Boca Watershed Assessment

USDA Forest Service
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Chapter 1. Introduction

Problem Statement and Need for Assessment

The Boca watershed was identified as a Priority Watershed in the 2016 Watershed Condition Framework Assessment completed by the Tahoe National Forest. This area has been heavily utilized by humans over the past 150 years and has a layering of issues pertaining to legacy impacts, development and maintenance of infrastructure, fire history, and recreational use (Figure 1; Figure 2). These uses have created long term impacts on wetlands, springs, streams, and meadows across the Boca watershed. Historic logging practices across the landscape included transporting logs downslope through the drainages which has affected upland drainages, stream stability and downstream meadow function (Figure 1). Over the last several decades, increased visitation to this area has strained existing infrastructure and created an urgency for ensuring that sensitive resources are protected while providing high quality recreational experiences. The combined impacts of historic impacts, ongoing use, and the fire history of the area has compromised the productivity and health of forest stands as well as impacting sensitive hydrologic features.

Figure 1. Hoke Valley area within the Boca watershed. 1939 (left) and 1966 (middle), 2019 (right). Information gleaned from these records are discussed in Chapter 3.

The need for this assessment was identified in conjunction with two other large planning efforts ongoing in this priority watershed, the East Zone Connectivity and Restoration (EZ Connect; USDA 2020a) and Ladybug projects (USDA 2020b). The EZ Connect Project addresses issues related to increased recreational useage and off highway vehicle (OHV) routes and trails, with a NEPA decision expected in early 2021. The Ladybug Forest Health Project will begin implementation in 2021, with treatments aimed at improving forest health across 2,900 acres. This assessment, in conjuction with these two projects, sets in motion a renewed effort to attain a restored landscape within the Boca watershed. These efforts center on creating a sustainable recreational network, healthy forested stands, and functioning hydrologic conditions, while addressing issues connected to historic impacts.

This watershed assessment includes an analysis of meadows, stream corridors, springs, and routes (roads and trails) that describes current conditions and identifies future restoration opportunities. This assessment builds upon actions previously completed within the Dry Creek watershed under the Dry Creek Watershed Assessment (USDA 2013) and other planning documents that resulted in vegetation, fuels, and meadow restoration projects throughout the watershed. While this document identifies restoration opportunities, the expanse and extent of the analysis area limits our ability to fully capture all opportunities for improvement. Future projects will span a significant time period with the goal of returning and sustaining ecosystem function to areas that are identified as impaired.

Watershed Assessment Goals

The overarching goal of the Boca Watershed Assessment is to assess current conditions and prioritize projects that will improve the hydrologic function of roads, streams, trails, meadows and other hydrologic features. Specific objectives of this assessment are to:

- Assess stream and meadow conditions,
- Assess routes; road and trail condition,
- Identify and prioritize restoration opportunities, and
- Create a prioritized list of problem areas for future restoration projects.

Assessment Process

To meet the stated goals of this assessment, we completed an inventory of key elements within the Boca watershed assessment area (Figure 2). Specifically, we looked for and documented impacts to hydrologic function, evidence of erosion and sediment production, aquatic and riparian quality, and road and trail issues and impacts. Aerial imagery and LiDAR were utilized to determine impacted areas and support the delineation of proposed remediation sites. The inventory was focused on roads and trails (routes), streams and meadow systems, and legacy impacts within the analysis area.

Stream and Meadow Systems

Stream and meadow systems were inventoried to identify meadow function and impairment, specifically related to vertical and longitudinal hydrologic connectivity, groundwater recharge, discharge capability, and meadow/channel response to peak flows, stream bed and bank stability, aquatic and riparian habitat quality, presence of erosion and channel incision, floodplain connectivity, and general hydrologic function. Aquatic and biological surveys were conducted on perennial drainages and intensified at sites where restoration will be pursued in the near term. Stream channels and tributaries were surveyed by ocular assessment, LiDAR derived digital elevation models (DEM), GPS features, photo documentation, and descriptions noting key characteristics and/or problem statements. Additional surveys were conducted in key meadow areas to support the feasibility of future restoration projects, including archeological surveys, botany surveys, and aquatics surveys. Priority areas included more detailed work including mapping and preliminary design elements.

Routes

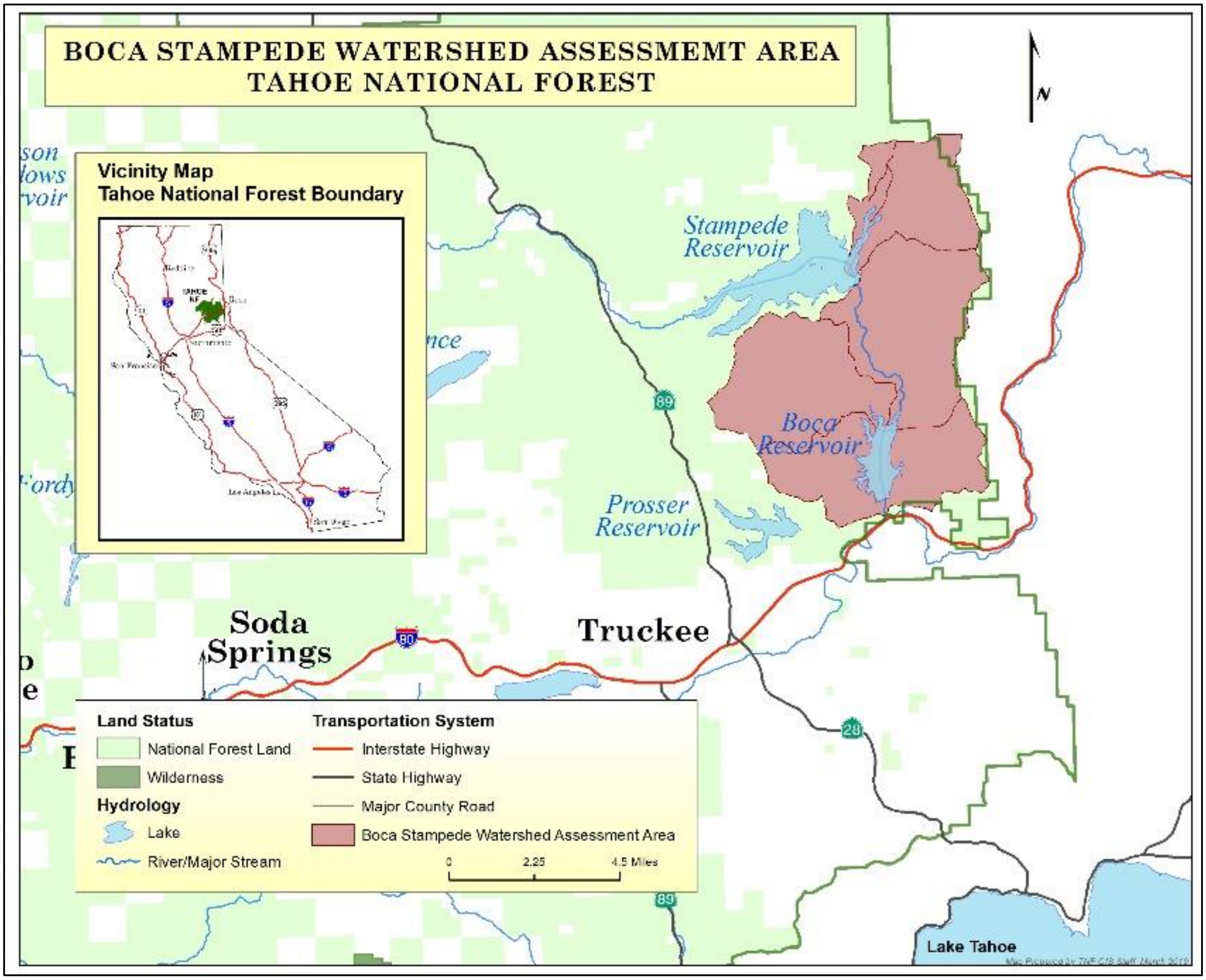
The road system was inventoried using the USDA Soil and Water Road Condition Index (SWRCI) protocol (USDA 2008). This road condition index uses key indicators to identify potential soil and water related issues on routes and evaluates route surface and subsurface drainage, stream crossing condition, diversion potential at crossings, road-stream connectivity, and hillslope condition to assign the road a rating of functional, at-risk, or impaired. The SWRCI data is used to target areas for specific road treatments.

Areas with impacts from roads were combined into proposed actions and incorporated into the NEPA for selected developed actions under the EZ Connect Project (USDA 2020).

Chapter 2. The Boca Watershed Setting

Location and General Setting

The Boca watershed assessment area is located in the eastern Sierra Nevada in Nevada and Sierra counties, near Truckee California, and lies almost entirely within the Tahoe National Forest with a small area in the Northeast corner of the watershed in the Humboldt-Toiyabe National Forest (Figure 2). The assessment area drains into Boca and Stampede reservoirs to the Truckee River via the Little Truckee River. The assessment area is approximately 28,450 acres in size, including the open water associated with the



receiving arm of Stampede Reservoir and Boca Reservoir, a surface area of approximately 1,214 acres.

Figure 2. The Boca Watershed Assessment Area.

The Boca Watershed Assessment area consists of an upper area and lower area. The upper area discharges into Stampede Reservoir and the lower area feeds Boca Reservoir and eventually the Truckee River. The upper drainage is smaller and is made up of a portion of the Merril Creek and Davies Creek drainages and includes the Hoke Valley drainage. The lower section is much larger and includes drainages that feed Boca Reservoir, including the Lower Little Truckee River drainage which collects waters flowing from the Stampede Reservoir outlet and areas to the south, including Dry Creek/Russel Valley, that drain into the northeast arm of Boca Reservoir. The Dry Creek/Russel Valley area was assessed for impacts to watershed health in the Dry Creek Watershed Assessment which is incorporated into this document by reference (USDA 2013).

Assessment area elevations range from 5,520 feet at the base of Boca Dam to 8,455 feet at the top of Verdi Peak. According to the Boca, CA Weather Station (39.38 ^{o} N 120.10 ^{o} W 5580 feet msl) which has a 45-year record, the mean annual precipitation for the Boca watershed is approximately 22 inches. Nearly 90% of the land in Boca watershed is managed by the Forest Service. The privately-owned lands are mostly in the Dry Creek subwatershed and one privately owned section spans the southern end of Hoke Valley and the northern section of the Lower Little Truckee River subwatershed. Some of the private land is residential use (primarily in Dry Creek/Russel Valley) and some is managed as forest.

Climate Change Considerations

The Sierra Nevada region is expected to experience increases in temperature and a shift in the precipitation regime compared to historic conditions; however it is also understood that there is a range of expected conditions across this large area (Reich et al. 2018). The precipitation regime in the Sierra Nevada is anticipated to shift to a regime where a greater proportion of precipitation falls as rain vs. snow, a declining snowpack and snow water equivalent, earlier spring runoff, increases in peak runoff, and an increase in the frequency, magnitude, and duration of droughts. Winter and early spring runoff is predicted to make up a greater proportion of total annual streamflow. As a result, flood potential, magnitude, and frequency is predicted to increase in the northern Sierra Nevada. A combination of changes to the precipitation regime, including predictions of longer drought periods and changes of the timing of snowmelt runoff leads to a potential for increasing debris flow and landslides (Mallek et al. 2014). This context sets the stage for planning efforts across the Sierra Nevada region, where the focus has shifted to restoration and management efforts that will facilitate resilience to this changing climate (Aslan et al. 2018; Vernon et al. 2019).

