Lower Redwood Creek Erosion Assessment and Restoration Planning Project Report

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Pacific Coast Fish, Wildlife and Wetland Restoration Association
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EXECUTIVE SUMMARY

The Lower Redwood Creek Erosion Assessment and Restoration Planning Project area is located approximately 35 miles north of Eureka, California. The project area is comprised of three sub-areas within Redwood National and State Parks in the lower Redwood Creek watershed. In 2010 and 2011, a field crew from Pacific Coast Fish, Wildlife and Wetlands Restoration Association (PCFWWRA) assessed 62 miles of roads for potential erosion. Redwood National and State Parks (RNSP) managed all data and performed analyses to develop an erosion prevention action plan that prioritizes all assessed sites in Redwood Creek using various analyses.

The assessment identified a total of 780 sites with the potential to deliver over 372,000 yds^3 of sediment to streams if left untreated. About 92% of the potential sediment volume is at sites recommended for decommissioning.

The estimated minimum cost to treat all sites in the assessment area is about $8,207,000, or about $132,000 per mile of road. The cost estimate does not include costs associated with logistics, materials or overhead, or costs to treat potential sediment sources associated with skid roads and other disturbances on adjacent hillslopes.

The road assessment data from this project are fully comparable with road assessment data collected in the upper Redwood Creek watershed by PCFWWRA and RNSP. All data are contained in tabular and spatial databases maintained by RNSP. Detailed road assessments started in earnest in 1996 in the upper Redwood Creek watershed (areas upstream of RNSP) through cooperative efforts of RNSP and private landowners to control and prevent erosion from logging roads. Those efforts have led to completion of assessments by PCFWWRA, RNSP and others on about 836 miles of roads. Assessments completed by PCFWWRA and RNSP in the upper watershed total about 722 miles using equivalent assessment methods that allow data analysis across assessment areas completed by them.

This report presents an erosion prevention action plan that prioritizes erosion control and prevention treatments based on road assessments completed by PCFWWRA and RNSP throughout the watershed through 2011, and accounts for implementation work completed through 2009. Prioritizations for recommended treatment work are based on various analyses of assessment data. Each analysis works at a different scale and provides prioritizations that can be used individually or in combination appropriate to the scale and objective of the erosion prevention project.

ACKNOWLEDGEMENTS

Funding for this project was provided by California Department of Fish and Game, Fisheries Restoration Grant Program and by Redwood National and State Parks. In-kind contributions were provided by Redwood National and State Parks and Pacific Coast Fish, Wildlife and Wetlands Restoration Association (PCFWWRA).

This report was prepared for Mitch Farro of PCFWWRA by Redwood National and State Parks under a cooperative agreement. We are grateful to Mr. Farro for his leadership role in Redwood Creek, as the project would not have occurred without his involvement. Pacific Watershed Associates provided invaluable technical oversight and quality control during this work as a sub-contractor to PCFWWRA. We are extremely grateful to Randy Lew who provided consistent quality control. Most importantly, we acknowledge the field crew who worked so diligently. They are dedicated and highly skilled, and did an outstanding job.

Road assessment projects in upper Redwood Creek would not have been possible without private landowner cooperation. The private landowners in Redwood Creek are willing partners who have provided access to their lands, funding, opinions and perspectives, and an optimistic outlook for improved watershed conditions. Numerous implementation projects have occurred on private lands since completion of the first assessment in the watershed using various public fund sources with matching contributions from the landowners.

We thank Judy Wartella for her expertise completing many of the GIS analyses contained in the report and her guidance in improving the database allowing for new developments in software and Mike Sanders for his thorough review of more than 15% of assessed sites and all assessed roads within this project.

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INTRODUCTION

Redwood Creek has known water quality problems that limit salmonid populations in the watershed. The creek is U.S. Environmental Protection Agency (USEPA) 303(d) listed for sediment and temperature impairment caused by past timber harvest activities and erosion during large floods (USEPA, 1998). Erosion from logging roads has been identified as the largest controllable source of sediment in the watershed (RNSP, 1997; USEPA, 1998). The Total Maximum Daily Load (TMDL) for sediment for Redwood Creek (USEPA, 1998), the Recovery Strategy for California Coho Salmon (CDFG, 2004), the Redwood Creek Watershed Assessment Report (Cannata et al., 2006), the Redwood National and State Parks (RNSP) General Management Plan/General Plan (NPS-CDPR, 1999), and the Integrated Watershed Strategy for Redwood Creek (RCWG, 2006) all encourage completion of road assessments, and implementation of road decommission and upgrade projects to provide lasting improvements to aquatic and riparian habitat and water quality.

Since 1978, Redwood National Park has been implementing a program to remove and upgrade roads within the watershed. The program was one of the first in the nation and was first implemented on land within the park. Since the mid-1990's the park has worked in cooperation with landowners upstream of the park and with Pacific Coast Fish, Wildlife and Wetlands Restoration Association (PCFWWRA) to identify sediment sources and implement road removal and upgrade projects to reduce potential sediment delivery to Redwood Creek.

A total of 782 miles of roads have since been assessed in the watershed using methods that have been shown to be consistent and comparable. This current project is the most recent assessment that adds to the body of data allowing for watershed-wide prioritization of treatments and development of cost-effective treatment projects.

PROJECT AREA DESCRIPTION

The current project area included selected areas in the lower Redwood Creek watershed within Redwood National and State Parks (Figure 1). The areas assessed were identified by park staff as areas in need of assessment, but park staff could not complete the assessment due to staffing limitations. Park staff are assessing other areas within the park and those data will be integrated with the larger dataset in the near future for further analysis. This road assessment, funded in part by the Fisheries Restoration Grant Program, with matching funds from the National Park Service, complements previous assessments completed within Redwood Creek watershed, upstream of the park, by PCFFWRA, RNSP and others.

Redwood Creek drains a 285 square mile watershed in the Coast Range of Northern California. The watershed is steep and mountainous, located within a tectonically active area with relatively rapid uplift. Weak, pervasively sheared rocks underlie the watershed. Mean annual watershed-wide precipitation averages about 80 inches. The combination of steep terrain, weak underlying geology and soils, and moderately high precipitation contribute to naturally high erosion rates and susceptibility to accelerated erosion.

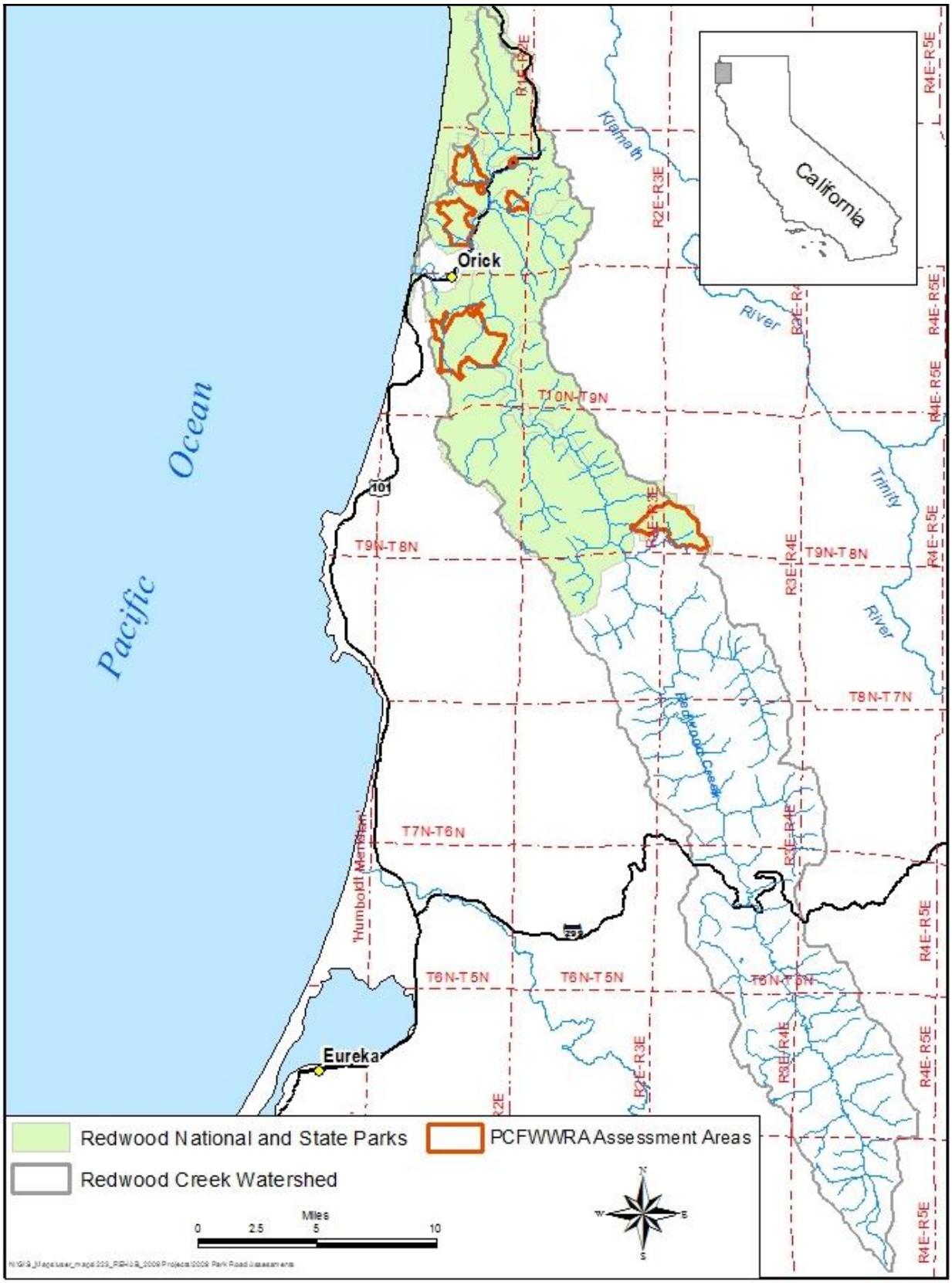


Figure 1. Location of Lower Redwood Creek Erosion Assessment and Restoration Planning Project.

LAND USE AND ROAD CONSTRUCTION HISTORY

The principal land uses in the watershed have historically been timber production and ranching. The 1968 establishment of Redwood National Park and subsequent expansion in 1978 and 1991 changed the principal land use in the lower watershed to conservation and recreation. Within the current project assessment areas ranching was the principal land use in the Coyote Creek area.

Logging and ranch roads were constructed in lower Redwood Creek as early as the late 1800s with settlement of the Bald Hills and Prairie Creek and Orick valley areas. Upon expansion of Redwood National Park in 1978 the NPS started a program to remove abandoned, unneeded roads within the park to reduce erosion and sediment delivery and to restore park lands. To date about 250 miles of roads have been decommissioned or removed. Approximately 280 miles remain within the park in the lower Redwood Creek watershed, of which about 75 miles will likely be retained for park management and visitor use. The construction history for roads within the park is shown in Figure A-1 in Appendix A.

METHODS

The lower Redwood Creek erosion assessment and restoration planning project consisted of two phases. The first phase was comprised of field work to locate and evaluate erosion. The volume expected to erode from each site was determined and corrective treatments were prescribed. Additional information describing estimated equipment and labor needed to implement treatments was recorded for all sites. Data were compiled on field forms and the sites were located and mapped on airphoto mylar overlays. The GPS coordinates of each site were also recorded. The second phase consisted of entering data into tabular (MSAccess) and spatial (ArcGIS) databases for analysis and development of an erosion prevention action plan for all of Redwood Creek. Both databases are maintained by RNSP and contain all road assessment data collected as part of the watershed-wide cooperative erosion control program for Redwood Creek.

RESULTS

A total of 62 miles of roads were assessed in this project. Assessed roads are shown in Figures 2 through 4. The original project proposal identified 69 miles for assessment. The discrepancy between the proposed and the actual is due to the substantial field time required to assess many of the sites on the larger roads. We knew that roads in the lower watershed were considerably larger than roads previously assessed in upper Redwood Creek. We attempted to factor this in to the time estimate for the project, but it quickly became clear that we underestimated the average size of the roads and the disturbance level at each site.

