Aquatic Condition Report for the Upper Battle Creek Watershed

Lassen National Forest
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Introduction

This report is the product of an agreement between the Lassen National Forest and the Battle Creek Watershed Conservancy. The objectives of this report are to: 1) summarize aquatic habitat inventories for all of the upper Battle Creek watershed tributaries under USFS jurisdiction, 2) evaluate condition of Riparian Habitat Conservation Areas and make treatment recommendations for those in poor condition, 3) identify road related erosion sites within riparian zones.

Watersheds
Sub-watersheds of the analysis area drain into the North and South forks of Battle Creek. This area includes 18 sub-watersheds that range in size from 2,162 acres (un-named sub-basin draining upper Battle Creek Meadows (BC-2)) to 10996 acres (Middle South Fork Battle Creek Meadows) and range in elevation from 2900 feet (lowest point in the Middle South Fork Battle Creek Meadows sub-basin, downstream from Battle Creek Campground) up to 10300 feet (highest point in the Manzanita Chutes sub-basin). The mean elevation for all sub-basins in the upper Battle Creek watershed is 5968 ft. This elevation range places much of the watershed within the rain on snow zone that extends from approximately 4,000 to > 6,000 feet. Rain on snow zones are characterized by heavy, warm rain on substantial snowpack, resulting in rapid snowmelt and high runoff rates.

Biological Description- Fisheries/Aquatics
Streams within the analysis area support native (rainbow trout) and introduced (brown and brook trout) salmonids. Anadromous salmonids are not present within the portion of the Battle Creek watershed considered in this analysis. Anadromous migration to the analysis area is blocked by natural gradient constraints. Rainbow trout were identified in Martin, Nanny Creeks, Manzanita, North Fork Battle, South Fork Digger, North Fork Digger, and South Fork Bailey Creeks in surveys conducted in 1976, 1997, and 2000. Surveys in 1997 identified rainbow trout in both Summit Creek and several unnamed tributaries of Battle Creek Meadows which drain to Battle Creek from the south and southeast. Brook trout were observed in South Fork Bailey Creek and the headwaters of South Fork Digger Creek during surveys conducted in 2000. No fishes were found in the headwaters of Panther Creek during observations and surveys made in 1997-00.Historical sightings of Cascade frogs (*Rana cascadae*) have been recorded within the analysis area. Zwiefel (1955) reported Sierra Nevada yellow-legged frog (*Rana boylii sierrae*) in Martin Creek, and Grinnell et al (1930) reported western spotted frog (*Rana pretosia*) in Battle Creek meadows, Summit Creek, Manzanita Lake, and near Brokeoff Meadows. Sierra Nevada yellow-legged were re-examined and later determined to be Cascade frogs. What were called western spotted frogs are now considered Cascades frogs (per Jennings, pers. comm. with Susan Chappell,). Cascades frogs were not found in Martin Creek, Nanny Creek, North and South Fork Bailey (near Brokeoff Meadows), and Manzanita Creek by National Biological Survey Crews in 1997, or by Forest Services crews in summer and fall of 1997 and 1998, in the spring of 1999, or during early summer of 1999

and 2000 (Fellers, 1994; Fellers 1998; USDA, Forest Service Amphibian Database, 2000). Summit Creek was surveyed for amphibians by Forest Service crews in the spring of 2001.

There are no current of historical records of mountain or foothill yellow-legged frogs or California red-legged frogs in the analysis area (USDA, Forest Service Amphibian Database, 2000). The nearest known historical records of mountain yellow legged frogs is in the vicinity of Jonesville, approximately 20 miles southeast of Mineral. The nearest existing population of mountain yellow-legged frogs in at Boulder Creek, a tributary to Antelope Lake, approximately 50 miles southeast of Mineral. Foothill yellow-legged frogs are present in Mill, Deer, and Antelope Creeks below 3500 feet and are common below 2000 feet. Although there are no records of this species in the upper Battle Creek watershed, they are probably present downstream.

Historically, the California red-legged frog was found west of the Sierra-Cascade crest at elevations below 5,000 feet elevation (Jennings and Hayes 1994). Currently, in the Sierra Nevada California red-legged frogs have only been found above the 3,500 foot elevation level at one location, Swamp Lake area of the Tuolumne River drainage (Jennings & Hayes 1992). There are no existing populations of California red-legged frogs in the Battle Creek watershed (Fellers, 1998). The nearest known historic population of California red-legged frogs is known from a pond at Elliots Ranch along Paynes Creek, approximately 10 miles southwest of the analysis area, in an adjacent watershed (Grinnell et al. 1930, Jennings and Hayes, 1996).

