews (CWHR, 1988). Douglas-fir communities primarily occur in the upper Bear watershed.

WHITE FIR

White fir communities are found in small patches near the headwaters of the Bear. This type is nearly monotypic and evenly aged, with >80% white fir. Heavy shading generally inhibits understory growth, though herbaceous species like wake robin, vetch, and pipsissewa may be found. White fir has become established as a mid-story in other conifer forests due to its shade tolerance, and changes in fire regime. A high percentage of white fir trees become defective with maturation, due to windthrow and heart rot fungus, and as a result, excellent habitat for snag and cavity nesting species occurs in white pine areas. As one of the most moist and cool non-riparian habitats, white fir communities provide preferred habitat for yellow-rumped warblers and western tanagers, and is used by other insectivores like the mountain chickadee, chestnut-backed chickadee, golden-crowned kinglets, and black-headed grosbeak (CWHR, 1988).

CLOSED-CONE PINE-CYPRESS

These habitats are usually dominated by a single species of closed-cone pines or cypress, though few stands contain both pines and cypress. In cypress habitats, the understory includes chaparral shrubs like chamise and manzanita. Shrub layer cover depends on soil type and quality. Associated species change as the dominant species changes, but may include foothill pine, manzanita, oaks, ceanothus, and poison-oak. Closed-cone pine-cypress habitats often occur as islands within a matrix of chaparral or forest types. Wildlife species such as tree squirrels and band-tailed pigeons use this type for feeding and cover, and great horned owls and red-tailed hawks will nest in this type (CWHR, 1988).

This is not a common habitat in the Bear watershed, with few small patches occurring in the mid-upper watershed. Closed cone pine and cypress are serotinous, which means that their cones do not open on their own when the seeds reach maturity. Human-induced changes to the natural fire regime have led to the disappearance of many of these tree stands. If the interval between fires is too short, trees are unable to reach reproductive age before the next fire, often causing them to be replaced by adjacent vegetation types. Cypress communities are considered a rare natural vegetation community by CNPS (Karen Callahan, CNPS, personal communication).

MONTANE RIPARIAN

Montane riparian zones are often variable and structurally diverse, often consisting of broad-leaved winter deciduous trees and a sparse understory. Cottonwood, bigleaf maple, dogwood, willows, quaking aspen, white and thinleaf alders are found in this type. The transition between montane riparian vegetation and non-riparian habitat is often abrupt, particularly in steep areas. Riparian zones are highly valuable for wildlife, providing water, thermal cover, migration corridors, nesting, and feeding opportunities. A wide variety of amphibians, reptiles, birds, and mammals may be found using montane riparian zones, including the Sierra Nevada red fox (CWHR, 1988). This type is found at the highest elevations in the Bear watershed.

Shrub Dominated Habitats

MIXED CHAPARRAL

Mixed chaparral can be found in patches through the watershed. Mixed chaparral habitat is structurally homogenous, and mature habitats can be impenetrable thickets. Roughly 240 woody plant species are supported by mixed chaparral type, with scrub oak, chaparral oak, ceanothus, and manzanita dominating the type. No wildlife species are entirely restricted to mixed chaparral habitat; instead, they utilize multiple, other types of chaparral habitat. Land management should consist of prescribed burning, as long-term fire suppression can lead to stand senescence and declines in deer, small mammals, birds, and reptiles. The majority of animals using chaparral habitats reach peak densities 1-15 years post-burn (CWHR, 1988).

MONTANE CHAPARRAL

Montane chaparral growth forms may vary from treelike to prostrate, and may be impenetrable to large mammals. Species commonly characterizing these communities include ceanothus, manzanita, bitter cherry, toyon, and whitethorn. Many montane chaparral species are fire adapted and will sprout back from root crowns. This community supports wildlife such as deer and other herbivores like rabbits and hares, and provides food, protection, and roosting/nesting sites for birds. The shade provided by chaparral habitats is particularly important in hot weather (CWHR, 1988).

Herbaceous Dominated Habitats

WET MEADOWS

Wet meadows can be found throughout the watershed in small patches adjacent to waterways as part of the floodplain, or they may occur due to topography as in montane meadows. The wet meadow habitat is structurally simple, consisting of a layer of herbaceous plants. Species found in wet meadows are widely variable, but common genera include *Agrostis, Carex, Danthonia, Juncus, Salix,* and *Scirpus*. Hydrology is the most important determinant of vegetation stability in wet meadows, and channel erosion can lower the water table and result in succession to species favoring dryer habitats. Use of wet meadows by wildlife varies by season, with small mammals visiting the dryer wet meadows of summer but not during wetter months. Mule deer (*Odocoileus hemionus*) and waterfowl (especially Mallard ducks, *Anas platyrhynchos*) forage forbs and grasses and utilize streams running through wet meadows. Yellow-headed and red-winged blackbirds (*Xanthocephalus xanthocephalus* and *Agelaius phoeniceus*) may nest in vegetation surrounded by enough water to discourage predators. The striped racer (*Masticophis lateralis*), various frog species, and six species of trout (brown, cutthroat, golden, rainbow, eastern brook, and Mackinaw) also use habitat features provided by the type (CWHR, 1988). In the Bear watershed, very little wet meadow habitat exists and is found mainly in small patches within large areas of annual grassland and cropland. Wet meadows in the mid-elevations Sierra Nevada's have a long history of conifer encroachment, possibly as a result of fire suppression, change in hydrology, and soil compaction. Wet meadows have resulted in a shift from a graminoid/herbaceous community to one dominated by woody species, potentially diminishing a meadow's water holding capacity and its ability to provide critical ecosystem services (Viers et al., 2013).

FRESH EMERGENT WETLANDS

Areas of fresh emergent wetland in the Bear watershed are small and patchy. The habitat is characterized by erect, rooted herbaceous hydrophytes, such sedges and rushes, and annual forbson saturated or periodically flooded soils. Wetter sites are populated by common cattail and bulrushes. The demarcation between fresh emergent wetlands and deep water habitat is at or above 2m in depth. As some of the most productive habitats in California, fresh emergent wetlands are utilized by numerous wildlife species for the food, cover, and water they provide. Mammals, reptiles, amphibians, and waterfowl are found using the habitat. Bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*) make use of feeding areas and roost sites provided by fresh emergent wetlands (CWHR, 1988).

In the upper watershed, fens are a hotspot of biodiversity and sensitive flora such as

California pitcher plant and sundew. Fens are determined by plant species composition, hydrology, and the amount of peat in the soil. A properly functioning fen will remain moist throughout the year. In the lower watershed, vernal pools are covered by shallow water for variable periods from winter to spring, but may be completely dry for most of the summer and fall. These wetlands range in size from small puddles to shallow lakes and are usually found in a gently sloping plain of valley grassland. The unique environment of vernal pools provides habitat for numerous rare plants and animals that are able to survive and thrive in these harsh conditions. In addition, birds such as egrets, ducks, and hawks use vernal pools as a seasonal source of food and water. Vernal pools are a valuable and increasingly threatened ecosystem, often smaller than the bulldozer that threatens to destroy them. More than 90% of California's vernal pools have already been lost. Two rare plants found in the watershed’s vernal pools include *Downingia pusilla* and *Legenere limosa* (Witham et al., 1998).

ANNUAL GRASSLAND

Annual grassland makes up a large portion of the lower Bear watershed, bridging croplands with oak and hardwood habitats. Introduced annual grass species dominate the type, including wild oats, soft chess, ripgut brome, red brome, wild barley, and foxtail fescue. Forbs can include broadleaf filaree, redstem fillaree, turkey mullein, true clovers, bur clover, popcorn flower, and California poppy, among others. Species composition is different at any given time due to seasonal and annual weather fluctuations. Many of the species found on annual grasslands also populate valley oak woodland habitats as understory plants. During the summer, large volumes of standing dead plant matter can be found. In small depressions throughout annual grasslands, vernal pool habitat may form, supporting a host of species differing from the surrounding annual grassland. Many wildlife species are found in annual grasslands for foraging, including the western fence lizard (*Sceloporus occidentalis*), western rattlesnake (*Crotalus oreganus*), common garter snake (*Thamnophis sirtalis*), black-tailed jackrabbit (*Lepus californicus*), California ground squirrel (*Spermophilus beecheyi*), Botta’s pocket gopher (*Thomomys bottae*), western harvest mouse (*Reithrodontomys megalotis*), California vole, badger, coyote, burrowing owl, short-eared owl, horned lark, western meadowlark, turkey vulture, northern harrier, American kestrel, black-shouldered kite, and prairie falcon. Special habitat features found in annual grasslands such as cliffs, caves, ponds, or woody plants may provide vital breeding, resting, and escape cover areas for wildlife (CWHR, 1988).

Aquatic Habitats

LACUSTRINE

Lacustrine habitats are made up of standing water found in inland depressions or dammed riverine channels. Lacustrine habitats along the Bear River are found at Camp Far West Reservoir, Rollins Reservoir, and Lake Combie. Organisms found in these habitats include plankton (phytoplankton like diatoms, desmids, algae, and zooplankton like rotifers, copepods, cladocerans), insects like mosquitoes, and submerged (algae and pondweed) and floating rooted aquatic plants (water lilies and smartweeds). Mammals, birds, reptiles, and amphibians may all utilize lacustrine habitats for one or more uses including reproduction, feeding, water, or cover (CWHR, 1988).

RIVERINE

Streams and rivers are closely connected, with streams originating at an elevated source and flowing down a slope, eventually becoming a river. In the transition from stream to river, water velocity and dissolved oxygen decrease, and water volume, temperature, and turbidity increase. Fast stream inhabitants live in riffles, including larvae of mayflies, caddisflies, alderflies, stoneflies, and true flies. Dragonflies, damselflies, and water striders dominate pool habitats. Rocks support algal growth. Riverine habitat support waterfowl by providing resting areas and escape cover. Gulls, terns, osprey, and bald eagle use waters for hunting, and insectivorous birds catch insects over the open water. Mammal-use includes river otters, mink, muskrats, and beaver (CWHR, 1988).

Developed Habitats

CROPLAND

The very lowest elevations of the Bear watershed are dominated by cropland. The vegetative structure of croplands is obviously dependent on crops being grown, which in turn affects the wildlife supported by these habitats. Commonly grown crops in California include corn, dry beans, safflower, alfalfa, hay, tomatoes, cotton, and lettuce. Within the Bear watershed, rice, wheat, and vegetables are some of the crops grown. More information on crops found in the Bear can be found in Section C.3e: Agriculture. Many species of rodents, birds, and waterfowl may use cropland; for example, some waterfowl depend on waste rice and corn left in fields, and deer will forage in alfalfa and grain fields. Sandhill cranes, insectivores, raptors, doves and pheasants may be found in this habitat. Croplands flooded for weed control, irrigation or waterfowl hunting can serve as habitat for shorebirds, wading birds, and gulls (CWHR, 1988). In the Bear watershed specifically, multiple bird species including egrets, harriers, raptors and waterfowl have all been observed using cropland (Alex Lincoln, personal communication).

ORCHARD/VINEYARD

California orchards are generally dominated by a single tree species and often have bushy trees with an open understory. Vineyards are similar in structure, with bushy and intertwined vines in the rows and open space between rows. Almonds, walnuts, stone fruit, and wine grapes are some of the dominant species grown and harvested in the Bear watershed. . Orchards and vineyards have often been planted on historically rich soil which would have supported productive natural habitats. Wildlife in these areas are often considered agricultural pests, resulting in human controls such as fencing, sound guns, scarecrows, or other management techniques. Deer and rabbits browse on trees and vines, squirrels and birds feed on fruit and nuts, and mourning doves (*Zenaida macroura*) and California quails (*Callipepla californica*) use habitat for cover and nesting. Other species frequently present include northern flicker (*Colaptes auratus*), scrub jay (*Aphelocoma californica*), American crow (*Corvus brachyrhynchos*), plain titmouse (*Baeolophus inornatus*), Brewer's blackbird (*Euphagus cyanocephalus*), house finch (*Carpodacus mexicanus*), and California ground squirrel (*Spermophilus beecheyi*) are said to feed on nuts (almonds and walnuts). These species, as well as the band-tailed pigeon (*Patagioenas fasciata*), yellow-billed magpie (*Pica nuttalli*), western bluebird (*Sialia mexicana*), American robin (*Turdus migratorius*), varied thrush (*Ixoreus naevius*), northern mockingbird (*Mimus polyglottos*), cedar waxwing (*Bombycilla cedrorum*), yellow-rumped warbler (*Dendroica coronata*), black-headed grosbeak (*Pheucticus melanocephalus*), Bullock's oriole (*Icterus bullockii*), desert cottontail (*Sylvilagus audubonii*), western gray squirrel (*Sciurus griseus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), and mule deer (*Odocoileus hemionus*) are also known to feed on apples, cherries, figs, pears and prunes

URBAN

Urban landscapes are found in Grass Valley, Colfax, Wheatland, Lake of the Pines, and Chicago Park. Urban landscapes are another highly variable habitat, with five defined types of vegetation structure: tree grove, street strip, shade tree/lawn, lawn, and shrub cover. The urban landscapes in the Bear watershed are generally more heavily vegetated than more populated larger urban areas, and like all urban areas contain a mixture of native and exotic species. Wildlife species richness at the center of the heavily-developed downtown is typically very low, but increases outwards towards urban residential and suburban areas. Raccoons (*Procyon lotor*), opossums (*Didelphis virginiana californica*), and striped skunks (*Mephitis mephitis*) are all animal associates of urban habitats. Suburban areas with mature vegetation closely resemble the natural environment. Bird species may include wrentits (*Chamaea fasciata*), bushtits (*Psaltriparus minimus*), plain titmouse (*Baeolophus inornatus*), chestnut-backed chickadee (*Poecile rufescens*), and California quail (*Callipepla californica*). Deer, black-tailed jackrabbit (*Lepus californicus*), gophersnakes (*Pituophis catenifer*), and western fence lizards (*Sceloporus occidentalis*) can also exist in the suburban zone (CWHR, 1988).

PASTURE

Pasture communities are made up of non-native annual and perennial grasses and legumes and may or may not be irrigated. Pastures are primarily range land for cattle in the lower part of the watershed. They are susceptible to overgrazing resulting in erosion and invasive species such as barbed goat grass and medusa head. Wildlife supported by pasture habitat includes ground-nesting birds like waterfowl and quail if adequate vegetation is present during the nesting season. Flood irrigation of pastures provides foraging and roosting sites for many wetland birds (CWHR, 1988).

Non-vegetated Habitats

BARREN

Defined by the absence of vegetation, few barren exist in the Bear watershed. Habitats with <2% total vegetation cover and <10% tree cover are said to be barren. Some plants can be found in these habitats, such as those specialized to grow in scree slopes and serpentine rock. Along rivers, this can include vertical river banks and canyon walls. Despite the lack of vegetation, many species of wildlife may utilize barren habitats, including hawks and falcons that may nest on rock ledges, bank swallows (*Riparia riparia*) that use vertical cliffs of friable soil along river corridors to excavate nests, and bats that prefer to forage on rocky river canyon walls above open water (CWHR, 1988).

III.B.2. Rare, sensitive, threatened, and endangered species

Knowledge of species-specific occurrence patterns is essential for determining the impacts and threats to rare species in the Bear Watershed, as well as the conservation and restoration activities necessary to prevent their extirpation and help facilitate species recovery (Lesica and Allendorf, 1992; 1995). Surveys for special-status species (plants and animals that are legally protected or otherwise considered sensitive by federal, state, or local resource conservation agencies and organizations) have been completed for only a small portion of the Bear River Watershed. The results from many of these surveys have been published to the California Natural Diversity Database (CNDDB) and are summarized in this chapter. Additional special-status species discussed in this chapter have not yet been documented in the Bear Watershed by CNDDB but may occur here, as suitable habitat is present and the watershed lies within the species' geographic range.

The CNDDB data shown in Figures 21 and 22 represent historical or present occurrences of plant and animal species listed on the CNDDB special status species list (CDFW, 2015a). Figure 21 corresponds to species that have received federal and/or state listing as threatened or endangered, while Figure 22 corresponds to species that are on the CNDDB special status species list but have other types of conservation status (e.g., CDFW California species of special concern, CNPS List 1b and 2). The CNDDB data varies in graphic accuracy, with irregularly shaped polygons representing a specific bounded area where the species has been recorded. Circles ranging in size represent data mapped at different levels of accuracy, with larger circles representing decreasing levels of accuracy (ranging from 1/10 to 5 miles in radius). A larger circle does not represent a larger occurrence in the CNDDB, rather it represents more vague data. The smallest circles (80m radius) are considered a specific bounded area representing a point. Managers should note that the absence of CNDDB data does not mean that the species is necessarily absent in an area, just that it has not been previously recorded.

Table 14 details species documented by CNDDB in the Bear Watershed, along with information provided by CNDDB regarding the observed occurrences and potential threats to the individuals or populations observed. Text following the table provides additional information on the habitat needs of each CNDDB-documented species and several additional special-status species with potential to occur in the Bear Watershed.

Figure 21. CNDDB-Documented Occurrences of Threatened and Endangered Species

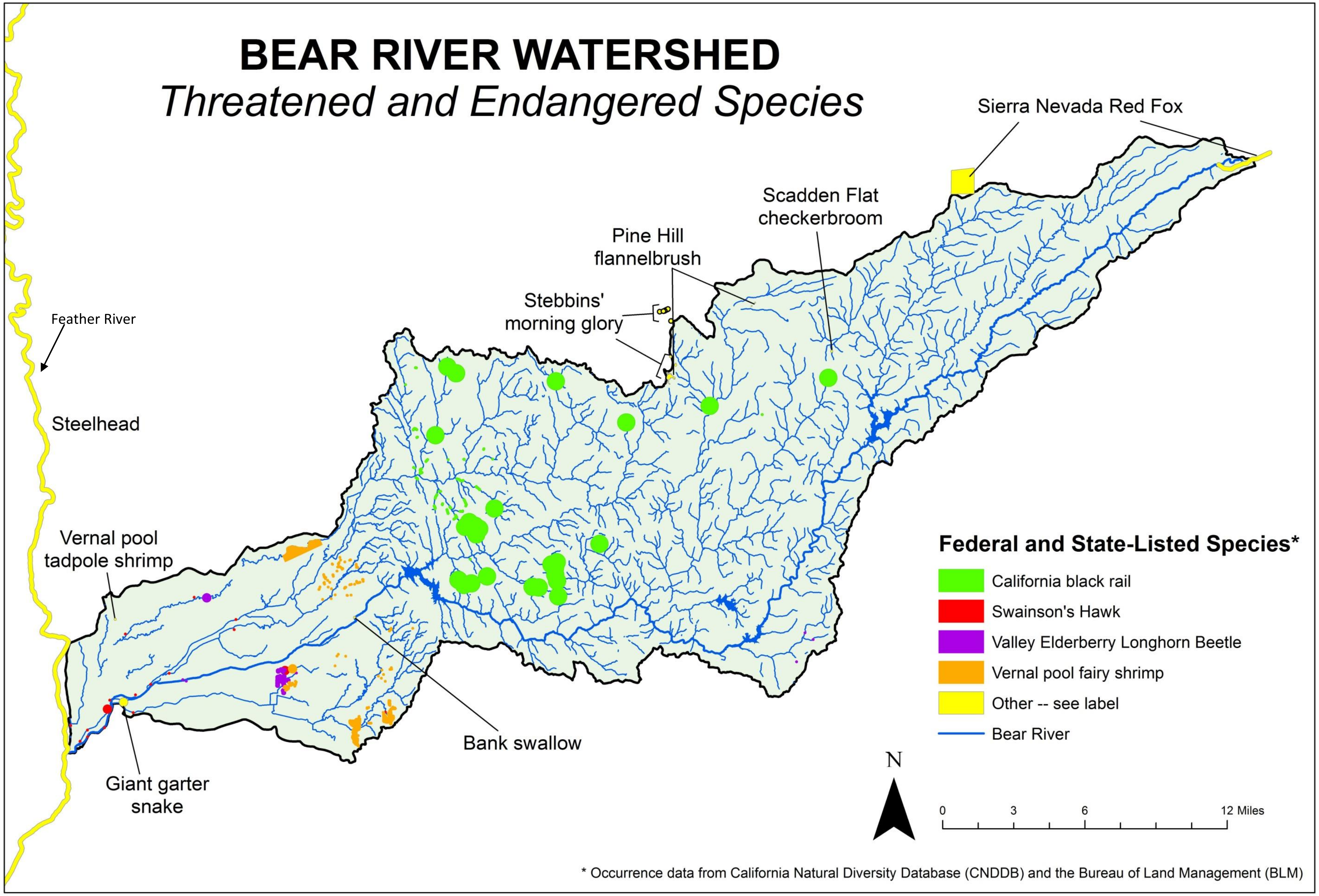


Figure 22. CNDDB-Documented Occurrences of Rare Special-status Species

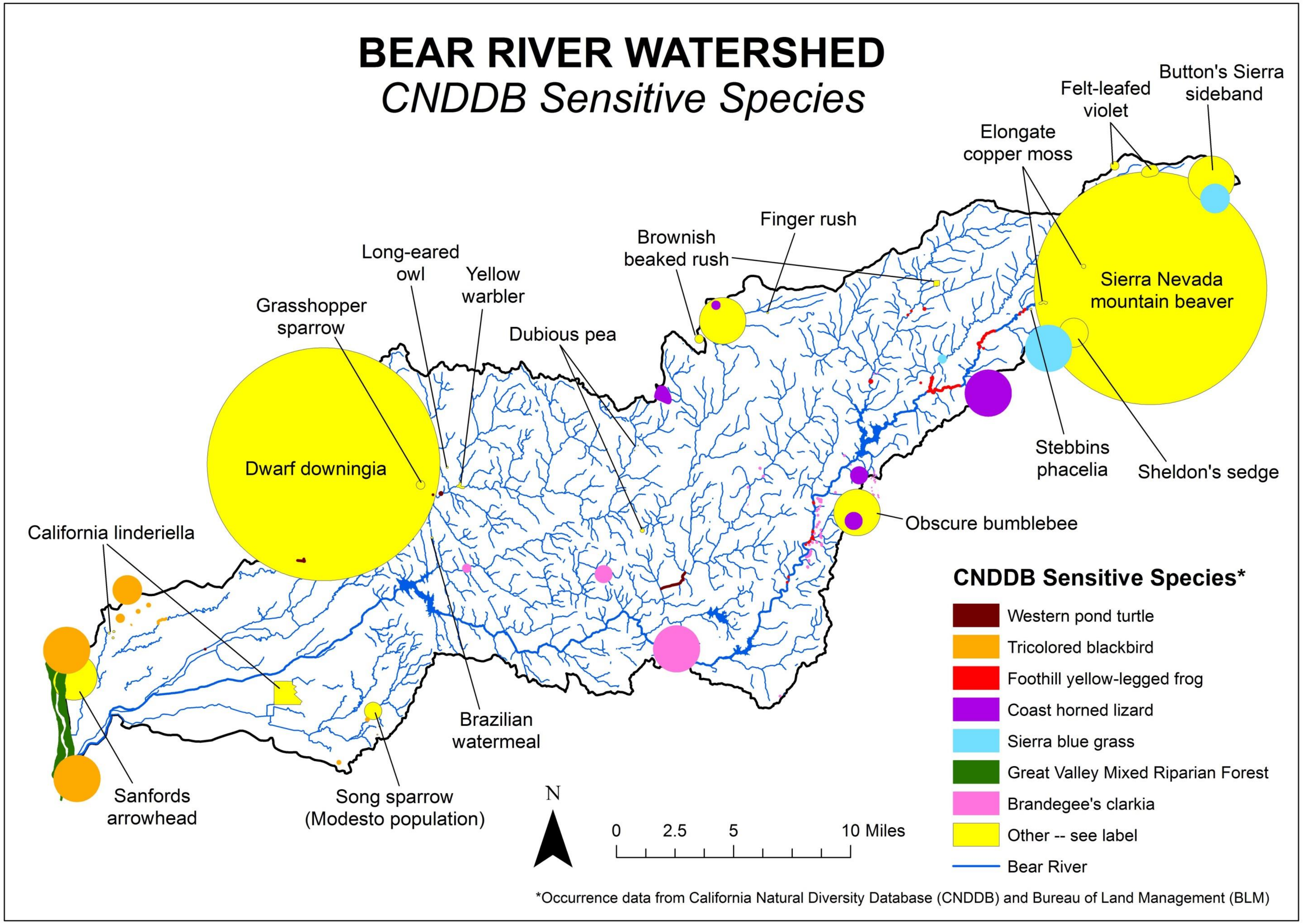


Table 14. **CNDDB Special-status Species**

Species	Species Status	No. of Records	Last Record	Notes	Threats
Bank swallow (*Riparia riparia*)	State Threatened	1	2008	25-30 burrows found along 30 ft of a vertical bank 20 ft tall. Presumed extant.	No specific threats listed in CNDDB data.
Brandegee's clarkia (*Clarkia biloba ssp. Brandegeeae*)	CNDDB Sensitive Species	14	2009	Hundreds of plants last seen in 2009 on road banks and exposed slopes. Presumed extant.	Road maintenance, herbicide, mowing and clearing.
Brazilian watermeal (*Wolffia brasiliensis*)	CNDDB Sensitive Species	1	2002	In shallow water of manmade pond. Noted as "common" in 2002 collection by Ahart. Presumed extant.	No specific threats listed in CNDDB data.
Brownish beaked rush (*Rhynchospora capitellata*)	CNDDB Sensitive Species	2	1978	With *Juncus, Eleocharis, Arctostaphylos viscid, Pinus ponderosa.* Presumed extant.	Traffic from campers.
Button's Sierra sideband (*Monadenia mormonum buttoni*)	CNDDB Sensitive Species	1	Unknown	Specimen in the California Academy of Sciences. Presumed extant.	No specific threats listed in CNDDB data.
California black rail (*Laterallus jamaicensis coturniculus*)	State threatened	36	2007	Habitat consists of palustrine emergent marsh. Presumed extant.	Habitat degradation due to grazing and noxious weeds.
California linderiella (*Linderiella occidentalis*)	CNDDB Sensitive Species	4	2004	Habitat consists of seasonal wetland or vernal pools. Presumed extant.	Future highway developments, disking/plowing.
Coast horned lizard (*Phrynosoma blainvillii*)	CNDDB Sensitive Species	5	1995	Found in open sandy areas or chaparral. Presumed extant.	Clearing and development.

Species	Species Status	No. of Records	Last Record	Notes	Threats
Dubious pea (*Lathyrus sulphureus* var. *argillaceus*)	CNDDB Sensitive Species	3	2001	In blue oak woodland and chaparral. Presumed extant.	Road maintenance and fuels reduction.
Dwarf downingia (*Downingia pusilla*)	CNDDB Sensitive Species	3	2005	850 and 1000 plants observed. In pools of standing water including vernal pools. Presumed extant.	Cattle grazing.
Elongate copper moss (*Mielichhoferia elongata*)	CNDDB Sensitive Species	2	2001	On wall of metamorphic rock in transition forest of douglas-fir and canyon live oak. Presumed extant.	No specific threats listed in CNDDB data.
Felt-leafed violet (*Viola tomentosa*)	CNDDB Sensitive Species	2	1984	Growing in openings of mixed coniferous forest. Presumed extant.	Disturbance by vehicular traffic.
Finger rush (*Juncus digitatus*)	CNDDB Sensitive Species	1	2011	Open chaparral surrounded by mixed oak habitat. Presumed extant.	Infrastructure development, altered hydrology.
Foothill yellow-legged frog (*Rana boylii*)	CNDDB Sensitive Species	9	2009	Habitat includes low to high gradient riffles, runs, edge water, side channels, and gravel substrate. Presumed extant.	ORV recreation, gold mining, flows management.
Giant garter snake (*Thamnophis gigas*)	Federally and State threatened	1	Prior to 1986-87	Presumed extant.	No specific threats listed in CNDDB data.
Grasshopper sparrow (*Ammodramus savannarum*)	CNDDB Sensitive Species	1	1994	1 Adult observed. Area invaded by weedy species. Presumed extant.	Flooding of area by proposed Waldo Dam.

Species	Species Status	No. of Records	Last Record	Notes	Threats
Great Valley mixed riparian forest	CNDDB Sensitive Species	1	1985	Tall lush veg of *Populus fremontii*, *Salix* spp., *Cephalanthus occidentalis*, *Platanus racemosa*, *Quercus lobata*, *Juglans* over *Acer negundo*, *Vitis*, *Rubus*, poison oak, *Rosa*, *Artemisiadouglasii*, *Elymustriticoides* & introduced annual grasses. Presumed extant.	No specific threats listed in CNDDB data.
Long-eared owl (*Asio otus*)	CNDDB Sensitive Species	1	1993	Nest tree at edge of grassland clearing and oak woodland. Presumed extant.	Human disturbance from curious observers.
Obscure bumblebee (*Bombus caliginosus*)	CNDDB Sensitive Species	1	1949	5 collected. Location centered on Colfax. Presumed extant.	No specific threats listed in CNDDB data.
Pine Hill flannelbrush (*Fremontodendron decumbens*)	Federally endangered, State rare	2	2010	Growing in chaparral. Presumed extant.	Lack of management, lack of disturbance, invasion by non-natives.
Sanford's arrowhead (*Sagittaria sanfordii*)	CNDDB Sensitive Species	1	1955	Based only on collection, needs fieldwork. Presumed extant.	No specific threats listed in CNDDB data.
Scadden Flat checkerbroom (*Sidalcea stipularis*)	State endangered	1	2008	Found in freshwater marsh. Associates: *Latifolia, Pinus ponderosa, Carex* spp. Presumed extant.	Development, grazing and mowing, invading blackberry, altered hydrology

Species	Species Status	No. of Records	Last Record	Notes	Threats
Sheldon's sedge (*Carex sheldonii*)	CNDDB Sensitive Species	1	1950	Found in wet grassy placed under *Pinus ponderosa*. Presumed extant.	No specific threats listed in CNDDB data.
Sierra blue grass (*Poa sierrae*)	CNDDB Sensitive Species	3	1964	Based only on collection, needs fieldwork. Presumed extant.	No specific threats listed in CNDDB data.
Sierra Nevada mountain beaver (*Aplodontia rufa californica*)	CNDDB Sensitive Species	1	1912	Locality described as Blue Canyon. Collected 1885, 1886. 1888, 1912. Presumed extant.	No specific threats listed in CNDDB data.
Sierra Nevada Red Fox (*Vulpes vulpes necator*)	State threatened	2	1989	Presumed to be SN Red Fox, but DNA analysis needed to confirm. Presumed extant.	No specific threats listed in CNDDB data.
Song sparrow (Modesto population) (*Melospiza melodia*)	CNDDB Sensitive Species	1	2005	3 pairs and 1 juvenile found in marsh within 1000-acre preserve. Presumed extant.	No specific threats listed in CNDDB data.
Stebbins phacelia (*Phacelia stebbinsii*)	CNDDB Sensitive Species	1	2011	Found in base of roadcut through bedrock, in chaparral opening within montane forest. Presumed extant.	Road maintenance and traffic.
Stebbins' morning glory (*Calystegia stebbinsii*)	Federally and State Endangered	3	2007	Found on rural residential lands, growing within serpentine chaparral. Presumed extant/possibly extirpated.	Development and residential landscaping.

Species	Species Status	No. of Records	Last Record	Notes	Threats
Steelhead - Central Valley DPS (*Oncorhynchus mykiss irideus*)	Federally threatened	1	2012	Most spawning in cool, stable flows. Young of the year disperse to warmer water. Presumed extant.	Redd superimposition, competition/genetic effects of hatchery fish, dams.
Swainson's hawk (*Buteo swainsoni*)	State threatened	18	2009	Found nesting in cottonwoods, valley oaks, and willows, surrounded by orchards, row crops, or grazing land. Presumed extant.	Future development.
Tricolored blackbird (*Agelaius tricolor*)	CNDDB Sensitive Species	10	2015	Habitat composed of cattail marsh or Himalayan blackberry. Presumed extant.	Habitat loss due to pond removal, landfill activities.
Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)	Federally threatened	8	2011	Found in habitat with elderberry along riparian areas. Presumed extant.	Vegetation management and trimming, invasion by non-natives.
Vernal pool fairy shrimp (*Branchinecta lynchi*)	Federally threatened	14	2014	Found in natural and constructed vernal pools. Presumed extant. Mapped points represent subset of population found.	Future development.
Vernal pool tadpole shrimp (*Lepidurus packardi*)	Federally endangered	1	2004	10-20 adults found in very long seasonal wetland by dirt road in slightly turbid water at 22°C. Presumed extant.	Disking/plowing and proposed levee improvement project.

Species	Species Status	No. of Records	Last Record	Notes	Threats
Western pond turtle (*Actinemys marmorata*)	CNDDB Sensitive Species	5	2008	Found in creeks with steady flows, partially submerged logs. Presumed extant.	Cattle grazing visible near site of occurrence.
Yellow warbler (*Setophaga petechia*)	CNDDB Sensitive Species	1	1994	3-4 pairs found nesting. Habitat is foothill riparian. Site contains high diversity of nesting birds. Presumed extant.	Inundation by proposed Waldo Dam and nest parasitism by cowbirds.

III.B.2a. Special-status plants

Of the seven river basins within the boundary of the northern Sierra Nevada, those of the Feather and American Rivers have the greatest number of plant taxa, including endemic and rare taxa, with the American River having at least 46 rare taxa and 85 Sierran endemics. The Yuba River has at least 69 Sierran endemics and 45 rare taxa documented within the watershed (Millar et al., 1996). The data from the Yuba and American River watersheds shows potential for similarly high levels of plant taxa diversity and rare and endemic plant presence within the Bear. The CNDDB list is limited to documented occurrences and is not a complete list of all sensitive plant species that may be found in the Bear watershed. There is a great need to increase the knowledge of rare plant diversity, abundance and location in the watershed and increase access to data that is already available.

Information on rarity and endemism for non-vascular plants, including lichens and bryophytes, for the Sierra Nevada is very speculative and fragmentary due to limited fieldwork and the small number of available collections. Many of these ensembles are located on unusual substrates or soils, occur in areas with high plant species diversity, or occur in uncommon habitats or vegetation types. There is a strong need to fill data gaps in non-vascular plant diversity, abundance, and location, throughout the watershed. For example, the structure of a lichen community in a forest (i.e., species presence and abundance) intrinsically provides a wealth of information about forest health, function, and local climatic conditions because some species are extremely sensitive to environmental change, a major reason for their popularity as bioindicators for natural resource assessment (Nimis et al., 2002).

Some plant, fungi, and plant community types that are of concern and may be found in the Bear watershed based on habitat and elevation requirements are in the Tahoe National Forest lists in Table 15 and Table 16. Species with a U.S. Fish and Wildlife ranking of endangered or threatened, and California Native Plant Society (CNPS) ranking of 1 or 2 are required to be included in environmental analysis including CEQA and NEPA.

***Table 15.* Tahoe National Forest Sensitive Plants and Fungi**

Species	Status USFWS	Status CNPS	Habitat
Astragalus webberi	None	1B.2	2,400-4,100', dry openings in forest/shrubs
Botrychium ascendens	None	2.3	4,000 feet +, moist/riparian areas
Botrychium crenulatum	None	2.2	4,000 feet +, moist/riparian areas
Botrychium lunaria	None	2.3	4,000 feet +, moist/riparian areas
Botrychium minganense	None	2.2	4,000 feet +, moist/riparian areas
Botrychium montanum	None	2.1	4,000 feet+, moist/riparian areas
Bruchia bolanderi	None	2.2	3,800-9,500 feet, moist/riparian areas
Cudonia monticola	None	None	No elevation restriction, older-mixed conifer
Dendrocollybia racemosa	None	None	No elevation restriction, older-mixed conifer
Fritillaria eastwoodiae	None	3.2	<4,900 feet, full to partial sun
Juncus luciensis	None	1B.2	925-6,235 feet, wetlands, riparian
Lewisia cantelovii	None	1B.2	1,000-4,500 feet, westside, cliffs/outcrops,
Lewisia kelloggii subsp.*hutchisonii*	None	3.3	4800-7,000 feet, rocky open ridges
Lewisia kelloggii subsp.*kelloggii*	None	None	5,000-9,000 feet, rocky open ridges
Lewisia serrata	None	1B.1	3,000-5,000 feet, westside, cliffs/outcrops
Meesia uliginosa	None	2.2	4,250-6,850 feet, wet areas, fens
Mielichhoferia elongata	None	2.2	1,600-4,300', rock with copper/heavy metals
Monardella follettii	None	1B.2	2,000-6,500 feet, serpentine
Peltigera gowardii	None	None	1,150 to 7,000 feet in clear, cold water
Penstemon personatus	None	1B.2	4,500-6,500 feet, partial sun
Phacelia stebbinsii	None	1B.2	2,000-6,800 feet, westside openings
Phaeocollybia olivacea	None	None	No elevation restriction, older-mixed conifer
Poa sierrae	None	1B.3	Mixed conifer forest, 1,000-5,500 feet
Sowerbyella rhenana	None	None	No elevation restriction, older-mixed conifer
Tauschia howellii	None	1B.3	5,500-8,500 feet, subalpine.

Table 16. **Tahoe National Forest Watchlist Plants and Plant Communities**

Species/Community	CNPS List	Habitat
Allium jepsonii	1B.2	900-4,400′, foothill woodland, lower montane coniferous forest, serpentinite or volcanic soils
Arctostaphylos nissenana	1B.2	1,500 to 3,500′, chaparral/closed-cone pine forest
Calochortus clavatus var. *avius*	1B.2	3,000-5,800′, forest edges American River
Cardamine pachystigma var.*dissectifolia*	3	Openings < 6,900 feet
Carex davyi	1B.3	4,800-10,600′, subalpine/red fir forest
Carex lasiocarpa	2.3	1,900-6,900 feet, fens, wet areas
Carex limosa	2.2	4,000-8,700 feet, fens, wet areas
Carex praticola	2.2	1,600-10,500 feet, meadows/wet areas
Carex sheldonii	2.2	4,000-5,000 feet, wet areas
Ceanothus arcuatus	None	1,900 and 7,025 feet, serpentinite soils
Chlorgalum grandiflorum	1B.2	800 to 4,100 feet, serpentinite soils
Clarkia mildrediae subsp. *mildrediae*	1B.3	800-5,650 feet, woodland/forest edges
Corallorhiza trifida	2.1	4,450-5,750 feet, wet areas
Drosera anglica	2.3	<7,000 feet, wetlands/riparian
Epilobium luteum	2.3	4,900-5,600 feet, wetland areas
Eriogonum umbellatum var. *ahartii*	1B.2	<6,600 feet, serpentinite soils
Eremogone cliftonii	1B.3	1,490-5,850 feet, opening in Chaparral, montane coniferous forest
Glyceria grandis	2.3	<6,890 feet, riparian/wetland
Hemieva ranunculifolia	2.2	4,900 and 8,200 feet, riparian/wetland
Horkelia parryi	1B.2	<3,400 feet openings/edges
Meesia longiseta	None	All elevations, wetland/riparian areas
Oreostemma elatum	1B.2	3,200-6,700′, wetland/riparian areas
Packera eurycephala var. *lewisrosei*	1B.2	900-6,200 feet, serpentinite soils
Penstemon sudans	1B.3	3,900-8,000 feet, edges/openings
Populus tremuloides	None	Above 5,500 feet, moist areas
Rhamnus alnifolia	2.2	4,500-7,000′, wetland/riparian areas
Rhynchospora alba	2B.2	150-6,700, wetlands/riparian areas
Rhynchospora capitellata	2B.2	150-6,600 wetlands/riparian areas
Sanicula tracyi	4.2	300-5,200 feet, openings/edges

Species/Community	CNPS List	Habitat
Schoenoplectus subterminalis	2.3	2,400-7,400 feet, wetlands
Scutellari agalericulata	2.2	4,000-7,000 feet, stream banks
Sedum albomarginatum	1B.2	850-6,400’, riparian/river canyons
Silene occidentalis subsp. *longistipitata*	1B.2	3,200-6,600 feet, forest edges/openings

III.B.2b. Special-status invertebrates

VALLEY ELDERBERRY LONGHORN BEETLE (*Desmocerus californicus dimorphus*)

Valley elderberry longhorn beetles are patchily distributed throughout riparian habitats of the Central Valley and Sierra foothills up to approximately 2,260 ft elevation (USFWS, 2014b). These beetles require elderberry shrubs (*Sambucus* spp.) for reproduction and survival, spending most of their 1-to-2-year life cycle as larvae within the stems. Individual valley elderberry longhorn beetles rely on the same elderberry plant (or cluster of plants) throughout their life cycle (Barr, 1991). Adults feed on the leaves and flowers, eggs are laid on the stem or leaves, and the larval and pupal stages develop within the pith of large stems, typically 1 inch or greater in diameter when measured at ground level. Valley elderberry longhorn beetles are listed as threatened under the federal Endangered Species Act. They are threatened within the Bear Watershed by loss and degradation of the riparian habitats in which their elderberry host plants most successfully grow, the fragmentation of habitat patches with elderberry shrubs, direct clearing of shrubs, and pesticide use.

Breeding valley elderberry longhorn beetles have been documented at several locations within the low- and mid-elevation portions of the Bear watershed, primarily below Camp Far West reservoir but also east of Lake Combie at elevations up to 1,880 ft, between Meadow Vista and Applegate and along the Bear Canal (CNDDB, 2015). These documented locations include riparian habitat along portions of the mainstem Bear River and several tributary streams and sloughs, as well as human-made mesic areas such as canals and roadsides. Valley elderberry longhorn beetles are likely to occur at a large number of additional sites in the Bear River Watershed that have not yet been surveyed.

VERNAL POOL CRUSTACEANS

Vernal pool fairy shrimp (*Lepidurus packardi*), vernal pool tadpole shrimp (*Branchinecta lynchi*), and California linderiella (*Linderiella occidentalis*, also commonly known as California fairy shrimp) are restricted to vernal pools, swales, and other seasonal wetlands within California's low-elevation grasslands and oak savannahs. Eggs of these species lie dormant during most of the year in the form of cysts, which are capable of withstanding extreme environmental conditions, such as heat, cold, and prolonged desiccation. The cysts hatch when the pools fill with rainwater, and the young rapidly develop into sexually mature adults. Not all of the cysts hatch with the first rainfall; some remain dormant to hatch during subsequent events or in later years. Eggs are dispersed from one pool to another on the feet of birds and mammals, which move between the pools. In locations where water moves seasonally between pools, or intermittently during peak rainfall events, vernal pool crustaceans also disperse directly with the movement of water.

Habitat loss and fragmentation are the largest threats to the recovery of vernal pool species (USFWS, 2005). In addition to direct habitat loss to development, roads and other infrastructure projects can result in the fragmentation and isolation of otherwise-functional vernal pool ecosystems, disrupting their hydrology and gene flow (USFWS, 2005). Conversely, activities which increase the connection between vernal pool complexes and permanent bodies of water may result in the local extirpation of vernal pool crustaceans due to the introduction of native predatory fish and nonnative invasive bullfrogs (*Rana catesbeiana*; Bauder, 1987). Ground-disturbing activities that cause erosion adjacent to or within the watersheds of vernal pools, such as grading, plowing, off-road vehicle use, poorly designed trail and road systems, or inappropriate management of livestock grazing, can cause additional threats through siltation when pools fill during the following wet season. Siltation may result in the burial and/or asphyxiation of vernal pool crustacean eggs and cysts, and high turbidity may result in the suffocation of adults (USFWS, 2005).

The timing, frequency, and duration of pool inundation are critical to the survival of vernal pool crustaceans, and differences on the scale of days can affect the ability of populations to reproduce (Helm, 1998). Artificially lengthened inundation periods may harm vernal pool crustaceans by providing suitable habitat for bullfrog larval development and/or an altered plant community. Artificial water flow into vernal pools during the summer can significantly alter vernal pool species composition (Clark *et al.*, 1998). Shortened inundation periods can result in premature pool dry-down before the life cycles of vernal pool crustaceans are completed, preventing reproduction. The construction of canals and other water conveyance systems through vernal pool habitats can shorten the inundation time of vernal pools via conduction of surface and subsurface flows into the canals, as can the construction of stockponds and other impoundments (USFWS, 2005). These and other soil disturbances can also result in the encroachment of nonnative annual grasses into pool margins and swales. This plant community alteration further decreases the hydroperiod of vernal pools, especially in low rainfall years (Barry, 1998). The removal of cattle grazing from historically grazed vernal pools has also been found to dramatically decrease the inundation period of vernal pools, as appropriate grazing practices reduce the accumulation of nonnative grasses and thatch while sustaining favorable soil conditions (Barry, 1995; Marty, 2004). Climate change raises additional concerns of the potential for chronically decreased inundation periods in previously healthy vernal pool complexes. This underscores the importance of conservation, restoration, and best management practices to maintain the resiliency of these rare ecosystems.

The vernal pool fairy shrimp is listed as threatened under the federal Endangered Species Act, and the vernal pool tadpole shrimp is federally listed as endangered. The California linderiella is more broadly distributed than the state's other endemic vernal pool crustaceans, and thus is not listed under the Endangered Species Act. However, California linderiella is included in the federal Vernal Pool Ecosystem Recovery Plan (USFWS, 2005), as it is affected by the same ecological processes, threats, conservation and restoration opportunities as its fellow vernal pool inhabitants. In the Bear River Watershed, vernal pool crustaceans have been documented at low elevations north and south of the mainstem (CNDDB, 2015), with the primary populations existing on Beale Air Force Base (BAFB, 2011).

BUTTON'S SIERRA SIDEBAND (*Monadenia mormonum buttoni*)

Presence of the Button's Sierra sideband (*Monadenia mormonum buttoni*) has been confirmed in the upper watershed in Bear Valley near Emigrant Gap. The distribution of this CNDDB special-status terrestrial mollusk also includes Nassau Valley, Calaveras County, Placer and Nevada Counties, and near Riverton in El Dorado County (Placer County, 2011). Planning documents from Placer County suggest that *M. m. buttoni* inhabits canyons (Placer County, 2011), however data gaps are significant in regard to specific habitat requirements, ecology, abundance, and threats. A similar mollusk endemic to northern California and southwest Oregon in the same genus, *M. chaceana* (Siskiyou Shoulderband), uses talus slopes as well as surrounding forest areas which provide food (i.e. arboreal foliose lichens) and conditions necessary for egg-laying (i.e. loose soil and litter) (Duncan, 2005). The lower third of talus slopes are preferred, due to large interstitial spaces between rocks where dependable refugia sites occur, providing protection from predators, desiccation, wildfire events, and winter conditions (Duncan, 2005). In more mesic, forested habitats, *M. chaceana* aestivates in hollow wood cavities and under woody debris (Duncan, 2005). Generally, dispersal of terrestrial mollusks is limited by barriers such as permanent water bodies greater than 30 m wide or dry areas (<6 inches of annual precipitation). Habitat must be moist, as moisture is required for respiration and egg hatching (NatureServe, 2015).

While the entire *M. mormonum* species is listed as Imperiled by CNDDB, the subspecies *M. m. buttoni* is listed as Critically Imperiled (NatureServe, 2015). Threats to species within the *Monadenia* genus include reduction of forest canopy from logging, or other habitat altering activities including wildfire, which can result in desiccation of important refugia sites and reduction of foraging habitat for arboreal species (USFS, 2009; Duncan, 2005). Conservation actions should include maintenance of interconnected areas of undisturbed forest with rock talus, woody debris, and riparian areas (USFS, 2009; Duncan, 2005). Fire management that includes reducing the intensity, duration, or frequency of fire through prescribed burning or other methods of fuels reduction could reduce the risk of catastrophic natural fires (Duncan, 2005).

SPECIAL-STATUS INSECTS, INCLUDING POLLINATORS

Pollinator populations in general are of great conservation concern, as many species are undergoing considerable declines, and are vital to the preservation of natural ecosystems and human food supplies. Pollinator species of particular concern in the Bear River Watershed include the obscure bumblebee (*Bombus caliginosus*), a CNDDB sensitive species classified as Vulnerable by the IUCN, and the western bumblebee (*Bombus occidentalis*), which was recently designated by the US Forest Service as a Sensitive Species on National Forests in California. Both of these species have recently disappeared from portions of their historical range and are declining elsewhere (Hatfield *et al*., 2014 and 2015). The monarch butterfly (*Danaus plexippus*) is another declining pollinator classified as a Sensitive species by the US Forest Service. Adult monarchs are known to migrate through the Bear River Watershed and pollinate a wide variety of flowers. This species may also breed in the watershed where adequate populations of its larval host plant, milkweed, (*Asclepias*, all species) are found, for example in riparian areas and meadows.

There are a variety of other insect species in the region that are of interest and potential concern. These include: the Blennosperma vernal pool andrenid bee (*Andrena blennospermatis*), the andrenid bee (*Andrena subapasta*), the Morrison bumblebee (*Bombus morrisoni*), the gold rush hanging scorpion fly (*Orobittacus obscurus*), the South Forks ground beetle (*Nebria darlingtoni*), Leech's skyline diving beetle (*Hydroporus leechi*), and the Wawona riffle beetle (*Atractelmis wawona*). There is evidence of these species in the watersheds adjacent to the Bear, but no evidence yet of their presence in the Bear specifically. Despite the lack of studies, the presence of these species in the larger region and their classification as CNDDB species of concern suggests that their protection should be considered in any future restoration plans.

III.B.2c. Special-status fish

CENTRAL VALLEY DPS STEELHEAD (*Oncorhynchus mykiss irideus*)

The Central Valley Distinct Population Segment of steelhead (*Oncorhynchus mykiss irideus*) has been federally listed as threatened under the Endangered Species Act since 1998 (CDPR, 2015). *O. mykiss* may either reside in freshwater (rainbow trout), or they may become anadromous (spending a portion of their lifecycle in the ocean and then returning to freshwater to spawn). Those that become anadromous are referred to as steelhead. Winter-run steelhead like those found in the surrounding watersheds (Feather, Yuba, American) enter freshwater between November and April and spawn soon afterwards (NOAA, 2016). The National Marine Fisheries Service's 2014 Recovery Plan for the Evolutionarily Significant Units of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon and the Distinct Population Segment of California Central Valley steelhead lists the Bear River as a Core 3 watershed for steelhead because populations are intermittently present (due to inadequate stream flow), and the existence of these populations depends on straying from nearby populations (National Marine Fisheries Service, 2014a). Intermittent populations such as these hold ecological importance since the juvenile movement and the straying of adults provides buffer populations that may allow the species to exist after periodic catastrophic disturbances in core habitat areas (Reeves et al., 1995).

Currently, the lowest reach of the Bear River below Camp Far West Reservoir is designated as critical habitat for Central Valley Steelhead, due to its use for non-natal rearing and as spawning grounds in the winter during periods of high flows. However, silted spawning gravel severely limits salmonid reproduction below Camp Far West Reservoir (National Marine Fisheries Service, 2014a). The South Sutter Irrigation District Dam creating the reservoir forms an impassable barrier to anadromous fish, and therefore steelhead distribution is limited to below the dam.

CENTRAL VALLEY CHINOOK (*Oncorhynchus tshawytscha*)

The Bear River watershed below Camp Far West Reservoir is also included in the designated critical habitat and distribution for Central Valley spring-run Chinook (National Marine Fisheries Service, 2014a). As of 2005, the lower Bear River was classified as occupied habitat for Central Valley spring-run Chinook, a state- and federally-threatened Evolutionarily Significant Unit (ESU), citing a public comment that it was used for non-natal rearing (NOAA, 2005). NOAA ranked the lower Bear River as having high conservation value to this ESU because it was likely used by at least two populations (i.e. Feather and Yuba Rivers) for this unique life-history strategy of non-natal rearing (National

Marine Fisheries Service, 2005a). However, the most current recovery plan for steelhead and Chinook salmon does not list the Bear as a watershed currently containing a population of Chinook (National Marine Fisheries Service, 2014a).

Historically, spring-run Chinook salmon have not been present in the Bear. Instead, the 15 mile reach just below present-day Camp Far West supported a fall-run of Chinook salmon of significant size (Yoshiyama et al., 2001). It is believed that adult salmon only ever reached as far upstream as 15 miles from the confluence with the Feather River due to a waterfall that likely barred further passage (Yoshiyama et al., 2001). Recent abundances of fall-run Chinook have not been near historical numbers in decades, though juvenile Chinook were recently found rearing in Dry Creek in 2015 (personal communications with Beth Campbell at USFWS and Chuck Carroll at Beale Air Force Base). It is currently unclear to what extent salmon are found in the lower Bear River or which migration runs utilize existing habitat.

GREEN STURGEON (*Acipenser medirostris*) and WHITE STURGEON (*Acipenser transmontanus*)

Sturgeon are long-lived anadromous fish. The Southern Distinct Population Segment (DPS) of Green Sturgeon (*Acipenser medirostris*), consisting of coastal and Central Valley populations south of the Eel River, is currently listed as threatened under the Endangered Species Act. White sturgeon (*Acipenser transmontanus*) are not a listed species, and with robust population sizes, the Sacramento-San Joaquin River subpopulations are listed as stable and an IUCN species of least concern (Duke et al., 2004).

While historical abundances of green sturgeon in the Feather River and the Bear River are undefined due to limited monitoring efforts, some sources report that both green and white sturgeon were observed in the Bear in 1989, 1990, and 1992 between the Highway 70 and Highway 65 bridges; however, no spawning or presence of larvae or juveniles were found (Beamesderfer et al., 2004). It is thought that green sturgeon currently enter the Bear River during the spring of most wet years (National Marine Fisheries Service, 2005b), and the green sturgeon Southern DPS has been documented spawning in the Feather River as recently as 2011 (National Marine Fisheries Service, 2015), suggesting the possibility that green sturgeon may currently utilize habitat, if not spawn, in the Bear River. It is possible that white sturgeon may also be found in the lower Bear River, as a white sturgeon was captured by an angler on the Feather River just upstream of the confluence with the Bear River in 2011 (Seesholtz, 2011). Further surveys should be done to resolve these uncertainties.

III.B.2d. Special-status amphibians

FOOTHILL YELLOW-LEGGED FROG (*Rana boylii*)

Foothill yellow-legged frogs (FYLF- *Rana boylii*) are characteristically associated with shallow streams (less than 3 feet deep) with cobble or gravel substrates and little to no aquatic or emergent vegetation. Ideal habitat contains edgewater or low-velocity areas and channel shading (NID and PG&E, 2010b). Egg masses are laid among the cobbles in areas lacking aquatic vegetation and free of crayfish and non-native bullfrogs (*Rana catesbeiana*), a source of both competition and predation on yellow-legged frogs (Moyle 1973, Borisenko and Hayes 1999). Because the egg masses of foothill yellow-legged frogs are relatively exposed, they are particularly vulnerable to destruction by high-water, artificial pulse flows if released by dams during the egg-laying season, and populations are less likely to occur downstream from such flows (Lind et al. 1996, Kupferberg 1996) or downstream from dams that impose artificial drought conditions (Moyle 1973, Kupferberg 1996). In addition to perennial streams, foothill yellow-legged frogs may occur in ephemeral creeks that retain perennial pools through the end of summer, provided that these pools maintain adequate flows for oxygenation of the egg masses prior to hatching and a minimum 15 weeks of water for larval development and metamorphosis.

California Department of Fish and Wildlife range maps indicate that foothill yellow-legged frogs may be found year-round throughout the majority of the upper Bear watershed. In visual encounter surveys done from 2008-2010 as part of the relicensing of the Yuba-Bear and Drum-Spaulding Hydroelectric Projects, foothill-yellow legged frogs were found at high frequency at several locations within the Bear River watershed, including at Steephollow Creek, (a tributary of the Bear River in the Chicago Park Powerhouse Reach), and the Dutch Flat Afterbay Dam Reach (NID and PG&E, 2010b). Fewer foothill yellow-legged frogs were detected in the Bear River Canal Diversion Dam Reach, Drum Afterbay Dam Reach on the Bear River, and near Stump Creek. FYLF were not found in any year along Dry Creek, Rock Creek, near Pittman Spill, or the Highway 20 Bear River Crossing (NID and PG&E, 2010b). Modeling of habitat for egg mass and tadpole suitability indicates that generally the amount of suitable habitat decreases with increased flow (NID and PG&E, 2011a). At the lowest modeled flow, 23.5% and 22.8% of the wetted area at Dutch Flat Afterbay Dam Reach was suitable for egg masses and tadpoles respectively. At the Bear River Canal Diversion Dam Reach, 10.8% of area was suitable for egg masses and 8.8% of area was suitable for tadpoles. In contrast, at the Chicago Park Powerhouse Reach, suitable habitat increased with increased flows, with a high of 9.8% and 10.4% of area suitable for egg masses and tadpoles respectively at the highest modeled flow (NID and PG&E, 2011a). Activities that alter streambeds and flows, such as gold mining and water releases from reservoirs, should be managed to minimize impacts on foothill yellow-legged frog breeding habitat (CaliforniaHerps, 2015).

SIERRA NEVADA YELLOW-LEGGED FROG (*Rana sierrae*)

The Sierra Nevada yellow-legged frog is part of the mountain yellow-legged frog complex which is composed of *Rana sierrae* and *Rana muscosa*. Sierra Nevada yellow-legged frogs are characteristically found in sunny river margins, meadow streams, isolated pools, and lake borders in the Sierra Nevada (IUCN Red List, 2015). The species utilizes relatively large, deep, permanent ponds without fish, and likely requires overwintering sites that do not freeze (Bradford, 1983; NID and PG&E, 2010c). Egg masses are deposited underwater in shallow vegetated areas and attached to rocks, gravel, or vegetation (Vredenburg, 2007). Suitable ponds often must be large enough to support tadpoles for the 2-4 years required to reach metamorphosis, however at lower elevations with longer summers tadpoles may grow to metamorphosis in a single season (NID and PG&E, 2010c; Storer, 1925).

The upper elevation (>4,400 ft) of the Bear Valley Meadow is the only potential habitat for Sierra Nevada yellow-legged frogs along the Bear River (NID and PG&E, 2010c; American Rivers, 2010). Surveys in the area done as part of the Yuba-Bear Hydroelectric Project and Drum-Spaulding Project documented favorable habitat characteristics but did not find Sierra Nevada yellow-legged frogs after 238 minutes of searching (NID and PG&E, 2010c). The species is critically endangered, with 92.5% of populations extinct as of 2005 (Vredenburg et al., 2007). Primary threats are introduced predators such as trout, and the lethal disease chytridiomycosis (Rachowicz et al., 2006). Sierra Nevada yellow-legged frogs rarely survive in lakes where trout were planted due to direct predation on the frogs and competition for resources (Finlay and Vredenburg, 2007). The Sierra Nevada yellow-legged frog is federally protected under the Endangered Species Act, and is listed as threatened by the California ESA, a Species of Special Concern by CDFW, a Sensitive Species by the USDA Forest Service, and IUCN endangered.

CALIFORNIA RED-LEGGED FROG (*Rana draytonii*)

California red-legged frogs (*Rana draytonii*) typically inhabit foothill streams with dense shrubby or emergent riparian vegetation. Adults forage, breed, and lay their eggs in still or slow-moving pools more than 2 feet deep that are shaded by low overhanging branches (e.g., willows) and concealed by emergent vegetation (e.g., cattails). Marshes and still-water ponds are occasionally used, and red-legged frogs may successfully breed in artificial water bodies without their preferred cryptic vegetation if introduced aquatic predators are absent (USFWS 2000). Breeding pools are often perennial, as they must remain inundated for a minimum of 11-20 weeks for tadpoles to complete larval development and metamorphose into adults. Well-vegetated terrestrial areas within the riparian corridor may provide important sheltering habitat during winter, and small mammal burrows and moist leaf litter in the riparian corridor provide refugia for summer aestivation (Jennings and Hayes 1994).

Historically, California red-legged frogs were abundant throughout California, however this species has been extirpated throughout 99% of the Sierra Nevada foothills (Jennings and Hayes, 1985; Tunstall and Fellers, 1999). Threats include non-native predators like bullfrogs and fish, habitat loss, pesticide pollution, and chytrid fungus (CaliforniaHerps, 2015). The species is listed as US ESA Threatened, a CDFW Species of Special Concern, and IUCN Vulnerable. While no occurrences of the California Red-legged Frog have recently been documented within the watershed, the species is known to have historically inhabited the area (BLM occurrence documented at 121°3′29.1″W 39°8′53.042″N). In the Bear watershed, California red-legged frogs were not observed during site assessments performed from 2007 to 2009 for NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project, including at Chicago Park Forebay, Dutch Flat Afterbay, and Rollins Reservoir (NID and PG&E, 2010f). However, the study results suggested that Chicago Park Forebay and Dutch Flat Afterbay contain suitable California red-legged frog breeding habitat, but that Rollins Reservoir does not (NID and PG&E, 2010f). Historically, California red-legged frogs have been recorded near the town of Dutch Flat in 1939 (0.42 miles from Dutch Flat Afterbay and 0.85 miles from Dutch Flat Forebay), however this population is likely not extant (NID and PG&E, 2010f).

WESTERN SPADEFOOT (*Scaphiopus hammondii*)

Western spadefoots (*Scaphiopus hammondii* or *Spea hammondii*) primarily inhabit grasslands below 3000 ft in elevation, but occasionally populate valley-foothill hardwood woodlands (CDFW, 2015b; NID and PG&E, 2011b). Eggs are laid in vernal pools, attached to underwater vegetation or detritus (CaliforniaHerps, 2015). The majority of the year adults are found in underground burrows which are self- or mammal-constructed (CDFW, 2015b). Breeding occurs exclusively in shallow temporary vernal pools, so sufficient rainfall is needed to form and maintain breeding ponds (CDFW, 2015b). Larvae are often found in turbid pools with little cover, and may alter the length of the tadpole stage to account for variation in pool duration or food availability (CaliforniaHerps, 2015; Lannoo, 2005). Desiccation of vernal pools can increase the risk of predation on larvae by California tiger salamander larvae, bullfrogs, garter snakes, raccoons, and ducks (CaliforniaHerps, 2015; Lannoo, 2005).

The western spadefoot has suffered from extensive habitat loss, and is currently listed as a

Species of Special Concern by the California Department of Fish and Wildlife, a Sensitive Species by the Bureau of Land Management, Near Threatened by the IUCN, and Vulnerable by the NatureServe Global and State Rankings. This species has not been observed within the Bear watershed, though suitable habitat within its range is found at the lower elevations of the watershed. Urban and agricultural development is the largest threat to *S. hammondii.* Current patterns of abundance have been altered by human activity, through destruction of natural habitat as well as addition of artificial pools as stock tanks in other areas in which toads will readily breed (Lannoo, 2005). Introduced fish like mosquitofish and green sunfish (*Lepomis cyanellus*) frequently prey upon western spadefoot toads when accidentally spread through flood or intentionally released into ephemeral ponds for mosquito control (Lannoo, 2005). Other introduced predators and competitors such as bullfrogs and fish cannot survive in ephemeral ponds, and are therefore not a conservation issue for the western spadefoot. The currently favored conservation action for the western spadefoot is maintaining balance between urban and agricultural development and undeveloped habitat (Lannoo, 2005). Protection of vernal pools can benefit other ephemeral pond breeders such as California tiger salamanders (*Ambystoma californiense*), Pacific chorus frogs (*Pseudacris regilla*), and western toads (*Bufo boreas*) (Lannoo, 2005).

III.B.2e. Special-status reptiles

GIANT GARTER SNAKE (*Thamnophis gigas*)

The giant garter snake inhabits sloughs, marshes, low-gradient streams, flooded rice fields, ponds, irrigation and drainage ditches, and adjacent upland habitats in California's Central Valley. This snake forages primarily at the interface between open water and emergent aquatic vegetation, and is most often found in habitats with slow flowing or standing water, permanent summer water, mud bottoms, earthen banks, and an abundance of prey such as small fish, frogs and tadpoles. Giant garter snakes use upland habitat with grassy or shrubby banks for basking and thermoregulation. They also use upland burrows and soil or rock crevices as nighttime refugia, daytime escape cover, and winter aestivation sites. Giant garter snakes typically emerge from winter retreats from late March to early April and can remain active through October. The timing of their annual activities is subject to varying seasonal weather conditions. Cool winter months are spent in dormancy or periods of reduced activity. While this species is strongly associated with aquatic habitats, individuals have been noted using burrows as far as 165 feet from marsh edges during the active season and retreats more than 800 feet from the edge of wetland habitats while overwintering.

The giant garter snake is listed as threatened under the California and federal Endangered Species Acts. Hydrological alteration has caused extensive loss of this species' wetland habitats by reducing valley floodplain width with levees, affecting downstream flow with Sierra dams, filling wetlands for residential and agricultural development, and diverting water for residential and agricultural use. The effects of water quality on giant garter snake health are also under investigation, particularly in regard to methylmercury, selenium, and cholinesterase-inhibiting insecticides such as diazinon and chlorpyriphos (Hansen *et al*., 2011). Introduced predators such as bass and invasive bullfrogs are known to reduce the survival rates of young giant garter snakes. Concerns have also been raised about the potential impacts of two recently introduced water snakes (*Nerodia fasciata* and *Nerodia sipedon*) that are reproducing in the Folsom and Roseville areas (Balfour and Stitt, 2002; Stitt *et al*., 2005; Balfour *et al*., 2007; CDFW, 2016d, CDFW, 2016e).

Giant garter snakes was observed in the Bear River Watershed and documented by researchers in 1986, northeast of Rio Oso, east of Highway 70, south of the mainstem Bear River (CNDDB 2015). Survey effort in this watershed has been limited in recent years, so it is unknown whether the species currently persists here.

WESTERN POND TURTLE (*Actinemys marmorata*)

Western pond turtles (*Actinemys marmorata*) are highly aquatic, often associating with permanent ponds, lakes, streams, irrigation ditches, or marshes along intermittent streams below an elevation of 6,000 ft (CDFW, 2015b; NID and PG&E, 2010d). Shallower areas with warmer water and basking substrates such as logs, rocks, cattail mats, and exposed banks are preferred habitat (CaliforniaHerps, 2015). Individuals are rare in high-gradient streams reservoirs and deep lakes, often due to a lack of basking habitat (NID and PG&E, 2010d). During summer droughts, turtles will travel to find isolated pools in creeks or into woodlands to bury themselves in loose soil, or estivate by burying themselves in soft bottom mud (CaliforniaHerps, 2015). Riparian forests are critical habitat for this species, as they serve as nesting grounds (River Partners, 2011). Requirements for nesting habitats include compacted soils of clay or loam, herbaceous cover or leaf litter, canopy cover of <10%, a southern aspect, and slope of 2-15 degrees (NID and PG&E, 2010d).

The western pond turtle is believed to be in decline in 75-80% of its range (River Partners, 2011). Hunting of pond turtles for their meat in the late 19th and 20th centuries greatly contributed to this decline (CaliforniaHerps, 2015). Present day threats include predation from the American bullfrog (*Lithobates catesbeianus*) and competition for basking sites with bullfrogs and the introduced red-eared slider (NID and PG&E, 2010d). Adequate basking habitat is therefore crucial in restoration efforts, especially considering that western pond turtles can become aggressive and enter physical combat in competing for preferred basking spots (CDFW, 2015b). The species is currently listed as a California Department of

Fish and Wildlife species of Special Concern, a BLM Sensitive Species, and USDA Forest Service Sensitive Species. Several western pond turtles, as well as suitable habitat for them, have been found at several sites along the Bear River. Turtles have been observed in the Dry Creek Restoration Area at Beale Lake, downstream of Dutch Flat, downstream of the Chicago Park Powerhouse, and downstream of the Bear River Canal Diversion (River Partners, 2011; NID and PG&E, 2010d). Suitable pools, basking habitat, and nesting habitat have been found at these sites as well as below the Bear Valley Meadow. The area below Drum was determined to have suitable pools and basking habitat, but not appropriate nesting sites (NID and PG&E, 2010d).