Mallek et al. (2014) provided a summary of current and predicted trends in the Tahoe and El Dorado national forests indicating that there have been shifts in both temperature and precipitation regimes. In data collected between 1905 and 2008, both precipitation and temperature regimes were changing significantly at lower elevations in the Tahoe National Forest (Nevada City) but the higher elevations were experiencing a lesser effect. Truckee, the closest location to the Boca watershed that was analyzed, experienced non-significant increases in maximum daily temperature (+1.7 degrees F) during the latter half of the time period examined (Mallek et al. 2014). While snowfall has remained relatively constant, snowmelt is typically occurring earlier regionally in the Sierra Nevada and in north eastern California at nearly 10 to 15 days earlier than in the mid-1900s. The watersheds in the northern Sierra Nevada were determined most likely to show the greatest reduction in mean annual streamflow as a result of a reduced snowpack. A departure from historic conditions, including increased variability of streamflow and extended dry and wet spells, increases difficulties in managing water resources with current and growing demands and existing infrastructure.

Forest Ecology

The forested areas within the Boca watershed are classified as predominantly Sierran Steppe Mixed Conifer forest (USDA FS GIS layer “ExistingVegetationEcObject”). The majority of the assessment area is made up of eastside pine and Jeffrey pine forest (USDA 2009). At lower elevations, the dominant tree species are Jeffrey pine and Ponderosa pine. Mid to upper elevations consist primarily of Jeffrey pine and white fir. At upper elevations, red fir, white fir, and western white pine are the dominant species. Incense cedar, western juniper, and lodgepole pine are found in smaller quantities throughout the watershed. Black cottonwood, quaking aspen, willow, and alder can be found in wet areas and along riparian corridors. Shrub cover consists of greenleaf manzanita, bitterbrush, sagebrush, and snowbrush ceanothus, among other species. As a result of intensive historic logging and fire suppression activities, much of the forest stands are similar in age, species, and genetic make-up. This homogeneity contributes to declining forest health. Numerous forestry related actions haven’t been completed and some are currently underway to bring vegetative stands into a desired condition (Table 1).

Overall tree health in the watershed has declined due to high stand density, recent prolonged drought, insects, and disease. Many of the forested areas are overstocked (primarily on north facing slopes), containing a large amount of standing dead and downed trees. Bark beetles, specifically the fir engraver beetle, have caused increased white fir mortality (Cluck 2018). White firs are also being impacted by Heterobasidion root disease (Cluck 2018).

Fire History

The Sierra Nevada region is expected to see increased fire activity due to the combination of changes to the precipitation regime, including predictions of longer drought periods, changes to winter precipitation (Mallek et al. 2014), and long term fire suppression (Steel et al. 2015). Fire suppression has led to an increase in dense forest stands and dead and downed trees which are one of the many drivers of high intensity fires (Mallek et al. 2013). Less than half of the assessment area, approximately 40%, has experienced fire in the past century. The largest fire, the Donner Ridge Fire of 1960, burned about 21% of the entire watershed area, including about 26% of the Dry Creek, 86% of the Lower Davies Creek, and 27% of the Hoke Valley subwatersheds. The Crystal Peak Fire of 1994 burned at generally high intensity in the northern third of the Hoke Valley subwatershed (USDA 1995).

Fuels and Forest Health Projects (1990-Present)

Currently, the Tahoe National Forest is actively working on reducing fuels by implementing fuel reduction and prescribed burning in the Dry Creek Project and the Ladybug Project. Since 1990 a variety of fuels and forest health work has been completed within the Boca watershed assessment (Table 1).

Table 1. Forestry Projects by NEPA Decision, active years, and treatments within HUC 14 subwatersheds.

NEPA Decision Document	Years Active	Boca	Dry Creek	Hoke Valley	Lower Davies	Lower Little Truckee	Merril
Allover	2002	CT, CC	PT, CT	CT	CT, PT	CT	CT
Dry Creek	2018	CT, PT	PT, CT, U, GSC				
Alder Prosser Compartment Plan	1997-98	CT, PT, SC	PT, CT, SC				
Canyons	2001-2013	CT, PT, SC, UB	CT	CT, PT	UB	CT, PT, UB	
Stampede	2001-2010	CT, PT, SC, U	CT, PT, SC, TH, UB, BB			TH	
Boca Hill	2013	PT					
Ladybug	2021	X		CT, TH	CT	CT	
Hobart YG	1992	PT, CC	CC				
Wornmill	2000-2013		PT, UB	CT, PT, TH, UB	CT, PT	CT, PT, UB, SC	
Billy Fuel Reduction	2015		PT				
Crystal Fire Salvage	1997			SV			
Granite YG	1992			CC		CC	

Scraps	?						C, PC, TH, UB
Davies	2000						CT
CT: Commercial Thin, CC: Stand Clearcut, PT: Precommercial Thin, SC: Sanitation Cut, SV: Salvage Cut, UB: Underburn, BB: Broadcast Burn, TH: Thinning for hazard fuels, SC: Salvage Cut							

Hydrology

The hydrologic response in the uplands of the Boca watershed analysis area is driven by snowmelt with peak flows generally occurring between March and June, depending on annual weather conditions. In the winter months, rain on snow events can create flooding in the watershed. Although the area receives little rainfall during the summer, there is spring and groundwater supported water release that maintains local areas of intermittent and perennial flow that supports mesic, riparian, and wetland systems.

In general, the presence of Boca and Stampede reservoirs within this area control runoff downstream to the Truckee River and in the Little Truckee River between the two reservoirs. Flow out of Boca Reservoir (40,900 acre-feet capacity) and Stampede Reservoir (226,500 acre-feet) is managed through the Truckee River Operating Agreement (TROA) signed in 2008 (TROA 2008). The minimum streamflow requirement in the Little Truckee River downstream from Stampede and upstream from Boca is 30 cubic feet per second (cfs).

Above Boca Reservoir, mean annual runoff was predicted for various return intervals using the regional curve method and data from the Little Truckee River above Boca Reservoir stream gage (USGS station 10344400; USDA 2014), resulting in an estimated discharge of 49 cfs at a 2 year return interval, 615 cfs on a 50 year return interval, and 879 cfs for a 100 year return interval. Flow from the Little Truckee River above Boca would be augmented by releases from Stampede Reservoir. Due to managed flow conditions downstream of Boca and Stampede reservoirs, the analysis showed that flows (1) resulted in increased baseflow and limited floods as compared with pre-dam flows, (2) reduced peak flows after 1970 to between 150 and 4,000 cfs, (3) reduced a 2-year flow from 1,120 to 700 cfs, and (4) reduced the 10-year flow from 4,800 cfs to 2,200 cfs (USDA 2014).

These flow changes changed the character of the Little Truckee River incising, eroding, and developing a single-channel meandering system. Of the contributing tributaries, Worn Mill Creek, was identified to provide a significant source of coarse sediment to the system. The reservoirs were also noted to reduce active recruitment and transport of large wood in the Little Truckee River, but some beaver activity was observed (USDA 2014).

Within the assessment area impacts from historic logging and grazing, reservoir building, and road and trail building have disrupted flow paths and impacted wetlands and riparian features. At individual project sites where restoration activities will be proposed, additional information on site specific impacts and local flow regimes will be analyzed to assess the sustainability of a restoration design. Additional information is contained in Chapters 3 and 4 within this assessment.

Hydrologic Units

The watershed analysis area lies within two Hydrologic Unit Code (HUC) 12 subwatersheds: Middle Truckee River – Boca Reservoir (Priority Subwatershed) and Davies Creek (Table 2).

Table 2. Hydrologic units 12 and 14 within the Boca Watershed Assessment area.

HUC 12 Subwatershed	HUC 14 Drainage	Acres Assessed	Open Water
Davies Creek Assessment Area 5,123 Acres	Lower Davies Creek	641	164
	Merril Creek	443	
	Hoke Valley	4,039	
Middle Truckee River-Boca Reservoir Assessment Area 23,213 Acres	Lower Little Truckee	8,469	62
	Boca Reservoir	7,440	854
	Russel Valley/Dry Creek	7,304	48

Geology

Some of the primary structural geologic features within this region that control the presence of water include faults and tension fractures, physical morphological features, such as glacial moraines, and outwash tills and rock types which include tuff breccia and tuff from the Tertiary period formation. Tuff can perch water and contribute to subsurface lateral flow. A recent exploration of an existing fault near Hoke Valley suggests the fault truncated an ancient buried stream channel that provides the water expressed as springs that support meadow features (Ian Pierce, pers. comm. 2020).

The Walker lane belt is a broad discontinuous strike slip fault and is a zone of transition along the east side of uplifting Sierra Nevada, resulting in the down drop region of the Truckee basin and Sierra Valley. Stampede and Boca dams are both located in the Walker lane belt and are within a transition zone along the western margin of the Medicine Lake trough that formed during the Miocene (Olig et al. 2005). Generally, most of the major landforms are suggested to be formed by faulting and warping after andesitic volcanism with deformation occurring in late Pliocene and early Pleistocene.

In the northeast portion of the analysis area bedrock is exposed from the Paleozoic-Permian time through Cenozoic –Tertiary era with pockets of Granitic Granodiorite igneous intrusive rock. These features are expressed in the north and eastern portion of the Hoke Valley Drainage. In other locations within the basin these rocks are buried and overlain in areas by ash flow tuffs (Melody 2009). Some of these tuffs are exposed along the road between Boca and Stampede reservoirs.

Multiple periods of volcanism affected portions of the assessment area. The geologic influence in the north eastern portion and area east of Boca Reservoir include Mafic and Felsic volcanic rocks. Originating from the Northern Sierra Nevada volcanism during the Paleozoic through Mesozoic – Jurassic periods. To the East of Boca Reservoir the bedrock is primarily comprised of Tertiary pyroclastic rock and volcanic mudflows and colluvium, resulting in various erosional features from volcanic plateaus near the topographic high of the watershed boundaries (Birkeland 1963). The oldest recognized feature from the Pleistocene era is expressed as flows on the Boca Ridge found at Boca Hill in the south portion of Boca Reservoir.

The surface geology on the west side of Boca Reservoir is comprised of alluvium, lake, playa, and terrace deposits; these include unconsolidated and semi-consolidated materials from the Pleistocene to Holocene time. Tectonic effects are said to contribute to damming from vulcanisim that created lakes and accumulated the alluvial and fluvial deposits on the west side of Boca Reservoir. Volcanic flows during the Lousetown formations include the youngest Hirshdale flow contributed to the Prosser Creek alluvium and fluviatile depositions (Birkeland 1963).

Most of the Boca watershed assessment area is influenced by glaciation. The southern lineaments that drain to Dry Creek were affected by tectonic settling which created a Folded Glacial Outwash; additional details on the geology of the Dry Creek watershed can be found in the Dry Creek Watershed Assessment (USDA 2013). Areas immediately surrounding the Boca Reservoir include younger exposed quaternary glacial outwash while the eastern upper ridges include glacial erosional features that originated during early periods of glaciation. The Donner Lake glaciation is one of the youngest periods and occupied the Prosser Creek drainage. The outwash tills expressed south of Boca Hill rests on the pleistocene volcanic flow and overlies Prosser Creek alluvium gravels. There is general agreement in the literature that geologic features in the assessment area were primarily affected and shaped by the Hobart-Donner Lake interglacial period.

Soils

Soil characteristics were assessed for the subwatershed HUC14 hydrologic units (Tables 2, 3, 4). These characteristics provide guidelines for identifying the susceptibility and risks associated with soils when planning for and implementing land management practices; including the management of roads and trails. Susceptibility and risk associated with these conditions vary across the landscape and these characteristics can vary greatly within a particular soil unit.