Geology

The geology of the area within the Mineral Management Area consists of Pleistocene volcanics which include basalts, andesites and pyroclastics in the region from Morgan Mountain south to Mineral summit. There are a few dacite domes near Morgan Mountain and some areas of rhyolite thoroughout the Summit and Martin Creek watersheds. Two small locations of underlying Sierran granite are exposed, one in the headwaters of Martin Creek, and the second east of McGowan Lake in the headwaters of Nanny Creek. The valley floor at Battle Creek Meadows and near Mineral consist of recent alluvium. The southern face of Hampton Butte is composed of older Pliocene volcanic andesite and basalts. The lower, western slopes of Morgan Mountain and Mineral Summit consist of even older Miocene volcanic pryoclastics. Most of the area north of Hampton Butte was once glaciated.

The basic processes which created the landscape within the analysis area include extruded volcanic andesites, basalts, rhyolites and mudflows that occurred during the last 30 million years. Within the last century and a half, Lassen volcano and nearby Cinder Cone have erupted and have helped to create the diverse landscape, topography and soils which are present now. During the ice ages, the higher elevations had glaciers which carved out pot-hole lakes and typical "U" shaped canyons found in Martin Creek Canyon.

The soils within the analysis area have one common feature, the preponderance of surface and subsurface rock. Soil series that are typical of meadow soils are found along riparian areas. These are the Chummy and Nanny series. Both are formed from alluvium and of medium texture. They occupy a relatively small proportion of the soils in the analysis area but play an important ecological function in their retention of water. In addition, the area has a component of colluvial land, rock land and rubble land. All of these areas tend to be found on steep slopes and are characterized by the presence of large boulders on the surface. Rhyolitic soils that are found in the area include the Lyonsville and Jiggs gravelly sandy loams. These soils are found on slopes from 10 to 65% slope and dominate the area between Morgan and Mineral Summit. The Windy, McCarthy and Cohassett soils are formed from volcanic parent material usually of andesitic and basalt origin. The erosion hazard for these soils is generally low to moderate up to 35 percent slope.

Areas of mass instability have been identified through review of past reports and field surveys. These areas are most often associated with saturated rhyolitic soils on very steep (>60%) slopes. Unstable landforms associated with streams exist in Summit, Nanny, and Martin Creek sub-basins.

Methods

Aquatic habitat inventories were conducted following the Lassen National Forest field extensive Streamscape Inventory (Lassen National Forest, 1996), and the USDA, Region 5 field intensive Stream Condition Inventory (SCI) (USDA, Forest Service, 2000). All streams were inventoried using the Streamscape method and the meadow reach of SF Bailey Creek was inventoried using the more intensive SCI. Stream data were collected by reach. Reaches were delineated based on changes in Rosgen channel type or changes in channel continuity at road crossings (Rosgen, 1996). Surveys were initiated at the Lassen National Forest Administrative Boundary and continued to the Lassen Volcanic National Park Boundary.

The near-stream road inventory was conducted simultaneously with the field extensive stream inventory. When near-stream roads were encountered, field observations were recorded detailing the extent to which the road functioned as a sediment source. The degree to which the road was contributing sediment was determined by comparing road related sediment source area to other sediment sources.

Stream data were summarized by reach and grouped by channel type for each stream. Battle Creek data were compared to data collected from streams on National Forests throughout California to determine the relative condition of Battle Creek tributaries. This regional data is summarized for reference (unmanaged) and non-reference (streams from watersheds with land management activities) streams.

Results

Regional Data

Regional data were obtained from 96 streams in reference and non-reference watersheds throughout the National Forests of California. Of the 96 regional streams, 24 were classified as reference streams and 72 were classified as non-reference. There were 38 streams of the Rosgen B channel type (transport channel) and 58 in the C or E channel type (response channel). Thirty-one of the B channels were non-reference and seven were reference. Forty-one of the C/E channels were non-reference and 17 were reference.

Analysis of regional data indicates there are differences in condition for all stream attributes except entrenchment ratios of transport channels (table 1). Pool tail fines, bank angle, and width-to depth were generally lower in reference streams, while shade, bank stability, and entrenchment were higher.

Table 1.- Significance table for USDA-Forest Service regional stream data, Rosgen B and C/E channel types.