COAST HORNED LIZARD (*Phrynosoma blainvillii*)

The coast horned lizard, also referred to as Blainville's horned lizard and California horned lizard, inhabits open habitats such as grassland, oak savannah, and chaparral. These lizards also occupy natural openings in denser habitats, such as burned or windblown patches of hardwood or conifer forests, and scoured patches of riparian woodland and scrub. Ants are the primary food source for coast horned lizards, although this species will also prey on small beetles and other insects. These ectotherms escape extreme temperatures by burrowing into loose, sandy soils; utilizing small mammal burrows; and excavating depressions under rocks and logs. The elevation range of the coast horned lizard extends up to 4,000 ft in the Sierra Nevada foothills (Zeiner *et al.*, 1988).

The coast horned lizard is listed by CDFW as a California Species of Special Concern, and is classified as Sensitive by the BLM. Habitat loss and fragmentation is the primary threat to this species, as residential development increases and agricultural lands previously used for livestock grazing are converted to croplands such as vineyards that are less compatible with the habitat needs of this species. Predation by domestic and feral cats further extends the effects of residential development beyond the housing footprint. Pesticides and invasive species also play roles in the decline of coast horned lizards, as their native insect prey base is reduced by chemical use and the invasion of Argentine ants.

Coast horned lizards have been documented at several sites throughout the Bear River Watershed (CNDDB 2015). Additional surveys are needed to determine this species' full distribution within the region.

III.B.2f. Special-status birds

The Bear River Watershed provides vital habitat for nesting, wintering, and/or migratory stop-over sites for over 200 bird species, including 47 species of special conservation concern (CNDDB, 2015; eBird, 2016). These special-status species are listed by the California Endangered Species Act (CESA), US Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), US Forest Service (USFS), Bureau of Land Management (BLM), and/or California Department of Forestry (CDF) as endangered (E), threatened (T), fully protected (FP), species of special concern (SSC), bird of conservation concern (BCC), sensitive (S), or watch list (WL). Except for where noted, all species described below have been observed and publicly documented within the Bear River Watershed by the CNDDB (2015) or a subset of curated experts at eBird (2016).

Flow, bank and floodplain dynamics are particularly significant for several of these species, which are associated with wetlands and riparian areas. Bank swallows (*Riparia riparia*, CESA:T, BLM:S) nest colonially on tall, sheer riverbanks with recent scour and friable soils in which to burrow for nesting. California black rails (*Laterallus jamaicensis coturniculus*, CESA:T, CDFW:FP, USFWS:BCC, BLM:S) nest and forage at foothill elevations in shallow marshes and wet meadows characterized by fine-stemmed vegetation such as rushes and sedges. Yellow warblers (*Setophaga petechia*, CDFW:SSC, USFWS:BCC), yellow-breasted chats (*Icteria virens*, CDFW:SSC), and song sparrows (*Melospiza melodia*, low-elevation "Modesto" population is CDFW:SSC) are special-status songbirds which nest and forage in riparian shrubs. White-faced ibis (*Plegadis chihi,* CDFW:WL) probe the mud for invertebrates in a variety of wetlands and flooded rice fields in the watershed's lower elevations. Tricolored blackbirds (*Agelaius tricolor*, CDFW:SSC, USFWS:BCC, BLM:S) nest in dense colonies in a variety of habitats, including freshwater cattail marsh, riparian scrub, and other vegetation that provides dense cover for protection from predators; they forage for insects in these wetlands as well as nearby grasslands and agricultural fields.

American white pelicans (*Pelecanus erythrorhynchos*, CDFW:SSC) and double-crested cormorants (*Phalacrocorax auritus,* CDFW:WL) forage for fish in the watershed's lakes. Migrating special-status ducks such as redhead (*Aythya americana*, CDFW:SSC) and the occasional Barrow's goldeneye (*Bucephala islandica*, CDFW:SSC) have also been observed passing through the watershed and feeding in its wetlands.

The diversity of habitats in the Bear River Watershed support an extraordinary diversity of special-status raptors. Northern goshawks (*Accipiter gentilis*, CDFW:SSC, USFS:S, BLM:S, CDF:S) nest and hunt in the coniferous forests of the upper watershed, while sharp-shinned and Cooper's hawks (*Accipiter striatus*, CDFW:WL; *Accipiter cooperii*, CDFW:WL) are seen nesting and hunting in a variety of elevations and wooded habitats including riparian woodlands, oak woodlands, coniferous forests, and suburban areas. Golden eagles (*Aquila chrysaetos*, CDFW:FP &WL, USFWS:BCC, BLM:S, CDF:S) and American peregrine falcons (*Falco peregrines anatum*, CDFW:FP, USFWS:BCC, CDF:S) have been observed hunting in the canyons and meadows of the middle and upper portions of the watershed during the spring breeding season, and may nest on secluded cliffs there. These two species have also been seen hunting low-elevation sites in the winter season, along with wintering ferruginous hawks (*Buteo regalis*, CDFW:WL, USFWS:BCC). Swainson's hawks (*Buteo swainsonii*, CESA:T, USFWS:BCC, BLM:S) have been documented nesting in riparian trees of the lower watershed and hunting over open grasslands and agricultural fields, along with white-tailed kites (*Elanus leucurus*, CDFW:FP, BLM:S), which additionally inhabit the middle watershed's oak woodlands. Northern harriers (*Circus cyaneus*, CDFW:SSC) hunt in low-elevation marshes and grasslands, and nest in secluded locations on the ground. Bald eagles (*Haliaeetus leucocephalus*, CESA:E, CDFW:FP, USFWS:BCC, USFS:S, BLM:S, CDF:S) and osprey (*Pandion haliaetus*, CDFW:WL, CDF:S) catch fish in the Bear River and lakes and nest in large trees. Merlin (*Falco columbarius*, CDFW:WL) hunt and nest in a variety of open and wooded habitats in the Bear Watershed.

Nesting long-eared owls (*Asio otus*, CDFW:SSC) have been documented in the watershed, and short-eared owls (*Asio flammeus*, CDFW:SSC) may visit low-elevation grasslands and wetlands in winter. The Bear Watershed also provides potential nesting and foraging habitat for California spotted owls (*Strix occidentalis occidentalis*, CDFW:SSC, USFWS:BCC, USFS:S, BLM:S), burrowing owls (*Athene cunicularia*, CDFW:SSC, USFWS:BCC, BLM:S), flammulated owls (*Otus flammeolus*, USFWS:BCC), and great gray owls (*Strix nebulosa*, CESA:E, USFS:S, CDF:S), although documentation is not available for these species because owl survey effort in the watershed has been limited, and location information for these owls is protected due to the sensitivity of these species.

Special-status woodpeckers known to inhabit the Bear Watershed include the oak woodland-associated Lewis' woodpecker (*Melanerpes lewis*, USFWS:BCC) and Nuttall's woodpecker (*Picoides nuttallii*, USFWS:BCC), the coniferous forest-associated white-headed woodpecker (*Picoides albolarvatus*, USFWS:BCC), and the primarily burned forest-associated black-backed woodpecker (*Picoides arcticus*, USFS:S). These excavators create nest cavities that are depended upon by flammulated owls and special-status songbirds including oak titmouse (*Baeolophus inornatus*, USFWS:BCC). An additional special-status, cavity-nesting songbird, the purple martin (*Progne subis*, CDFW:SSC), may also occur in the Bear Watershed's lower elevations, although this species has not been documented.

Shrub- and tree-nesting songbirds of special conservation concern in the Bear Watershed's upland habitats include the low-elevation loggerhead shrike (*Lanius ludovicianus*, CDFW:SSC, USFWS:BCC), Lawrence's goldfinch (*Spinus lawrencei*, USFWS:BCC) and black-chinned sparrow (*Spizella atrogularis*, USFWS:BCC); and the high-elevation olive-sided flycatcher (*Contopus cooperi*, CDFW:SSC, USFWS:BCC). Ground-nesting songbirds of special conservation concern in the Bear Watershed include the low-elevation grasshopper sparrows (*Ammodramus savannarum*, CDFW:SSC) and California horned larks (*Eremophila alpestris actia*, CDFW:WL). Although not technically a songbird, the iconic yellow-billed magpie (*Pica nuttalli*, USFWS:BCC) also nests and forages in the watershed's valley foothill riparian areas, oak woodlands and agricultural fields.

Willow flycatchers (*Empidonax traillii*, CESA:E, USFWS:BCC, USFS:S) have been reported to pass through the Bear Watershed on their migration between mountain meadow nest sites such as the nearby Perazzo Meadows and their winter haunts in Latin America. Greater sandhill cranes (*Grus canadensis tabida*, CESA:T, CDFW:FP, USFS:S, BLM:S) are frequently heard calling over the watershed while migrating between their Central Valley wintering grounds in wetlands and flooded agricultural fields, and their spring breeding grounds in montane meadows north of the Bear Watershed, such as Perazzo Meadows, the Sierra Valley, and the Modoc Plateau. Rufous hummingbirds (*Selasphorus rufus*, USFWS:BCC) are vital pollinators for Bear Watershed flowers as they fly through the watershed during their biannual neotropical migrations. Although not documented, there is potential for insectivorous Vaux's swifts (*Chaetura vauxi*, CDFW:SSC) and black swifts (*Cypseloides niger*, CDFW:SSC, USFWS:BCC) to migrate through the watershed, but habitat conditions are not likely to support nesting colonies of this species.

III.B.2g. Special-status mammals

SIERRA NEVADA RED FOX (*Vulpes vulpes necator*)

The Sierra Nevada red fox is genetically distinct from other red fox species in the region, including the population in the Sacramento Valley. As the only red fox that occurs in high mountain habitats, the Sierra Nevada red fox is found mostly above 2200 m in elevation (range is 1200 - 3700 m) (Sierra Nevada Red Fox Interagency Working Group, 2010; CDFW, 2015). Recent genetic studies have found Sierra Nevada red fox in California, southern Oregon, and western Nevada (Sierra Nevada Red Fox Interagency Working Group, 2010). They live in a range of habitats, including alpine dwarf-shrub, wet meadow, subalpine conifer lodgepole pine forests, red fir, aspen, montane chaparral, montane riparian, mixed conifer, ponderosa pine, and alpine fell-fields (CDFW, 2015; NatureServe 2015). Foxes use rock outcrops, hollow logs, and burrows in loose soil for dens, and hunt in meadows, fell-fields, grasslands, wetlands, and other open habitats (CDFW, 2015). Edge habitat is used extensively (CDFW, 2015).

Recently, populations of the Sierra Nevada red fox have been in decline. Two known populations inhabit the Lassen Peak region and an area near Sonora Pass, and the total population is predicted to be in the hundreds at most (NatureServe, 2015). According to the NatureServe database, the species has been documented in the Upper Bear watershed, however no confirmed recent records exist outside of Lassen Peak and Sonora Pass despite surveys using baited camera traps. Threats to the Sierra Nevada red fox are poorly understood, but could involve a variety of factors. Potential threats include the trapping that occurred prior to the 1974 California prohibition, habitat destruction, domestic dog-mediated disease, competition with coyotes, interbreeding with non-native red foxes, roadkill, or excessive livestock grazing which reduce prey populations (NatureServe, 2015; Sierra Nevada Red Fox Interagency Working Group 2010; CDFW, 2015).

RINGTAIL (*Bassariscus astutus*)

The ringtail (*Bassariscus astutus*) is fully protected under the California Department of Fish and Wildlife. Ringtails are found throughout much of California, occurring in riparian habitats and brush stands of forest and shrub habitats at low to middle elevations. They are particularly well adapted to rough, broken terrain, with naked soles of feet for increased traction on smooth surfaces. The relative abundance between habitats has not been investigated. Important habitat features include hollow trees, logs, snags, rock recesses, abandoned burrows, wootrat nests, and cavities for cover and/or nesting (CDFG, 2005). Ringtails will change dens often (NatureServe, 2015). The species is nocturnal, and not often found more than 1 km from permanent water. The ringtail is a primarily carnivorous mammal, feeding mostly on rodents (woodrats and mice) and rabbits, but may also eat birds, eggs, reptiles, invertebrates, fruits, nuts, and carrion. Bobcats, raccoons, foxes, and large owls may prey upon ringtails (CDFG, 2005).

Range maps indicate that ringtail may occur in the watershed (Patterson et al., 2003); however, its presence is unconfirmed. The NatureServe database (2015) suggests that ringtails may be extirpated/possibly extirpated from the upper bear watershed. In some areas it may be harvested for fur. The species may benefit from regulation of grazing and wood cutting to protect habitat (NatureServe, 2015).

SIERRA MARTEN (*Martes caurina sierrae*)

This subspecies of marten lives in the southern Cascades and Sierra Nevada, with an estimated population size of 2500-100,000 individuals (NatureServe, 2015). Optimal habitat is mixed evergreen forest with 40% crown closure, including red fir, lodgepole pine, subalpine conifer, mixed conifer, Jeffery pine, and eastside pine (CDFW, 2015). At elevations below 2,050 m, martens exhibit a strong preference for riparian lodgepole associations over brush, mixed conifer, and Jeffery pine (NatureServe, 2015). They forage along water edges and in trees, snags, logs, and rock areas. Large trees, snags, stumps, burrows, and crevices are important cover features for denning. Travel tends to occur along ridgetops with sufficient canopy cover, and habitat with limited human use is preferred (CDFW, 2015).

NatureServe lists the Sierra Marten as vulnerable, due to declines in distribution and abundance within recent decades. Timber harvest, human development, habitat loss and degradation, and fragmentation are among current threats (NatureServe, 2015). Management recommendations include leaving slash during timber cutting, using small clearcuts when necessary, and leaving refugia linked by corridors of mature forest with woody debris (Buskirk and Zielinski, 1997). Large patches of reproductive habitat in both riparian and fir-dominated stands should be retained, and diverse tree structure, snags, and downed woody material should be preserved (Moriarty *et al*., 2011). The Sierra Marten has been found in Nevada and Placer counties (NatureServe, 2015).

FISHER (*Pekania pennanti*)

The USFWS has defined fishers found on the west coast as a distinct population segment, within an area including the Cascade Mountains and areas west of the Cascades in Washington and Oregon, and in California from Mendocino County north to Oregon, east across the Klamath Mountains and down through the Sierra Nevada. The fisher is an uncommon permanent resident of the Sierra Nevada, and a current estimate of population size ranges from 100-600 (NatureServe, 2015). While it historically inhabited the northern Sierra Nevada, the only currently known populations are in the southern Sierra, besides one detection in 1995 in Plumas County (NatureServe, 2015).

Fishers occur in intermediate to large-tree coniferous forests and deciduous-riparian habitats. They require a high percent of canopy closure (>50%), and use protected cavities, brush piles, logs, and rock areas for dens and protection (CDFW, 2015). Fishers generally avoid areas of significant human disturbance, preferring large areas of contiguous forests. Significant reductions in range may be attributed to human trapping for furs and lethal predator control programs that occurred for nearly two centuries. While this threat is currently reduced due to trapping closures and other management methods that have been in place for several decades, other significant threats include the loss and fragmentation of suitable habitat and loss of important structural elements within forests due to timber harvest and fuels reduction treatments (NatureServe, 2015). The fisher is currently ranked by NatureServe as imperiled, and is a proposed threatened species under the U.S. Endangered Species Act.

The USFWS recently completed a 5-year action plan from 2010-2015 for the West Coast Distinct Population Segment of the fisher, in which conservation strategies, systematic surveys and monitoring, research in recovery, and augmenting existing populations should have occurred (NatureServe, 2015). Recommended protection needs include minimizing forest fragmentation, maintenance of forest floor structural diversity, protection of forested wetlands, and preserving large snags.

MOUNTAIN BEAVER (*Aplodontia rufa*)

Mountain beavers, also referred to as sewellels and distinct from the more familiar American beaver (*Castor canadensis*), are a rodent found from southwestern British Columbia to central California (Fellers *et al*., 2008). Habitat preferences include dense montaine riparian areas in the Sierra Nevada, with deep friable soils for burrowing. Dense understory is required for cover, and access to water is crucial as these animals need 22% of body weight in water per day (CDFW, 2015). Mountain beavers feed on vegetative parts of thimbleberry, salmonberry, blackberry, dogwood, ferns, lupines, willows, and grasses. Distribution is often scattered, and home ranges are small (ranging from 400-2000 m^2). Densities of mountain beaver increase in logged or disturbed areas compared to forest stands (CDFW, 2015).

There has been one recorded sighting of a mountain beaver within the Bear River watershed, dating back to 1912 (within a 5 mile radius of Blue Canyon in the upper watershed; Figure 22). Since, their presence has not been recorded within the watershed. Despite a low rate of reproduction, current global populations of the species are stable and do not experience severe fragmentation (Fellers *et al*., 2008). The IUCN lists *Aplodontia rufa* as a species of least concern. The species is considered a pest throughout much of its range due to its potential to cause damage to Douglas-fir (*Pseudotsuga mensiesii*), lodgepole pine (*Pinus contorta*), and ponderosa pine (*Pinus ponderosa*) at all stages of stand growth (Conover *et al*., 1995). The resulting tree death, reduced growth, or deformity of trees from mountain beaver feeding injuries can cause significant reductions in the success of reforestation efforts (Conover *et al*., 1995). Therefore, special consideration should be given to planned restoration and reforestation projects should future sightings of the mountain beaver occur.

SIERRA NEVADA SNOWSHOE HARE *(Lepus americanus tahoensis)*

Sierra Nevada snowshoe hares primarily inhabit montane riparian habitats with thickets of aspen (*Populus tremuloides*), alders (*Alnus* spp.) and willow (*Salix* spp.), as well as in dense stands of young conifers and patches of chaparral composed of *Ceanothus* and Manzanita (*Arctostaphylos* spp). Although any montane shrub habitat may be used by this species, they are more strongly associated with mesic sites near meadows and streams, rather than ridgetops or dry south-facing slopes. In the summer, snowshoe hares feed on a variety of forbs, ferns, grasses, and sedges. In the winter when this herbaceous vegetation is less available, their diet changes to the bark and small branches of evergreen shrubs, young conifers, and deciduous trees. Snowshoe hares are most active at night and in the early morning, moving via runways to reach feeding areas under protective cover. During the day, they rest in hiding under dense thickets of willows or evergreen shrubs, as well as under logs and in areas where young fir branches droop to the ground. The elevation range of this species extends primarily from 4,800-7,000 ft (Collins, 1998; Timossi *et al*., 1995).

This species is vulnerable to the loss and degradation of riparian habitat due to logging activities, grazing, fire suppression and wildland fuels reduction treatments, residential and recreational development, and other activities that remove or alter protective areas of brushy cover within the species' range. As shrubs provide an essential winter food supply, year-round cover and protection from predators, the conservation of brushy montane habitats and the hydrological restoration of alder/willow riparian habitats are essential to the preservation of the Sierra Nevada snowshoe hare (Collins, 1998).

Sierra Nevada snowshoe hares have been documented near the Bear River Watershed in the Yuba Gap/Cisco Grove area (Collins 1998), and may occur in suitable riparian, aspen, montane chaparral, and early-seral conifer habitats in the higher-elevation portions of the Bear River Watershed.

AMERICAN BADGER (*Taxidea taxus*)

American badgers are uncommon, permanent residents found throughout most of the state, although they have decreased substantially in abundance since historic times (Zeiner *et al*., 1990). Badgers are most abundant in drier open areas of shrub, forest, and herbaceous habitats, but can be found anywhere with friable soils and a suitable prey base. These carnivores are members of the weasel family, and prey primarily upon fossorial rodents such as ground squirrels and pocket gophers, which they capture by digging up their burrows. Badgers are also known to prey on other small mammals, reptiles, birds, eggs, insects, and carrion. Although badgers spend much of their time in underground dens, they forage throughout large home ranges, typically between 350 and 1550 acres in size per individual (Zeiner *et al*., 1990). American badgers are active year-round, though they tend to have smaller home ranges in winter than in other seasons. The American badger is listed by CDFW as a California Species of Special Concern.

SPECIAL-STATUS BATS

Four bat species with potential to occur in the Bear River Watershed are of particular conservation concern: Townsend's big-eared bat (*Corynorhinus townsendii*), pallid bat (*Antrozous pallidus*), western red bat (*Lasiurus blossevillii*), and western mastiff bat (*Eumops perotis californicus*). These species forage for flying insects above a variety of habitats including grasslands, woodlands, agricultural fields, marshes, open water, and urban areas, although each is most commonly found in a narrower range of preferred habitats. Townsend's big-eared bats and western red bats are more closely associated with mesic sites such as riparian woodlands, coniferous forests, oak woodlands, and occasionally orchards, especially near water. Townsend's big-eared bats occasionally roost in small groups (less than 100 individuals) in human-made structures such as mine shafts and bridges, but where suitable caves are available they roost in cave colonies of over 1,000 individuals. Western red bats, on the other hand, roost as solitary individuals and in single family groups, almost exclusively in trees, though occasionally in shrubs. Pallid bats and western mastiff bats forage primarily above dry, open habitats such as grasslands and chaparral. For winter roosting (hibernacula) and maternity roosts, pallid bats and western mastiff bats form small colonies of less than 100 individuals in large snags, mature trees, caves, mine shafts, rock crevices, and occasionally buildings and bridges (Bat Conservation International, 2008; Zeiner *et al*., 1990).

Although these special-status bats have not yet been documented in the Bear River Watershed, bats that nest in small colonies are typically under-reported in databases such as the CNDDB, due to their nocturnal nature and the relatively sparse research and monitoring of these species. Threats include destruction and disturbance of roosting sites (including trees and snags), loss and degradation of foraging habitat, bioaccumulation of toxins through their insect prey, and reduction in the quantity and quality of their prey base due to the use of pesticides. Bats exhibit high site fidelity and will not abandon an established roosting area unless disturbed, but disturbance can result in significant mortality and loss of reproductive potential. All four of these special-status species are listed by CDFW as California Species of Special Concern and as High-priority by the Western Bat Working Group. Townsend's big-eared bats are also listed as Candidate species for Threatened listing under the California Endangered Species Act. Pallid bats, western mastiff bats and Townsend's big-eared bats are also listed as Sensitive species by BLM, and the latter two species are listed as Sensitive by USFS.

III.B.3. Common terrestrial wildlife species

III.B.3a. Amphibians

Species-specific information for all amphibian species likely to occur in the Bear River Watershed are included below due to the multitude of challenges facing local and global amphibian species including: the growing impacts of the chytrid fungus, short-term drought and long-term climate change, altered hydrology and fire regimes, invasive species, air and water pollution, and development on local amphibian population dynamics, the great potential for riparian and other wetland restoration efforts to benefit amphibians, and the feasibility of addressing the relatively small number of species in this taxonomic class.

LONG-TOED SALAMANDER (*Ambystoma macrodactylum*)

The range of the long-toed salamander (*Ambystoma macrodactylum*) covers elevations from sea level to 9180 feet. Adults are subterranean for most of the year, utilizing mammal burrows or man-made structures (CDFW, 2015b). Breeding occurs in temporary ponds, and eggs are laid in clusters of 8-10 on the underside of logs and bark slabs in a variety of habitats, including seeps, backwaters of slow-flowing streams, temporary pools, and permanent lakes and ponds (CDFW, 2015b; Lannoo, 2005). Larvae prefer water less than 30 cm deep, and use vegetation and bottom debris for cover from predation by diving beetles, odonates, salmonid fish, introduced goldfish, other salamanders, bullfrogs, and garter snakes (CDFW, 2015b; Hamilton et al., 1998).

While *A. macrodactylum* has not been recently documented within the Bear watershed, range maps from the California Department of Fish and Wildlife indicate that they may occur in the very Eastern section of the watershed (CDFW, 2015b). Salamanders may suffer from local or regional threats, including habitat alteration from logging activities, loss of wetlands, predation from introduced fish, and chemical contaminants (Lannoo, 2005). However, these threats do not appear to be driving species-wide declines. The total population of long-toed salamanders is relatively stable, likely exceeding 10,000 individuals (IUCN Red List, 2015), though existing populations are restricted in pockets of fragile habitat (CDFW, 2015b). Restoring and protecting wetland habitat for the long-toed salamander is likely to aid other local amphibian species which coinhabit areas where *A. macrodactylum* is found, including California slender salamanders (*Batrachoseps attenuatus*), Pacific treefrogs (*Hyla regilla*), and western toads (*Bufo boreas*) (Lannoo, 2005). Restoration efforts should include addition of woody debris and cover objects to increase larval survival, as the diverse diets of feeding larvae often drive larvae into the open water column (Lannoo, 2005). Removal of introduced fish and bullfrogs may further relieve predation pressure and increase survival to adulthood.

CALIFORNIA NEWT (*Taricha torosa*)

The California newt (*Taricha torosa*) is terrestrial in the adult stage, seeking cover under surface objects or in mammal burrows and other structures. Breeding is aquatic, occurring in shallow pools of water found in intermittent streams, rivers, permanent or semi-permanent ponds, lakes, and reservoirs. Eggs are laid on submerged sections of emergent vegetation and under rocks (CDFW, 2015b). Eggs, larvae, and adults have few predators due to secretion of a potent skin toxin (tetrodotoxin); however, conspecific predation of eggs and larvae has been noted in the species (CDFW, 2015b; Lannoo, 2005). Introduced species such as bullfrogs (*Rana catesbeiana*), crayfish, and mosquitofish may prey on egg masses and larvae (Lannoo, 2005).

The California newt is likely to occupy a large portion of the Bear watershed, and has been confirmed at the Spenceville Wildlife Area (Friends of Spenceville, 2015; CDFW, 2015b). The IUCN Red List suggests that the species is found commonly throughout most of its range, excluding southern California where it is a California Department of Fish and Game Species of Special Concern (IUCN Red List, 2015). Newt populations are impacted by introduced predators, embryonic mortality from solar UV-B, and road mortality during breeding migrations (Lannoo, 2005; IUCN Red List, 2015). Newts display homing behavior, returning to the same breeding site each year to reproduce (CaliforniaHerps, 2015; Lannoo, 2005); therefore, continuing loss of breeding habitat may also negatively impact this species.

ENSATINA (*Ensatina eschscholtzii*)

Ensatinas are part of a complex with a ring-like distribution of seven subspecies around California's Central Valley (Lannoo, 2005). As a plethodontid (lungless) species, adults quickly dehydrate and therefore prefer moist, but not saturated, soils beneath surface objects like logs and rocks (CDFW, 2015b; Lannoo, 2005). *E. eschscholzii* is commonly found in edge habitats and flatter or gently sloped shelves above flood level (Stebbins, 1951). Ensatinas exhibit an elaborate courtship ritual and afterwards an average of 9-16 eggs are laid in dark moist habitat such as under logs or bark and inside animal burrows (CDFW, 2015b; Stebbins, 1951). The nest is guarded by the female until hatching, and the tiny terrestrial hatchlings leave the nesting site with the first saturating fall rains (CaliforniaHerps, 2015). Predators of ensatinas include Pacific giant salamanders, red-legged frogs, garter snakes, Steller's jays, and raccoons (CDFW, 2015b; Lannoo, 2005).

Ensatinas are found in elevations ranging from sea level to over 10,000 ft, and are generally common where present (CDFW, 2015b; Parks, 1999). The California Department of Fish and Wildlife range map suggests that the subspecies *Ensatina eschscholzii platensis* (Sierra Nevada Ensatina) should be found throughout the majority of the Bear watershed, however recently confirmed presence is currently lacking (CDFW, 2015b). The main threat to this species is habitat destruction through logging practices which remove downed wood that is needed for cover and nesting sites (Parks, 1999).

CALIFORNIA SLENDER SALAMANDER (*Batrachoseps attenuatus*)

The California slender salamander (*Batrachoseps attenuatus*) is a semi-fossorial species. From fall to spring, *B. attenuatus* seeks moist substrates such as decaying logs, leaf litter, bark, and flat stones, and when these substrates desiccate in late spring individuals shift microhabitat use to rodent burrows or termite tunnels (CDFW, 2015b). Reproduction occurs very early for a plethodontid salamander, with egg laying occurring in October and November (CDFW, 2015b; CaliforniaHerps, 2015). Females deposit eggs in moist areas underground or beneath cover objects, and may lay eggs communally with conspecifics (CaliforniaHerps, 2015). Predicted predators consist of small snakes, predatory arthropods, diurnal birds, and small mammals, and competitors may include juvenile Ensatina (*Ensatina eschscholzii*) where ranges overlap (CDFW, 2015b).

The California slender salamander is abundant throughout its range, which extends throughout much of the watershed, and is found up to 4600 ft (CDFW, 2015b). Like Ensatina, *B. attenuatus* is 10 times more abundant in old-growth forest compared to recently logged forest (Romansic, 1999), and would thus benefit from management of habitat rich in downed wood. However, despite development of habitat within the slender salamander's historical range, this species appears tolerant of moderate human activity and continues to be abundant in urban or suburban edge settings (Lannoo, 2005; Romansic, 1999).

MOUNT LYELL SALAMANDER (*Hydromantes platycephalus*)

The Mount Lyell salamander (*Hydromantes platycephalus*) is a terrestrial species endemic to California found at elevations over 4,000 ft (CaliforniaHerps, 2015). Activity is dependent on water availability from seeps, springs, drips, or spray (NID and PG&E, 2011b). Adults are commonly found in open areas down slope from melting snowfields beneath wet rocks, on bare earth, or within wet crevices and fissures (Stebbins, 1951). At low elevations they may be found at stream edges beneath rocks. Little is known about the salamander's breeding behavior, but it is thought to breed in wet limestone talus or other moist subterranean cavities (Lannoo, 2005).

The Mount Lyell salamander has not been directly observed in the Bear watershed;

however, multiple habitats were deemed suitable in a special-status wildlife assessment conducted for the relicensing process for the Yuba-Bear, Drum-Spaulding, and Rollins Transmission Line projects. Favorable habitat was found around the Chicago Park Powerhouse and Park, Rollins Reservoir and Powerhouse, Bear River Canal, and Dutch Flat Conduit, Forebay, Powerhouse, and Afterbay (NID and PG&E, 2011b). *H. platycephalus* is protected as a species of Special Concern by the California Department of Fish and Game. Few studies have been done on population dynamics and abundances; however, populations are believed to be secure and in good condition throughout the salamander's range (Lannoo, 2005).

WESTERN TOAD (*Bufo boreas*)

The western toad (*Bufo boreas* or *Anaxyrus boreas*) is split into two species recognized in California: the California toad (*Anaxyrus boreas halophilus*) and the boreal toad (*Anaxyrus boreas boreas*) (CaliforniaHerps, 2015). *A. boreas halophilus* is widespread throughout the majority of California, including the central and southern Sierra. Adults utilize a variety of habitats such as marshes, springs, creeks, small lakes, meadows, woodlands, and forests (CaliforniaHerps, 2015). During spring and early summer, toads bask on the water's edge, but during cold weather retreat to terrestrial burrows (Muths and Corn, 1997; CaliforniaHerps, 2015). Breeding is aquatic and synchronous, and egg-laying normally occurs in quiet waters less than 30cm in depth (CDFW, 2015b). Any form of standing water is often appropriate, including lakes, ponds, vernal pools, roadside ditches, irrigation canals, streams and rivers. Tadpoles tend to be numerous and form dense aggregations, and larval survival is highest in pools without fish (CDFW, 2015b). Adult western toads are preyed upon by snakes, coyotes, raccoons, birds, and badgers (Lannoo, 2005).

The western toad has experienced declines in the Rocky Mountains and is considered endangered in certain states due to habitat loss and chemical contamination of wetlands (Lannoo, 2005; IUCN red list; CaliforniaHerps, 2015). Other threats include prolonged drought, diseases such as chytrid, climate change, and increased UV-B exposure (Garcia, 1999). The pattern of decline seen in Rocky Mountain populations has not been seen in California, where western toads remain abundant. Along the Bear River, presence has been documented at the Spenceville Wildlife Area (Friends of Spenceville, 2015). Home ranges can be large, as individuals can be found 1000m from breeding sites; therefore large connected areas of habitat would be most beneficial to sustain populations of this species (CDFW, 2015b). The western toad shares habitat with spadefoot toads (*Spea* spp.), Pacific treefrogs (*Pseudacris regilla*), and *Rana* spp., so protecting *B. boreas* habitat will likely benefit multiple species (Lannoo, 2005).

PACIFIC CHORUS FROG (*Pseudacris regilla*)

The Pacific chorus frog within the region is sometimes referred to as the Sierra chorus frog (*Pseudacris sierra*), after debates over splitting *P. regilla* into three species (*P. sierra*, *P. hypochondriaca,* and *P. regilla*). The Pacific chorus frog is chiefly a ground-dweller, preferring habitats that are always moist, with clumps of vegetation and surface objects for daytime cover (CDFW, 2015b). The species inhabits a variety of areas, including grassland, chaparral, woodland, forest, permanent and seasonal ponds, marshes, lakes, reservoirs, and slow streams (NID and PG&E, 2011b). Temporary fishless shallow pools with submerged and emergent vegetation are favored for breeding and egg-laying (CaliforniaHerps, 2015; CDFW, 2015b). After breeding, frogs will move to cool, moist retreats to overwinter or aestivate (Lannoo, 2005).

This species is the most common amphibian in California and is found throughout the region and watershed. Sightings have recently been confirmed at the Chicago Park Conduit and Spenceville Wildlife Area (NID and PG&E, 2011b; Friends of Spenceville, 2015). Pacific chorus frogs are probably as common today as they were historically, though their tadpoles are preyed upon by introduced species such as sunfishes, mosquitofish, and bullfrogs (CDFW, 2015b). Tadpoles are also extremely sensitive to nitrites, with substantial mortality occurring at concentrations recommended by the EPA for drinking water; therefore, nitrogen compounds from agricultural runoff could cause larval harm (Schuytema and Nebeker, 1999a,b). Individuals may be carriers of chytrid fungus, but do not experience lethal effects themselves. Populations of pacific chorus frogs are robust; therefore, they do not have listed status and are not the target of conservation actions. Protection and restoration of their habitat, however, may benefit associated species such as long-toed salamanders (*Ambystoma macrodactylum*), western toads (*Bufo boreas*), mountain yellow-legged frogs, and spadefoot toads (*Spea hammondii*).

III.B.3b. Reptiles

Comprehensive reptile surveys have not been completed for the Bear River Watershed. Table 17 lists the reptile species that are likely to occur in the watershed, many but not all of which have been observed and documented. This table is based initially on the CWHR (California Wildlife Habitat Relationships) models created by CDFW. These models were applied to the Bear River Watershed by Shilling and Girvetz (2003). Table 17 has been further curated by this 2016 report's authors to:

- add species that were not included by the CWHR models but that have been recently documented within and/or adjacent to the watershed (e.g., giant garter snake; CNDDB, 2015);

- omit species for which recently updated geographic range information no longer approaches the Bear Watershed (e.g., long-nosed snake; CDFW, 2015b); and
- update recently changed scientific names of several species that have undergone recent taxonomic review by the scientific community.

Table 17. **Reptile species known or with potential to occur in the Bear River Watershed**

Northwestern Pond Turtle (CA Species of Special Concern)	*Actinemys marmorata*
Red-eared Slider (Non-native)	*Trachemys scripta elegans*
Blainville's Horned Lizard (CA Species of Special Concern)	*Phrynosoma blainvillii*
Western Fence Lizard	*Sceloporus occidentalis*
Western Sagebrush Lizard	*Sceloporus graciosus gracilis*
Western Skink	*Eumeces skiltonianus*
Gilbert's Skink	*Eumeces gilberti*
Tiger Whiptail	*Aspidoscelis tigris*
Southern Alligator Lizard	*Elgaria multicarinata*
Northern Alligator Lizard	*Elgaria coerulea*
Northern Rubber Boa	*Charina bottae*
Ringneck Snake	*Diadophis punctatus*
Common Sharptailed Snake	*Contia tenuis*
Western Yellow-bellied Racer	*Coluber constrictor mormon*
California Whipsnake/California Striped Racer	*Masticophis lateralis lateralis*
Gopher Snake	*Pituophis catenifer*
California Common Kingsnake	*Lampropeltis californiae*
California Mountain Kingsnake	*Lampropeltis zonata*
Giant Garter Snake (Listed as Threatened under ESA and CESA)	*Thamnophis gigas*
Valley Garter Snake	*Thamnophis sirtalis fitchi*
Sierra Garter Snake	*Thamnophis couchii*
Western Terrestrial (Mountain) Garter Snake	*Thamophis elegans elegans*
California Nightsnake	*Hypsiglena ochrorhyncha nuchalata*
Western Rattlesnake	*Crotalus oreganus*

III.B.3c. Birds

Over 200 species of birds have been observed and documented within the Bear River Watershed (eBird, 2016; Sullivan *et a*l., 2009), and use the watershed's many habitat types for spring nesting, winter roosting and foraging, and/or as vital rest stops along their annual migrations. The Sacramento River Basin Report Card and Technical Report assigned the Bear Watershed the highest score possible for bird diversity and stability within the 2000-2010 decade of study (Aalto *et al*., 2010).

***Table 18*. Bird Species Documented within the Bear River Watershed (eBird, 2016)**

Acorn Woodpecker *Melanerpes formicivorus*	Blue-gray Gnatcatcher *Polioptila caerulea*
American Avocet *Recurvirostra americana*	Blue-winged Teal *Anas discors*
American Bittern *Botaurus lentiginosus*	Brewer's Blackbird *Euphagus cyanocephalus*
American Coot *Fulica americana*	Brown Creeper *Certhia americana*
American Crow *Corvus brachyrhynchos*	Brown-headed Cowbird *Molothrus ater*
American Dipper *Cinclus mexicanus*	Bufflehead *Bucephala albeola*
American Goldfinch *Spinus tristis*	Bullock's Oriole *Icterus bullockii*
American Kestrel *Falco sparverius*	Bushtit *Psaltriparus minimus*
American Pipit *Anthus rubescens*	Cackling Goose *Branta hutchinsii*
American Robin *Turdus migratorius*	California Gull *Larus californicus*
American White Pelican *Pelecanus erythrorhynchos*	California Quail *Callipepla californica*
American Wigeon *Anas americana*	California Towhee *Melozone crissalis*
Anna's Hummingbird *Calypte anna*	Calliope Hummingbird *Selasphorus calliope*
Ash-throated Flycatcher *Myiarchus cinerascens*	Canada Goose *Branta canadensis*
Bald Eagle *Haliaeetus leucocephalus*	Canvasback *Aythya valisineria*
Band-tailed Pigeon *Patagioenas fasciata*	Cassin's Finch *Haemorhous cassinii*
Bank Swallow *Riparia riparia*	Cassin's Vireo *Vireo cassinii*
Barn Owl *Tyto alba*	Cattle Egret *Bubulcus ibis*
Barn Swallow *Hirundo rustica*	Cedar Waxwing *Bombycilla cedrorum*
Barrow's Goldeneye *Bucephala islandica*	Chestnut-backed Chickadee *Poecile rufescens*
Belted Kingfisher *Megaceryle alcyon*	Chipping Sparrow *Spizella passerina*
Bewick's Wren *Thryomanes bewickii*	Cinnamon Teal *Anas cyanoptera*
Black Phoebe *Sayornis nigricans*	Clark's Grebe *Aechmophorus clarkii*
Black Rail *Laterallus jamaicensis*	Clark's Nutcracker *Nucifraga columbiana*
Black-chinned Hummingbird *Archilochus alexandri*	Cliff Swallow *Petrochelidon pyrrhonota*
Black-chinned Sparrow *Spizella atrogularis*	Common Gallinule *Gallinula galeata*
Black-headed Grosbeak *Pheucticus melanocephalus*	Common Goldeneye *Bucephala clangula*
Black-necked Stilt *Himantopus mexicanus*	Common Merganser *Mergus merganser*
Black-throated Gray Warbler *Setophaga nigrescens*	Common Poorwill *Phalaenoptilus nuttallii*
Blue Grosbeak *Passerina caerulea*	Common Raven *Corvus corax*

Common Yellowthroat *Geothlypis trichas*
Cooper's Hawk *Accipiter cooperii*
Dark-eyed Junco *Junco hyemalis*
Double-crested Cormorant *Phalacrocorax auritus*
Downy Woodpecker *Picoides pubescens*
Dusky Flycatcher *Empidonax oberholseri*
Eared Grebe *Podiceps nigricollis*
Eurasian Collared-Dove *Streptopelia decaocto*
European Starling *Sturnus vulgaris*
Evening Grosbeak *Coccothraustes vespertinus*
Ferruginous Hawk *Buteo regalis*
Fox Sparrow *Passerella iliaca*
Gadwall *Anas strepera*
Golden Eagle *Aquila chrysaetos*
Golden-crowned Kinglet *Regulus satrapa*
Golden-crowned Sparrow *Zonotrichia atricapilla*
Grasshopper Sparrow *Ammodramus savannarum*
Great Blue Heron *Ardea herodias*
Great Egret *Ardea alba*
Great Horned Owl *Bubo virginianus*
Greater Scaup *Aythya marila*
Greater White-fronted Goose *Anser albifrons*
Greater Yellowlegs *Tringa melanoleuca*
Green Heron *Butorides virescens*
Green-tailed Towhee *Pipilo chlorurus*
Green-winged Teal *Anas crecca*
Hairy Woodpecker *Picoides villosus*
Hammond's Flycatcher *Empidonax hammondii*
Hermit Thrush *Catharus guttatus*
Hermit Warbler *Setophaga occidentalis*
Herring Gull *Larus argentatus*
Hooded Merganser *Lophodytes cucullatus*
Horned Grebe *Podiceps auritus*
Horned Lark *Eremophila alpestris*
House Finch *Haemorhous mexicanus*
House Sparrow *Passer domesticus*
House Wren *Troglodytes aedon*
Hutton's Vireo *Vireo huttoni*
Killdeer *Charadrius vociferus*
Lark Sparrow *Chondestes grammacus*
Lawrence's Goldfinch *Spinus lawrencei*
Lazuli Bunting *Passerina amoena*
Least Sandpiper *Calidris minutilla*
Lesser Goldfinch *Spinus psaltria*
Lesser Scaup *Aythya affinis*
Lewis's Woodpecker *Melanerpes lewis*
Lincoln's Sparrow *Melospiza lincolnii*
Loggerhead Shrike *Lanius ludovicianus*
MacGillivray's Warbler *Geothlypis tolmiei*
Mallard *Anas platyrhynchos*
Marsh Wren *Cistothorus palustris*
Merlin *Falco columbarius*
Mountain Bluebird *Sialia currucoides*
Mountain Chickadee *Poecile gambeli*
Mountain Quail *Oreortyx pictus*
Mourning Dove *Zenaida macroura*
Nashville Warbler *Oreothlypis ruficapilla*
Northern Flicker *Colaptes auratus*
Northern Goshawk *Accipiter gentilis*
Northern Harrier *Circus cyaneus*
Northern Mockingbird *Mimus polyglottos*
Northern Pintail *Anas acuta*
Northern Pygmy-Owl *Glaucidium gnoma*
Northern Rough-winged Swallow *Stelgidopteryx serripennis*
Northern Shoveler *Anas clypeata*
Nuttall's Woodpecker *Picoides nuttallii*
Oak Titmouse *Baeolophus inornatus*
Olive-sided Flycatcher *Contopus cooperi*
Orange-crowned Warbler *Oreothlypis celata*
Osprey *Pandion haliaetus*
Pacific Wren *Troglodytes pacificus*
Pacific-slope Flycatcher *Empidonax difficilis*
Peregrine Falcon *Falco peregrinus*
Phainopepla *Phainopepla nitens*
Pied-billed Grebe *Podilymbus podiceps*
Pileated Woodpecker *Dryocopus pileatus*
Pine Siskin *Spinus pinus*
Prairie Falcon *Falco mexicanus*
Purple Finch *Haemorhous purpureus*
Pygmy Nuthatch *Sitta pygmaea*
Red Crossbill *Loxia curvirostra*
Red-breasted Merganser *Mergus serrator*
Red-breasted Nuthatch *Sitta canadensis*

Red-breasted Sapsucker *Sphyrapicus ruber*
Redhead *Aythya americana*
Red-necked Phalarope *Phalaropus lobatus*
Red-shouldered Hawk *Buteo lineatus*
Red-tailed Hawk *Buteo jamaicensis*
Red-winged Blackbird *Agelaius phoeniceus*
Ring-billed Gull *Larus delawarensis*
Ring-necked Duck *Aythya collaris*
Ring-necked Pheasant *Phasianus colchicus*
Rock Pigeon *Columba livia*
Rock Wren *Salpinctes obsoletus*
Ross's Goose *Chen rossii*
Rough-legged Hawk *Buteo lagopus*
Ruby-crowned Kinglet *Regulus calendula*
Ruddy Duck *Oxyura jamaicensis*
Rufous Hummingbird *Selasphorus rufus*
Rufous-crowned Sparrow *Aimophila ruficeps*
Sandhill Crane *Grus canadensis*
Savannah Sparrow *Passerculus sandwichensis*
Say's Phoebe *Sayornis saya*
Sharp-shinned Hawk *Accipiter striatus*
Snow Goose *Chen caerulescens*
Snowy Egret *Egretta thula*
Song Sparrow *Melospiza melodia*
Sora *Porzana carolina*
Spotted Sandpiper *Actitis macularius*
Spotted Towhee *Pipilo maculatus*
Steller's Jay *Cyanocitta stelleri*
Swainson's Hawk *Buteo swainsoni*
Swainson's Thrush *Catharus ustulatus*
Townsend's Solitaire *Myadestes townsendi*
Townsend's Warbler *Setophaga townsendi*
Tree Swallow *Tachycineta bicolor*
Tricolored Blackbird *Agelaius tricolor*
Tundra Swan *Cygnus columbianus*
Turkey Vulture *Cathartes aura*
Varied Thrush *Ixoreus naevius*
Violet-green Swallow *Tachycineta thalassina*
Virginia Rail *Rallus limicola*
Warbling Vireo *Vireo gilvus*
Western Bluebird *Sialia mexicana*
Western Grebe *Aechmophorus occidentalis*
Western Kingbird *Tyrannus verticalis*
Western Meadowlark *Sturnella neglecta*
Western Screech-Owl *Megascops kennicottii*
Western Scrub-Jay *Aphelocoma californica*
Western Tanager *Piranga ludoviciana*
Western Wood-Pewee *Contopus sordidulus*
White-breasted Nuthatch *Sitta carolinensis*
White-crowned Sparrow *Zonotrichia leucophrys*
White-faced Ibis *Plegadis chihi*
White-headed Woodpecker *Picoides albolarvatus*
White-tailed Kite *Elanus leucurus*
White-throated Swift *Aeronautes saxatalis*
Wild Turkey *Meleagris gallopavo*
Williamson's Sapsucker *Sphyrapicus thyroideus*
Willow Flycatcher *Empidonax traillii*
Wilson's Snipe *Gallinago delicata*
Wilson's Warbler *Cardellina pusilla*
Wood Duck *Aix sponsa*
Wrentit *Chamaea fasciata*
Yellow Warbler *Setophaga petechia*
Yellow-billed Magpie *Pica nuttalli*
Yellow-breasted Chat *Icteria virens*
Yellow-rumped Warbler *Setophaga coronata*

III.B.3d. Mammals

Comprehensive mammal surveys have not been completed for the Bear River Watershed. Table 19 lists the mammal species that are likely to occur in the watershed, many but not all of which have been observed and documented therein. This table is based initially on the CWHR (California Wildlife Habitat Relationships) models created by CDFW. These models were applied to the Bear River Watershed by Shilling and Girvetz (2003). Table 19 has been further curated by this 2016 report's authors to:

- add species that were not included by the CWHR models but that have been documented within and/or adjacent to the watershed (e.g., Sierra Nevada red fox; CNDDB, 2015);
- omit species for which recently updated geographic range information no longer approaches the Bear Watershed (e.g., San Joaquin pocket mouse; CDFW, 2015b); and
- update recently changed scientific names of several species that have undergone recent taxonomic review by the scientific community.

***Table 19*. Mammal species known or with potential to occur in the Bear Watershed**

Ornate Shrew (*Sorex ornatus*)
American Water Shrew (*Sorex palustris*)
Trowbridge's Shrew (*Sorex trowbridgii*)
Broad-footed Mole (*Scapanus latimanus*)
Brush Rabbit (*Sylvilagus bachmani*)
Audubon's Cottontail (*Sylvilagus audubonii*)
Sierra Nevada Snowshoe Hare (*Lepus americanus tahoensis*)
Black-tailed Jackrabbit (*Lepus californicus*)
Sierra Nevada Mountain Beaver (*Aplodontia rufa californica*)
Yellow-pine Chipmunk (*Tamias amoenus*)
Allen's Chipmunk (*Tamias senex*)
Long-eared Chipmunk (*Tamias quadrimaculatus*)
Lodgepole Chipmunk (*Tamias speciosus*)
Yellow-bellied Marmot (*Marmota flaviventris*)
California Ground Squirrel (*Spermophilus beecheyi*)
Golden-mantled Ground Squirrel (*Spermophilus lateralis*)
Western Gray Squirrel (*Sciurus griseus*)
Douglas' Squirrel (*Tamiasciurus douglasii*)
Northern Flying Squirrel (*Glaucomys sabrinus*)
Botta's Pocket Gopher (*Thomomys bottae*)
Mountain Pocket Gopher (*Thomomys monticola*)
California Pocket Mouse (*Chaetodipus californicus*)
California Kangaroo Rat (*Dipodomys californicus*)
American Beaver (*Castor canadensis*)
Western Harvest Mouse (*Reithrodontomys megalotis*)
Deer Mouse (*Peromyscus maniculatus*)
Brush Mouse (*Peromyscus boylii*)
Piñon Mouse (*Peromyscus truei*)
Dusky-footed Woodrat (*Neotoma fuscipes*)
Bushy-tailed Woodrat (*Neotoma cinerea*)
Montane Vole (*Microtus montanus*)
California Vole (*Microtus californicus*)
Long-tailed Vole (*Microtus longicaudus*)
Muskrat (*Ondatra zibethicus*)
Western Jumping Mouse (*Zapus princeps*)
Common Porcupine (*Erethizon dorsatum*)
Coyote (*Canis latrans*)
Common Gray Fox (*Urocyon cinereoargenteus*)
Sierra Nevada Red Fox (*Vulpes vulpes necator*)
Black Bear (*Ursus americanus*)
Ringtail (*Bassariscus astutus*)
Common Raccoon (*Procyon lotor*)
Sierra Marten (*Martes caurina sierrae*)
Fisher (*Pekania pennanti*)
Ermine (*Mustela erminea*)
Long-tailed Weasel (*Mustela frenata*)
American Mink (*Mustela vison*)
American Badger (*Taxidea taxus*)
Western Spotted Skunk (*Spilogale gracilis*)
Striped Skunk (*Mephitis mephitis*)
Northern River Otter (*Lutra canadensis*)
Mountain Lion (*Felis concolor*)
Bobcat (*Lynx rufus*)
Mule Deer (*Odocoileus hemionus*)
Virginia Opossum (*Didelphis virginiana*)

III.B.4. Fisheries

III.B.4.a. Species present

A variety of cold-water and warm-water species are found along the Bear River. Native species include steelhead/rainbow trout (*Oncorhynchus mykiss*), speckled dace (*Rhinichthys osculus*), Sacramento sucker (*Catostomus occidentalis*), and Sacramento pikeminnow (*Ptychocheilus grandis*). Non-native fish species include brown trout (*Salmo trutta*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), spotted bass (*Micropterus punctulatus*), striped bass (*Morone saxatilis*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), green sunfish (*Lepomis cyanellus*), redear sunfish (*Lepomis microlophus*), channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), brown bullhead catfish (*Ameiurus nebulosus*), pond smelt (*Hypomesus nipponensis*), and golden shiner (*Notemigonus crysoleucas*). The fish community is dominated by rainbow trout, brown trout, or both trout species from the Bear headwaters until Chicago Park Powerhouse. Downstream of the powerhouse, the fish community is more diverse, including non-native warm-water fish species (NID and PG&E, 2010g). Table 20, on the following page, contains results of stream and reservoir fish population surveys completed in 2008-2009 as part of the FERC relicensing process for NID and PG&E's Yuba-Bear Drum-Spaulding (YBDS) Hydroelectric projects. Electrofishing and snorkel surveys were used to sample stream reaches, while electrofishing and gill net sampling were used to sample Rollins Reservoir.

Several of the fish species found during YBDS surveys had not been previously documented in the Bear watershed. Historically, surveys conducted by CDFG in 1987 and 1988 at eight locations on the Bear River found only rainbow trout (at densities of 29 fish/100 m) and brown trout (239 fish/100 m). Prior to the 2008 and 2009 surveys (Table 20), Sacramento sucker and speckled dace had not been documented in the Bear River sub-basin (NID and PG&E, 2010g). Fish that were historically found in Rollins Reservoir since its construction in 1964-1965, but not found in the surveys done for NID and PG&E include: Kokanee (*Oncorhynchus nerka*), common carp (*Cyprinus carpio*), tui chub (*Gila bicolor*), white crappie (*Pomoxis annularis*), and threadfin shad (*Dorosoma petenense*). Species not documented historically in the reservoir, but found in the 2008-2009 surveys include white catfish, Sacramento pikeminnow, and Sacramento sucker (NID and PG&E, 2010h).

Table 20. **Fish species found in the Bear River during Yuba-Bear Drum-Spaulding Project FERC relicensing by site**

Name*	Site Description	Habitat Types	Amount Suitable Spawning Gravel	Brown Trout #	Brown Trout *Density*	Rainbow Trout #	Rainbow Trout *Density*	Other Fish Species
Bear River Reach #1	0.3 mi long near headwaters	Cobble, boulders	Not evaluated	0	--	47	--	None
Bear River Reach #2 -- upper site	Large meadow, 5.7 mi upstream of Drum Powerhouse	Low-gradient riffle, run, glide, pool	159 sq ft in 2008; 53 sq ft in 2009	172 - 216	201 - 252 fish/100 m	1	--	None
Bear River Reach #2 -- middle site	3.5 mi upstream of Drum Powerhouse	Low- and high-gradient riffle, run, pool	2 sq ft in 2008; 0 sq ft in 2009	16 - 19	32 - 38 fish/100 m	58 -67	116 - 113 fish/100 m	None
Bear River Reach #2 -- lower site	1.3 mi upstream of Drum Powerhouse	High-gradient riffle, run, pool	0 sq ft	6 - 16	8 - 20 fish/100 m	40 - 70	50-88 fish/100 m	None
Drum Afterbay Dam Reach	1.7 mi downstream of Drum Afterbay Dam	Low-gradient riffle, run, pool	0 sq ft	0 - 1	--	50 - 60	68 - 81 fish/100 m	None
Dutch Flat Afterbay Dam Reach -- lower	2.2 mi downstream of Dutch Flat Afterbay Dam	Low-gradient riffle, run, pool	9-20 sq ft	0	--	7 - 44	7 - 41 fish/100 m	Speckled dace (n = 7-53)
Chicago Park Powerhouse Reach -- Level II	0.2 mi downstream of Steephollow Crk confluence	Low-gradient riffle, run, pool	24 sq ft	5	3 fish/100 m	0	--	Sacramento sucker (n = 24). Together, Sacramento pikeminnow and smallmouth bass made up 30% of species
Chicago Park Powerhouse Reach -- Level I	From Rollins Reservoir to Chicago Park Powerhouse (1.5 mi)	Riffle, glide	Not evaluated	1	--	0	--	None

Rollins Reservoir	--	Reservoir	Not evaluated	54	--	1	--	Smallmouth bass (n = 264), bluegill (n = 114), black crappie, green sunfish, redear sunfish, largemouth bass, channel catfish, white catfish, brown bullhead catfish, pond smelt, golden shiner
Bear River Canal Diversion Dam Reach -- upper site	2.6 mi downstream of Bear River Canal Diversion Dam	Low-gradient riffle, run	12-25 sq ft	10 - 35	23-67 fish/100 m	3 - 72	6 - 72 fish/100 m	Sacramento sucker, Sacramento pikeminnow, green sunfish
Bear River Canal Diversion Dan Reach -- lower site	7.2 mi downstream of Bear River Canal Diversion Dam	Low-gradient riffle, run	0 sq ft	2 - 8	2 - 6 fish/100 m	7 - 14	5 - 11 fish/100 m	Sacramento pikeminnow, Sacramento sucker (n = 2 - 760)
Bear River Canal Diversion Dam Reach -- Level I	From Lake Combie upstream to Bear River Canal Diversion Dam (10.4 mi)	Riffle (20%), glide (80%)	Not evaluated	0	--	0	--	Sacramento pikeminnow (n = 22, 81%), Sacramento sucker (n = 5, 19%)
Lake Combie†	--	Reservoir	Not evaluated	--	--	yes	--	Bluegill, largemouth bass
Larsen Reach†	844 ft reach from Lake Combie to confluence with Wolf Creek	--	Not quantified	--	--	--	--	Smallmouth bass (n=50), spotted bass (n=2)
Camp Far West Reservoir†	--	Reservoir	Not evaluated	--	--	--	--	Bluegill, channel catfish, largemouth bass, spotted bass, striped bass, crappie

* Sites ordered beginning at headwaters and moving towards confluence with the Feather River.

† Sites not evaluated in Yuba-Bear Drum-Spaulding FERC relicensing process. Data from May et al., 1999; Klasing and Brodberg, 2003; ECORP, 2014.

RAINBOW TROUT and STEELHEAD *(Oncorhynchus mykiss)*

A native coldwater fish, *Oncorhynchus mykiss* takes on two life history forms. Rainbow trout are resident freshwater species, while steelhead exhibit anadromy (migrating to the ocean before returning to freshwater to spawn). Steelhead may remain at sea for up to three years before returning to natal streams, and interestingly, may even choose to return to freshwater to overwinter in deep low-velocity pools before migrating back to sea without spawning (NOAA, 2016). Unlike other Pacific salmonid species, steelhead can spawn more than once (iteroparity). The Central Valley Distinct Population Segment (DPS) of steelhead received federal listing as a threatened DPS under the Endangered Species Act in 1998 and remains listed today (CDPR, 2015). Populations in the Bear River found below Camp Far West Reservoir are intermittently present due to variable flows, protecting the species from extinction should periodic catastrophic disturbances cause significant declines in more permanent populations of Central Valley steelhead (Reeves et al., 1995; see Special Status Species Fish section within this document for more). The species is found above Camp Far West Reservoir as well, however the South Sutter Irrigation District Dam is impassable to fish, creating populations of landlocked rainbow trout rather than anadromous steelhead.

O. mykiss utilizes a wide variety of cold waters, including creeks, small and large rivers, and lakes; steelhead also use estuaries and oceans. Ideal waters are clean, clear, cold, and free of fish passage barriers. Rainbow trout are opportunistic feeders, and in streams with riparian vegetation the trout will feed on terrestrial insects that fall into the stream. In rocky stream riffles, diet also includes benthic macroinvertebrates and crustaceans. In lakes, other invertebrates like plankton, snails, leaches, smaller fish, and fish eggs may also make up a portion of *O. mykiss* diet (NRCS and WHC, 2000). Rainbow trout will spawn in main river channels, tributaries, and inlet or outlet streams of lakes during spring and early summer, while steelhead will spawn mostly in winter and spring. Redds (nests) are formed in stream riffles and pool tail-out habitats with well-aerated gravels free of sediment. Preferred gravel substrate is 1-3 inch diameter gravels (NRCS and WHC, 2000). Rainbow trout are more solitary than social, so complex habitats with variety in structure and cover features (in-stream wood, boulders, vegetation) benefit the species by allowing individuals to comfortably partition available habitat into territories (NRCS and WHC, 2000).

Rainbow trout are found throughout much of the upper and middle watershed, at Bear River Reach #1, Bear River Reach #2 (upper, middle, and lower sites), Drum Afterbay Dam Reach, Dutch Flat Afterbay Dam Reach, Rollins Reservoir, Bear River Canal Diversion Dam Reach, and Lake Combie. Steelhead are found in the lower reach of the Bear below Camp Far West Reservoir and into Dry Creek, including in the Spenceville Wildlife Area (NID and PG&E,2010g; NID and PG&E, 2010h; USFWS, 2014a).

BROWN TROUT *(Salmo trutta)*

Brown trout (*Salmo trutta*) are a cold-water non-native species that was introduced from Europe to California in 1893 for angling (Dill and Cordone, 1997; Fuller et al., 2016a). Brown trout exists in high numbers throughout the state due to its popularity as a sport fish and its ability to compete with other trout species. *S. trutta* may reduce native salmonid populations through predation, displacement, and competition for food (Fuller et al., 2016a). Ideal habitat is medium to large, slightly alkaline, clear streams in riffles and deep pools. Fry use low velocity edge waters (<30cm deep), while adults use pools 0.7-3.5m deep. Primary prey of small fish are drift organisms (terrestrial insects), while larger fish shift diets to benthic macroinvertebrates, other fish, crayfish, and dragonfly larvae, and the largest fish (>40cm) feed almost exclusively on other fish (UCDANR, 2016). Spawning habitat is found at the tails of pools with deeper, less turbulent water, with cover and gravel 3-100 mm in diameter (Adams et al., 2008).

Brown trout occurrence often overlaps with rainbow trout occurrence in the watershed, inhabiting both stream/river and reservoir habitat. They have been found at Bear River Reach #2 (upper, middle, lower), Drum Afterbay Dam Reach, Chicago Park Powerhouse Reach, Rollins Reservoir, and Bear River Canal Diversion Dam Reach (upper and lower) (NID and PG&E, 2010g; NID and PG&E, 2010h).

SPECKLED DACE *(Rhinichthys osculus)*

Speckled dace (*Rhinichthys osculus*) is the most ubiquitous freshwater fish in the western US (NatureServe, 2013a). It is often found in shallow water (<0.5m deep) in small springs, large rivers, and lakes (NatureServe, 2013a; UCDANR, 2016). It is a highly morphologically and ecologically variable species across the west, and its success in the region is presumably due to its adaptability. Speckled dace is frequently used as a bait fish, and may be an important forage species to predators such as introduced trouts (*Salmo* spp.), introduced basses (*Micropterus* spp.), and green sunfish (*Lepomis cyanellus*) (NatureServe, 2013a). *R. osculus* requires clear, well-oxygenated water with movement and cover objects. Diet consists of aquatic insects in streams, while lake-dwelling populations may be more opportunistic feeders. Spawning occurs during summer months in riffles and graveled areas (UCDANR, 2016). Speckled dace have been observed at Dutch Flat Afterbay Dam Reach (upper and lower), and Chicago Park Powerhouse Reach -- Level II (NID and PG&E, 2010g).

SACRAMENTO SUCKER *(Catostomus occidentalis)*

The Sacramento sucker (*Catostomus occidentalis*) is a native species that thrives in diverse conditions, including streams, lakes, and mild estuarine environments. Juvenile fish forage on the bottom of warm streams, and may stay in warm water for several years prior to moving into lakes or larger rivers. Adults hold in deeper water during the daytime, and feed on algae, invertebrates, detritus, and diatoms by foraging on stream bottoms. Spawning is triggered by warmer water temperatures in February and June, and populations spawn in groups (UCDANR, 2016). Though often sharing reaches, studies have shown that the Sacramento sucker does not compete with rainbow trout for space in streams due to vertical segregation and differential use in microhabitats, with suckers remaining on the bottom of a water body and trout occupying the water column (Baltz and Moyle, 1984). The species has been found at Chicago Park Powerhouse Reach, Bear River Canal Diversion Dam Reach, and Lake Combie (NID and PG&E, 2010g; NID and PG&E, 2010h).

SACRAMENTO PIKEMINNOW *(Ptychocheilus grandis)*

A native species, the Sacramento pikeminnow is found in clear low to mid-elevation streams and rivers. They favor streams with deep pools and slow runs, and may be found with other native fish in slightly disturbed streams but are rarely found in highly polluted waters or in lakes with centrarchids (UCDANR, 2016). Juveniles eat aquatic insects, and as they grow larger will change their diet to crustaceans and fish. Other prey items can include frogs, large stoneflies, and small rodents. *P. grandis* spawns in April through May in riffles and pool tails with gravel substrate. A variety of microhabitats with good cover for young fish may be required for populations to persist, since pikeminnows are piscivores that will eat their own young. In the South Yuba River, Gard (2005) found that juveniles used shallower and slower conditions, especially in the presence of large adults. *P. grandis* also competes with trout, preys on young salmonids, and plays a role in determining the spatial structure of native stream fish assemblages; Brown and Brasher (1995) found that rainbow trout shift to shallower water to reduce vulnerability of being eaten by pikeminnows. The Sacramento pikeminnow species is stable and of little conservation concern (NatureServe, 2013b). *P. grandis* has been observed at Chicago Park Powerhouse Reach- Level II and Bear River Canal Diversion Dam Reach (NID and PG&E, 2010g).

SMALLMOUTH BASS *(Micropterus dolomieu)*

Smallmouth bass (*Micropterus dolomieu*) is native to the Great Lakes, Hudson Bay, and Mississippi River basins. Its introduction to California in 1874 is thought to precede that of the largemouth bass (Dill and Cordone, 1997). It is found in waters in the temperature range of 25-27°C, utilizing complex habitat in streams (pools, riffles, runs, rocky bottoms, overhanging trees), or concentrating in narrow bays along the shore of lakes. Younger fish tend to use warmer areas. Diet includes crustaceans and aquatic insects when small, then crayfish and fish once larger. Smallmouth bass may eat other prey items opportunistically, including amphibians and small mammals. *M. dolomieu* moves to shallow water to spawn in May-July, where nests are formed in rubble, gravel, or sand near cover objects such as submerged logs or boulders.

While popular among California anglers, smallmouth bass negatively impact native nongame fish through reducing the richness of fish communities (Fuller et al., 2016b). Kuehne and Olden (2012) found that juvenile Chinook salmon have fewer anti-predator flight responses when exposed to smallmouth bass odors compared to when exposed to odors from native predators, suggesting that salmonids may not recognize smallmouth bass as a predator. Water temperature strongly influences smallmouth bass distribution, so to limit future range expansions into salmon-rearing habitat where there may be direct predation or sublethal effects of bass on juvenile salmon, restoration activities should be focused on mitigating stream warming related to climate change or land-use change (Lawrence et al., 2012). Records of smallmouth bass presence exist at Chicago Park Powerhouse Reach -- level II, Rollins Reservoir, and Larsen Reach (NID and PG&E, 2010g; NID and PG&E, 2010h).

LARGEMOUTH BASS *(Micropterus salmoides)*

Another important sport fish, largemouth bass (*Micropterus salmoides*) is frequently stocked into water bodies in California for sport and also for mosquito and algae control (Dill and Cordone, 1997). Non-native to California, it often affects small native fishes (i.e. speckled dace) and native ranid frogs through direct predation (Fuller and Neilson, 2016a). Largemouth bass are found in warm shallow waters with beds of aquatic plants. *M. salmoides* is a highly adaptable and tolerant species. Fry feed on crustaceans and rotifers, while larger fish eat insects and fish fry, and become fully piscivorous at 50-60mm. They may also eat crayfish, tadpoles, and frogs. Spawning occurs in March through June in nests built in sand, gravel, or debris-littered bottoms next to submerged objects (UCDANR, 2016). Within the Bear watershed, largemouth bass can be found at Rollins Reservoir and Camp Far West Reservoir (NID and PG&E, 2010h).

SPOTTED BASS *(Micropterus punctulatus)*

The spotted bass (*Micropterus punctulatus*) was also intentionally introduced to California for angling in 1933 (Dill and Cordone, 1997). It is commonly found in moderately sized, clear, low gradient rivers and reservoirs. In streams, time is mostly spent in pools, avoiding riffles or areas with heavy plant growth. Reservoir populations tend to stay along rocky banks along the upstream end of reservoirs (UCDANR, 2016). Fry will eat zooplankton and small insects, and larger fish will eat crustaceans and larger aquatic insects as juveniles.