Soils within the assessment area are generally sandy loam. The soil unit symbols are soil complexes and are comprised of combinations of other soils within the adjacent land form (Figure 3). More detailed information on the soils combined in the units can be found in the Order 3, Soils Survey - Tahoe National Forest Soil Survey, (USDA FS 1994) and at websoilsurvey.nrcs.usda.gov.

A common characteristic identified in soils across the assessment area include a tendency towards ponding, rutting, and erosion that may lead to increased sediment delivery to streams. Soil erosion in forests generally follows a disturbance such as road construction, logging operations, or fire. In undisturbed forests, erosion is most often due to epochal events associated with fire cycles, landslides, flooding, and geologic gully incision. Ground cover by forest litter, duff, and organic material is the most important component of the forest environment for protecting the mineral soil from erosion. In addition, forest litter provides nutrients to the soil needed for sustainable forestry. Ground cover amounts can be reduced by logging operation (harvesting and site preparation) and burning by either wildfire or prescribed fire.

As a result of the Donner Ridge Fire, areas within the Boca watershed were terraced to reduce the potential for sediment loss in high intensity burn areas (Figure 11). The process of terracing removed most of the “A” and “B” soil horizons and pushed the soils onto benches where trees were then planted. The plantations on terraces in the Boca watershed resulted in relatively homogenous tree stands, difficult removal practices, and areas lacking topsoil.

Direct impacts to soils from anthropogenic disturbances include removal of topsoil, compaction from surface travel of equipment or grazing animals, and other factors. Road and trail construction combine removal of topsoil and compaction, altering hillslope hydrology and carrying sediment eroded from the road surface along linear features that mimic and extend stream channel systems. Watersheds with dense road networks experience increased sedimentation and as a result, peak flows. The Boca watershed assessment area is within the Middle Truckee River Total Maximum Daily Loading (TMDL) corridor and, as such, sediment reduction efforts are prioritized.

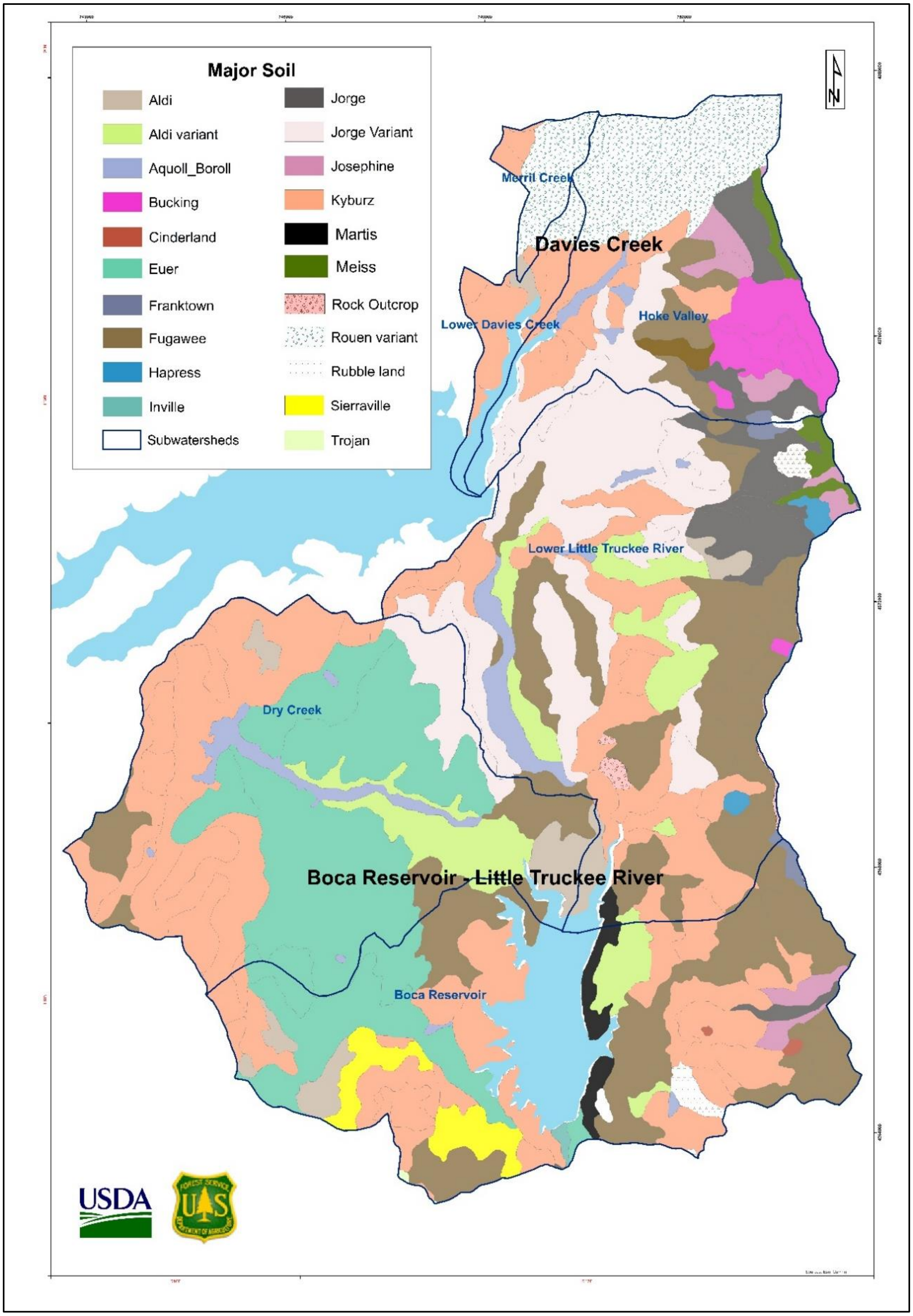


Figure 3. Major Soil Units within the Boca Watershed Assessment Area.

The information below includes an assessment of tendency toward soil puddling, soil rutting, and soil road-trail erosion that can be used to inform risk of these issues from land management activities. There are many additional variables (slope, soil cover, etc.) that should be taken into consideration when designing, constructing, and maintaining land management actions to understand the actual risk (high, medium, or low) associated with soil characteristics. Note that areas which are not rated (such as rock outcrops, water etc.) are not included in the percent affected area and so totals will not add up to 100%.

Soil Puddling

Puddling occurs when soil particles become dispersed in water and form a crust on the surface, or where compaction occurs and reduces porosity. The soil puddling rating is based on the upper 12 inches of the soil profile and soil texture groups (Table 3). **Low** soil puddling indicates soil that is resistant to puddling. **Medium** risk soils can be puddled by equipment operations but the damage is not extreme and mitigation measures are effective. **High** risk of soil puddling indicates soils can be readily puddled and mitigation measures are ineffective or costly and difficult to implement effectively.

Table 3. Puddling Risk (High, Medium, Low) as a percentage of different subwatersheds within the Boca assessment area. Note that areas which are not rated (such as rock outcrops, water etc.) are not included in the percent affected area and so totals will not add up to 100%.

Subwatershed	Puddling: Percent of Area Soils		
	High	Medium	Low
Merril-Davies	52.6	36.3	0
Hoke Valley	35.7	30.6	27.8
Lower Little Truckee River	0	93.1	1.1
Boca Reservoir	6.6	62.8	17.2
Percent is based on the Major Soil in the soil unit.			

Soil Rutting

Risk for the development of ruts or rutting is based on depth to water table and other soil properties (Table 4). The following qualitative descriptions provided from the Web Soil Survey are described as follows: **Slight** risk indicates little to no rutting potential, **Moderate** means rutting is likely, and **Severe** indicates ruts form readily.

Table 4. Soil Rutting (Severe, Moderate, and Slight) as a percentage of different subwatersheds within the Boca assessment area. Note that areas which are not rated (such as rock outcrops, water etc.) are not included in the percent affected area and so totals will not add up to 100%.

Subwatershed	Rutting: Percent of Area Soils		
	Severe	**Moderate**	**Slight**
Merril-Davies	16.1	37.7	35.1
Hoke Valley	18.0	31.6	44.6
Lower Little Truckee River	3.4	20.4	70.4
Boca Reservoir	6.6	62.8	17.2
Percent is based on the Major Soil in the soil unit.			

Soil Road-Trail Erosion

Soil trail erosion hazard is an indication of whether or not a road or trail will erode based on the characteristics of its underlying soil type (Table 5). **Slight** risk indicates that little or no erosion is likely. **Moderate** indicates that some erosion is likely, that the roads or trails may require occasional maintenance, and that simple erosion-control measures are needed**. Severe** indicates that significant erosion is expected, that the roads or trails require frequent maintenance, and that costly erosion-control measures are often needed.

Table 5. Soil Road-Trail Erosion (Severe, Moderate, and Slight) as a percentage of different subwatersheds within the Boca assessment area. Note that areas which are not rated (such as rock outcrops, water etc.) are not included in the percent affected area and so totals will not add up to 100%.

Subwatershed	Road Trail Erosion: Percent of Area Soils		
	Severe	**Moderate**	**Slight**
Merril-Davies	97.3	2.7	0
Hoke Valley	88.7	5.5	0
Lower Little Truckee River	92.2	0	3.1
Boca Reservoir	76	4.6	6
Percent is based on the Major Soil in the soil unit.			

Invasive Aquatic Species

Both plant and animal aquatic invasive species (AIS) present a risk to aquatic habitat in reservoirs and lakes as they have the ability to disrupt habitat quality, food chain pathways, and the nutrient levels of impacted waterbodies. The vulnerability of waterbodies to invasion by AIS is determined by both water chemistry (e.g. Calcium concentrations) and human behavior. People regularly transport boats and other recreational vessels between waterbodies which create a source of potential introduction with each visit. Boaters who visit Boca or Stampede reservoirs can reduce this risk by conducting voluntary self-inspections and by cleaning and draining vessels between visits to different waterbodies[1]. There has been no visual or DNA confirmation of mollusk veligers, Hydrilla sp. and Eurasian watermilfoil (Rammer and Chandra 2010; Chandra and Caldwell 2011; Caldwell and Chandra 2012; Gantz et al. 2018) in the region. However, a population of signal crayfish was introduced to Boca Reservoir in the late 1800's or earlier 1900's and is pervasive within the reservoir, though its impact on food availability for native fishes is unclear (Caldwell and Chandra 2012; Larson et al. 2017).

The Boca area was included in a study of the lower Truckee River basin between 2010 and 2012 which concluded that it was at low risk of invasion by aquatic mollusks and snails due to its relatively low levels of Calcium (4.85-8.04 ppm; Caldwell and Chandra 2012). However, it was noted that in dry water years, Calcium levels were higher, indicating that there may be a higher risk of invasion from mollusks and snails during drier water years when the reservoir level is lower (Caldwell and Chandra 2012). Elevated calcium levels in area reservoirs could become more of an issue as the climate changes and there is less available precipitation to fill reservoirs or elevated evaporation from reservoir surfaces.

[1] http://truckeeboatinspections.com/

Chapter 3. Human Disturbance and Effects on Watershed Function

The Boca watershed has been heavily impacted by human activity since Euro-American settlement in the mid-1800s. Historic logging, roads, railroads, and grazing over 150 years have severely degraded the Boca watershed. The Overland Emigrant Trail, which runs across the watershed, brought settlers into California starting in 1844. As the surrounding areas were settled, needs for lumber, ranching, and transportation rose. Logging in the Boca watershed began in 1866 (Worn Mill EA) and spurred the construction of a system of roads and railroads to move the harvested timber. Impacts from logging are easily seen today with skid trails, steam donkey trails, and old routes scattered across the landscape.