Stream Attribute	**Non-Reference**		**Reference**	
Response (alluvial) Streams	**range**	**mean**	**range**	**mean**
% Pool Tail Fines	0-100	37.8	0-100	19.7
% August Stream Shade	0-100	27.5	0-100	33.7
% Bank Stability	8-100	59.9	32-100	86.3
Bank Angle	0-190	135.6	0-190	102.7
Width-to-Depth Ratio	1.2-107.3	26.9	1.4-46.5	12.8
Entrenchment Ratio	0-100	49.7	0-100	86.8
Transport Streams				
% Pool Tail Fines	0-100	16.4	0-98	9
% August Stream Shade	1-100	51.3	1-99	58.5
% Bank Stability	6-100	58.6	36-100	76.8
Width-to-Depth Ratio	4.05-104.5	20.1	12.5-49.4	23.7
Entrenchment Ratio	1.02-16.9	2.2	1.1-13.5	2

South Fork Bailey Creek SCI

The alluvial meadow reach of upper South Fork Bailey Creek is considered a regional reference stream and, as expected, compares favorably with other reference streams in the region (table 2). The percent shade, percent pool tail fines, percent wood formed pools and residual pool depth values indicate a condition that exceeds the average regional reference condition. Other attributes that compare favorably with average reference values include width to depth, bank stability, and bank angle.

Table 2.- Stream Condition Inventory reach data summaries for South Fork Bailey Creek and R5 reference and non-reference channels of similar morphology.

Stream	Reach Length (m)	Gradient (percent)	Bankfull Width (m)	Width to Depth Ratio	Shade (percent)
SF Bailey	1362	0.6	6.2	17	62
R5 Reference	variable	0.8	-	13	34
R5 Non-reference	variable	1.2	-	27	28

Stream	% Pool Tail Fines	Residual Pool Depth (m)	% Wood Formed Pools	% Bank Stability	Bank Angle (degrees)
SF Bailey	7.3	0.61	63	69	115
R5 Reference	20	0.52	22	86	103
R5 Non-reference	38	0.59	17	58	136

Battle Creek Tributary Field Extensive Data (Streamscape Inventory Results)

Fifteen stream channels comprised of 66 reaches and spanning close to 25 miles were surveyed in the upper Battle Creek watershed (table 3). Reach lengths varied from 200 to 1600 meters, averaging 585 meters each. Stream channel and riparian attributes were collected for each stream. These attributes include gradient, in-channel large woody debris, large wood recruitment, pool frequency, residual pool depth, percent surface fines in pool tails, percent shade and pool tails, bank stability, and sediment sources.

Table 3.- List of streams inventoried in the upper Battle Creek watershed.

Stream	Watershed	No. of Reaches	Survey Length (meters)
Martin	South Fork	5	3500
Trib to Martin	South Fork	3	1300
Nanny Creek	South Fork	3	2500
Summit Creek	South Fork	6	3300
Trib # 1 to SF Battle	South Fork	1	900
Trib #2 to SF Battle	South Fork	2	1300
Panther	South Fork	3	1350
Dry Lake Outlet	South Fork	2	800
Dry Lake Trib "A"	South Fork	2	900
SF Digger	North Fork	9	4800
NF Digger	North Fork	10	5300
South Fork Bailey	North Fork	4	2500
North Fork Bailey	North Fork	5	3000
Manzanita	North Fork	5	2700
NF Battle	North Fork	6	3900
Total		66	38050

Gradient

Channels within the project area are typically steep. Channel gradients range from 1.8% to >20% with an average gradient of 7.5%. Eleven of 66 reaches have gradients less than 3%, comprising only 1% of the total stream length surveyed. These reaches are located

on Summit Creek upstream of Highway 36, Panther Creek upstream of Dry Lake, SF Digger Creek upstream of Forest road 30N17 (17 road), upper NF Digger, SF Bailey at Brokeoff meadows, and along portions of Manzanita and NF Battle Creeks.

Pool Tail Fines

Average percent pool tail surface fines ranged from 2 to 58% per reach. 40% of the streams have at least one reach where fines exceed 15%. Streams with average fines equaled or exceeded 15% include Trib to SF Battle #2 (22% pool tail fines), SF Digger (15% fines), Dry Lake Outlet (43% fines), SF Bailey (29% fines), Manzanita (58% fines), and NF Battle (17% fines).

The average fines for Battle Creek tributary transport and response channels are slightly higher than the average for regional reference streams (table 4). There is an eight percent difference for response channels and a three and one half difference for transport channels.

Table 4.- Comparison of Battle Creek tributary data to USDA-Forest Service regional reference data.