Adults feed on aquatic insects, fish, crayfish, and terrestrial insects. Lake nests are built in areas with large rocks and gravel, while nests in rivers are placed in areas with low current (UCDANR, 2016). Spotted bass are known to hybridize with smallmouth bass, and inhabit Larsen Reach and Camp Far West Reservoir (NID and PG&E, 2010h; ECORP, 2014).

STRIPED BASS *(Morone saxatilis)*

Striped bass (*Morone saxatilis*) are native to Atlantic drainages. Stocked in California for sport fishing in 1882, it has become hugely successful on the west coast (Dill and Cordone, 1997). Several habitat structures are needed by striped bass, including large cool rivers with sufficient flow for spawning, an abundance of prey items such as invertebrates and other fish, and protective rearing habitat for juveniles (typically estuarine) (UCDANR, 2016). Salmonids are known to make up part of their diet (Dill and Cordone, 1997). Striped bass spawning occurs in April. Recently, striped bass have only been recorded at Camp Far West Reservoir within the watershed (NID and PG&E, 2010h).

BLUEGILL *(Lepomis macrochirus)*

Bluegill (*Lepomis macrochirus*) is a warm-water non-native introduced to California in the 1890s. As an important sport fish, it is often intentionally planted alongside largemouth bass for angling or as forage for bass (Dill and Cordone, 1997; Fuller and Cannister, 2016). It is frequently found in warm, shallow lakes, reservoirs, ponds, or streams (if deep, well-covered, and contain vegetated pools). In lakes and reservoirs they are often found among aquatic plants growing in silt, sand, or gravel. Bluegill are opportunistic feeders, foraging on the bottom, on vegetation, or in midwater for insect larvae, plankton, flying insects, or snails (UCDANR, 2016). They spawn in summer through September, and make nests out of gravel, sand, or mud substrate in shallow water. *L. macrochirus* is known to hybridize with green sunfish and redear sunfish (Fuller and Cannister, 2016). Bluegill can be found in each of the three major reservoirs: Rollins Reservoir, Lake Combie, and Camp Far West Reservoir (NID and PG&E, 2010h).

BLACK CRAPPIE *(Pomoxis nigromaculatus)*

Black crappie (*Pomoxis nigromaculatus*) is native to most of the eastern US, but was planted in California in the late 1800s (NatureServe, 2013d; Dill and Cordone, 1997). Black crappie (*Pomoxis nigromaculatus*) is considered a small game fish, though the fishery for crappie is erratic and is often problematic in creating a sustained yield (Dill and Cordone, 1997). *P. nigromaculatus* is found in large, warm water lakes and reservoirs (27-29°C), and is highly resilient to high salinities and low levels of dissolved oxygen. Foraging often occurs in midwater, with young feeding on zooplankton and small insect larvae, and larger individuals eating aquatic insects and other fish. Black crappie spawn in March through July, constructing nests in mud or gravel near vegetation beds in shallow water (<1m deep). Large population sizes throughout the US make the black crappie of low conservation concern (NatureServe, 2013d). *P. nigromaculatus* is known to prey on juvenile salmon (Fuller et al., 2016c). This species has been observed in Rollins Reservoir and possibly Camp Far West Reservoir (NID and PG&E, 2010h).

GREEN SUNFISH *(Lepomis cyanellus)*

Green sunfish (*Lepomis cyanellus*) is thought to have been introduced to California in 1891 as a food source for smallmouth bass (Dill and Cordone, 1997). It is often found in rocky places associated with smallmouth bass, utilizing slow-moving warm streams, ponds, or shallow weedy areas of lakes (NatureServe, 2013c). *L. cyanellus* does well in disturbed areas, as it can tolerate temperatures greater than 38°C, dissolved oxygen levels less than 1mg/L, and alkalinities up to 2,000 mg/L. They are opportunistic predators, feeding mostly on invertebrates and small fish. Spawning occurs in May-Aug in areas with fine gravel bottoms (UCDANR, 2016).

The species had status as a "game fish", but in 1944 it was classified as an undesirable fish by California Department of Fish and Game (CDFG) due to its tendency to compete and predate on other game fishes and native nongame fishes (Dill and Cordone, 1997). It may also contribute to declines of native ranid frogs, as the decline of the foothill yellow-legged frog (*Rana boylii*) is associated with invasion by green sunfish (Kupferberg, 1996). In contrast, tadpoles of invasive bullfrogs are eaten only very rarely by sunfish (Kruse and Francis, 1977; Kupferberg, 1996). Green sunfish records exist at Rollins Reservoir and Bear River Canal Diversion Dam Reach (NID and PG&E, 2010g; NID and PG&E, 2010h).

REDEAR SUNFISH *(Lepomis microlophus)*

The redear sunfish (*Lepomis microlophus*) is non-native to California, originating on the Atlantic coast (Fuller et al., 2016d). CDFG approved the import and propagation of redear sunfish in 1954, when it was placed into reservoirs as a substitute for bluegill/largemouth bass communities (Dill and Cordone, 1997). It is commonly found in deeper waters of warm, quiet ponds and lakes with substantial beds of aquatic vegetation. The diet of *L. microlophus* mostly consists of hard-shelled invertebrates (bottom-dwelling snails and clams), and benthic invertebrates (dragonfly and midge larvae) (UCDANR, 2016). Their preference for mollusks may lead to significant impacts on snail and clam abundances if redear sunfish populations are high enough (Fuller et al., 2016d). Nests are constructed in sand, gravel, or mud (UCDANR, 2016). The redear sunfish is currently only recorded within Rollins Reservoir (NID and PG&E, 2010h).

CHANNEL CATFISH *(Ictalurus punctatus)*

The first record of introduction of the channel catfish (*Ictalurus punctatus*) to California is in 1891 into the Feather River near Gridley, CA (Dill and Cordone, 1997). Since then, it has been continually stocked for sport fishing and food; it was the first species to be raised in commercial aquaculture for food in the US (Fuller and Neilson, 2016b). Channel catfish are found in main channels of large, warm water streams with sand, gravel, or rubble bottoms, but may also be found in turbid, muddy waters. These fish tend to reside beneath logjams and undercut banks during the day, using faster moving parts of the stream at night to forage for crustaceans, fish, and crayfish. *I. punctatus* needs sheltered, cave-like sites for nests, often utilizing old muskrat burrows, undercut banks, logjams, or even dumped barrels (UCDANR, 2016). Channel catfish are found in Rollins Reservoir and Camp Far West Reservoir (NID and PG&E, 2010h).

WHITE CATFISH *(Ameiurus catus)*

Another non-native, white catfish (*Ameiurus catus*), was introduced to California in 1874 as a sport fish (Dill and Cordone, 1997). It inhabits deep lakes and reservoirs, as well as slow moving sections of rivers and streams. In streams, *A. catus* stays in water >2m deep. They may shift their depth with the seasons to pursue waters >21°C when found in lakes or reservoirs: in late spring/early summer they are found 3-10m deep, and in winter they are 17-30m deep (UCDANR, 2016). As carnivorous bottom-feeders, they eat amphipods, shrimp, insect larvae, fish, and larger invertebrates. When given the opportunity, they will also scavenge carrion or eat planktivorous fish. Spawning occurs in June or July into September, with nests made in sand or gravel near vegetative cover (UCDANR, 2016). White catfish have been observed in Rollins Reservoir (NID and PG&E, 2010h).

BROWN BULLHEAD CATFISH *(Ameiurus nebulosus)*

After its introduction in 1874 for food and sport, the brown bullhead catfish (*Ameiurus nebulosus*) has become the most widely distributed catfish in the state of California (Dill and Cordone, 1997). *A. nebulosus* is an extremely adaptable species that can inhabit warm turbid slough to clear mountain lake habitats. It is mostly found in large bodies of water in California (i.e. reservoirs), where they remain in deep regions of littoral zone near aquatic plants and muddy substrate. In rivers, they occur in slow-moving, low gradient, turbid streams with deep pools (UCDANR, 2016). Spawning happens in May through July in sexually mature individuals. Rollins Reservoir is the only recorded location of Brown bullhead catfish in the Bear watershed (NID and PG&E, 2010h).

POND SMELT *(Hypomesus nipponensis)*

Pond smelt, or Wakasagi (*Hypomesus nipponensis*), were introduced experimentally to California in 1959 from Japan to provide a planktivorous forage fish for trout lakes (Dill and Cordone, 1997). As pelagic plankton feeders, they are found in open lakes, streams, and reservoirs, feeding on copepods and insect larvae. In their home range of Japan, wakasagi are anadromous, though this behavior has not been seen in California populations. Spawning occurs between April and May in sand or gravel (UCDANR, 2016). Pond smelt are known to exist in Rollins Reservoir (NID and PG&E, 2010h).

GOLDEN SHINER *(Notemigonus crysoleucas)*

Golden shiners (*Notemigonus crysoleucas*) have become widely distributed in California after being planted in 1891. They are often used by anglers as live bait, but the purpose of the introduction was also as a forage fish. However, it has not added much to the forage fish supply since it does not often establish significant wild populations (Dill and Cordone, 1997). *N. crysoleucas* is found around aquatic vegetation in warm, shallow ponds and lakes. Diet consists mainly of zooplankton and small flying insects for smaller individuals, while larger individuals may eat small fish, mollusks, and aquatic insect larvae. The spawning period for Golden shiner is between March and September (UCDANR, 2016). Golden shiners have been observed in Rollins Reservoir (NID and PG&E, 2010h).

III.B.4.b. Habitat Conditions for Fish

Fifteen miles of habitat exist for anadromous salmonids on the Bear below Camp Far West Reservoir (National Marine Fisheries Service, 2014a), however a large portion of this habitat is not appropriate for spawning due to siltation of spawning gravels. While historically, this 15 mile stretch supported substantial populations of fall-run Chinook salmon, siltation of spawning gravels from mining sediments following the floods of winter 1860-61 reduced the amount of suitable spawning gravel and Chinook use of the Bear has declined significantly since then (Yoshiyama et al., 2001). In addition to siltation, inadequate stream flows (minimum release flows from Camp Far West Reservoir are 25 cfs in spring and 10 cfs at all other times) contribute to reduced streamflow and reduced habitat suitability in the reach (Jones & Stokes, 2005). While Chinook salmon and steelhead may migrate and spawn in the lower Bear River during heavy rain events, water temperatures are typically above the suitable level for steelhead rearing by mid-June or July. The 4 mile reach on the Bear located just below Camp Far West Reservoir has poor riparian shade, resulting in quick warming of waters released from the reservoir and therefore increased mortality of Chinook salmon adults and eggs and steelhead eggs and juveniles (Jones & Stokes, 2005). Additionally, agricultural runoff that frequently occurs in the area is likely to adversely affect water quality in this 15-mile reach.

Dry Creek provides some additional accessible habitat for steelhead and salmon since its confluence with the Bear is below Camp Far West. Surveys done by the US Fish and Wildlife Service of a 5.3 mile segment of Dry Creek within the Spenceville Wildlife Area found 5.25 miles of accessible anadromous salmonid habitat (USFWS, 2014a). One 3.4 foot cascade was observed, preventing upstream passage to adult salmonids at all flows due to the lack of a downstream plunge pool. Seven percent of the reach was found to have spawning gravels, and 51% of habitat had banks with woody cover, suggesting that the limiting factors for this reach are amount of spawning gravel and woody cover, and that the highest priority for restoring habitat is addition of spawning gravels. The reach within the Spenceville Wildlife Area would need flows of at least 120 cfs to support upstream passage, so it is likely that passage of fall-run Chinook salmon would not occur until the first big rain event of the fall (USFWS, 2014a).

Above Camp Far West, the Bear River is generally bedrock controlled, though sections of habitat are well suited for trout species of multiple life stages (ECORP, 2014). In a report done by ECORP Consulting (2014), an 844-ft reach between Lake Combie and the confluence with Wolf Creek was surveyed and used in habitat modeling. The surface sediments of this reach are dominated by gravels (77-100%) and cobbles (23-79%), with substrate diameters generally slightly larger than optimal for spawning trout (ECORP, 2014). Results of ECORP Consulting habitat modeling indicate that:

- the reach is best suited for adult and juvenile cyprinids (i.e. adult and juvenile Sacramento pikeminnow, juvenile Sacramento sucker).
- adult spawning rainbow and brown trout prefer flow rates up to 2.0 feet per second (fps) while trout juvenile and fry life stages prefer 0.2-0.37 fps.
- Sacramento sucker and Sacramento pikeminnow juveniles prefer shallower habitat than adults, and fry occupying the widest range of habitat depths.
- Spawning adult trout prefer shallow areas (0.6-1.5 ft) with high flow velocities and spawning gravels between 1-100 mm in diameter. Non-spawning adult trout prefer the deepest habitats.

Additional habitat mapping and modeling to predict availability of suitable fish habitat was done as part of the FERC relicensing process for NID and PG&E's Yuba-Bear Drum-Spaulding (YBDS) Hydroelectric Project (NID and PG&E, 2011b). The study compared time of year by month and the location along the Bear River to explore whether current flow conditions or an estimation of unimpaired flows (i.e. natural conditions) provided more suitable habitat for adult rainbow trout. Modeling results varied, with the amount of suitable habitat under current flow conditions and unimpaired flow conditions differing widely based on time of year and site. With the exception of Bear River Canal Diversion Dam Reach, flows suitable for adult and juvenile rainbow trout peaked between 5-25 cfs at eight sites considered along the river (Bear River Reach #1, Bear River Reach #2: Meadow and Boardman sub-reaches, Drum Afterbay Dam Reach, Drum Flat Afterbay Dam Reach, Chicago Park Powerhouse, Bear Canal Diversion Dam Reach: Taylor Crossing and Dog Bar sub-reaches). See Figure 6 for locations of these sites within the watershed. A full description of the models, inputs, and results can be found in the Technical Memorandum 3-2: Instream Flow (NID and PG&E, 2011b), and similar habitat modeling done for Sacramento sucker and Sacramento pikeminnow are included in an attachment to the document (see Technical Memorandum 3-2 Instream Flow: Attachment 3-2E, Part 3).

In channel morphology surveys done for the same YBDS relicensing, no trout spawning gravels (between 6.4 and 63.5 mm in diameter) were found at Dutch Flat Afterbay Dam Reach or Bear River Canal Diversion Dam Reach. Trout spawning gravels found at Bear River Reach #2 (Meadow sub-reach) were generally found to mobile under median and high flows in both current flow conditions (regulated) and estimated unimpaired flow conditions (NID and PG&E, 2011a). At the this site (Bear River Reach #2, Meadow sub-reach), 18% of sediments were reported as under 0.80mm, likely due to upstream bank failures, which is of importance because a high percentage of fine particles may affect fry emergence (NIG and PG&E, 2011a). Additional studies have found that as the percentage of sediment <1mm in diameter increases, overall trout biomass decreases (Edwards et al., 2007). The NID and PG&E memorandum indicates that this was likely a local sediment issue, as surrounding sub-reach sample sites within Bear River Reach #2 did not have similar fine sediment issues (NID and PG&E, 2011a).

III.B.4.c. Fish Passage Barriers

The South Sutter Water District Dam at Camp Far West is a large impassable barrier to anadromous fish. Prior to construction of Camp Far West Reservoir, adult Chinook ascended only as far as the present-day reservoir site due to a waterfall that likely barred passage, thus construction of the dam did not significantly decrease available salmonid habitat (Yoshiyama et al., 2001).

Beyond Camp Far West, several other barriers (including upstream dams at Lake Combie and Rollins Reservoir) are barriers to migration for other resident fish species. Fish passage barriers were assessed within the FERC relicensing process for YBDS Hydroelectric projects, with an upstream fish barrier defined as a single vertical rise of ≥ 3 ft, or a thalweg depth of < 1 ft for a distance of over 3 ft (NID and PG&E, 2010a). In the survey period of 2008-2009, no potential fish barriers were found on Steephollow Creek, Greenhorn Creek, or the mainstem Bear just above Rollins Reservoir. A beaver dam was identified as the only barrier on the surveyed reach of Dry Creek. Further upstream, in a 5.3 mile reach of the mainstem between the Boardman Canal Diversion and Drum Afterbay, 22 natural barriers were observed (NID and PG&E, 2010a). An additional data source for fish passage and barriers is the California Department of Fish and Wildlife's Passage Assessment Database (https://nrm.dfg.ca.gov/PAD/).

III.B.4.d. Stocking and Hatcheries

The California Department of Fish and Wildlife (CDFW) operates 14 trout hatchery facilities and ten salmon and steelhead hatchery facilities throughout the state of California (Jones & Stokes, 2010). The purpose of trout stocking is to augment trout populations where angling demand exceeds natural production, and the purpose of salmon and steelhead stocking is largely mitigation but also enhancement and conservation. Stocking sites and species often vary from year to year, and timing of fish plants varies based on environmental factors (Jones & Stokes, 2010).

Rollins Reservoir is presently stocked with hatchery trout (brown trout and rainbow trout) by CDFW, and its fish populations have a high dependence (67-99%) on hatchery fish (Jones & Stokes, 2010). Between 2002 and 2004, CDFG stocked Rollins Reservoir with 320,000 fish (rainbow trout, brown trout, Kokanee). Since 2005, it is annually stocked with 30,000 fish (NID and PG&E, 2010h). The reservoir is also fished for bass, bluegill, crappie, and channel catfish. Camp Far West Reservoir has previously been stocked with spotted and striped bass, and now, with a self-sustaining population of striped bass is considered one of the best bass fishing spots in the Central Valley (Klasing and Brodberg, 2003). Lake Combie is not currently stocked by CDFW. While not stocked directly into the Bear River, 3.5 million spring-run Chinook fry and yearlings and 0.4 million steelhead yearlings originating from the Feather River Hatchery were released into the Feather River between 2004 and 2008 (Jones & Stokes, 2010). Some of these hatchery salmon and steelhead may utilize habitat in the lower Bear River.

Stocked fish may originate from various hatcheries. From 2004-2008, Nevada county received hatchery trout and salmon from six hatcheries (American River Hatchery, Crystal Lake Hatchery, Hot Creek Hatchery, Moccasin Creek Hatchery, San Joaquin Hatchery, and Silverado Fisheries Base), and Yuba county from three hatcheries (American River Hatchery, Crystal Lake Hatchery, and Silverado Fisheries Base) (Jones & Stokes, 2010).

Beyond CDFG stocking, private landowners may also stock private ponds and lakes through private stocking permits issued by CDFG. Throughout the CDFG North Central Region (Region 2), a total of 127 private stocking permits were issued between 2004 and 2008 (averaging 25 permits per year). Half of these were for stocking rainbow, brown, and brook trout in foothill elevations of Nevada, El Dorado, Plumas, Placer, and Sierra counties (Jones & Stokes, 2010). Other plantings involved stocking rainbow, brown, brook, and Lahontan cutthroat trout into public lakes or streams, including Greenhorn Creek. Permits are not required from CDFG to stock white catfish, channel catfish, largemouth bass, bluegill, rainbow trout, or redear sunfish in private ponds if located in Sutter or Yuba counties, or Nevada or Placer counties if west of Highway 49 (Jones & Stokes, 2010). Publicly owned lakes may also be stocked without a permit if a cooperative agreement exists with CDFG.

Stocking activities done by CDFG are exempt from CEQA review processes (Section 15301(j) of State CEQA Guidelines), however an internal review outlined many potential biological impacts of the hatchery and stocking program (Jones & Stokes, 2010), including:

- Water quality concerns from aquaculture chemicals and drugs transferred with hatchery fish;
- Introduced pathogen effects on native amphibians (fish are carriers of amphibian viruses and fungal diseases) and on wild populations of native fish;
- Introducing aquatic invasive species into native ecosystems;
- Spreading invasive species via anglers;
- Predation and competition effects from stocked trout on sensitive and special-status wildlife species (steelhead, Chinook salmon, California red-legged frog, foothill yellow-legged frog, mountain yellow-legged frog);
- Genetic effects on wild fish from interbreeding with stocked fish;
- Disturbance of riparian systems due to vehicle and foot travel during stocking/recreation.

It is possible that disease may not be a primary concern, since the known seven bacterial pathogens, one virus, and 17 parasites found in hatchery fish are also found in wild fish populations (Jones & Stokes, 2010). The recreational and economic benefits to stocking are locally important to anglers and local businesses, with an estimated $1.1 billion spent on freshwater fishing trips and equipment across the state in 2006 (Jones & Stokes, 2010).

III.B.4.e. Other Impacts to Fish

Bioaccumulation of heavy metals, including mercury, should be considered in the restoration of healthy fish populations and in assessing impacts to human health. As of 2009, the safe eating guidelines set by the California Office of Environmental Health Hazard Assessment (OEHHA) suggest that young women (ages 18-45) and children avoid eating catfish or largemouth, smallmouth, and spotted bass from Camp Far West Reservoir based on mercury levels. Similar guidelines for Lake Combie encourage this demographic to avoid suckers and bass, and advise young women and children to limit catfish consumption to one serving a week from Rollins Reservoir (OEHHA, 2009). Levels of total mercury in fish tissue have been found exceeding the Food and Drug Administration (FDA) limit for commercial fish in bluegill, threadfin shad, and spotted bass in Camp Far West Reservoir (Slotton et al., 1995; see the Mine Lands and Mercury section within this document). Due to the nature of bioaccumulation, piscivorous fish have been found to have significantly higher concentrations of mercury than rainbow trout from the same locations (Slotton et al., 1995).

Flows may impact reproductive success, distribution of fish, habitat use, and physiology. Brown and Ford (2002) found that flows on the Tuolumne River the previous year affect the reproductive success of both native and non-native fishes. Habitat suitability is also impacted by flows, as minimum releases below Rollins Reservoir and Lake Combie result in warm water temperatures that are suitable for warm-water species but not cold-water species (National Marine Fisheries Service, 2014c). In a study done by Thompson et al. (2011), a single-day flow pulse in a tributary of the South Fork American River revealed that most adult rainbow and brown trout were unaffected during pulse flows of 18.5 m^3/s, however smaller fish were more likely to be displaced downstream. These smaller fish, often juveniles, likely utilize rock substrate for hydraulic cover during increased flows to decrease water velocity experienced (Chun et al., 2011), since mean oxygen consumption rates are positively correlated with flow and increased flow can result in energetic costs and decreased foraging opportunities (Cocherell et al., 2011). Controlled flood releases can allow species that are not typically highly mobile to make large movements, as seen in a study by Jeffres et al. (2006) where suckers moved >8100 m up and downstream of pre-flood locations (typical movements are <550 m).

The conservation of other wildlife species is closely linked to that of fish. As main prey items for many fish species, the health of benthic macroinvertebrate taxa should also be considered in fish conservation, particularly EPT taxa (mayflies, stoneflies, caddisflies). See the Aquatic Macroinvertebrate Species section below for additional information. Impacts of non-native trout on invertebrates and zooplankton may influence primary production and community structures (Dunham et al., 2004). Additionally, studies have shown that several amphibian species are negatively affected by non-native trout species through increased predation pressure and reducing the availability of fishless habitat, including the chorus frog (*Pseudacris regilla*) and the mountain yellow-legged frog (*Rana muscosa*) which are both found in the Bear watershed (Durham et al., 2004). Other fish such as bass and the Sacramento pikeminnow are thought to be associated with declines of the foothill yellow-legged frog (*Rana boylii*) (Kupferberg, 1996). It is possible, and even likely, that non-native trout impact other amphibian species found in the watershed, however these relationships have not been previously examined.

III.B.4.f. Recovery and Restoration for Fish

The National Marine Fisheries Service (2014c) has identified the following recovery and restoration actions for improving salmonid habitat in the lower Bear watershed:

- Physical remediation to address the deeply incised channels caused by the accumulation of mining sediments and the presence of levees.
- Eradication of invasive plant species such as the Giant arundo.
- Supplementing downstream gravel recruitment.
- Addressing low flows that result in high water temperatures unsuitable to salmonids, including considering reservoir storage and mixing as well as volume, timing, source, and temperature of upstream flow.

Additional restoration suggestions for rainbow trout habitat put forth by the Natural Resources Conservation Service and the Wildlife Habitat Council (NRCS and WHC, 2000) include:

- Maintaining or restoring connectivity of habitat through eliminating or modifying fish passage barriers and maintaining sufficient flows
- Restore or maintain high water quality by fencing livestock to prevent soil erosion and bank collapse, and to limit the nutrient additions to waterways from livestock waste
- Implement seasonal grazing patterns to minimize livestock damage to banks and

riparian vegetation, and buffer zones of 80-100 ft around riparian zones

- Use channel constrictors/deflectors in very shallow, wide streams to concentrate flow, create deeper channels, and increase velocities
- Restore riparian vegetation to protect habitat from siltation, provide habitat for fish prey sources, and provide cover for trout
- Add habitat structures such as in-stream wood and boulders to increase habitat variability and provide cover objects
- Design culverts and bridges to allow for upstream and downstream fish passage (minimum water depth of 0.8 feet, maximum hydraulic drop at the outfall of 0.8 feet, maximum water velocity <4.0 feet/second)

Programs that may provide financial and technical assistance to private landowners for fish habitat improvement include: Conservation Reserve Program (contact: NRCS or FSA State or County Office), Environmental Quality Incentives Program (contact: NRCS State or County Office), Partners for Fish and Wildlife Program (contact: local office of the U.S. Fish and Wildlife Service), Waterways for Wildlife (contact: Wildlife Habitat Council, 301-588-8994), Wetlands Reserve Program (contact: NRCS State or County Office, Wildlife at Work (contact: Wildlife Habitat Council), Wildlife Habitat Incentives Program (contact: NRCS State of County Office), and state and wildlife agencies and private groups such as Trout Unlimited. See the Fish and Wildlife Habitat Management Leaflet Number 13: Rainbow Trout (*Oncorhynchus mykiss*) for land eligibility details and type of assistance (NRCS and WHC, 2000).

III.B.5. Aquatic macroinvertebrate species

III.B.5.a. Introduction

Benthic macroinvertebrates (insects and similar organisms that spend all or a portion of their life cycle within the substrate at the bottom of rivers and creeks) are powerful indicators of stream health. Some benthic macroinvertebrates are very sensitive to changes and disturbances in their aquatic environment and can indicate the conditions of their stream habitat (Bell, 2013). Benthic macroinvertebrates are often incorporated into aquatic bioassessments because in they are easy to sample, have a wide range of responses to anthropogenic and natural disturbance stressors, and are relatively sedentary and long-lived. Activities that disrupt the natural processes in a watershed can have a significant impact on the types and abundances of benthic macroinvertebrates found in a stream reach (Bell, 2013). Resident aquatic species can indicate the habitat quality of a waterway in a more comprehensive manner than many chemical or physical measures because they incorporate all of the biogeochemical influences to which they are exposed throughout their lifetimes (Karr 1991, Barbour et al. 1996, 2000, Karr and Chu 2000, Bell 2013). Aquatic organisms can also reflect changes that are often not detected by chemical toxicity tests including temperature changes, sediment deposition, nutrient runoff, and habitat degradation (Karr and Chu 1999, Barbour et al. 2000, Bell 2013). Characteristics of a macroinvertebrate assemblage, known as metrics, help describe the structure and function of the aquatic community, with many metrics responding to disturbances in a predictable manner (Barbour et al., 1996).

III.B.5.b. Available Data

Benthic macroinvertebrate data has been collected at multiple sites in the Bear River and its tributaries. Macroinvertebrate data was reviewed and summarized from five separate studies completed in the Bear River Watershed since 1999:

1. 1999-2001 study by the USGS (Alpers *et al.,* 2005) on mercury contamination in the Greenhorn Creek watershed that sampled macroinvertebrates at 31 sites with the goal of identifying candidate locations for remediation efforts by the Bureau of Land Management and the US Dept. of Agriculture – Forest Service.

2. 2002 NCRCD Proposition 204-funded water quality project (van der Veen, 2003) that sampled 15 sites throughout the watershed during the spring and fall of 2002. These findings include a summary of key taxonomic indices from the initial data analysis.

3. 2006 PG&E Bear River Monitoring Project (Jones & Stokes, 2006) that sampled ten

sites yearly from 2003-2005, between Dutch Flat Afterbay and Chicago Park Powerhouse, in response to flume overtoppings (spill events).

4. 2010 NID Yuba-Bear / PG&E Drum-Spaulding Project (NID and PG&E, 2010e) that sampled 6 sites during the spring and fall of 2009 as a part of FERC relicensing efforts.

5. 2014 NID Instream Flow and Sediment Studies for Bear River and Deer Creek completed by ECORP Consulting, Inc. (ECORP, 2014) that sampled from the 844 ft Laursen reach between Highway 49 and the confluence of Wolf Creek on October 11, 2012 in support of NID's ongoing licensing efforts with the State Water Resources Control Board.

Further analysis of NID's Instream Flow and Sediment Studies on the Bear (ECORP, 2014) can be found in Section C.4: Water Management. In-depth information on mercury contamination more broadly from the USGS Study (Alpers et al., 2005) can be found in Section C.5a: Mine Lands and Mercury.

III.B.5.c. Sampling Sites

The sampling sites used in these studies can be found in Map Form in Figure 9. They are listed below in Table 21.

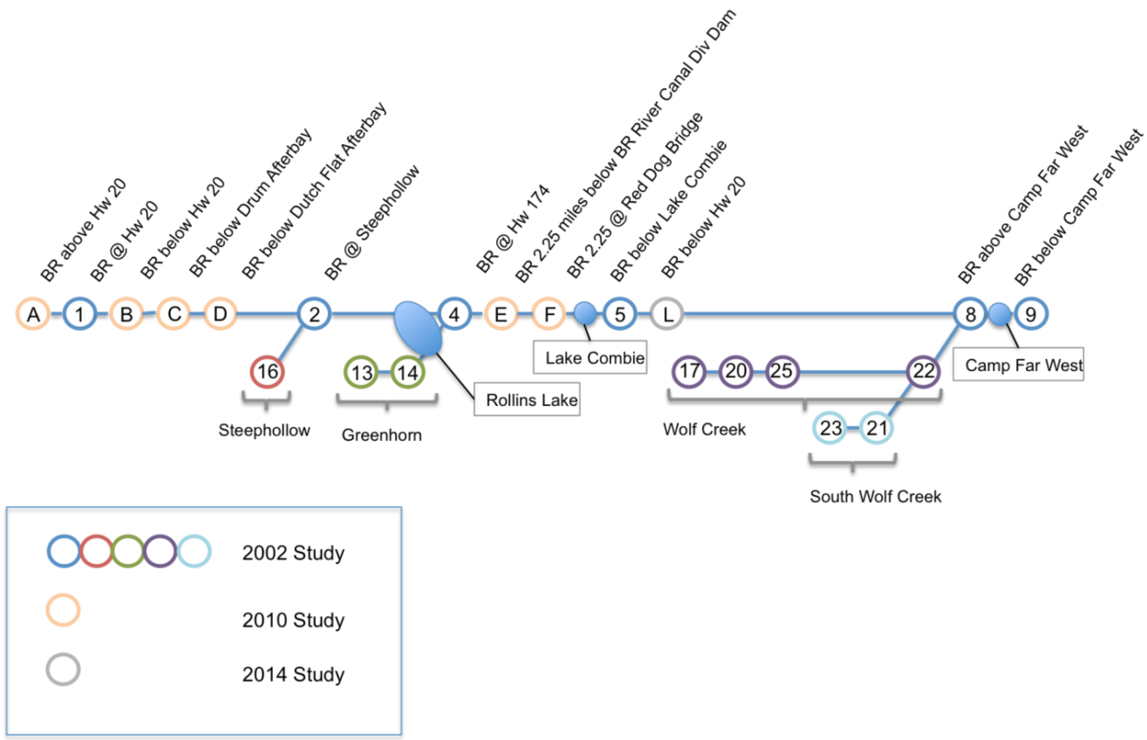
***Table 21*. Macroinvertebrate Sampling Locations**

Site	Location
2002 SITES	
1	Bear River (BR) at Highway 20
2	Bear River at Steephollow Creek
4	Bear River at Highway 174
5	Bear River below Lake Combie
8	Bear River above Camp Far West
9	Bear River at Highway 65
13	Greenhorn Creek (GH) at Red Dog Rd.
14	Greenhorn Creek at You Bet Rd.
16	Steephollow (SH) Creek at Hwy 20
17	Wolf Creek (WC) at Loma Rica Ranch
20	Wolf Creek at Lime Kiln Rd.
21	South Wolf Creek (SWC) at Hwy 49
22	Wolf Creek at Wolf Rd.
23	South Wolf Creek at Dog Bar Rd.
25	Wolf Creek at North Star Mine Museum

Site	Location
2006 SITES	10 Sites between Dutch Flat Afterbay and Chicago Park Powerhouse (specific locations being researched)
2010 SITES	
A – Bear River #1	Bear River 0.1 miles downstream of Drum Canal inflow
B – Bear River #2	Bear River 2.25 miles downstream of Drum Canal inflow
C - Drum Afterbay Dam	1.42 miles downstream of Drum Afterbay
D - Dutch Flat Afterbay Dam	.72 miles downstream from Dutch Flat Afterbay
E – Bear River Canal Diversion Dam Upper	2.25 miles downstream of the Bear River Canal Diversion Dam
F – Bear River Canal Diversion Dam Lower	7.16 miles downstream of the Bear River Canal Diversion Dam
2014 SITE	
Laursen Reach	.5 miles downstream of Hwy 49 crossing
1999-01 SITES	31 sites within Greenhorn watershed

Figure 23 is provided in order to more easily understand and compare the charts of benthic macroinvertebrate (BMI) data from the various studies and locations. It helps visualize the spatial relationship of data from the various years (2002, 2010, 2014) and tributaries (Steephollow, Greenhorn, Wolf Creek, and South Wolf Creek) covered in these data sets. It also provides visual reminders as to the location of the key disturbances including Rollins Reservoir, Lake Combie, and Camp Far West. Please refer to this diagram when interpreting the graphs of taxonomic indices.

Figure 23. Relationship of Bear River BMI Sampling Sites



III.B.5.d. Results

Previous studies on mercury bioaccumulation in fish (May, 2000) led to the identification of three reservoirs and the section of Bear River near Dog Bar Road as impaired water bodies pursuant to the Clean Water Act (California Regional Water Quality Control Board, 2003). The follow-up study analyzed water, sediment, invertebrate, and frog samples from 40 sites in the Greenhorn Creek area in order to identify candidate "hot spots" with high levels of total mercury (THg) and methyl mercury (MeHg) contamination and bioaccumulation, with the goal of providing input to stakeholders to help identify future mercury remediation and removal projects (Alpers et al., 2005). Stakeholders included Bureau of Land Management, California State Water Resources Board, Nevada County Resources Conservation District, US Department of Agriculture – Forest Service. Thirty one of the 40 sites provided samples used to report on mercury bioaccumulation in invertebrates. The results of mercury sampling in invertebrates on Greenhorn Creek is summarized in Table 22.

Results identified two remediation site candidates: abandoned sluice tunnels in the Sailor

Flat Mine area, and the Boston Mine area. The study concluded that annual changes in MeHg by taxon varied with habitat stability, with permanent habitats showing consistently high MeHg concentrations, and with predator taxa having higher percentages of MeHg (MeHg/THg) than herbivores, detritivores, and omnivores (Alpers et al., 2005). The study showed that several taxa of predatory insects could serve as consistent and reproducible indicators for mercury bioaccumulation levels, with consistent levels found within local contamination sites (however concentrations were variable for all taxa across the broader study area (Alpers, et al. 2005).

***Table 22*. Methylmercury Concentrations in Greenhorn Creek Invertebrates (data from Alpers et. al, 2005)**

Taxa	Common name	MeHg (µg/g)
Gastropoda: Arionidae	banana slugs	0.0012-0.048
Megaloptera: Corydalidae	dobsonflies	0.027-0.39
Odanata: Aeshnidae, Cordulegastridae, Gomphidae, Libellulidae	dragonflies	0.011-1.6
Plecoptera: Perlidae	predacious stoneflies	0.026-0.52
Coleotera: Dytiscidae	predacious diving beetles	0.029-0.50
Hemiptera: Gerridae	water striders	0.061-0.55

Taxonomic data that is available for each year of study is shown in Table 23. Data from the 2006 studies has not yet been acquired.

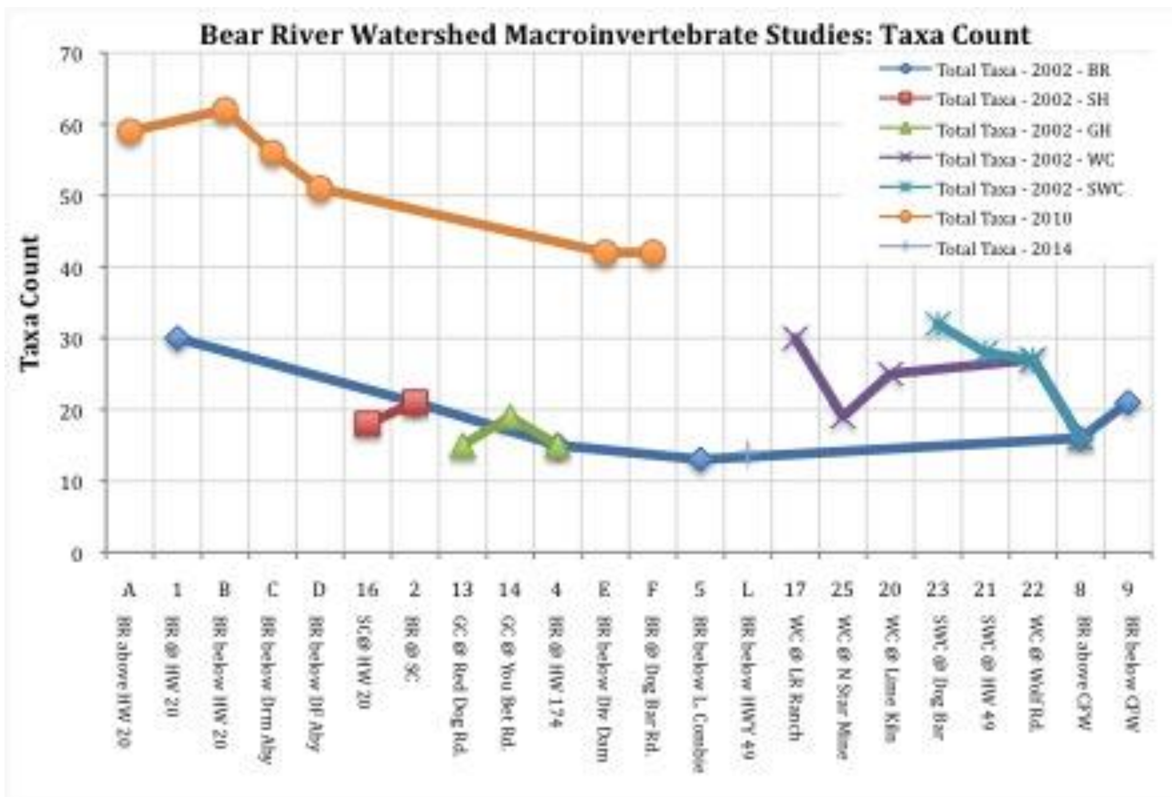
***Table 23*. Taxonomic Data Availability by Year**

Metric	2002	2010	2014
Taxa Richness	X	X	X
EPT Taxa	X	X	X
Shredder %	X	X	
Collector/Gatherer %	X	X	
Tolerant %	X	X	
Intolerant %	X	X	
IBI		X	
MMI		X	

The figures on the following pages and text compare two taxonomic richness measures (Total Taxa, Figure 24 and EPT Taxa, Figure 25) that were available across each of the 2002, 2010, and 2014 studies. It also reviews two tolerance measures (Tolerant %, Figure 26, and Intolerant %, Figure 27), and functional feeding group measures (Shredder %, Figure 28, Collector/Gatherer %, Figure 29) that were available in both the 2002 and 2010 studies. Finally, Index of Biotic Integrity (IBI) and Multi-metric Index (MMI) metrics (Figure 30) are summarized as reported in the 2010 study, with considerations for use of various IBI algorithms for future Bear River watershed reporting (NID and PG&E, 2010e).

TAXA RICHNESS BASED ON TOTAL TAXA COUNT

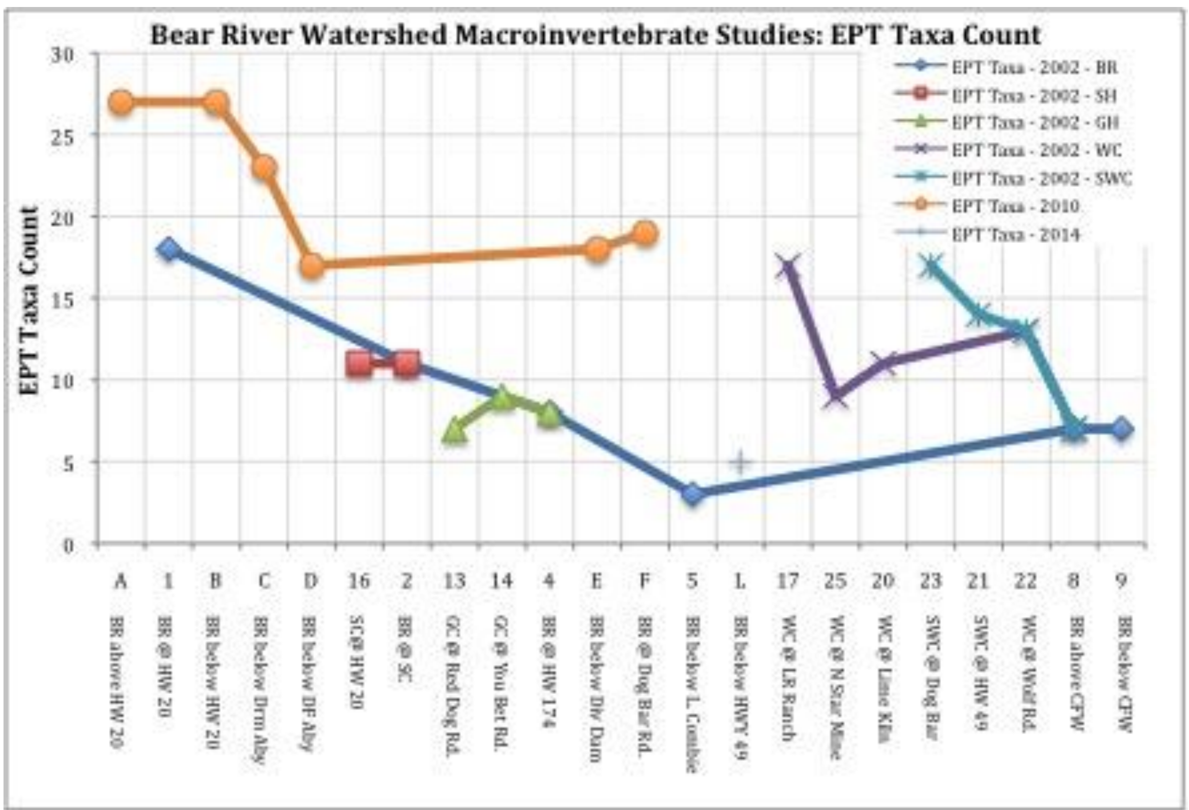
Figure 24. Total Taxa Counts for 2002, 2010, and 2014 Sites



The total taxa count is a measure of overall variety of the macroinvertebrate assemblage, and a primary indication of the health of the local water system. This metric was reported across the 2002, 2010, and 2014 studies and allows for a key point of comparison between sampling sites and years. In general, the data for both 2002 and 2010 indicate a gradual reduction in the total taxa count from the headwaters of the Bear River to the sampling sites around Lake Combie. Data from 2002 indicates a similar pattern from the headwaters of Wolf Creek and South Wolf Creek to sampling points on the Bear River above Camp Far West. The 2002 and 2014 data shows the sampling points below Lake Combie (points 5 & L) have the lowest total Taxa Count when compared to all other sites and years. It's important to note that the 2014 Laursen reach data downstream of Lake Combie is consistent with the total taxa count below Lake Combie from the 2002 study, although the 2014 study was qualitative in nature (ECORP, 2014). While the 2014 study concluded from the Laursen reach data that the Bear River had the lowest species diversity (based on taxa richness), and the lowest EPT counts compared to communities in the neighboring Sierra watersheds of South Fork American, North Fork Mokelumne, and Middle Fork Yuba Rivers, the taxa count for the several other sites sampled in 2002 and 2010 are comparable to the ranges reported for other watersheds in the 2014 study (ECORP, 2014).

EPT TAXA

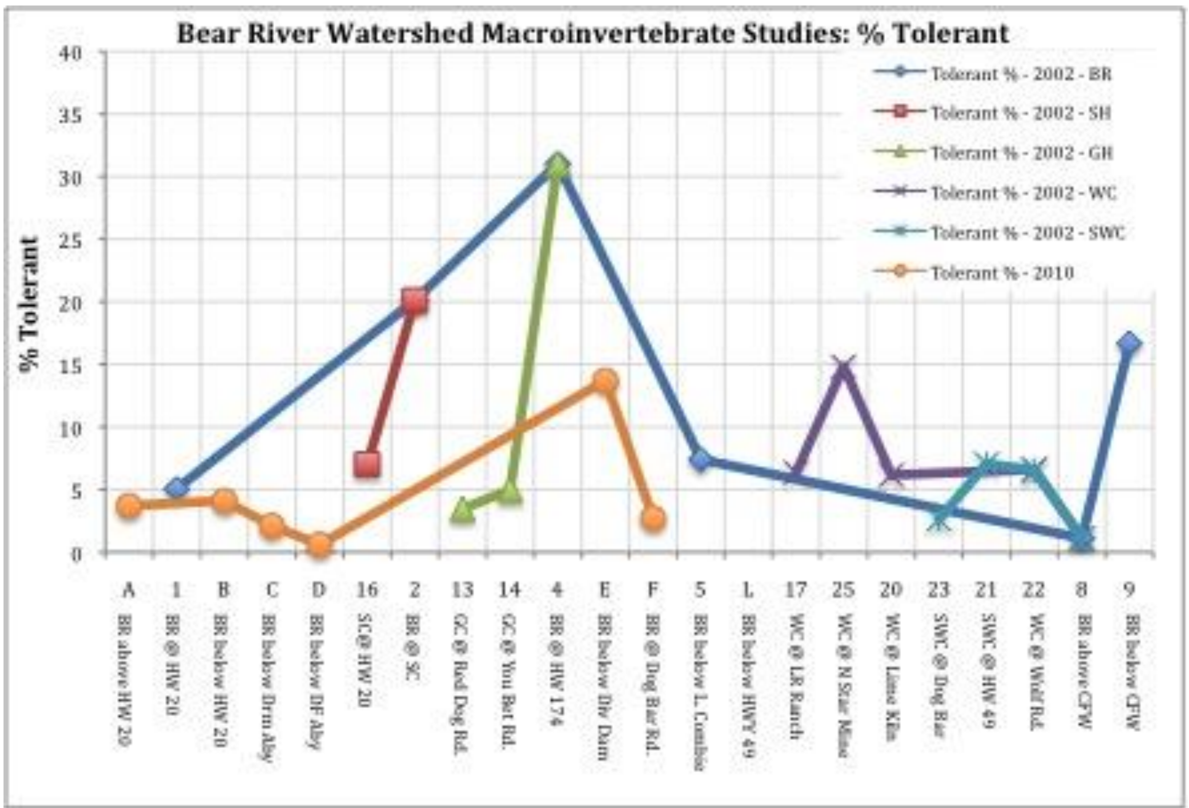
Figure 25. EPT Taxa Counts for 2002, 2010, and 2014 Sites



This metric describes the number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These macroinvertebrate taxa are generally sensitive to the effects of pollutants and disturbances in the water system. This metric was also reported across the 2002, 2010, and 2014 studies and allows for a second point of comparison. The EPT taxa counts were highest at sampling sites near the headwaters of the Bear River, Wolf Creek, and South Wolf Creek, dropping to their lowest point in the surveys below Lake Combie in 2002 (point #5) and 2014 (point L). Again, it's important to note that the 2014 report used data from the Laursen reach below Lake Combie to conclude that the Bear River had lower EPT counts than neighboring watersheds (see total taxa discussion); however, the EPT numbers from other 2002 and 2010 sites are comparable to the ranges reported for other watersheds in the 2014 study (ECORP, 2014).

PERCENTAGE OF TOLERANT BMI

Figure 26. Percentage of Pollution-Tolerant Samples per Site for 2002 and 2010 sites

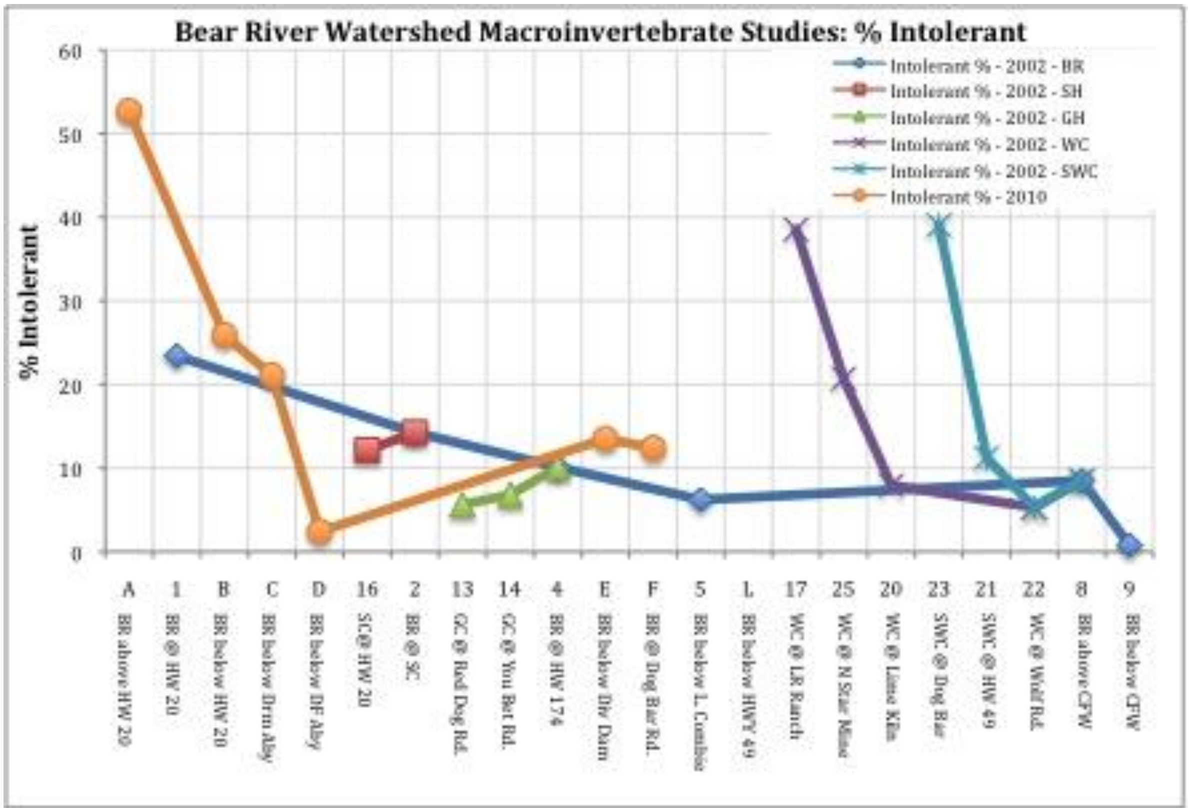


This metric defines the percentage of macroinvertebrates considered to be tolerant of various types of perturbations to the water system. Here the 2002 and 2010 data show an increase in the percent of tolerant organisms from the headwaters of the Bear River and the Steephollow and Greenhorn tributaries to the highest percentages for each study at sampling points below Rollins Reservoir. Percentages then decrease again at sampling points approaching (2010) and below (2002) Lake Combie, suggesting a significant change in environmental factors affecting aquatic organisms from Rollins Reservoir, along the Bear

River to, and through, Lake Combie. This portion of the river includes several current disturbances, including Rollins Reservoir dam and an active gravel quarry. It is also the proposed site for the Centennial/Parker Dam and sediment/mercury removal just upstream from Lake Combie. It would be useful to re-sample the sites that were sampled in the 2002 and 2010 studies to provide data on existing conditions within this reach, to confirm the results from previous studies, and to identify additional sampling points along this stretch of river in order to monitor the effects from disturbances within this reach.

POLLUTION-INTOLERANT PERCENTAGE

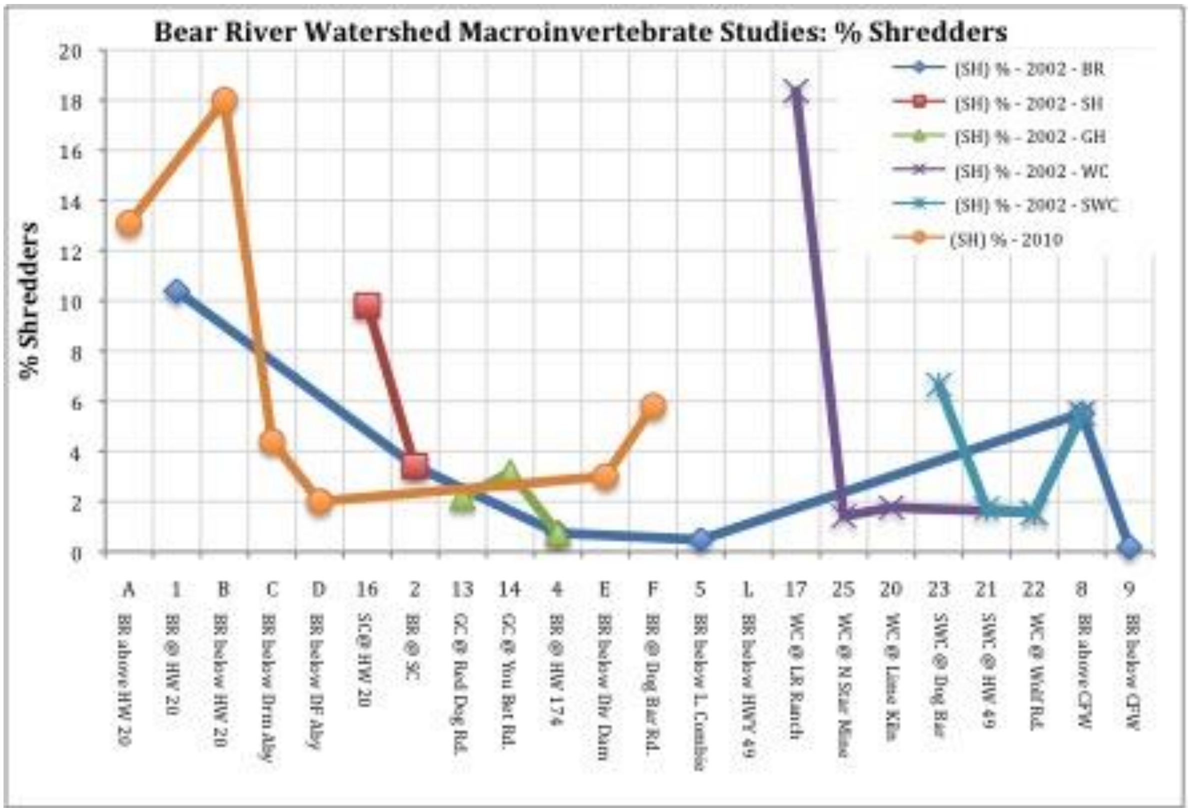
Figure 27. Percent of Pollution-Intolerant Samples per Site for 2002 and 2010 sites



This metric defines the percentage of macroinvertebrates that are intolerant to perturbations in the water system. In a highly manipulated water system such as the Bear River watershed, this number will typically decline from the headwaters to the lower reaches. For both the 2002 and 2010 studies there was a decline from the headwaters of the Bear River and Wolf Creek tributaries when compared with samples at convergence or downstream points on the Bear River.

PERCENTAGE OF SHREDDERS

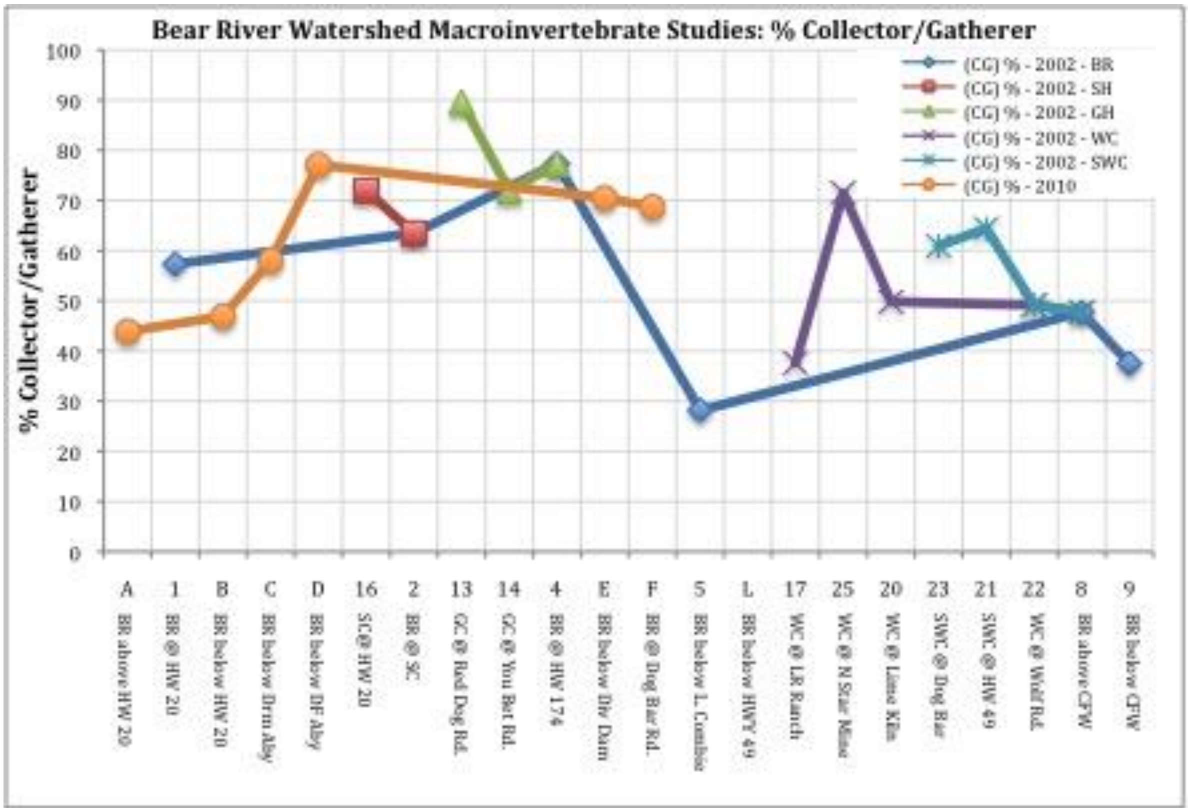
Figure 28. Percentage of Shredder Samples for 2002 and 2010 Sites



Analysis of macroinvertebrate functional feeding groups can provide insight into the status of food sources targeted by those groups and unusual changes to those food sources caused by perturbations in the local environment (Barbour et al., 1996). In particular, shredders are specialized in breaking down coarse particulate organic matter (CPOM) in areas of rich vegetation and canopy that is typical of the upper reaches of the Bear River and its tributaries. The percentage of shredders, or the Shredder Index, at sites in the watershed headwaters was higher in both the 2002 and 2010 studies than at sites located downstream. In the 2002 study, the Shredder Index dropped to less than 1% below Rollins Reservoir and below Lake Combie, rising to 5% again above Camp Far West, and dropping again to less than 1% below Camp Far West. The low values downstream of Rollins Reservoir, Lake Combie, and Camp Far West are likely due to the reservoirs capturing CPOM, with the increase between Lake Combie and Camp Far West reflecting CPOM contributions from Wolf Creek and other tributaries. While a decrease in the total percentage of shredders with distance from the headwaters is expected, additional analysis is needed on the low numbers below Rollins Reservoir, Lake Combie, and Camp Far West, including comparisons with nearby watersheds.

PERCENTAGE OF COLLECTOR / GATHERERS

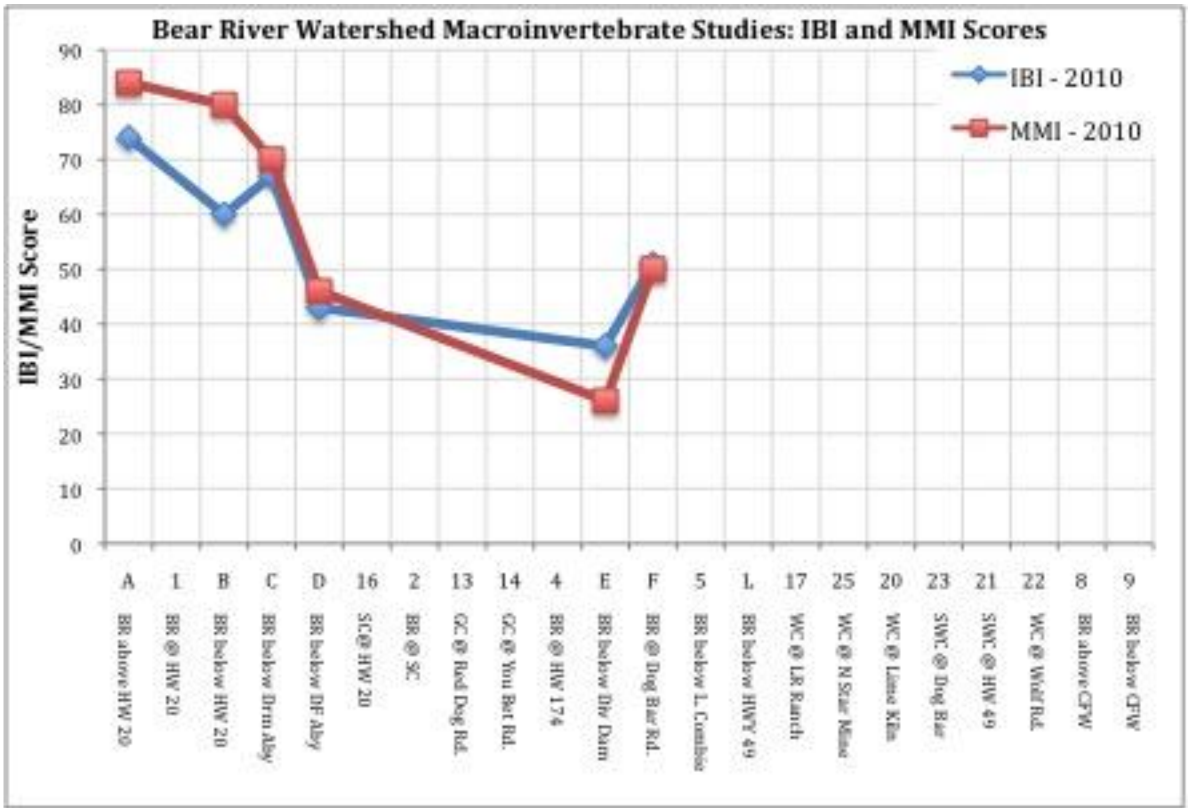
Figure 29. Percentage of Collector/Gatherer Samples per Site for 2002 and 2010 Sites



Another functional feeding group of interest is the generalist macroinvertebrates that collect and gather fine particulate organic matter transported in the water column from local and upstream sources. Both the 2002 and 2010 studies show a general increase in the percentage of collector/gatherers in the Bear River from the headwaters to below Rollins Reservoir. Interestingly, in the 2002 study the percentage of collector/gatherers drops significantly below Lake Combie (point #5), potentially reflecting the influence of the reservoir on downstream habitat and aquatic species. Given the low total taxa and EPT counts downstream of Lake Combie in the 2002 and 2014 studies, further analysis is required to identify factors influencing conditions in that reach, including repeat sampling at sites sampled in previous studies.

INDEX OF BIOTIC INTEGRITY (IBI) AND MULTI-METRIC INDEX (MMI)

Figure 30. Index of Biotic Integrity (IBI) and Multi-Metric Index (MMI) for 2010 sites



Benthic macroinvertebrate data can be evaluated using combined measures of biological condition known as indices of biotic integrity (IBIs) or multi-metric indices (MMIs) (Bell, 2013). An index of biotic integrity or multi-metric index uses several characteristics of benthic macroinvertebrate assemblages and aquatic habitats, to evaluate the health and function of the aquatic community, as well as how the community responds to disturbances (Barbour et al., 1996; Bell 2013). The 2010 IBI and MMI scores generally decreased with elevation downstream to Rollins Reservoir, and increased for the lowest elevation reach between Rollins Reservoir and Lake Combie (NID and PG&E, 2010e). The IBI scores for the upper three higher elevation montane sites, A and B in Bear Valley, and C below the Drum Afterbay Dam scored in the 95th percentile of scores from 16 Western-slope Sierra Nevada reference sites (Rehn, 2009; NID and PG&E, 2010e). The three lower elevation sites, D (a montane ecozone below Dutch Flat Dam), E and F (two foothill ecozone sites below the Bear River diversion dam), all ranked in the 50th percentile or less (NID and PG&E, 2010e). According to the 2010 report, both D and E sites “had the lowest IBI and MMI scores in the Bear River, despite having moderate riparian vegetation development and a diverse streambed substrate composition. Disruption of the stream flow regime at both diversion dams possibly has an important influence on the BMI community composition here (NID and PG&E, 2010e)." This is consistent with other taxonomic data presented above, which also points to the need for additional studies in the reach from Rollins Reservoir and Dutch Flat dam downstream through Lake Combie.

SUMMARY OF 2006 FINDINGS (Jones & Stokes, 2006)

Only a high level summary of select findings from the benthic macroinvertebrate sampling is provided for the 2006 study. The report author and PG&E project lead have been contacted for access to the report's Appendix "C," which contains more detailed data and information.

The high level summary describes highly varied effects on BMI metrics from a series of spill events in the study area (Jones & Stokes, 2006). In particular, there was an observed decrease in % Baetidae (as much as 40% at some sites) as the river system flushed out sediment from the spills over the course of the three-year study (Jones & Stokes, 2006).

III.3.5.e. Conclusion and Summary of Macroinvertebrate Results

1. Data from 1999-2001 study on mercury levels in the Greenhorn Creek watershed show that certain taxa of macroinvertebrates can be used as effective indicators of mercury bioaccumulation, which along with other data can help identify candidate locations for mercury remediation and removal. This data would also be useful in assessing the impact of any new disturbances (e.g. dredging, gravel quarry, new construction, etc…) that might release residual mercury into the water column and biocommunity. Consideration should be given to establishing a baseline mercury analysis from a selected subset of BMI sampling sites to address questions regarding the impact of mining and mercury contamination within the watershed.
2. Taxa studies from 2002, 2006, 2010, and 2014 provide a useful spatial and temporal analysis across the watershed, with richness, functional feeding group, and tolerance showing generally good riparian health near the headwaters and decreasing with elevation, with particular degradation at sampling points below the primary dams (Dutch Flat Afterbay, Rollins, Bear River Diversion, Lake Combie, and Camp Far West specifically). This effect seems consistent with findings in neighboring watersheds.