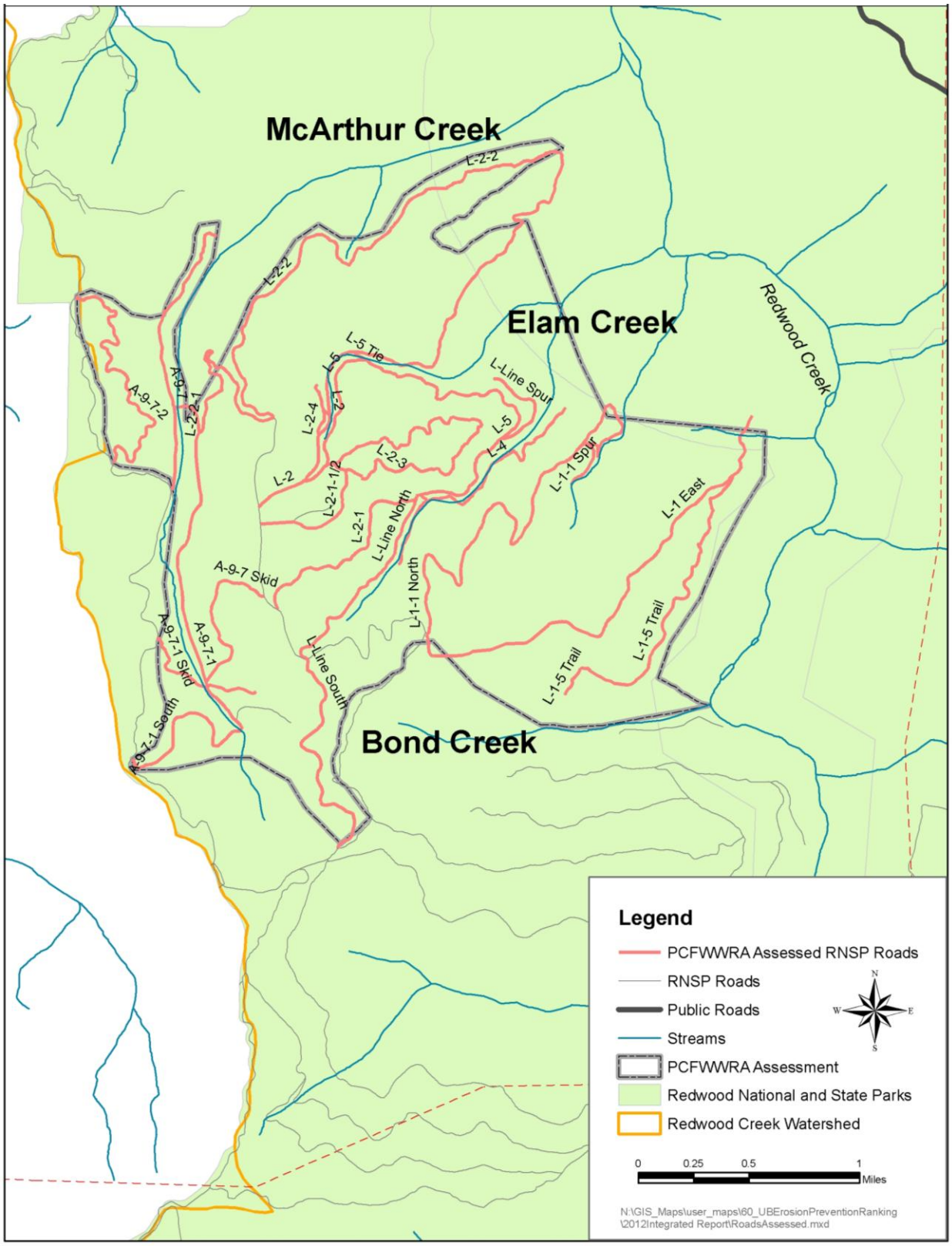


Figure 2. Location of assessed roads in McArthur, Elam and Bond Creek watersheds.

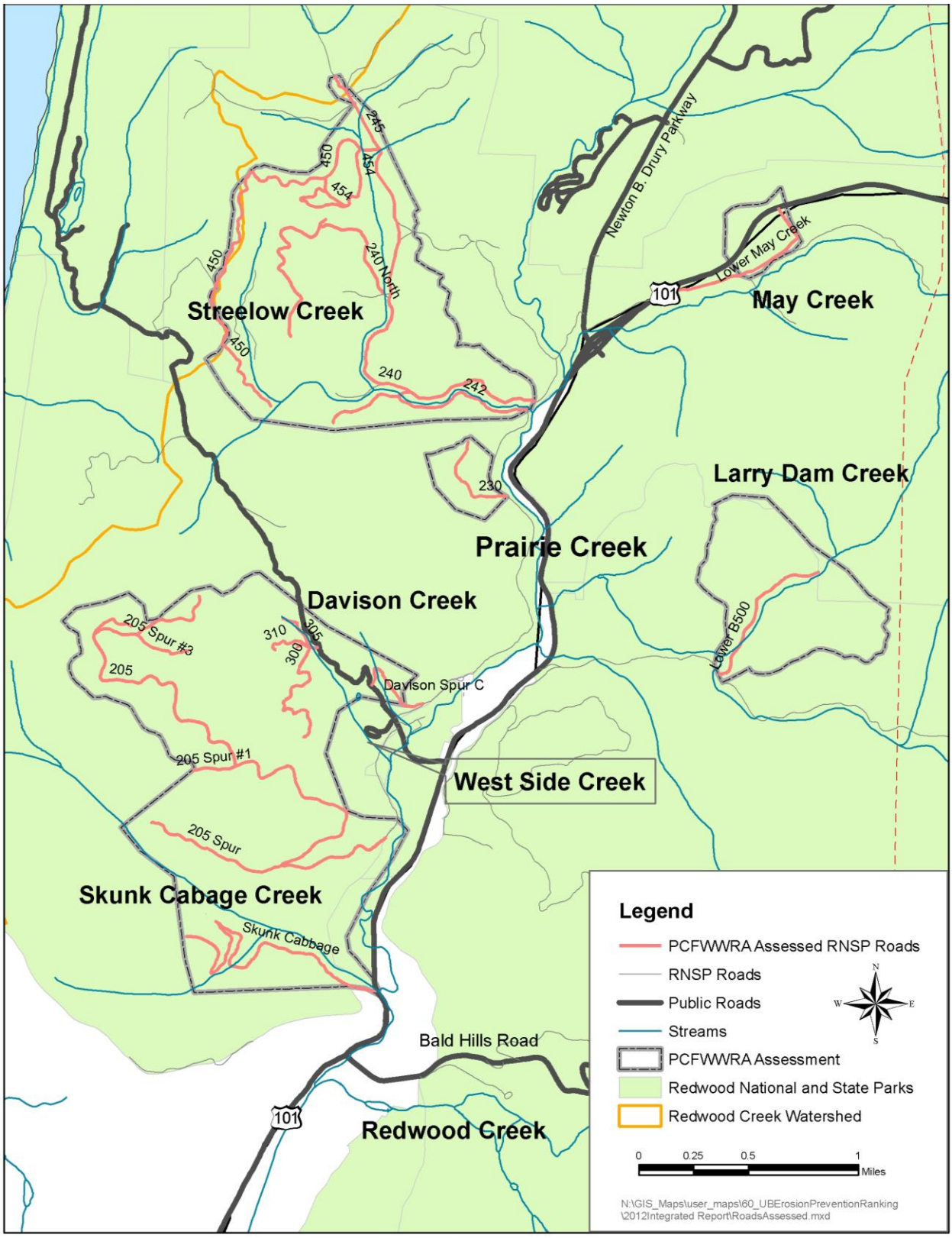


Figure 3. Location of assessed roads in Prairie Creek watershed.

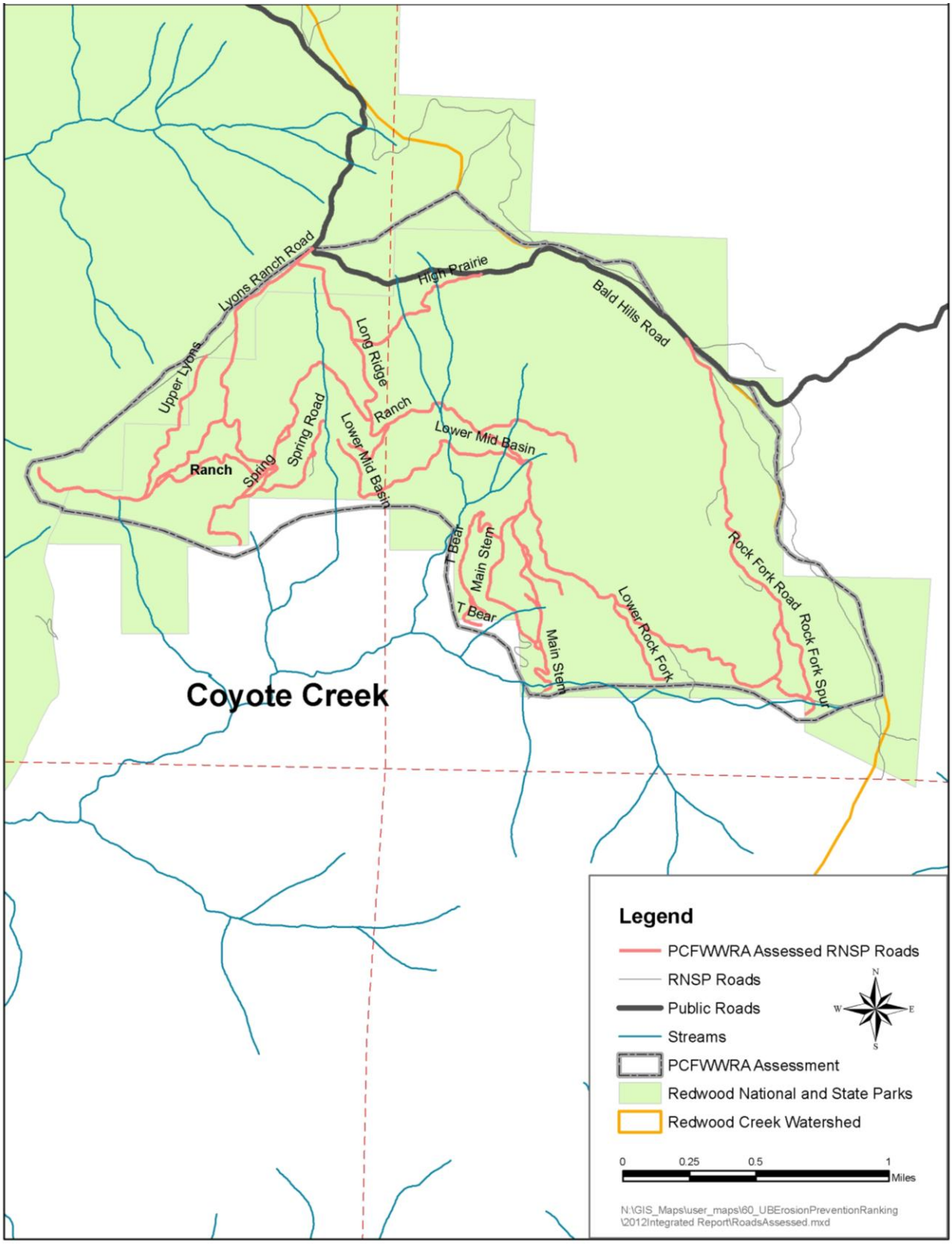


Figure 4. Location of assessed roads in Coyote Creek watershed.

Field crews noted and the park was already aware that the haul roads in the lower portions of the park are but a small portion of the potential sediment that can erode from the logged areas. The associated skid roads and layouts also contain unstable fills and contribute to stream diversions that must be corrected to meaningfully reduce the potential sediment delivery from these slopes. The cost for assessing the full extent of disturbance is beyond the scope of this current project. We have assessed only the main logging haul roads to help with identifying the scale of erosion potential, to develop work priorities based on actual quantifiable field data and to assist with estimating costs for corrective treatments. The park will use the data from this assessment as a basis for developing erosion prevention implementation projects. After identifying implementation project areas, further detailed geomorphic mapping and surveys of the areas will be completed in preparation for specific project implementation.

DRIVABILITY STATUS

Of the 62 miles evaluated, about 19 miles (30%) of roads were drivable by a standard 4WD vehicle and about 43 miles (70%) were not drivable.

POTENTIAL SEDIMENT YIELD

A total of 780 sites were evaluated in the project area. Sites were categorized into two general groups based on the dominant erosional process at the site. Fluvial sites include haul road and skid road crossings, ditch relief culverts (DRCs), road reaches and springs. Landslide sites generally include debris slides and deep-seated features. There were 529 fluvial erosion sites and 251 landslide sites assessed. Total potential sediment yield from all sites is estimated to be about 373,000 yds^3. Site locations are shown on maps in Appendix B. General site information is summarized in Table 1.

In this report, *potential sediment yield* is always the larger of *site potential yield* or the *extreme potential yield* for each site. The site potential yield was measured for each potential erosion site in the field during the assessment using tape and clinometer surveys of the crossing fill and represents the volume of material that can potentially erode and be delivered to a stream during a large storm. The extreme potential yield was also estimated in the field. It is the volume of sediment that can be delivered from an extreme erosional event (e.g., a debris torrent initiating at a stream crossing) at a site. It is larger than the site potential yield when the possibility for an extreme event was identified. Additional details of road assessment methods are described in Bundros, et al. (2004).

Table 1. Potential sediment yield for roads assessed in Redwood National and State Parks.

	No. of Sites	Erosion Volume[1] (yds^3)	Site Potential Yield (yds^3)	Extreme Potential Yield (yds^3)	Potential Sediment Yield [2] (yds^3)	% of No. of Sites	% of Pot. Sediment Yield
Sites Inventoried	780	548,300	283,000	112,800	372,900	100%	100%
All Sites with no yield	30	0	0	0	0	4%	0%
All Sites, Yield > 0	750	548,300	283,000	112,800	372,900	96%	100%
M-H Sites, Yield > 0	321	287,700	163,800	95,000	241,300	41%	65%
All Fluvial Sites	529	233,700	233,300	39,300	261,500	68%	70%
All Landslide Sites	251	314,500	49,700	73,500	111,400	32%	30%
Field Prescriptions							
Decommission	585	514,400	258,300	106,800	343,700	75%	92%
Upgrade	191	32,600	23,900	6,000	28,300	24%	8%
Maintain	4	1,300	800	0	800	1%	0%

Table notes:
[1] Erosion Volume is that amount of sediment that can potentially erode from a site. Not all sediment eroded will be delivered to a stream.
[2] Potential Sediment Yield is the greater of the site potential yield and the extreme potential yield for each site then summed for all sites. It is not the sum of the two columns "Site Potential Yield" and "Extreme Potential Yield".

FLUVIAL EROSION SITES

Of the 529 fluvial sites, 29 sites had no potential for sediment delivery. The 500 sites with delivery potential can potentially deliver about 261,000 yds^3 of sediment to streams. About 96 percent of the sediment is associated with stream crossings, the remainder is associated with skid trail crossings and gully erosion from ditch relief culverts, and along road reaches. Potential sediment yield from stream diversions was not estimated during the assessments. Stream diversions can cause a significant amount of erosion and sedimentation, but estimating the potential yield from future hillslope gully erosion would be speculative. Data for fluvial erosion sites are summarized in Table 2.