Channel Type and Attrubute	**Battle Creek Tributaries**	**Regional Reference Data**
Response - Pool Tail Fines	28.3	20
Transport - Pool Tail Fines	12.6	9

A graphic comparison of the average percent fines observed in the transport reaches of Battle Creek tributaries with USDA Region 5 reference and non-reference channels shows that the distribution of Battle Creek fines is most similar to reference channels, however, some similarities to non-reference channels are evident (figure 1). Similarities to non-reference conditions are mostly in the <2% and the >32% classes. Nine percent of the reference channels evaluated have less than 2% pool tail fines while none of the non-reference or Battle Creek tributary channels have mean fines values in this category. Also, none of the reference channels have fines in the >32% category, while 10% of the non-reference and 7% of the Battle Creek tributary channels have fines in this category. The “in between” categories (2-4% to 16-32% fines classes) show that pool tail fines in Battle Creek tributaries have a strong relationship to reference condition channels.

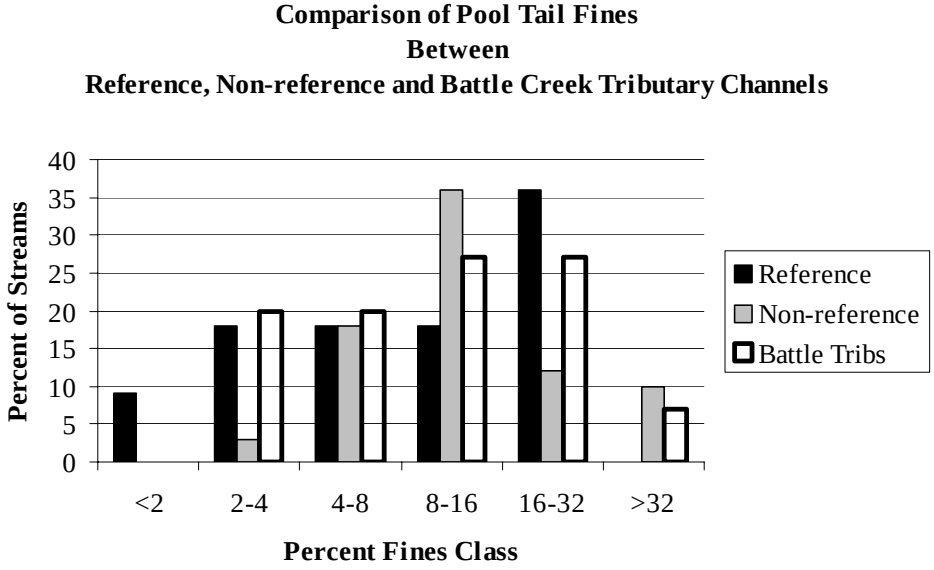

Figure 1.- Comparison of pool tail fines between USDA Region 5 reference transport, non-reference transport, and Battle Creek transport tributaries.

Sediment Sources

Sediment is contributed to stream channels through a variety of mechanisms in the Battle Creek watershed. These mechanisms include delivery from eroded stream banks, mass wasting, roads paralleling streams, and stream crossings.

With the exception of the North and South Forks of Digger and Bailey Creeks, all streams inventoried had more than 50 square meters of sediment sources for every 100 meters of channel (figure 2). Survey notes indicate that the majority of sediment sources recorded are related to natural bank failures and landslides attributed to the January 1997 flood.

The amount of estimated road related sediment is broken out from the total level of estimated sediment sources in order to evaluate its contribution in the upper watershed (figure 2). Road related sediment sources are present along 11 of 15 streams. There are 7 streams in which road related sediment sources comprise greater than 10% of the total sediment source area. These are Summit Creek, Panther Creek, Manzanita Creek, tributaries #1 and #2 to SF Battle, Dry Lake outlet, and Dry Lake tributary "A". Road related sediment sources exceed 30% of the total sediment source along tributary #1 to SF Battle, Panther Creek, Dry Lake trib A, and Manzanita Creek.