3. Taxa metrics from 2002 and 2014 indicate particularly low taxa richness in the reach below Lake Combie, before the confluence with Wolf Creek.
    a. Given the presence of two significant disturbance sites (Lake of the Pines and the South Nevada County Water Treatment Plant) on the Magnolia Creek tributary, which feeds into this section of the Bear River downstream of Lake Combie, it would be useful to consider additional sampling locations in this portion of the watershed to evaluate the effects of these disturbances on aquatic organisms.
4. The 2002 and 2010 studies both suggest a significant decrease in stream health immediately below Dutch Flat Afterbay dam, Rollins Reservoir dam, and the Bear River Canal diversion dam, followed by a noticeable improvement in metrics sampled at downstream points prior to Lake Combie. The 2002 study shows further decreases in riparian health indicators in the reach below Lake Combie. It would be useful to consider obtaining additional sampling points in these reaches in order to isolate and monitor the causes of this variability. This would be useful for isolating effects from specific disturbances, such as from each current and proposed dam, and from current and future gravel quarrying and sediment removal operations targeted for these reaches.
5. The 2006 study provides useful data on the impact of scouring type flows on the watershed, showing significant changes in the habitat profile. It would be useful to obtain the original BMI data to further investigate the impact of these changes to the macroinvertebrate community.
6. Only the 2010 report utilized an Index of Biotic Integrity. It would be useful to agree on a common IBI or MMI that can help summarize and compare benthic macroinvertebrates and aquatic habitat data across the various local, state, and federal studies.
7. None of the studies reviewed here address the Magnolia or Dry Creek tributaries – additional data from those watersheds would be useful for establishing baseline conditions and to evaluate important disturbances in those areas. In addition, other than the single site from the 2002 study, there seems to be a lack of data from the significant stretch of Bear River below Camp Far West. Additional BMI sampling sites near the convergence of the Feather River could provide valuable insight on the impact of the agriculture-related disturbances common in that portion of the watershed.

III.B.6. Invasive species

III.B.6a. Invasive plants

Throughout California, urban and suburban development, livestock, roads, and agriculture have been cited as the predominant causes of native plant population declines; however, on a local scale, the introduction and spread of non-native plants has also been implicated in the decline of numerous special status plant species (D'Antonio et al., 1992). Invasive plant species can outcompete native plants and significantly alter plant and animal communities, threatening entire ecosystems. Restoration efforts are often limited by time and funding; therefore, the focus of invasive species control should be on those posing the greatest threat to native ecosystems. WHIPPET, or the "Weed Heuristics: Invasive Population Prioritization for Eradication Tool" (whippet.cal-ipc.org), draws on data from the Calflora database (www.calflora.org) to prioritize 200 Californian weeds for eradication based on the plant's potential impact, invasiveness, and feasibility of eradication. Impact is scored through impacts to wildlands and site value, while invasiveness is based on distance to other conspecifics, rate of spread, and distance to dispersal vectors such as roads, rivers, and mines. Feasibility of eradication considers population size, reproductive ability, species detectability, site accessibility, control effectiveness, and control cost. Overall scores are on a scale of zero to ten. The WHIPPET tool emphasizes cost-effective efforts to control high-risk populations, therefore smaller populations and species that are easier to control are scored higher than populations that are larger or more difficult to control.

Due to variations in invasiveness and feasibility of eradication, populations of the same species may receive different WHIPPET scores. However, species with consistently high scores in the Bear River watershed are:

- *Lepidium latifolium* (perennial pepperweed)
- *Arundo donax* (giant reed)
- *Onopordum acanthium* (Scotch thistle)
- *Sesbania punicea* (scarlet wisteria)
- *Lythrum salicaria* (purple loosestrife)
- *Rubus armeniacus* (Himalayan blackberry).

Species that are commonly found in the Bear River watershed but frequently received a lower WHIPPET score due to difficulty of eradication include:

- *Centaurea solstitialis* (yellow starthistle)
- *Centaurea stoebe ssp. micranthos* (spotted knapweed)
- *Cytisus scoparius* (Scotch broom)
- *Hordeum murinum* (hare barley)
- *Lolium multiflorum* (Italian ryegrass).

Figure 31 shows the WHIPPET scores of all locations surveyed within the watershed, while Figure 32 isolates the 15 highest priority sites determined by WHIPPET score. Sites in Figure 32 are numbered in order of priority. Many of the priority sites are found on PG&E land, which will soon be transferred to conservation easements held by the Bear Yuba Land Trust and Placer Land Trust. Table 24 describes the populations of invasive plant species found at each of these high priority sites. Populations that were surveyed many years ago may need to be verified.

There is a strong need to fill data gaps of targeted invasive plant species abundance and location throughout the watershed in order to prioritize invasive plant control needs. Databases and resources to research while creating an invasive plant management plan include the Jepson Herbarium (http://ucjeps.berkeley.edu/), the California Vegetation Map Catalog put together by the UC Davis Information Center for the Environment (http://ice.ucdavis.edu/project/veg-map-catalog), and federal datasets such as BLM's National Invasive Species Information Management System (NISIMS; http://www.ntc.blm.gov/krc/viewresource.php?courseID=404) or USFS's National Invasive Plant Inventory (http://apps.fs.usda.gov/ArcX/rest/services/EDW/EDW_InvasiveSpecies _01/MapServer).

Weed Management Areas (WMAs) are local stakeholder groups, organized by county through county Agricultural Commissioners' offices, who develop a strategic plan that identifies top priorities for local weed management. The Bear River has two active WMA's, Placer/Nevada County and Yuba/Sutter County. WMA's plan and implement projects on-the-ground, collaborate on mapping and public education, and are likely to be a great resource.

Figure 31. WHIPPET-Documented Invasive Plant Populations

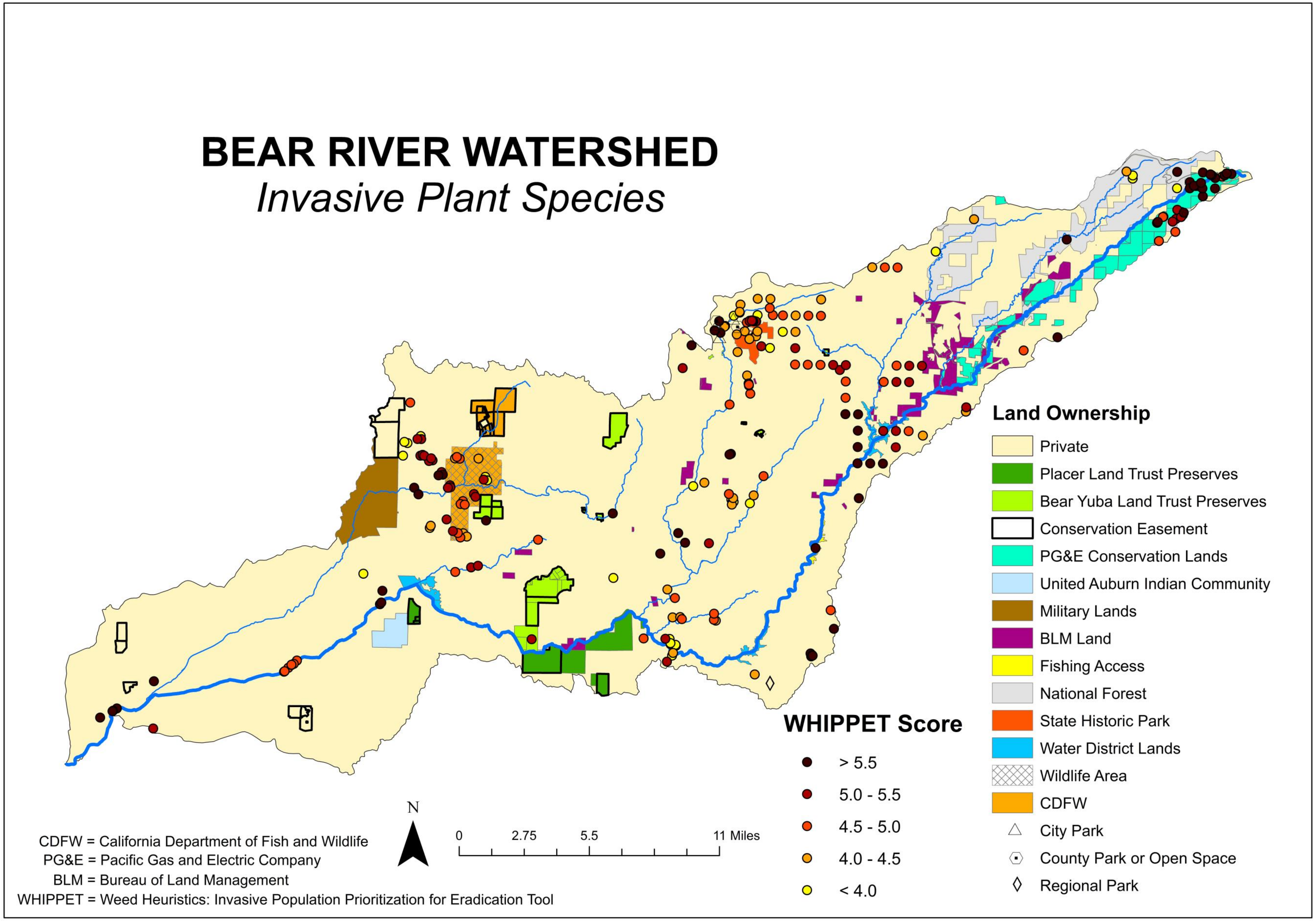


Figure 32. Top 17 WHIPPET Priority Invasive Plant Populations

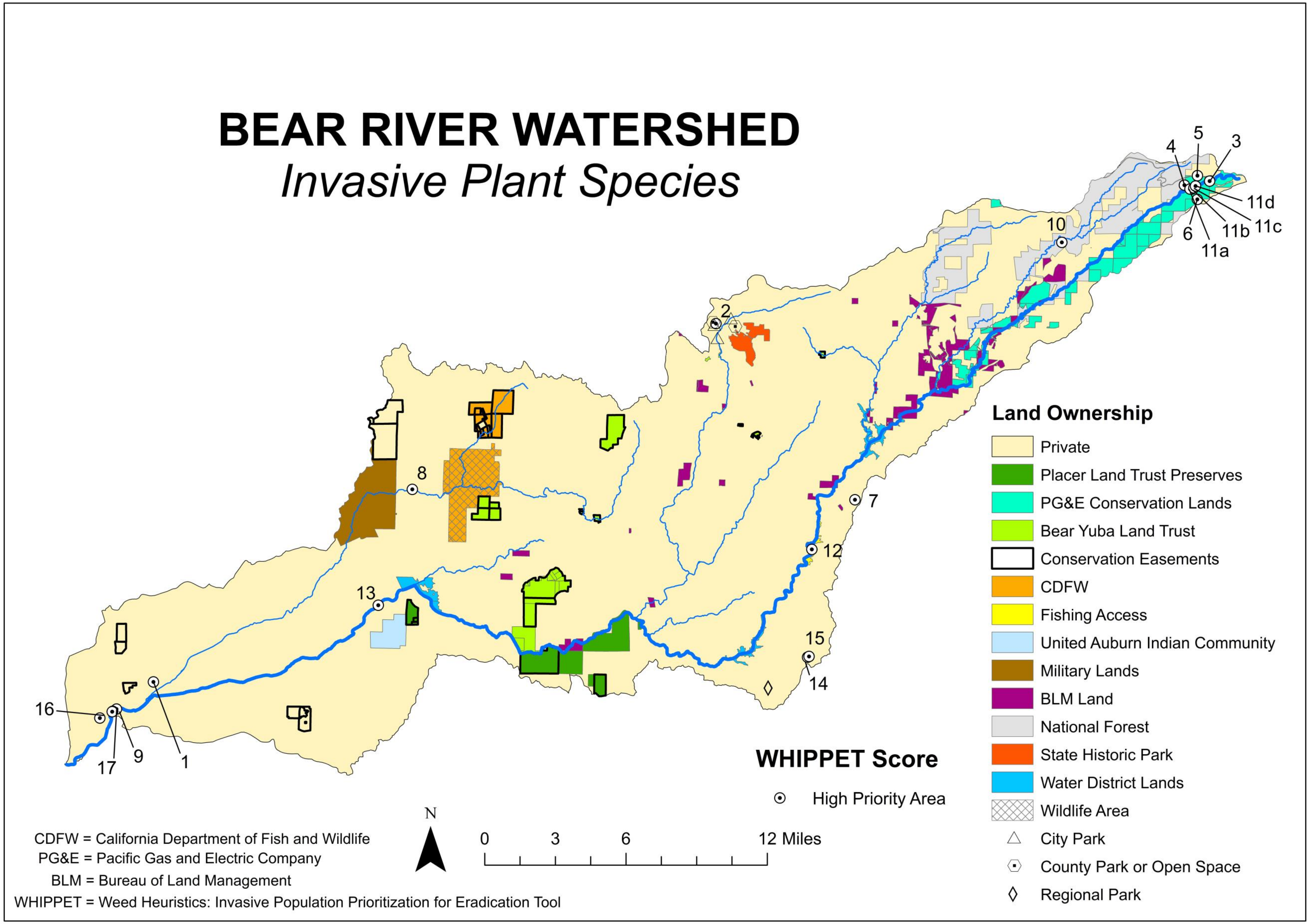


***Table 24*. Invasive plants with highest priority for eradication in the Bear River Watershed, as ranked by the California Invasive Plant Council**

Site	Invasive Species	Population Size	WHIPPET Score	Survey Date	Land Ownership
1	Purple loosestrife (*Lythrum salicaria*)	Not given	7.333	7/26/1993	Private
2	Uruguay/creeping water-primrose	Not given	7.157	7/27/2004	Private
3	Scotch thistle (*Onopordum acanthium*)	0.01 acres	7.151	6/17/2015	PG&E
	Scotch thistle (*Onopordum acanthium*)	0.0 acres	6.753	10/6/2015	
4	Perennial pepperweed (*Lepidium latifolium*)	Not given	7.123	9/10/2009	Private
5	Scotch thistle (*Onopordum acanthium*)	Not given	7.013	4/7/1988	PG&E
6	Scotch thistle (*Onopordum acanthium*)	Not given	6.961	11/22/1995	PG&E
7	Purple loosestrife (*Lythrum salicaria*)	Not given	6.934	7/28/2003	Private
8	Poison-hemlock (*Conium maculatum*)	Not given	6.8	8/5/2005	Private
9	Scarlet wisteria (*Sesbania punicea*)	Not given	6.743	6/29/2010	Private
10	Medusahead (*Elymus caput-medusae*)	0.1967 acres	6.723	10/18/2010	Tahoe Nat'l Forest
11	Scotch thistle (*Onopordum acanthium*)	0.0 acres	6.701	10/6/2015	PG&E
12	Italian thistle (*Carduus pycnocepthalus*)	Not given	6.698	7/16/1990	State Fishing Access
13	Scarlet wisteria (*Sesbania punicea*)	Not given	6.691	9/22/2015	Private
14	Himalayan blackberry (*Rubus armeniacus*)	Not given	6.683	5/18/2012	Private
	French broom (*Genista monspessulana*)	Not given	6.622	5/18/2012	Private
15	Russian knapweed (*Acroptilon repens*)	Not given	6.611	7/6/2015	Private
	Scarlet wisteria (*Sesbania punicea*)	Not given	6.57	6/29/2010	Private

III.B.6b. Invasive plant pathogens

BIG LEAF MAPLE SCORCH

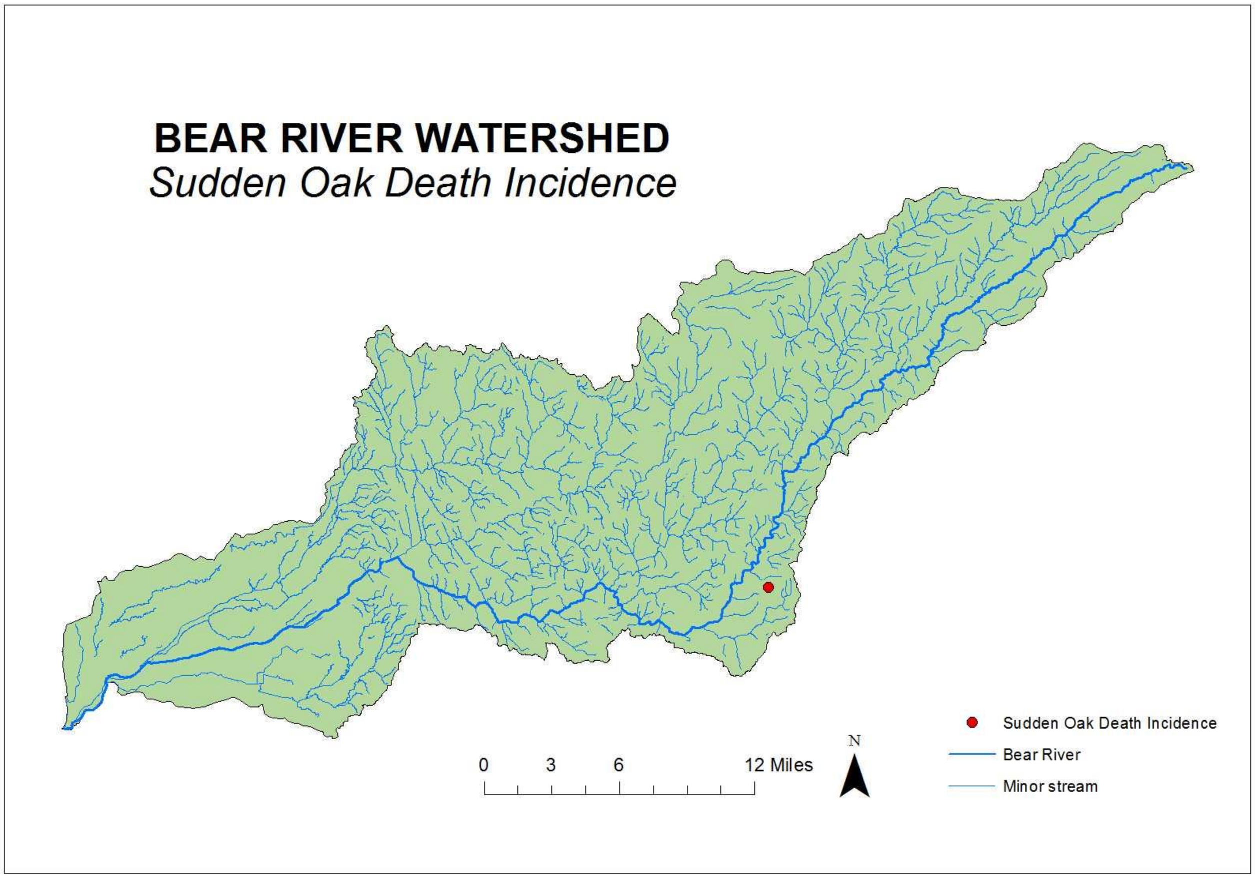
Big leaf maple leaf scorch (*Xylella fastidiosa*) is a parasitic bacterium which has become established in Nevada County and is impacting big leaf maples (*Acer macrophyllum*) in the Yuba watershed (Marilyn Tierney, Tahoe National Forest Wildlife Biologist, personal conversation). *Xylella fastidiosa* is transmitted from diseased to healthy plants by insects with piercing or sucking mouthparts, such as sharpshooters, which feed on xylem (plant tissue that transports water and minerals from roots)(Purcell, 1985). This can lead to stress and mortality in infected plants. This pathogen has been found in Placer and Yuba Counties. No positive detections of the pathogen have been documented in the Bear watershed, but there is a good possibility of infection due to location. Drought and climate change may increase mortality in big leaf maples trees which could have devastating effects on some riparian areas. Currently, the best way to manage *Xylella fastidiosa* is to prevent the spread of its vectors and to detect and remove infected plants as early as possible.

SUDDEN OAK DEATH

Since the mid-1990s, millions of native oak trees in the Coast Ranges of California and Oregon have fallen to Sudden Oak Death, a newly introduced disease caused by the microscopic pathogen *Phytophthora ramorum*. In addition to killing tan oak and several true oak species such as California black oak and canyon live oak, *Phytophthora ramorum* causes twig and foliar diseases in many other trees and shrubs such as California bay laurel, Douglas-fir, madrone, rhododendron, and coast redwood.

The first and only Sierra record of *Phytophthora ramorum* was discovered in the Bear River Watershed in 2012, at the location shown in Figure 33 (Garbelotto and Barbosa 2014). The pathogen was identified in the foothills of Placer County, in a garden rhododendron at ~1,800 ft elevation. The infected plant was removed and the surrounding area was surveyed, with no evidence that the pathogen had infected nearby plants. The infected rhododendron had been sourced from a retail nursery and had been planted in the Placer County location for one year before its removal. Researchers from the UC Berkeley Forest Pathology and Mycology Lab have surveyed the Sierra foothills for Sudden Oak Death from El Dorado County north through Butte County, including portions of the Bear River Watershed in Placer and Nevada Counties. A map of their survey sites is available online at http://nature.berkeley.edu/garbelottowp/?p=1596. To date, no additional infected plants have been found in the Sierra or Cascade ranges.

Figure 33. Incidence of Sudden Oak Death



In 2012, a related pathogen *Phytophthora tentaculata* was detected in several California native plant nurseries in Butte, Monterey, Placer, Santa Cruz Counties. These were the first detections of *P. tentaculata* in the USA. The pathogen was detected on native woody plant species including toyon (*Heteromeles arbutifolia*) coffeeberry (*Frangula californica* and sticky monkey flower (*Diplacus aurantiacus* subsp. *aurantiacus*, and was found on several restoration sites along the central coast. If spread to the Bear Watershed in the future, this pathogen could have devastating effects on plant communities.

III.B.6c. Invasive Wildlife Species

Several animal species within the Bear River Watershed are introduced exotic species that prey upon, parasitize, and compete with native wildlife, and act as reservoirs for diseases that affect native wildlife. Invasive species currently impacting the Bear River Watershed include the American bullfrog (*Lithobates catesbeianus*), red-eared slider (*Trachemys scripta* *elegans*), brown-headed cowbird (*Molothrus ater*), Eurasian collared-dove (*Streptopelia decaocto*), European starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), wild pigs (*Sus scrofa*), and feral cats (*Felis catus*). Additional invasive animal species that are reproducing in watersheds adjacent to the Bear Watershed include New Zealand mud snails (*Potamopyrgus antipodarum*), northern watersnakes (*Nerodia sipedon*), and southern watersnakes (*Nerodia fasciata*). Non-native species such as these significantly reduce the survival and reproduction of native wildlife populations.

III.C. Human Community and Land Use Setting

III.C.1. Indigenous Communities

Prehistorical Context

Current evidence suggests that human use of the northern Sierra Nevada foothills and upper slopes began more than 8,000 years ago (NID and PG&E, 2011f), while some archaeological evidence indicates the sporadic presence of small, mobile bands of people in the Central Valley as early as 12,000 years ago (Yuba County, 1994). The Bear River watershed lies within the ancestral homeland of the Nisenan who have inhabited the area for the past 1,500 years. A second group, the Washoe, whose territory extends from Lake Tahoe to the western edge of the Great Basin, historically migrated annually to upper portions of the Bear River watershed during the late warm season for harvesting and trade (NID and PG&E, 2011f).

Valley and Hill Nisenan groups were culturally, linguistically, and presumably ethnically related, but the valley people tended to interact socially and economically more with non-Nisenan valley peoples, such as the Patwin who lived on the western side of the Sacramento Valley, than with the Hill Nisenan. Similarly, Hill Nisenan peoples were more likely to have close relations with surrounding non-Nisenan hill and mountain peoples, including the Konkow, Mountain Maidu, Washo and Sierra Miwok (Yuba County, 1994).

It has been noted that the economy of the Hill Nisenan (the people who inhabited the Sierra foothills) was so diversified, the means of resource use so effective, and the carrying capacity so relatively high, that Hill Nisenan territory was among the most densely populated in prehistoric California. Hill and mountain Nisenan villages were located on ridges adjacent to streams or on flats along the rivers. Valley Nisenan villages were generally distributed along the margins of primary watercourses. Few villages occupied the valley plain between the Sacramento River and the foothills, although the valley people hunted and gathered there. Most villages had bedrock mortar sites associated with them (Yuba County, 1994).

Historical Context

Even before large-scale white settlement occurred in Nisenan territory around the time of the Gold Rush, the Valley Nisenan were decimated by what is thought to have been a malaria epidemic brought to the Sacramento Valley by white trappers from Oregon in 1833. As many as 75% of Central Valley Indian groups perished in the plague. Beginning about

1850, surviving Nisenan were subjected to murder, enslavement, forced relocation and other deprivations (Yuba County, 1994).

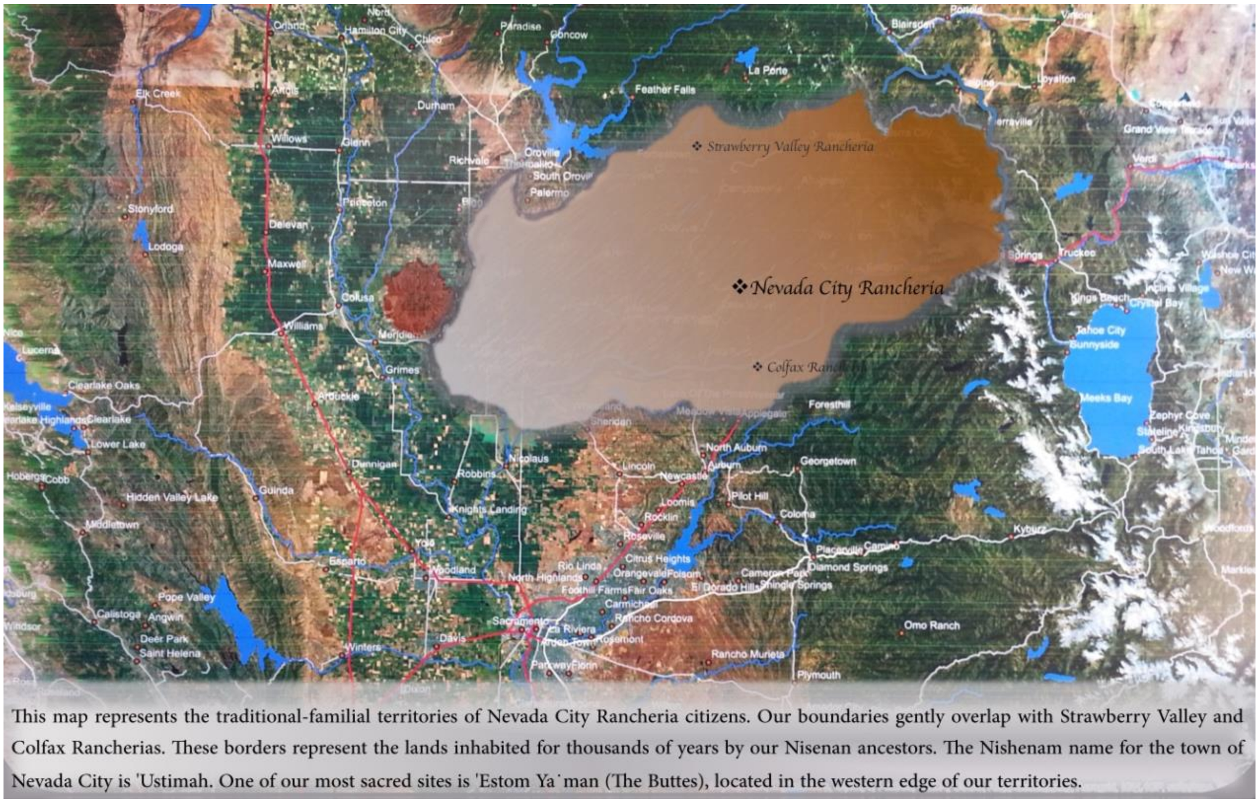
Prior to 1929, the estimated number of full-blooded Nisenan was 1,000-1,200 people, most of whom were dispersed throughout their traditional territory (NID and PG&E, 2011f). Currently the Nisenan associated with the Nevada City Rancheria number "no more than 100 recognized members with another nearly as many pending confirmation" (Nisenan Tribe, 2009).

Currently, three indigenous groups are based within portions of the Bear River watershed: the Colfax-Todds Valley Consolidated Tribe (Colfax Rancheria), the Nisenan of Northern California (Nevada City Rancheria), and the United Auburn Indian Community (Auburn Rancheria). All three of these tribes were historically recognized by the US federal government and the surrounding indigenous nations, but their federal recognition was terminated in 1958, 1964, and 1967, respectively. Federal recognition was restored to the United Auburn Indian Community in 1994. The Colfax and Nevada City Rancherias continue to petition for the reinstatement of their federal recognition, while members of all three tribes remain connected to their vital cultural heritage. Figure 34 shows the territory traditionally inhabited by one of these tribes, the Nevada City Rancheria. This map was graciously provided to us by the tribal secretary, Shelly Covert. As we continue to build relationships toward a collaborative Restoration Plan for the Bear River Watershed, we hope to learn more about the cultural landscape inhabited by all three tribes.

Significant Cultural Resources

In Nevada County, approximately 52,069 acres, or about eight percent of the county has been subjected to archaeological survey with relatively "complete" systematic coverage. Complete coverage implies the implementation of a systematic survey at 30 m transect intervals or less. About 29,300 acres have been surveyed on private lands, 22,769 acres on Forest Service lands and 482 acres on BLM lands. Within this total area, approximately 1,490 prehistoric and historic archaeological sites have been recorded to date (see Appendix E of the Nevada County Master Environmental Inventory). Considering the total number of sites recorded in the County and given the amount of acreage that has been surveyed, it can be estimated that the potential number of sites expected within Nevada County number about 17,900, leaving about 16,400 potential archaeological sites yet undiscovered. On the average, one site is expected per every 35 acres surveyed within Nevada County. This figure accounts for a relatively high site density, especially when considering that nearly half of the total prior archaeological coverage within the County falls on forested and mountainous public lands which are, overall, less likely to contain cultural resources (Nevada County, 1995).

Figure 34. Map of Historical Territory Occupied by the Nevada City Rancheria



For purposes of watershed restoration, sites and resources of significance to tribal groups should be identified and prioritized for protection. However, because of the vulnerable nature of these resources, their specific locations need to remain confidential. Based on public data sources currently available, the following areas have been identified as significant to local tribal groups:

- A highly sensitive area in the Bear Valley Meadow (American Rivers, 2014).
- One area, including an archaeological site, associated with the Drum-Spaulding project area identified as a Traditional Cultural Property (TCP) eligible for listing on the National Register of Historic Places (NRHP) (NID and PG&E, 2011f).

Data sources currently available for the Disturbance Inventory include:

- Bear Valley Cultural Preservation Plan. 2011. Tsi Akim Maidu Tribe, Sierra Fund
- Headwaters Restoration in a Changing Climate – The Meadows of Bear Valley. Americans Rivers, Tsi Akim Maidu Tribe et al.
- Native American Traditional Cultural Properties, Technical Memorandum 13-1a Drum-Spaulding Project. FERC Project No. 2310-173. 2011. Pacific Gas & Electric Company (TM 13-1a)

- Native American Traditional Cultural Properties, Technical Memorandum 13-1b Rollins Transmission Line Project. FERC Project No. 2784-003. 2010. Pacific Gas & Electric Company (TM 13-1b)
- Native American Traditional Cultural Properties, Technical Memorandum 13-1c Yuba-Bear Hydroelectric Project. FERC Project No. 2266-096. 2011. Nevada Irrigation District (TM 13-1c)

In an effort to augment our understanding of the extent of sensitive and significant cultural resources, we are currently contacting the following information sources:

- Nisenan of Northern California (Nevada City Rancheria),
- Colfax-Todds Valley Consolidated Tribe (Colfax Rancheria),
- United Auburn Indian Community (Auburn Rancheria), and
- California Historical Resource Inventory System (CHRIS).

It is certain there are more areas of special significance to local indigenous people than are documented in the publicly-available data sources. Representatives of local tribal groups have expressed their view that all of their ancestral aboriginal territories are traditional cultural properties, and they do not agree with addressing these territories in accordance with the non-native perspective (NID and PG&E, 2011f). Thus far, the Disturbance Inventory has listed specific geographical sites of significance as the type of resource to be restored/protected. We hope to have further discussions with tribal groups that will ascertain other concepts and approaches related to restoration that they deem important to an effective and meaningful restoration process.

III.C.2 Governmental Jurisdictions

Cities

Four cities lie within the Bear Watershed: Grass Valley (in Nevada County), Wheatland (in Yuba County), Meadow Vista (in Placer County) and Colfax (in Placer County). Grass Valley is the largest city with a 2010 population of 12,860, followed by Wheatland, Meadow Vista, then Colfax whose 2010 populations were 3,456; 3,217 and 1,971, respectively (US Census, 2010). There are also several rapidly urbanizing areas along the highway 49 corridor (e.g., Lake of the Pines). The overarching planning mechanism for cities is the General Plan, which serves as the policy basis for land use decisions within their incorporated borders as well as surrounding unincorporated areas within a city's sphere of influence. General plans address housing, economic, infrastructure, recreation and open space issues.

The City of Grass Valley approved the Loma Rica Ranch Specific Plan in 2011. The design of this 452 acre development located southeast of the Brunswick Basin area was informed by a public design charrette held in 2003. Of the total area, 314 acres (69%) will be reserved for open space, including parkland, wetlands, creeks, organic farmland and conserved open spaces. The developed portion of the site (314 acres, or 31%) will include 700 dwelling units, 26.6 acres of business and light industrial uses and 10.3 acres of commercial/retail uses. Wolf Creek, Whitewater Creek and Olympia Creek flow through the site. According to the Specific Plan, the City of Grass Valley population is projected to grow to 24,000 by the year 2020, well over its 2011 population of 13,000 (Loma Rica Ranch LLC., 2011).

The City of Wheatland recently approved a proposed development of the Johnson Rancho (part of an original Mexican land grant) and Hop Farm, a 4,149 acre territory of prime farmland east of the city limits between Dry Creek and the Bear River. Assuming a 3.04 average household size, at buildout, this development would add an estimated 43,763 new residents, a 1,233% increase over the 2009 Wheatland population of 3,548. The proposed development at full buildout would allow for construction of approximately 14,396 dwelling units and 131 acres of commercial mixed use, 274 acres of employment use with 5,940,540 commercial (employment) square footage, 95 acres of school sites, 31 acres for the proposed Wheatland Expressway, as well as parks, recreation, and open space. The Statewide General Construction Permit requires on-site mitigation of 100% of the volume of water drained. Impacts from impervious surfaces for the 85th percentile storm event are eliminated through low-impact development measures (LID), on-site storage, infiltration and grassy swales. It is estimated that an additional 57 cfs will be pumped into the Bear River (Raney, 2008).

Counties

The Bear River watershed lies within four counties – Nevada, Placer, Yuba and Sutter. Portions of Nevada and Yuba Counties form the northern side of the watershed, and portions of Placer and Sutter Counties form the watershed's southern side. A majority of the watershed is within Nevada County.

Counties have jurisdiction over land use and development decisions in their unincorporated regions. The overarching planning document for counties is the General Plan, which sets forth broad goals and policies regarding future community development, including intentions about housing, economic development, transportation, recreation, open space, agriculture, cultural resources and the environment. A review of the four pertinent county general plans reveals that all jurisdictions state a general intent to locate new development adjacent to already urbanized areas and preserve open space, sensitive habitats, cultural resources and aesthetic values within their regions. However, these counties are also experiencing growth that exerts pressure to convert open space and agricultural lands for the development of housing and associated commercial services.

Within the Bear River Watershed in unincorporated Nevada County, the greatest residential density occurs in the area of Alta Sierra and Lake of the Pines. When the county population reaches 105,000, Nevada County has some sites set aside, including a new town site in the area of Mc Courtney and Spenceville Roads (west of Grass Valley), which may be considered for development (Nevada County, 2014).

Recently approved projects within the Bear River watershed in Nevada County include expansion of the Hansen Brothers gravel operation on Greenhorn Creek, the Blue Lead Gold Mine at Bear's Elbow and Rincon del Rio, a 225 acre high-density continuing care retirement facility located at Higgins Corner near Alta Sierra. In Placer County, expansion of the CEMEX gravel operation in the Bear River was recently permitted.

Placer County is currently preparing a Conservation Plan which would designate permanently protected areas in the western county as well provide as a conservation strategy. This plan is scheduled to be finalized and available to the public at the end of 2016. The Placer County Conservation Plan (PCCP) is a County-proposed solution to coordinate and streamline the project permitting process by allowing local entities to issue state and federal permits (Placer County, 2014a). The proposed PCCP is a Habitat Conservation Plan (HCP) under the Federal Endangered Species Act and a Natural Community Conservation Plan (NCCP) under the California Natural Community Conservation Planning Act . As proposed, the PCCP would include the County Aquatic Resources Program (CARP) to issue permits related to the Federal Clean Water Act and the California Fish and Game Code. The proposed PCCP is a landscape-level plan so that each project would be issued permits based on how it contributes to the County's natural, social, and economic health now and in the future. Placer Legacy is the County-wide open space and habitat protection program based on the existing County General Plan and the PCCP (Placer County, 2014b). The lands in the PCCP are designated as areas to be protected, but have not yet been designated as such. The potential to permanently protect and restore lands within the Bear watershed should be addressed in the Bear Restoration plan. There is limited data on the natural resources found in the Bear watershed within the scope of the Placer Legacy program. Additional data should be collected in this area to properly support restoration goals and work with the County to permanently protect these areas.

Sutter and Yuba Counties are jointly preparing a Regional Conservation Plan scheduled to be finalized in 2016. The Yuba-Sutter NCCP/HCP has goals regarding no net loss of wetlands, establishment of a resource conservation district and native plant use for revegetation and landscaping. Further, the plan aims to: preserve the Bear River Corridor as important habitat, recreation and open space resources; protect surface water resources including the Bear River and its significant tributaries; and protect views of scenic resources including Bear River, wildlife and habitat areas (CDFW, 2016c). The potential to permanently protect and restore lands within the Bear watershed should be addressed in the Bear Restoration plan. Additional data should be collected in this area to properly support restoration goals and work with the Counties to permanently protect these areas.

Nevada County attempted to develop its version of a habitat conservation plan in the year 2000 through the Nevada Heritage 2020 project. Due to strong opposition from some segments of the population, this project was abandoned.

State and Federal Agencies

The jurisdictional landscape for watershed management in the Bear is complex, with a system of overlapping state, federal and regional authorities. Within the state government, the Bear watershed encompasses parts of California Senate Districts 01 (MTCAP) and 04 (Yuba), and parts of Assembly Districts 01 (MTCAP), 03 (Yuba) and 06 (NSAC). Of the 12 Funding Areas identified in Proposition 1, which authorized the appropriation of Integrated Regional Water Management funding, the Bear includes pieces of both the Mountain Counties and Sacramento River areas. For Proposition 84, which designated 11 areas to help local public agencies receive Integrated Regional Water Management funding through California Department of Water Resources (DWR), the Bear watershed is included in the Sacramento River area.

For the US Bureau of Land Management and US Forest Service, the two largest federal landowners in the region, the watershed falls into the California Region, Mother Lode Field Office and the Pacific Southwest Region, respectively. For the California Department of Fish and Wildlife, the Bear is encapsulated within Region 2 (North Central).

For DWR, the watershed falls into the North Central Region. It is part of California Regional Water Quality Control Board Region 05 (Central Valley) and US EPA Region 09 (Pacific Southwest). According to the 2012 Central Valley Flood Protection Plan, the terminus of the watershed falls under the purview of the Feather River Regional Flood Planning Area. The terminus of the watershed also includes portions of four different reclamation districts: 1001 (Nicolaus), 2103 (Wheatland), 0817 (Carlin) and 0784 (Plumas Lake). These reclamation districts are legal subdivisions within the Central Valley that are responsible for maintaining flood protection structures.

The Bear also encompasses multiple units within the different organizational layers of the California Water Plan. At the broadest scale, the watershed is within Hydrologic Region 05 (Sacramento River). At the next level, the majority of the watershed falls under Water Planning Area 508, but it also overlaps with planning areas 507 and 511. At the most specific level, the largest area of the watershed is encompassed within Detailed Analysis Unit 156 (Yuba-Bear), though it also encompasses parts of Units 171 and 172 (Yuba), 160 (Yuba Foothill), and 161 (Placer Foothill). In addition, while most of the Bear is managed under the Cosumnes American Bear Yuba (CABY) Integrated Regional Water Management Plan, the western and southern portions of the watershed are also managed by the Yuba County and American River Basin plans.

Water Districts

Perhaps the most complicated layer of jurisdictional authority in the Bear watershed is the complex system of water agencies, irrigation districts and companies that control the flow, appropriation and sale of water from the Bear River and its tributaries. The largest entity in the watershed, in terms of area in operation, is Nevada Irrigation District (NID), which works primarily in the upper and middle portion of the watershed. The largest unit by area operated by NID is the Loma Rica unit.

Placer County Water Agency (PCWA), a conglomeration of water companies and community districts, is another important entity in the watershed, operating primarily in the Upper and Middle Bear subwatersheds. Meadow Vista County Water District is the local organization, within PCWA, responsible for the wholesale and resale of water for the Meadow Vista and Applegate area. Within Placer County, there are also the Auburn Valley Community Service District, the Heather Glen Community Service District and the Midway Heights County Water District, among others.

Similarly, the Yuba County Water Agency unites many of the water districts operating within Yuba County, including the Dry Creek Mutual Water Company, River Highlands Community Service District, and South Yuba Water District. Also operating in Yuba County are: the US Air Force, which controls water supplies on Beale Air Force Base; the Wheatland Water District, which provides irrigation water for the large developments around Wheatland; the Camp Far West Irrigation District; and the Plumas Mutual Water Company at the terminus of the watershed.

Within Sutter County, the South Sutter Water District, which provides irrigation water, is the major player along with Reclamation Districts 1001, 2103, 0817, and 0784.

The cities of Grass Valley and Wheatland operate their own water systems within city limits.

More information on these jurisdictions can be found using DWR's Water Management Planning Tool (https://gis.water.ca.gov/app/boundaries/). This tool allows one to map all relevant jurisdictions; however, it is currently in beta testing and thus the geospatial data cannot yet be directly downloaded.

Tribes

As discussed in the Historical Context of Section III.C.1: Indigenous Communities, of the three tribal groups located in the Bear River watershed, only United Auburn Indian Community has current federally-recognized status. Nevada City Rancheria and Colfax-Todds Valley Rancheria are working to have their previous federal recognition reinstated.

III.C.3. Existing Land Uses

III.C.3a. Population Density, Growth and Exurban Migration

Exurban migration is the relocation of people from larger metropolitan areas to rural small town regions usually in seek of a better quality of life. The Sierra Nevada foothills region has been the locus of extensive exurban migration in the past decades since the 1960s. This population change has significantly altered the region's landscape, culture and economy.

Following the Gold Rush of 1849, open-range cattle grazing, orchards, timber production and deep, hard-rock gold mining were the economic mainstays. By the mid-1950s, however, the last major commercial mines closed and the traditional natural resource-based economy went into steady decline (Walker et al., 2003). In Nevada County, by the late 1960s, a "second Gold Rush" arrived, in the form of land speculation and development for waves of residential migrants moving to the county in search of investments in cheap land and a better quality of life. Between 1965 and 2001, Nevada County's population nearly quadrupled, from 25,100 to 94,361, almost exclusively through in-migration (Walker et al., 2003).

Throughout the Bear River watershed, 80,048 people resided in 35,837 housing units in 2010, representing an average household size of 2.23 (US Census, 2010). A total of 18,279 people, or 23% of the total watershed population, resided within the watershed's three cities. Population density as shown in Figure 35 is divided by census blocks. The highest population densities are found along highway corridors and residential areas, including Grass Valley, Alta Sierra, Lake of the Pines, Beale Air Force Base, Wheatland, and Plumas Lake.

Population density in Nevada County as a whole was 103 residents per square mile in 2010, lower than the California state average of 244 residents per square mile (Nevada County, 2014). Within the City of Grass Valley, 2010 population density was 2,711 residents per square mile.

According to U.S. Census data, in Placer County as a whole, population density in 2010 was 248 residents per square mile. Within the City of Colfax, 2010 population density was 1,395 residents per square mile. In Yuba County as a whole, 2010 population density was 157 residents per square mile. Within the City of Wheatland, population density in 2010 was 2,326 residents per square mile. In Sutter County as a whole, 2010 population density was 114 residents per square mile.

Population across the watershed grew from 2000 to 2010, though considerably less in Nevada County (7%) than in Placer (40%), Yuba (20%), or Sutter (20%) Counties (Nevada County, 2014). Projections made by the California Department of Finance indicate that by the year 2030, the population of Nevada County is expected to increase 12.2% (11,500 people), Placer County by 20% (74,100 people), Yuba County by 27.1% (20,300 people), and Sutter county by 22.6% (22,200 people) (Department of Finance, 2014). Mapping changes in population by watershed (Figure 36) indicates that the Best Slough-Bear River, Grasshopper Slough-Dry Creek, and Vineyard Creek-Dry Creek subwatersheds may be most significantly impacted by increased human populations. Comparing Figure 35 and Figure 36, we can see a trend of population increase in rural areas over the last decade. The development of rural areas and the associated increase in infrastructure often results in habitat fragmentation, decreased habitat availability and reductions in water quality.

Within the watershed's three cities, population growth between the year 2000 and 2010 was significant compared to the statewide growth rate of 10% for the same period. The City of Grass Valley population grew from 10,922 (2000) to 12,860 (2010), an 18% increase. The City of Colfax population increased 31%, from 1,296 (2000) to 1,963 (2010). In the City of Wheatland, population increased 52%, from 2,275 (2000) to 3,456 (2010) (US Census, 2010).

III.C.3b. Parcel Size and Density

The exurban migration mentioned above also has implications for parcel size. The increase in rural-residential land use is associated with a decrease in the size of landholdings (the total acres in all parcels held by a single owner). In Nevada County, for example, the median size of landholdings decreased from 550 acres in 1957 to 9 acres in 2001, reflecting a shift from large ranches and timber operations to single-family residential units on parcels typically ranging from 3 acres to 15, 20, or occasionally, 40 acres or more. The 1957 landscape of a few large parcels has been almost completely replaced countywide by a fragmented landscape of many small parcels (Walker et al., 2003). Parcel size is an indicator of population pressure and economic changes as land is subdivided in response to declining agricultural pursuits and increasing demand for residential development. Parcel size also affects the challenges facing a watershed's ability to maintain healthy, functioning ecosystems.

Data from the Nevada County Tax Assessor's office for 2001 shows that while suburban-style parcels of 1 acre or less account for 31% of all private rural parcels, they represent only 1.5% of the total private rural acreage (0.9% of the total area). As such, highly visible suburban-style developments have relatively little spatial impact on the landscape. Much more of the rural landscape is dominated by low-density residential development on parcels typically ranging from 5 to 40 acres (Walker et al., 2003). It is widely accepted that the presence of more houses is associated with increased disturbance of wildlife (due to fence construction, and harassment and predation by domestic cats and dogs) and decreased biodiversity (Hansen et al., 2002; Hansen and Rotella, 2002).

Within the Bear watershed, there are 248 parcels in Sutter County in an area of 9,068 acres, suggesting an average parcel size of 36.6acres and low parcel density. In comparison, there are over 27,000 parcels in Nevada County in an area of roughly 174,000 acres, suggesting an average parcel size of only approximately 6 acres and a much higher parcel density, particularly along the north-south Highway 49 corridor. In Placer County, over 7,000 parcels occupy an area of just under 63,000 acres, corresponding to an average parcel size of 8.84 acres and a relatively high parcel density. In Yuba County, approximately 5,440 parcels are found in an area of greater than 57,500 acres, corresponding to an average parcel size of 10.6 acres and an intermediate parcel density. The density is particularly high along State Highway 70, in the western edge of the watershed. The largest parcel in the watershed is over 1,130 acres and located in Yuba County.

Parcel data, displayed in Figure 37, was acquired through the individual websites of each of the four counties in the watershed: Nevada, Yuba, Sutter and Placer. Data was clipped to include just the area within the watershed and then merged to form one coherent map of parcel information for the entire watershed. County lines were acquired from the US Census Bureau Cartographic Boundary Shapefiles program, at a resolution of 1:500,000.

Information on parcel density indicates the extent to which areas have been subdivided into different ownership, which has implications for conservation. Land development is considered one of the primary threats to wildlife and ecosystems in this region, And at the same time, as Walker et al. (2003) pointed out, low density rural residential development sometimes offers habitat restoration opportunities, depending on the conservation attitudes of the property owners.

Figure 35. Human Population Density

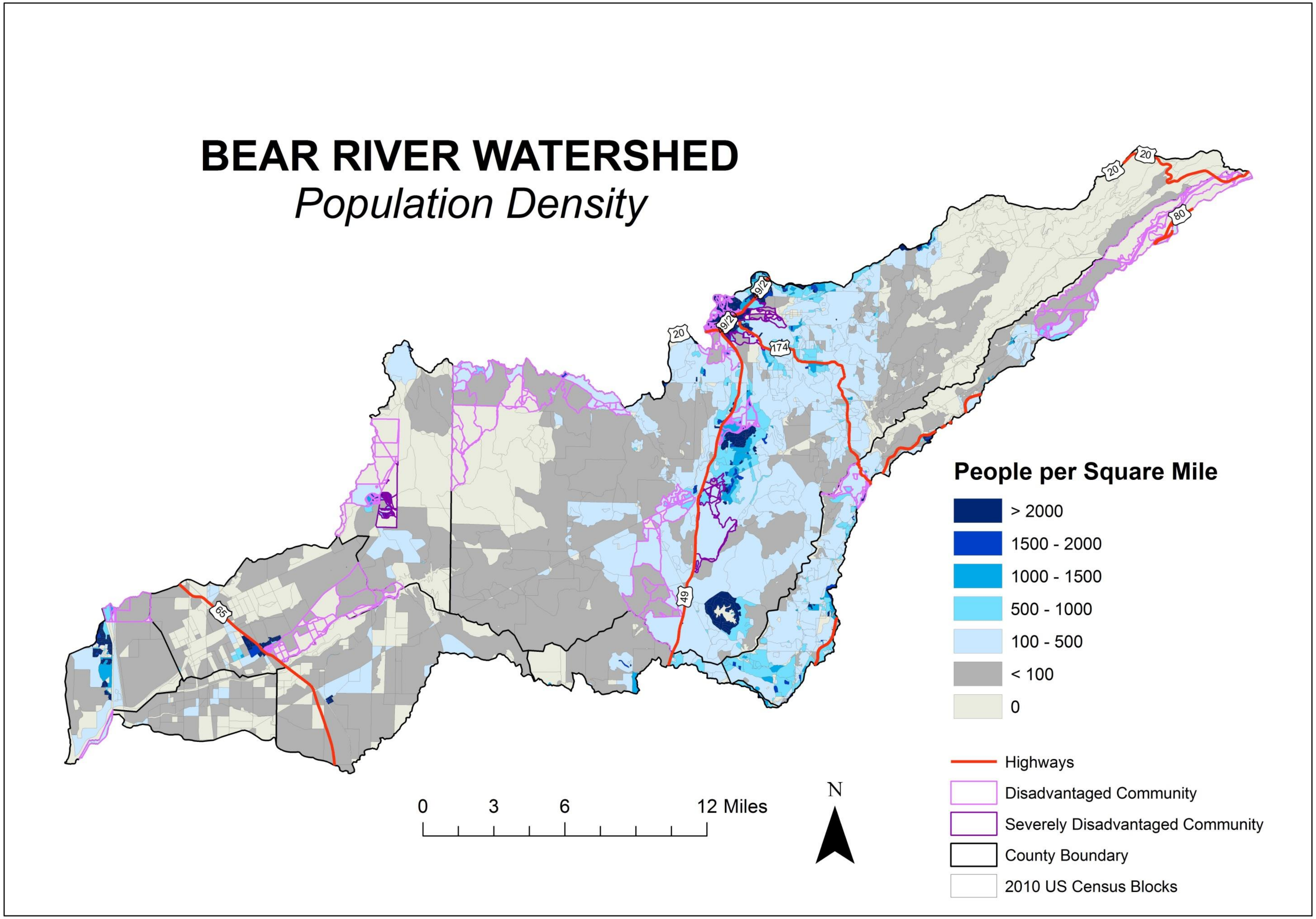


Figure 36. Human Population Change by Subwatershed

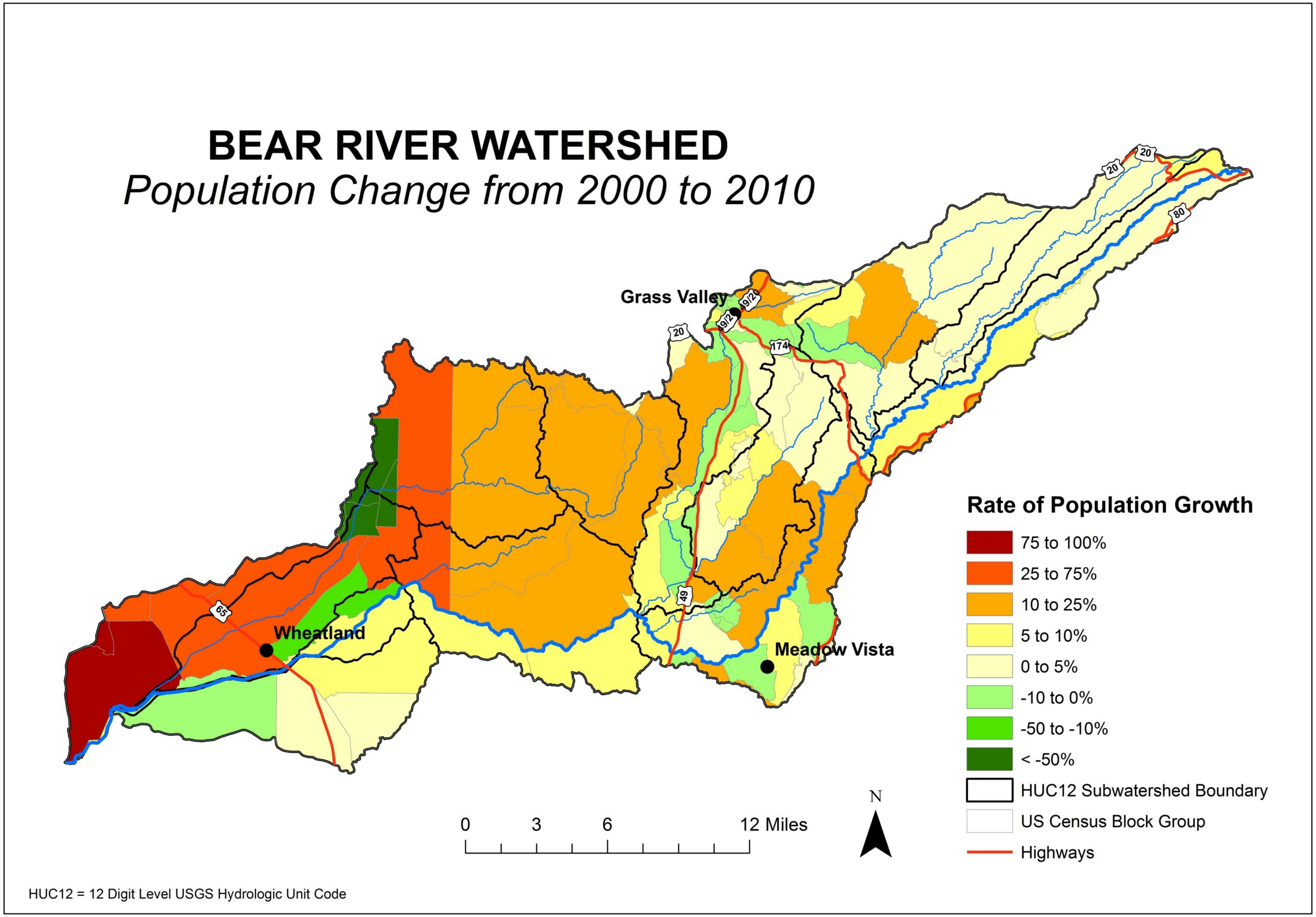


Figure 37. County Parcel Boundaries

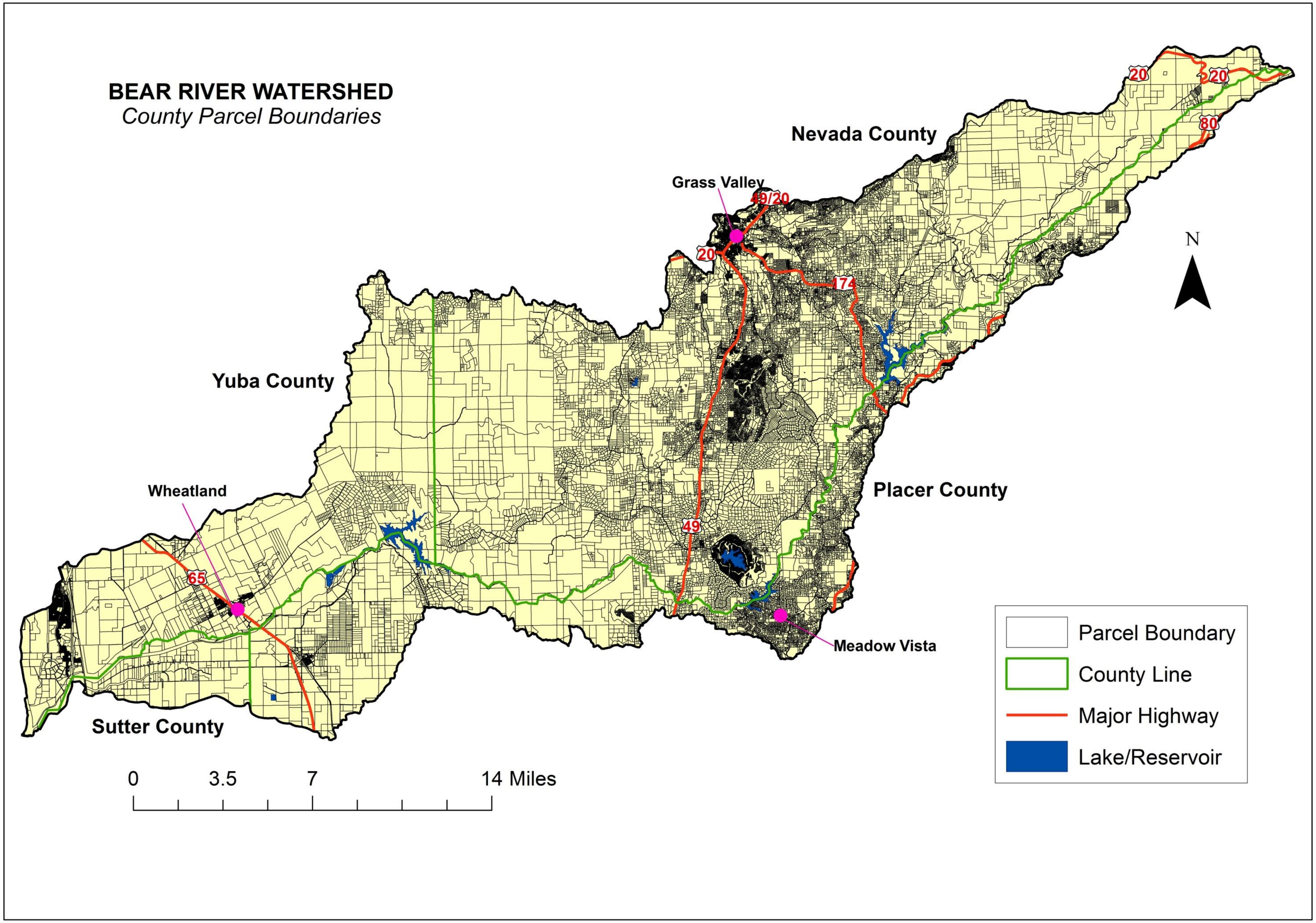
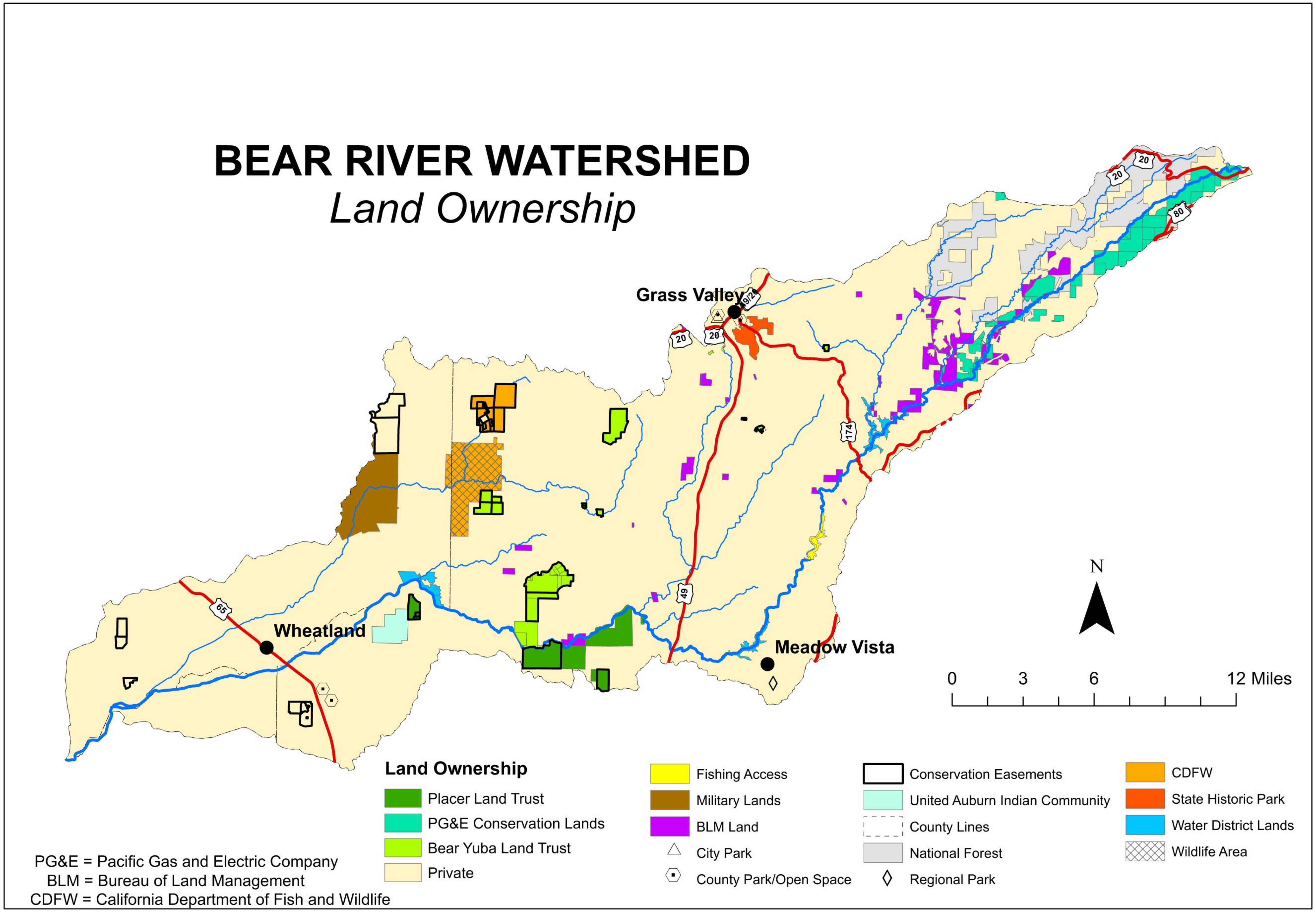


Figure 38. Land Ownership



III.C.3c. Land Ownership

The majority of property in the watershed is privately owned (75%, 228,232 acres) and is used for logging, grazing, vineyards, or as large residential properties. Land ownership data is displayed in Figure 38. Much of the lower watershed is made up of large agricultural parcels, while much of the property in the upper watershed is owned by the US Forest Service/Tahoe National Forest (15.5%, 46,953 acres) and the utility PG&E (2,039 acres). PG&E lands are currently undergoing compulsory divestment, and large parcels will soon be protected permanently through conservation easements held by Bear Yuba Land Trust and Placer Land Trust.

The Bear Yuba Land Trust (BYLT) currently protects 3,164 acres, while 3,400 acres of land are under Placer Land Trust protection. BYLT Preserves include: Pioneer Dawson Nichols Ranch, Quail Ranch, Wild Rock Ranch, Willow Tree Ranch, Adam Ryan Preserve, North Star Historic District, North Star Wolf Creek Easement, Peardale Bird Sanctuary and Mathis Pond Park. Placer Land Trust Preserves include: Shutamul Bear River Preserve, Harvego Bear River Preserve, Garden Bar, Kirk Ranch, Outman and Liberty Land Trust.

Land owned by the Bureau of Land Management accounts for 6,969 acres (<1%), mostly in the upper watershed. A portion of the Beale Air Force Base (4,079 acres, <1%) is also found in the watershed. Three city parks make up 19 acres of the watershed, and Nevada, Placer, Yuba and Sutter Counties own another 30 acres used for parks and open spaces. Only one regional park (Meadow Vista Park) is found in the watershed, measuring 15 acres. Along the Bear River, in the Middle Bear subwatershed, 540 acres are allocated for fishing access on public lands. The state owns Empire Mine State Historic Park (826 acres) and Spenceville Wildlife Area (4,040 acres, <1% in the lower watershed), which is one of the few wildlife areas in the Sierra foothills and contains blue oak-gray pine woodland.

III.C.3d. Land Use Categories

Watershed-wide Land Use

Figure 39 shows the county general planning designations on a watershed-wide scale.

In Sutter County (within the Bear Watershed), the majority of land is designated as agricultural, with some space available as public land.

Within Placer County, the upper and lower part of the watershed is designated for agriculture or timberland with some public and rural estate land. The middle portion of the watershed, within Placer County around Meadow Vista, is rural or estate land, with some medium and low-density residential area.

In Yuba County, the City of Wheatland and surrounding area is designated under its own zoning code. However, the majority of land in the county is designated for agriculture. There is a large swath of planned development adjacent to the City of Wheatland near the watershed outlet and, alongside the border with Nevada County, there is a large amount of rural estate land and public and open space. This includes the Spenceville Wildlife Refuge and Beale Air Force Base.

In Nevada County, the majority of land in the watershed is designated in the General Land Plan as estate or rural. The northern third of the county, within the watershed, is all forest or mineral reserve. There are also large swaths designated as planned developments or planning districts throughout the county. Along Highway 49 and in Grass Valley, low to high-density residential land dominates.

County planning data was acquired through the individual websites of each of the four counties in the watershed: Nevada, Yuba, Sutter and Placer. Data was clipped to include just the area within the watershed and then merged to form one coherent map of zoning information for the entire watershed. County lines were acquired from the US Census Bureau Cartographic Boundary Shapefiles program, at a resolution of 1:500,000. Because each county uses their own zoning code system for community planning, the different classifications were slightly generalized, particularly for Nevada and Placer counties, and grouped together in order to create a unified, watershed-wide map. For more detailed information on the systems used, as well as more specific zoning code information, one should look at Placer Community Planning (http://www.placer.ca.gov/departments/communitydevelopment/planning/zoning%20ordinance/zoningdefs) for Placer County and Nevada Land Use Codes (https://www.mynevadacounty.com/nc/igs/gis/docs/LandUseCodes.pdf) for Nevada County.

Land Cover by Subwatershed

Figures 40 through 44 show existing land use with more detail, at a subwatershed level scale. Having data on land cover at a finer resolution allows for a differentiation of types of agricultural production. This information is important given the different impacts various agricultural and nonagricultural land uses have on the environment.

In the Dry Creek subwatershed (Figure 40), while grass and pasture land is still the primary agricultural land use, there is a wider variety of crops grown as one moves downstream, including rice, almonds, walnuts and vegetables. Forest is still the dominant non-agricultural land cover.

The Lower Bear subwatershed (Figure 41) is highly agricultural, with a wide variety of crops grown. Rice is the third largest agricultural land use by acreage. This is the only subwatershed where there is no forestland, and developed and open space dominates the non-agricultural land use. There are also significant areas of low- and medium-intensity residential development.

The Middle Bear subwatershed (Figure 42) has more developed land, particularly around Meadow Vista, though evergreen and deciduous forests still dominates. There are increasing amounts of grass and pastureland as one moves downstream, roughly west. Other crops in cultivation to a much lesser extent include alfalfa, wheat, hay, rye and canola.