LANDSLIDE SITES

Estimates for site potential yield at a landslide site were made by delineating the boundaries of the future landslide, calculating the volume of material and then estimating the percent of the volume that would reach a stream. The site potential yield generally includes only the erosion volume directly associated with the road prism. For most landslide sites, the yield does not include the volume of material that can erode downslope from a road when road failures occur, nor the volume associated with larger landslide features that can extend far upslope or downslope from the road.

Table 2. Selected information for fluvial erosion sites in the project area.

Fluvial Features, Yield>0	All Urgency Sites		Medium to High Urgency Sites			
	No. of Sites	Potential Sediment Yield (yds^3)	No. of Sites	Potential Sediment Yield (yds^3)	% of No. of Sites	% of Pot. Sediment Yield
Road Crossings	446	252,200	199	153,200	89%	98%
DRC	35	1,800	10	1,200	7%	1%
Road Reaches	9	600	3	500	2%	0%
Skid Trail Crossings	6	2,800	4	1,400	1%	1%
Spring	4	4,000	1	500	1%	0%
Totals	500	261,500	217	156,800	100%	100%

Field crews measured only that portion of the landslide mass that could be directly associated with the road prism. There were two situations where the yield included more than just the road prism: 1, deep seated landslides where the road mass likely initiated a failure that is incorporating native ground and 2, landslide sites where 'extreme erosion' had been identified and quantified. Other than these two exceptions, the total volume associated with a large landslide that may or may not be exacerbated by a road was not quantified as part of this assessment. Because volume estimates for most landslide sites include only the landslide extent within the road prism, volume and yield estimates for potential landslide erosion are likely conservative. Selected information for landslide sites is shown in Table 3.

Table 3. Selected information for landslide sites in the project area.

Landslide Features	All Urgency Sites		Medium to High Urgency Sites			
	No. of Sites	Potential Sediment Yield	No. of Sites	Potential Sediment Yield	% of No. of Medium + Sites	% of Pot. Sediment Yield
Road	224	102,800	97	79,700	93%	94%
Landing	24	7,700	7	4,800	7%	6%
Hillslope	2	900	0	0	0%	0%
Totals	250	111,400	104	84,500	100%	100%

FISH PASSAGE AT STREAM CROSSINGS

Within the project area, there were four Class I (fish bearing) stream crossings (Table 4). Two of the crossings appeared to be barriers to fish at the time of the assessment. Listed site urgencies are for need to control potential erosion only and range from low-med to med-high.

Table 4. Status of Class I stream crossings in the project area.

Site ID	Road Name	Watershed	Type	Urgency	Comment
9017001	L-2-2-1	McArthur	Culvert	Med	On mainstem, ~ 3 mi. above a natural fish barrier near mouth.
9047011	Lower B500	Larry Dam	Bridge	Med-High	Collapsing log-stringer on mainstem, presently not a barrier, but has potential to become one.
9054014	245	Streelow	Humboldt / Culvert	Low-Med	On tributary to Streelow. Young-of-year fish at upstream end of culvert.
9062008	Skunk Cabbage	Skunk Cabbage	Culvert	Med	Fish barrier at culvert plunge pool

COSTS

Treatment costs were estimated for each site prescribed for decommission and upgrade treatments. Costs were estimated based on equipment and labor needs to treat each site. Equipment needs were determined for each site based on site surveys and estimated production rates at each site. Most treatments require the use of heavy equipment for excavating and hauling material from sites and replacing culverts. Labor is required for culvert replacement, water management during stream excavations and mulching and seed application following ground disturbance.

Costs do not include logistics costs for mobilization, road opening, materials such as culverts and rock, project management, overhead or other associated costs. Also, identified costs do not include costs for treating unassessed areas on hillslopes adjacent to assessed roads. These areas were not included in this road assessment and erosion sites are likely present on skid roads and layouts (bedding constructed for landing a felled tree) that are associated with logging old growth redwood in the 1960s and 1970s. Based on our knowledge of these lands, erosion prevention treatments for the hillslope areas could be significant. Hillslope areas will be assessed prior to road treatment.

A total of 585 sites located along about 46 miles of road were prescribed for decommission treatments and total about $7.8 million. Upgrade treatments were prescribed for 191 sites along 7 miles of roads with equipment and labor estimated at about $373,400. The estimated average cost per mile to decommission roads prescribed as such averages about $170,000 and for road prescribed for upgrade treatments, the average cost is estimated at about $54,000 per mile. No treatments were needed for nine miles of the assessed roads. Estimated costs are shown in Table 5.

The estimated cost per mile for decommissioning the assessed roads in lower Redwood Creek is substantially higher than costs estimated for upper Redwood Creek; $169,700 (site treatments only) compared to $72,700 (logistics and overhead included). The large difference is directly related to the generally larger roads found in the lower watershed and also possibly the larger extent of disturbance. This is evident when comparing the average estimated sediment yield per stream crossing and the average number of assessed sites per mile of road in the upper watershed with the lower watershed.

In the upper watershed, assessments completed in 2003 identified an average estimated sediment yield per stream crossing in the upper watershed was about 353 cubic yards (Bundros, et al 2003) and for the lower watershed the estimate is about 570 cubic yards. The upper watershed assessments identified an average of 7.8 potential erosion sites per mile of road assessed (Bundros, et al 2003) compared with 12.6 sites per mile in the lower watershed assessment.

Table 5. Estimated costs for heavy equipment and labor for assessed roads based on recommended treatment types.

Proposed Treatments	Miles Prescribed	% of Assessed Miles	No of Sites	% of Assessed Sites	Estimated cost for all sites	Average Cost / mile
Decommission	46.2	74%	585	75%	$7,834,000	$169,700
Upgrade	7.0	11%	191	24%	$373,400	$53,500
Maintain	8.9	14%	4	1%	na	na
	62.1	100%	780	100%	$8,207,400	$132,200

Note: Costs are specific to assessed sites along roads. Costs do not include costs for logistics, mobilization, road opening, materials such as culverts and rock, project management, overhead or costs for treating additional sites on adjacent hillslopes

EROSION PREVENTION ACTION PLAN – TREATMENT PRIORITIES

Data from the road assessment can be used to prioritize work and ensure cost effective treatments. Establishing priorities helps determine where the greatest benefit can be achieved so that limited funds are spent wisely.

Assessment data were analyzed using three different methods to prioritize treatments that have been used previously to prioritize treatments in upper Redwood Creek (Bundros, et al, 2003 and 2004; Bundros and Short, 2011). The analyses are repeated here and now include new information from the assessment area in lower Redwood Creek. Each method analyzes road assessment data differently and at a different scale. The first methods use database queries that prioritize individual roads and individual sub-watersheds. The second method uses Geographic Information System (GIS) spatial analysis that identifies areas in the watershed that have a high density of potential sediment yield. The third method uses a numeric risk analysis that prioritizes sub-watersheds. The third analysis is performed twice. First, the analysis prioritizes sub-watersheds based on the likelihood for and magnitude of erosion, or *resource threat*. The analysis is repeated a second time using anadromous salmonids as the *resource at risk*.

ROADS

This analysis establishes a treatment priority for individual *roads* using database queries and data for sites assessed by PCFWWRA, and not decommissioned. Roads that contained sites with medium to high treatment urgencies were ranked based on three criteria: 1) potential yield (volume of sediment that can enter a stream) from the entire road; 2) potential yield per mile of road

evaluated, and; 3) treatment cost-effectiveness (the cost per cubic yard to prevent sediment from entering a stream). Road treatment priority was based on the ranking of each criterion for each road. Of the 416 named roads assessed, Table 6 lists, in alphabetical order, the 19 roads that have the highest treatment priority based on potential sediment yield, potential yield per mile of road and/or treatment cost-effectiveness when the top 42 roads (10%) of each criterion was considered. Tables C-1, C-2, and C-3 (Appendix C) show how each road ranked for each criterion.

Table 6. Treatment priority for roads based on potential sediment yield, yield per mile and/or treatment cost-effectiveness. (The five roads with bolded names rank high in all three criteria.)

Road Name	Length (mi)	Total No. of ALL Sites	Total No. of M to H Sites	Potential Sediment Yield for ALL Sites (yds3)	For Medium to High Urgency Sites			
					Potential Sediment Yield (yds3)	Potential Sediment Yield per Mile (yds3/mi)	Cost/Yard "Saved"	Total Cost
831	2.1	13	7	7,699	7,338	3,578	$2.02	$14,821
1140	0.8	15	7	12,616	7,144	9,516	$3.34	$23,856
1410	1.9	23	12	8,125	7,602	3,994	$4.43	$33,660
1433	0.5	7	7	3,978	3,978	7,835	$3.04	$12,109
1440	1.5	18	15	15,155	14,588	9,657	$2.15	$31,314
1440	**1.5**	**18**	**15**	**15,155**	**14,588**	**9,657**	**$2.15**	**$31,314**
800G	0.3	2	2	3,726	3,726	12,298	$3.28	$12,236
A-9-7-1 South	0.8	10	7	19,349	15,096	20,060	$27.10	$409,054
A-9-7-2	1.5	22	14	21,408	18,411	12,678	$20.05	$369,138
Dolly Varden	11.8	155	114	109,890	103,954	8,793	$11.87	$1,234,068
L-2-2-1	**0.9**	**15**	**11**	**23,251**	**22,314**	**24,363**	**$3.79**	**$84,601**
L-4	1.3	19	14	11,796	10,278	8,209	$28.77	$295,695
L-5	1.6	23	16	22,729	20,226	12,440	$21.62	$437,251
LC5000	**2.3**	**26**	**21**	**23,659**	**23,089**	**10,176**	**$2.57**	**$59,360**
L-Line South	**1.1**	**14**	**9**	**36,511**	**36,000**	**34,139**	**$3.49**	**$125,470**
PR1106	**0.6**	**5**	**5**	**10,417**	**10,417**	**17,639**	**$3.02**	**$31,477**
R1000	2.1	21	11	8,914	8,598	4,080	$3.62	$31,121
R3800	0.9	11	10	9,796	9,774	11,364	$5.89	$57,576
R3810	0.1	2	1	5,000	3,500	43,126	$2.90	$10,165

Note: Costs include only heavy equipment costs for site specific treatments and laborers for culvert installations. Costs do not include mobilization, road opening, materials, oversight, report preparation, overhead or logistics.

This prioritization method identifies the 1440, L-2-2-1, LC5000, L-Line South and PR1106 roads as the highest treatment priority because they appeared in the top 42 roads (10% of roads) and in all three criteria. These roads have relatively high potential sediment yield, high yield per mile of road, and high treatment cost-effectiveness. Two of the roads are located in Lacks Creek on BLM land – PR1106 and LC5000. Two roads are located in the lower watershed in McArthur Creek on park land – L-2-2-1 and L-Line South. One road is located in Coyote Creek on private land – the 1440. The other roads listed in Table 6 ranked high in at least two of the three criteria.

Prioritizing Areas within the Watershed Using a GIS Spatial Analysis

This analysis establishes a treatment priority for *areas* in the watershed using a GIS spatial analysis and data from sites assessed by PCFWWRA throughout the watershed and RNSP in the upper watershed. Data from sites subsequently decommissioned and sites assessed by others were excluded from the analysis. Rather than focusing on a specific road or sub-watershed, this method analyzes potential sediment yield throughout the watershed and highlights discrete areas by the concentration or *density* of potential sediment yield. The spatial analysis ignores sub-watershed boundaries.

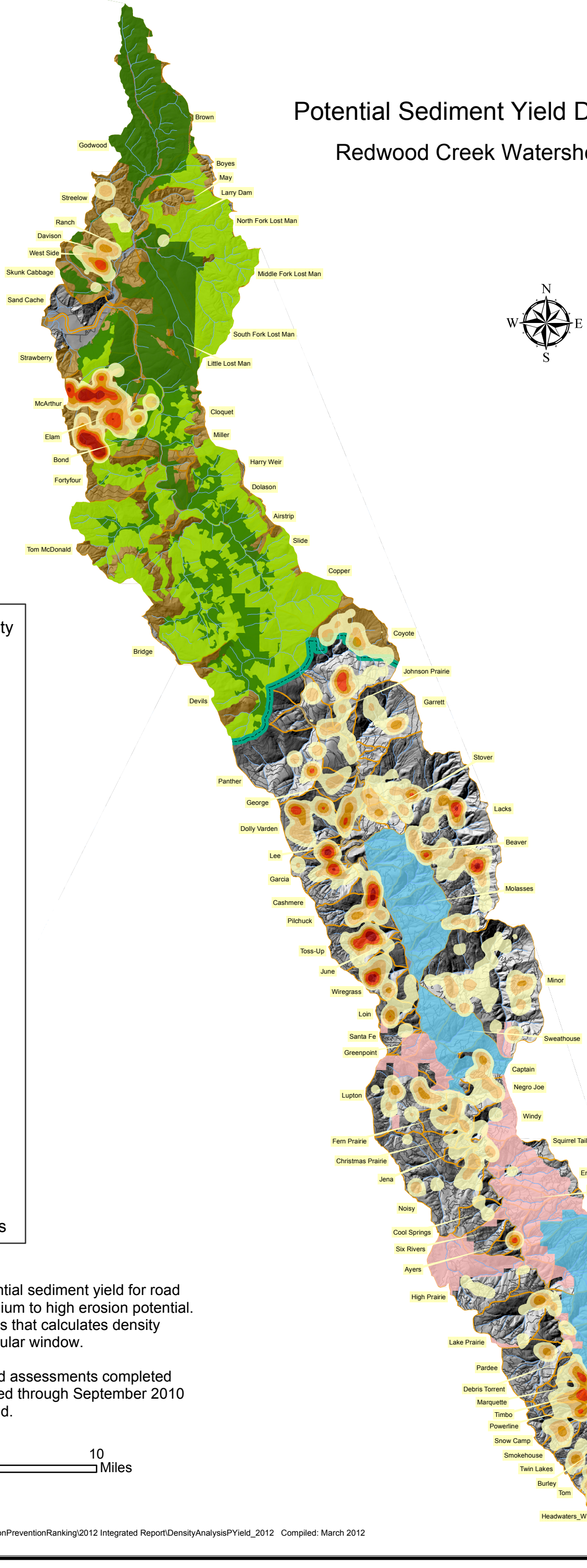
The analysis uses both numeric and spatial data. Numeric data are the potential sediment yield values for sites as estimated by the field crews, and the spatial data comes from GIS point coverage for each site evaluated during the assessment. Because each point represents the location of a site, the analysis can evaluate the potential sediment yield of one site in relation to the potential sediment yield of sites that surround it.