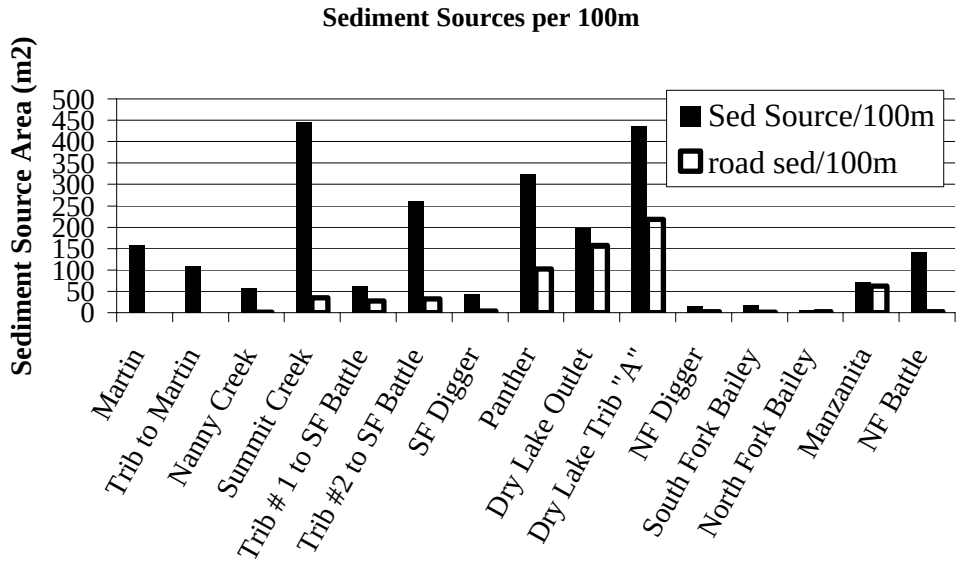

Figure 2.- Sediment source areas for upper Battle Creek tributaries. Total sediment source and road related sediment source areas are shown.

Field observations indicate that pool tail fines are visibly higher downstream from road related sediment sources. Figure 3 shows correlation between pool tail fines and the percent of sediment source area caused by roads. Though the correlation is weak, generally, as the amount of road related sediment sources increase, so does the amount of pool tail fines.

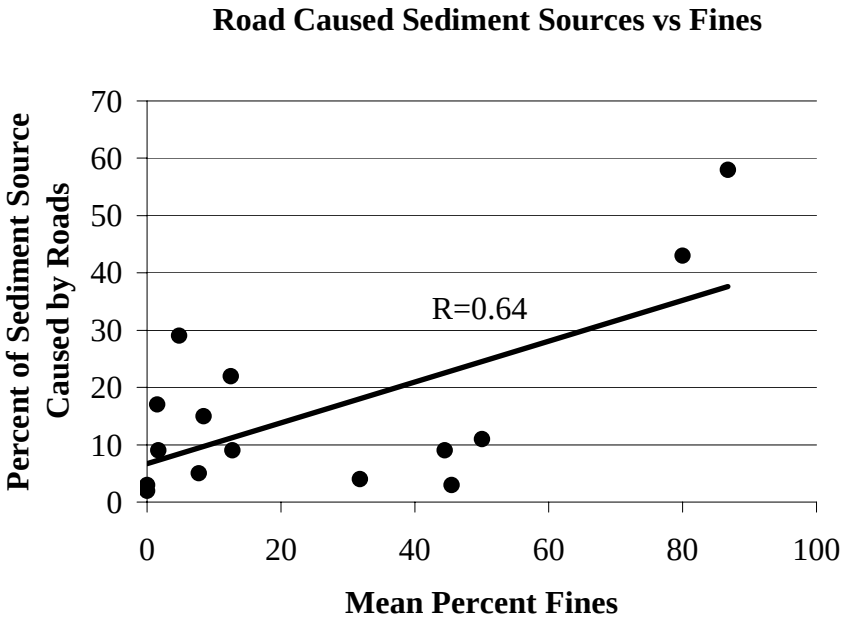

Figure 3.- Percent sediment source caused by roads plotted against pool tail fines with trend line showing correlation.

Percent Shade

Average percent shade ranged from 40 to 80%. Shade values are not available for Martin, Trib to Martin, Nanny, Summit, and Tribs #1 and #2 to SF Battle. These streams were classified as having an open, closed or mixed closure canopy. All three classes of canopy closure are present along these streams. The variety of canopy closure conditions are similar to other streams in the analysis area, for which shade data are available. These conditions appear to represent natural variation and site potential. On a reach scale, shade is slightly lower along response reaches than transport.

There are significant differences between Battle Creek tributary and R5 reference data for both transport and alluvial channels (table 5). The average percent shade is significantly higher in Battle Creek tributaries than in the regional data (approximately 31% higher for C channels, 17% for B channels).

Table 5.- Significance table for shade comparing Battle Creek tributary data to USDA-Forest Service regional reference data.

Channel Type and Attrubute	Battle Creek Tributaries	Regional Reference Data
Response - Shade	64.8	33.7
Transport - Shade	75.8	58.5

Large Woody Debris

Large woody debris was present in 98% of the reaches surveyed. Large wood aggregates (a large woody debris cluster of 4 or more pieces) were present along 64% of the reaches. The average amount of large wood per stream ranged from 19 to 204 pieces per kilometer (km) with an average of 103 pieces per km for all reaches combined. The number of key pieces in aggregates ranged from 4 (the minimal number required to comprise an aggregate) to 222 pieces (lower Martin Creek) with an average of 15 pieces for all streams combined. The only reach absent of large wood is located along Summit Creek downstream of the 29N60 road crossing.