Modern human activities continue to impact the area. The Boca Dam was constructed in 1937 and the Stampede Dam was built in 1970. Both reservoirs are managed by the Bureau of Reclamation. As infrastructure needs continued with population growth powerlines, a petroleum pipeline, and fiber-optic lines were constructed during the 1960s and 1970s. Recreational activities have drawn people to the area for decades. Hiking, mountain biking, boating, horseback riding, fishing, and off-highway vehicle use are popular activities currently in the Boca watershed.

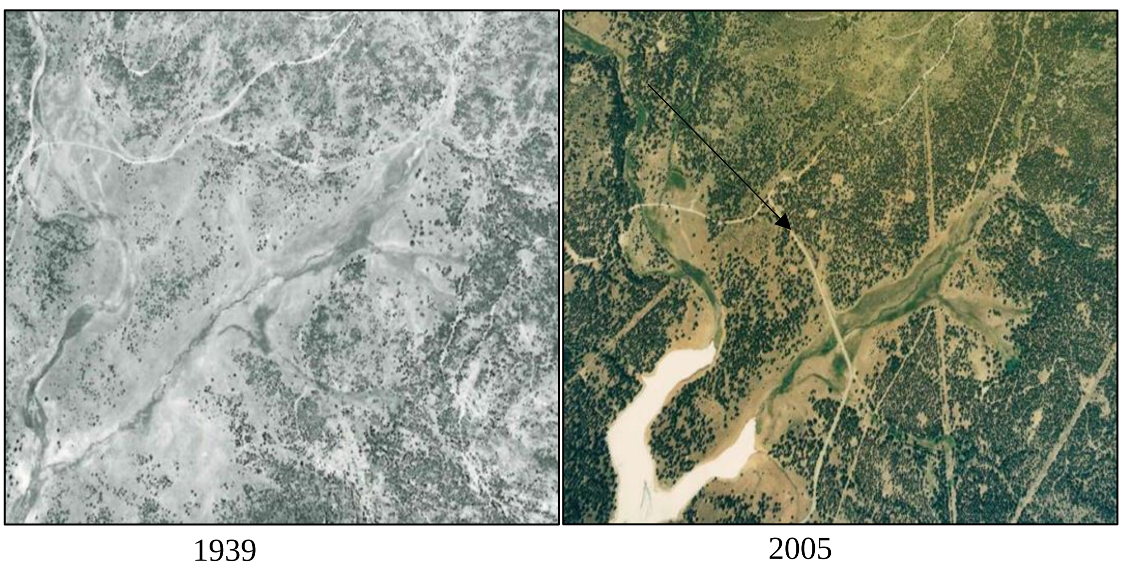


Figure 4: Hoke Valley. Since 1939, many developments have occurred in Hoke Valley. Notice the addition of County Road 270 (arrow), powerlines, a petroleum pipeline, and a fiber optics cable, all of which cross the meadow.

Many historic and more contemporary routes are located adjacent to, across and through sensitive hydrologic features and serve as conduits for intercepting subsurface flows and concentrating surface runoff (Figure 4). Numerous pipeline and powerline roads and other linear infrastructure features disrupt natural overland and subsurface flow and constrict

Figure 6. Failing Marston Mat grade control structures in Canyon 4.

flow patterns to these features. Existing local roads bisect meadows and concentrate flows that contribute to degradation of meadow systems and stream channels. Recreational uses can include unsustainable routes, compaction from dispersed camping, and user created trails that concentrate water. Sheep grazing patterns have resulted in areas of soil compaction within sheep camps and other areas. These combined impacts lead to erosive flows and increased sediment delivery resulting in the incision of drainages and the disrupted function of the hydrologic system. Additional information on impacts specific to the Dry Creek watershed can be found in Chapter 3 of the Dry Creek Watershed Assessment (USDA 2013).

In the modern era, there have been numerous attempts to restore parts of the Boca watershed. In the 1970s and 1980s, Gabion baskets were constructed in several drainages, including Hoke Valley and Canyon 3, in order to stabilize banks and in some cases to induce channel aggradation. During this time, several types of grade control structures were installed in other drainages. These structures were made from metal ‘Marston Mats,’ wooden logs, and stacked rocks (Figures 5 and 6). In some places, these structures performed well and improved stream function for at least 5-10 years after they were installed. However, most structures, especially those outside of wetlands, are now failing. Streams are now cutting around some of the structures and contributing to sediment transport.

Figure 5. Canyon 4 in 1978 when metal grade control structures were installed (left) and one of those structures in 2019 (right).

Chapter 4. Survey Information

Assessment of Routes and Trails

The Boca Watershed Assessment Area has a system of official and unofficial roads and trails, owned and maintained by private, county, and federal agencies. This roads assessment provides a snapshot of existing conditions applicable to the survey date (Table 5; Figure 7). It can also provide insights to roads that may need more regular maintainence, design modifications or enhancements. A new road and trail management plan is proposed within the East Zone Connectivity and Restoration Project. Elements of that project proposal are guided by information collected under this assessment. This section provides a descriptive summary of the data collected using the Soil and Water Resource Condition Index (SWRCI). Surveyed route types are identified as Forest Service routes or trails, legacy routes, unauthorized routes and some incidentally gathered information on other routes such as county, private and non- motorized trails. The areas shown as "At risk", "Impaired" or "Functional" only assess condition for the point of time that the survey was conducted.

For the most part, the routes surveyed are rated based on the SWRCI method as follows:

- **at-risk** are segments in need of maintenance
- **impaired** are segments that are contributing erosion and may need maintenance or design improvements, and
- **functional** are segments that are currently meeting objectives for hydrologic connectivity and sediment control.

Surveyed Routes

The National Forest system roads where the SWRCI surveys were completed are primarily Maintenance Level (ML) ML-2 roads or other routes or trails with native or gravel surfaces. Under Forest Service Handbook 7709.58,10, ML-2 roads are open for use by high-clearance vehicles. Traffic is normally minor and roads consist of one or a combination of administrative, permitted, dispersed recreation, or other specialized uses. In addition, other recreational motorized trails were incorporated into the assessment. Surveyed routes include unauthorized routes or trails. Desktop analysis for potential issue areas was conducted using a 2014 1-meter scale LiDAR derived digital elevation model (DEM) as both a preliminary step to target features for survey and as a follow-up step to assess if field data collection efforts were comprehensive. A majority of the surveys were collected between 2017-2019 while surveys were conducted in the Dry Creek watershed in 2011. Data collected was quality controlled for duplicates, errata, and GPS data was reviewed to ensure that only relevant information was collected to the extent it provided improved information and could be associated with on the ground or features visible from LiDAR derived DEMs. Additional ground truthing may need to be completed prior to planning restoration actions.

Unauthorized routes are defined as occurring under one or more of the following conditions: (1) roads or trails that are not part of the official forest service system routes,

(2) authorized under a special use permit but are not identified within the forest system routes, and (3) routes that are officially closed but the general public continues to have or has gained access to.

A complete assessment of The Centennial Overland Emigrant Trail (COET) was not conducted however some segments were surveyed, including the area within the Dry Creek watershed. Within the Dry Creek watershed approximately 5.4 miles of the COET was surveyed and one mile was classified as "impaired", 1.6 miles as "at risk" and the remaining 2.8 miles as "functional."

Small segments of roads in the lower end of Merril Valley and Davies Creek subwatersheds were surveyed and are combined with Hoke Valley data as they are all part of the Davies Creek HUC 12. Very limited surveys occurred on private roads within the assessment area due to access limitation issues.

Since 2011, some areas prioritized for restoration have been restored or treated and are now currently being monitored for enhanced function. For instance, in 2019 the 72 Road was improved by adding drainage features to address previously identified erosion or drainage issues. In addition, road segments associated with the Dry Creek Restoration Project were completed and are presented in the subwatershed assessment for Dry Creek and under the section entitled *Watershed Restoration* below.

Table 5. Total Miles Surveyed using the SWRCI Rating (188.9 miles).

SWRCI Rating	**Boca Assessment Area Watershed Total**		Hoke Valley Merril/Davies Subwatershed		Lower Little Truckee River Subwatershed		Boca Reservoir Subwatershed		Dry Creek Subwatershed	
	Miles	**%**	Miles	%	Miles	%	Miles	%	Miles	%
Functional	**67.7**	**36%**	5.8	17%	16.4	32%	11.1	31%	30.5	49%
At-Risk	**76.3**	**40%**	11.6	34%	18.9	36%	16.1	45%	28.2	45%
Impaired	**45.8**	**24%**	16.5	49%	16.5	32%	8.3	24%	3.5	6%
Total	**188.9**		**33.9**		**51.8**		**35.5**		**62.2**	
Total for Assessment area includes COET features not tallied in subwatersheds										

Davies Creek: Hoke Valley, Dry creek and Merril Watersheds (33.9 miles)

Of the surveyed routes there were 13.1 miles of unauthorized routes (Table 5; Figure 7). Incidental areas included 1.2 miles on the Humboldt Toiyabe National Forest and 1.9 miles of County Roads.

Lower Little Truckee River

Of the surveyed routes there were 10 miles of unauthorized routes, which are a combination of special use permits, routes from older timber sales, and public recreational uses (Table 5; Figure 7). This survey data also included a decommissioned segment that was rated as "impaired" and is a segment that is a candidate for review and potential remediation.

Boca Reservoir

Of the surveyed routes there were 10.8 miles of unauthorized routes, these are primarily routes from older timber sales and public recreational uses (Table 5; Figure 7). Incidental areas included 2.5 miles of private roads.

Dry Creek

Of the surveyed routes there were 13.8 miles of unauthorized routes (Table 5; Figure 7). Incidental areas included 2.6 miles of private roads and included a decommissioned segment that was rated as “impaired” and “at risk”. These segments are candidates for review and potential remediation.

Other Legacy Routes

A total of 43.7 miles of prominent legacy features were identified within the Boca watershed assessment area. Within Hoke Valley/Merril/Lower Davies area 6.3 miles of legacy features were identified, 13.8 miles within the Lower Little Truckee River, 15.7 miles in Boca Reservoir LiDAR, and 7.8 miles were identified as legacy routes in Dry Creek/Russel Valley. Legacy landscape features that are identifiable on the LiDAR DEM may require additional assessment if restoration actions are pursued (Figure 11). Most of these features are older with associated bench cuts and could be in various states of stability. Many have some level of ground cover or vegetation.