Using GIS and the data sources described above, the density or "hot spots" (potential sediment yield per square mile) throughout the Redwood Creek watershed was computed. Simply stated, an analysis tool found in GIS software can scan and analyze a contiguous area using a moving one square mile circular "window." As the window sweeps across the landscape, it notes the potential sediment yield at each site location and adds to it the yield associated to neighboring sites if they are within one square mile of the site being evaluated. The results of this analysis are shown in Figure 5. The darkest colors represent the areas that contain the highest density of potential sediment yield, suggesting another possible treatment priority.

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Potential Sediment Yield Density

Redwood Creek Watershed



Potential Sediment Yield Density
(cubic yards/square mile)

- 0 - 5,000
- 5,000 - 15,000
- 15,000 - 30,000
- 30,000 - 45,000
- 45,000 - 70,000
- 70,000 - 100,000

Areas Excluded from Analysis

- Currently Unsurveyed
- Limited Data
- Surveys in Progress
- Park - Old Growth
- Park - Treated Areas
- Roads
- SouthParkBoundary
- Streams (1:24k)
- Sub-watershed Divides

This map shows the density of potential sediment yield for road assessment sites rated to have medium to high erosion potential. It was produced using a GIS analysis that calculates density using a moving one square mile circular window.

The analysis includes data from road assessments completed 1996 - 2011 and road work completed through September 2010 within the Redwood Creek watershed.

0 5 10 Miles

Source: RNSP GIS - N:\GIS_Maps\user_maps\60_UBErosionPreventionRanking\2012 Integrated Report\DensityAnalysisPYield_2012 Compiled: March 2012

Figure 5. Potential sediment yield density.

SUB-WATERSHEDS

This analysis establishes a treatment priority for individual *sub-watersheds* using database queries and data for sites assessed by PCFWWRA and RNSP, and not decommissioned. Sites assessed by others were omitted because we determined the volume estimates are inaccurate (Bundros and Short, 2009). The analysis presents basic information for each sub-watershed, and computes the total potential sediment yield per mile of road (yds^3/mile) for each sub-watershed. The query evaluates sites with medium to high erosion potentials in sub-watersheds where at least 40 percent of the road miles had been evaluated. The results were sorted by the potential sediment yield per mile of road and assigned a priority ranging from very low to very high. The priority for each sub-watershed was assigned by comparing its yield per mile to the highest yield per mile value of the sub-watersheds considered. The very low priority sub-watersheds would yield 0-20 percent of the yield per mile for the sub-watershed with the highest value, and the very high priority sub-watershed would yield 80-100 percent of the highest yielding sub-watershed.

Table 7 shows the query results and establishes a treatment priority for each sub-watershed by the total potential sediment yield per mile of road. Potential sediment yield per mile ranged from about 52 yds^3/mile in Six Rivers Creek to about 6,740 yds^3/mile of road in McArthur Creek. Lacks Creek has the highest potential sediment yield, about 142,000 yds^3. Lacks Creek is more than twice the size of the next largest sub-watershed, so the fact that it has the highest total potential yield is no surprise. Of the 46 sub-watersheds considered, 18 sub-watersheds can potentially yield more than 10,000 yds^3 of sediment per square mile.

Table 7. Sub-watershed treatment priority based on potential sediment yield per mile of road.

Sub-Watershed	Acres	Roads			Potential Sediment Yield			Sub-Watershed Priority
		Total (miles)	Evaluated (%)	Density (mi/mi^2)	Total (yds^3)	Yield/$mile^2$ (yds^3/mi^2)	Yield/Mile (yds^3/mi)	
McArthur	2,417	18.2	61%	4.8	122,782	32,507	6,737	Very High
West Side	425	2.9	98%	4.4	19,099	28,771	6,561	Very High
Lee	292	3.1	100%	6.7	17,546	38,495	5,745	Very High
Elam	1,573	14.9	84%	6.0	63,057	25,653	4,244	High
Wiregrass	1,153	9.5	92%	5.3	34,515	19,152	3,635	Medium
Johnson Prairie	386	2.2	87%	3.6	7,338	12,179	3,371	Medium
Davison	264	2.2	56%	5.4	7,319	17,731	3,277	Medium
Larry Dam	1,182	0.6	100%	0.3	1,688	914	2,825	Medium
Toss-Up	1,709	15.7	97%	5.9	43,662	16,355	2,778	Medium
Pilchuck	1,086	8.8	92%	5.2	24,398	14,381	2,773	Medium
Loin	601	5.0	81%	5.3	12,515	13,328	2,517	Low
Timbo	229	3.8	94%	10.7	8,769	24,478	2,295	Low
Headwaters_W	179	1.7	52%	6.0	3,740	13,361	2,235	Low
Stover	544	4.8	56%	5.7	9,885	11,621	2,052	Low
Powerline	408	4.3	94%	6.8	8,874	13,916	2,048	Low
Garcia	905	10.1	90%	7.2	20,627	14,581	2,036	Low
Dolly Varden	2,151	23.5	92%	7.0	44,327	13,191	1,883	Low

Sub-Watershed	Acres	Roads			Potential Sediment Yield			Sub-Watershed Priority
		Total (miles)	Evaluated (%)	Density (mi/mi^2)	Total (yds^3)	Yield/$mile^2$ (yds^3/mi^2)	Yield/Mile (yds^3/mi)	
Tom	259	2.2	93%	5.4	4,067	10,044	1,853	Low
June	125	0.9	100%	4.8	1,694	8,701	1,803	Low
Lacks	10,977	82.5	85%	4.8	142,333	8,298	1,724	Low
Smokehouse	426	5.8	74%	8.7	9,210	13,850	1,594	Low
Coyote	5,045	37.9	82%	4.8	59,168	7,507	1,560	Low
Negro Joe	806	9.3	65%	7.4	12,380	9,830	1,332	Very Low
George	699	6.4	100%	5.8	8,145	7,461	1,282	Very Low
Twin Lakes	811	9.4	90%	7.4	11,125	8,777	1,188	Very Low
Fern Prairie	509	6.5	73%	8.2	7,310	9,194	1,124	Very Low
Streelow	1,811	9.3	56%	3.3	9,990	3,531	1,074	Very Low
Skunk Cabbage	1,442	3.0	65%	1.3	2,757	1,223	930	Very Low
Lupton	3,329	40.1	62%	7.7	35,637	6,852	888	Very Low
Garrett	2,643	21.1	62%	5.1	18,688	4,525	886	Very Low
Minor	8,248	84.6	87%	6.6	73,535	5,706	869	Very Low
Burley	255	3.0	91%	7.4	2,564	6,443	866	Very Low
Snow Camp	773	8.2	66%	6.8	6,262	5,182	767	Very Low
Panther	3,799	30.8	95%	5.2	21,745	3,663	707	Very Low
Lake Prairie	2,144	18.8	82%	5.6	12,760	3,810	678	Very Low
Jena	246	4.1	47%	10.7	2,715	7,060	659	Very Low
Cashmere	861	9.3	80%	6.9	5,554	4,130	595	Very Low
Pardee	1,985	23.6	68%	7.6	11,020	3,554	467	Very Low
Christmas Prairie	455	6.9	73%	9.8	3,033	4,267	437	Very Low
Noisy	4,030	46.7	73%	7.4	19,326	3,069	414	Very Low
Marquette	492	6.7	91%	8.7	2,747	3,572	410	Very Low
Cool Springs	737	9.5	45%	8.3	3,592	3,118	377	Very Low
High Prairie	3,476	40.2	50%	7.4	7,961	1,466	198	Very Low
Joplin	440	3.8	88%	5.5	657	956	173	Very Low
Ayers	242	3.6	97%	9.5	511	1,350	143	Very Low
Six Rivers	741	9.2	57%	8.0	479	414	52	Very Low

Also from Table 7, three sub-watersheds in lower Redwood Creek rank in the top four for yield/ mi of road and yield per square mile of sub-watershed area. These are McArthur, West Side and Elam creek sub-watersheds. Roads in lower Redwood Creek were generally built substantially wider than roads in the upper watershed. This may be attributable to tree size during first harvests. In the lower watershed, large old-growth redwood trees had substantial diameters requiring larger, straighter roads for hauling. The era of logging in these sub-watersheds may also have influenced road size and locations as many roads were constructed with bulldozer in an age of equipment development and with few or no restriction for construction methods.

PRIORITIZING SUB-WATERSHEDS USING RISK ANALYSES

This analysis establishes treatment priorities using a numeric risk analysis and data from sites assessed by PCFWWRA throughout the watershed and RNSP in the upper watershed, and not decommissioned. Rather than analyzing a specific road or broad contiguous area, this method prioritizes each *sub-watershed* based on specific criteria. Similar to other analyses, at least 40 percent of the road length in each sub-watershed must have been assessed to be considered, and only sites with medium or higher erosion potential are included in the analysis. The analysis is performed twice. First, it evaluates sub-watersheds based on the likelihood for and magnitude of potential erosion which we call *resource threat*. Then, anadromous salmonids are added to the analysis that considers salmonids as the *resource at risk*.

RESOURCE THREAT

This risk analysis establishes a sub-watershed treatment priority based on resource threat, or the likelihood for and magnitude of erosion in each sub-watershed. The resource threat for each sub-watershed considers two criteria: 1) potential sediment yield and 2) Shalstab Count. Resource threat was computed as follows:

Resource Threat = Yield + Shalstab Count

where, for each sub-watershed:

Yield is the total potential sediment yield for the sub-watershed, and

Shalstab Count is the number of Shalstab sites in the sub-watershed.

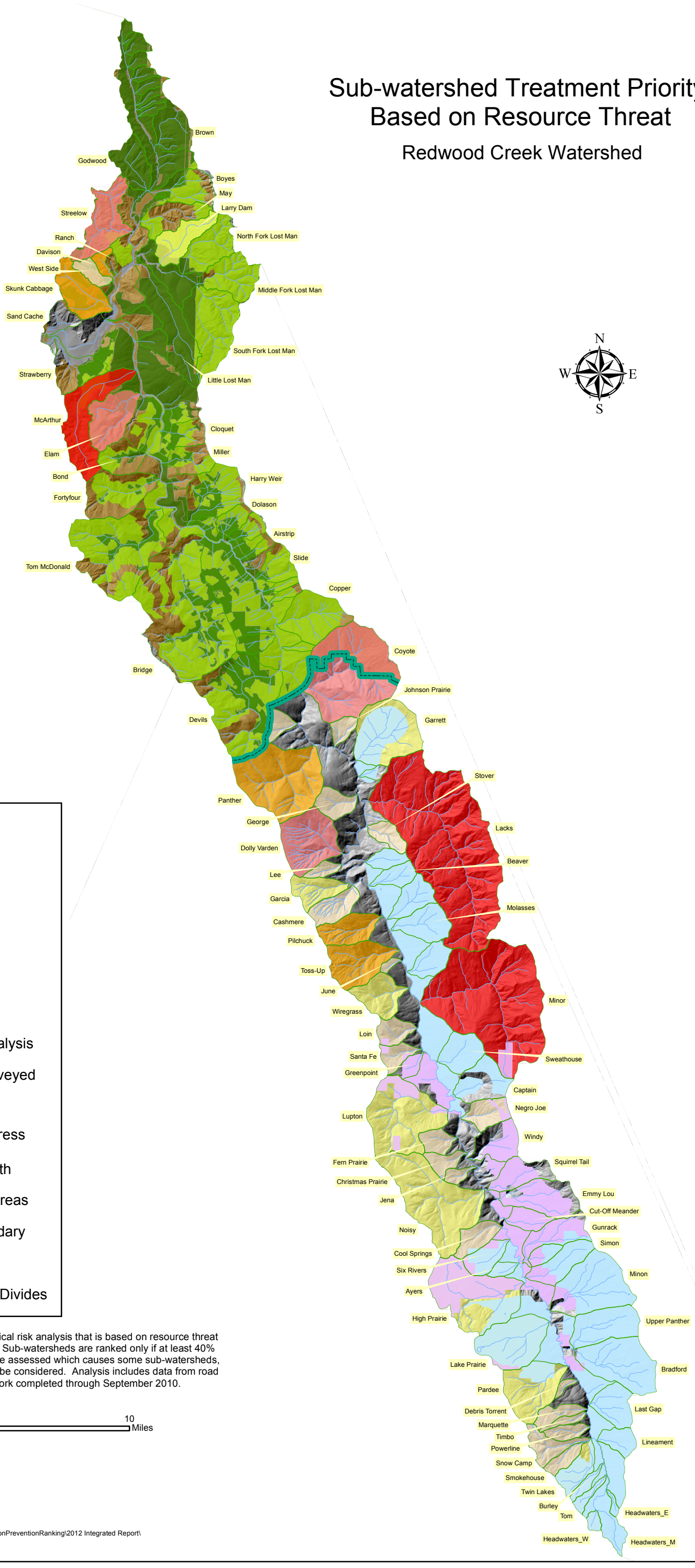
Weighted values were assigned to each criterion (Appendix D) based on the actual range of values for each criterion. The weighted values were then summed to create a final score for each sub-watershed. The final scores were sorted from high to low values and a sub-watershed treatment priority assigned based on 20% breaks in cumulative total scores. The results are shown in Figure 6 and Table 7 and suggest that Lacks, Minor, Toss-Up and McArthur creeks have the highest treatment priority based on potential resource threat. The results are in general agreement with the spatial analysis for potential sediment yield density (Figure 5).