Fifty-seven reaches were classified as having high large wood recruitment. Only nine of the 66 reaches were rated as poor in terms of woody debris recruitment. Two cases, Manzanita Creek, and Tributary to Martin Creek, were related to a wildfire. At Panther Creek, extensive timber harvest had depleted the amount of near stream wood. At Summit Creek, reach # 6, log landings had been placed near the stream and reduced the amount of nearstream area producing recruitable wood.

Pool Depths

Average residual pool depths ranged from 0.29 meters to 0.73 meters. There is a strong relationship between pool depth and basin size. In general, pool depth increases with basin size (figure 4). Pool depths of Battle Creek tributary transport channels compare

favorably with USDA reference pool depths. Noteworthy exceptions are at NF Battle Creek and Manzanita Creek where pool depths correlate most strongly with non-reference pools. This correlation means that NF Battle and Manzanita Creek have relatively low pool depths for their basin size.

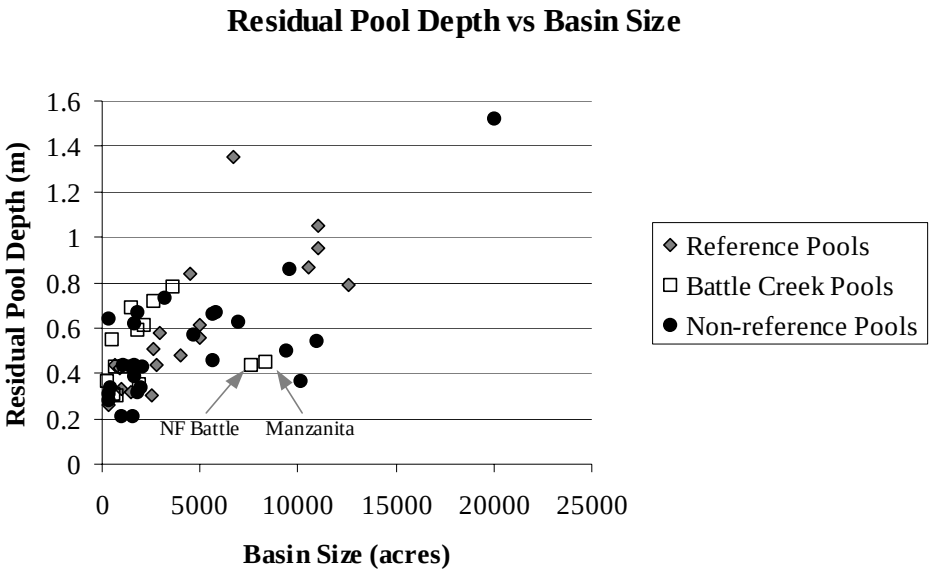

Figure 4.- Chart Plotting of residual pool depth against basin size for USDA Region 5 reference transport channels, USDA Region 5 non-reference transport channels, and transport channels in the upper Battle Creek watershed.

Bank Stability

Bank stability was rated using four classes ranging from high to low stability. A stream with 100% high bank stability would have no visible bank erosion. A moderate classification would have some erosion visible at outside meanders. Figure 5 shows the percentage of each stream length classified as having moderate to high bank stability. A composite of high and moderate classifications is necessary due to the fact that a high stability rating is based on no erosion, a situation that does not accurately represent a natural range of conditions. Streams with the highest bank stability (>60%) are tributary to Martin, Nanny, Summit, Panther, upper NF Digger, SF Bailey, NF Bailey, Manzanita, and NF Battle Creeks. Martin, trib #1 to SF Battle, trib #2 to SF Battle, SF Digger, and Dry Lake trib A had the lowest stability.