In the Upper Bear subwatershed (Figure 43), grass and pastureland are the dominant agricultural land use while evergreen forest is the primary non-agricultural land use and the primary overall land use. Other crops in this subwatershed include non-alfalfa hay, winter wheat and rye.

Wolf Creek subwatershed (Figure 44) has the most developed and open space land. There are also some low and medium intensity developments, particularly around Grass Valley. Evergreen forest still dominates, with grass and pasture land still the primary agricultural land use.

These maps were produced through the USDA CropScape database, operated by the National Agricultural Statistics Service (USDA, 2014). The Cropland Data Layer is a geo-referenced, categorized land cover data set produced with satellite imagery and updated on an annual basis. The data shown in the maps are from the 2015 database. CropScape is able to show both agricultural and non-agricultural land uses and to rank each category by acreage.

III.C.3e. Agriculture

Working landscapes, both farms and ranches, are one of the most common land uses on private land in the Bear River watershed. Agriculture is both a major sector of the economy of the counties encapsulated by the watershed and a foundation of the cultural identity of many of its communities, particularly in the lower watershed (van Wagtendonk, 2013). In the Lower Bear River and Dry Creek subwatersheds, agriculture consists of primarily vineyards, rice and deciduous orchards, whereas in the Upper, Middle and Wolf Creek subwatersheds, agriculture is dominated by vineyards (Aalto et al., 2010). More specifically, the California Augmented Multisource Land Cover Map, produced jointly by the Departments of Forestry and Fire Protection, Water Resources and Pesticide Regulation, illustrates that in the lower third of the watershed, and to some extent in central Nevada

Figure 39. County Planning Designations

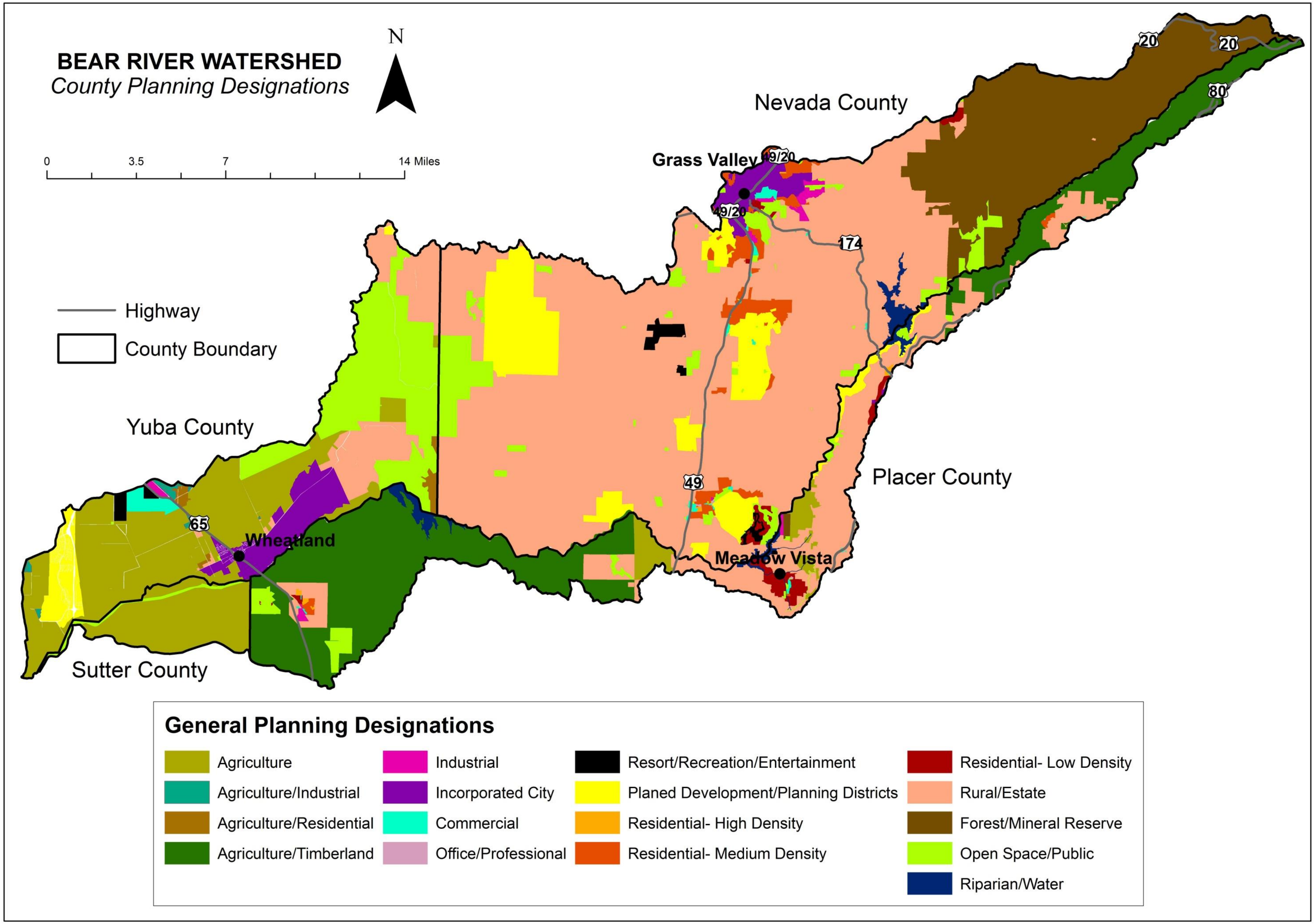
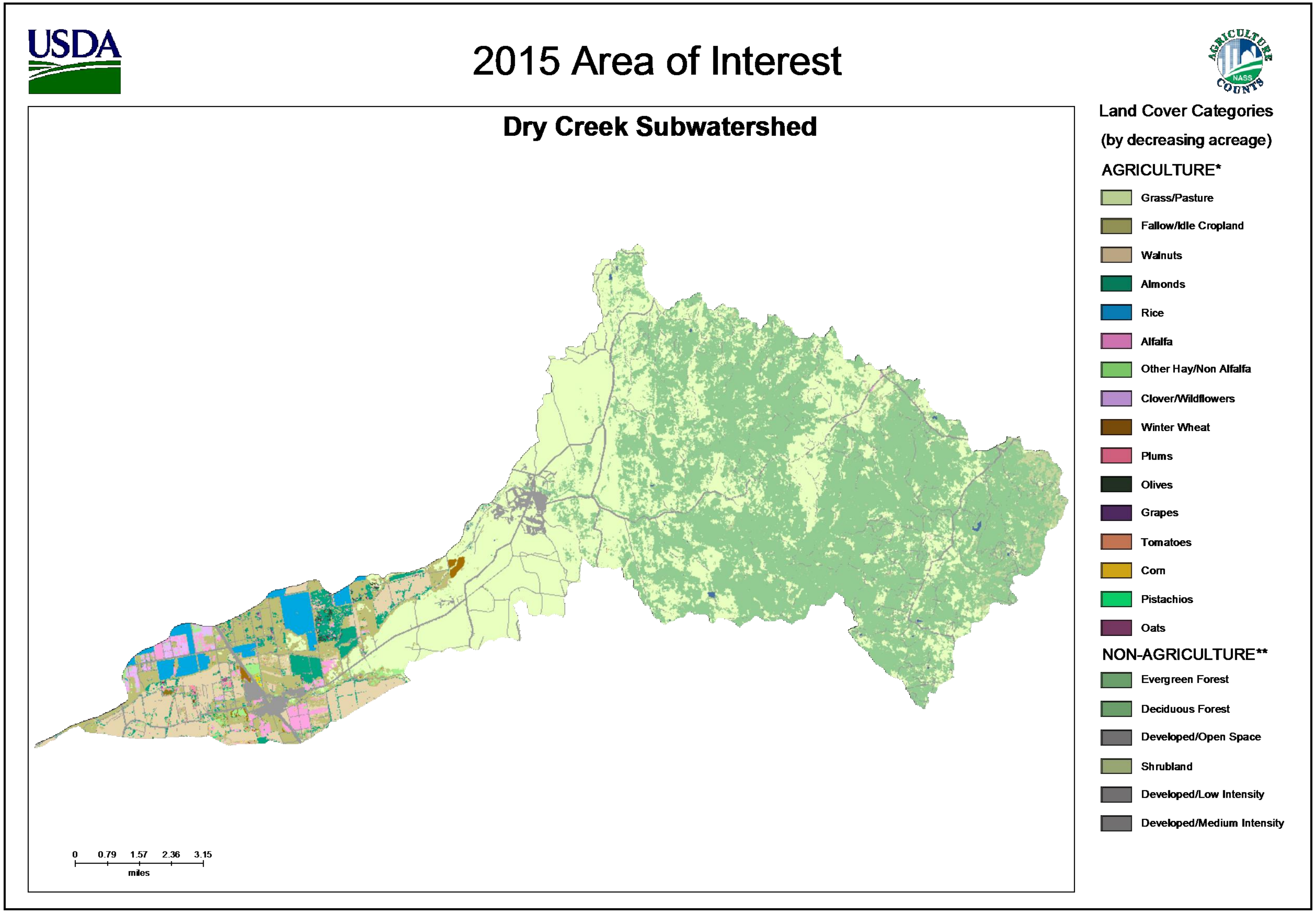


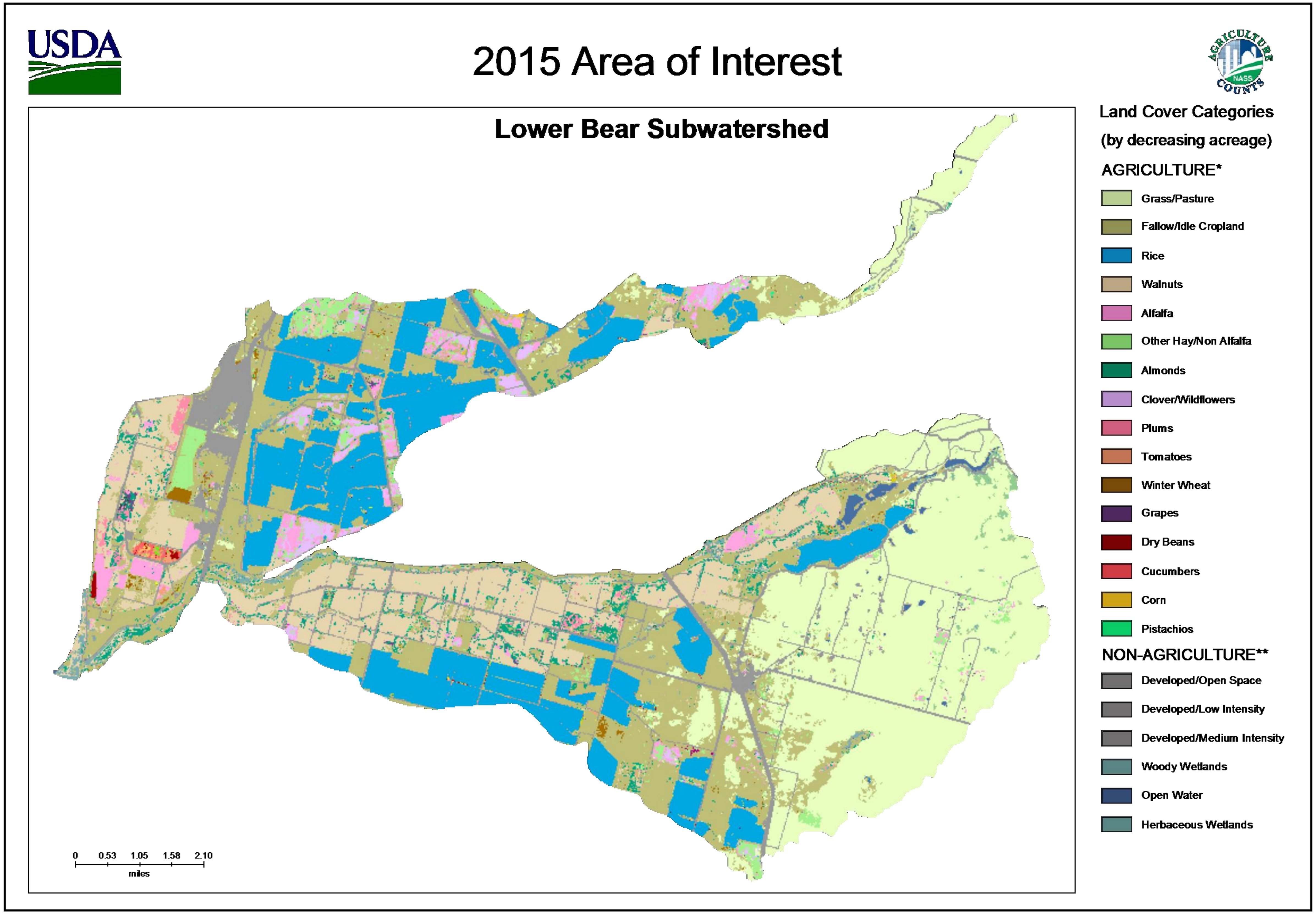
Figure 40. Land Cover in the Dry Creek Subwatershed



Produced by CropScape - http://nassgeodata.gmu.edu/CropScape

culture categories are listed.

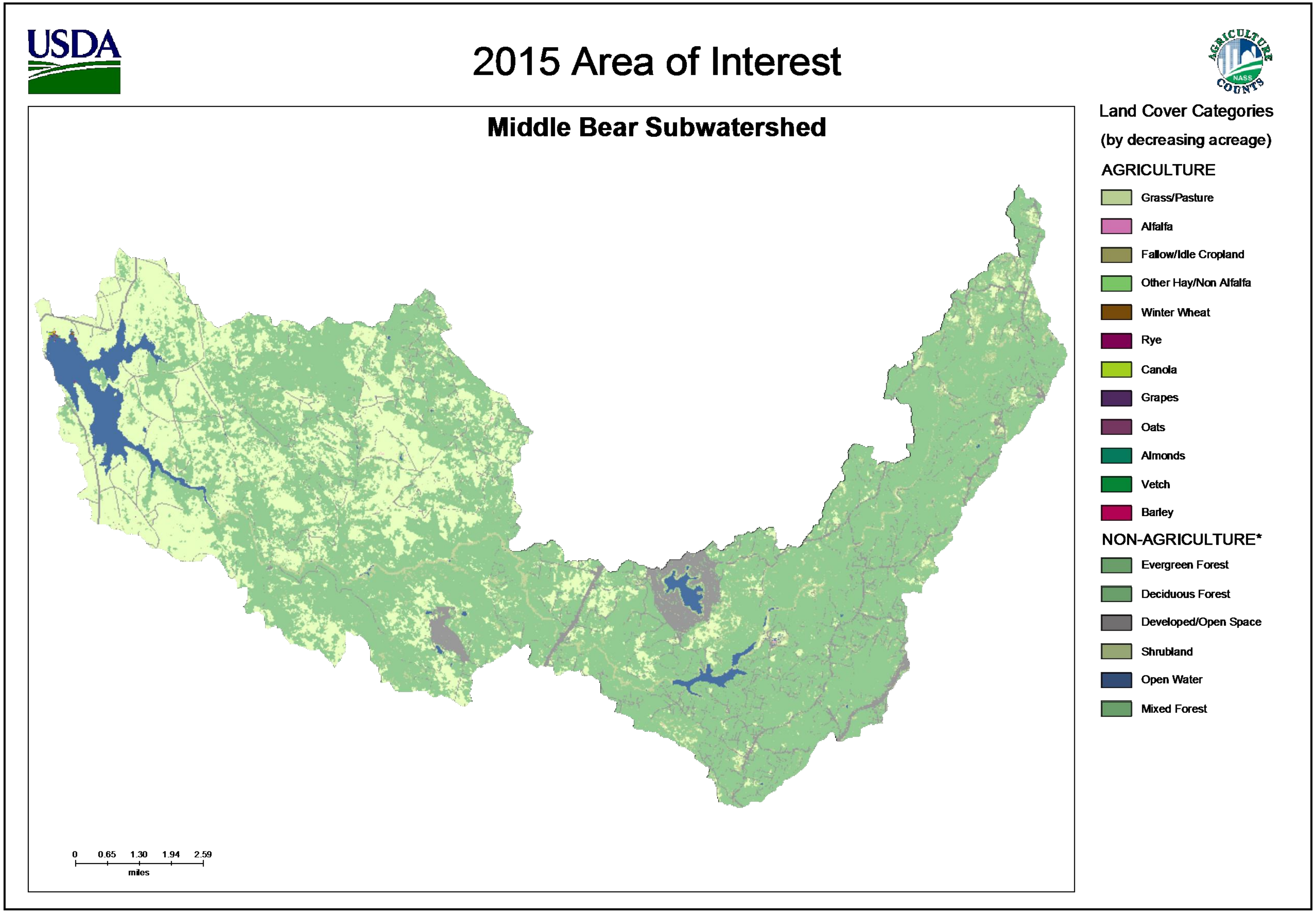
Figure 41. Land Cover in the Lower Bear Subwatershed



Produced by CropScape - http://nassgeodata.gmu.edu/CropScape

culture categories are listed.

Figure 42. Land Cover in the Middle Bear Subwatershed



Produced by CropScape - http://nassgeodata.gmu.edu/CropScape

* Only top 6 non-agriculture categories are listed.

Figure 43. Land Cover in the Upper Bear Subwatershed

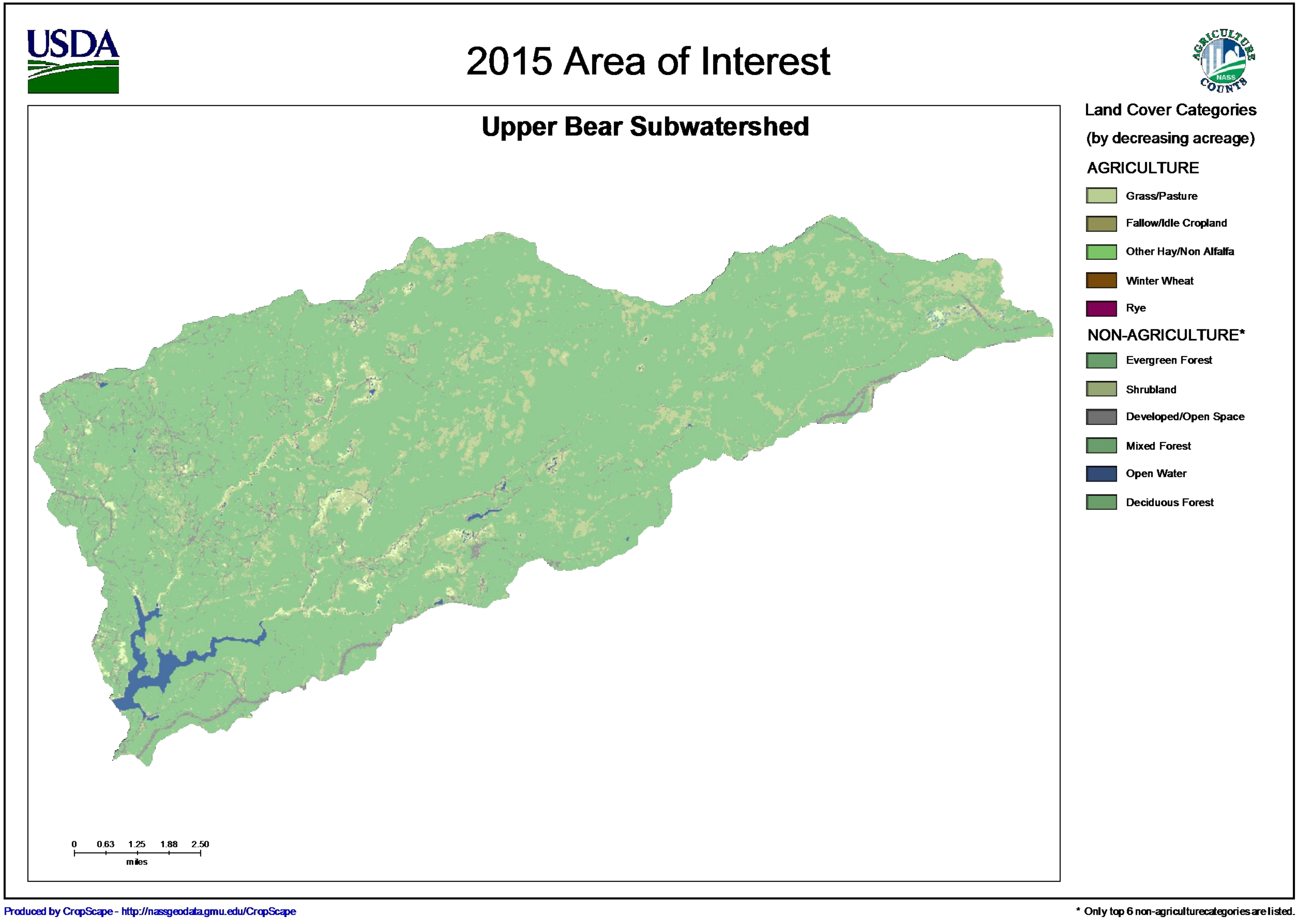
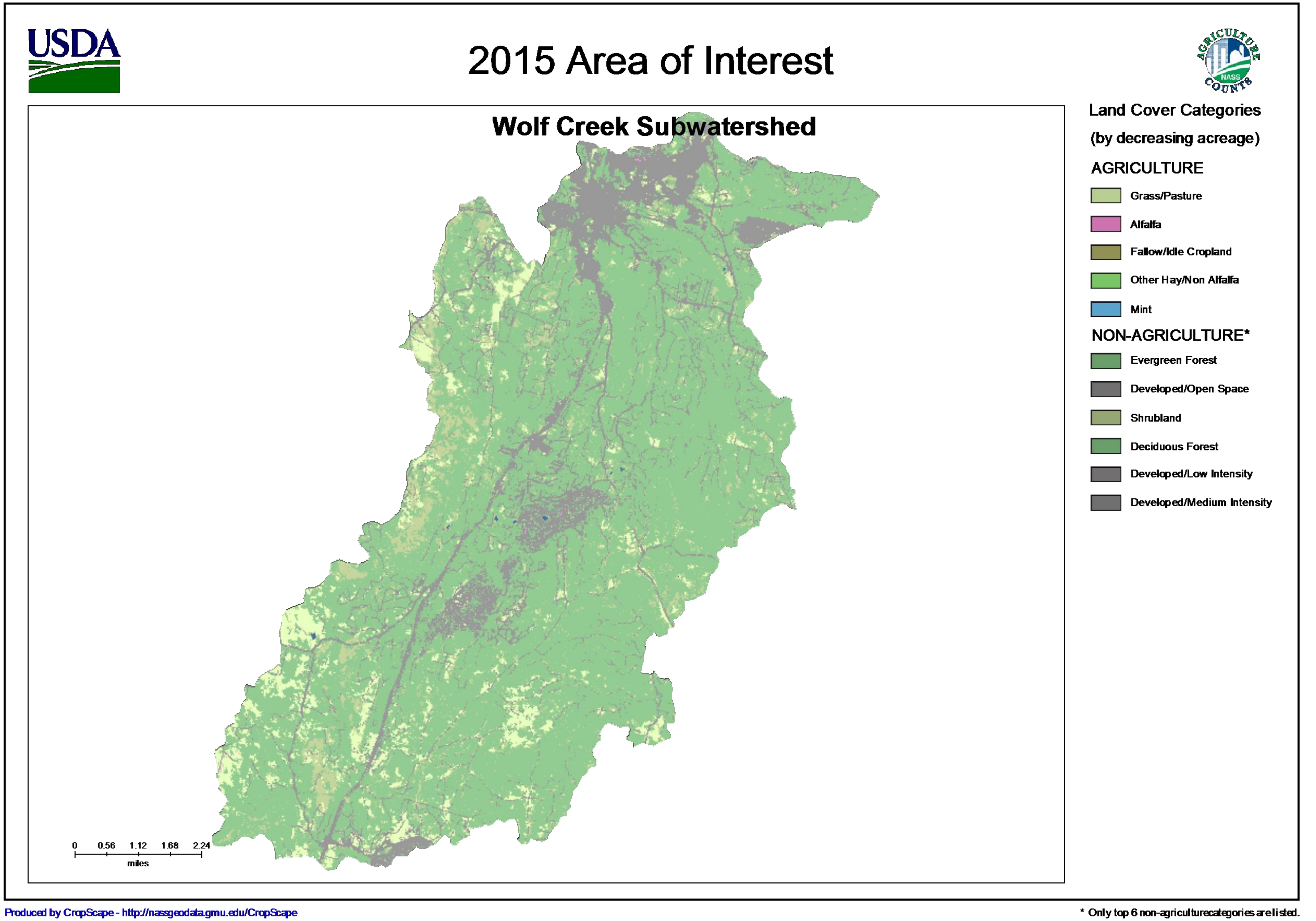


Figure 44. Land Cover in the Wolf Creek Subwatershed



County, deciduous orchards and rice farms dominate, with some irrigated hayfields (UC Davis, 2010).

According to county zoning data, almost 128,000 acres, over 40% of the watershed area, is zoned for general or exclusive agriculture. This includes almost all of Sutter, much of Yuba, and a large portion of central Nevada County, within the limits of the watershed. In addition, another almost 69,000 acres, over 20% of the watershed, are zoned as combined-agriculture (i.e. joint agricultural and industrial or residential). However, despite this large area, the percent of private lands in working landscapes in Nevada and Placer counties was actually the lowest in the larger Sierra Nevada Conservancy region (see map at http://www.sierranevadaconservancy.ca.gov/our-region/snc-subregions). In addition, the greatest percent conversion of working lands to other uses between 2000 and 2010 was in Placer and adjacent El Dorado counties, which also had the smallest median farm size and some of the highest population density compared to other counties in the region (van Wagtendonk, 2013).

While agriculture is important in the economy of the Bear watershed, the counties it encompasses rank relatively low in statewide agricultural production. Nevada County is ranked 54th in the state, as of 2010, with total production of almost $15 million. The leading commodities in the county (including area outside of the watershed) are cattle and pasture land, grapes, fruits and nuts and nursery products. Similarly, in Placer County, ranked 43rd in the state with production of over $62 million in 2010, the important crops are rice, cattle and other livestock, nursery products, and walnuts. The important crops in Yuba County include rice, walnuts, plums and peaches, with Yuba County ranked 30th in the state with a production of almost $208 million (van Wagtendonk, 2013). The important crops in Sutter County, which had a total production of over $400 million in 2014, are almonds, peaches, plums and walnuts (Sutter County, 2014).

Data for agricultural production value are not available at a greater resolution than the county scale. However, the USDA CropScape Database, produced by the Agricultural Statistics Service, provides a useful tool for visualizing acreage estimates of crop production in the watershed, as well as for mapping changes in crop distribution. According to CropScape, the dominant agricultural land use in the watershed, with over 72,000 acres, is grass and pasture land, followed by fallowed and idle cropland. The major crops grown are walnuts and rice, both covering over 10,000 acres each. Other crops grown, with varying acreage and intensity include: almonds, alfalfa, wildflowers, hay, plums, corn, oats, olives, peaches, cherries, barley, and honeydew melons. Between 2010 and 2014, approximately 1000 net acres across the watershed were converted from deciduous forest to grass/pasture land. In addition, over those years, 1404 acres of rice were converted to fallow/idle cropland, along with 782 acres of walnuts, 625 acres of winter wheat, and 320 acres of almonds (USDA, 2014).

Unlike other regions in California, the proportion of farms that are organic, particularly in the lower watershed, is minimal, with little change in recent years. According to the Feather River Report Card developed by the Sacramento River Watershed Program and described in the Introduction, the Lower Bear, which includes the Lower Bear and Dry Creek subwatersheds, has a score of only 62 in the Pesticide Use/Organic Agriculture Category. The only subwatersheds in the larger Sacramento River Basin with lower scores were the Lower Yuba and Lower Feather. In comparison, the Upper Bear was given a score of 100, indicating widespread wildlife-friendly agricultural practices. Between 2000 and 2005, the acreage in organic agriculture was low, with only minimal increases over time, in Nevada, Sutter and Yuba counties (Aalto et al., 2010). In fact, according to Klonsky and Healy (2013), between 2009 and 2012, the total acreage in organic agriculture decreased from 161 to 128 acres in Nevada County, 2,683 to 2,415 acres in Placer County, and 1,166 to 1,058 acres in Yuba County. Despite these decreases in acreage, it should be noted that the actual number of organic-certified operations increased in Nevada and Placer County over that time period. There was also an increase in acreage from 9343 to 10,799 acres of organic farms in Sutter County (Klonsky and Healy, 2013). There is no dataset describing organic agriculture and the adoption of other wildlife-friendly agricultural practices at a finer resolution than the county scale. However, the metrics of organic agriculture and reduced pesticide use suggest broader acceptance of ecosystem-friendly agricultural practices and reconciliation between economic and ecological health in the watershed (Aalto et al., 2010). For this reason and to fully understand the impacts of agriculture, it will be important to map these practices at a finer spatial scale in the Bear watershed.

III.C.3f. Timber Production

Often considered a subset of agricultural production, timber harvesting (silviculture) is a significant activity in the upper portions of the Bear River watershed in Nevada and Placer Counties. The California Natural Resources Agency shares with the California Environmental Protection Agency the responsibility for implementing the Timber Regulation and Forest Restoration Program established in the Public Resources Code. Cal FIRE's Forest Practice Geographical Information System (GIS) captures current and historic timber harvesting activities for over 4 million acres of California timberland.

Within the Bear River watershed, 38,268 acres of privately-owned land for timber harvesting are held by a range of companies, trust funds and private owners (Cal Fire, 2012). PG&E owns 12,352 acres, mostly in Placer County at the very top of the watershed.

The other major private company is Sierra Pacific Industries, which owns 10,802 acres, all in upper portion of the watershed, mostly in Nevada County. The top three private individual timber landowners collectively own over 3,000 acres in Nevada and Placer counties. The largest sole private timber owner in Nevada County, by acreage, is Mark Paye, with 906 acres and 941 acres of joint ownership. Larry and Patsy Rieger are also large private timber owners, with 1012 acres, most of which is in joint ownership with PG&E. Most of their land is in Placer County at the very top of the watershed. Including land owned by the family trust, Leroy Waddle is the other major private landowner with 1133 acres, all in Nevada County (Cal Fire, 2012). In most cases the landowner and the timber owner are the same with some exceptions, such as where PG&E or NID partially own the land but not the timber, or where there are multiple owners of the land and timber who don't fully overlap.

Impacts from timber harvest could include increased sedimentation from road building, introduction of invasive plants and pathogens, habitat fragmentation, changes in forest structure and diversity, and decrease in biodiversity (Laudenslaker, 1990). These impacts increase with clear cut harvesting and lessen with the use of sustainable harvest practices, such as though outlined in U.S. Forest Service General Technical Report GTR 220, "An Ecosystem Management Strategy for Sierran Mixed-ConiferForests," (North *et al*., 2009).

Table 25 lists the types of silviculture prescriptions used and the acreage associated with each category in the Bear River watershed (Cal Fire, 2012). It should be noted that some areas have two silviculture designations; this table reflects only the primary designation.

***Table 25.* Types of silviculture prescriptions used and acreage in the Bear Watershed**

Silviculture Prescriptions	Description	Acres
ALPR	Alternative prescription	6,825
CLCT	Clear cut	984
CMTH	Commercial thinning	358
CONV	Conversion	235
FBRK	Fuel break	318
GSLN	Group selection	14,129
NHRV	No harvest area	578
REHB	Rehab of under-stocked	563
ROAD	Road right of way	52
SASV	Sanitation salvage	2,930
SHRC	Shelterwood removal	5,092
SLCN	Selection	5,509
STRC	Seed tree removal	130
STRT	Seed tree removal/commercial thinning	16
STSC	Seed tree seed cut	192
TRAN	Transition	357

III.C.3g. Roads, Trails and Off-Highway Vehicle Use

Roads and Rail

Figure 45 illustrates the dense network of roads and railways across the watershed. Road density is greatest in the roughly vertical area between Grass Valley and Meadow Vista in the Middle Bear and Wolf Creek subwatersheds.

Data on railways is taken from the Caltrans Rail Network, last updated in 2013. There are 14 tracks and lines, totaling over 32 miles of rail, in the watershed. The tracks are a combination of passenger lines, operated by Amtrak, and freight lines, operated by the BNSF and Union Pacific Railway companies, the two largest railroad networks in the country. Passenger train lines have speed limits primarily between 40 to 60 mph, with some lines as low as 30 and as high as 75 mph. Freight lines have speed limits between 25 to 70 mph, with the majority between 30 and 50 mph.

Highway data is from a combination of sources, including the Placer County GIS Office and the National Highway System (NHS) MAP-21 program. The MAP program comes out of the Moving Ahead for Progress in the 21st Century Act, signed into law in 2012 with the goal of integrating real world data into the planning of national transportation infrastructure. There are 148km of highway within the watershed, including roads in the National Highway System, interstates and MAP-21 'Principle Arterials' which incorporates major highway ramps. The largest highway in the watershed is Interstate-80, though, in terms of length through the watershed, the longest are State Highways 49 and 20. Other important arteries include State Highways 174, 65 and 70.

Data on smaller roads in Placer, Nevada and Yuba counties are taken from the US Census Bureau Topologically Integrated Geographic Encoding and Referencing (TIGER) database, which contains Census Bureau geographic data, last updated in 2014. Road data for Sutter County was acquired through the Sutter County Planning Office. There are almost 2,200 miles of roads in the watershed across all four counties, in addition to the highways. These roads range from less than 1 mile up to 15 miles in length, with the majority less than 3 miles long.

Understanding the patterns and density of roads and rail lines is critical for prioritizing areas at risk for erosion, altered hydrologic function, invasive plant establishment and habitat fragmentation. Transportation infrastructure also has the additional impacts of local pollution and air quality problems from nitrogen oxide emissions and smog. Near aquatic environments, transportation-associated pollution and erosion can severely impair water quality; thus, it is important to understand how the roads and stream networks in the watershed overlap (Water Education Foundation, 2011). Figure 46 categorizes the roads of the watershed, including highways, based on distance from the nearest stream or river, not including canals and other artificial waterways. The majority of the roads in the watershed (64%, over 1240 miles), are within 100 meters of a stream. Fewer roads (13%) are at an intermediate distance, 100-200 meters from streams. Almost a quarter of all roads (24%, almost 560 miles), are greater than 200 meters from a stream. Most of the farther roads are located in densely populated areas, like Grass Valley and Meadow Vista, and in the lower watershed, along Highway 70.

Trails

Hiking, equestrian and cycling trails, though less problematic than roads, can also have similar negative environmental impacts. This includes soil compaction and erosion, pollution and litter, nutrient loading, the introduction of invasive species, noise disturbance and habitat fragmentation. However, trails can also have important benefits in terms of public health, the economy and community engagement.

The Bear River Watershed contains at least 188 non-motorized recreational trails, totaling over 75 miles, presented in Figure 47. Trails vary dramatically in length from less than one miles to over 7 miles (excluding trail segments outside of the watershed), with the majority falling into the shorter range. Most public trails in the area are hiking and pedestrian trails, though many allow mountain biking and some are specifically designed for cycling. The longest trail is the Pioneer Trail, which is almost 25 miles long. The segment of the Pioneer Trail within the watershed is in the Upper Bear subwatershed, starting in the Bear Valley. The Meadow Vista and Grass Valley areas have the largest concentration of trails in the watershed, including some along the main stem of the Bear River.

In Placer County, the majority of trails are operated through the Weimar/Applegate/Clipper Gap Community Plan. The Meadow Vista Trail Association also has a variety of proposed trails, totaling 20 miles. There is no information, as of 2009, on the status of these trails, the majority of which are less than 1 mile.

In Nevada County, trails are operated by a variety of agencies including the Bear Yuba Land Trust (BYLT), the Pacific Gas and Electric Company (PG&E), Nevada Irrigation District (NID), the State Park System, California Fish and Wildlife (CDFW), Tahoe National Forest, and the City of Grass Valley. Data for trails in Placer and Nevada County were taken from the County GIS and Planning offices. Neither Yuba nor Sutter County has publicly available trails data.

The actual impact of trails is highly dependent on the primary users of the trail, their popularity, and the environmental setting. Not all of this information is readily available for all trails in the watershed and thus the actual impact of these trails, and their potential role in future restoration plans, requires further research.

Off-Highway Vehicle Use

The use of off-highway vehicles (OHV) is prevalent throughout the watershed. Areas along Greenhorn and Steephollow Creek, and in mine diggings, are very popular for OHVs. Both private and public lands (USFS, BLM) are heavily used in all regions of the watershed. There is great concern that the movement of sediments in mine soils and gravels will increase heavy metal input into waterways. OHVs can cause substantial erosion of the soils on which they travel. They can impact vegetation directly through trampling, soil compaction and pollution, which can be devastating to an area of the forest by resulting in fewer and less vigorous plants, reduced plant cover, lower plant diversity, adverse changes in plant species composition and disruptions to natural plant succession and nutrient cycling processes. OHV use can impact wildlife through direct mortality, general disturbance, noise impacts and habitat degradation. Aquatic habitat is also significantly affected through increased sedimentation, destruction of important aspects of aquatic systems through direct contact and decreased hydrologic health through the effects of pollution (Berry et al., 1996). It is unknown how many miles of permitted OHV trails are in the watershed, or the extent of OHV use on private land and unpermitted areas. Land impacted by OHV use may be most in need of restoration.

Figure 45. Roads and Railways

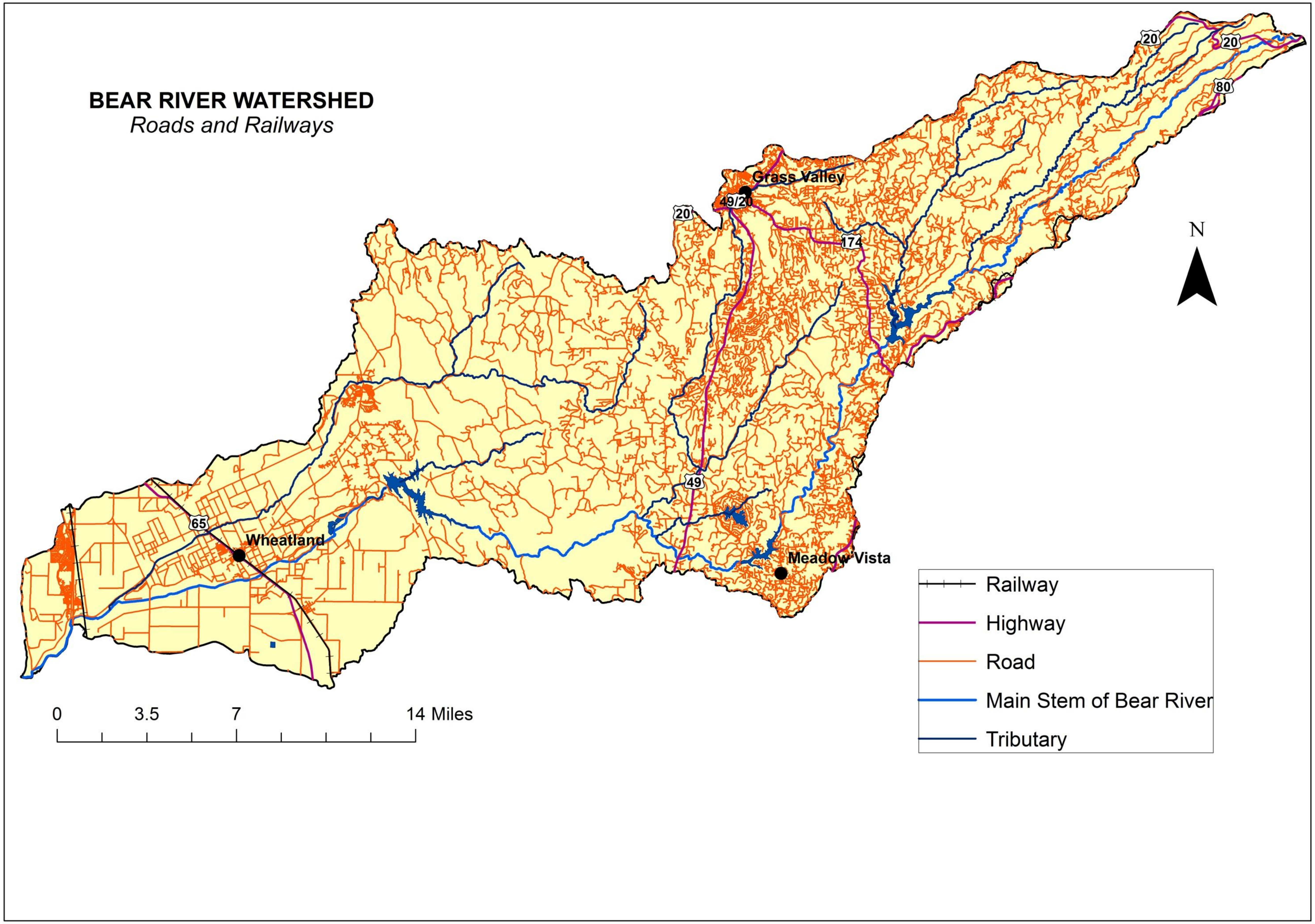
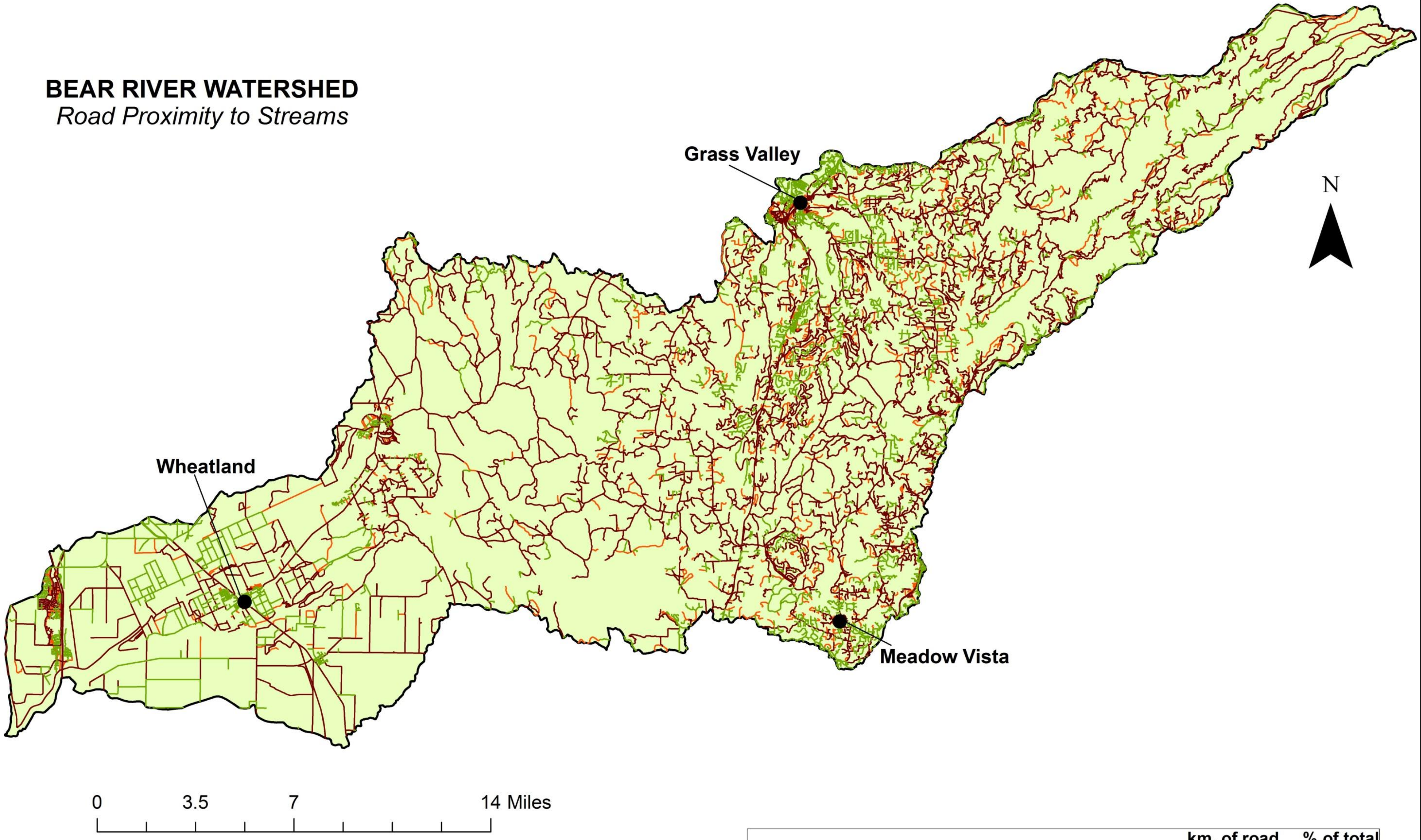
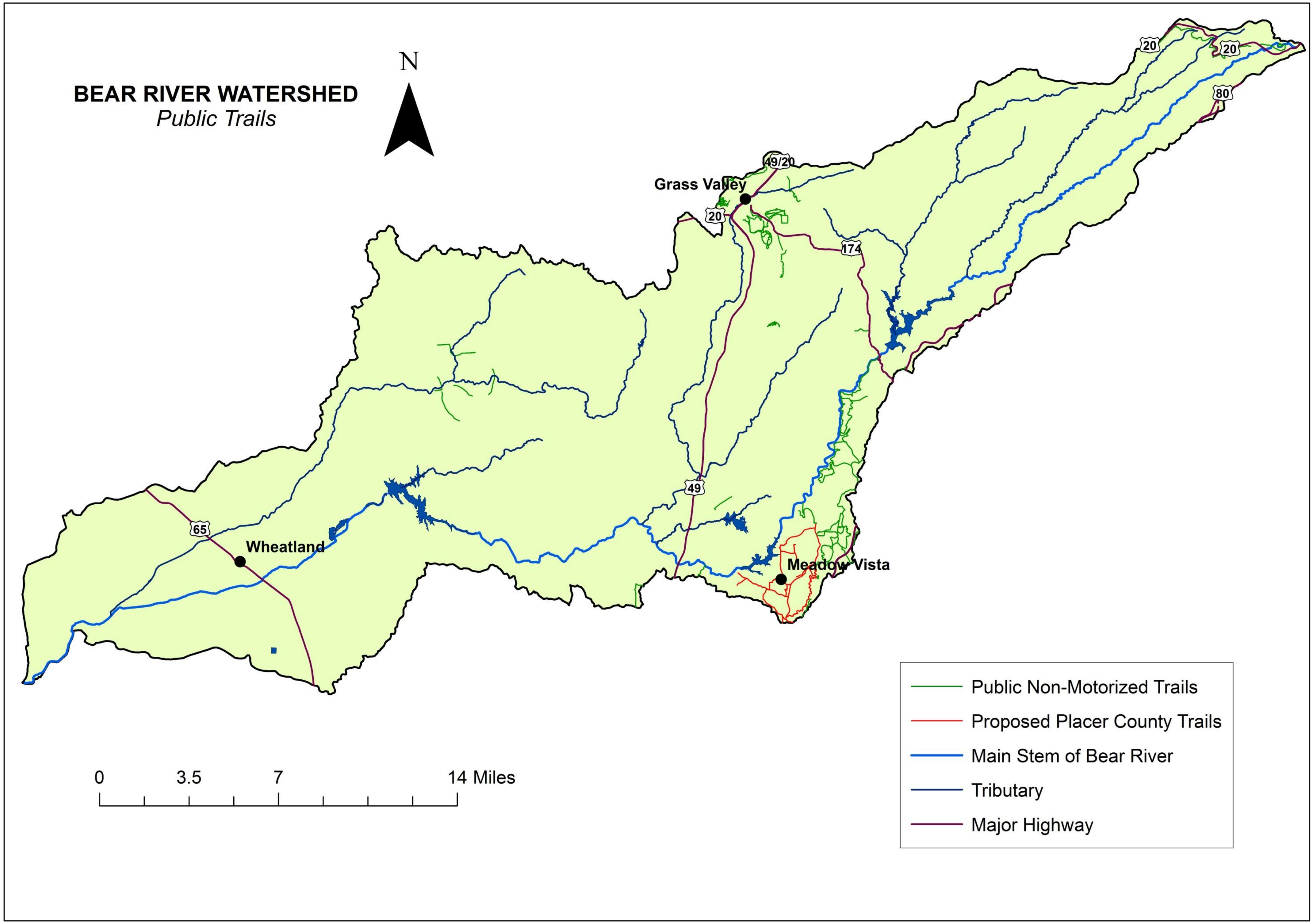


Figure 46. Road Proximity to Streams



	km. of road	% of total
Roads within 100m of a stream	2361.4	64%
Roads between 100m and 200m of a stream	474.8	13%
Roads greater than 200m from a stream	848.3	23%

Figure 47. Existing and Proposed Public Trails



III.C.4. Water Management

Water Rights

In addition to the intricate system of dams, diversions and canals, the watershed also has a complex arrangement of water rights holders under the complicated California water rights system. Water rights, which are typically licensed by the State Water Resources Control Board, give the holders the right to use the water, not, explicitly, to own it. According to the California Water Code, anyone who takes water from a lake, river, or creek, or from underground supplies, for a beneficial use (defined in the Water Code) is required to have a water right. Those that divert only small amounts of water for solely domestic purposes, or commercial livestock watering purposes, are exempt from the water right requirement, but are required to submit a Statement of Water Diversion and Use to the State Water Board. The maximum allowance under this registration system is 4,500 gallons per day for immediate use or 10 acre feet (ac-ft) per year for storage. The current water rights system distinguishes between a water right permit and a license. A permit is an authorization to develop a water diversion and use project. A license can be acquired after the project is constructed and water consumption has begun, if water is being used beneficially and the operator is complying with all the conditions of the permit (State Water Resources Control Board, 2016).

Currently licensed appropriative water rights holders in the Bear Watershed include: Asian Pacific Group LLC., the Bethel Church of Nevada County, Morehead Land LLC., the Pine Lake Association, United Auburn Indian Development Corp., CDFW, Spring Valley Homeowner's Association, LCB Properties LLC., Smith and Smith Ranch, the Lakewood Association, and a large number of private landowners. The largest private appropriative water right license, in terms of annual acre feet, belongs to Sheila St. Germain who has a license for 5,166 ac-ft/yr. The US Forest Service also has an appropriative license for 12 ac-ft/yr. The California Department of Transportation has an appropriative water right license that was revoked. Sierra Pacific Industries, Smith and Smith Ranch, Green Vista Holdings LLC., and Hidden Acres Limited Partnership, as well as private landowners, all have claimed water through a Statement of Water Diversion and Use (State Water Resources Control Board, 2016).

The four largest appropriative water right license holders, in terms of quantity of water diverted, are the Camp Far West Irrigation District, Nevada Irrigation District (NID), Pacific Gas & Electric Company (PG&E), and South Sutter Water District (SSWD). Under its current appropriative rights, NID has the right to 1,226,144 ac-ft of water from its post-1914 license, as well as 203,905 ac-ft and 3,339 cubic feet per second (cfs) of pre-1914 water rights, which are exempt from the current license system. In comparison, PG&E holds a license for

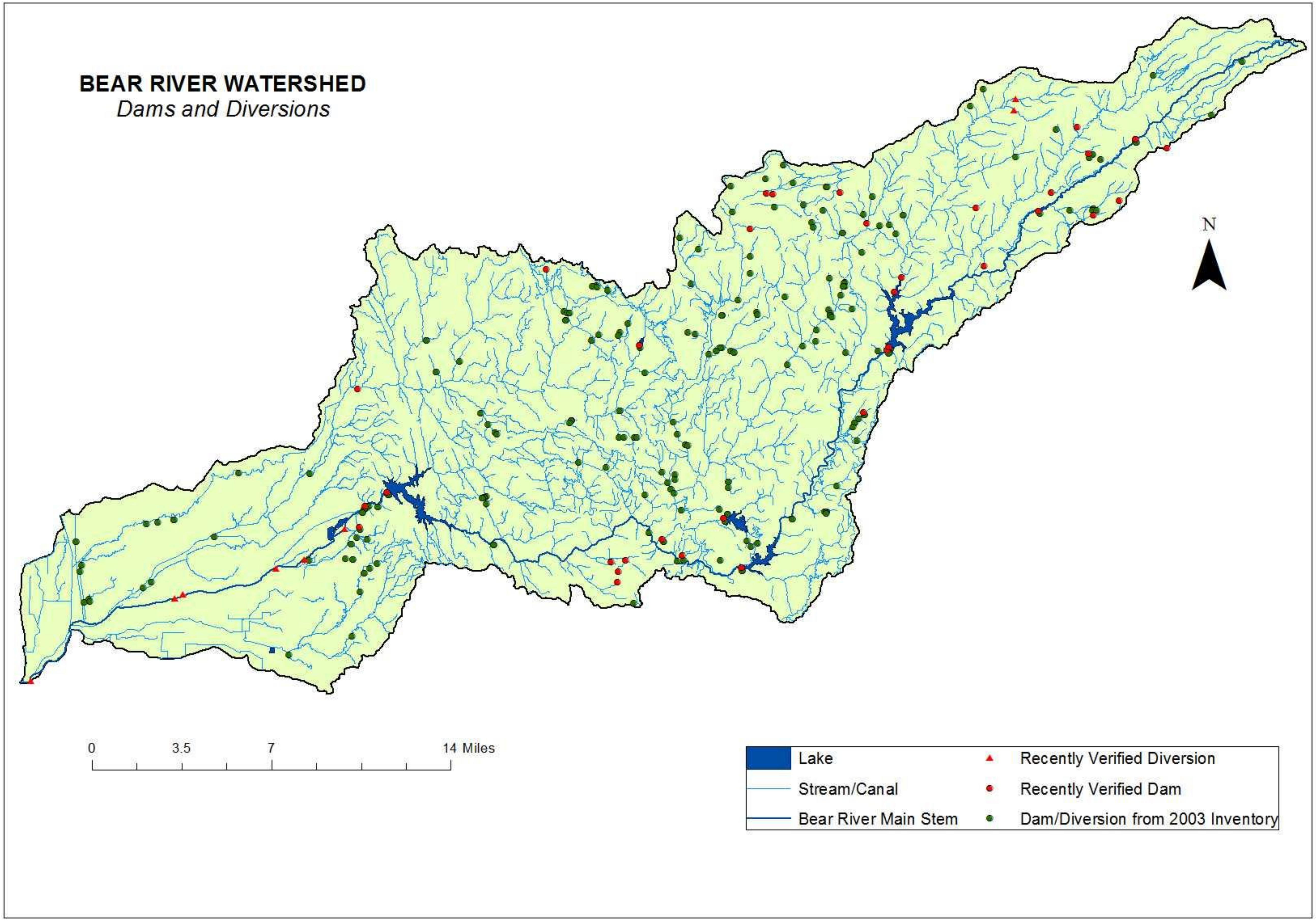
110,646 ac-ft and 1,837 cfs pre-1914, in addition to 491,759 ac-ft and 1,445 cfs post-1914. SSWD currently holds a license for 275,458 ac-ft and a permit for an additional 627,984 ac-ft. However, this value reflects the maximum amount of water licensed, rather than what is actually available or generally allowed. The Water Resource Board Water Rights Database also licenses diversions of the same water for consumptive use and power generation separately. As such, the actual amount available in post-1914 licenses for NID and PG&E is more like 450,000 and 98,234 ac-ft per year, respectively (State Water Resources Control Board, 2016).

Water permits can only be obtained if the project is in the public interest, the project does not unreasonably harm the environment, and if there is water available for appropriation. The State Water Board can issue decisions that there is no water available from a particular water body and add that stream to the Fully Appropriated Streams List. The list was created under Order WR 98-08, which gives the State Water Board the authority to declare critical reaches of stream systems fully appropriated. By Order 89-25, any declaration that a stream is fully appropriated includes all upstream sources that are hydraulically connected to the stream system. In the Bear watershed, in the 1998 Declaration of Fully Appropriate Stream Systems, South Wolf Creek (by decision 1059), Magnolia Creek (by decision 1402), and the Bear main stem below (decision 1090) and above (decision 1091) Camp Far West Reservoir were declared fully appropriated (State Water Resources Control Board, 2015).

Dams and Levees

According to Schilling and Girvetz (2003), there are 172 jurisdictional dams in the Bear River watershed. These are defined as "artificial barriers, together with appurtenant works, which are 25 feet or more in height or have an impounding capacity of 50 acre-feet or more. Any artificial barrier not in excess of 6 feet in height, regardless of storage capacity, or that has a storage capacity not in excess of 15 acre-feet, regardless of height, is not considered jurisdictional." In addition to these sites, the 2003 Bear River Watershed Disturbance Inventory includes 78 additional dams and diversions that do not meet these criteria, across the watershed, all labeled as Dam/Diversion from 2003 Inventory in Figure 48. This data supposedly came from the Department of Water Resources and California Fish and Game and was produced in 1994; however, it could not be relocated or verified. Recently verifiable data on dams and diversions comes from the California Department of Fish and Wildlife Fish Passage Database. The Passage Assessment Database is an on-going inventory, updated as of 2013, of known and potential barriers to anadromous fish in California, integrating data from a variety of agencies, organizations and private landowners. More information on the database can be found at http://www.calfish.org/tabid/420/Default.aspx.

Figure 48. Dams and Diversions



Data from the Passage Database is divided into diversions, which includes two road crossings, and dams. Out of the eight diversions mapped in the Bear watershed, all are considered total barriers to fish passage. The two road crossings, owned by the Forest Service, are located on Greenhorn Creek in the upper Bear subwatershed. The remaining six diversions are operated by the Department of Water Resources and are located on the main stem of the Bear. In contrast to the data of Fraser and Girvetz (2003), there are only 36 dams listed in the watershed, most with unknown fish passage status. Camp Far West Diversion Dam and Camp Far West Dam, on the main stem of the Bear, as well as Beale Dam, on Dry Creek, are total barriers to fish passage. The majority of dams in the watershed are located in the upper half of the watershed, specifically in the upper and middle Bear subwatersheds and the Wolf Creek watershed. These dams are owned by a variety of agencies including the Nevada County Department of Transportation, the Lakewood Association, US Air Force, private landowners, Lake of the Pines Association, Golf Resources of Auburn Valley, South Sutter Water District, PG&E and NID. A map of dams and diversions from the Fish Passage Database and the 2003 inventory can be found in Figure 48.

As discussed in Section C.2: Governmental Jurisdictions, a variety of reclamation districts providing flood control to the Sacramento River Valley operate partially in the Bear River watershed. This includes Districts 1001 (Nicolaus), 817 (Carlin), 2103 (Wheatland Vicinity), and 784 (Plumas Lake). District 1001 constitutes six levee units, including two on Yankee Slough, of 3.66 and 4.17 miles each, and one on the Bear River of 12.60 miles. These levees are meant to provide direct flood protection to adjacent agricultural lands. District 2103 has two levees, one on the Bear River of 5 miles and one on South Dry Creek of 4.77 miles. Districts 817 and 784 help protect each other, as well as District 1001, and 784 is considered an essential feature of the Sacramento River Flood Control Project. District 817 includes three levees, one on South Dry Creek (3.82 miles), one on Dry Creek (1.5 miles) and a 3.87 mile levee on the Bear River. District 784 constitutes eight levees, including one on South Dry Creek of 1.5 miles and one on the Bear River of 4.73 miles (Department of Water Resources, 2013b).

Hydroelectric Projects and FERC Relicensing

In addition to the presence of large numbers of dams and levees, a major component of water management on the Bear is the series of imports and exports of water from the adjacent watersheds. About 200,000 ac-ft (acre-feet) is imported annually from the Yuba and American Rivers through the Drum Canal, South Yuba and Lake Valley Canal systems. Conversely, about 290,000 ac-ft of water from the Bear is exported annually below Rollins through the Bear River Canal for use by the Placer County Water Agency (PCWA), Nevada Irrigation District (NID) ID, PG&E and the South Sutter Water District (SSWD). The NID diverts an additional 43,400 ac-ft through the Combie Phase I Canal below Lake Combie, while SSWD takes an average of 124,500 ac-ft below Camp Far West Reservoir through the South Sutter and Camp Far West canals. From unpublished data prepared for a study on the proposed Garden Bar Dam, it was estimated that, for the years 1921-1983, the average unimpaired discharge at the watershed outlet near Wheatland was 323,000 ac-ft per year versus an observed, impaired discharge of only 292,500 ac-ft per year. This corresponds to a difference in average discharge of 418 cfs (cubic feet per second) for unimpaired flow versus 21 cfs under current conditions (Bear River Awakening, 2016).

The primary operators of the system of canals, diversions, and hydroelectric facilities that characterize the Bear are NID, which controls the Yuba-Bear Hydroelectric Project (FERC #2266), PG&E, which operates the Drum-Spaulding Hydroelectric Project (FERC #2310), and SSWD, which operates the Camp Far West Hydroelectric Project (FERC #2297).

The major hydroelectric project operated by NID in the Bear watershed is the Yuba-Bear Project, which received a license in 1963 and was completed in 1966. The project covers an elevation range from Rollins Reservoir at 2,171 ft to 6,6665 ft, and includes facilities on the Middle and South Fork of the Yuba and the Bear River. The FERC-authorized capacity of the project is 79.32 megawatts (MW). The initial license included ten reservoirs and two powerhouses, but was amended in 1982 to allow for the construction and operation of Rollins and Bowman Powerhouses and Bowman-Spaulding Transmission Line. The entire project development stores 218,700 ac-ft of water and has had, between 1972 and 2007, an annual power generation of 354.3 gigawatt-hours (GWh), 161.9 GWh of which comes from the Chicago Park Powerhouse. The system contains 11 reservoirs, including four in the Bear watershed (Dutch Flat No. 2 Forebay, Dutch Flat Afterbay, Chicago Park Forebay and Rollins Reservoir), the largest of which, by gross storage, is Rollins with 58,682 ac-ft of storage and a 252.5 ft high dam. The largest reservoir in the system is Bowman Lake, in the Canyon Creek watershed, with a gross storage of 68,363 ac-ft (NID, 2012). In collaboration with the Drum-Spaulding Project, NID operates the Bowman-Spaulding Conduit, which diverts flow from the Middle Yuba River and Canyon Creek and their tributaries into Fuller Lake and Lake Spaulding in the South Yuba watershed, which is operated by PG&E. Similarly, the Dutch Flat Conduit, with a maximum capacity of 610 cfs, diverts water from PG&E's Drum Afterbay Reservoir to NID's Dutch Flat Forebay. Dutch Flat Forebay has a usable storage capacity of only 185 ac-ft. This water is returned to the Bear River into the Dutch Flat Afterbay then rediverted into the Chicago Park Flume to be returned again into the river above Rollins (NID, 2010). In the Bear watershed, NID also operates the Lake Combie and Combie North Aqueduct Projects, which are FERC Project Numbers 2981 and 7731, respectively. These projects have a combined authorized capacity of 1.85 MW and are exempt from FERC license expiration (NID, 2012).

The other major hydroelectric project in the Bear is PG&E's Drum-Spaulding Project, which began in 1912 and was PG&E's second-ever hydroelectric project. The Drum-Spaulding Project, which included the largest concrete arch-style dam ever constructed at the time in 1919, currently includes 12 powerhouses, 29 reservoirs, six overhead transmission lines and 80 miles of canals and tunnels on the South Yuba, Bear and North Fork of the American rivers. The overall system has a capacity of 191.5 MW and a combined usable storage capacity of 151,355 ac-ft. In the Bear River watershed, the project includes one on-stream reservoir, Drum Afterbay, one off-stream impoundment, Drum Forebay, one diversion dam, Bear River Canal, and three powerhouses. The largest powerhouse by installed licensed capacity is Drum No. 1 with 56.4 MW, but the largest by annual average power is Drum No. 2 with an average of 273,481 MWh between 1972 and 2007 (PG&E, 2012). Through the project, water is imported from the South Yuba River near the Bear River headwaters through either the South Yuba Canal at gauge YB-139 (upstream of USGS Gauge 11421710) or the Drum Canal, which is over 9 miles long with a capacity of 840cfs, at YB-137 (upstream of YB-139). Water is imported in low flow years to maintain a 5 cfs flow minimum in the Bear mainstem, as measured at gauge YB-198 (USGS Gauge 11421710), and in high flow years in anticipation of a spill in Lake Spaulding. The Bear River Canal diverts water from the Bear River to the American via the Halsey Forebay at a rate of up to 470 cfs. Spill facilities in the watershed are also utilized for excess storm water removal from the canals, flow augmentation, and emergencies such as canal failure downstream (American Rivers, 2010; PG&E, 2012).

A schematic of the Yuba Bear and Drum Spaulding Hydroelectric Projects can be found http://www.eurekasw.com/NID/Project Maps and Figures/Yuba-Bear Project Flow Schematic and Fact Sheet/Yuba-Bear and Drum Spaulding Projects Schematic (Modeling Version).pdf.

Unlike the Yuba-Bear and Drum-Spaulding Projects, the Camp Far West Hydroelectric Project, operated by SSWD and constructed in 1981, does not include any open water conveyance facilities or transmission lines. It also does not include the diversion dam located downstream of Camp Far West Dam, the SSWD Conveyance Canal, or Camp Far West Irrigation District's Camp Far West Canal. The project solely consists of the Camp Far West Powerhouse, with an average annual energy production of 26,900 MWh, and the Camp Far West Reservoir, which has a usable storage of 92,430 ac-ft. The main embankment dam is an earthfill structure of 185 ft. When the reservoir was initially constructed, the gross storage was 104,000 ac-ft, versus only 93,740 ac-ft today (SSWD, 2016). South Sutter also operates the Vanjop No. 1 Hydroelectric Project, FERC Project No. 7580, which has a capacity of 0.42 MW and is exempt from FERC license expiration (NID, 2012).

In recent years, South Sutter Water District began the review process for a new proposed reservoir at Garden Bar on the Bear River between Lake Combie and Camp Far West. The proposed project, supported by a variety of out-of-county partners including three major Southern California water districts, included a 350 ft dam and reservoir with up to 400,000 ac-ft of storage. National activist organization, American Rivers, claimed that the project ignored state flow criteria, the potential impacts of climate change and possible changes in operations of upstream dams following FERC relicensing (American Rivers, 2011). The project was opposed by a variety of local organizations including the Nevada and Placer County Boards of Supervisors, the California Resources Agency, the Bear Yuba Land Trust, NID, the Auburn United Indian Community, and the Placer County Fish and Game Commission (Brennan, 2012). The Garden Bar proposal has been officially abandoned for now because of the potential environmental impacts and the inability of SSWD to acquire the necessary water permits.

The three major hydroelectric projects in the watershed all have licenses through the Federal Energy Regulatory Commission (FERC): Yuba-Bear Hydroelectric Project (FERC #2266), Drum-Spaulding Hydroelectric Project (FERC #2310) and Camp Far West Hydroelectric Project (FERC #2297). All three of these projects are approaching the end of their initial FERC licenses. NID and PG&E began the application renewal process for a new license in 2008, officially filing their application in 2011. The two organizations have collaborated on their applications and the necessary technical studies. The Yuba-Bear and Drum-Spaulding licenses expired in April 2013. However, their applications are still processing, and it may take years for the new licenses to be issued. In the meantime, they are operating primarily on the original license agreements. Information on the measures proposed by NID and PG&E, as well as which measures have been agreed upon, can be found http://www.eurekasw.com/NID/Final License Application/Yuba-Bear Amended License Application/2012-0618_PUBLIC YB Amended App pdf.pdf and http://www.eurekasw.com/DS/Final License Application/Drum-Spaulding Project - Amended Application/2012 - 0618 - PUBLIC_DS Amended Application.pdf, respectively. A major component of PG&E's proposed changes to the Drum-Spaulding Project is the separation of the Deer Creek Facilities from the larger project (PG&E, 2012). The FERC license for Camp Far West was issued in 1981 and will expire in June 2021. SSWD submitted a notice of intent to file an application in March 2016. The final date at which SSWD can file a final license application is July 2019.