Previous risk analyses performed in Redwood Creek included a third criterion for "Critical Crossings" (Cxings) (Bundros and Short 2011, Bundros and Short 2009, Bundros et al 2004, Bundros et al 2003). By definition, Cxings have a diversion potential, an undersized culvert, and at least a medium plug potential (Bundros et al 2003). Because just 7 percent of the crossings evaluated in the Lower Redwood Creek assessment area did not meet this definition, the criterion for Cxings was dropped from the analysis.

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Sub-watershed Treatment Priority Based on Resource Threat

Redwood Creek Watershed



Sub-watershed Priority

- Very High
- High
- Medium
- Low
- Very Low
- Not Ranked

Areas Excluded from Analysis

- Currently Unsurveyed
- Limited Data
- Surveys in Progress
- Park - Old Growth
- Park - Treated Areas
- SouthParkBoundary
- Streams (1:24k)
- Sub-Watershed Divides

This map shows the result of a numerical risk analysis that is based on resource threat (potential sediment yield + Shalstab). Sub-watersheds are ranked only if at least 40% of the roads in the sub-watershed were assessed which causes some sub-watersheds, such as Bond and May creeks, to not be considered. Analysis includes data from road assessments 1996 - 2011 and road work completed through September 2010.

0 5 10 Miles

Source: RNSP GIS - N:\GIS_Maps\user_maps\60_UBErosionPreventionRanking\2012 Integrated Report\ WshdRankByThreat.mxd. Compiled: March 2012

Figure 6. Sub-watershed ranking based on resource threat.

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Table 8. Sub-watershed treatment priority based on resource threat.

Sub-Watershed	Acres	Weighting Values for:		Total Score	Sub-Watershed Priority
		Potential Sediment Yield	Shalstab		
Lacks	10,977	9	9	18	Very High
Minor	8,248	7	9	16	Very High
Toss-Up	1,709	5	9	14	Very High
McArthur	2,417	9	3	12	High
Elam	1,573	7	3	10	Medium
Coyote	5,045	5	5	10	Medium
Dolly Varden	2,151	5	5	10	Medium
Lupton	3,329	5	5	10	Medium
Panther	3,799	3	3	6	Medium
Garcia	905	3	3	6	Medium
Pilchuck	1,086	3	3	6	Medium
Wiregrass	1,153	3	3	6	Medium
Timbo	229	1	3	4	Low
Twin Lakes	811	1	3	4	Low
Garrett	2,643	3	1	4	Low
Lee	292	3	1	4	Low
Pardee	1,985	1	3	4	Low
Lake Prairie	2,144	1	3	4	Low
Negro Joe	806	1	3	4	Low
Noisy	4,030	3	1	4	Low
Cool Springs	737	1	3	4	Low
West Side	425	3	0	3	Low
Powerline	408	1	1	2	Very Low
Davison	264	1	1	2	Very Low
Streelow	1,811	1	1	2	Very Low
Burley	255	1	1	2	Very Low
Joplin	440	1	1	2	Very Low
Johnson Prairie	386	1	1	2	Very Low
Six Rivers	741	1	1	2	Very Low
George	699	1	1	2	Very Low
Cashmere	861	1	1	2	Very Low
Stover	544	1	1	2	Very Low
Skunk Cabbage	1,442	1	1	2	Very Low
Loin	601	1	1	2	Very Low
High Prairie	3,476	1	1	2	Very Low
Marquette	492	1	1	2	Very Low
Christmas Prairie	455	1	1	2	Very Low
June	125	1	1	2	Very Low
Jena	246	1	0	1	Very Low
Larry Dam	1,182	1	0	1	Very Low

Sub-Watershed	Acres	Weighting Values for:		Total Score	Sub-Watershed Priority
		Potential Sediment Yield	Shalstab		
Santa Fe	530	1	0	1	Very Low
Tom	259	1	0	1	Very Low
Snow Camp	773	1	0	1	Very Low
Ayers	242	1	0	1	Very Low
Fern Prairie	509	1	0	1	Very Low
Smokehouse	426	1	0	1	Very Low
Debris Torrent	129	1	0	1	Very Low
Headwaters_W	179	1	0	1	Very Low

RESOURCE THREAT AND RESOURCE AT RISK

This risk analysis uses the same methods used to describe resource threat, but now integrates anadromous salmonids present in each sub-watershed as the *resource at risk*. Doing so adds a biological element to the previous analysis that prioritized sub-watershed treatment only in terms of the likelihood for and magnitude of potential erosion, or *resource threat*. In this analysis risk is defined as follows:

Risk = Resource Threat + Resource at Risk

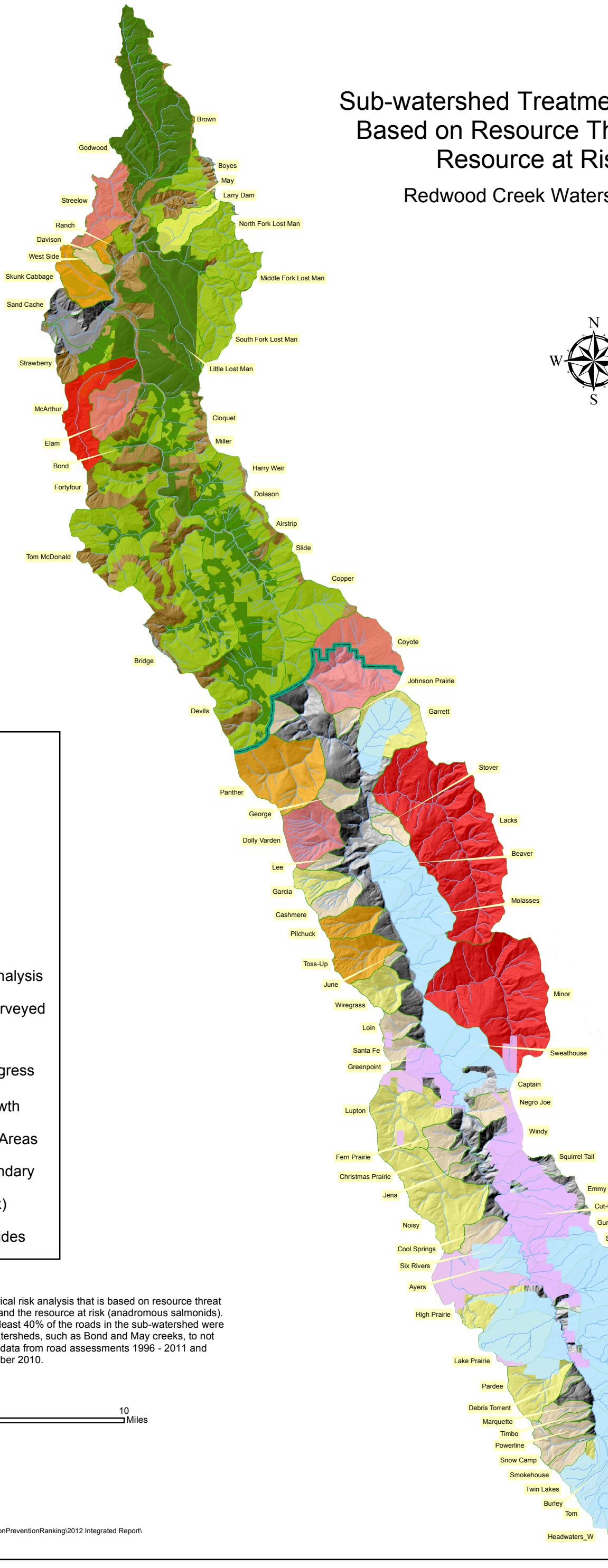
Resource Threat was defined in the previous analysis. *Resource at Risk* considers the number of anadromous salmonid species observed in each sub-watershed. Salmonid distribution information for the Redwood Creek watershed is from documented stream surveys performed since 1965 and is shown in Figure D-1 (Appendix D).

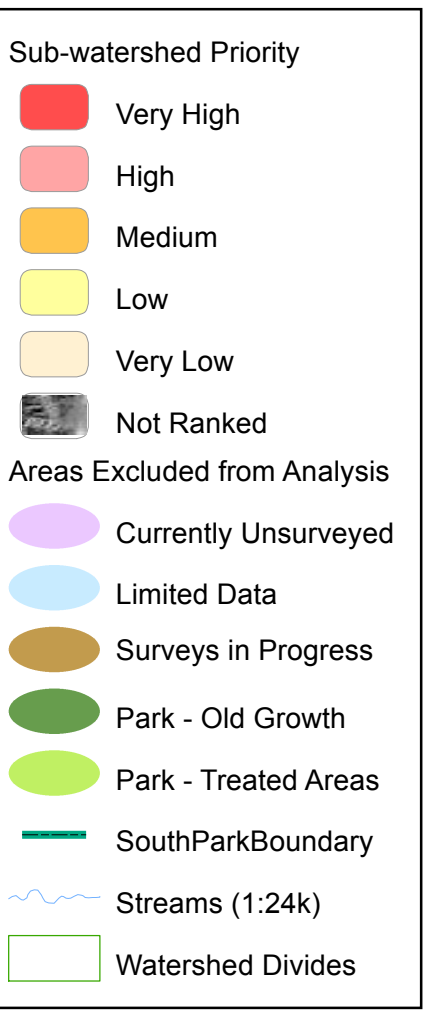
The results from this analysis are shown in Figure 7 and Table 9. Lacks McArthur and Minor creeks are the highest priority for treatment because they have high sediment threats and support at least three salmonid species. The treatment priority for Streelow Creek moved from Very Low in the previous analysis to High in this analysis, because it has relatively low sediment threats and but supports four salmonid species. Other sub-watersheds, such as Davison, Skunk Cabbage and Larry Dam moved up in priority from Very Low to Medium or Low because they support three salmonid species.

It is important to note that the number of anadromous salmonid species observed in each sub-watershed does not consider the length of stream available as habitat. For example, McArthur Creek has had all four species observed in the sub-watershed, but the channel has a barrier for all stages of fish about 0.5 mi upstream from its confluence with Redwood Creek. Streelow Creek also has had all four species observed in the sub-watershed and has 1.3 mi of stream accessible to fish (Brown, 1988). Our current analysis gives McArthur Creek the same score for resource at risk as Streelow Creek. In the future, we will further refine the "resource at risk" value in the analysis to consider other factors for salmonids.

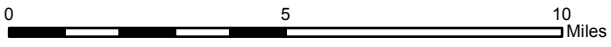
Sub-watershed Treatment Priority Based on Resource Threat and Resource at Risk

Redwood Creek Watershed





This map shows the result of a numerical risk analysis that is based on resource threat (potential sediment yield + Shalstab) and the resource at risk (anadromous salmonids). Sub-watersheds are ranked only if at least 40% of the roads in the sub-watershed were assessed which causes some sub-watersheds, such as Bond and May creeks, to not be considered. The analysis includes data from road assessments 1996 - 2011 and road work completed through September 2010.



Source: RNSP GIS - N:\GIS_Maps\user_maps\60_UBErosionPreventionRanking\2012 Integrated Report\ WshdRankByThreatAndFish.mxd. Compiled: March 2012

Figure 7. Sub-Watershed ranking based on resource threat and resource at risk.

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Table 9. Sub-watershed treatment priority based on resource threat and resource at risk.