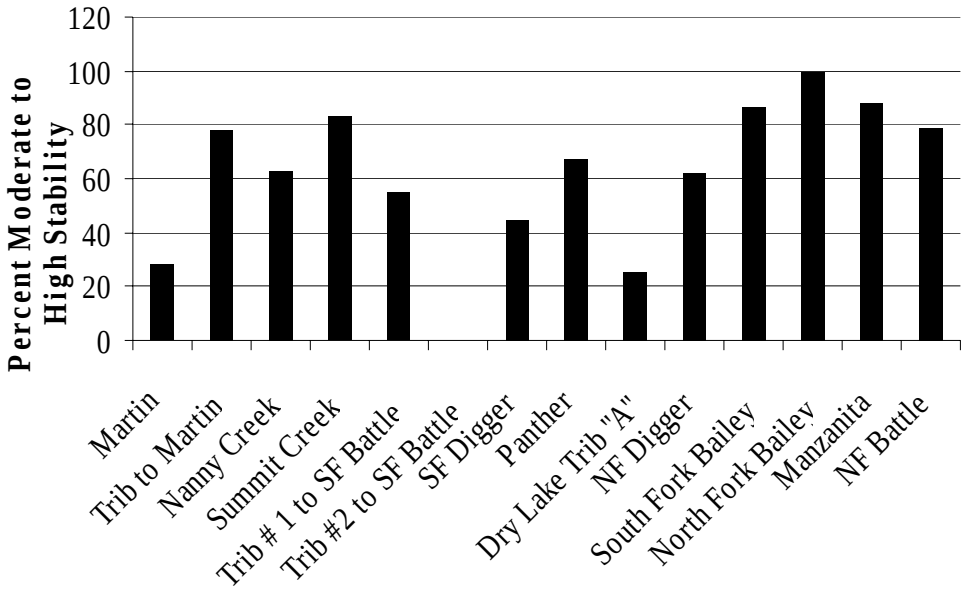

Figure 5.- Streams with high bank stability.

Riparian Vegetation

Riparian Vegetation was assessed during the stream surveys. Areas with willow, alder, aspen or cottonwood were mapped and rated. Alder, willow, aspen, and cottonwood are the riparian hardwood species present in the upper watershed. Of these species, alder is the most widely distributed. Willow is the next most common, followed by aspen and cottonwood. Creeks with at least one of these species present were Nanny, Summit, Martin, an unnamed tributary to Martin Creek, the tributaries to Battle Creek Meadows, Manzanita, SF Digger, NF Digger, SF and NF Bailey, and NF Battle.

Alder was the most common species encountered, present in all the streams. All streams except Nanny Creek had communities that were rated as diverse in terms of seral stages present (at least 70% of the stream length with alder). In Nanny Creek, only about 40% of the reach length was in this condition, about 60% was rated as decadent. Aspen stands were identified on seven streams. Although most of these stands were sparse, they reflected a healthy diversity of age classes. Decadent stands are located along the upper reaches of NF and SF Bailey Creeks. These aspen stands are abundant, but dominated by older age classes with a conifer overstory. Cottonwoods were found in Nanny, Martin and Summit Creeks, greater than 50% of these communities (by channel length) were rated as decadent.

Near-stream road assessment

Field surveys inventoried near stream roads and evaluated their erosion potential. Many crossings in the watershed are existing sources of sediment. Notable in this regard are the crossing of Summit Creek by Forest road 29N64, the crossing of Nanny Creek by Forest road 29N22, the crossing of South Fork Bailey Creek meadows by road 31N12, and the crossing of upper Panther Creek by Forest road 29N21YA, the crossing of SF and NF Digger, and SF Bailey by the 17 road, and Highway 44 where it parallels Manzanita Creek. Flow was diverted down the roadway and over unprotected fill slopes by the 1997

storm at the Summit and Nanny Creek sites, and potentially at the streams crossing the 17 road. Additionally, the crossing of Summit Creek by Forest road 29N60 has historically acted as a barrier to the passage of bedload.

Several stream crossing pose potential fish passage problems. Concrete box culverts are located along Highway 36 at Nanny and Martin Creek. The Martin Creek crossing may pose velocity and depth constraints while the Nanny crossing may pose, leap, velocity and depth constraints. The crossing of North and South Forks of Digger Creek, and the crossing of Bailey Creek along 31N17 may also have fish passage constraints. These crossings have corrugated metal pipe (CMP) type culverts that are perched, to some degree, above the channel, requiring fish to leap for upstream access. Other culverts are present in the upper watershed, however, their affect on fish passage is less clear.

Discussion

Generally, all the streams inventoried are in good condition. Aquatic habitat has been negatively affected by site problems at several locations; most of these problems are road related. Although a few streams have high fines, levels in Battle Creek tributaries, as a whole, compare favorably with reference streams throughout California. Streams with average fines exceeding 10% include Trib to SF Battle #2 (22% pool tail fines), SF Digger (15% fines), Dry Lake Outlet (43% fines), Dry Lake Trib "A" (11% fines), SF Bailey (29% fines), Manzanita (58% fines), and NF Battle (17% fines).

In-channel large wood and large wood recruitment both rated high across the analysis area. A few reaches were low in large wood and recruitment. Two cases, Manzanita Creek, and Tributary to Martin Creek, were related to a wildfire. At Panther Creek, extensive timber harvest had depleted the amount of near stream wood. At Summit Creek, reach # 6, log landings had been placed near the stream. Along the upper reaches of SF and NF Digger the stream is within a meadow. Large wood in the channel appears to represent a natural range of variability. On a reach scale, stream shade varied from low to high, but was generally high across the analysis area. There do not seem to be any problems with stream shade that would result in any negative affect on water temperature.