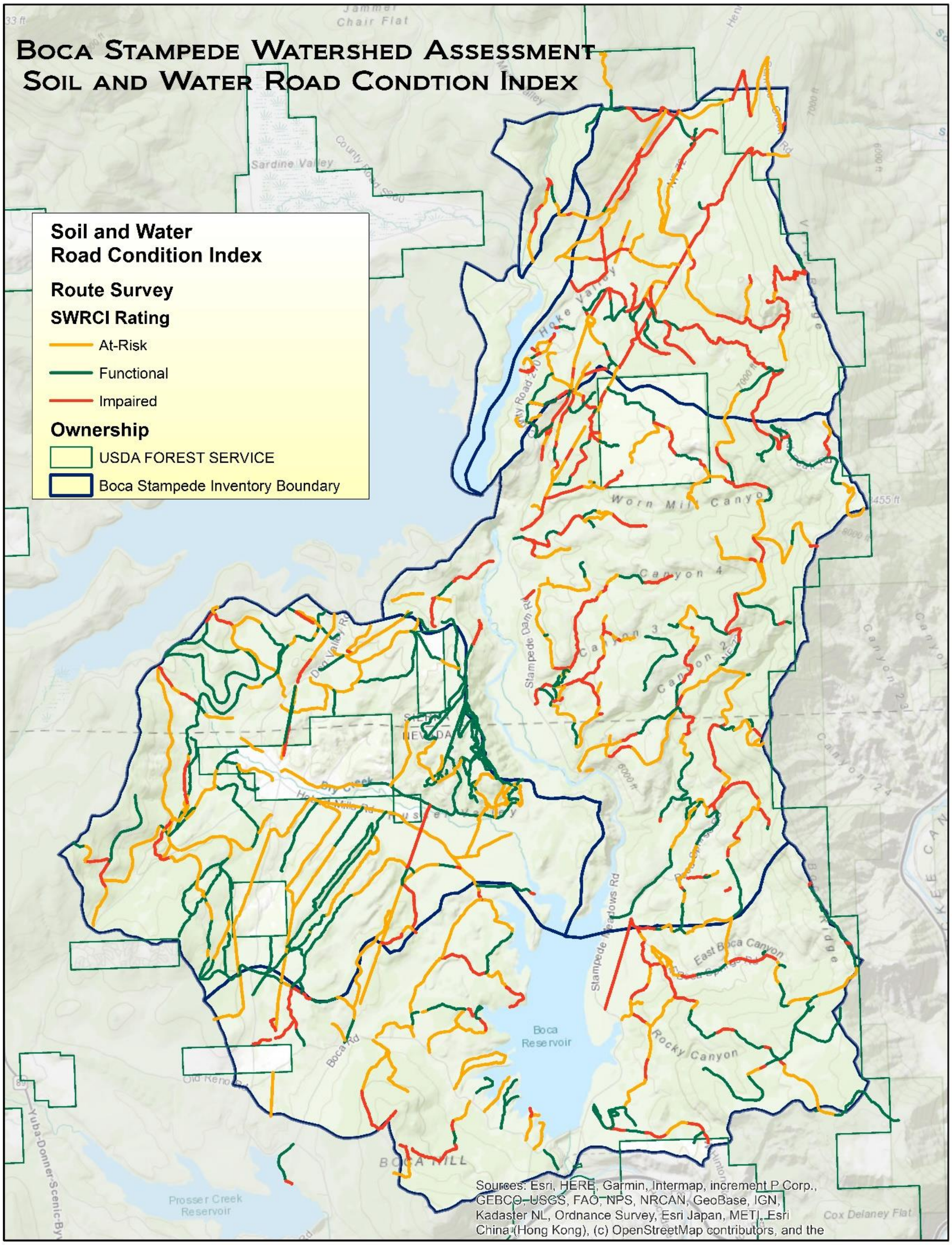


Figure 7. Soil and Water Resource Condition Index for the Boca Watershed Assessment Area.

Problematic Soils for Routes and Trails

Problematic soils for road placement in localized areas can be analyzed by identifying roads that are commonly problematic in terms of their tendency towards rutting, rilling, and eroding and reviewing SWRCI survey data and soil characteristics. For example, the 72 road recently failed due to a blocked culvert. This road is located on Bucking soils which are known to become easily gullied due to non-cohesive, granitic soil properties. Similarly, the Rouen Variant soil type is a silt loam which is prone to rutting and does not drain well, particularly when routes are developed over low angle topography; roads on Rouen Variant soils commonly exhibit frequent riling and rutting. Many of the routes in this assessment that are rated as “Impaired” intersect with Jorge Variant; these road segments were rutted and rilled in steep and flatter road alignments alike.

Summary

Much of the information collected for this section is intended to guide future planning and the relevant findings were incorporated into the EZ Connect Project EA. Conditions change frequently on roads and routes as a result of weather events and travel during non-sustainable soil conditions. New routes or the management of existing routes should take soil properties and other relevant variables into consideration in advance of construction or maintenance measures.

Stream Surveys

Stream survey data was acquired during the summer months between 2017-2019. Information gathered was quality controlled and compiled; supporting information includes spatial data and site photos.

Davies Creek- Merril, Davies and Hoke Valley Tributaries

Davies and Merril Creeks

Davies and Merril Creek contributes the northern most perennial streamflow into Stampede Reservoirs north arm. Runoff is contributed from forest service lands originating on the Sierraville Ranger District and outside of this analysis area. The largest impact to the drainages in these watersheds are the railroad system that was constructed in the 1920-30 timeframe in order to log the area. The railroad grades are often within the 100 year floodplain of the streams and streamflow was often redirected to facilitate placement of the grade. The result is that stream, riparian, and aquatic habitat degradation is pervasive throughout these watersheds. More information on the Davies Creek watershed can be found in the Merril-Davies Watershed Assessment (USDA 2003). Some restoration of railroad grades in floodplains and meadows was conducted at sites 1 (2010-2011), 2 (2006), 3 and 4 (2007), 5 (2005-2006), 6 (2005), and 7-8 (2010-2011) within and adjacent to the assessment area (Figure 8; USDA 2003).

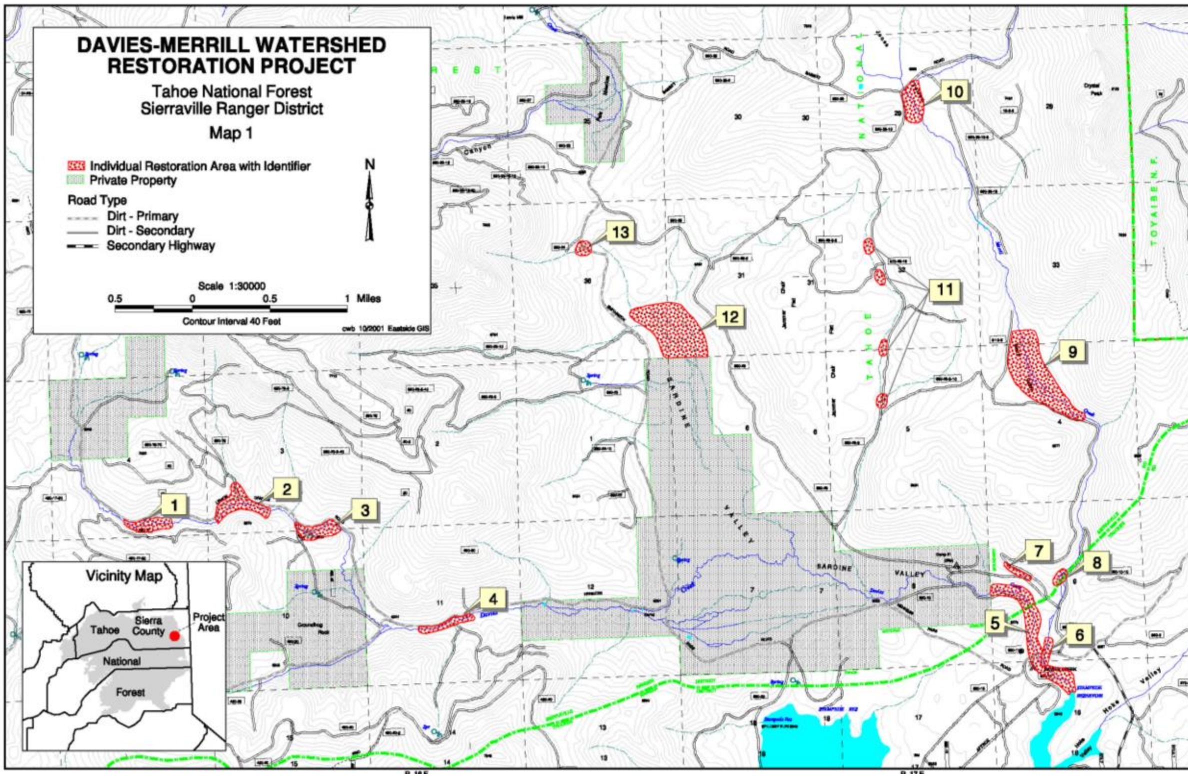


Figure 8. Davies- Merrill Watershed Restoration Project: Sites 5-8 are within the Boca Watershed Assessment Area and have been completed.

Hoke Valley

The next major tributary is the northeast arm of Stampede and originates from Hoke Valley. Hoke Valley's main drainage becomes increasingly incised as it moves down the valley and is actively eroding in sections. This valley is heavily impacted by old railroad grades, historic logging activity, roads, an underground petroleum pipeline and fiber optics cables and associated road. Significant impacts from steam donkey logging are visible along steep slopes within the northwest flowing tributary. Railroad grades cross many tributaries associated with this drainage and the main channel. There are many old skid trails and drag channels crisscrossing drainages and the hillsides. The petroleum pipeline and fiber optics cables run parallel, within, and across stream tributaries and cross the meadow. Due to its alignment, water is diverted from the pipeline and access routes. Tributaries to this drainage have significant groundwater discharge and perennial spring fed streams that support the riparian vegetation and wetlands that create the meadow system.

Lower Little Truckee River Tributaries

Northern Tributary

The Lower Little Truckee River watershed has also been negatively impacted by historic railroad systems and the logging practices of the region. The railroad grades are often built within the floodplain resulting in stream, wetland, riparian and aquatic habitat degradation. The northern most tributary in this subwatershed flows from forest service land, through private land, and back onto forest service lands. The channel is disrupted by numerous powerlines, utilities and roads at the lower end near where it parallels county road 270 and crosses it via a culvert with a ten foot outfall. The segment where the stream crosses the utility corridor has some head cutting identified, however it is not expected to migrate significantly and falls low on the list of restoration priorities. In the upper watershed, the 72-025 road connects USFS lands to private land and is situated directly adjacent to the floodplain of the drainage. It is located at the upper end of the canyon and then meets low angle topography on private land, which keeps the impact localized.

Worn Mill Canyon

The next significant tributary is Worn Mill Canyon, which joins the upper end of the Little Truckee River below Stampede Reservoir. Transmission lines cross the lower section of the stream channel and floodplain area. An old railroad grade was built within the broad valley bottom and has confined the stream channel and floodplain, leading to channel incision and erosion. Tributary streams are also headcutting due to the lowered base level of the main channel. Additionally, the upper end of this drainage is a perennial spring fed wetland and has a developed water source adjacent to the 72 road.

To improve stream conditions, stream stabilizing practices included use of old structures made of repurposed metal 'Marston Mats' (Figure 9). The structures were largely successful in agrading sediments above the structure, but the utility of the design is now outlived and most of these structures have failed (Figure 9). Failure is occurring with the stream cutting around one side of the structure resulting in the stream head cutting up the channel undoing the previous benefit of the structure. The headcuts range from 1 to 3 feet deep and the channel incision varies from 1 to at most about 5 to 6 feet deep. Polygon LTR-A and LTR-B covers restoration considerations for this tributary, the upstream railroad, and the weirs at the bottom end of the drainage (Figure 11).

Figure 9. Erosion from the stream cutting around the grade control structures shown above.

Canyon 4

As with Worn Mill, Canyon 4 drainage has been impacted by railroad grades constructed in the valley bottom and within the stream channel and riparian zone. More than 30 grade control structures were identified in this drainage, most constructed from Marston Mats but also log and stacked rock structures, many of which are no longer stable or show signs of degradation (Figure 10). The structures extend up the creek about ¾ mile to a sedge willow wetland at the confluence of a tributary. These structures were installed and maintained in the 1970s and 1980s. This area is part of the proposed restoration polygon LTR-B and LTR-A (Figure 11).