Sub-Watershed	Acres	Fish		Scores		Total Score	Sub-Watershed Priority
		# of Species	Weighting Value	Resource Threat	Resource at Risk (2x weight)		
Lacks	10,977	4	9.00	18	18	36	Very High
McArthur	2,417	4	9.00	12	18	30	Very High
Minor	8,248	3	6.75	16	13.5	29.5	Very High
Elam	1,573	3	6.75	10	13.5	23.5	High
Coyote	5,045	3	6.75	10	13.5	23.5	High
Streelow	1,811	4	9.00	2	18	20	High
Dolly Varden	2,151	2	4.50	10	9	19	High
Toss-Up	1,709	1	2.25	14	4.5	18.5	Medium
Davison	264	3	6.75	2	13.5	15.5	Medium
Skunk Cabbage	1,442	3	6.75	2	13.5	15.5	Medium
Pilchuck	1,086	2	4.50	6	9	15	Medium
Panther	3,799	2	4.50	6	9	15	Medium
Larry Dam	1,182	3	6.75	1	13.5	14.5	Low
Lupton	3,329	1	2.25	10	4.5	14.5	Low
High Prairie	3,476	2	4.50	2	9	11	Low
Garcia	905	1	2.25	6	4.5	10.5	Low
Wiregrass	1,153	1	2.25	6	4.5	10.5	Low
Lake Prairie	2,144	1	2.25	4	4.5	8.5	Low
Pardee	1,985	1	2.25	4	4.5	8.5	Low
Noisy	4,030	1	2.25	4	4.5	8.5	Low
Twin Lakes	811	1	2.25	4	4.5	8.5	Low
Garrett	2,643	1	2.25	4	4.5	8.5	Low
Loin	601	1	2.25	2	4.5	6.5	Very Low
Cashmere	861	1	2.25	2	4.5	6.5	Very Low
Six Rivers	741	1	2.25	2	4.5	6.5	Very Low
Jena	246	1	2.25	1	4.5	5.5	Very Low
Smokehouse	426	1	2.25	1	4.5	5.5	Very Low
Santa Fe	530	1	2.25	1	4.5	5.5	Very Low
Snow Camp	773	1	2.25	1	4.5	5.5	Very Low
Lee	292	0	0.00	4	0	4	Very Low
Cool Springs	737	0	0.00	4	0	4	Very Low
Negro Joe	806	0	0.00	4	0	4	Very Low
Timbo	229	0	0.00	4	0	4	Very Low
West Side	425	0	0.00	3	0	3	Very Low
Burley	255	0	0.00	2	0	2	Very Low
Johnson Prairie	386	0	0.00	2	0	2	Very Low
George	699	0	0.00	2	0	2	Very Low
Marquette	492	0	0.00	2	0	2	Very Low
Stover	544	0	0.00	2	0	2	Very Low

Sub-Watershed	Acres	Fish		Scores		Total Score	Sub-Watershed Priority
		# of Species	Weighting Value	Resource Threat	Resource at Risk (2x weight)		
June	125	0	0.00	2	0	2	Very Low
Christmas Prairie	455	0	0.00	2	0	2	Very Low
Ayers	242	0	0.00	1	0	1	Very Low
Headwaters_W	179	0	0.00	1	0	1	Very Low
Fern Prairie	509	0	0.00	1	0	1	Very Low
Tom	259	0	0.00	1	0	1	Very Low
Debris Torrent	129	0	0.00	1	0	1	Very Low

DISCUSSION

This erosion assessment project provides data for quantifying potential road related erosion and sediment delivery in Lower Redwood Creek watershed. It also provides descriptions of site specific treatments to prevent erosion, and quantifies equipment and labor needs for implementation. It provides data that are fully comparable to road assessment data collected on approximately 720 miles of roads in upper Redwood Creek. When combined, the data allow prioritizing treatment projects that can be used for developing the most cost-effective projects to most effectively correct sediment threats throughout the watershed using limited funds.

This project completed assessments on 62 miles of roads in the lower watershed. There are approximately 200 miles of roads in the lower watershed with RNSP. The park is presently assessing roads in key watersheds within the park and those data are intended to be compatible with all other road assessment data collected in the watershed by PCFWWRA and the park. The park will perform thorough review of road assessments completed by park staff in the park to ensure data quality before integrating park data with the larger data set.

An erosion prevention action plan has been presented which places all assessed potential sediment delivery sites within the watershed in priority order for treatments. Several different prioritizations are presented based on different analyses. Each analysis works at a different scale and has its strengths and weaknesses. When used together, the analyses can be used to identify areas that consistently rank as high priority for treatment. These areas should be considered for immediate treatments.

The 'best' prioritization method would probably use a combination of the analyses presented in this report, and would depend on the scale and objectives of the planning effort. For example, a landowner in the upper watershed, willing to implement an erosion control project, might use database queries in combination with the spatial analysis to prioritize work on their land. If the protection of sub-watersheds that supports the greatest number of salmonid species is the

objective, then the numeric risk analysis that integrates salmonid information would be appropriate in combination with the database query that considers treatment cost-effectiveness. The spatial analysis could also help pinpoint priority areas within the sub-watershed.

A more regional approach for prioritizing areas for treatment would consider the importance of limiting sedimentation in the main channel of Redwood Creek, because of its importance to fisheries and the threat sediment poses to downstream aquatic and riparian resources. Outside of the Prairie Creek sub-watershed, the main channel of Redwood Creek represents about 70 percent of all accessible anadromous salmonid habitat in the Redwood Creek watershed (California Resources Agency, 2002), and severe aggradation of the main channel, as experienced during past large storms, would threaten the riparian areas downstream, including the alluvial old-growth groves in the national park. Thus, a watershed-wide planning effort that sets sediment reduction to the main channel of Redwood Creek as its primary objective could use the numeric risk analysis based on resource threat in combination with the analysis that identifies the "hot spots" throughout the entire watershed.

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Waanenen, A. O. and J. R. Crippen. 1977. Magnitude and Frequency of Floods in California. U. S. Geological Survey Water-Resources Investigations 77-21. 96p.

Lower Redwood Creek Erosion Assessment and Restoration Planning Project
Pacific Coast Fish, Wildlife and Wetland Restoration Association
Redwood Creek Watershed, Humboldt County, California

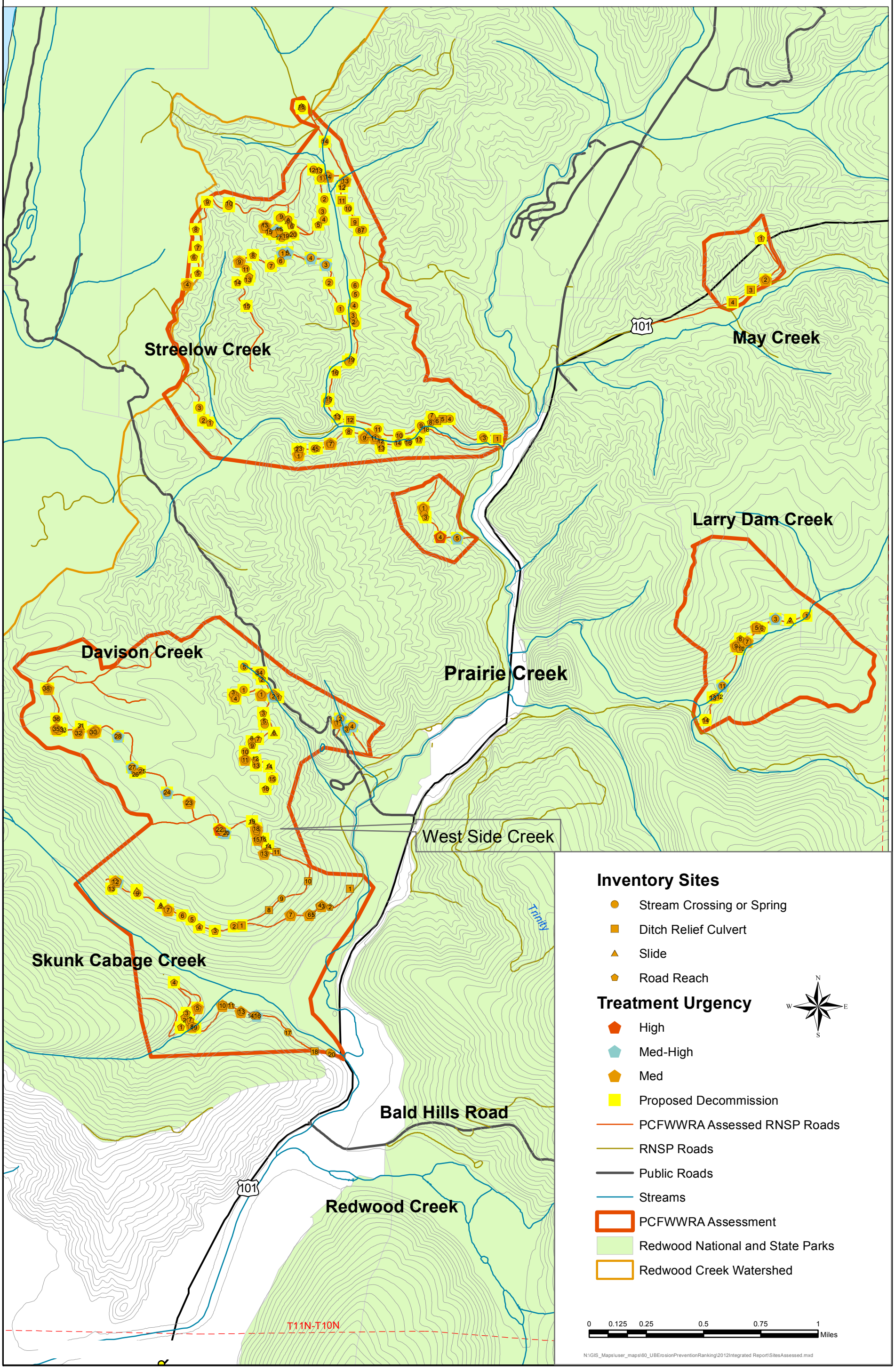


Figure B-1. Lower Redwood Creek road assessment site map, Prairie Creek area.

Lower Redwood Creek Erosion Assessment and Restoration Planning Project
Pacific Coast Fish, Wildlife and Wetland Restoration Association
Redwood Creek Watershed, Humboldt County, California

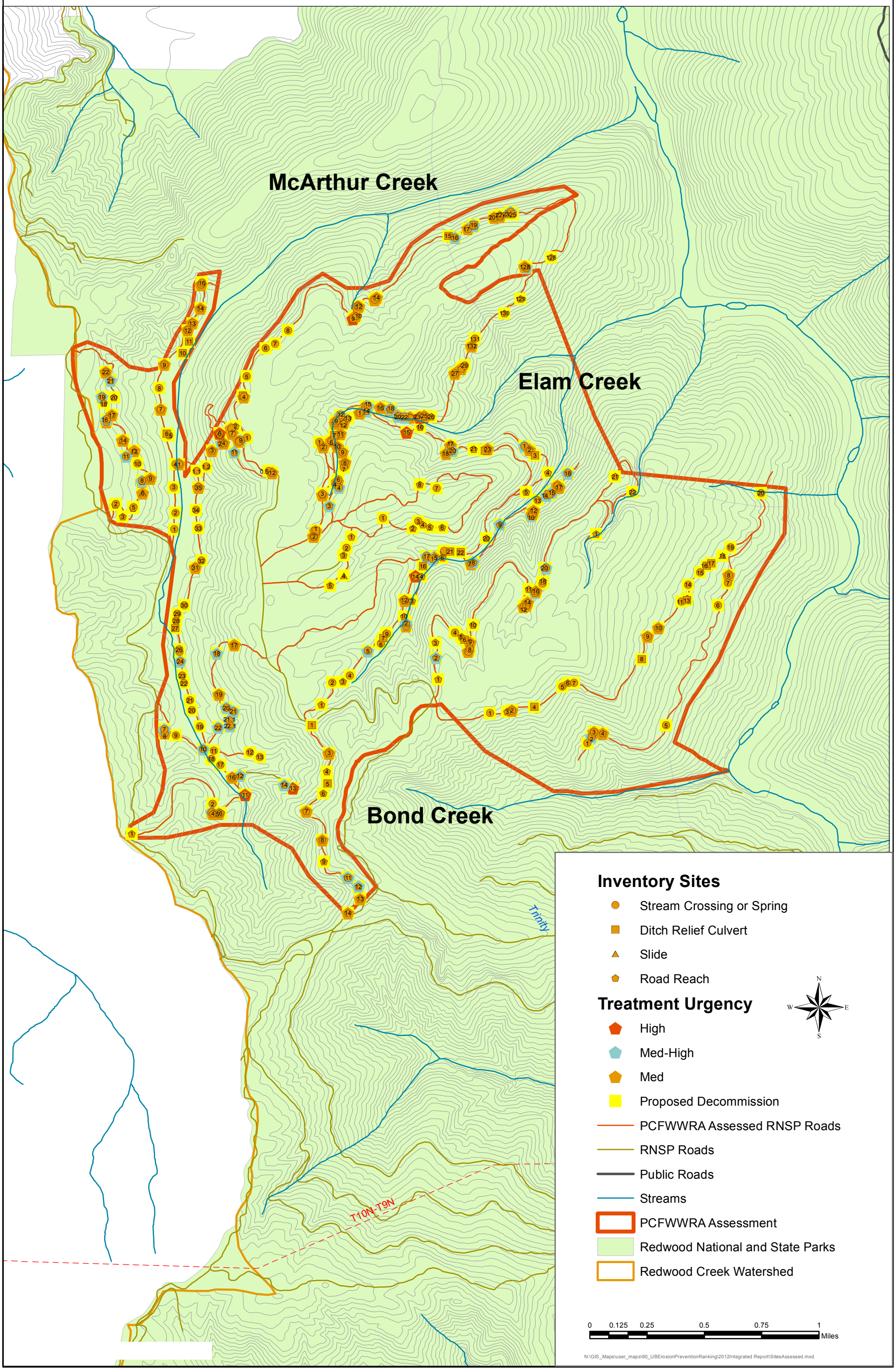


Figure B-2. Lower Redwood Creek road assessment site map, McArthur, Elam and Bond creeks.