Impacts of Hydrologic Alteration

Understanding the hydrological alteration of the Bear watershed due to water management and hydroelectric power is important given the complex role of flow in maintaining geomorphic stability and ecosystem health. Inter- and intra-annual variation in flow is essential to the lifecycle of many aquatic and riparian species by influencing reproductive success, habitat availability, and competition (Aalto et al., 2010; Sierra Streams Institute, 2011). The flood pulse concept emphasizes the importance of floods in the disturbance regime for renewing riparian and aquatic ecosystems (Rood et al., 2005). By affecting sediment transport, temperature, and dissolved oxygen concentrations, the duration and frequency of flooding can influence soil moisture and anaerobic stress for riparian vegetation, soil mineral availability, access to habitat for both terrestrial and aquatic organisms, nutrient concentrations, and channel structure. Similarly, flooding can trigger migration and spawning cues, recharge groundwater in the floodplain, thus helping sustain flow in low flow conditions, maintain riparian species diversity and abundance, transport organic material and woody debris into the channel for food and habitat, purge invasive species, restore water quality and temperature by flushing out pollution, aerate eggs and prevent siltation (Sierra Streams Institute, 2011). In addition, flow pulses directly support the establishment of riparian vegetation by transporting seeds onto the banks and providing sufficient soil moisture for germination (Aalto et al, 2010). Present management not only changes the timing, duration and magnitude of these flows, it also leads to more rapid fluctuations in flow that can be harder on aquatic species (Bear River Awakening, 2016).

Particularly important for maintaining ecosystem health, and most noticeably impacted by reservoir development, is the frequency, timing and magnitude of low flow events. Seasonal variations in low flows impose constraints on aquatic and riparian habitat and food supply, impacting species composition and abundance. Similarly, low flows can cause dehydration in terrestrial species, soil moisture stress in riparian plants, and intolerably high temperatures and low oxygen conditions for aquatic organisms (Sierra Streams Institute, 2011). High temperatures, which can be caused by naturally low flows or diversions for human use, can alter species composition and viability and facilitate colonization by invasive species (Poole and Berman, 2001). This is in addition to the physical barrier extremely low flow conditions can pose for aquatic species. In a watershed like the Bear with additional nutrient inputs into the system from wastewater treatment and agricultural runoff, particularly in the lower watershed, low flows can be even more stressful for aquatic organisms due to high nutrient concentrations that can lead to algal blooms and hypoxic conditions (Sierra Streams Institute, 2011).

Variations in flow and sediment transport, such as the attenuation of floods and artificially high base flow conditions, due to river infrastructure has long lasting impacts on the geomorphology of the aquatic system (Rood et al., 2005). Dams and diversions, which can trap sediment, may cause downstream flows to become sediment-starved and thus more erosive. This 'hungry water,' as it is known, can cause channel incision, the coarsening of bed material, the loss of spawning habitat as smaller gravels are eroded and transported downstream, and the artificial stabilization of the channel path. Erosion can leave deposits of larger gravel and cobbles that can armor the bed. Conversely, reservoir operations may reduce peak flows, inducing aggradation of fine material, leading to siltation, which also destroys spawning habitat (Kondolf et al., 1997).

By changing flow and sediment conditions, the current system of water management in the watershed can have serious consequences for important fish species. The National Marine Fisheries Service identifies five important stressors to the Central Valley steelhead in the Bear, though these stressors are evident for the majority of anadromous fish species in the system: alterations of natural river morphology, riparian and floodplain habitat; changing flow conditions that influence migratory cues; artificial water temperatures; loss of physical habitat through changing sediment size distribution; and shifts in flow-dependent habitat (National Marine Fisheries Service, 2014a).

In addition, reservoirs can create sites for mobilization and methylation of mercury. More information on the role of reservoirs as interceptors of mercury and possible mercury-remediation techniques in reservoirs can be found below in Section C.5a: Mines and Mercury.

Evidence of Hydrologic Alteration on the Bear

Several studies have been conducted to investigate the impacts of hydrological alteration and management on particular reaches of the Bear watershed. In 2014, ECORP Consulting conducted an instream flow and sediment study for NID on the main stem of the Bear, specifically a 5.5 mile stretch from Lake Combie to its confluence with Wolf Creek. The study estimated bankfull discharge in the stretch to be 60-80 cfs and found that the larger gravels in the substrate over much of the reach were typically immobile at this bankfull flow. However, on average across the reach, approximately 50% of sediments would be entrained and mobilized at flows as little as 15 cfs. In part due to this high mobility, and the attenuation of peak flows by Lake Combie, any smaller gravels remaining in the substrate were typically armored beneath a layer of larger boulders and cobbles, and therefore unsuitable for fish spawning. The armoring of channel sediments here implies that highly erosive, scouring flows dominate the system, likely due to sediment being trapped behind upstream reservoirs (ECORP, 2014). In this reach, the channel substrate was found to be typically bedrock, and thus only 3-23% of substrate was gravel-sized sediments. While the optimal median sediment size (the D50) for trout spawning gravel is estimated at 0.59-0.98 in, the D50 over much of the reach was between 0.79 and 6.61 in. As such, it was estimated that appropriate spawning habitat was completely absent from most areas and less than 1% on average throughout the reach. However, habitat suitability curves on this reach found that good habitat conditions existed for trout species at all other life stages, besides spawning, and that the habitat was ideal for minnow family species like the pikeminnow and Sacramento sucker. Unfortunately, the potential for high flows up to 823 cfs, due to reservoir releases, as well as the mobility of most suitable spawning gravel at flows as little as 10 cfs, make gravel augmentation projects to improve spawning habitat typically unsuitable for this reach (ECORP, 2014).

Many of the studies on flow conditions in the Bear River have been completed as Technical Memoranda for the Federal Energy Regulatory Commission (FERC) relicensing process of the Drum-Spaulding and Yuba-Bear Hydroelectric projects. The majority of these studies, through the collaboration between PG&E and NID, focused on a reach of the river near the headwaters through Bear Meadow, known as Reach #2, the section below Dutch Flat Afterbay, and the Canal Diversion reach, a 10.4 mile stretch below Rollins Reservoir and the Canal Diversion to Lake Combie. Other reaches of focus also included the reach just above Bear Meadow, know as Reach #2b, and around Drum Afterbay (NID and PG&E, 2011a; NID and PG&E, 2011c). The precise location of these reaches can be seen above in Figure 9. These studies measured the entrenchment ratio (the width at two times bankfull depth divided by the bankfull width) at a series of transects through these reaches in order to quantify incision and erosion of the channel. A smaller ratio indicates greater entrenchment. At Dutch Flat, the entrenchment varied from 1.5-1.7, and the bank erodibility index was rated as high to extreme. At the Canal Diversion, the entrenchment varied from 1.3-1.6, with a low bank erodibility index, and at Reach #2, entrenchment was between 1.3 and 2.4. Despite the relatively low entrenchment ratios, the 'first break' discharge, the point at which flows spread out on to the surrounding surface, was found to be comparable to the bankfull discharge, calculated with vegetative indicators, at all three reaches (NID and PG&E, 2011a).

The FERC Relicensing Technical Memoranda also compared observed annual discharge to estimated unimpaired, natural discharge for median flows (50% exceedance) and high flow conditions (25% exceedance). These flows in cubic feet per second (cfs), as well as the ratio of regulated to unimpaired flows, for each reach are shown below in Table 26. Unsurprisingly, the lower the entrenchment ratio for a reach, the larger the difference between regulated and natural flows, indicating more hydrological alteration due to management (NID, 2011a). The ratio of regulated to natural flows at the Canal Diversion reach is lower than might be expected because, at this site, imports and exports of water in and out of the main stem almost balance. Similarly, below Drum Afterbay, the low regulated to natural flows ratio is likely due to the fact that, through this reach, most of the additional imported water does not flow through the main channel of the Bear, but rather through a series of parallel flumes and tunnel structures (ECORP, 2014).

Table 26: **Comparison of regulated and natural flows for median and high flows**

Site	Regulated		Natural		Regulated: Natural (%)	
	Median Flow (cfs)	**High Flow (cfs)**	**Median Flow (cfs)**	**High Flow (cfs)**	**Median Flow (cfs)**	**High Flow (cfs)**
Bear #2 (1.3-2.4)	115	187	43	100	267	187
Dutch Flat (1.5-1,7)	112	590	496	1313	23	45
Canal Diversion (1.3-1.6)	1732	4300	2014	5383	86	80
Bear #2b	311	440	266	676	117	65
Drum Afterbay	98	338	322	834	30	41

The Technical Memorandum on channel morphology (NID and PG&E, 2011a) also found that the mobility of sediment, averaged across the Bear and Deer Creek watersheds, changed between unimpaired and regulated conditions. The D50 sediment tended to be more mobile for natural conditions, for both median and high flow events. There was little difference, averaged annually, for larger sized sediment, and the finest material was less mobile in natural conditions. However, at Bear Reach #2, in Bear Meadow, sediment that fit in the size range for trout spawning gravels, estimated to be 0.25-2.5 in for this study, was found to be more mobile at high flows and less mobile at median flows for natural conditions. This was likely because management attenuates larger peak flow events and increases median flows, making sediment more immobile at high flows and more mobile under normal conditions (NID and PG&E, 2011a).

The Technical Memorandum also researched the availability of habitat for different fish species, particularly the rainbow trout. It was found that habitat availability curves for adult, juvenile and spawning trout typically followed a pattern of an initial rise in habitat with increasing flow, followed by a decrease in habitat availability due to unsuitably high water velocity and depth. This pattern was evident at multiple reaches on the Bear River, including Reach #2, Drum Afterbay and the Canal Diversion (NID and PG&E, 2011b). However, at Dutch Flat, at peak flows, habitat availability increased again with increasing flow, likely due to the channel overtopping its low banks and recruiting more habitat in the riparian zone. At the Chicago Park Powerhouse, below the Bear's confluence with Steephollow Creek, habitat area continued to increase with flow. This is likely because the river at this point is underfit relative to the channel so that more habitat can be recruited without containment by the river's banks. Considering the habitat availability for current conditions versus unimpaired flows, it was found that regulated flows typically provided more habitat during the low flow season in the summer and fall and less habitat at higher flows in the winter (NID and PG&E, 2011b).

In addition to work on instream flow and sediment, the ecological functioning of riparian habitat at three reaches was assessed in more detail (NID and PG&E, 2011c). At the Canal Diversion reach, upstream of Lake Combie, certain sections were found not be vegetated and the channel was found to be confined by bedrock. However, this section was rated as Properly Functioning because, over most of the reach, the floodplain was still hydrologically connected to the stream. As such, the floodplain was still inundated by seasonal flows and riparian vegetation was beginning to take hold where the banks were not dominated by bedrock. The reach by Dutch Flat, further upstream, was rated as Functional-At Risk, in large part due to the presence of large terraces, up to 60 ft high, of hydraulic mining debris that confine the channel, prevent the recharge of groundwater in the floodplain, and hamper the reestablishment of riparian vegetation. Bear Reach #2, through Bear Meadow, was also rated as Functional-At Risk. There is some evidence of localized bank failure and channel incision, illustrated by the low entrenchment ratio at some transects. Currently, the channel is hydrologically disconnected from the floodplain in the upper and middle meadow where there is a large berm and the channel is at its steepest. This incision resulted in a head cut migration, likely due to the concentration of artificially high discharges through a single channel. Regulated baseflows at this site, because of the Drum-Spaulding Project, are typically higher than in unimpaired conditions, particularly in summer and early fall when the project keeps flow artificially high to meet minimum flow requirements (NID and PG&E, 2011c).

American Rivers has also investigated hydrologic alteration and restoration potential in the Bear Meadow, near the Technical Memoranda Reach #2 (American Rivers, 2010). This reach is particularly interesting because it is part of the Bear River Planning Unit, a group of PG&E land parcels that will be conserved in perpetuity for public benefit through the Pacific Forest and Watershed Lands Steward Council's Land Conservation Program. The meadow's location near the headwaters of the Bear means it is also hydrologically and ecologically important for the functioning of the entire river system, while also providing valuable habitat for trout, as well as special status species such as the yellow-legged frog. In their study, American Rivers found that the Bear has incised 5 to 15 ft across the meadow, changing the stream from a meadow to a canyon bottom type channel. This incision has lowered the water table and disconnected the stream from its floodplain, while also giving the current channel the capacity to support flows that are 2 to 10 times higher than typical natural high flows, which leads to greater sediment mobility and thus loss of substrate habitat. Unfortunately, there are no clear signs of a remnant channel that could easily provide a model for the recreation of a floodplain-level channel through restoration efforts (American Rivers, 2010).

Given the impacts of water management, the population of steelhead in the Bear is classified as Core 3, implying that populations are present on only an intermittent basis and that the population extinction risk is uncertain. Hatchery steelhead use the river for limited spawning during high flow years, but artificial flow conditions prevent the establishment of a self-sustaining population. Furthermore, high water temperatures prevent an early enough migration of steelhead into the river for the recreational fishery. The minimum flow requirements below Rollins Reservoir and Lake Combie can also result in water temperatures that are too high for trout and may only support bass and other warm water species (Bear River Awakening, 2016). In addition, upstream dams and structures present a barrier to migration. As part of the FERC Relicensing process for the Yuba-Bear and Drum-Spaulding Hydroelectric projects, multiple reaches of the Bear and its tributaries were assessed for the presence of fish barriers, and 22 natural barriers were found between the Boardman Canal Diversion and Drum Afterbay (NID and PG&E, 2010a). For anadromous species, Camp Far West Reservoir, 15 miles from the confluence with the Feather River, presents a total physical barrier to upstream migration, and summer temperatures are typically too high below the dam to support large salmonid populations (National Marine Fisheries Service, 2014a). More information on the impact of dams as barriers to fish passage can be found above in Section III.B.4.c: Fish Passage Barriers.

Climate Change and Data Gaps

Even with the current knowledge about the hydrological system of the Bear watershed, it is important to understand how this system may change in the near future due to climate change and how this may have an impact on restoration planning. Global warming is reducing snowpack, changing the timing of snow melt, extending the length of the dry season, increasing the frequency of extreme storms, and shifting the rain-snow line in mountain environments worldwide, which is already presenting serious challenges to water availability and management (Flint and Flint, 2014). In response to these challenges, a variety of new tools have been developed in recent years such as parallel climate models, the Water Evaluation and Planning System, and the Basin Characterization Model, to understand the impacts of these effects on hydrological systems on a watershed scale (Stewart et al., 2004; Null et al., 2010; Flint and Flint, 2014). Using some of these tools, Stewart et al. (2004) predict warmer springtime temperatures resulting in dramatic changes in snow melt and runoff timing in the Sierras, up to 35 days earlier in the northern Sierras in the next 50 years, a shift that has already begun to be observed. Snowmelt is the largest contribution to annual flow in most mountain systems, often comprising 50-80% of the total annual discharge, and, thus, this change has the potential to decrease storage efficiency, extend the length of the summer dry season, increase winter flows, dramatically reduce summer base flows, and make peak flows more flashy (American Rivers, 2010; Stewart et al., 2004).

Similarly, Null et al. (2010) have found that the northern Sierra Nevada watersheds, including the Bear, are the most vulnerable to decreased mean annual flow in the whole mountain range, primarily due to higher evapotranspiration from higher temperatures. This change will be felt dramatically in the Bear watershed, which is one of the most heavily managed in the range, by stressing the balance between human and environmental water use. Given a current annual baseflow of 398,871 ac-ft, the study predicts, using a weekly rainfall-runoff model, decreases in flow of 14.6, 26.8, and 38.1 thousand ac-ft per year for a 2°C (3.6°F), 4°C (7.2°F) and 6°C (10.8°F) increase in temperature, respectively. When normalized by area, this gives the Bear the highest predicted change in mean annual flow for a 2°C temperature increase of the 15 major western Sierra Nevada watersheds. On the other hand, the Bear, as well as the Cosumnes and Calaveras watersheds, that are lower in elevation and experience less snowfall, will likely not experience as dramatic a change in runoff centroid timing, which measures the time it takes for half of the annual runoff to pass the watershed outlet. However, the Bear, as well as the American, Yuba, Mokelumne and Cosumnes watersheds, were predicted to have the greatest environmental changes due to the impact of flow reductions on ecosystem health (Null et al., 2010). Predicting these changes with better spatial and temporal resolution will thus be crucial to designing long-term restoration projects throughout the watershed.

Despite the amount of data that is available for the Bear watershed and our understanding of regulated and natural flow regimes in the Sierra Nevada more broadly, a variety of data gaps remain that must be addressed before implementing large-scale restoration. The desired condition of the hydrologic regime should be as close to the natural regime that existed before any large scale infrastructure was built on the watershed, which suggests that we need a more complete understanding of the natural flow regime and how it compares to the current regime. We should be particularly interested in the natural flood and low flow conditions that existed, and how these shaped fish species distributions before the construction of any major barriers on the river. This will require, in part, a better understanding of the structure of the Bear headwaters to better quantify inputs into the system, as well as more research into the extent and effects of water diversions for illegal marijuana grows and personal use. In addition, the watershed has a multitude of irrigation ditches, many of which are no longer in use. We will need to better map, perhaps through aerial imagery, the extent of these ditches and their operation status. However, any restoration efforts must also be designed with the future flow regime in mind, so more research is needed into the potential impacts of climate change on the hydrologic system in the Bear more specifically to support the long-term viability of restoration (Aalto et al., 2010; American Rivers, 2010). Other important questions include identifying barriers to fish migration on Dry Creek and below Camp Far West, instream flow studies on the major tributaries of the Bear, the seasonal patterns of water temperature and their impacts on aquatic organisms, the impact of agriculture on the lower watershed, the potential for new, and the effectiveness of current fish passage structures (National Marine Fisheries Services, 2014a).

The major dam proposal currently in review in the Bear watershed is NID's Centennial Reservoir Project. The Centennial Reservoir, also known locally as Parker Dam, is currently planned for a site, between Rollins Reservoir and Lake Combie, that was first identified for its potential in 1926 (Scherzinger, 2014). The site was subsequently assessed and rejected in 1957, but reconsidered in 2014 following passage of the Proposition One Water Bond. The proposed reservoir would have a capacity of approximately 110,000 ac-ft, lower-elevation storage that NID believes is crucial for adapting to changing climate patterns in the Sierra foothills. NID filed an application in mid-2014 with environmental reviews scheduled through 2017 and construction slated to begin in 2021. NID also requested the rights to divert an additional 112,000 ac-ft for hydroelectric purposes (Scherzinger, 2014). NID's Notice of Preparation was approved in 2015 and the environmental review process mandated by the State Water Resource Control Board has begun (McFarland, 2015). Through the feasibility analysis and preparation of the Environmental Impact Report, many studies on the viability and potential impact of the project will be conducted; these studies should be considered, when publicly available, in the planning for future restoration work in the watershed.

III.C.5. Extractive Industries and Pollution

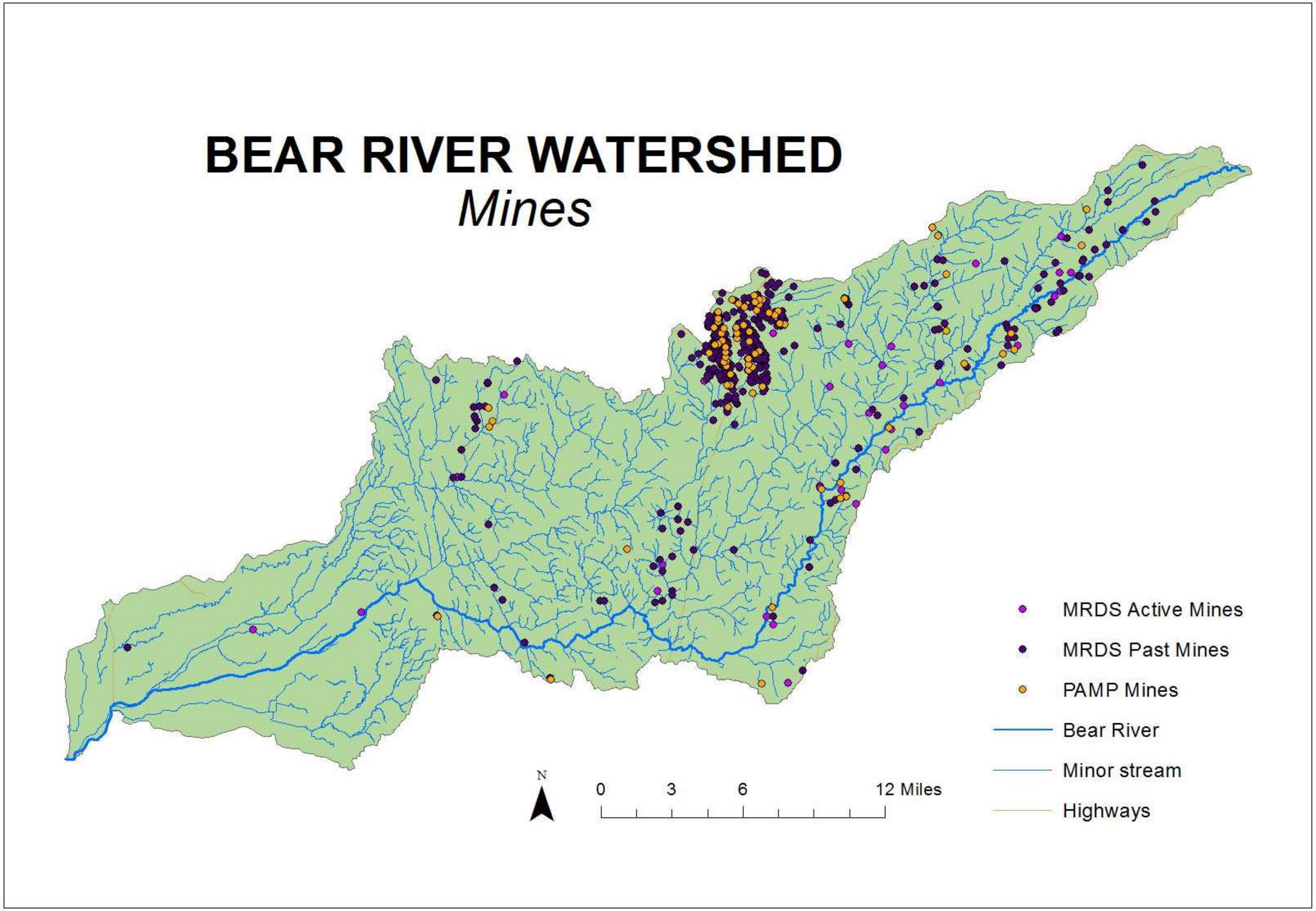
III.C.5a. Mine Lands and Mercury

Data Availability and Mining in the Bear Watershed

The northern Sierra Nevada was the focal point of the California Gold Rush beginning with the discovery of gold at Sutter's Mill in 1849. The relatively cheap and easy practice of panning for gold in streams and rivers soon gave way to the more capital intensive, dangerous and environmentally destructive practices of hard rock and hydraulic mining. These practices continued with varying intensity across the state into the 20th century, leaving a legacy of eroding hillsides, mercury contamination and excess sediment across the Sierras. The Office of Mine Reclamation estimates that there are approximately 39,000 historic and inactive mine sites across the state, over 4,000 of which are assumed to present environmental hazards and almost 33,000 of which are presumed to contain physical safety risks. It is also estimated that there are approximately 128,800 mining features remaining in the landscape, including tailings and mine shafts, throughout the state (Dept. of Conservation, 2000).

There is no single database of all mines in the Bear River watershed illustrated in Figure 49. Instead, two national datasets provide information on the location of historic and active mines, their operation status, and information about the minerals at each site. The US Geological Survey (USGS) Mineral Resources Data System (MRDS) combines information from a variety of federal and state agencies. It contains information on mine name, location, deposit type, mineral age, major and minor commodities, and local tectonics. "Active" MRDS mines refer to those that were in production at the time of data entry, while "Past" mines refer to a site that may have been dismantled or simply abandoned. The online version of MRDS now incorporates spatial data from the larger Minerals Availability System (MAS)/Mineral Industry Location System (MILS) operated by the US Bureau of Mines. Updates to the MRDS ceased in 2011, and the USGS is currently working on a new system. The other major dataset, the California Department of Conservation Principle Areas of Mine Pollution (PAMP), is a compilation of 2,422 mining operations in California and their potential water-quality problems. Initially compiled in 1972 by the State Water Resources Control Board, it includes operations where production exceeded $100,000 or where other factors suggested a high risk of pollution. There are 74 PAMP sites, 48 active and 426 historic MRDS sites (as of 2011) in the Bear River watershed. Due to the lack of consolidation of the datasets, it is possible that a single mine may be represented by multiple points.

Figure 49: Historic and Active Mines



The process of hydraulic mining, through which entire mountain slopes were stripped away by pressurized jets of water to separate gold out of the sediments, was first used adjacent to the Bear River watershed. It has been estimated that between the 1850s and early 1900s, hydraulic mining displaced 254 million cubic yards of gravel and sediment within the watershed, second only in the state to the much larger Yuba River watershed (Alpers et al., 2005). Hydraulic mining all but ceased by the late 1800s, due to the Sawyer Decision in 1884 and then the Caminetti Act of 1893. The former, announced when state courts ruled in favor of farmers suing a mining company for downstream flooding and sedimentation, represented one of the first environmental regulations in American history, while the latter formed the California Debris Commission, which led to much greater regulatory oversight over regional mining (Alpers et al., 2005; Hunerlach et al., 1999). However, recent studies suggest that more than 139 million cubic yards of hydraulic mining sediment remains stored in the watershed and is subject to remobilization during high flow events (Hunerlach et al., 1999).

Excessive sedimentation resulting from historic hydraulic mining can have disastrous impacts on channel morphology and riparian vegetation. In 2009, the Nevada Irrigation District (NID) and the Pacific Gas and Electric Company (PG&E), as part of the FERC re-licensing process, conducted a study on riparian habitat throughout the Bear and Yuba watersheds, assessing the Proper Functioning Condition of these areas (NID/PG&E, 2011). Utilizing a checklist of 17 items, which included historic land use, the study rated two of the sites within the Bear Watershed, specifically the reach below Dutch Flat Afterbay Dam and Bear River Reach #2, at river mile 35, as 'Functional-At Risk,' the intermediate category. These sites contained an incised, braided channel, with some evidence of localized bank failure and slow revegetation. Remobilization of stored hydraulic mining sediment downstream has created terraces of mining waste up to 60 ft high at these sites, disconnecting the river from its historic floodplain. Upland plant species have colonized these terraces, while the fine mining sediment along the streambed, which is loosely consolidated and non-cohesive, has prevented the reestablishment of vegetation with strong root-holds. The reach below Rollins Dam was listed as 'Properly Functioning.'

Mercury Contamination

One of the most persistent reminders of the region's mining history is widespread mercury contamination due to the use of elemental mercury in gold mining. Miners injected mercury into the sediment-water slurry produced in hydraulic mining in order to recover gold from the sediments, and today much of that mercury remains in the system (Marvin-DiPasquale et al., 2011). Most of the mercury used in the Sierras was obtained from the mercury mines of the Coast Range, which reached a peak production of 6,120,000 lbs in 1877 (Hunerlach et al., 2011). Most of the excess mercury not bound up in the mercury-gold amalgamation process was inadvertently leached out into soils and streams. Loss of mercury was often reported to be as high as 30%, suggesting that well over five million pounds of mercury may have seeped into the environment throughout the northwestern Sierras in the second half of the 19^{th} century (Hunerlach et al., 2011; Jones and Slotton, 1996; Slotton et al., 1995). Currently, the federal drinking water standard set by the EPA for total mercury in unfiltered water is 2000 nanograms per liter (ng/L), while the criterion set by the California Toxics Rule is as low as 50 ng/L (Alpers et al., 2005).

The distribution of sediment size affects the diffusion of oxygen and the rate of bacterial activity, and is, thus, instrumental in determining the production of methyl mercury ($HgCH_3$), the biologically active form of mercury (Jones and Slotton, 1996; NID, 2009). Typically, in aquatic environments, contamination of mercury and other heavy metals from mining is strongly associated with the proportion of fine particles, as finer sediments contain more adsorption sites (due to their larger surface area) and can thus accumulate greater concentrations of heavy metals (Jones and Slotton, 1996). It should be noted, however, that there is no direct correlation between the concentration of total mercury in the environment and methyl mercury found in organisms. Other important factors influencing the rate of methylation include pH, temperature, salinity, and the rate of sediment deposition (Jones and Slotton, 1996).

Methyl mercury is the most concerning form of mercury in the environment because it can be absorbed by organisms and make its way up the food chain in a process known as bioaccumulation. With each trophic level, the mercury is concentrated, or biomagnified, until it can reach dangerously high levels in the large predatory fish that are popular for human consumption (NID, 2009; Shilling and Girvetz, 2003). Ingesting methyl mercury is considered one of the most harmful forms of mercury exposure, potentially causing permanent damage to the brain and kidneys. Additional neurological impacts of continued mercury exposure include irritability, changes in vision and hearing, shyness, tremors, and memory problems, as well as blindness, seizures, the inability to speak, and permanent brain damage in children. In addition, the EPA classifies methyl mercury as a potential human carcinogen (EPA, 2000). For these reasons, the current action level set by the FDA for maximum mercury concentration in commercial fish is 1 mg/kg, or approximately 1 part per million (ppm). However, the EPA and the California Office of Environmental Health Hazard Assessment (OEHHA) have set a screening value, the contaminant concentration that MAY be of concern and thus warrants greater attention, of 0.3 ppm in fish tissue (May et al., 2000). A summary of relevant limits and regulations set for mercury can be found in Table 27.

***Table* 27. Relevant limits and regulations for mercury in the Bear River Watershed**

Hazardous Waste Criteria for Total Mercury in Sediment	*Federal Drinking Water Standard for Total Mercury (EPA)*	*State Drinking Water Standard for Total Mercury (CA Toxics Rule)*	*Action Level for Maximum Mercury in Commercial Fish (FDA)*	*Screening Value for Mercury in Commercial Fish (OEHHA/EPA)*
20 ppm	2000 ng/L	50 ng/L	1 ppm	0.3 ppm

Sporadic sampling of mercury concentrations in invertebrates and small fish, by the Toxic Substances Monitoring Program in the 1990s, found an elevated signature of mining-derived mercury in the upper forks of the Yuba River, the Middle Fork of the Feather River, the Bear River, and the North Fork of the Cosumnes River. These studies also suggested that mercury bioaccumulation was positively associated with the intensity of historic hydraulic mining and thus more pronounced in the heavily mined Bear and South Yuba River watersheds than in other watersheds in the region (Hunerlach et al., 1999; Slotton et al., 1995; Alpers et al., 2005). The Office of Mine Reclamation's Abandoned Mine Lands Program listed the Bear as one of the watersheds with the highest potential in California for impacts from acid rock drainage, arsenic and mercury. They estimated that as of 2000, there were 32 mines in the watershed at risk from acid drainage, three with a high potential of impact from arsenic, and 22 at risk from mercury due to placer or hydraulic mining (Dpt. of Conservation, 2000). As a result of these studies, the USGS joined forces with a variety of public agencies to assess mercury and methyl mercury concentrations in the Bear River, Deer Creek, and South Yuba River watersheds. The results stemming from this collaboration led to the first state-level fish consumption advisory in the Sierra Nevada and the listing of multiple reaches of the Bear River as impaired under the Clean Water Act (specifically, the segment near Dog Bar Road, as well as Lake Combie and Rollins and Camp Far West reservoirs, all of which remain listed as of 2010). In addition, the results motivated the federal remediation of multiple sites (Dutch Flat by the EPA in 2000, Sailor Flat by the USFS in 2003 and Boston Mine by the BLM in 2006) (Alpers et al., 2005). An overview of the results of this sampling can be found in Table 28.

Table 28. **Results of Past Mercury Sampling in the Watershed**

Site	Total Mercury, Water (ng/L)	Methyl Mercury, Water (ng/L)	Total Mercury, Sediment (ppm)	Methyl Mercury, Sediment (ppm)	Methyl Mercury, Invertebrates (ppm)	Methyl Mercury, Frogs (ppm)
Dutch Flat (Hunerlach et al., 1999)	40-10,400	0.01-1.12	600-26,000			
Hwy 70, near Rio Oso (Domalgaski, 2001)				0.00055		
Hwy 49 Bridge (Slotton et al., 1995)					0.29-0.77	
Greenhorn Creek (Alpers et al., 2005)	0.8-153,000	0.04-9.1			0.01-1.6	0.23-0.39
Below Camp Far West (Slotton et al., 1995)					0.17	
Above Camp Far West (Slotton et al., 1995)					0.29-0.46	

Mercury in the water column and soil was sampled by Hunerlach et al. (1999) in the Dutch Flat Mining District, upstream of Rollins Reservoir. Total unfiltered mercury concentration found in their samples ranged from 40 ng/L to 10,400 ng/L. Unfiltered methyl mercury concentrations ranged from 0.01 ng/L to 1.12 ng/L. Concentrations of total mercury in the sediments of old sluice boxes ranged from 600 mg/kg, or 600 ppm, to 26,000 mg/kg. For comparison, the applicable hazardous waste criteria set a maximum concentration of only 20 mg/kg. This is unsurprising as much of the mercury found in rivers and streams is trapped in bottom sediments and is only suspended into the water column in response to human disturbance or high flow events. Domalgaski (2001), who studied mercury and methyl mercury concentrations in streambed sediments throughout the Sacramento River Basin in 1995, 1997 and 1998, found an average methyl mercury concentration in the Bear River of only 0.00055 mg/kg. It is important to note that the Bear River sampling site of Domalgaski (2001) was at Highway 70 near Rio Oso, at the downstream end of the river, near its confluence with the Feather River. This result implies that mercury levels remain higher in upstream areas closer to historic mining sites, but suggests that mercury in streambed sediments has the potential to be remobilized and migrate downstream. The work of Domalgaski (1998) also found higher concentrations of methyl mercury in the water column at downstream sites following winter storms and other high flow events.

Many of the studies on mercury in the region have focused on quantifying concentrations within different components of the food web and better understanding the process of biomagnification because of the health concerns of methyl mercury in commercial fish. A summary of the results of methyl mercury sampling of commercial fish tissue is shown in Table 29. Slotton et al. (1995) sampled different feeding groups of invertebrates at 16 sites in the northwestern Sierra Nevada, finding elevated mercury concentrations in Bear River and Wolf Creek, a tributary of the Bear. Samples from the site at the Highway 49 Crossing over the Bear River contained a methyl mercury concentration of 0.29 ppm for *Hydropsychidae*, a net collector, 0.34 for *Rhyacophyllidae*, a small predator, and 0.77 for *Corydalidae*, a larger predator. These values are not only significantly higher than almost every other site in the study (which covered the entire northwestern Sierras), they also illustrate the biomagnification of mercury as it moves up the food chain. May et al. (2000) also found trout near Dog Bar Road with methyl mercury concentrations between 0.38 and 0.43 ppm, all above the OEHHA screening value of 0.3 ppm in fish tissue.

Table 29. **Concentration of Methyl Mercury (ppm) in Commercial Fish Tissue**

Site	Trout	Bluegill	Threadfin Shad	Spotted Bass	Channel Catfish	Black Crappie	Largemouth Bass
Dog Bar Rd. (May et al., 2000)	0.38-0.43						
Camp Far West (May et al., 2000)				0.58-1.5	0.75		
Rollins Reservoir (May et al., 2000)	0.1				0.35	0.31	
Lake Combie (May et al., 200)							0.74-1.2
Camp Far West (Saiki et al., 2010)		1.96 (total mercury)	1.34 (total mercury)	4.41 (total mercury)			

One of the most comprehensive studies of mercury concentrations in stream environments in the Sierras is Alpers et al. (2005). The authors of that study sampled the concentrations of mercury and other heavy metals in water, sediment, macroinvertebrates and amphibians at multiple sites on Greenhorn Creek, a tributary in the Upper Bear subwatershed. Total unfiltered mercury concentration in the water was rated extremely high at six sites and high to moderately high at eight additional sites, the highest being at Buckeye Flat Mine. Values ranged from 0.8 to 153,000 ng/L, with a median value of 9.6 ng/L, a much larger range than found by Hunerlach et al. (1999) for the Dutch Flat District downstream. While this median value is relatively low, more than half the samples taken were above the drinking water criterion of 50 ng/L set by the California Toxics Rule. The incredibly high values found at Buckeye Flat were likely due to the remobilization of sediment following recent suction dredging for gold. Alpers et al. (2005) also found methyl mercury values in unfiltered water to be extremely high at three sites, again with the highest concentrations found at Buckeye

Flat. Concentrations were high to moderately high at ten additional sites, ranging from 0.04 to 9.1 ng/L with a median of 0.07 ng/L. Typically, 0.1 ng/L is considered an indicator value of non-pristine conditions when exceeded, suggesting high rates of methyl mercury bioaccumulation in this system. The lowest values of both total mercury and methyl mercury were found at Poore Mine and Tom and Jerry Mine, as well as above Starr and Buckeye Flat mines and below Boston Mine, which was subsequently remediated by the BLM. Total mercury in streambed sediments was highest at Sailor Flat, which was remediated in 2003 by USFS (after the sampling period of Alpers et al., 2005), and Boston and Starr mines. During water quality sampling, Alpers et al. (2005) also found pH values as low as 3.4 due to acid drainage, as well as elevated concentrations of aluminum, cadmium, copper, iron, manganese, nickel and zinc, particularly at the Buckeye Flat site. Sulfate, which plays a role in the methylation of mercury, is typically a dominant ion in highly acidic waters, contributing to the increased formation of methyl mercury in already contaminated waters.

In addition, Alpers et al. (2005) found that 21 of 29 sites had at least one species of aquatic invertebrate with high or moderately high concentrations of methyl mercury. Sampled values ranged from 0.01 ppm (0.01 mg/kg) to 1.6 ppm. In fact, the ratio of methyl mercury to total mercury, which is a measure of the bioavailability of the mercury in the food web, was greater than 50% in 74 of the 78 invertebrate samples. In frog species, specifically the foothill yellow-legged frog, Pacific tree frog, and bullfrog, concentrations of methyl mercury were high to moderately high at nine of 17 sites, with values between 0.23 to 0.39 ppm. The areas with the highest mercury concentration in frogs were Missouri Canyon, Boston Mine and Polar Star Mine, which was remediated during the course of the study in 2000 by the EPA.

It should be noted that Slotton et al. (1995), while finding high values of mercury in invertebrate samples at many of their Bear River sites, found mercury bioavailability to be low downstream of Camp Far West Reservoir. This suggests that mercury concentration typically decreases with distance from the bulk of mining sites, but also that Camp Far West Dam may help capture the migrating mercury. As a result, caddis nymphs were found to contain approximately 0.17 ppm mercury below Camp Far West, compared to 0.29 and 0.46 ppm at upstream sites. Due to evidence that reservoirs can serve as interceptors of mercury, much of the work on mercury in the Bear watershed has been done in the handful of large reservoirs in the system like Camp Far West, Lake Combie and Rollins Reservoir. Studies have found that reservoirs can trap not only sediment-based elemental mercury, but also bioavailable methyl mercury, often with fish species downstream demonstrating reduced tissue concentrations, as illustrated in Slotton et al. (1995), Jones and Slotton (1996) and Alpers et al. (2008).

The accumulation of mercury in reservoirs, likely due to the low flow, and thus, low oxygen conditions, can lead to dangerously high concentrations of methyl mercury in resident fish. For example, in Camp Far West Reservoir, Saiki et al. (2010), found maximum concentrations of mercury in bluegill (up to 1.96 ppm), threadfin shad (1.34 ppm) and spotted bass (4.41 ppm), all above the FDA limit for commercial fish (1ppm). In addition, Alpers et al. (2006) found that the biomagnification process in Camp Far West was relatively efficient, even compared to other northern California reservoirs, with the bioaccumulation factor (BAF - a standardized value of methyl mercury) increasing from 190,000 for zooplankton up to 10 million for spotted bass. As a result, the study found that Camp Far West had fish with the highest concentrations of mercury in the watershed, with a mean value of 0.92 µg/g, just below the FDA limit. Alpers et al. (2008) also found that the methylation of mercury in reservoirs typically follows certain spatial and temporal patterns. Methylation takes place in anoxic, or low oxygen, conditions in the water column and shallow sediments and, as such, methyl mercury concentrations were greater in the summer and early fall, when the reservoir was thermally stratified. In addition, total mercury concentration tended to decrease seasonally with warmer weather, leading to a systematic increase in the ratio of methyl to total mercury from winter to summer.

May et al. (2000) also offers a comprehensive look at mercury bioaccumulation in commercial fish in the three major reservoirs of the Bear River watershed. In Rollins Reservoir, 15 of 28 samples, representing fish from a spectrum of trophic levels, contained mercury concentrations greater than 0.3 ppm, the OEHHA screening value for concern. Due to the high rates of methylation in shallow sediments, channel catfish, a species of bottom-feeder, had the highest concentration with a mean of 0.35 ppm. In addition, given the process of biomagnification, the samples of trout, which are primarily insectivores, had mercury concentrations less than 0.1 ppm, compared to the samples of black crappie, an intermediate trophic-level predator, which had a mean concentration of 0.31 ppm. In Lake Combie, downstream of Rollins, mercury concentrations in largemouth bass, a top predator and popular sport fish, ranged from 0.74 to 1.2 ppm, which is above the FDA regulations of 1 ppm. At Camp Far West, 19 of 21 samples were found to have concentrations greater than the OEHHA screening value of 0.3 ppm. Concentrations in spotted bass ranged from 0.58 to 1.5 ppm, with half of the samples above the FDA limit. As in Rollins, the channel catfish samples had high concentrations up to 0.75 ppm. Because of the impact of dissolved oxygen and temperature on methylation, it is unsurprising that the lowest and thus warmest reservoir, Camp Far West, has the highest concentrations of methyl mercury in its resident fish. However, this also brings up the issue of reservoirs as interceptors of mercury, as Camp Far West, with its high mercury concentration, is also downstream of a series of large reservoirs.

Remaining Questions and Remediation Techniques

While most of the mercury in the system is due to historic mining activities, it should be noted that gold mining is ongoing in the region. The most common form is personal panning for gold. In addition, suction dredging, though on moratorium in the state since 2009, does still occur and can disturb and remobilize mercury-laden sediments. There is also always the possibility of historic hydraulic and hard rock mining sites being reopened. One such example is the Blue Lead Mine, a 74-acre site 7 miles east of Nevada City that was hydraulically and placer mined until the 1940s and then abruptly abandoned (Nevada County, 2015a). Blue Lead Gold Mining LLC received approval from the Nevada County Board of Supervisors in 2014 for a placer mining operation with the hope of reprocessing the surface sediments left over from historic hydraulic mining. An initial appeal against the approval forced the company to expand its studies on the potential noise, water and metal contamination issues associated with mining. The company later received a second approval by the Board in April 2015. Though they are currently in litigation with the Bear Yuba Watershed Defense Fund, Blue Lead has released a mitigation plan to minimize the impacts to cultural and biological resources, water and air quality and public services, and has included a reclamation plan to make the land suitable for rural residential development following mining. At the same time, Hansen Brothers Enterprises have submitted an application to expand their gravel and sand mining operation on nearby Greenhorn Creek. The company believes their mining technique will help remove mercury from the stream and they have undertaken extensive water supply, soil and mercury sampling (Nevada County, 2015b). While there are strict environmental regulations in place, and both companies have promised to undertake rigorous pre- and post- site monitoring, the possibility of new mining sites and the reopening of old ones, made possible by improved gold recovery technology, will require further analysis in the restoration plan.

Beyond the possibility of new mining operations in the watershed, a variety of important questions remains unanswered and will require further analysis. Arguably, the most pressing issue is to more accurately inventory and map the location of all historic and modern mines in the watershed to acquire a more comprehensive database. In addition, restoration must address both of the two primary sources of historic mercury: mercury already in the water column and streambed sediments, that is remobilized and methylated (by both natural mechanisms and human disturbance), and fresh mercury leaking from abandoned tunnels, sluices, pits and tailings. However, because of the lack of baseline monitoring data upstream and downstream of most of the mines, it is difficult to differentiate these diffuse and point sources. This distinction has an impact on the remediation and cleanup techniques utilized (Nevada County, 2015a; Hunerlach et al., 1999;

Shilling and Girvetz, 2003). In addition, the Abandoned Mines survey completed by the Office of Reclamation, which provides the most comprehensive database in the state of abandoned mines and their potential hazards, has not been updated since 2000 (DoC, 2000).

Ongoing atmospheric deposition of mercury is an important source of modern mercury in the watershed that is less well understood and harder to quantify than direct mining inputs. However, it is an important source to consider given that it is ongoing and controlled by global forces, and thus harder to manage. In addition, unlike elemental mercury from mining that can be trapped in sediments, mercury washed out of the atmosphere by rain is already mobile when it enters soils and surface waters and can thus present a problem across the entire watershed. Currently atmospheric deposition is the primary modern source of mercury in the US (USGS, 2002). Atmospheric deposition takes place when gaseous elemental mercury is transformed into its highly water-soluble ionic form and deposited onto the surface, through rain or dry deposition. Before being released, mercury in the atmosphere can be transported around the planet and thus sources of deposition can be local or global (DWR, 2007). Wildfires, the burning of fossil fuels, volcanoes, hot springs and decomposition are all important sources of atmospheric mercury (Jones and Slotton, 1996). Mining, specifically of coal, has been recognized as a major source of atmospheric mercury deposition in the eastern US for many years. However, it has relatively recently been identified as a problem in California, from both modern coal mining in Asia, as well as historic mercury mining in California in the 19th century (DWR, 2007; Steding and Flegal, 2002). Prior to post-WWII industrialization, gold rush mining operations presented the most significant anthropogenic source of mercury found in the geological record. In a 270-year glacial record examined by the USGS, mercury peaked in 1877, not coincidentally at the height of mercury mining operations in the Coast Range (USGS, 2002). A recent study by Weiss-Penzias et al. (2016) found that while atmospheric mercury deposition has been decreasing nationally in North American since 1997, it has been increasing in the western states, most likely due to the explosion of coal mining in China. Scrubbing technology for cleaning the emissions from power plants has been used in the US since the early 1990s, but has not yet been widely implemented in parts of Asia. The topographic rise of the Sierra Nevada has caused large quantities of the mercury coming from Asia to thus be deposited through rain in the foothills and western slopes of the mountain range (Weiss-Penzias et al., 2016). While our understanding of atmospheric mercury deposition is not well resolved at the watershed scale, it is clearly a background source of contamination that needs to be considered and better studied in the future. However, given the global nature of the problem, it is unlikely that the problem can be addressed at the watershed-restoration scale.

Another important question, which may take multiple years to answer, is how the ongoing drought, and the potential El Niño system in 2015/2016, by changing flow, fire, and erosion regimes, as well as thermal stratification in larger water bodies, will impact mobilization of mercury-laden sediment, mercury accumulation in reservoirs and the rate of methylation. In particular, increased erosion following fires could be a large source of fresh mercury into the system after multiple years of drought. In addition, rising global temperatures, which affect dissolved oxygen, may increase the rate of methylation in local reservoirs. As a result, it will be important to continue to study concentrations of both total and methyl mercury across the watershed in stream and reservoir environments, as well as the concentrations of methyl mercury in organisms throughout the food web. Only with a more complete understanding of mercury transport and bioavailability in the watershed, can one begin to remediate and manage the risks of historic and modern mercury.

In addition to the obvious need to regulate and monitor ongoing and new mining projects, it is important to consider opportunities to reclaim and remediate historic mining contamination. Popular methyl mercury remediation techniques typically follow one of two approaches. The first is the reduction of the source of methylation, in this case, the elemental mercury trapped in sediments and river beds. The other approach is to interrupt the methylation process so as to limit the conversion of elemental mercury into the more biologically harmful methyl mercury form (NID, 2009). One of the important questions when choosing a remediation approach is whether one is interested in point source or area source control. Point source control is typically easier and can be done by chemical or mechanical means at individual sites. Unfortunately, mining-derived and atmospheric mercury have been found to be largely dispersed, complicating the use of point source cleanup techniques, and often requiring the use of regulatory or administrative action. Sierra Streams Institute is currently considering a project to monitor storm water runoff in order to distinguish historical sources of mercury already in the system versus new point source inputs. However, area source control approaches will still be necessary in the Bear watershed given the geography of historic gold mining, as well as the continuous cycling and mobilization of mercury through the system and atmospheric deposition (Jones and Slotton, 1996).

Fortunately, point source approaches have been found to be effective, particularly in reservoirs, which, given the high concentrations of total mercury and methyl mercury found in those systems, suggests a potentially high benefit approach. As an example, the Nevada Irrigation District (NID) is currently working on a multi-year mercury removal project in Lake Combie. Conventional dredging to remove sediments, in order to maintain storage capacity, was used at Combie for 15 years until 2003 when reports of high mercury concentration in the dredge waste halted operations and raised questions about NID's ability to supply clean drinking water to its customers. In response, NID proposed a project to remove elemental mercury from dredged sediments using a Knelson Concentrator, a patented technology that is often used in gold mining to recover free particles of gold. According to NID, the project will utilize both remediation approaches, simultaneously removing the source of methyl mercury through dredging, while also creating conditions less conducive to methylation, by creating deeper and cooler conditions in the reservoir. NID plans to undertake pre- and post-project monitoring of the effects of the operation on water quality and biota. In addition, the company has already created a mitigation plan for impacts on water quality, drainage patterns, cultural resources and sensitive species. After a successful pilot demonstration in 2012-2013, NID announced plans to begin larger-scale dredging in the spring of 2016 for at least two years with on-going maintenance scheduled every ten years. This project exemplifies how point-source mercury control in reservoirs can have multiple benefits, including recreation and public access, water quality improvement, and water supply reliability, for a reasonable price with public support. It also presents a unique opportunity to undertake valuable research on mercury transport and contamination by providing an almost unparalleled dataset on pre- and post-remediation conditions.

Other opportunities for mercury remediation and mine reclamation can be found in the archives of the Sierra Streams Institute, which has studied both area and point source control methods for mercury contamination (SSI, 2012). The recommendations considered by SSI included cleaning up known sources of mining contamination, including waste rock and tailings piles, using erosion control, caps, and excavation of sediments contaminated with mercury and other heavy metals. Additional mechanical and chemical cleanup methods include building settling basins downstream to collect contaminated sediments, refurbishing roads and trails to restore natural hydrologic function, and other Best Management Practices to control mercury transport via erosion and storm water runoff. From a management perspective, recommendations include protecting areas prone to erosion from vehicles and livestock grazing, educating public and private landowners on Best Management Practices and working with them to identify and map priority contamination sites. In addition, reservoir operations should be managed to reduce the rate of methylation (by increasing dissolved oxygen via water aeration), reduce releases of mercury-laden sediment downstream, intensify reservoir water quality monitoring, and direct flow away from areas of high mercury contamination. For further reference, the Sierra Fund has also released a similar document on obstacles to and recommendations for remediation of mine contamination (Sierra Fund, 2008).

Many of the SSI and Sierra Fund recommendations encouraged further study to fill in some of the data gaps previously discussed. This includes: further study on sediment and mercury loading and transportation processes to identify priority areas and point sources, the use of phytoremediation to reduce total mercury concentrations, the feasibility of harvesting algae blooms to interrupt a theoretically important, seasonal mercury transport pathway, and the potential of using floating turbidity booms to capture mercury-bearing sediments flowing through reservoir spillways (SSI, 2012). It will also be necessary to monitor the results of NID's Lake Combie project. These are just a handful of possible approaches for controlling mercury and methyl mercury contamination in the Bear River watershed. It will be important to pursue a variety of different methods and undertake comprehensive monitoring for adaptive management in order to fully understand and alleviate the impacts of the region's extensive mining history.

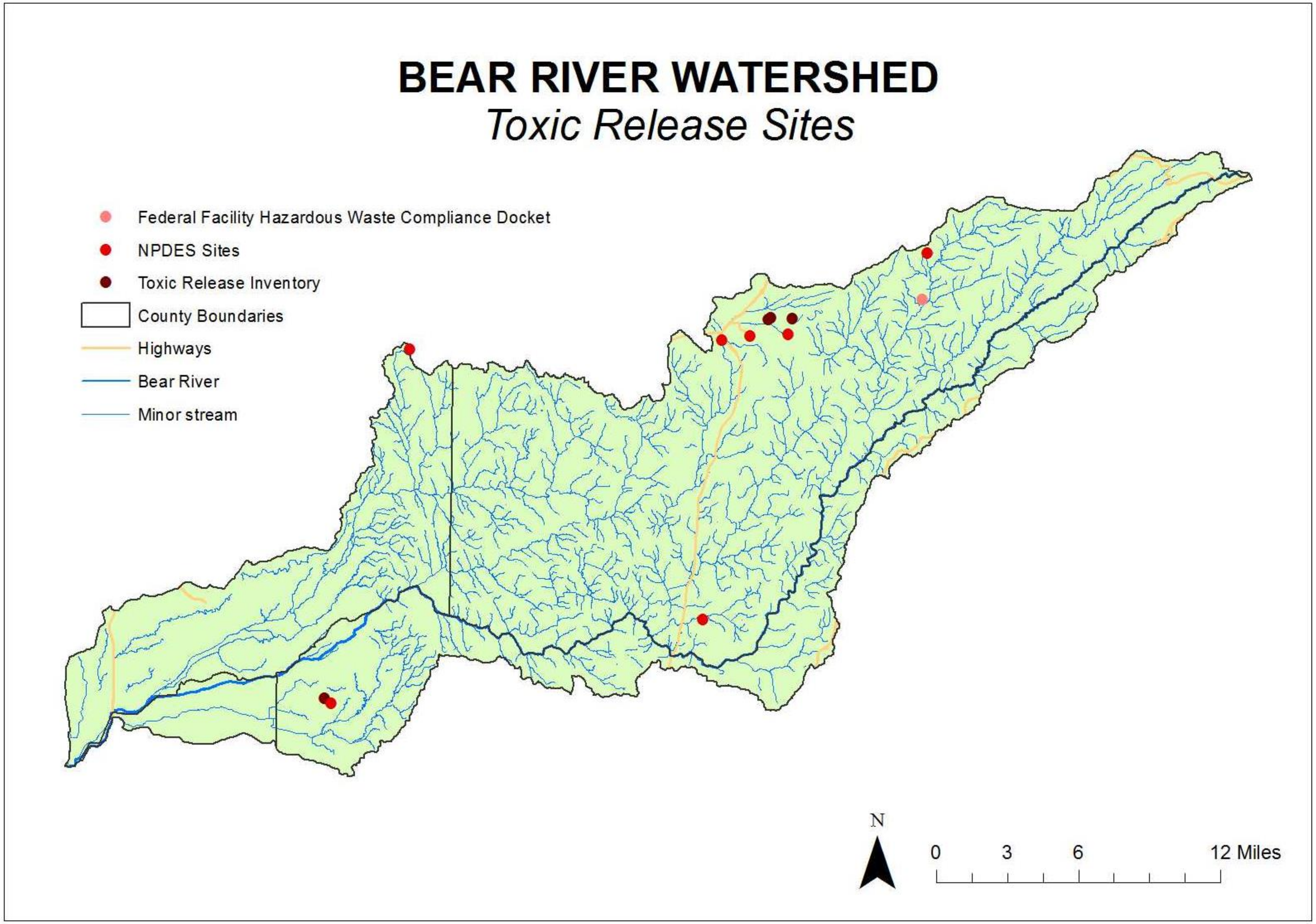
III.C.5b. Point Source Pollution and Toxic Release Sites

The EPA Facility Registry Service maintains data from multiple sources on facilities and sites that are subject to regulation. Twelve are found within the Bear River watershed (Figure 50). The Federal Facility Hazardous Waste Compliance Docket (FFDocket) is a listing of federal facilities that are currently managing or have managed hazardous waste, or have previously had a release of hazardous waste. Surface water permits issued under the Clean Water Act are tracked by the National Pollutant Discharge Elimination System (NPDES), which requires all facilities that release pollutants from a point source into waterways be permitted. Permits typically limit what may be discharged and require monitoring and reporting. Toxic Release Inventory (TRI) sites may use, manufacture, treat, transport, or release toxic chemicals, and are reported annually by industry groups and federal facilities. FFDocket, NPDES, and TRI sites are primarily clustered in the upper watershed along Wolf Creek. Other streams near release sites include Greenhorn Creek, Magnolia Creek, and Vineyard Creek, as well as unnamed intermittent streams in the lower watershed. Table 30 shows a list of the sites maintained by the EPA Facility Registry Service in each county.

***Table 30.* EPA Data of Regulated Facilities or Clean Up Sites**

Database	Site Name	County
FFDocket	Poore Mine	Nevada
NPDES	Hammonton Gold Village WWTP	Yuba
NPDES	Empire Mine State Park	Nevada
NPDES	Grass Valley WWTP	Nevada
NPDES	Idaho-Maryland Mine	Nevada
NPDES	Cascade Shores WWTP	Nevada
NPDES	Lake of the Pines WWTP	Nevada
NPDES	SA NO28, Zone NO6	Placer
TRI	Replacon Inc.	Placer
TRI	Grass Valley Group Inc.	Nevada
TRI	JDK Controls Inc.	Nevada
TRI	Lanmark Circuits Inc.	Nevada

Figure 50. EPA Permitted Toxic Release and Cleanup Sites



III.C.5c. Pesticides and Agricultural Impacts

Broad Impacts of Agriculture on Ecological Health

Assessing the actual impacts of widespread agriculture on the ecological health of the Bear watershed is highly complicated, with a suite of potential positive and negative effects. On the one hand, working lands, particularly when well managed, can provide open space and critical habitat for a large number of species native to the Sierra foothills, particularly pollinators and migrating mammals (Department of Water Resources, 2013; van Wagtendonk, 2013). In addition, agricultural lands can provide land and water for wetlands restoration and can help control and improve the water quality of urban runoff. In contrast, the conversion of working lands to other, more developed uses can compromise the ability of the landscape to provide a range of ecosystem services including flood management, water conservation and groundwater recharge, food production, and carbon sequestration. In fact, climate models illustrate that a loss of agricultural lands may lead to a loss of biodiversity (Department of Water Resources, 2013). However, to fully reap the positive benefits of agricultural land, appropriate land stewardship and the adoption of ecosystem-friendly practices, as mentioned above, are critical.

The negative impacts of widespread agriculture, particularly using modern techniques at an industrial scale, are also well understood. The doubling of food production around the world in the last 35 years has been associated with an almost seven-fold increase in nitrogen fertilization and 3.5-times increase in phosphorous fertilization. This has resulted in dramatic changes in global nutrient cycling, which have severely eutrophied many aquatic ecosystems (Tilman, 1999). In turn, eutrophication can lead to a loss of biodiversity and fisheries value, shifts in the food web and colonization by invasive species. In addition, despite the potential of agricultural lands for carbon sequestration, industrial agriculture is also a major producer of potent greenhouse gas emissions, including methane from livestock and nitrous oxide from fertilizer application. Perhaps most detrimentally, large-scale agriculture has led to a homogenization and simplification of terrestrial systems, as complex ecosystems with thousands of species have been replaced by virtual monocultures (Tilman, 1999). When poorly managed, even smaller scale agriculture can lead to genetic simplification, wasteful water consumption, pollution and soil degradation. As of 2012, an average of ten times as much soil eroded from American farms than was replaced by natural formation processes. In turn, soil erosion can result in decreases in water quality, reduced reservoir capacity, increased flooding, and the destruction of critical terrestrial and aquatic habitat. Surface runoff of fertilizers and pesticides, in particular, can further impair water quality, while percolation of water through cultivated fields can potentially contaminate groundwater supplies (Trautmann et al., 2012). The extent to which these impacts have been felt in the Bear watershed specifically is not well understood and will require fine-scale mapping of agricultural practices.

Laws Governing Pesticide Use and Agricultural Pollution in California

Because of the harmful impacts and widespread use of pesticides for pest control on agricultural lands, several federal and state laws and programs exist to govern their use.

Clean Water Act and 303(d) Listing

The major goal of the federal Clean Water Act, enacted in 1972, is to restore and maintain the quality of the "waters of the United States" (EPA, 2016). As implemented, the act applies to interstate waters, intrastate waters used in interstate/foreign commerce or for navigation, and their associated wetlands and tributaries. Irrigation and flood control channels are only included if they carry water for at least three months of the year and feed into a navigable waterway. The Army Corps of Engineers has the discretion to include additional waterways on a case-by-case basis. Riparian habitat and agricultural fields may be considered wetlands, and thus possibly subject to the Clean Water Act, if they meet specific soil, hydrology and vegetation criteria (Strohm *et al*., 2007). Section 305(b) of the Act requires each state to biennially report on the status of the water quality of all water bodies in the state. In contrast, Section 303(d) of the Act requires states to report only on those waterbodies impaired by a pollutant, for which technology-based regulations and controls have not helped meet water quality standards (EPA, 2016). In California, factors for 303(d) listing and subsequent delisting include: numeric water quality objectives and criteria, standards for bacteria where recreational uses apply, health advisories, bioaccumulation of pollutants in aquatic tissue, water/sediment toxicity, adverse biological response, trends in water quality, degradation of biological populations, and "nuisance," which considers water odor, color and taste, algae growth, foam, turbidity, oil, and trash (California Water Boards, 2004).

As part of 303(d) listing, states, which collectively includes territories, states and authorized tribes, must establish a priority ranking of and develop a Total Maximum Daily Load (TMDL) for impaired waterbodies (EPA, 2016). In California, the Water Resources Control Board and nine Regional Water Quality Control Boards are responsible for TMDL development and implementation; however, to avoid interstate variations, the federal EPA provides a nonexclusive list of information that must be considered (California Water Boards, 2004). The TMDL is essentially a budget of point and non-point sources of pollution, allocating necessary pollution reductions to one or more sources. In addition, the budget must also include a margin of safety to account for seasonal variations in water quality and uncertainty in predicting the outcomes of pollutant reduction (Cal EPA, 2009;

Strohm *et al*., 2007). Once the TMDL is developed and enacted, the water body is officially no longer on the 303(d) list, but it is still tracked until water quality standards are met.

According to the California EPA, there are five steps in producing a TDML: stakeholder involvement, water body assessment, defining the total and allocating pollutant loads, developing an implementation plan, and amending the basin plan. In California, TMDLs have no legal standing under state law, and are thus unenforceable by regional water quality boards unless incorporated into regional basin plans. TMDLs can be developed by the US EPA; however, such plans do not contain comprehensive implementation programs similar to those developed by the water quality control boards (Cal EPA, 2009).

In the Bear Watershed, there are currently six impaired waterbodies. This includes Wolf Creek, Lake Combie, French Ravine, Upper Bear River, Rollins Reservoir, and below Camp Far West (CABY, 2014). Most reaches are listed for historic resource extraction of copper and mercury, while Wolf Creek is also listed for fecal coliform and bacteria. In addition, the Bear River, along with the South Fork Yuba River, has been identified by the Regional Water Quality Control Board as a Priority 1 Impaired Watershed as a result of widespread mercury contamination. Currently, below Camp Far West is the only reach of the Bear listed explicitly because of the impacts of agriculture, specifically the use of the pesticides diazinon and chloryprifos (Cal EPA, 2009).

PRESCRIBE Limit Use Requirements

The Department of Pesticide Regulation (CDPR) currently operates the PRESCRIBE database through the California Pesticide Information Portal (CalPIP). The database, which is the Pesticide Regulation's Endangered Species Custom Realtime Internet Bullet Engine, provides information on pesticide use limitations for the protection of endangered species for user-selected locations and pesticides. The provided use limitations are defined as methods of application, restrictions or prohibitions for any of the active ingredients of a pesticide being considered for use near endangered species habitat (CDPR, 2015). They are based primarily on existing best management practices and designed to benefit wildlife by reducing potential pesticide impacts and enabling native habitats to be restored without additional regulatory restrictions (Strohm *et al*., 2007).

Within the rough area of the watershed, PRESCRIBE identifies 22 special status, non-target plant and wildlife species, many of which are discussed above in Section B.2: Rare, Sensitive, Threatened and Endangered Species. The federally endangered species found include: Chinook salmon (Sacramento River winter run and Central Valley spring run), pine hill flannel bush, Sierra Nevada yellow-legged frog, Stebbin's morning-glory, vernal pool tadpole shrimp and the Pacific fisher, which is only proposed as endangered.

Federally threatened species include: the giant garter snake, Central Valley steelhead, valley elderberry longhorn beetle, and vernal pool fairy shrimp. Rare, currently not listed species found include: bank sallow, Brandegee's clarkia, Butte County fritillary, California black rail, Cantelow's lewisia, Jepson's onion, Scadden Flat checkerbloom, Sierra Nevada red fox, Swainson's hawk, tricolored blackbird and veiny monardella (CDPR, 2015).

For all versions of diazinon and chlorpyrifos, there are four use limitations provided for the endangered and threatened species listed above. It is recommended that these particular pesticides not be used in currently occupied habitat. In addition, growers should provide a 20-ft minimum strip of vegetation, without pesticide application, along water bodies and on the downhill side of fields. Runoff should also be closely controlled, cover crops should be planted adjacent to off-target water sites, and irrigation should be done efficiently to prevent excessive loss of irrigation water. The time between irrigation, rain and pesticide applications should be maximized. In addition, pesticide spraying should be scheduled and planned to minimize the blowing of pesticides onto non-target areas (CDPR, 2015).

Ground Water Protection Areas Program

In 2004, the Department of Pesticide Regulations (CDPR) developed a database of Ground Water Protection Areas (GWPAs) for identifying areas at risk of groundwater contamination from pesticide use. Designation as a GWPA is either based on detection of pesticide contamination or prediction based on local soil characteristics and depth to groundwater. GWPAs are one-square mile in area and identified as at risk from leaching, runoff, or both, depending on the predicted pathway to groundwater. Pesticide use is restricted in established GWPAs, and users must obtain county permits and follow strict management practices to use pesticides in those areas. Specific regulations differ depending on whether it is a leaching or runoff area. There are also special management options and regulations for pesticides applied to engineered rights of ways or in canals and ditches (CDPR, 2013).

Currently, there are 105 pesticides identified in the program's Groundwater Protection List as having the potential to pollute groundwater. The database is up to date as of 2004. There are no GWPAs mapped in Nevada County, but there are 72 GWPAs partially or entirely enclosed within the Bear watershed, equal to an area of over 37,000 acres. The majority of sites are listed as at risk from runoff (CDPR, 2013).

The GWPA database also includes a handbook of management practice options available to those who have acquired a permit to apply pesticides within a GWPA. For a Leaching GWPA, pesticide users must choose one of four management options including: no irrigation within six months of pesticide application, irrigation at a ratio of 1.33 for the amount applied to the net irrigation requirements for six months after pesticide application, an alternative approved by the Director of Pesticide Regulation, or pesticide application only on berms above the level of irrigation water within six months. For a runoff GWPA, pesticide users have more available options including: incorporation of the pesticide into the soil within 48 hours, soil disturbance within seven days, band treatment of pesticides adjacent to crops, use of pesticides only between April 1 and July 31, retention of runoff for six months, directing runoff into a fallow field for at least six months, or an alternative approved by the Director of Pesticide Regulation (CDPR, 2013).

Federal Insecticide, Fungicide and Rodenticide Act

The Federal Insecticide, Fungicide and Rodenticide Act is administered by the US EPA and state agricultural agencies and regulates pesticide manufacturing, distribution, and application. For pesticide application, specifically, the law requires users to acquire certification, complete state-level training programs, keep records of application, and use registered pesticides strictly in accordance with product labels. However, not all commonly used pesticides are included yet in the Act's database (Strohm *et al*., 2007).