Throughout this lower reach, the channel is incised from 2 to about 6 feet. Above the sedge/willow wetland, the stream discharges through a narrow canyon and is incised up to about 9 feet in depth. There are old roads and railroad grades constricting the valley bottom along the stream, leading to the deep incised channel. Due to channel capture on some legacy routes, multiple parallel gullies have developed within a segment of the valley bottom.

At the upper end of the Canyon 4 drainage is a spring with fen characteristics and wetlands that were impacted from historic practices. A road and ditch at the bottom of this feature drain the wetland. Restoring the spring slope and topography could improve the function of this feature. This area is included in restoration polygon LTR- A (Figure 11).

Figure 10. Erosion of grade control structures.

Canyon 3

Moving south, Canyon 3 has an intermittent stream and the lower reaches are impacted by the 270-01-10, a closed road that runs parallel to the stream. This drainage has a highly mobile cobble/boulder bed, with some areas cut down 1-2 feet while others are only slightly incised. The 270-01-10 road provides access to LTR-A (Figure 11) and sediment transport along the old roadbed could be reduced with additional drainage features.

Canyon 2

In Canyon 2, before it enters the Little Truckee River, the stream crosses the Nevada County road 270 via a 5.5 foot diameter culvert. In the first 100 feet above the culvert there are 3 gabion baskets, spaced about 100 feet apart, the first was constructed in 1978, the second in 1979, and the third was constructed around 1986. The gabion structures are located above the depositional transition of an older alluvial fan, which appears to have common elevations with the abandoned terrace adjacent to the Little Truckee River. From here down, the channel is deeply incised through the old fan. The gabion structures are around 20-30 feet across and range from a one foot to a six foot drop. Above and associated with the gabion structures, flows have widened and are spread across the valley floor. This section is associated with area LTR-G and LTR-D (Figure 11).

Above the gabion baskets, the stream becomes channelized and starts to incise at depths between one to four feet. All tributaries enter at least one foot above the channel bottom, with many entering two to three feet higher. Stream destabilization may be the result of early logging but is also naturally influenced by geology and erosive soils and re-stabilization of banks through natural revegetation has not been successful.

In the upper reaches of Canyon 2 the drainage runs along a narrow valley bottom. The middle and upper reaches of the channel are characterized by a narrow, incised channel that had ponded water in small pools at the time of survey. Water does flow perennially for a few hundred feet just above the crossing with road 72-2-5.

Boca Springs Wash

Near the northeast arm of Boca Reservoir, the Boca Springs Wash joins the Little Truckee River. It has a very narrow valley bottom and an intermittent stream. The stream crosses the 270 road via an approximately eight foot diameter culvert. Most of the stream is slightly incised, between 0.5 to one foot, with a few areas of more severe bank erosion. A few old roads run parallel to reaches of the stream and there are a total of four road crossings. This area is associated with restoration polygon LTR-1 (Figure 11).

The Little Truckee River between Stampede and Boca Reservoirs was assessed and discussed under Chapter 4 Lower Little Truckee River. Stream restoration and fish habitat enhancement measures could be conducted throughout this section. Additionally, improvements to streamside recreation facilities at Boynton Mill Campground could occur to reduce potential erosion issues and have been proposed and partially funded through Nevada County RAC funding. These areas are associated with restoration polygons LTR-F, LTR-G and LTR-H (Figure 11).

Boca Reservoir

East Boca Canyon/East Arm

East Boca Canyon is an intermittent drainage discharging into the south east arm of Boca Reservoir. It feeds an alluvial fan that has numerous OHV routes that run through the meadow and intercept the drainage. Actions can be taken to improve hydrologic connectivity through restoring drainage pathways and decommissioning or rerouting roadways. This area was incorporated into the East Arm Restoration Site (see Chapter 5 below) that will improve hydrologic connectivity through the meadow and restore hydrologic connectivity across roads and has been funded by the National Fish and Wildlife Foundation (NFWF). It also includes the adjacent area to the south where many OHV routes were analyzed for construction or decommissioning as part of the EZ Connect Proposed Action.

Rocky Canyon

Rocky Canyon is a perennial stream that flows across an open fan that has linear geologic displacement and segmented mesic systems surrounded by wet vegetation such as willows, aspen, and sedges. In the upper reaches, the valley bottom is very wet. In several locations, the stream splits into several channels and high flows spread across this meadow area. The upper portion of the stream is slightly constrained by an old road and is incised in many places. There are also a few small headcuts, all less than a 1.5 foot elevation drop. This drainage crosses county road 270 via a two-foot diameter culvert.

Further south is an unnamed stream segment which has a broad floodplain which is fed from subsurface flows and a manmade pond that was developed just east of the Boca Reservoir Shooting Area. The water flows out of the pond and down a rocky substrate before joining other dispersed flows and subsurface water that feeds Rocky Canyon.

Boca Hill Tributary

The next surveyed tributary to the west of the dam is an intermittent stream that collects water off Boca Hill. It runs through a larger dry meadow in many small channels before reaching the stringer meadow that feeds the central arm of the reservoir. These channels cross County Road 890 via several culverts, each about one foot in diameter. At the time of survey, one of these culverts was almost completely filled with sediment. One channel is diverted down a ditch beside the road for about 300-feet until it reaches a culvert where it can cross. As the stream leaves the meadow and enters a more forested area, several active head cuts exist and the channel becomes incised. This incision is primarily driven by the changing reservoir elevation and the stream becomes perennial in this area. The channel is narrow and is incised about one to two feet, however just upstream from its entry into the reservoir, the channel is cut down about eight to ten feet and remains relatively narrow.

West Arm/Woodchoppers Spring

Further north, Nevada County Road 890 bisects a long meadow system and intercepts a western drainage that channelizes runoff down this road and back into the drainage through several meadows and into the reservoir. The surrounding seasonal meadow supports spring blooms of Camas lily (*Camassia quamash)*. This meadow is often accessed by OHV's during the wet and spring seasons resulting in trailing through what remains of the intact meadow system. During spring runoff, Nevada County Road 890 becomes the lower west arm stream of the drainage. Water moves off the roadbed near the junction of County Road 866 E, going through a culvert on the Old Reno Road and a 4-way junction before connecting back to the lower meadows. At the upper end of the west arm there is a smaller meadow system and the Old Reno Road crosses at the lower end of the meadow before heading across private land and back toward Prosser Reservoir. This area is referred to as Woodchoppers Spring.

Further down from the culvert the fiber optics line crosses diagonally over through the floodplain. Below the Old Reno Road at the meadow near the lower end of this tributary, is a manmade pond that supports frog habitat and other wildlife.

The northern most tributary is an ephemeral stream that runs through dissected terrain and the 890-14 road parallels one of these drainages before entering the reservoir. This road requires additional assessment to determine long term maintenance and drainage needs to protect it during spring or fall runoff periods.

Chapter 5: Opportunities for Watershed Improvement and Forest Resiliency Projects

While the Boca Watershed Assessment is not a complete or exhaustive list of issues and opportunities within the Boca watershed, it does provide land managers with an overview of issue areas that can be prioritized for restoration. The overview below includes restorative measures that can be taken to enhance or improve issues and impacts that have been documented by this assessment. This section starts with guidance for restorative measures for soils, streams, aspen and conifer complexes and is followed by opportunities and priorities by subwatershed.

Soils

Organic Matter Enhancement

Organic matter enhances water and nutrient holding capacity and improves soil structure. Managing for soil carbon through organic matter enhancement can enhance vegetative productivity and can reduce the severity and costs of natural phenomena, for example, issues caused by drought like pests and disease and erosion caused by floods. In addition, increasing soil organic matter levels can reduce the release of atmospheric CO_2 levels and help store carbon in the soil. Organic matter enhancement should be prioritized during roadbed restoration or in areas where vegetation is not readily recovered after some disturbance. Common disturbances in the Boca area include the scraping of topsoils such that the soils no longer have organic matter and the soil structure is inadequate to readily grow the natural potential vegetation (e.g. terracing or legacy routes). Organic matter is naturally recruited in mature forested areas by the accumulation of duff (e.g. pine needles, downed limbs, scensecent vegetation) after periods without fire. Organic matter enhancement can occur by utilizing duff from adjacent mature forested stands which will often include a local seed component and organisms that can increase the rate of native recruitment, as long soils are decompacted to restore pore space in disturbed soils.

Soil Decompaction

In the past, forest management practices included scraping and piling soil to control fuels or to prepare the ground to plant trees. These practices often scraped away the existing topsoil layer. Additionally, skidding of logs during Comstock Era logging practices and steam donkey timber operations caused deep furrows which displaced soils. Development of roads or skid trails can also result in compacted soils. Soil decompaction is a measure that improves infiltration and should be combined with revegetation or mulching measures to increase longterm success.

Decompaction can be achieved using a dozer/backhoe, excavator, or similar equipment. During decompaction, it is important to disrupt furrows and linear features by implementing restorative actions perpendicular to the slope. This ensures that water does not collect in a continuous fashion across or down the newly decompacted area. For instance, furrows can be disrupted by staggering blade or bucket tines and by placing water bars intermittently along the length of a compacted route or surface.

Terrace Regrading

Terraced areas within the assessment area are primarily within plantations and a logging/fuels reduction treatment combined with a regrading treatment may be most beneficial for this landscape. Regrading treatments would be designed based on exisiting and targeted final slope and could include the integration of chipped smaller material from fuels reduction treatments to help improve water holding capacity. While regrading would result in short term impacts, over a longer timeframe the restored slopes would have improved soil productivity, enhanced wildlife habitat, and restored hydrologic connectivity.

Legacy Route or Road Obliteration

Across the Boca watershed, the targeted removal of legacy fills and berms will assist with the reconnection of hydrologic features. Other measures that can be taken to reduce road related hydrologic concerns include pulling back road shoulders and cut and fill embankments. These types of restoration actions on roads ensure overland flow is reconnected across hillslopes rather than disrupted within the road prism. For drainages that cross roads, reconnecting drainages to natural drainage features rather than re-routing them down road diches and through misaligned culverts will benefit the restoration of natural flow paths and reduce the potential for sediment transport from roads into waterways. In areas where sensitive resources along the route need protection, exclusion from ground disturbing activities may be necessary.

Vegetation Management and Forest Health

The Ladybug Forest Health Project will treat 2,927 acres in the Hoke Valley and Lower Little Truckee River subwatersheds. This includes hand and mechanical fuels treatment, commercial thinning, and under burning. Beginning in 2021, implementation of the Ladybug project should additionally increase stream flow in Hoke Meadow through thinning and prescribing burn treatments across 980 acres within the overstocked forests in the upper Hoke watershed. These treatments increase the amount of available soil moisture and sunlight for individual trees, enabling remaining trees to be more resistant to insects and diseases (Boisrame, et al. 2017; Slaughter and Parmeter 1989, Ferrell et al. 1994) and to high severity wildfire (Steel et al. 2015). Funding for the Ladybug Project has been secured by the USFS and through a grant received by the National Forest Foundation from The California Wildlife Conservation Board.