Lower Redwood Creek Erosion Assessment and Restoration Planning Project
Pacific Coast Fish, Wildlife and Wetland Restoration Association
Redwood Creek Watershed, Humboldt County, California

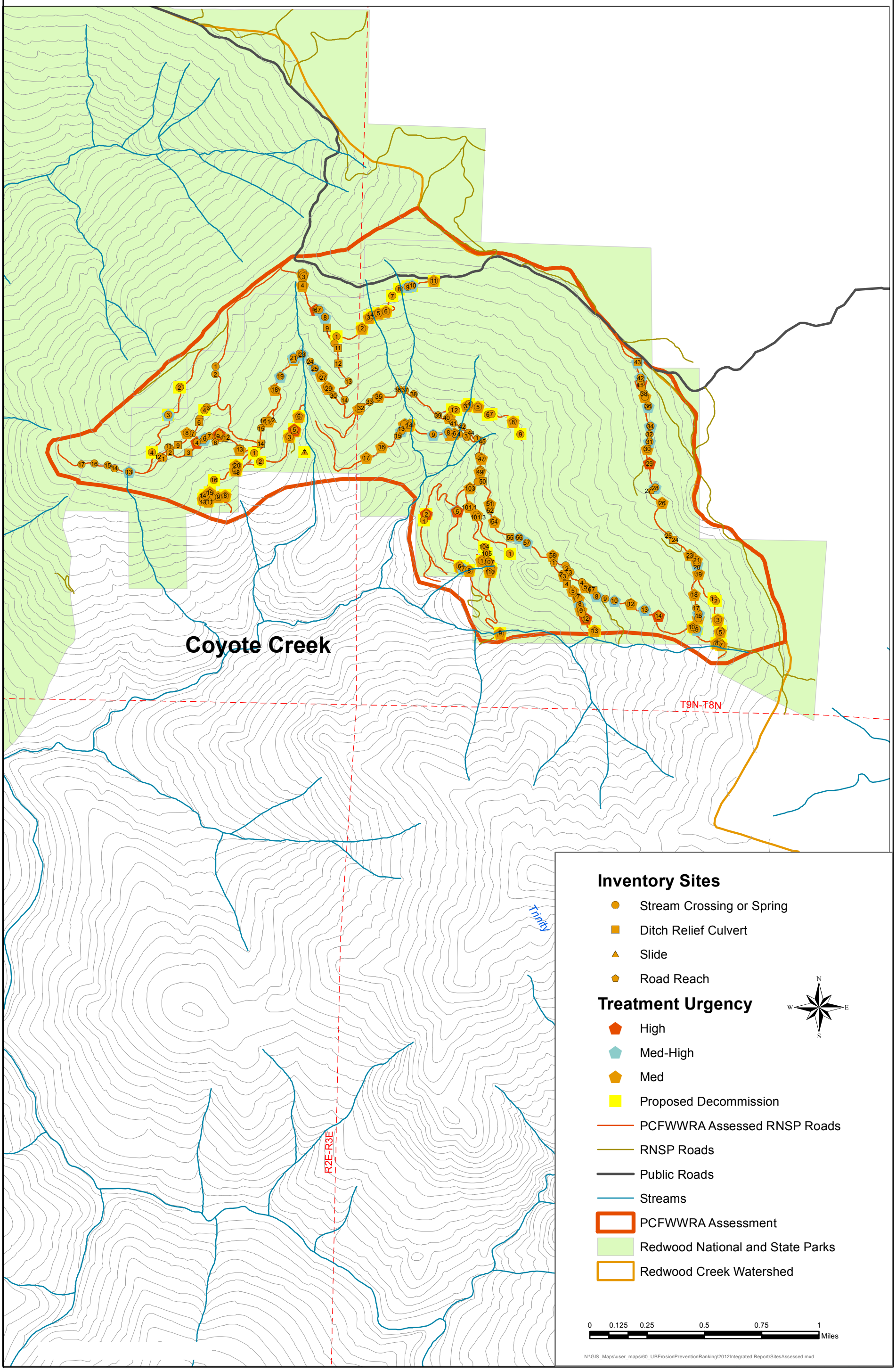


Figure B-3. Lower Redwood Creek road assessment site map, Coyote Creek.

Table C-1: Roads in lower Redwood Creek assessment ranked by potential sediment yield for medium to high urgency sites.

Road Name	Length (mi)	Total No. of ALL Sites	Total No. of M to H Sites	Potential Sediment Yield for ALL Sites (yds^3)	Potential Sediment Yield for M to H Sites (yds^3)	Percent of Potential Sediment Yield Volume for M to H Sites	Potential Sediment Yield per Mile for M to H Sites (yds^3/mi)	Total Cost for M to H Sites	Cost/Yard "Saved"
Dolly Varden	11.8	155	114	109,890	103,954	95%	8,793	$1,234,068	$11.87
L-Line South	1.1	14	9	36,511	36,000	99%	34,139	$125,470	$3.49
Old K&K	8.3	97	35	43,395	33,359	77%	4,042	$307,439	$9.22
LC5000	2.3	26	21	23,659	23,089	98%	10,176	$59,360	$2.57
K&K West	7.9	79	30	37,375	23,063	62%	2,909	$263,580	$11.43
205	3.4	38	19	27,769	22,383	81%	6,526	$665,239	$29.72
L-2-2-1	0.9	15	11	23,251	22,314	96%	24,363	$84,601	$3.79
LC1000	6.5	42	27	22,770	20,241	89%	3,134	$191,878	$9.48
L-5	1.6	23	16	22,729	20,226	89%	12,440	$437,251	$21.62
A-9-7-2	1.5	22	14	21,408	18,411	86%	12,678	$369,138	$20.05
1400	4.6	47	32	19,382	17,301	89%	3,753	$96,655	$5.59
PR1100	5.4	69	44	19,033	16,068	84%	2,958	$141,382	$8.80
A-9-7-1 South	0.8	10	7	19,349	15,096	78%	20,060	$409,054	$27.10
Old HWY 299	2.5	52	39	16,040	15,064	94%	6,074	$233,836	$15.52
1440	1.5	18	15	15,155	14,588	96%	9,657	$31,314	$2.15
1000	3.9	37	16	14,312	14,050	98%	3,616	$74,023	$5.27
809	1.8	15	13	16,032	12,510	78%	7,032	$156,745	$12.53
L-1-1 North	2.4	22	9	17,436	11,902	68%	5,007	$416,232	$34.97
L2010	4.3	42	27	15,483	11,689	76%	2,750	$136,646	$11.69
808	3.9	40	21	19,766	11,684	59%	3,032	$125,299	$10.72
L-2-2	2.5	26	14	14,688	11,325	77%	4,493	$327,535	$28.92
MC1000	6.5	82	53	15,313	10,897	71%	1,691	$191,235	$17.55
Mainline	2.7	33	16	13,611	10,585	78%	3,875	$145,608	$13.76
PR1106	0.6	5	5	10,417	10,417	100%	17,639	$31,477	$3.02
UPR-10	4.7	38	24	14,685	10,394	71%	2,197	$126,230	$12.14
L-1 East	2.0	20	3	23,040	10,291	45%	5,075	$312,975	$30.41
L-4	1.3	19	14	11,796	10,278	87%	8,209	$295,695	$28.77
R3800	0.9	11	10	9,796	9,774	100%	11,364	$57,576	$5.89
LC4000	2.5	35	24	17,335	9,436	54%	3,849	$85,283	$9.04
1431	1.7	29	22	9,479	9,375	99%	5,626	$95,960	$10.24
RC-2	1.5	25	14	10,122	9,120	90%	6,168	$134,682	$14.77
L-2	2.1	36	25	13,606	8,940	66%	4,222	$260,683	$29.16
R1000	2.1	21	11	8,914	8,598	96%	4,080	$31,121	$3.62
1410	1.9	23	12	8,125	7,602	94%	3,994	$33,660	$4.43
LC2000	2.6	17	13	8,762	7,591	87%	2,881	$108,119	$14.24
1020	1.7	18	12	8,059	7,544	94%	4,465	$36,317	$4.81
L2171	1.4	16	12	7,884	7,532	96%	5,446	$110,514	$14.67
FP500	1.6	29	18	9,014	7,351	82%	4,733	$110,692	$15.06
831	2.1	13	7	7,699	7,338	95%	3,578	$14,821	$2.02
DVA	1.3	18	15	7,480	7,292	97%	5,640	$112,964	$15.49
1140	0.8	15	7	12,616	7,144	57%	9,516	$23,856	$3.34
DVD-1	1.4	12	11	7,102	7,004	99%	5,162	$69,224	$9.88

Additionally ranked roads available upon request.

Table C-2: Roads in lower Redwood Creek assessment ranked by potential sediment yield per mile for medium to high urgency sites.

Road Name	Length (mi)	Total No. of ALL Sites	Total No. of M to H Sites	Potential Sediment Yield for ALL Sites (yds^3)	Potential Sediment Yield for M to H Sites (yds^3)	Percent of Potential Sediment Yield Volume for M to H Sites	Potential Sediment Yield per Mile for M to H Sites (yds^3/mi)	Total Cost for M to H Sites	Cost/Yard "Saved"
454	0.0	20	3	6,577	807	12%	79,923	$27,322	$33.86
Streelow Spur	0.1	18	6	5,737	2,779	48%	49,114	$66,165	$23.81
L2010-B	0.1	1	1	3,334	3,334	100%	44,387	$35,350	$10.60
R3810	0.1	2	1	5,000	3,500	70%	43,126	$10,165	$2.90
L-5 Tie	0.1	1	1	2,795	2,795	100%	42,768	$77,226	$27.63
240 North Spur	0.1	1	1	2,080	2,080	100%	41,959	$56,013	$26.93
L-Line South	1.1	14	9	36,511	36,000	99%	34,139	$125,470	$3.49
450	0.0	14	2	4,367	844	19%	32,901	$14,577	$17.27
HP-22	0.0	3	2	1,204	804	67%	25,588	$23,005	$28.60
L-2-2-1	0.9	15	11	23,251	22,314	96%	24,363	$84,601	$3.79
L-4 Tie	0.0	1	1	900	900	100%	21,916	$22,788	$25.32
311	0.0	1	1	857	857	100%	21,666	$25,145	$29.34
A-9-7-1 South	0.8	10	7	19,349	15,096	78%	20,060	$409,054	$27.10
PR1106	0.6	5	5	10,417	10,417	100%	17,639	$31,477	$3.02
3C2010	0.2	6	5	4,000	3,500	88%	16,972	$49,559	$14.16
HP-21	0.1	1	1	1,014	1,014	100%	15,504	$13,523	$13.34
Davison Spur C	0.3	4	4	4,358	4,358	100%	14,322	$105,950	$24.31
A-9-7-2	1.5	22	14	21,408	18,411	86%	12,678	$369,138	$20.05
L-5	1.6	23	16	22,729	20,226	89%	12,440	$437,251	$21.62
800G	0.3	2	2	3,726	3,726	100%	12,298	$12,236	$3.28
R3800	0.9	11	10	9,796	9,774	100%	11,364	$57,576	$5.89
BO1306	0.4	4	4	3,789	3,789	100%	10,207	$46,725	$12.33
LC5000	2.3	26	21	23,659	23,089	98%	10,176	$59,360	$2.57
L2173	0.2	3	3	1,845	1,845	100%	9,979	$11,595	$6.28
1440	1.5	18	15	15,155	14,588	96%	9,657	$31,314	$2.15
1140	0.8	15	7	12,616	7,144	57%	9,516	$23,856	$3.34
R1050	0.2	2	1	1,829	1,778	97%	9,405	$11,362	$6.39
Dolly Varden	11.8	155	114	109,890	103,954	95%	8,793	$1,234,068	$11.87
A-9-7 Skid	0.8	8	8	6,590	6,590	100%	8,543	$114,275	$17.34
AM-4-1	0.1	1	1	500	500	100%	8,438	$2,712	$5.42
UBR	0.2	3	2	1,775	1,723	97%	8,402	$27,722	$16.09
L-4	1.3	19	14	11,796	10,278	87%	8,209	$295,695	$28.77
L2011	0.6	10	7	5,822	5,261	90%	8,177	$83,782	$15.92
L1000-E	0.1	2	2	961	961	100%	8,082	$16,272	$16.93
R4250	0.1	2	2	625	625	100%	8,031	$8,981	$14.38
3C2002	0.1	1	1	1,050	1,050	100%	8,007	$7,458	$7.10
DVJ	0.3	4	2	2,792	2,269	81%	7,882	$16,272	$7.17
1433	0.5	7	7	3,978	3,978	100%	7,835	$12,109	$3.04
LC5005	0.5	3	1	7,074	3,500	49%	7,405	$9,095	$2.60
R2100	0.2	2	2	1,557	1,557	100%	7,402	$4,746	$3.05
A-9-7-1 Skid	1	7	3	6,007	4,481	75%	7,374	114,930	$25.65
N500A	0.2	3	3	1,697	1,697	100%	7,318	$8,348	$4.92

Additionally ranked roads available upon request.

Table C-3: Roads in lower Redwood Creek assessment ranked by cost-effectiveness for medium to high urgency sites.