California Food and Agricultural Code

The Food and Agricultural Code, seeks to reconcile natural resource management and agricultural production, with strict pesticide regulations administered by the Department of Pesticide Regulation (CDPR). It requires that pesticides be used in accordance with product labels, which they are regulated by the Department of Food and Agriculture to restrict those that are environmentally harmful, and it applies to all non-target areas. However, standard used to define "environmentally harmful" is designed to protect water and air quality, rather than habitat specifically (Strohm *et al*., 2007).

Porter-Cologne/California Water Code

The Porter-Cologne section of the California Water Code is the state-level equivalent of the Clean Water Act, meant to include any surface or groundwater within the boundaries of the state, including irrigation ditches and agricultural drains. The Act regulates the discharge of any anthropogenic waste material. Under the Water Code, water quality control and planning is designated to the nine Regional Water Quality Control Boards, which are required to prepare and routinely update a basin-wide plan to protect regional water quality. The requirements of the federal Clean Water Act are enacted through the basin plans (Strohm *et al*., 2007).

Pesticide Contamination Prevention Act

The Pesticide Contamination Prevention Act (PCPA) was passed in 1985 in response to reports by the Department of Pesticide Regulation (CDPR) of pesticide contamination in groundwater. The act was designed to prevent further pollution of pesticides to groundwater drinking supplies. The program identifies pesticides with the potential to pollute groundwater, requires sampling of wells for contamination, maintains a database of all wells sampled and their results, and requires CDPR to conduct a formal review of potential changes to pesticide use to protect drinking water (Strohm *et al*., 2007).

Irrigated Lands Regulatory Program

The Irrigated Lands Regulatory Program (ILRP), created in 2003 and operated through the Regional Water Quality Control Boards, regulates discharges from irrigated lands by issuing Waste Discharge Requirements to growers. The discharge orders require water quality monitoring of receiving water bodies and certain corrective actions when quality has been impaired. Other activities of the program include education and outreach to growers. According to the program, agricultural discharges include irrigation return flow, storm water runoff, and flow from tile drains, all of which can transport pesticides, sediments, salts, nutrients, pathogens and heavy metals from cultivated fields into surface and groundwater. Currently, there are approximately 6 million acres and 40,000 growers, individually and through coalitions, enrolled in the program. There has been some evidence of improvement to water supplies, but it is too early to tell whether these improvements are permanent or widespread (Cal EPA, 2015).

Pesticide Use

According to the California Pesticide Information Portal (CalPIP), there are over 131 different chemicals used as pesticides within the townships intersecting the Bear watershed boundaries, shown in Table 31. California requires monthly reporting of all agricultural pesticide use to county agricultural commissioners, who then report the data to the Department of Pesticide Regulation. Reporting requirements include pesticide applications to parks, golf courses, cemeteries, rangeland, pastures, along roadsides and railways, postharvest treatments of agricultural commodities, treatments in poultry and fish production and livestock applications. Exceptions to reporting include home and garden, industrial, and institutional uses (CalPIP, 2013).

The pesticides listed in Table 31 are used within the Bear River watershed to treat alfalfa hay, pecan, rice, walnut (English and Persian), almond, forage-fodder grasses, pastures, prune, apple, cantaloupe, grapes/wine, pear, squash, non-outdoor container/field grown plants, apricot, cherry, nectarine, peach, plum, corn (for human consumption and forage-fodder), sunflower, persimmon, pumpkin, wheat, blackberry, uncultivated areas, rangeland, forest trees, aquatic areas, beehives, rights of way, and landscape maintenance. In total, over the year 2013, 455,295 pounds of pesticide were applied (equaling over 176,746 pounds of chemical).

***Table 31*. Pesticides used within the Bear River Watershed**

(S)-CYPERMETHRIN	1,3-DICHLOROPROPENE
2,4-D, DIETHANOLAMINE SALT	2,4-D, DIMETHYLAMINE SALT
ABAMECTIN	ACEPHATE
ACETAMIPRID	AZOXYSTROBIN
BENSULFURON METHYL	BIFENAZATE
BIFENTHRIN	BISPYRIBAC-SODIUM
BOSCALID	CARFENTRAZONE-ETHYL
CHLORANTRANILIPROLE	CHLOROPICRIN
CHLOROTHALONIL	CHLORPYRIFOS
CHROMOBACTERIUM SUBTSUGAE STRAIN PRAA4-1	CLETHODIM
CLOFENTEZINE	CLOMAZONE
CLOPYRALID, MONOETHANOLAMINE SALT	CLOTHIANIDIN
CODLING MOTH GRANULOSIS VIRUS	COPPER HYDROXIDE
COPPER OXIDE (OUS)	COPPER OXYCHLORIDE
COPPER SULFATE (BASIC)	COPPER SULFATE (PENTAHYDRATE)
CYHALOFOP-BUTYL	CYPRODINIL
DIFENOCONAZOLE	DIQUAT DIBROMIDE
DIURON	E,E-8,10-DODECADIEN-1-OL
E-8-DODECENYL ACETATE	ESFENVALERATE
ETHEPHON	ETOXAZOLE
FENARIMOL	FENBUCONAZOLE
FENPROPATHRIN	FLUAZIFOP-P-BUTYL
FLUBENDIAMIDE	FLUMIOXAZIN
FLUTOLANIL	FORMIC ACID
GLUFOSINATE-AMMONIUM	GLYPHOSATE, ISOPROPYLAMINE SALT
GLYPHOSATE, POTASSIUM SALT	HALOSULFURON-METHYL
HEXAZINONE	HEXYTHIAZOX
IMAZAMOX, AMMONIUM SALT	IMAZAPYR, ISOPROPYLAMINE SALT
IMAZOSULFURON	IMIDACLOPRID
INDAZIFLAM	IPRODIONE
KAOLIN	KRESOXIM-METHYL
LAMBDA-CYHALOTHRIN	LIME-SULFUR
MANCOZEB	MCPA, DIMETHYLAMINE SALT
MEFENOXAM	METHOXYFENOZIDE

METRAFENONE
MINERAL OIL
MYCLOBUTANIL
NAA, AMMONIUM SALT
ORYZALIN
OXYFLUORFEN
OXYTETRACYCLINE, CALCIUM COMPLEX
PACLOBUTRAZOL
PARAQUAT DICHLORIDE
PENDIMETHALIN
PENOXSULAM
PENTHIOPYRAD
PERMETHRIN
PETROLEUM DISTILLATES, REFINED
PETROLEUM OIL, PARAFFIN BASED
PETROLEUM OIL, UNCLASSIFIED
PHOSMET
POTASSIUM BICARBONATE
PRODIAMINE
PROPANIL
PROPICONAZOLE
PSEUDOMONAS FLUORESCENS, STRAIN A506
PYRACLOSTROBIN
QUINOXYFEN
REYNOUTRIA SACHALINENSIS
RIMSULFURON
SAFLUFENACIL
SETHOXYDIM
SIMAZINE
S-METOLACHLOR
SODIUM CHLORATE
SODIUM HYPOCHLORITE
SPINETORAM
SPINOSAD
SPIROMESIFEN
SPIROTETRAMAT
STREPTOMYCES LYDICUS WYEC 108
STREPTOMYCIN SULFATE
SULFUR
TAU-FLUVALINATE
TEBUCONAZOLE
TETRACONAZOLE
THIAMETHOXAM
THIOBENCARB
TRIBENURON-METHYL
TRICLOPYR, TRIETHYLAMINE SALT
TRICLOPYR, BUTOXYETHYL ESTER
TRIFLOXYSTROBIN
TRIFLUMIZOLE
TRIFLURALIN
TRINEXAPAC-ETHYL
TRITICONAZOLE
Z-8-DODECENOL
Z-8-DODECENYL ACETATE
ZIRAM
Other chemicals not listed in CalPIP database
AMINO ETHOXY VINYL GLYCINE HYDROCHLORIDE
AMINOPYRALID, TRIISOPROPANOLAMINE SALT
BACILLUS THURINGIENSIS (BERLINER), SUBSP. KURSTAKI, STRAIN SA-11
BACILLUS THURINGIENSIS, SUBSP. KURSTAKI, STRAIN ABTS-351, FERMENTATION SOLIDS AND SOLUBLES
COPPER ETHANOLAMINE COMPLEXES, MIXED
DIGLYCOLAMINE SALT OF 3,6-DICHLORO-O-ANISIC ACID
MYROTHECIUM VERRUCARIA, DRIED FERMENTATION SOLIDS & SOLUBLES, STRAIN AARC-0255

Diazinon and Chlorpyrifos

One of the most pressing water quality issues in the Bear River is agricultural pesticide use, especially in the lower watershed. In particular, the insecticides diazinon and chlorpyrifos have recently been present in the river at concentrations exceeding EPA safety thresholds.

Sources of diazinon in the Central Valley region include agricultural and urban nonpoint source runoff, stormwater point source discharges, irrigation return water, and rainwater (CVRWQCB, 2010; CVRWQCB, 2013). Diazinon has a low vapor pressure, and thus some fraction of applied diazinon is presumed to volatize from soil, crops, and surface water into the atmosphere where it can be transported by bulk movement of air. Supporting this assumption, diazinon has been documented in air and rain samples (Dileanis et al., 2003). Transport of volatized diazinon from the Central Valley to the Sierra Nevada Mountains has been observed, where the chemical is then subject to deposition (especially wet deposition) onto ground surface, vegetation, or into surface waters (Regional Water Quality Control Board, 2013). The solubility of diazinon in water is relatively high for a pesticide, and along with a low tendency to absorb to soil, this makes diazinon very susceptible to runoff and region-wide movement (CVRWQCB, 2013). This chemical is typically applied to orchards (plum, peach, almonds) as a pesticide for spider mites, boring insects, aphids, peach twig borer, and San Jose scale. The California Pesticide Information Portal (CalPIP) also lists peach, prune, melons, pear, tomatoes (for canning), plum, walnut, apple, and nectarine as diazinon-treated crops within the townships intersecting the Bear watershed. Many of these crops are grown in the lower watershed or middle watershed. Runoff issues associated with dormant spray of diazinon (occurring in December through March during peak rainfall months) are particularly prevalent.

Sources of chlorpyrifos include spray drift during application and runoff up to several months post-application. Chlorpyrifos is also expected to volatize due to low vapor pressures, and the mechanism of deposition is primarily dry deposition (CVRWQCB, 2013). Compared to diazinon, chlorpyrifos has a higher tendency to adsorb to soil and sediment, and thus chlorpyrifos runoff is typically via adsorption to eroding soil instead of via dissolution in runoff water (CVRWQCB, 2013). Chlorpyrifos is applied in the dormant season, but more often in the irrigation season. Since 2000, according to CalPIP, chlorpyrifos has been used to treat apple, peach, walnut, prune, and pear in townships intersecting the Bear watershed, with the vast majority of chemical used to treat walnut orchards. It is also found in some roach bait products and fire ant mound treatments, and is also used as an aerial and ground-based fogger adult mosquitocide (US EPA, 2015). Again, chlorpyrifos use is mostly in the lower and mid-watershed.

Impaired Waters Listing and Reaction: Diazinon

Elevated levels of diazinon and chlorpyrifos in the Bear watershed have prompted the California Central Valley Regional Water Quality Control Board to add 21 miles of the lower Bear River (below Camp Far West Reservoir) to California's 1994 Clean Water Act Section 303(d) List of Impaired Waters (California Water Board, 2016). The reach below Camp Far West Reservoir has been 303(d) listed for diazinon since 2002, and 303(d) listed for chlorpyrifos, copper, and mercury since 2010 (California Water Board, 2016).

After the initial 303(d) listing, the development of a Total Maximum Daily Load (TMDL) was initiated and implemented in 2003 for diazinon. The TMDL for chlorpyrifos is expected to be completed in 2021. An amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins in 2007 outlined a maximum concentration of 0.16 μg/L (1-hr average; acute) and 0.10 μg/L (4-day average; chronic) for diazinon, and 0.025 μg/L (1-hr average) and 0.015 μg/L (4-hr average) for chlorpyrifos (US EPA, 2007). In 2003, the US EPA modified dormant spray restrictions for diazinon, and in 2004 terminated registration and sales of diazinon-containing pesticides for indoor use, non-agricultural outdoor use, and application to some agricultural crops (alfalfa, bananas, dried beans, peas, coffee, and others) and agricultural land covers (pasture, rangeland, orchard). Likely as a result of these regulations, diazinon has been slowly phased out and was not applied anywhere within the watershed since 2011 (Table 32). However, areas surrounding the lower watershed did receive applications of diazinon in 2013, with the closest being 5 miles away from the watershed boundary. Watershed-wide improvements to water quality in the Feather River watershed have been seen since 2002 as a result of reduced diazinon usage (Central Valley Regional Water Quality Control Board, 2010). Despite this, the Bear has not yet been delisted for diazinon due to data gaps and an inconclusive analysis of the last water samples taken in 2001 and 2002. The State Water Board, Regional Water Board, and U.S. EPA are currently creating a 2012 Integrated Report outlining updates to the 303(d) list, and an eventual 2014 Integrated Report will include updated listings in the Central Valley Region.

Table 32. **Diazinon and Chlorpyrifos use in Bear watershed townships since 2000***

Year	Pounds of Diazinon applied	Pounds of Chlorpyrifos applied
2013	0	2773
2012	0	2589
2011	159	2839
2010	126	2594
2009	100	3441
2008	139	4221
2007	130	5086
2006	299	2966
2005	447	5779
2004	625	5550
2003	449	3417
2002	797	3489
2001	667	1417
2000	1244	3219

*Values are an overestimate, since values represent pesticide use in groups of entire townships, parts of which may lie outside of Bear watershed.

According to the Central Valley Regional Water Quality Control Board (2010), multiple watershed plans exist to combat the remaining 117 river miles that remain on the list of diazinon-affected waters within the Sacramento River and San Joaquin River Basin, including: 1) SRWP Sacramento and Feather Rivers OP Pesticide Management Plan: Identification and Evaluation of Pesticide Management Practices (2001); 2) Water Quality Plan for Sacramento and San Joaquin Rivers Amendments (2003, 2007) (California Water Board, 2008a and 2008b; US EPA 2007); 3) Diazinon Runoff Management Plan for Orchard Growers in the Sacramento Valley (2006); 4) Stormwater Quality Improvement Plan (2010); 5) Monitoring Reports -- Diazinon Runoff Management Plan for Orchard Growers in the Sacramento Valley (SVWQC, 2006-08); and 6) Sacramento Valley Water Quality Coalition Water Quality Management Plan (SVWQC, 2009).

While use of diazinon may be in decline, an ongoing concern throughout the Central Valley is that diazinon is frequently replaced with pyrethriod pesticides, which are highly toxic in aquatic environments (Central Valley Regional Water Quality Control Board, 2010).

Impaired Waters Listing and Reaction: Chlorpyrifos

The 303(d) listing in 2010 for chlorpyrifos is based on water monitoring results indicating that concentrations exceeded TMDL criterion in 2000 and 2005. Since 2000, chlorpyrifos has been consistently used in the lower watershed (Table 32). The US EPA has taken several actions to limit national use of chlorpyrifos since 2000, including: eliminating homeowner use and phasing out termiticide uses (2000), discontinuing use on tomatoes and restricting apple and grape applications (2000), restricting use on citrus and tree nuts (2002), and lowering pesticide application rates and creating buffer zones around public spaces (2012). Since nearly all non-agricultural uses have been banned, remaining usage is primarily agricultural (CVRWQCB, 2013). However, following a Revised Human Health Risk Assessment for Registration Review in 2014, the EPA has recently issued a proposal to revoke all chlorpyrifos tolerances in October of 2015 which would cease all agricultural uses (US EPA, 2015). This proposal is the result of concerns to human health including dietary exposure to chlorpyrifos from food and drinking water, as well as occupational exposure.

Control Programs for Diazinon- and Chlorpyrifos-Impacted Waters

Recommended strategies for pollution prevention include integrated pest management techniques and less toxic pest control methods. Examples of integrated pest management techniques include biological control, habitat manipulation, modification of cultural practices, use of pesticides only after monitoring indicates the necessity and with the goal of removing only the target pest, and selection of pesticides to minimize risks to human health, non-target organisms, and the environment (US EPA, 2015).

In the 2013 Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Discharges, the Central Valley Water Board suggests that in addition to pest management practices, changes to water management practices, pesticide application practices, and vegetation management practices can reduce diazinon and chlorpyrifos agricultural discharge (CVRWQCB, 2013). Improvements to water management may involve increased monitoring of soil moisture, increased use of tailwater return systems and vegetated drainage ditches. Changes in application practices including eliminating outward facing sprayer nozzles at the end of crop rows, improved sprayer technology and frequent calibration of sprayer equipment, using aerial drift retardants, and improved mixing/loading procedures may also help control runoff (CVRWQCB, 2013). Improved vegetation management techniques to minimize runoff and reduce pesticide loadings include use of cover crops, riparian buffers, filter strips, hedge rows, and vegetated swales (Central Valley Regional Water Quality Control Board, 2010; Central Valley Regional Water Quality Control Board, 2013). Results from Yolo County RCD and the U.S. Department of Agriculture have shown that vegetated agricultural drainage ditches are twice as effective at removing 50% of pesticide concentrations (including diazinon and chlorpyrifos) compared to unvegetated ditches (Central Valley Regional Water Quality Control Board, 2010; Moore et al., 2010). Other research by Colusa County RCD, Community Alliance with Family Farmers and the Audubon Society is focusing on diazinon loads before and after storm events to test effectiveness of BMPs (cover crops, hedgerows, vegetated swales), and the Sacramento Water Quality Coalition is examining how orchard floor vegetation and vegetated filter strips may reduce diazinon and chlorpyrifos loads (CVRWQCB, 2010).

Since storm water runoff is the primary mechanism of diazinon and chlorpyrifos transport during the dormant season, the Central Valley Regional Water Quality Control Board (2013) recommends using pesticide application practices, pest control practices (use less or alternative pesticides), and passive runoff control (i.e. buffer strips) in the dormant season. During the growing season, when chlorpyrifos transport occurs primarily through irrigation runoff, the use of pesticide application practices, pest management practices (use less or alternative pesticides), and irrigation water management practices are recommended (CVRWQCB, 2013). The costs associated with different management practices are estimated by the Regional Water Quality Control Board as follows: alternative pest management ($17 to $219/acre-yr), pesticide application practices ($0/acre-yr), irrigation water management ($50-88/acre-yr), pressurized irrigation system ($160/acre-yr), tailwater recovery system ($89/acre-yr) (CVRWQCB, 2013).

Pesticide Impacts

Effects on Salmon

According to NOAA, use of both chlorpyrifos and diazinon is expected to have consequences on Central Valley spring-run Chinook salmon (NOAA, 2008). Both chemicals are commonly applied in dormant spray periods in Delta agricultural lands, the timing of which overlaps with fry rearing and migratory periods for spring-run salmon as they move through the Delta (NOAA, 2008). NOAA expects that the resulting poor water quality from agricultural runoff in the Delta has both individual- and population-level fitness consequences to salmon, especially when considered alongside additional stressors such as habitat loss from dams and reduced access to cool water (NOAA, 2008). Despite being considered highly acutely toxic to fish, some studies have found that diazinon has low potential to bioconcentrate in aquatic organisms (96-97% of accumulated diazinon residues clear from fish tissue in 7 days) (CVRWQCB, 2013).

Effects on Wildlife

Diazinon and Chlorpyrifos, other organophosphates, and carbamate insecticides are in the family of cholinesterase-inhibiting compounds. Cholinesterase is a family of enzymes essential for proper neurological function. Studies across a wide range of taxa including reptiles, amphibians, birds, mammals, fish, and invertebrates have documented the direct death of individuals whose cholinesterase activity dropped to lethal levels following acute exposure to carbamate or organophosphate pesticides (Grue *et al*. 1997, Mileson *et al*. 1998, Fulton and Key 2001, Rattner and McGowan 2007). Among surviving individuals exposed to sublethal doses of these pesticides, decreased cholinesterase activity has been shown to impair breathing, digestion, vision, feeding, hunting, escaping predators, and other movements and functions that are essential for long-term survival in the wild (Russell and Overstreet 1987, Grue *et al*. 1997, Fulton and Key 2001). Through its impairment of neurotransmitter function both within the nervous system and at neuromuscular junctions, decreased cholinesterase activity has been shown in many species to cause lethal respiratory failure and sublethal breathing dysfunction (impaired control of the constriction and dilation of the lungs) (Sidell 1994); lethal muscle paralysis and sublethal decoordination of muscle movement and impaired ability to capture or hold food, escape predators, swim, walk, fly, or stand (Fryday *et al*. 1994, 1995, 1996; Hopkins *et al*. 2005); lethal paralysis of the gastrointestinal tract and sublethal dysfunction of the exocrine glands and metabolism (Grue *et al*. 1991, 1997; Brunet *et al*. 1997); and sublethal impairment of sight through decoordination of the iris and other essential muscles of the eye (Koelle 1994).

In many of these studies, the subjects were intentionally euthanized less than 3 days after pesticide exposure in order to measure cholinesterase activity in the brain tissue. Information is thus incomplete as to the post-exposure duration with which cholinesterase activity, neurological health, and survival-related functions and behaviors are impaired. Among the studies in which subjects were observed for longer periods of time, recovery times varied considerably according to species, dose, specific pesticide used, and specific health parameter being measured. In many of these cases, however, subjects demonstrated consistent impairment for 2-4 weeks after exposure to some cholinesterase-inhibiting pesticides (Fleming and Grue 1981, Roberts *et al*. 1988, Brunet and Cyr 1992, Grue *et al*. 1997). Although studies have rarely observed subjects longer than four weeks post-exposure, at least one study has documented functional impairment a full nine weeks after exposure to a cholinesterase-inhibiting pesticide (Khoshbavar-Rostami *et al*. 2006). Decreased cholinesterase activity has also been shown to lead to delayed-onset paralysis up to three weeks after exposure to cholinesterase-inhibiting organophosphates, resulting from demyelination of nerve fibers and subsequent neuropathy (Sultatos 1994). Cellular death and damage to the liver, kidneys, and muscle tissue has also been documented following sublethal exposure to cholinesterase-inhibiting compounds (Rao 2006).

Because of its important role in neurotransmitter function, cholinesterase activity is essential for reproduction as well as survival. Several studies have reported reduced clutch size and/or delayed ovulation as a result of decreased cholinesterase activity and its subsequent reductions in leutenizing hormone and other reproductive gonadotropin hormones (Stromborg 1981, Rattner *et al*. 1982, Rattner and Michael 1985, Grue *et al*. 1997).

Altered reproductive behavior has also been documented in both sexes and a variety of species following exposure to cholinesterase-inhibiting pesticides at doses lower than those shown to significantly impair survival-related functions (Grue *et al*. 1997).

In addition to the effects described above that are visible at the behavioral and organismal scales, several studies have documented the health impacts of cholinesterase inhibition at the hematological scale. Significant reductions have been recorded in hematocrit, hemoglobin, red blood cell count, white blood cell count, plasma protein, and glucose for at least several days and in some cases more than 30 days (Jenkins *et al*. 2003) following sublethal exposure to cholinesterase-inhibiting pesticides (e.g., Gluth and Hanke 1984, Svoboda *et al*. 2001, Adedeji *et al*. 2009). These decreases in hematocrit, hemoglobin, red blood cell count, white blood cell count, plasma protein, and glucose have been documented even where the pesticide exposure was considered "minute," for example 5ppb, less than one quarter of the concentration that would have been be lethal to half the population (Jenkins *et al*. 2003). When these six hematological parameters have been measured concurrently with cholinesterase activity following pesticide exposure (e.g., Sancho *et al*. 2000), declines in all seven parameters have been strongly correlated.

Several hypotheses have been published that may explain the biological mechanisms by which exposure to cholinesterase-inhibiting pesticides and subsequent reductions in cholinesterase activity may cause these observed declines in hematological health. Reductions in red and white blood cell counts and hematocrit (packed cell volume) may be caused by decreased blood cell production in the bone marrow (Svoboda *et al*. 2001, Adedeji *et al*. 2009), increased blood cell destruction in the spleen (Jenkins *et al*. 2003), and/or osmoregulatory dysfunction (Gluth and Hanke 1984). Reductions in hemoglobin may reflect a reduced number of red blood cells as described above, or may reflect iron deficiency in the diet. Dietary deficiencies in nutrients such as iron may be explained by the decoordination of muscle movement and impaired ability to capture food that is caused by inadequate cholinesterase activity at neuromuscular junctions (Fryday et al. 1994, 1995, 1996; Bridges 1997; Grue *et al*. 1997), and/or by a similar cholinesterase-related dysfunction of the gastrointestinal muscles and glands of the digestive tract (Koelle 1994, Sidell 1994, Grue *et al*. 1997, Brunet *et al*. 1997). Dietary deficiency may also explain the published reductions in plasma protein and glucose following pesticide exposure and cholinesterase inhibition, although these results may also be explained by increased utilization and rapid depletion of these nutrients to fuel the spasmodic movements, tremors, and hypercontractions of the skeletal muscles that are associated with cholinesterase inhibition (Jenkins *et al*. 2003, Rao 2006). An additional published hypothesis suggests that altered concentrations of plasma protein may be caused by a cholinesterase-related disturbance of kidney function and the deregulation of solutes in the bloodstream (Gluth and Hanke 1984, Sancho *et al*. 2000).

Effects on Giant Garter Snakes

In the first study of its kind, Hansen *et al*. (2011) tested cholinesterase levels and several hematological health parameters with blood tests sampled from wild, federally threatened giant garter snakes (*Thamnophis gigas*) and common valley garter snakes (*Thamnophis sirtalis*) that were captured, tested, and released. Their results suggest that a significant portion of the snakes they tested had been exposed in the field to cholinesterase-inhibiting pesticides at concentrations high enough to cause discernible impacts to snake health via the physiological mechanisms described above. Among these aquatic snakes tested at four sites throughout the Sacramento and San Joaquin Valleys, decreased cholinesterase was associated with decreased hematocrit, hemoglobin, and plasma protein; and increased sodium (p = 0.003 for hematocrit, 0.01 for hemoglobin, 0.0001 for plasma protein, and 0.02 for sodium; model-averaged Akaike parameter weight = 100% for hematocrit, 96% for hemoglobin, 84% for plasma protein, and 53% for sodium).

IV. Conclusion

The Bear River Watershed is exceedingly complex in its hydrological, ecological, and social intricacies. Historical and current impacts to the watershed have been vast, and many species and ecosystem functions remain as opportunities for conservation and restoration. With funding from the Bureau of Reclamation and technical support from the members of the Bear Watershed Stakeholder Group, Sierra Streams Institute has assembled the information available for the watershed to date. The next step is to engage the stakeholders in a collaborative process to develop a Bear Watershed Restoration Plan.

V. Literature Cited

Aalto, E., J. Hemmert, A. Hollander, K. Keightley, M.L. Knech, L. Komoroske, C. Monohan, C. Murray, D. Pickard, M. Porter, F. Shilling, D. Waetjen, and K. Wieckowski. 2010. *Sacramento River Basin Report Card & Technical Report: Feather River Watershed.* Sacramento River Watershed Program. <http://www.sacriver.org/files/documents/2010/SacRiverBasin_ReportCard_Report.pdf>

Adams, P., C. James, and C. Speas. 2008. *Brown trout (Salmo trutta) Species and Conservation Assessment*. Prepared for the Grand Mesa, Uncompahgre, and Gunnison National Forests, Colorado <http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5199817.pdf>

Adedeji, O. B., O. K. Adeyemo and S. A. Agbede. 2009. Effects of diazinon on blood parameters in the African catfish (*Clarias gariepinus*). *African Journal of Biotechnology* 8:3940–3946.

Alpers, C.N., M.P. Hunerlach, J.T. May, R.L. Hothem, H.E. Taylor, R.C. Antweiler, J.F. de Wild and D.A. Lawler. 2005. *Geochemical characterization of water, sediment, and biota affected by mercury contamination and acidic drainage from historical gold mining, Greenhorn Creek, Nevada County, California, 1999–2001*. U.S. Geological Survey Scientific Investigations Report 2004-5251. <http://pubs.usgs.gov/sir/2004/5251/sir_2004-5251.pdf>

Alpers, C.N., A.R. Stewart, M.K. Saiki, M.C. Marvin-DiPasquale, B.R. Topping, K.M. Rider, S.K. Gallanthine, C.A. Kester, R.O. Rye, R.C. Antweiler and J.F.de Wild. 2008. *Environmental Factors Affecting Mercury in Camp Far West Reservoir, California, 2001-03*. US Geological Survey Scientific Investigations Report 2006-5008. <http://pubs.usgs.gov/sir/2006/5008/>

American Rivers. 2010. *Headwaters Restoration in a Changing Climate: The Meadows of Bear Valley*. Sierra Nevada Conservancy: Auburn, CA. <http://www.americanrivers.org/our-work/water-supply/storage-flows/bearvalley-meadow.html>

American Rivers. 2011. *Stop Sierra Nevada Rivers from Misguided Dam Proposals.* The River Blog. American Rivers: Washington DC. 12 July 2011 <http://www.americanrivers.org/blog/saving-sierra-nevada-rivers-from-misguided-dam-proposals/>

American Rivers. 2014. *Bear Valley Meadow Restoration Project*. Water Supply Projects. American Rivers: Washington, DC <http://www.americanrivers.org/initiative/water-supply/projects/bear-valley-meadow-restoration-project/>

Amirbahman, A., P.L. Ruck, I.J. Fernandex, T.A. Haines, and J.S. Kahl. 2004. The effect of fire on mercury cycling in the soils of forested watersheds: Acadia National Park, Maine, U.S.A. *Water, Air and Soil Pollution* **152**: 313-331.

Balfour, P. S., and E. W. Stitt. 2002. Geographic distribution: *Nerodia fasciata fasciata* (banded watersnake). USA: California: Sacramento Co. *Herpetological Review* 33:150.

Balfour, P. S., E. W. Stitt, and M. M. Fuller. 2007. Geographic distribution: *Nerodia fasciata* *pictiventris* (Florida water snake). *Herpetological Review* 38:363.

Baltz, D. and P. Moyle. 1984. Segregation by species and size classes of rainbow trout, *Salmo gairdneri*, and Sacramento sucker, *Catostomus occidentalis,* in three California streams. *Environmental Biology of Fishes* **10**:101-110.

Barbour, M., J. Gerritsen, G. Griffith, R. Frydenborg, E. McCarron, J. White, and M. Bastian. 1996. A framework for biological criteria for Florida streams using benthic macroinvertebrates. *Journal of the North American Benthological Society* **15**:185–211.

Barbour, M. T., W. F. Swietlik, S. K. Jackson, D. L. Courtemanch, S. P. Davies, and C. O. Yoder. 2000. Measuring the attainment of biological integrity in the USA: a critical element of ecological integrity. *Hydrobiologia* **422-423**:453–464.

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. *Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition*. Environmental Protection Agency Report 841-B-99-002.

Barr, C. 1991. *The Distribution, Habitat, and Status of the Valley Elderberry Longhorn Beetle* Desmocerus californicus dimorphus. Sacramento, CA.

Barry, S. J. 1998. Managing the Sacramento Vernal Pool Landscape to Sustain Native Flora. Pages 236–240 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren, Jr., and R. Ornduff (Editors). *Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference*. California Native Plant Society, Sacramento, CA.

Bat Conservation International. 2008. Western Red Bat. <http://www.batcon.org/SPprofiles/detail.asp?articleID=101>

Bauder, E.T. 1987. Threats to San Diego Vernal Pools and a Case Study in Altered Pool Hydrology. Pages 209–213 *in*: Elias, T.S. (Editor). *Conservation and Management of Rare and Endangered Plants*. Proceedings of a California Conference on the Conservation and Management of Rare and Endangered Plants. California Native Plant Society.

Beale Air Force Base. 2011. *Integrated Natural Resources Management Plan*. Beale Air Force Base, California.

Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko. 2004. *Historical and current information on green sturgeon occurrence the in the Sacramento and San Joaquin rivers and tributaries*. State Water Contractors: Sacramento, CA <http://www.sacramentoriver.org/forum/scripts/library/file.php?file_id=783>

Bear River Awakening. 2016. *Bear River Summary*. Accessed 15 January 2016. <http://bearriver.us/docs/summary.pdf>

Bell, A. 2012. *Deer Creek Index of Biotic Integrity*. Paper presented at Yuba-Bear Watershed

Council Symposium.

Bell, A. 2013. *Development of an Index of Biotic Integrity (IBI) for Deer Creek, Nevada County, California: Family-level IBI for citizen-science bioassessment*. Sierra Streams Institute: Nevada City, California.

Bergkamp, G., and K. Cross. 2006. Groundwater and Ecosystem Services: towards their sustainable use. *Proceedings of the International Symposium on Groundwater Sustainability (ISGWAS)*, Alicante, Spain. p. 177-193

Berry, K., S. Busack, S. Byrne, E. Davidson, M. Fox, J. Keefe, and R. Luckenbach. 1996. *The effects of off-road vehicles on animal populations and habitats: a review of the literature*. National Biological Service, Riverside Field Office, Riverside, CA.

Borisenko, A. and M. P. Hayes. 1999. *Status of the Foothill Yellow-legged Frog (Rana boylii) in Oregon*. Final report prepared for The Nature Conservancy under contract to the U. S. Fish and Wildlife Service: Washington, DC.

Bradford, D.F. 1983. Winterkill, oxygen relations, and energy metabolism of a submerged dormant amphibian, *Rana muscosa*. *Ecology* **64**: 1171-1183.

Brennan, D. 2012. *Letter supporting Nevada Irrigation District's opposition to the proper Garden Bar Dam*. City of Nevada City, City Council Meeting. Nevada City, CA. 27 June 2012 <http://www.nevadacityca.gov/sites/all/modules/tinytinymce/tinymce/jscripts/tiny_mce/plugins/filemanager/files/ccpackets2012/cc-jun27-04_001.pdf>

Bridges, C. M. 1997. Tadpole swimming performance and activity affected by acute exposure to sublethal levels of carbaryl. *Environmental Toxicology and Chemistry* 16:1935–1939.

Brown, L. R. and A. M. Brasher. 1995. Effect of predation by Sacramento squawfish (*Ptychocheilus grandis*) on habitat choice of California roach (*Lavinia symmetricus*) and rainbow trout (*Oncorhynchus mykiss*) in artificial streams. *Can. J. Fish Aquat. Sci*. **52**:1639-1646.

Brown, L. R., and T. Ford. 2002. Effects of flow on the fish communities of a regulated California river: implications for managing native fishes. *River Research and Applications* **18**: 331-342.

Brunet, R., and A. Cyr. 1992. The impact of dimethoate on rhythms of three granivorous bird species. *Agriculture, Ecosystems and Environment* 41:327–336.

Brunet, R., C. Girard, and A. Cyr. 1997. Comparative study of the signs of intoxication and changes in activity level of red-winged blackbirds (*Agelaius phoeniceus*) exposed to dimethoate. *Agriculture, Ecosystems and Environment* 64:201–209.

Buskirk, S.W. and W.J. Zielinski. 1997. *American marten (Martes Americana) ecology and conservation*. Mesocarnivores of Northern California: Biology, Management, & Survey Techniques, p. 17-22. <http://www.fs.fed.us/psw/publications/zielinski/zielinski5.PDF>

CABY. 2014. *CABY Integrated Regional Water Management Plan (IRWMP).* 2014 Updated Plan. Consumnes, American, Bear and Yuba (CABY). <http://cabyregion.org/caby-irwmp-sections>

Cal EPA- *see* California Environmental Protection Agency

Cal Fire. 2012. Forest Practical Geographical Information System. Cal Fire Resource Management Programs. <http://calfire.ca.gov/resource_mgt/resource_mgt_forestpractice_gis>

CalPIP- *see* California Pesticide Information Portal

California Department of Fish and Game. 2005. *California Wildlife Habitat Relationships System: Ringtail*. <https://nrm.dfg.**ca**.gov/FileHandler.ashx?DocumentVersionID=17969>

California Department of Fish and Game. 2007. *Assessment of Ecological Impacts of Hydropower Projects on Benthic Macroinvertebrate Assemblages: A Review of Existing Data Collected for FERC Relicensing Studies.* CDFG Bioassessment Lab, Sacramento, CA.

California Department of Fish and Wildlife. 2015a. *Special Animals List*. Periodic publication. 55pp. CDFW Natural Diversity Database.

California Department of Fish and Wildlife. 2015b. *Species Explorer - Browse Species*. Available: <https://nrm.dfg.ca.gov/taxaquery/BrowseSpecies.aspx>

California Department of Fish and Wildlife. 2016a. *Steelhead trout*: *Oncorhynchus mykiss irideus.* California Department of Fish and Wildlife: Sacramento, CA. Accessed March 2016 <http://www.dfg.ca.gov/fish/Resources/SteelHead/>

California Department of Fish and Wildlife. 2016b. *Chinook salmon: Oncorhynchus tshawytscha.* California Department of Fish and Wildlife: Sacramento, CA. Accessed March 2016 <http://www.dfg.ca.gov/fish/Resources/Chinook/>

California Department of Fish and Wildlife. 2016c. *NCCP Plan Summary- Yuba Sutter Regional Conservation Plan*. CDFW Natural Community Conservation Planning <https://www.wildlife.ca.gov/Conservation/Planning/NCCP/Plans/Yuba-Sutter>

California Department of Fish and Wildlife. 2016d. California's Invaders: Northern Watersnake. https://www.wildlife.ca.gov/Conservation/Invasives/Species/Northern-Watersnake. Accessed March 2016.

California Department of Fish and Wildlife. 2016e. California's Invaders: Southern Watersnake. https://www.wildlife.ca.gov/Conservation/Invasives/Species/Southern-Watersnake. Accessed March 2016.

California Department of Pesticide Regulation. 2013. *Ground Water Protection Program*. Environmental Monitoring Branch: Sacramento, CA <http://www.cdpr.ca.gov/docs/emon/grndwtr/>

California Department of Pesticide Regulation. 2015. *About Pesticide Regulations' Endangered*

Species Custom Realtime Internet Bulletin Engine (PRESCRIBE) Data Source [web application]. California Pesticide Information Portal. Accessed Feb 2016. <http://calpip.cdpr.ca.gov/infodocs.cfm?page=aboutprescribe>

California Environmental Protection Agency. 2003. *State of the Watershed Report for Sacramento River Watershed*. Central Valley Regional Water Quality Control Board. Watershed Management Initiative- Central Valley Region Chapter. Sacramento, CA. http://www.waterboards.ca.gov/centralvalley/water_issues/watershed_management/04sacr.pdf

California Environmental Protection Agency. 2009. Total Maximum Daily Loads (TMDLs) and Impaired Water Bodies 303(d) List. Central Valley Regional Water Quality Control Board. California Environmental Protection Agency. Sacramento, CA. <http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/>

California Environmental Protection Agency. 2015. *Irrigated Lands Regulatory Program*. State Water Resources Control Board. California Environmental Protection Agency. Sacramento, CA. <http://www.swrcb.ca.gov/water_issues/programs/agriculture/>

California Herps. 2015. *A guide to the Amphibians and Reptiles of California*. Available: <http://www.californiaherps.com/>

California Pesticide Information Portal (CalPIP). 2013. *Results of electronic record search*. California Department of Pesticide Regulation. Sacramento, CA. Accessed 1 Feb 2016. Available: <http://calpip.cdpr.ca.gov/main.cfm>

California Regional Water Quality Control Board. 2003. *2002 CWA (Clean Water Act) Section 303(d) List of Water Quality Limited Segment* (approved July 2003 by the U.S. Environmental Protection Agency). Central Valley Region.

California Regional Water Quality Control Board. 2010. *Water quality control plan (basin plan) for the Sacramento River and San Joaquin River Basins*. Central Valley Region. Available: < http://www.swrcb.ca.gov/~rwqcb5/home.html>

California Regional Water Quality Control Board. 2013. *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Discharges*. State Water Resources Control Board. Sacramento, CA. <http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/central_valley_pesticides/2013_03_05_cv_dc_bpa_rpt_.pdf>

California Water Board. 2004. *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List*. State Water Resources Control Board/Regional Water Quality Control Boards. California Environmental Protection Agency. Sacramento, CA. <http://www.waterboards.ca.gov/water_issues/programs/tmdl/docs/ffed_303d_listingpolicy093004.pdf>

California Water Board. 2008a. *Sacramento and Feather Rivers Diazinon and Chlorpyrifos - 2003 Basin Plan Amendment*. State Water Resources Control Board. Sacramento, CA. Available:

<http://www.swrcb.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/sacramento_feather_op_pesticide/2003_amendment/index.shtml>

California Water Board. 2008b. *Sacramento and Feather Rivers Diazinon and Chlorpyrifos - 2007 Basin Plan Amendment*. <http://www.swrcb.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/sacramento_feather_op_pesticide/2007_amendment/index.shtml>.

California Water Board. 2016. *Impaired Water Bodies*. State Water Resources Control Board. Sacramento, CA. Available: <http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml>

CDFG- *see* California Department of Fish and Wildlife

CDFW- *see* California Department of Fish and Wildlife

CDPR- *see* California Department of Pesticide Regulation

Central Valley Regional Water Quality Control Board. 2010. *FY2010 SP12 Final Report*. California Regional Water Quality Control Boards. Sacramento, CA. Available: <http://www3.epa.gov/region9/water/watershed/measurew/feather-sac/2010SacFeatherRiverSP12final-Rpt.pdf>

Chun, S. N., S. A. Cocherell, D. E. Cocherell, J. B. Miranda, G. J. Jones, J. Graham, A. P. Klimley, L. C. Thompson and J. J. Cech Jr. 2011. Displacement, velocity preference, and substrate use of three native California stream fishes in simulated pulsed flows. *Environ Biol Fish* **90(1)**: 43-52.

Clark, G. M., T. J. Roscoe, M. J. van Ess, and N. Wymer. 1998. Management considerations for small vernal pool preserves: the Phoenix vernal pools. Pages 250-254 *in*: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren, Jr., and R. Ornduff (Editors). *Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference*. California Native Plant Society, Sacramento, CA.

Cocherell, S, A., D. E. Cocherell, G. J. Jones, J. B. Miranda, L. C. Thompson, J. J. Cech Jr., and A. P. Klimley. 2011. Rainbow trout *Oncorhynchus mykiss*energetic responses to pulsed flows in the American River, California, assessed by electromyogram telemetry. *Environ Biol Fish* **90(1)**: 29-41.

Cohen, A.N. 2008. *Potential Distribution of Zebra Mussels(Dreissena polymorpha) and QuaggaMussels (Dreissena bugensis) in California Phase 1 Report*. San Francisco Estuary Institute: Oakland, CA and Center for Research on Aquatic Bioinvasions: Richmond, CA.

Collins, P. W. 1998. Sierra Nevada snowshoe hare, *Lepus americanus tahoensis. In:* Bolster, B. C., Ed. *Terrestrial Mammal Species of Special Concern in California*, pages 80-82. California Department of Fish and Game, Sacramento, CA.http://www.dfg.ca.gov/wildlife/nongame/ssc/1998mssc.html

Conover, M.R., W.C. Pitt, K.K. Kessler, T.J. DuBow, and W.A. Sanborn. 1995. Review of human injuries, illnesses, and economic losses caused by wildlife in the United States. *Wildlife Society Bulletin* **23(3)**: 407-414.

CRWQCB- *see* California Regional Water Quality Control Boards

CWHR- *see* California Wildlife Habitat Relationships

D'Antonio, C.M., E.L. Berlow, and K.L. Haubensak. 2004. *Invasive Exotic Plant Species in Sierra Nevada Ecosystems*. USDA Forest Service Gen. Tech. Rep. PSW-GTR-193. Cal-IPC, 2011. *Arundo donax* Distribution and Impact Report, Agreement: No. 06-374-559-0 Submitted to: State Water Resources Control Board. <http://www.calipc.org/ip/research/arundo/Arundo%20Distribution%20and%20Impact%20Report_Cal-IPC_March%202011.pdf>

Dileanis, P.D., D. L. Brown, D.L. Knifong, and D. Saleh. 2003. *Occurrence and transport of diazinon in the Sacramento River and selected tributaries, California, during two winter storms, January-February 2001*. U.S. Geological Survey. Water-Resources Investigations Report 03-4111. Sacramento, CA.

Dennis, N. 1989. *The effects of fire on watersheds: A summary*. USDA Forest Service Gen. Technical Report PSW-109. <http://wwwtest.fs.fed.us/psw/publications/documents/psw_gtr109/psw_gtr109a.pdf - page=96>

Department of Conservation. 2000. *California's Abandoned Mines: A Report on the Magnitude and Scope of the Issue in the State, Volume 1*. Office of Mine Reclamation, Abandoned Mine Lands Unit. Sacramento, CA <http://www.conservation.ca.gov/omr/abandoned_mine_lands/AML_Report/Pages/volume_1.aspx>

Department of Finance. 2014. Total Population: State and County Population Projections, 2010-2060. State of California, Sacramento, California.

Department of Water Resources. 1998. *California Water Plan Update*. Bulletin 160-98. 3 v. State of California Resources Agency: Sacramento, CA.

Department of Water Resources. 2003*. California's Groundwater*. Bulletin 118 – Update 2003. State of California Resources Agency: Sacramento, CA.

Department of Water Resources. 2007. *Mercury contamination in Fish from Northern California Lakes and Reservoirs*. State of California Resources Agency: Sacramento, CA. <http://www.water.ca.gov/pubs/waterquality/mercury_contamination_in_fish_from_northern_california_lakes_and_reservoirs/mercurycontaminationfinalonline.pdf>

Department of Water Resources. 2013a. *California Water Plan: Agricultural Land Stewardship*. California Water Plan Update 2013. Volume 3: Resource Management Strategies, Chapt. 21.

State of California Resources Agency: Sacramento, CA. <http://www.waterplan.water.ca.gov/docs/cwpu2013/Final/Vol3_Ch21_Ag-Lands-Stewardship.pdf>

Department of Water Resources. 2013b. *Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Protection System*. Code of Federal Regulations. Department of Water Resources Division of Flood Management. State of California Resources Agency: Sacramento, CA. <http://cdec.water.ca.gov/cgi-progs/products/Local_Maintaining_Agency_Annual_Report_2013.pdf>

Department of Water Resources. 2014a. *Summary of Recent, Historical, and Estimated Potential for Future Land Subsidence in California*. State of California Resources Agency: Sacramento, CA. <http://www.water.ca.gov/groundwater/docs/Summary_of_Recent_Historical_Potential_Subsidence_in_CA_Final_with_Appendix.pdf>

Department of Water Resources. 2014b. *Public Update for Drought Response: Groundwater Basins with Potential Water Shortages, Gaps in Groundwater Monitoring, Monitoring of Land Subsidence, and Agricultural Land Fallowing*. State of California Resources Agency: Sacramento, CA. <http://www.water.ca.gov/waterconditions/docs/DWR_PublicUpdateforDroughtResponse_GroundwaterBasins.pdf>

Department of Water Resources. 2015. *California's Groundwater Update 2013: Chapter 7 Sacramento River Hydrologic Region*. State of California Resources Agency: Sacramento, CA. <http://www.waterplan.water.ca.gov/topics/groundwater/index.cfm>

Department of Water Resources. 2016. *Groundwater.* State of California Resources Agency: Sacramento, CA. <http://www.water.ca.gov/groundwater/>

Dill, W. A., and A. J. Cordone. 1997. *History and Status of Introduced Fishes in California, 1871-1996*. Fish Bulletin 178. California Department of Fish and Game: Sacramento, CA. Accessed March 2016 <http://www.oac.cdlib.org/view?docId=kt8p30069f&query=&brand=calisphere>

DoC- *see* Department of Conservation

Domagalski, J. 1998. Occurrence and transport of total mercury and methyl mercury in the Sacramento River Basin, CA. *Journal of Geochemical Exploration* **64 (1-3)**: 277-291.

Domagalski, J. 2001. Mercury and methyl mercury in water and sediment of the Sacramento River Basin, CA. *Applied Geochemistry* **16(15)**: 1677-1691.

Duke, S. (USF&WS), Down, T., Ptolemy, J., Hammond, J. & Spence, C. (Ministry of Water, Land & Air Protection, Canada). 2004. *Acipenser transmontanus*. The IUCN Red List of Threatened Species 2004: e.T234A13043189. Accessed March 2016 <http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T234A13043189.en>

Duncan, N. 2005. *Conservation Assessment for Monadenia (Shastelix) chaceana*. Chace Sideband. USDA Forest Service Region 6 and Bureau of Land Management, Oregon and Washington.

Accessed 3 Dec 2015. <http://www.blm.gov/or/plans/surveyandmanage/files/ca-ig-monadenia-chaceana-2005-08-09.pdf>

DWR- *see* Department of Water Resources

eBird. 2016. eBird: *An online database of bird distribution and abundance* [web application]. eBird, Ithaca, New York. Accessed March 2016. <http://www.ebird.org>

ECORP. 2014. *Instream Flow and Sediment Studies for Bear River and Deer Creek*. Prepared by ECORP Consulting, Inc. for Nevada Irrigation District.

Edwards, P. J., T.C. Cain, and C.J. & Gagen. 2007. Using multiple fine-sediment size classes to evaluate the condition of trout spawning habitat. *Advancing the Fundamental Sciences*, **94**.

EPA- *see* U.S. Environmental Protection Agency

Fellers, G.M., W.Z. Lidicker Jr., A.V. Linzey and Nature Serve (Williams, D.F. & G. Hammerson). 2008. *Aplodontia rufa*. The IUCN Red List of Threatened Species 2008. Accessed 8 Jan 2016. <http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T1869A8505447.en>

Finlay, J. C., and V. T. Vredenburg. 2007. Introduced trout sever trophic connections in watersheds: consequences for a declining amphibian. *Ecology* **88**: 2187-2198.

Fleming, W. J., and C. E. Grue. 1981. Recovery of cholinesterase activity in five avian species exposed to dicrotophos, an organophosphorus pesticide. *Pesticide Biochemistry and Physiology* 16:129–135. Cited in Grue *et al*. 1997.

Flint, L.E. and A.L. Flint. 2014. *California Basin Characterization Model: A Dataset of Historical and Future Hydrological Response to Climate Change*. USGS Survey Data Release. USGS California Water Science Center. <http://ca.water.usgs.gov/projects/reg_hydro/projects/dataset.html>

Fryday, S. L., A. D. M. Hart, and N. J. Dennis. 1994. Effects of exposure to an organophosphate on the seed handling efficiency of the house sparrow. *Bulletin of Environmental Contamination and Toxicology* 53:869–876.

Fryday, S. L., A. D. M. Hart, and S. D. Langton. 1996. Effects of exposure to an organophosphorus pesticide on the behavior and use of cover by captive starlings. *Environmental Toxicology and Chemistry* 15:1590–1596. Cited in Grue *et al*. 1997.

Fryday, S. L., A. D. M. Hart, and T. H. Marczylo. 1995. The effects of sublethal exposure to an organophosphate on the flying performance of captive starlings. *Bulletin of Environmental Contamination and Toxicology* 55:366–373. Cited in Grue *et al*. 1997.

Fuller, P. and M. Cannister. 2016. *Lepomis macrochirus*. USGS Nonindigenous Aquatic Species Database: Gainesville, FL. Revision Date: Apr 2013. <http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=385>

Fuller, P. and M. Neilson. 2016a. *Micropterus salmoides*. USGS Nonindigenous Aquatic Species Database: Gainesville, FL. Revision Date: July 2015. <http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=401>

Fuller, P. and M. Neilson. 2016b. *Ictalurus punctatus*. USGS Nonindigenous Aquatic Species Database: Gainesville, FL. Revision Date: May 2012. <http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=2341>

Fuller, P., J. Larson, A. Fusaro, T.H. Makled, and M. Neilson. 2016a. *Salmo trutta*. USGS Nonindigenous Aquatic Species Database: Gainesville, FL. Revision Date: Jan 2015 <http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=931>

Fuller, P., M. Cannister, and M. Neilson. 2016b. *Micropterus dolomieu*. USGS Nonindigenous Aquatic Species Databas: Gainesville, FL. Revision Date: Jan 2016 <http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=396>

Fuller, P., M. Cannister, and M. Neilson. 2016c. *Pomoxis nigromaculatus*. USGS Nonindigenous Aquatic Species Database: Gainesville, FL. Revision Date: May 2012 <http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=409>

Fuller, P., G. Jacobs, M. Cannister, J. Larson, A. Fusaro, T.H. Makled and M. Neilson. 2016d. *Lepomis microlophus*. USGS Nonindigenous Aquatic Species Database: Gainesville, FL. Revision Date: Apr 2013 <http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=390>

Fulton, M. H., and P. B. Key. 2001. Acetylcholinesterase inhibition in estuarine fish and invertebrates as an indicator of organophosphorus insecticide exposure and effects. *Environmental Toxicology and Chemistry* 20:37–45.

Garbelotto, M., and D. Barbosa. 2014. First Report of the NA2 Lineage of *Phytophthora ramorum* from an Ornamental *Rhododendron* in the Interior of California. *Plant Disease, Disease Notes* **98(6)**: 849. <http://nature.berkeley.edu/garbelotto/downloads/Garbelottobarbosa2014.pdf>

Garcia, E. 1999. *Anaxyrus boreas*. Accessed 1 Dec 2015. <http://amphibiaweb.org/cgi/amphib_query?where-genus=Anaxyrus&where-species=boreas&account=amphibiaweb>

GISD- *see* Global Invasive Species Database

Global Invasive Species Database. 2015. *Species profile Salmo trutta*. Accessed March 2016 <http://www.issg.org/database/species/ecology.asp?si=78&fr=1&sts=sss>

Gluth, G., and W. Hanke. 1984. A comparison of physiological changes in carp, *Cyprinus carpio*, induced by several pollutants at sub-lethal concentration. II. The dependency on the temperature. *Comparative Biochemistry and Physiology* 796:39–45. Cited in Sancho *et al*. 2000.

Grue, C. E., P. L. Gibert, and M. E. Seeley. 1997. Neurophysiological and behavioral changes in non-target wildlife exposed to organophosphate and carbamate pesticides: thermoregulation, food consumption, and reproduction. *American Zoologist* 37:369–388.

Grue, C. E., A. D. M. Hart, and P. Mineau. 1991. Biological consequences of depressed brain cholinesterase activity in wildlife. *In* P. Mineau (ed.), *Cholinesterase-inhibiting Insecticides: Their Impact on Wildlife and the Environment*. pp. 151–209. Elsevier Science Publishers B.V., Amsterdam, The Netherlands. Cited in Grue *et al*. 1997.

Hamilton, G.B., C.R. Peterson and W.A. Wall. 1998. *Distribution and habitat relationships of amphibians on the Potlatch Corporation operating area in northern Idaho*. Potlatch Corporation, Unpublished report, Lewiston, Idaho.

Hansen, A.J. and J.J. Rotella. 2002. Biophysical factors, land use and species variability in and around nature reserves. *Conservation Biology* **16(4)**:22.

Hansen, A.J., R. Rasker and B. Maxwell. 2002. Ecological causes and consequences of demographic change in the New West. *Bio-Science* **52(2)**:68.

Hansen, E., R. Wack, R. Poppenga, K. Strohm, C. Johnson, D. Bunn, and R. Scherer. 2011. *Comparative pathology, health, and contaminant exposure within San Joaquin Valley and Sacramento Valley giant garter snake (*Thamnophis gigas*) populations.* Report submitted to the Central Valley Project Conservation Program.

Hatfield, R., S. Jepsen, R. Thorp, L. Richardson, and S. Colla. 2014. *Bombus caliginosus*. The IUCN Red List of Threatened Species 2014: e.T44937726A69000748. http://dx.doi.org/10.2305/IUCN.UK.2014-3.RLTS.T44937726A69000748.en. Accessed March 2016.

Hatfield, R., S. Jepsen, R. Thorp, L. Richardson, S. Colla and S. Foltz Jordan. 2015. *Bombus occidentalis*. The IUCN Red List of Threatened Species 2015: e.T44937492A46440201. http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T44937492A46440201.en. Accessed Dec 2015.

Helm, B. P. 1998. Biogeography of Eight Large Branchiopods Endemic to California. Pages 124-139 *in:* C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Editors). *Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference*. California Native Plant Society, Sacramento, CA.

Helsel, D.R. and R.M. Hirsch. 2002. *Statistical Methods in Water Resources*. Techniques of Water-Resources Investigations of the US Geological Survey: Book 4- Hydrologic Analysis and Interpretation. US Geological Survey. <http://water.usgs.gov/pubs/twri/twri4a3/>

Herbst, D.B., M.T. Bogan, M.T. and R.A. Lusardi. 2008. Low specific conductivity limits growth and survival of the New Zealand mud snail from the upper Owens River. *California Western North American Naturalist* **68(3)**:324-333.

Hopkins, W.A., C.T. Winne, and S.E. DuRant. 2005. Differential swimming performance of two natricine snakes exposed to a cholinesterase-inhibiting pesticide. *Environmental Pollution* 133:531–540.

Hunerlach, M.P., J.J. Rytuba, and C.N. Alpers. 1999. *Mercury Contamination from Hydraulic Placer-Gold Mining in the Dutch Flat Mining District, California*. US Geological Survey Water-Resources Investigations Report 99-4018B. <http://ca.water.usgs.gov/mercury/dutch/wrir994018b.pdf>

International Union for Conservation of Nature Red List. 2015. *The IUCN Red List of Threatened Species.* Version 2015-4. Available: <http://www.iucnredlist.org/>

Jeffres, C. A., A. P. Klimley, J. E. Merz, and J. J. Cech Jr. 2006. Movement of Sacramento sucker, *Catostomus occidentalis*, and hitch, *Lavinia exilicauda*, during a spring release of water from Camanche Dam in the Mokelumne River, California. *Environmental Biology of Fishes* **75**:365-373.

Jenkins, F., J. Smith, B. Rajanna, U. Shameem, K. Umadevi, V. Sandhya, and R. Madhavi. 2003. Effect of sub-lethal concentrations of endosulfan on hematological and serum biochemical parameters in the carp *Cyprinus carpio*. *Bulletin of Environmental Contamination and Toxicology* 70:993–997.

Jennings, M. R., and M. P. Hayes. 1994. *Amphibian and Reptile Species of Special Concern in California*. Final report to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, CA, under contract 8023.

Jennings, M.R. and M.P. Hayes. 1985. Pre-1900 overharvest of the California red-legged frog (*Rana aurora draytonii*): the inducement for bullfrog (*Rana catesbeiana*) introduction. *Herpetologica* **41**: 94–103.

Jones, A.B. and D.G. Slotton. 1996. *Mercury Effects, Sources and Control Measures*. San Francisco Estuary Regional Monitoring Program. SF Estuary Institute, Richmond, CA <http://www.sfei.org/sites/default/files/mercury.pdf>

Jones & Stokes. 2005. *Assessment of habitat conditions for Chinook salmon and steelhead in western Placer county, CA*. Placer County Planning Department: Auburn, CA <http://www.placer.ca.gov/~/media/cdr/planning/pccp/biostudies/finalsalmonidassessment pdf.pdf?la=en>

Jones & Stokes. 2006. *Bear River Recovery Monitoring Project – 3 year summary report* (J&S 06374.06). Prepared for The Pacific Gas and Electric Company.

Jones & Stokes. 2010. *Hatchery and Stocking Program Environmental Impact Report/Environmental Impact Statement*. Final. January.(ICF J&S 00264.08) (SCH #2008082025). Sacramento, CA. Prepared for the California Department of Fish and Game and U.S. Fish and Wildlife Service: Sacramento, CA.

Jordan, M. 2000. *Ecological Impacts of Recreational Use of Trails: A Literature Review*. The Nature Conservancy. <http://www.parks.ca.gov/pages/795/files/ecologicalimpactsrecreationalusers.pdf>

Jovan, S. 2008. *Lichen bioindication of biodiversity, air quality, and climate: Baseline results from monitoring in Washington, Oregon, and California*. Gen.Tech. Rep. PNW-GTR-737. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Karr, J. 1991. Biological Integrity : A Long-Neglected Aspect of Water Resource Management. *Ecological applications* **1**:66–84.

Karr, J. R., and E. W. Chu. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Pages 1–206.

Karr, J. R., and E. W. Chu. 2000. Sustaining living rivers. *Hydrobiologia* **422-423**:1–14.

Khoshbavar-Rostami, H. A., M. Soltani, and H. M. D. Hassan. 2006. Immune response of great sturgeon (*Huso huso*) subjected to long-term exposure to sublethal concentration of the organophosphate, diazinon. *Aquaculture* 256:88–94.

Klasing, S. and R. Brodberg. 2003. *Evaluation of potential health effects of eating fish from selected water bodies in the northern Sierra Nevada foothills (Nevada, Placer, and Yuba counties): Guidelines for sport fish consumption*. Office of Environmental Health Hazard Assessment: Oakland, CA <http://oehha.ca.gov/fish/pdf/SierraLakesAdvisoryfinal.pdf>

Klasing, S., and R. Brodberg. 2004. *Fish consumption guidelines for Lake Natoma (including nearby creeks and ponds) and the lower American River (Sacramento County)*. Office of Environmental Health Hazard Assessment: Oakland, CA http://www.oehha.ca.gov/fish/pdf/NatomaFinalAdvisory9204.pdf>

Klonsky, K. and B. D. Healy. 2013. *Statistical Review of California's Organic Agriculture: 2009-2012*. University of California Agricultural Issues Center. Davis, CA. <http://aic.ucdavis.edu/publications/StatRevCAOrgAg_2009-2012.pdf>

Koelle, G. B. 1994. Pharmacology of organophosphates. *Journal of Applied Toxicology* 14:105–109.

Kondolf, G.M. 1997. Hungry Water: Effects of Dams and Gravel Mining on River Channels. *Environmental Management* **21 (4)**: 533-551.

Kruse, K. C. and M. G. Francis. 1977. A predation deterrent in larvae of the bullfrog, *Rana catesbeiana*. *Transactions of the American Fisheries Society* **106**: 248-252.

Kupferberg, S. J. 1996. Hydrologic and geomorphic factors affecting conservation of a river-breeding frog *(Rana boylii). Ecological Applications* **64(4)**: 1332–1344.

Kutner, L. S., and L. E. Morse. 1996. *Reintroduction in a changing climate*. In: Falk, D.A., C. I. Millar, and M. Olwell, (eds.). Restoring Diversity: strategies for reintroduction of endangered plants. Island Press, Washington, DC.

Lannoo, M. 2005. AmphibiaWeb: *Information on amphibian biology and conservation*. [web application]. Berkeley, California <AmphibiaWeb>

Laudenslaker, Jr., W.F., 1990. *Historical effects of logging on forests of the Cascade and Sierra Nevada ranges of California*. Transactions of the Western Section of the Wildlife Society 26:12-32, Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, 2081 E. Sierra Avenue, Fresno, CA 93710.

Lawrence, D. J., J. D. Olden, C. E. Torgersen. 2012. Spatiotemporal patterns and habitat associations of smallmouth bass (*Micropterus dolomieu*) invading samlon-rearing habitat. *Freshwater Biology* **57**:1929-1949.

Lesica, P., and F. W. Allendorf. 1992. Are small populations of plants worth preserving? *Conservation Biology* **6(1)**:135–39.

Lesica, P., and F. W. Allendorf. 1995. When are peripheral populations valuable for conservation? *Conservation Biology* **9(4)**:753–60.

Lind, A. J., H. H. Welsh Jr., and R. A. Wilson. 1996. The effects of a dam on breeding habitat and egg survival of the foothill yellow-legged frog (*Rana boylii*) in Northwestern California. *Herpetological Review* **27(2)**: 62–67.

Loma Rica Ranch, LLC. 2011. *Loma Rica Ranch Specific Plan*. City of Grass Valley. <http://www.cityofgrassvalley.com/files/document_central/final_sp_100711_inserts_red.pdf>

Marty, J. 2005. Effects of cattle grazing on diversity in ephemeral wetlands. *Conservation Biology* 19:1626-1632.

Marty, J. 2008. Effects of cattle grazing on diversity in ephemeral wetlands. *Conservation Biology* 19:1626-1632. http://www.vernalpools.org/documents/Marty%20Cons%20Bio.pdf

Marvin-DiPasquale, M., J.L. Agee, E. Kakouros, L.H. Kieu, J.A. Fleck, J.A., and C.N. Alpers. 2011. *The effects of sediment and mercury mobilization in the South Yuba River and Humbug Creek confluence area, Nevada County, California: Concentrations, speciation and environmental fate—Part 2: Laboratory Experiments*. US Geological Survey Open-File Report 2010−1325B. <http://pubs.usgs.gov/of/2010/1325B/>

May, J.T., R.L. Hothem, C.N. Alpers and M.A. Law. 2000. *Mercury bioaccumulation in fish in a region affected by historic gold mining: The South Yuba River, Deer Creek and Bear River Watershed, California, 1999*. US Geological Survey Open-File Report 2000-367. <http://ca.water.usgs.gov/archive/reports/ofr00367/>

Mayer, K.E. and W.F. Laudenslayer, Jr., editors. 1988. *A Guide to Wildlife Habitats of California*. State of California, Resources Agency, Department of Fish and Game, Sacramento, CA. 166 pp.

Mazor, R.D., P. R. Ode, A. C. Rehn, M. Engeln, T. Boyle, E. Fintel, S. Verbrugge, and C. Yang.

2015. *The California Stream Condition Index (CSCI): Interim instructions for calculating scores using GIS and R.* SCCWRP Technical Report #883. SWAMP-SOP-2015-0004.

McFarland, S. 2015. *Acceptance and Environmental Review Process for State-Filed Water Right Application 5634x01 of Nevada Irrigation District to Appropriate Water from Bear River in Nevada County*. State Water Resources Control Board. Sacramento, CA. 22 Jan. 2015 <http://nidwater.com/wp-content/uploads/2014/08/SWRCB-Application-5634X01-Accepted.pdf>

Mileson, B. E., J. E. Chambers, W. L. Chen, W. Dettbarn, M. Enrich, A. T. Eldefrawi, D. W. Gaylor, K. Hamernik, E. Hodgson, A. G. Karczmar, S. Padilla, C. N. Pope, R. J. Richardson, D. R. Saunders, L. P. Sheets, L. G. Sultatos, and K. B. Wallace. 1998. Common Mechanism of Toxicity: A Case Study of Organophosphorus Pesticides. *Toxicological Sciences* 41:8–20.

Millar, C.I., M. Barbour, D. Elliott-Fisk**,** J.R. Shevock**,** and W. Woolfenden. 1996. *Significant Natural Areas*. In: D.C. Erman, ed. Sierra Nevada Ecosystem Project. Final Report to Congress, Vol. 2 Assessments and Scientific Basis for Management Options, Davis: Univ. of Calif., Centers for Water and Wildland Resources p.691-707.

Miller, J.D., and H.D. Safford. 2012. Trends in wildfire severity 1984-2010 in the Sierra Nevada, Modoc Plateau and southern Cascades, California, USA. *Fire Ecology* **8**: 41-57.

Moore, M.T., D.L. Denton, C.M. Cooper, J. Wrysinski, J.L. Miller, I. Werner, G. Horner, D. Crane, D.B. Holcomb, and G.M. Huddleston. 2010. Use of vegetated agricultural drainage ditches to decrease pesticide transport from tomato and alfalfa fields in California, USA. *Environmental Toxicology and Chemistry* **30(5)**: 1044-1049.

Moriarty, K.M., W.J. Zielinski, and E.D. Forsman. 2011. Decline in American Marten occupancy rates at Sagehen Experimental Forest, California. *Journal of Wildlife Management* **75(8)**: 1774-1787.

Moyle, P. B. 1973. Effects of introduced bullfrogs, *Rana catesbeiana*, on the native frogs of the San Joaquin Valley, California. *Copeia* **(1)**:18–22.

Muths, E. and P.S. Corn. 1997. Basking by adult boreal toads (*Bufo boreas boreas*) during the breeding season. *Journal of Herpetology* **31**:426–428.