Aspen

Quaking aspen (*Populus tremuloides*) stands support a wide range of plant and animal species. Aspen stands often occur on the meadow or wetland to forest transition zone and are an important refuge for flora and fauna of the Sierra Nevada. Due to fire suppression, severe drought, grazing, conifer competition, and mortality from disease and insects, aspen are in decline across the West (Campbell and Bartos 2001; Di Orio et al 2005). Although aspen are only documented to occur across a small percentage of the Boca watershed, they are an important component of the biodiversity of the area. Increased temperatures and drought, which are expected to be more frequent under climate change, pose a risk to aspen and could decrease a stands health, abundance, and regeneration. Maintaining and restoring healthy aspen communities at a landscape-scale through conifer removal, prescribed fire, protection from herbivory, and root separation has the potential to mitigate climate stressors, increase resiliency, and decrease stand fragmentation.

Meadows, Streams and other Mesic Features

Meadow and stream restoration opportunities are targeted at restoring floodplain and streamflow connectivity to benefit stream, wetland, and floodplain habitat function and other ecosystem services provided by these systems. Actions to restore these areas may include gully and channel fill measures to raise the elevation of the streambed, installation of wood structures (e.g. BDAs), reconnection of abandoned stream segments, and the removal of access routes and fill material that impede flow across a floodplain surface or that can be redistributed to restore floodplain connectivity. Additional actions may include taking specific actions to enhance riparian and fish habitat, such as the development of backwater pools, woody debris placement, rock weirs, riffles and other hydrologic design features. Restoring and enhancing natural springs and disturbed drainage surrounding springs and fens will support the flow of perennially wet systems. Where historically modified marston mat weirs or other old structures are failing, more sustainable restoration actions can be designed to create continuity of sediment transport and hydrologic connectivity.

Other Point Source Issues

Source points survey information collected are available for reference. Issues identified include: shotgun culverts, historic road or access channel fills, previously developed weirs, headcuts and other smaller scale point features. These points are included in the survey data and that data should be reviewed when approaching a larger project to determine feasibility of inclusion in the priority projects identified in the sections below.

Education and Outreach

There are several opportunities to enhance educational awareness of the Boca watershed area and its physical, biologic, and historic resource areas. Providing information that is accessible to visitors about the areas recreation opportunities while highlighting the importance of the areas wildlife, invasive aquatic or biotic species, sensitive botanical species, and historic and prehistoric sites will help better protect the area through a shared understanding of the many values it contains. This component could be provided through informational and interpretive signage, pamphlets, public tours, hikes or trail rides, site visits, and volunteer restoration opportunities, as well as through educational programs offered by USFS partners.

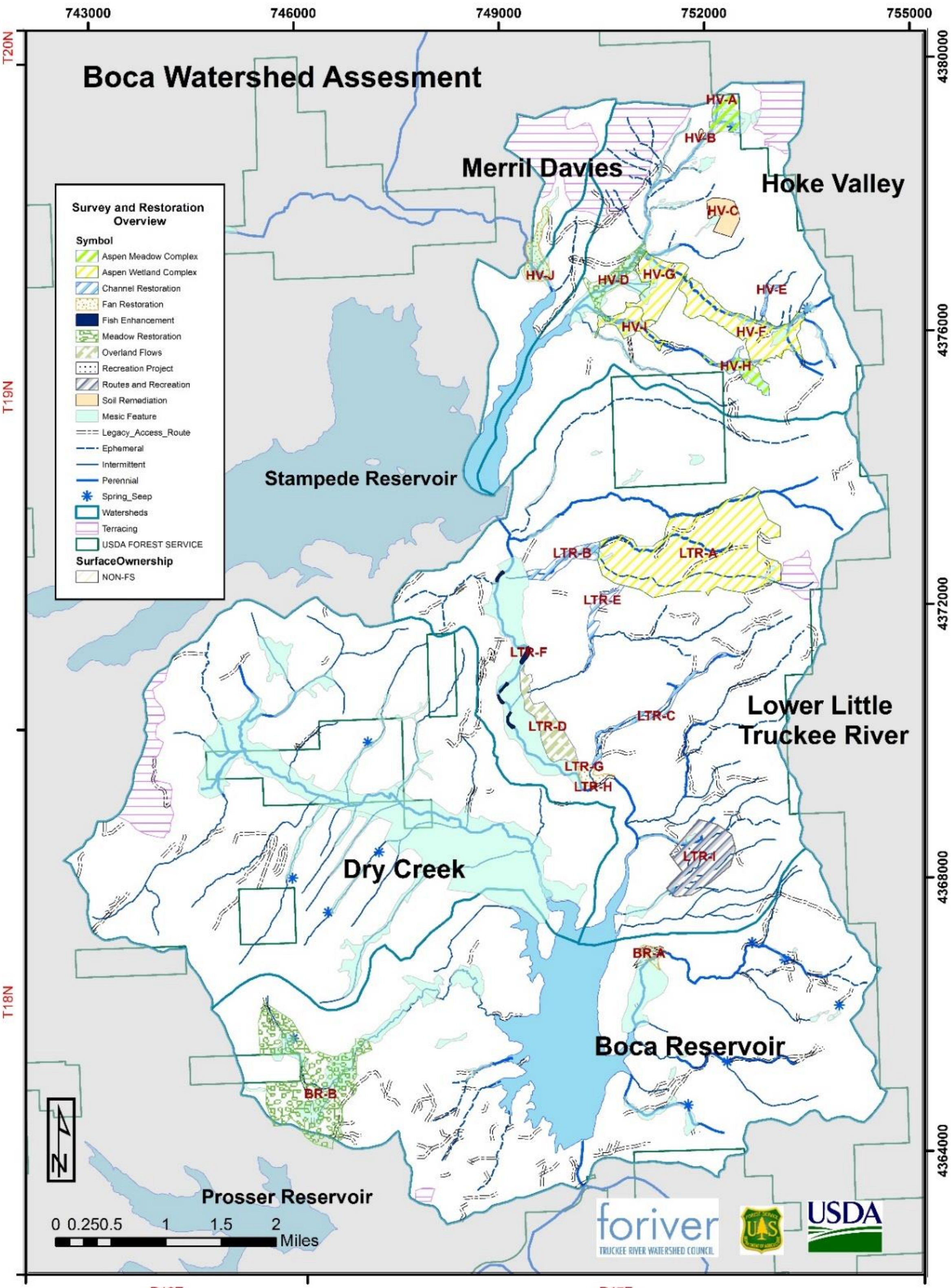


Figure 11. Boca Watershed Assessment Restoration Opportunities

Opportunities by Subwatershed

Survey data and background data gathered as part of this assessment have highlighted a variety of different areas and opportunities for restoration actions within the Boca watershed. While the primary objective of the assessment was to identify hydrologic improvements, many of the priority areas that have been identified might also benefit from aspen and timber improvements that support restoration of a historically impacted hydrologic feature.

Dry Creek Watershed Restoration

The Dry Creek Watershed Assessment was completed in 2013 (Figure 12). The assessment found that hydrologic function of the watershed was heavily impacted by past activities including clear cut logging, roads, railroads, and intensive grazing. Sites 1 through 8 were identified as good opportunities for restoration to improve overall watershed function. Since the assessment was completed, several projects have been completed in the Dry Creek watershed.

Between 2015 and 2017, Phase 1 of the Dry Creek Restoration Project was completed. This first phase included the restoration of two intermittent tributaries by decommissioning roads that diverted flows and filling in gullies so flows can access remnant channels in the meadows. Phase 2 of the project was completed in 2019. A large meadow on the main stem of Dry Creek was restored, roads were removed or relocated on two tributaries, and an eroding gully and headcut were repaired. Sites 1 and 4 were completed between 2015 and 2017. Sites 5, 6, 7, and 8 were completed in 2019 (Figure 12). Sites 2 and 3 have not been completed.

Since the watershed assessment in 2013, nearly 51 acres of meadow and over 2,500 miles of stream channel have been restored in Dry Creek (Figure 13). This includes over 30 acres of restored meadow on private land, with efforts being led by the Truckee River Watershed Council. In addition, approximately ¼ mile of road previously positioned through drainages were obliterated.

There is still additional work that can be completed in the Dry Creek watershed, which is identified in the assessment as Areas 2 and 3.

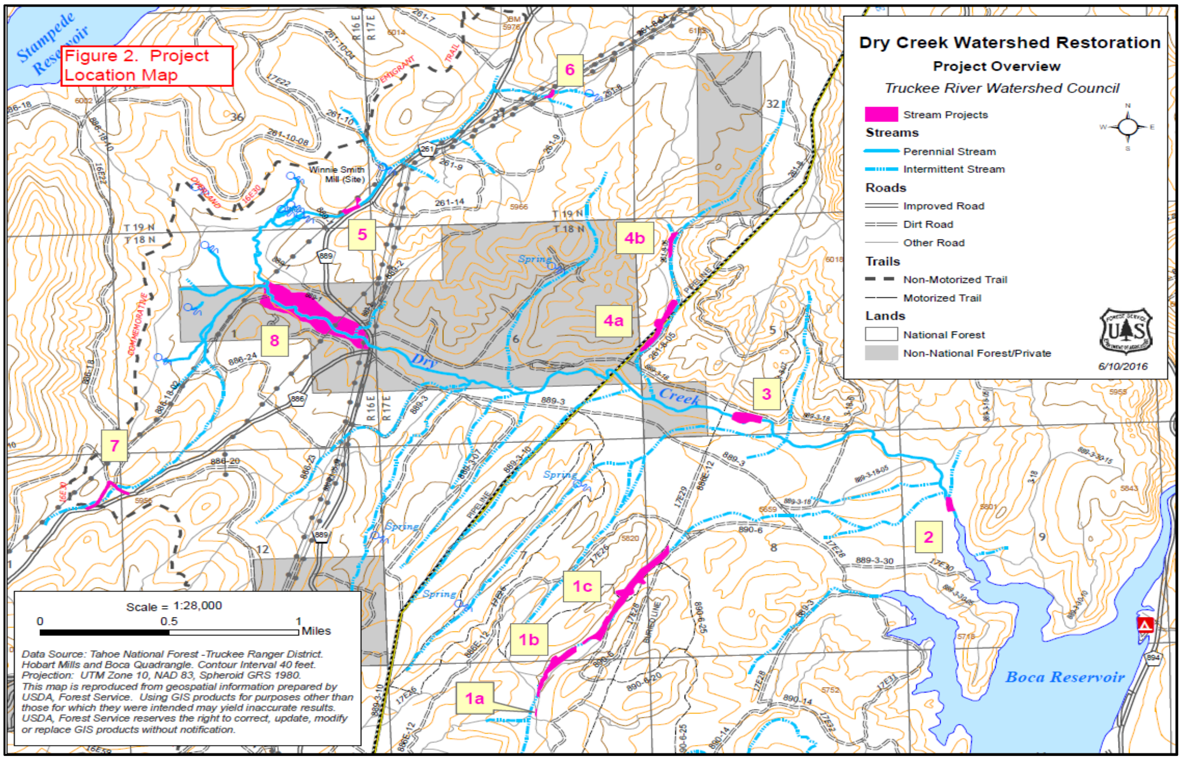


Figure 12. Dry Creek Watershed Restoration projects. Sites 1 and 4 were completed between 2015 and 2017. Sites 5, 6, 7, and 8 were completed in 2019. Sites 2 and 3 have not been completed.

Figure 13. Site 4 of the Dry Creek Restoration project was completed in 2016. Before (left) the meadow was dominated by sagebrush. In 2019 (right), wet vegetation had taken over the meadow.

Merril Creek, Lower Davies Creek

The Merril Creek and Lower Davies Creek potential restoration areas are shown in Figure 11. The primary characteristics influencing this subwatershed include terracing shown in the upper portion of the assessment area (Figure 14). Some evidence of past terracing failure can be seen on the LiDAR DEM and may have contributed to the braided fan (shown just above the north arm of the stampede reservoir). Restorative actions in HV-J could result in increased fan function (Figure 11). This fan was disrupted in the past from railroad grade and roads developed across the drainage. It is possible the function was further affected from the terrace failure.