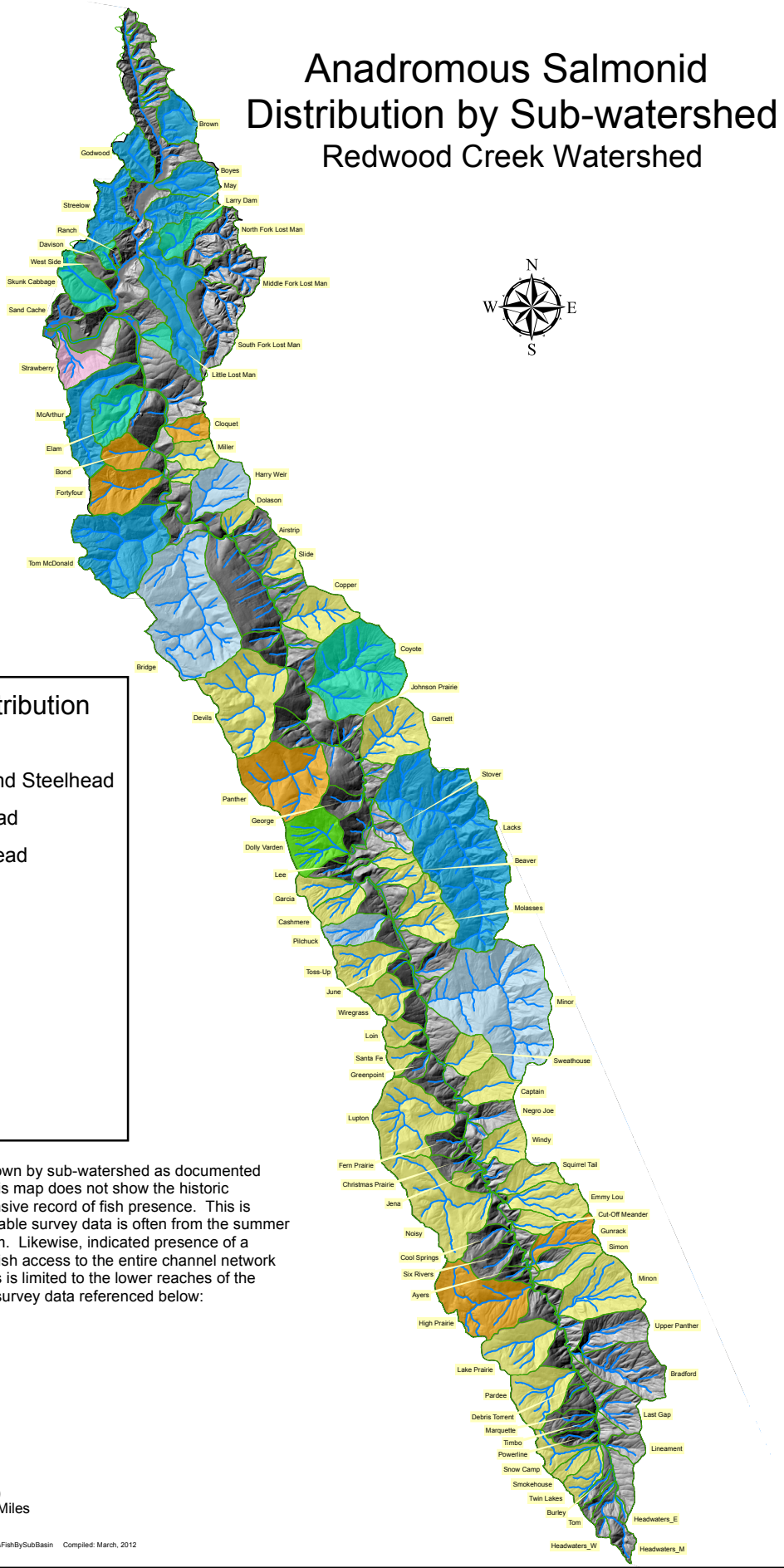
Road Name	Length (mi)	Total No. of ALL Sites	Total No. of M to H Sites	Potential Sediment Yield for ALL Sites (yds^3)	Potential Sediment Yield for M to H Sites (yds^3)	Percent of Potential Sediment Yield Volume for M to H Sites	Potential Sediment Yield per Mile for M to H Sites (yds^3/mi)	Total Cost for M to H Sites	Cost/Yard "Saved"
UPC-BC	0.7	4	3	2,194	1,694	77%	2,609	$2,034	$1.20
R3351	0.1	1	1	750	750	100%	6,544	$1,017	$1.36
Ranch Spur 2	0.1	1	1	500	500	100%	5,704	$678	$1.36
930	1.7	4	1	750	750	100%	434	$1,119	$1.49
N550A	0.2	1	1	750	750	100%	3,276	$1,356	$1.81
O-8	0.1	1	1	95	95	100%	728	$177	$1.86
831	2.1	13	7	7,699	7,338	95%	3,578	$14,821	$2.02
Upper Lyons	0.7	4	1	602	500	83%	753	$1,017	$2.03
1440	1.5	18	15	15,155	14,588	96%	9,657	$31,314	$2.15
800I	0.8	2	2	1,517	1,517	100%	1,913	$3,745	$2.47
3C2512	0.3	6	1	3,066	1,500	49%	5,349	$3,729	$2.49
LC5000	2.3	26	21	23,659	23,089	98%	10,176	$59,360	$2.57
LC5005	0.5	3	1	7,074	3,500	49%	7,405	$9,095	$2.60
R3970	0.2	2	2	910	910	100%	3,741	$2,569	$2.82
PR1107	0.8	3	3	3,500	3,500	100%	4,690	$9,900	$2.83
R3810	0.1	2	1	5,000	3,500	70%	43,126	$10,165	$2.90
PR1106	0.6	5	5	10,417	10,417	100%	17,639	$31,477	$3.02
R3200	1.3	13	3	1,338	435	32%	333	$1,316	$3.03
1433	0.5	7	7	3,978	3,978	100%	7,835	$12,109	$3.04
R2100	0.2	2	2	1,557	1,557	100%	7,402	$4,746	$3.05
800G	0.3	2	2	3,726	3,726	100%	12,298	$12,236	$3.28
1140	0.8	15	7	12,616	7,144	57%	9,516	$23,856	$3.34
CR2900	7.2	80	13	17,836	5,958	33%	829	$20,437	$3.43
L-Line South	1.1	14	9	36,511	36,000	99%	34,139	$125,470	$3.49
LC5001	0.1	1	1	750	750	100%	5,246	$2,622	$3.50
R1000	2.1	21	11	8,914	8,598	96%	4,080	$31,121	$3.62
R3900	1.7	16	6	12,255	4,508	37%	2,706	$16,304	$3.62
L-2-2-1	0.9	15	11	23,251	22,314	96%	24,363	$84,601	$3.79
1055	0.3	1	1	89	89	100%	263	$339	$3.81
RV-1	0.7	3	3	178	178	100%	252	$708	$3.98
HRPR-1	0.2	3	2	840	807	96%	4,086	$3,390	$4.20
PR1104	0.4	1	1	400	400	100%	920	$1,695	$4.24
FL1025	0.9	8	7	3,982	3,947	99%	4,671	$17,178	$4.35
1410	1.9	23	12	8,125	7,602	94%	3,994	$33,660	$4.43
LPC-PC-1	0.2	3	1	935	750	80%	5,052	$3,390	$4.52
N750	0.3	2	1	426	371	87%	1,267	$1,695	$4.57
CP1210	1.4	19	1	6,324	686	11%	491	$3,210	$4.68
1020	1.7	18	12	8,059	7,544	94%	4,465	$36,317	$4.81
N500A	0.2	3	3	1,697	1,697	100%	7,318	$8,348	$4.92
LC-7	0.7	6	2	1,611	649	40%	942	$3,216	$4.96
R5000	1.4	9	3	1,474	814	55%	569	$4,168	$5.12
L2000	0.5	10	3	1,403	1,293	92%	2,484	$6,734	$5.21

Additionally ranked roads available upon request.

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Anadromous Salmonid Distribution by Sub-watershed

Redwood Creek Watershed



Anadromous Salmonid Distribution by Sub-watershed

- Coho, Chinook, Cutthroat and Steelhead
- Coho, Chinook and Steelhead
- Coho, Cutthroat and Steelhead
- Coho and Steelhead
- Coho and Cutthroat
- Cutthroat and Steelhead
- Steelhead
- No data available
- Streams (1:24k)
- Watershed divides

The distribution of anadromous salmonids is shown by sub-watershed as documented by stream survey data collected since 1965. This map does not show the historic range of individual species nor is it a comprehensive record of fish presence. This is particularly true with respect to Chinook as available survey data is often from the summer months when Chinook are not in the river system. Likewise, indicated presence of a species within a sub-watershed does not imply fish access to the entire channel network within the sub-watershed - in most cases access is limited to the lower reaches of the sub-watershed. Information is from the stream survey data referenced below:

Anderson, D.G. 1988.
Brown, R.A. 1988.
California Department of Fish and Game, 2011.
California Department of Fish and Game, 2002.
California Department of Fish and Game, 1965.
California Department of Fish and Game, 1966.
Redwood National and State Parks, 2001.
Redwood National and State Parks, 2010.

0 1 2 4 6 8 10 Miles

Source: RNSP GIS - N:\GIS_Maps\user_maps\60_UBErosionPreventionRanking\2012 Integrated Report\FishBySubBasin Compiled: March, 2012

Appendix E. **Requested information from page A-3 and A-4 of Grant contract**

Grant Number: P0910511
Project Name: Lower Redwood Creek Erosion Assessment and Restoration Planning Project
Geographic area: Lower Redwood Creek
Location of work: Lower Redwood Creek, Humboldt County. See figure 1.
Geospatial reference: Center of each area:

Elam-McArthur: Lat. 412398.73 Long: 4566937.51
Prairie Creek: Lat: 412019.84 Long: 4577293.69
Coyote Creek: Lat: 426417.46 Long: 4554560.00

Project Start and End dates: June 1, 2010 through March 31, 2012
Total of each fund source, by line item expended to complete the project, breaking down Grant dollars, by line item and any other funding, including type of match (cash or in-kind service):
Lower Redwood Creek Erosion Assessment and Restoration Planning Project
Agreement Number P0910511 - FINAL BUDGET

The following is our actual expenses under subject contract from June 1, 2010 through March 31, 2012.

	CDFG	RNSP				CDFG Total	RNSP Cash Match	RNSP In-Kind Match	Grand Total
PERSONAL SERVICES									
Level of Staff									
Project Manager	89.5		hrs @	$40	/hour	$3,580.00			$3,580.00
Field technicians	1,192	1,335	hrs @	$20	/hour	$23,840.00	$26,700.00		$50,540.00
Staff Benefits			@ 20%			$5,484.00	$5,340.00		$10,824.00
Total Personal Services						**$32,904.00**	**$32,040.00**		$64,944.00
OPERATING EXPENSES									
Subcontract Costs									
Pacific Watershed Associates						$46,457.71			$46,457.71
RNSP - Data Entry, Analysis, and Report Preparation								$24,202.00	$24,202.00
Materials and Supplies									$0.00
Transportation, miles	12,210		miles @	0.5	/mile	$6,105.00			$6,105.00
Total Operating						$52,562.71		$24,202.00	$76,764.71
Subtotal						**$85,466.71**	**$32,040.00**	**$24,202.00**	**$141,708.71**
Administrative Overhead			@ 10-13.9188%			$11,094.71			$11,094.71
TOTAL EXPENDITURES						**$96,561.42**	**$32,040.00**	**$24,202.00**	**$152,803.42**

In-kind match from RNSP consisted of geologist field review of 15% of assessed sites, data management and analysis and report preparation.

Expected benefits to anadromous salmonids from the project

This project identified treatable sources of future sediment delivery to stream channels and the treatments needed to prevent it. It allows for prioritizing sediment reduction efforts to protect and restore salmonid habitat. The report will be used to guide sediment reduction implementation in the Redwood Creek watershed.

Labeled before and after photos: Not Applicable (NA).

Specific project access using public and private roads and trails, with landowner name and address:

Landowner contact for entire area is Darci Short, Geologist, RNSP (707) 825-5144.

Drive north on Highway 101 to the town of Orick.

Figure 2: From Orick head south about 1 mile to Hilton's Road. Turn left on Hilton's Road and go about 1 mile to RNSP gate. Go through gate with park key. Travel about 2 miles to A-9-7 Road. Other roads are accessed from this same general area.

Figure 3. From Orick head north about 3 miles to Davison Road (well marked on highway sign). Turn left on Davison road, go 0.2 miles and turn left into visitor area. Roads in this area are accessed on foot. Drive north another 4 miles and turn onto Newton B. Drury Parkway, go 0.2 miles and turn onto dirt road, enter through gate with RNSP key, follow road across bridge and immediately park. Roads are accessed on foot.

Figure 4: From Orick head north about 1 mile to Bald Hills Road. Go about 21 miles to Lyons Ranch parking lot, near School House Peak. Go through park gate with key to access all roads in this area.

Complete as built project description: NA.

An erosion prevention action plan: see final report.

Final GIS maps:

Road history maps by air photo timeframe – see report

Field inventory site maps by site type and treatment immediacy – see report

Report measurable metrics for the project by responding to the restoration project metric listed below.

Habitat Projects (all):

- Identify the watershed/sub-basin plan in which the project is identifies as a priority: California Dept. of Fish and Game. 2004. Recovery Strategy for California Coho Salmon.
- Name the priority habitat limiting factors addressed by the project. Sediment.
- Type of monitoring included in the project: NA

- Number of stream miles treated/affected by the project within the project boundaries: NA

Watershed Evaluation, Assessment, and Planning (PL)

- Miles of stream assessed: NA
- Miles assessed that contain anadromous salmonids: NA
- Miles assessed that are in need of restoration: NA
- Acres assessed that are in need of restoration: NA
- Number of fish passage barriers assessed: 4
- Acres assessed: 7,641 acres

Type of planning / assessment activities conducted:

- If the project involves development of a plan or assessment:
  - Has the plan or assessment supported by this project been completed?
    Yes. See report.
  - Does the project support development of a recovery plan, an implementation action plan, a monitoring plan, or a watershed assessment?
    Yes. This project contributes to the body of data used in developing a watershed-wide implementation planning report for Redwood Creek. More specific implementation projects can be developed from data collected as part of this planning project.
  - Name of the plan/assessment developed by the project:
    Lower Redwood Creek Erosion Assessment and Restoration Planning Project Report
  - Acres covered by the plan/assessment: 7,641
    Is this different from acres assessed requested above?
  - Describe extent, purpose and application of the plan/assessment:
    The project consisted of an erosion assessment of 62 miles of unneeded logging roads in lower Redwood Creek watershed for the purpose of establishing prioritizations for development of cost effective implementation projects that address preventing erosion and sedimentation in the watershed.
  - Does the plan/assessment update or revise/replace an existing plan?
    Yes. This planning report updates the most recent watershed planning report for Redwood Creek: by Bundros, J. and Short, D. 2011.
  - Name of the plan/assessment revised /replaced by the project, in the format Author, date, title, name source, source address:
    Bundros, G.J. and Short, D. 2011. Redwood Creek- Progress Report on Erosion Control Work and Sediment TMDL. Redwood National and State Parks report to the Pacific Coast Fish, Wildlife and Wetlands Restoration Association, unpublished, 84 pp. Redwood National and State Parks, 1655 Heindon Road, Arcata, CA 95521.
- If the project involves coordinating implementation or maintaining the standards of recovery plans: Not applicable.