MWH. 2007. *Western Placer County Groundwater Management Plan*. Placer County: Auburn, CA. Accessed March 2016 <http://www.water.ca.gov/groundwater/docs/GWMP/SR-33_WesternPlacerCounty_GWMP_2007.pdf>

National Marine Fisheries Service. 2005a. *Endangered and threatened species; Designation of critical habitat for seven evolutionarily significant units of Pacific salmon and steelhead in California*. National Oceanographic and Atmospheric Administration: Washington, DC <http://www.westcoast.fisheries.noaa.gov/publications/frn/2005/70fr52488.pdf>

National Marine Fisheries Service, 2005b. *Green Sturgeon (Acipenser medirostris) status review update*. National Oceanographic and Atmospheric Administration: Washington, DC

<http://www.nmfs.noaa.gov/pr/pdfs/statusreviews/greensturgeon_update.pdf>

National Marine Fisheries Service. 2014a. *Recovery Plan: For the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead*. NOAA California Central Valley Office. July 2014. Sacramento, CA. <http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/california_central_valley/final_recovery_plan_07-11-2014.pdf>

National Marine Fisheries Service. 2014b. *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead: Appendix A- Central Valley Watershed Profiles*. National Oceanographic and Atmospheric Administration: Washington, DC. <http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/california_central_valley/appendix_a_watershed_profiles_7102014.pdf>

National Marine Fisheries Service. 2014c. *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead: Appendix B- Threats Assessment for the Evolutionary Significant Units of Winter-run Chinook Salmon (Oncorhynchus tshawystscha) and Central Valley Spring-run Chinook Salmon (O. tshawytscha), and the Distinct Population Segment of Central Valley Steelhead (O. mykiss)*. National Oceanographic and Atmospheric Administration: Washington, DC <http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/california_central_valley/appendix_b_-threats_assessment_7-10-2014.pdf>

National Marine Fisheries Service. 2015. *Southern Distinct Population of the North American Green Sturgeon (Acipenser medirostris): 5-Year Review Summary and Evaluation*. National Oceanographic and Atmospheric Administration: Washington, DC <http://www.fisheries.noaa.gov/pr/listing/southern_dps_green_sturgeon_5-year_review_2015__2_.pdf>

National Oceanic and Atmospheric Administration. 2008. *Biological Opinion: Environmental Protection Agency Registration of Pesticides Containing Chlorpyrifos, Diazinon, and Malathion*. National Marine Fisheries Service Endangered Species Act Section 7 Consultation. <http://www.nmfs.noaa.gov/pr/pdfs/pesticide_biop.pdf>

National Oceanic and Atmospheric Administration. 2016. *Steelhead Trout* (*Oncorhynchus mykiss*). Washington, DC <http://www.fisheries.noaa.gov/pr/species/fish/steelhead-trout.html>

Natural Resources Conservation Service and Wildlife Habitat Council. 2000. *Fish and Wildlife Habitat Management Leaflet: Rainbow Trout (Oncorhynchus mykiss)*. US Fish and Wildlife Service: Washington, DC <http://www.fws.gov/northeast/wssnfh/pdfs/RAINBOW1.pdf>

NatureServe. 2013a. *Rhinichthys osculus*. The IUCN Red List of Threatened Species 2013: e.T62205A18231790. Accessed March 2016 <http://dx.doi.org/10.2305/IUCN.UK.2013-

1.RLTS.T62205A18231790.en>

NatureServe. 2013b. *Ptychocheilus grandis*. The IUCN Red List of Threatened Species 2013: e.T202358A18231558. Accessed March 2016 <http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T202358A18231558.en>

NatureServe. 2013c. *Lepomis cyanellus*. The IUCN Red List of Threatened Species 2013: e.T61248A18229074. Accessed March 2016 <http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T61248A18229074.en>

NatureServe. 2013d. *Pomoxis nigromaculatus*. The IUCN Red List of Threatened Species 2013: e.T202603A18236602. Accessed March 2016 <http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T202603A18236602.en>

NatureServe. 2015. *NatureServe Explorer: An online encyclopedia of life* [web application]. Version 7.1. NatureServe. Arlington, Virginia. Accessed Nov. 2015-March 2016. <http://explorer.natureserve.org>

Nevada County. 1995. *Nevada County General Plan*. Prepared with Harland Bartholomew and Associates Inc. Nevada County: Nevada City, CA <https://www.mynevadacounty.com/nc/cda/planning/docs/General%20Plan/Volume%201.%20Nevada%20County%20General%20Plan%20(1995%20with%202008%20and%202010%20updates)/Complete%20Document%20Nevada%20County%20General%20Plan%20Vol.%20I.pdf>

Nevada County. 2014. *Nevada County Demographic and Statistical Profile*. Accessed 20 Nov 2015. Nevada County Executive Office. <http://www.mynevadacounty.com/nc/bos/docs/Demographics%20Report%20FY%2013-14.pdf>

Nevada County. 2015a. *Blue Lead Mine*. My Nevada County Planning Department, Nevada City, CA. Accessed 30 Nov 2015. <http://www.mynevadacounty.com/nc/cda/planning/Pages/Blue-Lead-Mine.aspx>

Nevada County. 2015b. *Hansen Brothers Greenhorn Creek Mining Expansion*. My Nevada County Planning Department, Nevada City, CA. Accessed 1 Dec 2015. <http://www.mynevadacounty.com/nc/cda/planning/Pages/Hansen-Brother-Greenhorn-Creek-Mining-Expansion.aspx>

Nevada Irrigation District. 2009. *Combie Reservoir Sediment and Mercury Removal: A Water Supply Maintenance Project*. Project Description. Nevada Irrigation District. July 2009. Accessed 30 Nov 2015 <http://nidwater.com/wp-content/uploads/2012/04/Project_Description.pdf>

Nevada Irrigation District. 2010. Nevada Irrigation District's Yuba-Bear Hydroelectric Project Fact Sheet. Public Website for the Relicensing of NID's Yuba-Bear Hydroelectric Project, FERC Project No. 2266. Accessed 20 Jan 2016 <http://www.eurekasw.com/NID/default.aspx>

Nevada Irrigation District. 2012. *Amended Application for New License Major Project- Existing Dam:*

Amended Exhibits A, E & G. Yuba-Bear Hydroelectric Project. NID: Grass Valley, CA <http://www.eurekasw.com/NID/Final License Application/Yuba-Bear Amended License Application/2012-0618_PUBLIC YB Amended App pdf.pdf>

Nevada Irrigation District and Pacific Gas & Electric Company. 2010a. *Technical Memorandum 3-4: Fish Passage*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2010b. *Technical Memorandum 3-6: Special Status Amphibians Foothill Yellow-Legged Frog Surveys*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2010c. *Technical Memorandum 3-8: Special Status Amphibians Sierra Nevada Yellow-Legged Frog*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2010d. *Technical Memorandum 3-9: Special-Status Aquatic Reptiles, Western Pond Turtle*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2010e. *Technical Memorandum 3-10 Aquatic Macroinvertebrates.* Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2010f. *Technical Memorandum 7-1: ESA-Listed Amphibians - California Red-Legged Frogs*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2010g. *Technical Memorandum 3-1: Stream Fish Populations*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2010h. *Technical Memorandum 3-12: Reservoir Fish Populations*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2011a. *Technical Memorandum 1-1: Channel Morphology*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project. October 2011.

Nevada Irrigation District and Pacific Gas & Electric Company. 2011b. *Technical Memorandum 3-2: Instream Flow*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project. October 2011.

Nevada Irrigation District and Pacific Gas & Electric Company. 2011c. *Technical Memorandum 3-7: Special Status Amphibians Foothill Yellow-Legged Frog Habitat Modeling*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2011d. *Technical Memorandum 4-1: Special-status wildlife -- California wildlife habitat relationships*. Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2011e. *Technical Memorandum 6-1: Riparian Habitat. Yuba-Bear Hydroelectric Project and Drum-Spaulding Project.* Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

Nevada Irrigation District and Pacific Gas & Electric Company. 2011f. *Technical Memorandum 13-1: Native American Traditional Cultural Properties. Yuba-Bear Hydroelectric Project and Drum-Spaulding Project.* Prepared for the FERC Relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project.

NID- *see* Nevada Irrigation District

Nimis, P.L., C. Scheidegger, and P.A. Wolseley, eds. 2002. *Monitoring with lichens* . NATO Science Series. IV. Earth and Environmental Sciences, 7. The Netherlands: Dordrecht, Kluwer Academic Publishers.

Nisenan Tribe. 2009. *Nisenan Rancheria*. Nisenan of Northern California. <http://www.nevadacityrancheria.org/>

NOAA- *see* National Oceanographic and Atmospheric Administration

Norton J.B., L.J. Jungst, U. Norton, H.R. Olsen, K.W. Tate and W.R. Horwath. 2011. Soil carbon and nitrogen storage in upper montane riparian meadows. *Ecosystems* **14(8)**:1217–1231.

North, M., P. Stine, K. O'Hara, Z. William and S. Stephens. 2009. *Gen. Tech. Rep. PSW-GTR-220* (Second printing, with addendum). Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

NRCS- *see* Natural Resources Conservation Service

Null, S.E., J.H. Viers, and J.F. Mount. 2010. Hydrologic Response and Watershed Sensitivity to Climate Warming in California's Sierra Nevada. *PLoS ONE* **5(4)**.

OEHHA- *see* Office of Environmental Health Hazard Assessment

Office of Environmental Health Hazard Assessment. 2009. *Safe Eating Guidelines*. Oakland, CA. Accessed March 2016 <http://oehha.ca.gov/fish/so_cal/index.html>

Pacific Gas and Electric Company. 2010. *Pacific Gas and Electric Company Drum-Spaulding Project Fact Sheet*. Public Website for the Relicensing of PG&E's Drum-Spaulding Project, FERC Project No. 2310. Accessed 20 Jan 2016 <http://www.eurekasw.com/DS/default.aspx>

Pacific Gas & Electric Company. 2012. *Amended Application for New License Major Project- Existing Dam: Summary of Amended Application*. Drum-Spaulding Project. PG&E: San Francisco, CA

<http://www.eurekasw.com/DS/Final License Application/Drum-Spaulding Project - Amended Application/2012 - 0618 - PUBLIC_DS Amended Application.pdf>

Parks, D. 1999. *Ensatina eschscholtzii*. Accessed 1 Dec 2015. Available: <http://amphibiaweb.org/cgi/amphib_query?where-genus=Ensatina&where-species=eschscholtzii&account=amphibiaweb>

Patterson, B.D., G. Ceballos, W. Sechrest, M.F. Tognelli, T. Brooks, L. Luna, P. Ortega, I. Salazar, and B.E. Young. 2003. *Digital Distribution Maps of the Mammals of the Western Hemisphere, version 1.0.* NatureServe, Arlington, Virginia, USA.

PG&E- *see* Pacific Gas & Electric Company

Placer County. 2011. *Placer County Conservation Plan, Western Placer County: Appendix C*. Community Development Resources Agency. Auburn, CA. Accessed 4 Dec 2015. Available: <http://placer.ca.gov/~/media/cdr/Planning/PCCP/PolicyDoc2011/Appendix%20C.pdf>

Placer County. 2014a. *Placer County Conservation Plan*. County Planning Services Division. <http://www.placer.ca.gov/Departments/CommunityDevelopment/Planning/PCCP.aspx>

Placer County. 2014b. *Placer Legacy*. County Planning Services Division. http://www.placer.ca.gov/Departments/CommunityDevelopment/Planning/PlacerLegacy.aspx

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The Natural Flow Regime; a paradigm for river conservation and restoration. *American Institute for Biological Sciences* **47**:769-784.

Poole, G.C. and C.H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. *Environmental Management* **27**: 787-802.

Prichard, D., W. Hagenbuck, R. Krapf, R. Leinard, S. Leonard, M. Manning, C. Noble, and J. Staats. 1999. *Riparian area management - a user guide to assessing proper functioning condition and the supporting science for lentic areas*. Technical Reference 1737-16. USDI Bureau of Land Management. National Applied Resource Sciences Center. Denver, CO. p. 109

Purcell, A. H. (1985). *The ecology of bacterial and mycoplasma plant diseases spread by leafhoppers and planthoppers*. The Leafhoppers and Planthoppers. L. R. Nault and J. G. Rodriguez. New York, J. Wiley & Sons**:** 351-380.

Rachowicz, L. J., R.A. Knapp, J.A.T. Morgan, M.J. Stice, V.T. Vredenburg, J.M Parker, and C.J. Briggs. 2006. Emerging infectious disease as a proximate cause of amphibian mass mortality. *Ecology* **87**: 1671-1683.

Raney, T. 2008. *Notice of Preparation Scoping Meeting Date Change*. City of Wheatland Community Development: Wheatland, CA <http://co.yuba.ca.us/departments/BOS/documents/agendas/2008/MG59988/AS59994/AS60021/AS60030/AI60872/DO61041/DO_61041.PDF>

Rao, J. V. 2006. Toxic effects of novel organophosphorus insecticide (RPR-V) on certain biochemical parameters of euryhaline fish, *Oreochromis mossambicus. Pesticide Biochemistry and Physiology*. 86:78–84.

Rattner, B. A., and S. D. Michael. 1985. Organophosphorus insecticide induced decrease in plasma luteinizing hormone concentration in white-footed mice. *Toxicology Letters* 24:65–69.

Rattner, B. A., L. Sileo, and C. G. Scanes. 1982. Oviposition and the plasma concentration of LH, progesterone and corticosterone in bobwhite quail (*Colinus virginianus*) fed parathion. *Journal of Reproduction and Fertility* 66:147–155.

Rattner, B. A., and P. C. McGowan. 2007. Potential hazards of environmental contaminants to avifauna residing in the Chesapeake Bay estuary. *Waterbirds* 30:63–81.

Rehn, A.C. 2009. Benthic macroinvertebrates as indicators of biological condition below Hydropower Dams on west slope Sierra Nevada streams, California, USA. *River Research and Applications* **25 (2)**: 208-228.

Rehn, A.C., N. Von Ellenrieder, and P. R. Ode. 2007. *Assessment of Ecological Impacts of Hydropower Projects on Benthic Macroinvertebrate Assemblages: A Review of Existing Data Collected for FERC Relicensing Studies*. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-040.

Rehn, A.C., R.D. Mazor and P.R. Ode. 2015. *The California Stream Condition Index (CSCI): A New Statewide Biological Scoring Tool for Assessing the Health of Freshwater Streams*. Swamp Technical Memorandum SWAMP-TM-2015-0002.

Richards, A.B., and D.C. Rogers. 2011. *List of freshwater macroinvertebrate taxa from California and adjacent states including standard taxonomic effort levels*. Southwest Association of Freshwater Invertebrate Taxonomists. Chico, CA. Available from <http://www.safit.org>

River Partners. 2011. *Restoration Plan for the Dry Creek Riparian Area, Beale Air Force Base*. Yuba County, California. Prepared for Tulsa District, U.S. Army Corps of Engineers.

Roberts, D. K., N. J. Silvy, and E. M. Bailey, Jr. 1988. Brain acetylcholinesterase activity recovery following acute methyl parathion intoxication in two feral rodent species: Comparison to laboratory rodents. *Bulletin of Environmental Contamination and Toxicology* 41:26–35. Cited in Grue *et al*. 1997.

Rogers, D. C. and A.B. Richards. 2006. *Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) Rules for the Development and Maintenance of the Standard Level of Taxonomic Effort*. On-line publication. 165 pp.

Romansic, J. 1999. *Batrachoseps attenuatus*. Accessed 1 Dec 2015. <http://amphibiaweb.org/cgi/amphib_query?where-genus=Batrachoseps&where-

species=attenuatus>

Rood, S.B., G.M. Samuelson, J.H. Braatne, and C.R. Gourley. 2005. Managing River Flows to Restore Floodplain Forests. *Frontiers in Ecology and the Environment* **3 (4)**: 193-201.

Russell, R. W., and D. H. Overstreet. 1987. Mechanisms underlying sensitivity to organophosphorus anticholinesterase compounds. *Progress in Neurobiology* 28:97–129.

Sacramento Valley Water Quality Coalition. 2006-2008. *Annual Monitoring Reports of Diazinon Runoff Management Plan for Orchard Growers in the Sacramento Valley*. California Water Board. Sacramento, CA. http://www.waterboards.ca.gov/water_issues/programs/tmdl/records/region_5/2008/ref2871.zip

Sacramento Valley Water Quality Coalition. 2009. *Stormwater Quality Improvement Plan*. California Water Board. Sacramento, CA. <http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2010-0017_2009sqip.pdf>

Saiki, M.K., B.A. Martin, T.W. May, and C.N. Alpers. 2010. Mercury concentrations in fish from a Sierra Nevada foothill reservoir located downstream form historic gold mining operations. *Environmental Monitoring and Assessment* **163 (1):** 313-326.

Sancho, E., J. J. Ceron, and M. D. Ferrando. 2000. Cholinesterase Activity and Hematological Parameters as Biomarkers of Sublethal Molinate Exposure in *Anguilla anguilla. Ecotoxicology and Environmental Safety* 46:81–86.

Schuytema, G.S. and A.V. Nebeker. 1999a. Comparative toxicity of ammonium and nitrate compounds to Pacific treefrog and African clawed frog tadpoles. *Environmental Toxicology and Chemistry* **18**: 2251–2257.

Schuytema, G.S. and A.V. Nebeker. 1999b. Effects of ammonium nitrate, sodium nitrate, and urea on red-legged frogs, Pacific treefrogs, and African clawed frogs. *Bulletin of Environmental Contamination and Toxicology* **63**: 357–364.

Sacramento River Watershed Program. 2016. *Bear River Watershed*. Accessed 9 Jan 2016. <http://sacriver.org/aboutwatershed/roadmap/watersheds/american/bear-river-watershed>

Seesholtz, A. 2011. *Attachment A: Lower Feather River Sturgeon Information*. State Water Resources Control Board: Sacramento, CA <http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/oroville_ferc2100/oro_petition_attch.pdf>

Shilling, F., and E. Girvetz. 2003. *Bear River Watershed: Disturbance Inventory and Spatial Data Encyclopedia*. University of California, Davis, CA.

Sidell, F. R. 1994. Clinical effects of organophosphorus cholinesterase inhibitors. *Journal of*

Applied Toxicology 14:111–113.

Sierra Fund. 2008. *Mining's Toxic Legacy: An Initiative to Address Mining Toxins in the Sierra Nevada*. Published by The Sierra Fund: Nevada City CA, March 2008.

Sierra Nevada Red Fox Interagency Working Group (SNRFIWG). 2010. *Sierra Nevada Red Fox fact sheet*. <http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5282562.pdf>

Sierra Streams Institute. 2011. The Deer Creek Watershed Restoration Plan. Sierra Streams Institute/Friends of Deer Creek. Nevada City, CA. <http://www.sierrastreamsinstitute.org/documents/DeerCreekRestorationPlan2011.pdf>

Sierra Streams Institute. 2012. *Recommendations to Reduce Impacts from Legacy Mercury Contamination in the Deer Creek Watershed. Sierra Streams Institute/Friends of Deer Creek*. Sierra Nevada Conservancy Grant Program Final Report: Mercury Bioavailability and Transport in Deer Creek over Lake Wildwood Reservoir. Nevada City, CA.

Slotton, D.G., S.M. Ayers, J.E. Reuter, and C.R. Goldman. 1995. *Gold mining impacts on food chain mercury in northwestern Sierra Nevada streams*. University of California Water Resources Center. Technical Completion Report W-816.

South Sutter Water District. 2009. *Groundwater Management Plan*. South Sutter Water District: Trowbridge, CA. Accessed March 2016 <http://www.water.ca.gov/groundwater/docs/GWMP/SR-28_SouthSutterWD_GWMP_2009.pdf>

South Sutter Water District. 2016. *Existing and Proposed Project*. Pre-Application Documents, Section 2. Camp Far West Hydroelectric Project (FERC No. 2997). <http://sswdrelicensing.com/home/documents/relicensing-docs/>

SSWD- *see* South Sutter Water District

State Water Resources Control Board. 2008. *Chemical Hotspot Legend*. GeoTracker Gama: Groundwater Ambient Monitoring and Assessment. Available: <http://geotracker.waterboards.ca.gov/gama/gamamap/public/chemical_hotspots.asp>

State Water Resources Control Board. 2015. *Fully Appropriated Streams*. California Environmental Protection Agency. Sacramento, CA http://www.waterboards.ca.gov/waterrights/water_issues/programs/fully_appropriated_streams

State Water Resources Control Board. 2016. *eWRIMS- Electronic Water Rights Information Management System*. California Environmental Protection Agency. Sacramento, CA <http://www.waterboards.ca.gov/waterrights/water_issues/programs/ewrims/>

Stebbins, R.C. 1951. *Amphibians of Western North America*. University of California Press, Berkeley, California.

Steding, D. J. and A. R. Flegal. 2002. Mercury concentrations in coastal California precipitation:

evidence of local and trans-Pacific fluxes of mercury to North America. *Journal of Geophysical Research* **107 (24)**: 4764.

Stevens, J.T., H.D. Safford, and A.M. Latimer. 2014. Wildfire-contingent effects of fuel treatments can promote ecological resilience in seasonally dry conifer forests. *Canadian Journal of Forest Research* **44(8)**:843-854.

Stewart, I.T., D.R. Cayan, and M.D. Dettinger. 2004. Changes in Snowmelt Runoff Timing in Western North American under a 'Business as Usual' Climate Change Scenario. *Climatic Change* **62**: 217-232.

Storer, T.I. 1925. *A synopsis of the Amphibia of California*. University of California Publications in Zoology, Number 27, Berkeley, California.

Strohm, K. H., R. Unger, and T. Walker. 2007. *Partners in Restoration and Agriculture: Colusa Subreach Pest and Regulatory Effects Study*. Prepared by EDAW for the Nature Conservancy.

Stromborg, K. L. 1981. Reproductive tests of diazinon on bobwhite quail. *In* D.W. Lamb and E. E. Kenaga (eds.), *Avian and Mammalian Wildlife Toxicology: Second Conference*, pp. 19–30. American Society for Testing and Materials, Philadelphia, PA. Cited in Grue *et al*. 1997.

Sullivan, B.L., C.L. Wood, M.J. Iliff, R.E. Bonney, D. Fink, and S. Kelling. 2009. eBird: a citizen-based bird observation network in the biological sciences. *Biological Conservation* **142**: 2282-2292.

Sultatos, L. G. 1994. Mammalian toxicology of organophosphorus pesticides. *Journal of Toxicology and Environmental Health* 43:271–289.

Sutter County. 2014. *2014 Crop and Livestock Report*. Sutter County Agricultural Department. Yuba City, CA <https://www.co.sutter.ca.us/pdf/ag/CropReports/2014_Crop_Report.pdf>

Svoboda, M., V. Luskova, J. Drastihova, and V. Zlabek. 2001. The effect of diazinon on haematological indces of common carp (*Cyprinus carpio*). *Acta Veterinaria Brno* 70:457–465.

SVWQC- *see* Sacramento Valley Water Quality Coalition

Thompson, L. C., S. A. Cocherell, S. N. Chun, J. J. Cech, Jr., and A. P. Klimley. 2011. Longitudinal movement of fish in response to a single-day flow pulse. Environ Biol Fish **90(3)**:253-261. DOI: 10.1007/s10641-010-9738-2

Tierney T.A and J.H. Cushman. 2006. Temporal changes in native and exotic vegetation and soil characteristics following disturbances by feral pigs in a California grassland. *Biological Invasions* **8**: 1073–1089.

Tilman, D. 1999. Global environmental impacts of agricultural expansion: The need for sustainable and efficient practices. *Proceedings of the National Academy of Sciences* **96 (11)**: 5995-6000.

Timossi, I. C., E. L. Woodard, and R. H. Barrett. 1995. Habitat suitability models for use with ARC/INFO: Snowshoe hare. *CWHR Tech. Report No. 20.* California Department of Fish and Game, California Wildlife Habitat Relationships Program, Sacramento, CA.

Trautmann, N.M., K.S. Porter, and R.J. Wagenet 2012. *Modern Agriculture: Its Effects on the Environment*. Pesticide Safety Education Program Fact Sheet. Natural Resources Cornell Cooperative Extension. Ithaca, NY. <http://psep.cce.cornell.edu/facts-slides-self/facts/mod-ag-grw85.aspx>

Tunstall, T. and G. Fellers. 1999. *Rana draytonii: California Red-Legged Frog*. Accesssed 1 Dec 2015. <http://amphibiaweb.org/cgi/amphib_query?where-genus=Rana&where-species=draytonii&account=amphibiaweb>

UC Davis. 2010. *California augmented multipurpose land cover map* [web application]. UC Davis Information Center for the Environment. Davis, CA. <http://www.californialcc.org/news/new-hosted-dataset-california-augmented-multisource-landcover-map>

UCDANR- *see* University of California Division of Agriculture and Natural Resources

University of California, Division of Agriculture and Natural Resources. 2016. *California Fish Species*. University of California: Davis, CA. Accessed March 2016 <http://calfish.ucdavis.edu/>

U.S. Census. 2010. *United States Census 2010*. U.S. Census Bureau: Suitland, MD < http://www.census.gov/2010census/>

U.S. Department of Agriculture. 2014. *CropSpace* [web application]. US Department of Agriculture National Agricultural Statistics Service. Accessed Feb 2016. <http://www.nass.usda.gov/Research_and_Science/Cropland/sarsfaqs2.php - Section1_1.0>

U.S. Environmental Protection Agency. 1986. *Quality Criteria for Water* [The Gold Book]. <http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/upload/2009_01_13_criteria_goldbook.pdf>

U.S. Environmental Protection Agency. 1988. *Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria*. <http://nepis.epa.gov/Exe/ZyNET.exe/00001NC8.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1986+Thru+1990&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=h>

U.S. Environmental Protection Agency. 2000. *Polar Star Mine Tunnel: US EPA Removal Action Field World to start in May*. EPA Region 9. Apr 2000. Accessed 30 Nov 2015. <http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/328d45149e0f867f882574260072fae2/9ce016c9e7f7b50f882570070063c2e3/$FILE/PolarStar4_00.pdf>

U.S. Environmental Protection Agency. 2007. *Control of diazinon and chlorpyrifos runoff into the Sacramento and Feather Rivers*. Resolution No. R5-2007-0034.

<http://www.swrcb.ca.gov/centralvalley/board_decisions/adopted_orders/resolutions/r5-2007-0034.pdf>

U.S. Environmental Protection Agency. 2015. *Proposal to Revoke Chlorpyrifos Food Residue Tolerances*. <http://www.epa.gov/ingredients-used-pesticide-products/proposal-revoke-chlorpyrifos-food-residue-tolerances>

U.S. Environmental Protection Agency. 2016a. *EnviroAtlas*. US Environmental Protection Agency. Washington, DC <https://www.epa.gov/enviroatlas>

U.S. Environmental Protection Agency. 2016b. Implementing the Clean Water Act Section 303(d): Impaired Water Loads (TMDLs). US Environmental Protection Agency. <http://www.epa.gov/tmdl>

U.S. Fish and Wildlife Service. 2000. *Draft recovery plan for the California red-legged frog (Rana aurora draytonii).* Portland, OR.

U.S. Fish and Wildlife Service. 2005. *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon*. Portland, OR. http://www.fws.gov/sacramento/ES/Recovery-Planning/Vernal-Pool/es_recovery_vernal-pool-recovery.htm

U.S. Fish and Wildlife Service. 2014a. *Identification of the instream flow requirements for anadromous fish in the streams within the Central Valley of California and fisheries investigations: Annual progress report, fiscal year 2014* <http://www.fws.gov/lodi/instream-flow/Documents/CVPIA_Annual_Progress_Report_Fiscal_Year_2014.pdf>

U.S. Fish and Wildlife Service. 2014b. Endangered and Threatened Wildlife and Plants; Withdrawal of the Proposed Rule to Remove the Valley Elderberry Longhorn Beetle From the Federal List of Endangered and Threatened Wildlife. *Federal Register* Vol. 79, No. 180, Pages 55874-55917. 50 CFR Part 17. September 17, 2014. Docket No. FWS–R8–ES–2011–0063; FXES11130900000C2–123–FF09E32000. RIN 1018–AV29. https://www.gpo.gov/fdsys/pkg/FR-2014-09-17/pdf/2014-21585.pdf

U.S. Forest Service. 2009. *Species Fact Sheet*: *Deschutes sideband*. Accessed 3 Dec 2015. <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=0ahUKEwjXwvDfrsDJAhVujoMKHSpLAZkQFghAMAc&url=http%3A%2F%2Fwww.fs.fed.us%2Fr6%2Fsfpnw%2Fissssp%2Fdocuments%2Fplanning-docs%2Fsfs-ig-monadenia-fidelis-ssp-nov-deschutes-2010-05.doc&usg=AFQjCNHlNmx12r-RQR8QaNrlQ2A9LVt6GQ>

U.S. Geological Survey. 2002. *Glacial Ice Cores Reveal a Record of Natural and Anthropogenic Atmospheric Mercury Deposition for the Last 270 Years*. US Geological Survey Fact Sheet FS-051-02. <http://toxics.usgs.gov/pubs/FS-051-02/pdf/fs-051-02.pdf>

U.S. Geological Survey. 2015. *Yuba and Bear Rivers Study Unit- Shallow Assessment*. California Water Science Center. <http://ca.water.usgs.gov/projects/gama/SU_shallow/yubear.htm>

USDA- *see* U.S. Department of Agriculture

USEPA- *see* U.S. Environmental Protection Agency

USGS- *see* U.S. Geological Survey

van der Veen, J. *Water Monitoring Quality Assurance Project Plan for the Yuba Watershed Council Monitoring Committee*. Revision 1, November 12, 2003.

van Wagtendonk, L. 2013. *System Indicators: Agricultural Lands and Ranches*. Sierra Nevada Conservancy. Auburn, CA. <http://www.sierranevada.ca.gov/our-region/sys_ind_docs/SystemIndicatorsAgLandsRanches.pdf>

Viers, J.H., S.E. Purdy, R.A. Peek, A. Fryjoff-Hung, N.R. Santos, J.V.E. Katz, J.D. Emmons, D.V. Dolan, and S.M. Yarnell. 2013. *Montane Meadows in the Sierra Nevada: Changing Hydroclimatic Conditions and Concepts for Vulnerability Assessment*. Center for Watershed Sciences Technical Report (CWS-2013-01), University of California, Davis.

Vredenburg, V.T. 2007. *Rana Sierrae: Sierra Nevada Yellow-Legged Frog*. AmphibiaWeb: Information on amphibian biology and conservation. [web application]. 2015. Berkeley, California: AmphibiaWeb. Accessed Dec 2015. <http://amphibiaweb.org/cgi/amphib_query?where-genus=Rana&where-species=sierrae>

Vredenburg, V. T., R. Bingham, R. Knapp, J.A.T. Morgan, C. Moritz, and D. Wake. 2007. Concordant molecular and phenotypic data delineate new taxonomy and conservation priorities for the endangered mountain yellow-legged frog (Ranidae: Rana muscosa). *Journal of Zoology* **271**: 361-374.

Walker P., S. Marvin, and L. Fortmann. 2003. Landscape changes in Nevada County reflect social and ecological transitions. *Cal Ag* **57(4)**:115-121.

Water Education Foundation. 2011. *Looking to the Source: Watersheds of the Sierra Nevada*. Prepared for Sierra Nevada Conservancy: Auburn, CA. <http://www.sierranevada.ca.gov/our-region/docs/waterreport.pdf>

Weiss-Penzias, P.S., D.A. Gay, M.E. Brigham, M.T. Parsons, M.S. Gustin, and A. ter Schure. 2016. Trends in mercury wet deposition and mercury air concentrations across the US and Canada. *Science of the Total Environment*. In Press.

Westerling A.L. and B.P. Bryant. 2008. Climate change and wildfire in California. *Climate Change* **87**:231–249. <http://dx.doi.org/10.1007/s10584-007-9363-z>

Witham, C. W., E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Editors). 1998. *Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference*. California Native Plant Society: Sacramento, CA. 1998.

WHC- *see* Wildlife Habitat Council

Wolf Creek Community Alliance. 2013. *Wolf Creek Water-Quality Monitoring Data Analysis 2004-2012.* Wolf Creek Community Alliance Monitoring Program. Accessed 8 Mar 2016. <http://www.wolfcreekalliance.org/documents/MonitoringDataSummaryFinal.pdf>

YCWA- *see* Yuba County Water Agency

Yoshiyama, R.M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. *Contributions to the Biology of Central Valley Salmonids, Fish Bulletin* **179**: 71-176.

Yuba County. 1994. *General Plan*. Yuba County Department of Planning and Building Services: Marysville, CA <http://www.co.yuba.ca.us/departments/community%20development/planning/documents/General%20Plan/1996/Volume%20I/YC%20Gen%20Plan%20-%20Cover%20&%20Table%20of%20Contents.pdf>

Yuba County Water Agency. 2010. *Groundwater Management Plan*. Yuba County Water Agency: Marysville, CA. Accessed March 2016 <http://www.water.ca.gov/groundwater/docs/GWMP/SR-36_YubaCountyWA_GWMP_2010.pdf>

VI. Acronyms

Acronym	Definition	Description
ac-ft	Acre Feet	Unit of measure for water volume defined as the volume of one acre of surface area to a depth of one foot
BLM	Bureau of Land Management	Department of the Interior agency, formed in 1946, that administers public lands in the US and the federal government's subsurface mineral estate
BMI	Benthic Macroinvertebrate	Organisms without backbones that are big enough to be seen with the naked eye and spent at least part of their lives in or on the bottom of a body of water
CABY	Cosumnes, American, Bear, Yuba	A cooperative planning effort aimed at bringing diverse stakeholders together. Currently more than 30 member organizations. Serves as a vehicle for bringing funding into the region.
Cal EPA	California Environmental protection Agency	Cabinet level state agency, formed in 1991, with the mission to restore, protect, and enhance the environment and ensure public health, environmental quality and economic vitality
CALPIP	California Pesticide Information Portal	Database of the California Department of Pesticide Regulation that provides public access to the department's pesticide use and label information, Groundwater Protection Area information, and Pesticide Regulation's Endangered Species Custom Real-time Internet Bulletin Engine
CASGEM	California Statewide Groundwater Elevation Monitoring	Monitoring program established by the state legislature that requires local agencies to monitor the elevation of their groundwater basins to help better manage the resource
CDEC	California Data Exchange Center	Online database of the California Department of Water Resources that installs, maintains and operates the state's hydrologic data collection network and provides a centralized location for hydrologic information gathered by various cooperators in the state
CDFG	California Department of Fish and Game	**See* CDFW
CDFW	California Department of Fish and Wildlife	Department within the California Natural Resources Agency, formed in 1909 as the California Department of Fish and Game (CDFG), that manages and protects the state's fish, wildlife, plant resources and native habitats.
CDPR	California Department of Pesticide Regulation	Department within the California Environmental Protection Agency with the mission to protect human and environmental health by regulating pesticide sales and use and educating landowners on pesticide management
CESA	California Endangered Species Act	Law enacted by the state in 1970 to protect and conserve endangered species and their environments; currently lists 49 animals and 132 land plant species as endangered

Acronym	Definition	Description
cfs	Cubic feet per second	Unit of measure expressing the rate of discharge of flow of water; equal to the discharge through a one-foot cross section at a rate of one foot per second
CNDDB	California Natural Diversity Database	Online database of the Department of Fish and Wildlife's Habitat Conservation Planning Division that inventories the locations of the state's rarest species and natural communities
CNPS	California Native Plant Society	California-based environmental non-profit that seeks to increase understanding of the state's native flora and protect it for future generations
CRMP	Coordinated Resources Management Plan	A plan created by a consensus decision-making process
CRWQCB	California Regional Water Quality Control Board	Nine semi-autonomous bodies of the State Water Resource Control Board, created in 1949 that are responsible for protecting the surface, ground and coastal waters of their region
CWD	Coarse Woody Debris	Term used for fallen dead trees and the remains of large branches on the ground in forests, rivers or wetlands
CWHR	California Wildlife Habitat Relationships	Information system that contains life history, geographic range, habitat relationships and management information of 712 species known to occur in California
DO	Dissolved Oxygen	The microscopic bubbles of gaseous oxygen that are mixed in water and available to aquatic organisms whose concentrations serves as important indicator of water quality
DEM	Digital Elevation Model	Digital model or 3D representation of a terrain's surface created from elevation data
DPS	Distinct Population Segment	Smallest division of a taxonomic species permitted to be protected under the Endangered Species Act
DWR	California Department of Water Resources	Department within the California Natural Resources Agency, formed in 1956, that is responsible for the state's management and regulation of water usage
EPA	Environmental Protection Agency	Agency of the federal government created in 1970 to protect human health and the environment by writing and enforcing environmental regulations
EPT	Ephemeroptera, Plecoptera, and Trichoptera	A group of stream insect orders that tend to be more sensitive to the effects of pollutants in the water system; Ephemeroptera are mayflies, plecoptera are stoneflies and trichoptera are caddisflies
ESA	Federal Endangered Species Act	1973 legislation that serves to carry out the provisions of The Convention on International Trade in Endangered Species of Wild Fauna and Flora
FDA	US Food and Drug Administration	Federal agency in the Department of Health and Human Services that is responsible for protecting and promoting public health through the regulation of food safety, among other things
FERC	Federal Energy Regulatory Commission	The federal agency with jurisdiction over the licensing of hydropower dams

Acronym	Definition	Description
FFDOCKET	Federal Facility Hazardous Waste Compliance Docket	Document that contains information reported to the EPA by federal facilities that manage hazardous waste or form which hazardous substances, pollutants or contaminants may be been released
FOS	Friends of Spenceville	Non-profit formed to help preserve and educate the public about the Spencville Wildlife Area
FRAP	Fire and Resources Assessment Program	Program of the California legislature that has required CALFIRE to produce periodic assessments of the forests and rangelands of California since the 1970s
GAMA	Groundwater Ambient Monitoring & Assessment	Program of the State Water Resources Control Board that provides data, information and tools to enable assessment of groundwater quality and quantity
GIS	Geographic Information System	Computational system designed to capture, store, manipulate, analyze, manage and present all types of spatial or geographical data
GWPA	Groundwater Protection Area	One-square mile areas of land sensitive to the movement of pesticides, where pesticide use is restricted, established by the Department of Pesticide Regulation
GSA	Groundwater Sustainability Agency	Local agencies created under the Sustainable Groundwater Management Act that have the responsibility of assessing conditions in their water basins and adopting locally-based management plans within 20 years
HUC	Hydrologic Unit Code	Unique code to identify hydrologic features consisting of two to eight digits based on the four levels of classification in the hydrologic unit system of the USGS
IBI	Index of Biotic Integrity	Scientific tool used to identify and classify water pollution programs that associated anthropogenic influences and biological activity in a water body
ILRP	Irrigated Lands Regulatory Program	Program of the State Wate Resources Control Board, established in 2003, to control and assess the effects of discharges from irrigated agricultural lands
IRWMP	Integrated Regional Water Management Plan	A comprehensive planning document to encourage regional strategies for management of water resources.
IUCN	International Union for Conservation of Nature	International organization, founded in 1948, with the goal of influencing, encouraging and assisting society to conserve nature and the sustainable use of natural resources
LCC	Landscape Conservation Cooperative	Applied conservation science partnerships which promote collaboration and provide the science and technical expertise needed to support conservation planning at landscape scales – beyond the reach or resources of any one organization.
MAS/MILS	Minerals Availability System/Mineral Industry Location System	Database begun in the 1960s by the US Bureau of Mines that classifies mineral resources according to their extraction technologies, economics and commercial availability

Acronym	Definition	Description
MMI	Multi-metric Index	Index of biotic integrity that integrates an array of metrics that each provide different information on a biological attribute
MRDS	Mineral Resources Data System	USGS Mining Database, with data from other agencies, containing information on mine name, location, deposit type, mineral age, commodities and local tectonics
NCCP	Natural Community Conservation Plan	Program of the California Department of Fish and Wildlife that encourages broad-based ecosystem approaches to planning for the protection of biological diversity
NCRCD	Nevada County Resource Conservation District	Local resource conservation non-profit mandated by the California Public Resources Code to promote responsible resource management in Nevada County
NHD	National Hydrography Dataset	Digital GIS dataset operated by the USGS that contains hydrographic features, designed for general mapping and the analysis of surface water systems
NID	Nevada Irrigation District	Independent agency, formed in 1921, that provides water for much of Nevada County and portions of Placer and Yuba County for irrigation, municipal and domestic purposes
NOAA	National Oceanographic and Atmospheric Administration	Scientific agency within the US Department of Commerce that assesses, monitors, predicts, and educates the public about the conditions of the ocean and atmosphere
NPDES	National Pollutant Discharge Elimination System	Permit system within the Clean Water Act for regulating point sources of pollution into surface waters
NRCS	National Resources Conservation Service	Agency within the US Department of Agriculture, founded in 1932 as the Soil Conservation Service, that provides technical assistance to farmers and landowners to protect natural resources on private lands
NWIS	National Water Information System	Database designed to make USGS water data publically available
OEHHA	California Office of Environmental Health Hazard Assessment	Specialized department within the California Environmental Protection Agency that is responsible for evaluating health risks from environmental chemical contaminants
PAMP	Principle Areas of Mine Pollution	California Department of Conservation Database of mining operations in CA and their potential water quality problems
PCCP	Placer County Conservation Plan	County-proposed solution to coordinate and streamline the permitting process for local entities that serves as the county Habitat Conservation Plan under the Endangered Species Act
PCPA	Pesticide Contamination Prevention Act	California law enacted in 1985 designed to prevent further pesticide pollution of groundwater aquifers
PCWA	Placer County Water Agency	Primary water resource agency for Placer County that supplies irrigation an drinking water and hydroelectric energy

Acronym	Definition	Description
PG&E	Pacific Gas and Electric Company	Utility company, founded in 1905, that provides natural gas and electricity to most of the northern two-thirds of California
QAPP	Quality Assurance Project Plan	A document that outlines the procedures that those who conduct a monitoring project will take to ensure that the data they collect and analyze meets project requirements
SGMA	Sustainable Groundwater Management Act	State legislation passed in 2014 that provides a framework for the sustainable management of groundwater supplies by local authories
SNRF	Sierra Nevada Red Fox	*Vulpes vulpes necator*; Subspecies of red fox, also known as the High Sierra fox, and likely one of the most endangered mammals in North America
SSI	Sierra Streams Institute	A non-profit organization dedicated to promoting community stewardship and scientific knowledge of Sierra watersheds through monitoring, research, restoration, and education.
SSWD	South Sutter Water District	Primary water agency for south Sutter County, formed in 1954, that develops, stores and distributes surface and groundwater to western Placer and southern Sutter counties.
SWAMP	Surface Water Ambient Monitoring Program	The monitoring program of the CA State Water Resources Control Board. Conducts monitoring directly and through collaborative partnerships
TEK	Traditional Ecological Knowledge	Indigenous knowledge regarding management and sustainability of local resources.
TIGER	Topologically Integrated Geographic Encoding and Referencing	System used by the US Census Bureau to describe land attributes and census tracts in geospatial data
TMDL	Total Maximum Daily Load	Regulatory concept from the Clean Water Act, describing a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards
TNF	Tahoe National Forest	US National Forest located northwest of Lake Tahoe, operated by the US Forest Service, located in parts of six counties including Placer, Nevada and Yuba counties
TRI	Toxic Release Inventory	Publically available database developed by the EPA, containing information on toxic chemical releases and other waste management activities in the US
USDA	United States Department of Agriculture	US federal executive department responsible for developing and executing government policy on farming, agriculture, forestry and food
USEPA	United States Environmental Protection Agency	**See* EPA

Acronym	Definition	Description
USFS	United States Forest Service	Federal agency within the US Department of Agriculture, formed in 1905, with the mission of sustaining the health, diversity and productivity of public forests and grasslands
USFWS	United States Fish and Wildlife Service	Federal agency within the US Department of Interior, formed in 1940, dedicated to the management of fish, wildlife and their natural habitats
USGS	United States Geological Survey	Scientific agency, without regulatory responsibility, within the Department of the Interior that studies the landscape and natural resources of the country and the natural hazards that threaten it
WAF	Watershed Assessment Framework	Method of reporting on key indicators of watershed health over time to guide watershed management, outlined in the 2006 California Watershed Action Plan
WBD	Watershed Boundary Dataset	Digital GIS dataset operated by the USGS that defines the areal extent of surface water drainages and identifies them by a unique Hydrologic Unit Code
WCCA	Wolf Creek Community Alliance	A volunteer-run nonprofit based in Grass Valley, CA with the mission of protecting, enhancing and restoring Wolf Creek and its tributaries
WHIPPET	Weed Heuristics: Invasive Population Prioritization for Eradication Tool	Online database produced by the California Invasive Plant Council that prioritizes weed infestations for eradication based on potential impact, potential spread and feasibility of control
WPT	Western Pond Turtle	*Emys marmorata*; small to medium sized turtle, also known as the Pacific pond turtle, found only on the west coast of the US and Mexico, having been extirpated in Canada
YBDS	Yuba Bear Drum Spaulding	Joint relicensing program through FERC of NID’s Yuba-Bear and PG&E’s Drum-Spaulding Hydroelectric projects
YCWA	Yuba County Water Agency	Public agency, established in 1959 with the primary functions of developing and selling hydroelectric power, flood control, storage and supply of water, recreation and conservation.

VII. Data Dictionary

This table below identifies the source of the GIS data for each layer used to create the maps within this document.

Data	Source
Wetlands	USFWS National Wetlands Inventory
Groundwater Wells	DWR CASGEM and California Water Data Library
Historical groundwater elevation changes	DWR, 2014a [Summary of Recent, Historical and Estimated Potential for Future Land Subsidence in California]
Plant communities	CDFW Vegetation Datasets
CNDDB	CDFW Biogeographic Data Branch
Invasive Species	Cal-IPC WHIPPET
Sudden Oak Death	Garbelotto and Barbosa, 2014
County Lines	US Census Bureau
Cover maps	ArcGIS National Geographic/USA Topo base maps
Watershed Boundary	USGS Watershed Boundary Dataset
Land Cover and Crops	USDA National Agricultural Statistics Service CropScape
Subwatersheds	USGS Watershed Boundary Dataset, USDA National Resources Conservation Service
Hydrography	USGS National Hydrography Dataset
Topography/Elevation	USGS National Atlas Small Data Sets
Slopes	Contour data taken from individual county websites
Soils	USDA National Resources Conservation Service Web Soil Survey
Groundwater quality	Water Board Geotracker GAMA
Monitoring Stations	USGS National Water Information System, California Data Exchange Center, National Weather Service
Dams and Diversions	CDFW Fish Passage Dataset, 2003 Inventory (CDWR)
Mines	USGS Mineral Resources Data System
PAMP Mines	CA Department of Conservation
Toxics Release Inventory, NPDES, FFDOCKET	EPA
Census Boundaries	US Census Bureau
Human Population	US Census Bureau
Population and housing	US Census Bureau
Parcels/Zoning	Individual county websites
Military Lands	Office of the Assistant Secretary of Defense
Other land ownership	Already available on server
Railways	California Rail Network
Roads	US Census Bureau, National Highway System, Individual county websites
Trails	Individual county websites

VIII. Appendix

A. List of Soil Classification Descriptions and County-Specific Unit IDs

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Ahwahnee sandy loam, 2 to 9 percent slopes	Ahw1	AdB				
Ahwahnee sandy loam, 9 to 15 percent slopes	Ahw1	AdC				
Ahwahnee sandy loam, 15 to 30 percent slopes	Ahw2	AdD				
Ahwahnee-Rock outcrop complex, 15 to 30 percent slopes	AhwRo 1	AeD				
Ahwahnee-Rock outcrop complex, 30 to 50 percent slopes	AhwRo 2	AeE				
Aiken loam, 2 to 9 percent slopes	Ai1	AfB	100			
Aiken loam, 9 to 15 percent slopes	Ai1	AfC				
Aiken loam, 15 to 30 percent slopes	Ai2	AfD				
Aiken loam, 30 to 50 percent slopes	Ai3	AfE				
Aiken cobbly loam, 2 to 30 percent slopes	AiC1	AgD	102			
Aiken cobbly loam, 30 to 50 percent slopes	AiC2	AgE				
Alamo variant clay, 2 to 15 percent slopes	Ala		105			
Alluvial land, loamy	AllL	Am				
Alluvial land, clayey	AllC	Ao				
Andregg coarse sandy loam, 2 to 9 percent slopes	And		106			
Andregg coarse sandy loam, 9 to 15 percent slopes	And		107			

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Andregg-Shenandoah complex, 2 to 15 percent slopes	AndSh		113			
Aquolls and Borolls, 0 to 5 percent slopes	Aq				AQB	
Argonaut gravelly loam, 2 to 15 percent slopes	ArG	ArC				
Argonaut-Auburn complex, 3 to 8 percent slopes	ArAu1	102				102
Argonaut-Auburn complex, 8 to 15 percent slopes	ArAu1					103
Argonaut-Auburn complex, 15 to 30 percent slopes	ArAu2					104
Argonaut-Rock outcrop complex, 2 to 30 percent slopes	ArRo	AsD				
Auberry sandy loam, 5 to 15 percent slopes	Aub	AtC				
Auberry-Rock outcrop complex, 15 to 30 percent slopes	AubRo1	AuD				
Auberry-Rock outcrop complex, 30 to 50 percent slopes	AubRo2	AuE				
Auburn loam, 2 to 15 percent slopes	Au1	AvD	114			106
Auburn loam, 2 to 15 percent slopes	Au1	AvD	114			107
Auburn loam, 15 to 30 percent slopes	Au2	108				108
Auburn loam, 30 to 50 percent slopes	Au3					109
Auburn-Sobrante complex, 3 to 8 percent slopes	AuSo1					110
Auburn-Sobrante complex, 8 to 15 percent slopes	AuSo1	111				111

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Auburn-Sobrante complex, 15 to 30 percent slopes	AuSo2	112	118			112
Auburn-Sobrante-Rock outcrop complex, 2 to 30 percent slopes	AuSoRo1		119			
Auburn-Sobrante-Rock outcrop complex, 30 to 50 percent slopes	AuSoRo2		120			
Auburn-Sobrante-Rock outcrop complex, 50 to 70 percent slopes	AuSoRo3		121			
Auburn-Argonaut complex, 2 to 15 percent slopes	AuAr	AwC	115			
Auburn-Argonaut-Rock outcrop complex, 2 to 15 percent slopes	AuArRo		116			
Auburn-Rock outcrop complex, 2 to 30 percent slopes	AuRo1	AxD	117			
Auburn-Rock outcrop complex, 30 to 50 percent slopes	AuRo2	AxE				
Boomer loam, 5 to 15 percent slopes	Bo1	BoC	122			
Boomer loam, 15 to 30 percent slopes	Bo2	BoD	123			
Boomer-Rock outcrop complex, 5 to 30 percent slopes	BoRo1	BrD	124			
Boomer-Rock outcrop complex, 30 to 50 percent slopes	BoRo2	BrE	125			
Boomer-Rock outcrop complex, 50 to 70 percent slopes	BoRo3		126			

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Boomer variant stony sandy loam, 2 to 15 percent slopes	BoS1		127			
Boomer variant very stony sandy loam, 15 to 50 percent slopes	BoS2		128			
Capay clay loam, 0 to 1 percent slopes	Cap					130
Caperton-Rock outcrop complex, 2 to 30 percent slopes	CaRo		132			
Chaix-Hotaw complex, 5 to 15 percent slopes, eroded	ChaHo 1	ChC2				
Chaix-Hotaw complex, 15 to 30 percent slopes, eroded	ChaHo 2	ChD2				
Chaix-Hotaw complex, 30 to 50 percent slopes, eroded	ChaHo 3	ChE2				
Chaix-Rock outcrop complex, 30 to 75 percent slopes	ChaRo	CkF				
Chaix very stony loam, thick solum variant, 5 to 15 percent slopes	ChaS	ClC				
Cohasset loam, 2 to 9 percent slopes	Coh1	CmB	134			
Cohasset loam, 9 to 15 percent slopes	Coh1	CmC	135			
Cohasset loam, 15 to 30 percent slopes	Coh2	CmD	136			
Cohasset cobbly loam, 5 to 30 percent slopes	CohC1	CoD	137			
Cohasset cobbly loam, 5 to 30 percent slopes	CohC1	CoD	138			

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Cohasset cobbly loam, 30 to 50 percent slopes	CohC2	CoE	139			
Cohasset-Aiken-Crozier complex, 2 to 30 percent slopes	CohAiCr				COE	
Cohasset-McCarthy cobbly loams, 15 to 50 percent slopes	CohMc1	CsE				
Cohasset-McCarthy cobbly loams, 50 to 75 percent slopes	CohMc2	CsF				
Columbia fine sandy loam, 0 to 2 percent slopes, MLRA 17	Col1			117		138
Columbia fine sandy loam, clay substratum, 0 to 2 percent slopes	Col2			119		137
Columbia fine sandy loam, frequently flooded, 0 to 2 percent slopes	Col1			121		139
Cometa loam, 0 to 2 percent slopes	Com			123		
Cometa-Fiddyment complex, 1 to 5 percent slopes	ComFi		141			
Cometa-Ramona sandy loams, 1 to 5 percent slopes	ComRa		142			
Conejo loam, 0 to 2 percent slopes	Con					141
Conejo loam, 0 to 1 percent slopes, occasionally flooded	Con					142
Crozier-Cohasset complex, 2 to 30 percent slopes	CrCoh1				CSE	
Crozier-Cohasset complex, 2 to 30 percent slopes, altered	CrCoh1				CSE5	

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Crozier-Cohasset complex, 30 to 50 percent slopes	CrCoh2				CSF	
Crozier-McCarthy-Cohasset complex, 2 to 30 percent slopes	CroMc Coh1				CTE	
Crozier-McCarthy-Cohasset complex, 2 to 30 percent slopes, altered	CroMc Coh1				CTE5	
Crozier-McCarthy-Cohasset complex, 30 to 75 percent slopes	CroMc Coh2				CTG	
Crozier-Mariposa-Cryumbrepts, wet complex, 30 to 75 percent slopes	CroMa Cry				CUG	
Cut and fill land	Cut	Ct				
Dam	Dam	Da	DAM			
Deadwood-Rock outcrop-Hurlbut complex, 30 to 75 percent slopes	DeRo				DEG	
Dubakella, shallow variant-Rock outcrop complex, 2 to 50 percent slopes	DubRo	DrE	143		DUE	
Dubakella, shallow variant-Rock outcrop complex, 2 to 50 percent slopes	DubRo	DrE	143		DUF	
Flanly sandy loam, 8 to 15 percent slopes	Fl	149				149
Fiddyment-Kaseberg loams, 2 to 9 percent slopes	FiKa		147			
Granitic rock land	Gr	Gr				
Hoda sandy loam, 5 to 9 percent slopes	Ho1	HnB				
Hoda sandy loam, 9 to 15 percent slopes	Ho1	HnC				
Hoda sandy loam, 15 to 50 percent slopes	Ho2	HnE				

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Hoda cobbly sandy loam, 2 to 15 percent slopes, eroded	HoC	HoC2				
Holillipah loamy sand, 0 to 2 percent slopes	Hol1			133		161
Holillipah loamy sand, channeled, 0 to 2 percent lopes, MLRA 17	Hol2			134		162
Holillipah loamy sand, frequently flooded, 0 to 2 percent slopes	Hol2			135		163
Holillipah sandy loam, 0 to 2 percent slopes	HolS			136		
Hollenbeck silty clay loam, 0 to 1 percent slopes	HolS					131
Hollenbeck silty clay loam, 0 to 1 percent slopes, occasionally flooded	HolS					132
Hollenbeck-Urban land complex, 0 to 1 percent slopes	HolUr					134
Horseshoe gravelly loam, 2 to 9 percent slopes	Hor1		149			
Horseshoe gravelly loam, 9 to 15 percent slopes	Hor1	HrC	150			
Horseshoe gravelly loam, 15 to 30 percent slopes	Hor2	HrD			HrDnc	
Horseshoe-Jocal-Mariposa complex, 2 to 30 percent slopes	HorJoM a				HRE	
Horseshoe-Rubble land complex, 2 to 30 percent slopes*	HorR		151			

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Horst sandy loam, 0 to 1 percent slopes	Hors					169
Horst silt loam, 0 to 2 percent slopes	Hors					170
Hotaw, rhyolitic substratum-McCarthy-Cryumbrepts, wet complex, 30 to 75 percent slopes	HotMc				HTF	
Hurlbut-Deadwood-Mariposa complex, 2 to 30 percent slopes	HuDeMa				HUE	
Hurlbut, thin surface-Deadwood-Rock outcrop complex, 2 to 30 per cent slopes, severely eroded	HuDeRo1				HUE3	
Hurlbut, thin surface-Hurlbut-Deadwood complex, 2 to 30 percent slopes, altered	HuDe1				HUE5	
Hurlbut-Deadwood-Rock outcrop complex, 30 to 75 percent slopes	HuDeRo2				HUG	
Hurlbut, thin surface-Deadwood-Rock outcrop complex, 30 to 75 pe rcent slopes, severely eroded	HuDeRo2				HUG3	
Hurlbut, thin surface-Hurlbut-Deadwood complex, 30 to 75 percent slopes, altered	HuDe2				HUG5	
Huysink-Horseshoe complex, 2 to 30 percent slopes	HuyHor1				HSE	
Huysink-Horseshoe complex, 30 to 50 percent slopes	HuyHor2				HSF	

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Iron Mountain cobbly loam, 2 to 50 percent slopes	IrC	ImE				
Iron Mountain-Rock outcrop complex, 2 to 30 percent slopes	IrRo		156			
Jocal-Sites-Mariposa complex, 2 to 30 percent slopes	JoSiMa1				JYE	
Jocal-Sites-Mariposa complex, 2 to 30 percent slopes, altered	JoSiMa1				JYE5	
Jocal-Sites-Mariposa complex, 30 to 50 percent slopes	JoSiMa2				JYF	
Jocal-Jocal variant-Cryumbrepts, wet complex, 50 to 75 percent s lopes	JoCry				JZG	
Josephine loam, 2 to 9 percent slopes	Jos1		157			
Josephine loam, 9 to 15 percent slopes	Jos1	JoC	158			
Josephine loam, 15 to 30 percent slopes	Jos2	JoD	159			
Josephine loam, 30 to 50 percent slopes	Jos3	JoE	160			
Josephine cobbly loam, 5 to 30 percent slopes	JosC	JpD				
Josephine-Mariposa complex, 15 to 50 percent slopes, eroded	JosMa1	JrE2	164		JrE2nc	
Josephine-Mariposa complex, 15 to 50 percent slopes, eroded	JosMa1	JrE2	165		JrE2nc	
Josephine-Mariposa complex, 50 to 75 percent slopes, eroded	JosMa2	JrF2	166			

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Josephine rock-Outcrop complex, 15 to 50 percent slopes	JosRo	JsE	161			
Kilaga loam	Kil		162			183
Kimball loam, 0 to 1 percent slopes	Kim					185
Ledmount-McCarthy-Rock outcrop complex, 2 to 30 percent slopes	LedMc Ro1				IME	
Ledmount-McCarthy-Rock outcrop complex, 30 to 75 percent slopes	LedMc Ro2				IMG	
Marcum clay loam, 0 to 2 percent slopes	Mar			140		
Mariposa gravelly loam, 2 to 30 percent slopes	MaG	MaD	163			
Mariposa-Rock outcrop complex, 2 to 50 percent slopes	MaRo1	MkE	167			
Mariposa-Rock outcrop complex, 50 to 70 percent slopes	MaRo2		168			
Mariposa-Jocal complex, 2 to 30 percent slopes	MaJo1				MAE	
Mariposa-Jocal complex, 2 to 30 percent slopes, altered	MaJo1				MAE5	
Mariposa-Jocal complex, 30 to 75 percent slopes	MaJo2				MAG	
Maymen-Mariposa complex, 2 to 50 percent slopes, eroded	MayMa 1	MmE2				
Maymen-Mariposa complex, 50 to 75 percent slopes, eroded	MayMa 2	McF2				

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Maymen-Rock outcrop complex, 9 to 50 percent slopes	MayRo 1		169			
Maymen-Rock outcrop complex, 50 to 75 percent slopes	MayRo 2		170			
McCarthy sandy loam, 15 to 50 percent slopes	McS	MnE				
McCarthy cobbly sandy loam, 5 to 30 percent slopes	McCS		171			
McCarthy cobbly sandy loam, 30 to 50 percent slopes	McCS		172			
McCarthy cobbly loam, 5 to 15 percent slopes	McC	MoC				
McCarthy cobbly loam, 15 to 50 percent slopes	McC	MoE			MoEnc	
McCarthy-Ledmount-Crozier complex, 2 to 30 percent slopes	McLed Cr1				MCE	
McCarthy-Ledmount-Crozier complex, 2 to 30 percent slopes, altered	McLed Cr1				MCE5	
McCarthy-Ledmount-Crozier complex, 30 to 75 percent slopes	McLed Cr2				MCG	
Meiss-Gullied land-Rock outcrop complex, 30 to 75 percent slopes	Me				MHG	
Musick sandy loam, 5 to 15 percent slopes	Mus1	MrC				
Musick sandy loam, 15 to 50 percent slopes	Mus2	MrE				
Musick-Rock outcrop complex, 5 to 50 percent slopes	MusRo	MsE				

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Perkins loam, 0 to 2 percent slopes, MLRA 17	Per					203
Pits and dumps	Pit		173		HYE	
Pits and dumps	Pit		173		PX	
Placer diggings	Dig	Pr	Prna			
Ponto variant-Neer complex, 2 to 30 percent slopes	PoNe1				FFE	
Ponto variant-Neer complex, 30 to 50 percent slopes	PoNe2				FFF	
Putt-McCarthy-Zeibright complex, 2 to 30 percent slopes	PuMcZ 1				PME	
Putt-McCarthy-Zeibright complex, 30 to 75 percent slopes	PuMcZ 2				PMG	
Putt-Rock outcrop-Cryumbrepts, wet complex, 2 to 30 percent slopes	PuRoCr y				PTE	
Putt-Rock outcrop, granitic-Zeibright complex, 2 to 30 percent slopes	PuRoZ1				PVE	
Putt-Rock outcrop, granitic-Zeibright complex, 30 to 75 percent slopes	PuRoZ2				PVG	
Putt-Rock outcrop, metamorphic-Zeibright complex, 2 to 30 percent slopes	PuRoZ1				PWE	
Putt-Rock outcrop, metamorphic-Zeibright complex, 30 to 75 percent slopes	PuRoZ2				PWG	
Ramona sandy loam, 0 to 2 percent slopes	Ra		174			
Redding gravelly loam, 0 to 3 percent slopes	Red					207

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Redding gravelly loam, 3 to 8 percent slopes	Red					208
Redding-Corning complex, 0 to 8 percent slopes	RedCor					209
Redding-Corning complex, 0 to 8 percent slopes	RedCor					210
Redding and Corning gravelly loams, 2 to 9 percent slopes	RedCor		176			
Redding and Corning gravelly loams, 9 to 15 percent slopes	RedCor		177			
Rescue-Rock outcrop complex, 5 to 30 percent slopes	ReRo	RkD				
Ricecross loam, 0 to 2 percent slopes, occasionally flooded	Rice	212				212
Riverwash	Wash	178	178	178pl	R	213
Rock land	Rock	Rn				
Rock outcrop	Ro		179		VRG	
Rock outcrop-Ahwahnee complex, 9 to 50 percent slopes	RoAhw	RoE				
Rock outcrop-Auburn complex, 2 to 30 percent slopes	RoAu	RpD				
Rock outcrop-Deadwood association, 50 to 100 percent slopes	RoDe				DDH	
Rock outcrop-Dubakella complex, 5 to 50 percent slopes	RoDub	RrE			RDE	
Rock outcrop-Dubakella complex, 5 to 50 percent slopes	RoDub	RrE			RDG	

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Rock outcrop, metamorphic-Putt-Deadwood complex, 30 to 75 percent slopes	RoPuDe				MMG	
Rubble land	Rub		180			
Rubble land-Rock outcrop complex	RubRo				SUG	
San Joaquin sandy loam, 1 to 5 percent slopes	Sj		181	158		214
San Joaquin sandy loam, 1 to 5 percent slopes	Sj		181	158		215
San Joaquin sandy loam, 1 to 5 percent slopes	Sj		181	158		216
San Joaquin-Cometa sandy loams, 1 to 5 percent slopes	SjCom		182			
Secca-Rock outcrop complex, 2 to 50 percent slopes	SecRo	ScE				
Shenandoah sandy loam, 2 to 15 percent slopes	Sh	SdC				
Shanghai silt loam, 0 to 2 percent slopes	Sha			162		218
Shanghai silt loam, clay substratum, 0 to 2 percent slopes	Sha			163		220
Shanghai silt loam, frequently flooded, 0 to 2 percent slopes	Sha			165		219
Shanghai variant loamy sand, 0 to 1 percent slopes	Sha			168		
Sierra sandy loam, 2 to 9 percent slopes	Sie1	SfB				
Sierra sandy loam, 9 to 15 percent slopes	Sie1	SfC				
Sierra sandy loam, 15 to 30 percent slopes	Sie2	SfD				

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Sierra-Rock outcrop complex, 15 to 30 percent slopes	SieRo1	SkD				
Sierra-Rock outcrop complex, 30 to 50 percent slopes	SieRo2	SkE				
Sites loam, 2 to 9 percent slopes	Si1	SlB	186			
Sites loam, 9 to 15 percent slopes	Si1	SlC	187			
Sites loam, 15 to 30 percent slopes	Si2	SlD	188			
Sites loam, 30 to 50 percent slopes	Si3		189			
Sites very stony loam, 2 to 15 percent slopes	SiS1	SmC				
Sites very stony loam, 15 to 50 percent slopes	SiS2	SmE				
Sites-Jocal complex, 2 to 30 percent slopes	SiJo				SKE	
Sites-Jocal-Mariposa complex, 30 to 50 percent slopes	SiJoMa				SKF	
Sites-Rock outcrop complex, 15 to 30 percent slopes	SiRo		190			
Snelling loam, 0 to 2 percent slopes	Sn			169		
Snelling loam, occasionally flooded, 0 to 2 percent slopes	Sn			170		
Sobrante loam, 2 to 15 percent slopes	Sob1	SoC	191			
Sobrante loam, 15 to 30 percent slopes	Sob2	SoD				
Sobrante-Rock outcrop complex, 2 to 30 percent slopes	SobRo1	SrD				
Sobrante-Rock outcrop complex, 30 to 50 percent slopes	SobRo2	SrE				

Name	Map	Nevada County	Placer County	Sutter County	Tahoe Natl Forest	Yuba County
Sobrante-Timbuctoo complex, 30 to 50 percent slopes	SobTi					241
Tailings	Tail	Ta			Ta_nc	146
Tallac-Cryumbrepts, wet complex, 2 to 30 percent slopes	TalCry1				TBE	
Tallac-Cryumbrepts, wet complex, 30 to 50 percent slopes	TalCry2				TBF	
Tisdale clay loam, 0 to 2 percent slopes	Tis			174		
Tujunga sand, 0 to 1 percent slopes	Tuj					249
Water	Water	W	198	177	W	254
Xerorthents, cut and fill areas	Xcut	196	196		196pc	
Xerofluvents, sandy	XS		192			
Xerofluvents, occasionally flooded	XOf		193	193pl		
Xerofluvents, frequently flooded	XFf		194	194pl		
Xerofluvents, hardpan substratum	XH		195			
Zeibright gravelly fine sandy loam, 2 to 30 percent slopes	Z1				ZEE	
Zeibright gravelly fine sandy loam, 30 to 50 percent slopes	Z2				ZEF	
Zeibright-Putt-Cryumbrepts, wet complex, 30 to 60 percent slopes	ZPuCry				ZFF	