Most streams had stable banks. Response reaches (upper forks of Digger Creek and Bailey Creek) are heavily vegetated, with high water tables and undercut banks. Stream with the lowest bank stability are Martin, Tributary # 2 to SF Battle, lower SF Digger, and lower NF Digger. Bank stability at Tributary #2, SF Battle, lower SF and NF Digger was high immediately below road crossings but improved on the upstream side.

The meadow portion of South Fork Bailey Creek is in excellent condition. Several stream condition indicators suggest that the condition of this stream exceeds the average condition of other regional reference streams. A few indicators point out that the condition of South Fork Bailey Creek has room for improvement; for example bank stability is lower than the regional average. Field observations indicate that bank stability

is low at the intersection of Forest road 31N12. At this intersection, an old landing (now used as a dispersed campsite) is located in the near stream area and contributes to unvegetated stream banks. During the field survey there was evidence that four wheel drive vehicles have accessed the meadow and crossed the stream, contributing to further bank instability.

Riparian vegetation is generally in good condition. Diverse forms of riparian vegetation and high levels of stream shade are present along most reaches. Although riparian conditions are good, the distribution and condition of aspens is a concern. Some aspen in the upper South and North Forks of Bailey Creek are decadent, with little regeneration and heavy encroachment by conifers.

Mass wasting in Martin Creek, Nanny Creek, and other Battle Creek tributaries is a result of the combination of steep, unstable soils (glacial material on volcanic mudflows, or rhyolitic parent material) and heavy precipitation events. Mass wasting and hillslope erosion are major mechanisms that transport sediment to streams in mountainous regions (Swantson, 1996). Heavy runoff and precipitation during the winter of 1996-97 triggered several mass-wasting events in some tributaries to Battle Creek Meadows. These debris slides scoured channels to bedrock and removed nearstream vegetation. Large flows also scoured sections of Martin Creek just upstream of the Battle Creek Meadows. Aside from road contributions, mass wasting and storm related bank instability appear to be the primary sediment sources in the area.

Roads affect stream condition by accelerating erosion, increasing sediment delivery to streams, and by altering channel morphology (Furniss et al. 1996). Poorly designed roads can prevent or restrict fish migration of both juvenile and adult salmonids (Furniss et al. 1996). Culverts are the most common migration barriers associated with roads. Several culverted stream crossings in the upper watershed may pose migration barriers to salmonids (Powers and Orsborn, 1985). The most notable are the concrete box culverts where Nanny and Martin Creek cross Highway 36. Potential barriers also exist along Forest road 31N17 at the North and South Fork Digger Creek, and Bailey Creek stream crossings. It is difficult to assess the degree to which culverts in the analysis area restrict fish migration without formal fish passage assessments at each fish-bearing stream crossing.

Treatment Opportunities

Three general treatment opportunities are present in the upper watershed: roads, eroding timber harvest sites, and riparian vegetation. Road issues stem from road location, design, and condition, and riparian issues center on the viability of aspen stands. This section will identify several site-specific opportunities for improving aquatic and riparian condition in the upper Battle Creek watershed.

Opportunities to reduce chronic sediment sources are found throughout the sub-watersheds and are associated with previously harvested areas, landings, skid trails, and

especially, near stream roads. Correction of near-stream road problems along Summit Creek, Nanny Creek, and Battle Creek tributaries near Turner Mountain and along the 17 road will help to improve the physical and biological resources within these areas. Opportunities also exist along State highway 44 where it parallels Manzanita Creek. Highest priority is Upper Panther Creek, which has the greatest amount of near stream roads. The condition of the alluvial reach of South Fork Bailey Creek could be improved by rehabilitating the near stream landing and armoring the culverted crossing at the 31N12 intersection, as well as blocking four wheel drive access to the meadow.

Opportunities to improve fish passage are also present in the upper watershed. A fish passage assessment of all fish bearing stream crossings in the analysis area is recommended to assess the degree to which crossings in the analysis area affect fish migration. Treatments should be developed for those crossings that pose either a partial barrier (pass fish on favorable flows) or a total barrier (do not pass fish at any flow).

Opportunities to improve riparian diversity involve treating aspen stands. Several stands in the upper forks of Bailey Creeks would benefit from treatments that reduced competition from conifers and stimulated regeneration. An effective treatment would be to remove conifers that are interspersed with aspens and introduce low to moderate intensity fire.

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