Figure 13. Nonlinear, nonvegetated features and exposed subsoils from terraced area on south facing slope along Merril Creek.

This area could benefit from additional planning and more analysis to determine where actions should occur and would be most beneficial. Alluvial fan/road interaction improvements could help to reconnect the hydrology in this area. In addition, terracing restoration may result in some ecosystem services for wildlife and redistribution of the hydrologic system across resources.

Hoke Valley

Soils

Soils restoration priorities within the Hoke Valley watershed include areas showing signs of soil impact, including HV-B and HV-C (Figure 11). Area HV-B (Figure 11) is an area that is used as a logging landing and has had recreation impacts that have reduced soil health. Mechanical site prep in this area was completed in 1981 followed by planting. This area should be assessed for potential soil remediation possibilities. Similarly, HV-C is an area that shows signs of high soil impact that can be seen on the LiDAR DEM and aerial photography. This area needs further assessment to determine viability of soil remediation practices.

Aspen Meadow Complex and Aspen Wetland Complexes

In the Hoke Valley main stream channel, early Comstock logging practices included heavy impact and transport of logs through drainages. Much of what we see today in this system is a result of those activities. The ultimate impact was evidenced by the large incision within Hoke Valley meadow which has significant incision. Photos can be seen in the expanded discussion below.

HVA and HVH (Figure 11) are project areas which both contain wet complex areas associated with aspen that are surrounded by conifer. HVA is associated with a meadow system and forest service road 860-02, named Sunrise. This road segment is proposed to be rerouted out of the wet area and more work could be conducted within the meadow system. Some past landing locations within the upper drainage are legacy impacts that could use further review to aid in improving the hydrologic system supporting the meadow in this area.

HVH is similar, however the bottom end of this site has soils that act as a recharge/discharge zone to the downstream drainage. This area shows numerous signs of access impacts. While portions of this site show signs of a dry meadow system it appears to be critical to stream function. The aspen stand includes encroaching conifers that should also be treated to improve overall habitat function and future sustainability. Further assessment of this area is needed to attain proper function in this area.

HVFD, HVG and HVI project areas (Figure 11) all contain wet complex areas associated with aspen that are surrounded by conifer and a goshawk PAC. However, these are associated with very wet complex areas and geologically controlled groundwater. Ditching, draglines and other impacts have significantly changed the hydrology in the associated drainage areas and work could be done to improve drainage here.

Lower Little Truckee River
Aspen Meadow Complex and Aspen Wetland Complexes

In the Lower Little Truckee River, LTR-A (Figure 11) contains wet complex areas and spring fed systems that have become compromised and could be improved by restoring topographic features to improve surface and subsurface hydrologic connectivity. Other components associated with this area that may benefit from restorative practices include a goshawk PAC and numerous legacy routes and road engineering practices or OHV routes that contribute to erosion and sediment transport.

Channel Restoration

LTR-B, LTR-E and LTR-G (Figure 11) are areas associated with legacy routes closely connected with drainages and areas where past practices resulted in considerable stream channel incision. Many of these were treated with gabion structures and other previously widely used practices. While the sites have accumulated sediment, their utility is now undermined by current conditions. Most structures, especially those outside of wetlands, are now failing. The streams are now cutting around some of the structures and contributing to sediment transport as presented in Chapter 3. These areas could be assessed to improve stream channel function, increase stability and enhance hydrologic function.

Riverine/Fish Habitat Improvements

LTR-F (Figure 11) involves project elements that can be worked on in partnership with Trout Unlimited (TU). TU has proposed fish habitat improvements along reach segments of the Little Truckee River that would add to the fish improvement project completed in 2015. Under the LTR Fish Habitat assessment, the stream reach between Boca and Stampede reservoirs was identified to be lacking in fish habitat features and requires additional actions to improve fish habitat within this area.

Routes and Recreation

LTR-I is associated with existing forest service routes (Figure 11) and some of these routes have been addressed by the EZ Connect Project. However, a closer look at road and stream interactions needs to occur in the context of proposed actions and existing conditions during implementation. Primarily, the combination of road density and poorly located roads are affecting stream function. The EZ Connect Project proposed action did consider this issue in the final proposed action however, it is possible further review could aid in identifying areas that may continue to improve the hydrologic system in this area.

Boca Reservoir

Meadow Restoration

In the Boca Reservoir areas BR-A and BR-B are areas associated with existing routes that disrupt flows to the adjacent area meadows (Figure 11) and require additional assessment. Some of these are already slated to be decommissioned or restored in the EZ Connect Project. Additional solutions could be determined near the inlet to the reservoir where fluctuating water levels increase incision at the inlet of the drainages on the west shore of Boca.

Priorities for Restoration

Hoke Valley Meadow Restoration

The Hoke Valley Restoration Project HV-D is currently in the design phase (Figure 11). The meadow has been impacted by historic railroad grades and logging, in addition to an underground fiber-optic cable and petroleum pipeline that run across the meadow. This project will restore the meadow and main channel between County Road 270 and Forest

Service road 860-5. The project will address meadow incision and reconnect meadow soil hydrology.

Sunrise Meadow Restoration HV-A

This site will improve hydrologic connection of 21 meadow acres, 750 feet of stream channel, and improve hydrology for 4.5 acres of aspen habitat. Implementation actions at this site may include protecting and expanding existing meadow habitat by re-routing a road that bisects the upper edge of a meadow and reconnects hydrology across the restored road surface. Restoration actions will include importing material to restore topography and soil conditions in decommissioned road segments and compacted sites. Additional measures include the development of a re-routed road segment outside of sensitive areas, restoring the decommissioned segment of the existing roadbed and re-contouring to match adjoining grades, reconnection of historic drainage paths to restore hydrology to a degraded meadow, and seed and mulch disturbed areas with native materials.



Canyon 3 Valley Fan Stampede Meadows

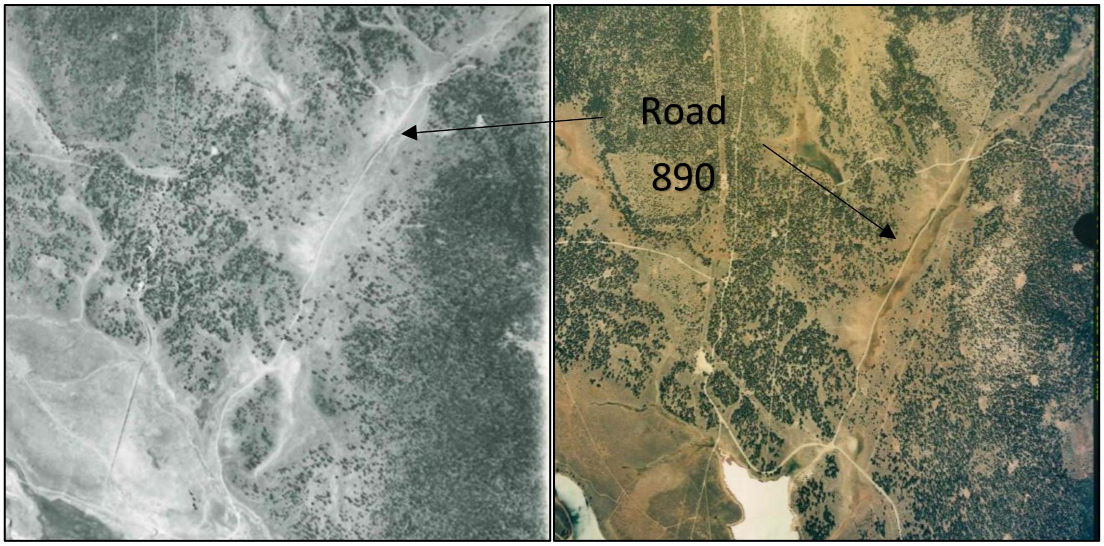
This site will improve hydrologic processes across a mountain valley fan to restore two meadow acres and 450 feet of intermittent stream. This site was assessed and incorporated into the proposed action and decision memo for the Little Truckee River Habitat Improvement Project. A railroad grade bisects this meadow, interfering with natural flow paths. Implementation actions at this site include protecting and expanding meadow habitat, reconnecting drainage paths, and removing and restoring the damaging railroad grade. The project will also enhance habitat for *Ivesia sericoleuca* by retaining shallow pools preferred by this species. Actions will include the removal of railroad grade fill from meadow. Use some material onsite to bring up base elevations of drainage, off haul most material to use at the East Arm or Sunrise Meadows sites. Grade to include vernal pools for *Ivesia* habitat, match meadow surface, reconnect drainage swales across grade and seed and mulch with native materials.

East Arm Boca Meadow: BR-A

This site will address 106 meadow acres, 2,000 feet of stream channel, and will include 5.1 miles of road restoration/decommissioning. OHV routes have impacted a historical alluvial fan at this location, leading to the desiccation and degradation of meadow habitat. Implementation actions at this site include protecting and expanding existing meadow habitat, reconstructing the alluvial fan to restore meadow hydrology, restoring stream drainages to historic paths, decommissioning and restoring damaging OHV routes across the alluvial fan, removing roads from stream drainage paths, and installing or maintaining gates (or other structural protections) to prevent access to the site. Actions will include removing road fill, re-contour roadbeds to match existing surfaces and allow overland flow to be reconnected to the meadow, reconnect drainage paths, and rebuild alluvial fan. Off-haul from the Canyon 3 Valley Fan Stampede Meadows site will be used to fill incised road segments and stream channels. Spread native seeds and mulch on disturbed areas. Install gates or other structural protection to block future OHV access.

890 Meadow Bisect BR-B

This area is proposed for stream and meadow restoration. The existing county road bi-sects the meadow and intercepts the west drainage that contributes spring flow down this drainage to the reservoir (Figure 14). It is a seasonal meadow that supports spring blooms of Camas lily, *Camassia quamash*. This meadow is often accessed during the wet season and results in unauthorized OHV trailing the remaining adjacent meadow system.



1939 2005

Figure 14. Since before 1939, County Road 890 has run through this meadow on the west side of Boca Reservoir, just north of Prosser Reservoir. To help restore the meadow, this road could be rerouted.

Conclusions

The Boca Watershed Assessment highlights the need to take a more active management approach in terms of stream and wetland restoration actions, addressing legacy impacts, forest health treatments, and ongoing travel and recreation management. Stream and wetland restoration measures that have been completed in the past or that are proposed here may require ongoing management and should be monitored to ensure that restored function and habitat value continues to be achieved over time with special consideration taken after large storm events. Legacy impacts from past activities, fire, and abandoned infrastructure are important to monitor and prioritize for remediation if necessary. Forest health and fuel reduction efforts should be designed and implemented to protect sensitive habitats and encourage healthy tree and vegetation growth while protecting streams and wetlands. Travel and recreation management should be focused on improving recreational experiences and infrastructure while decreasing the risk of soil compaction or erosion, sediment delivery to waterways, and hydrologic disconnection of streams. Over the last several years, the Tahoe National Forest and its partners have planned projects to address many of these issues, through Ladybug EA, the EZ Connect Project, the Little Truckee River Fish Habitat Improvement Project, the Dry Creek Watershed Assessment and implementation projects, Merril-Davies Creek Projects, and future proposed projects included in this watershed assessment. The successful implementation of these projects and future projects will enhance the Boca watershed and reset the baseline for ongoing management and restoration actions into the future.

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