Klamath National Forest
Sediment and Temperature Monitoring Plan

and

Quality Assurance Project Plan

Proposal Identification Number: ________

September 28, 2010

USDA, Forest Service
Klamath National Forest

QAPP Revision
Number : 1.0

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APPROVAL SIGNATURES

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD NORTH COAST REGION	**U.S. FOREST SERVICE PACIFIC SOUTHWEST REGION KLAMATH NATIONAL FOREST**
11-29-10 Date	10·25·10 Date

By signature above, the Regional Water Board Quality Assurance Officer certifies that data collected consistent with this Quality Assurance Project Plan (QAPP) will be expected to satisfy all data quality requirements for the parameters described herein. Similarly, by signing above, the Klamath National Forest commits to collecting all relevant data consistent with this QAPP. Monitoring completed in accordance with the plan, will be done pursuant to the Memorandum of Understanding between the Regional Water Board and the US Forest Service Klamath National Forest. As stated in section E.9 of the Memorandum of Understanding between the Regional Water Board and the Forest Service, completion of all activities and reporting described in this plan is contingent upon the availability of appropriated funds.

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3. Distribution List

Title:	Name (Affiliation):	Tel. No.:	QAPP No*:
Executive Officer	Catherine Kuhlman (North Coast Regional Water Board)	(707) 576-2225	1
Forest Supervisor	Patricia A. Grantham (U.S. Forest Service, Klamath National Forest)	(530) 841-4502	1
USFS Regional Hydrologist	Barry Hill (U.S. Forest Service, Regional Office)	(707) 562-8968	1
Regional Board QA Officer	Rich Fadness (North Coast Regional Water Board)	(707) 576-6758	1

4. PROJECT ORGANIZATION AND RESPONSIBILITIES

Roles and Responsibilities of key parties responsible for the execution of this plan are displayed in Figure 1.

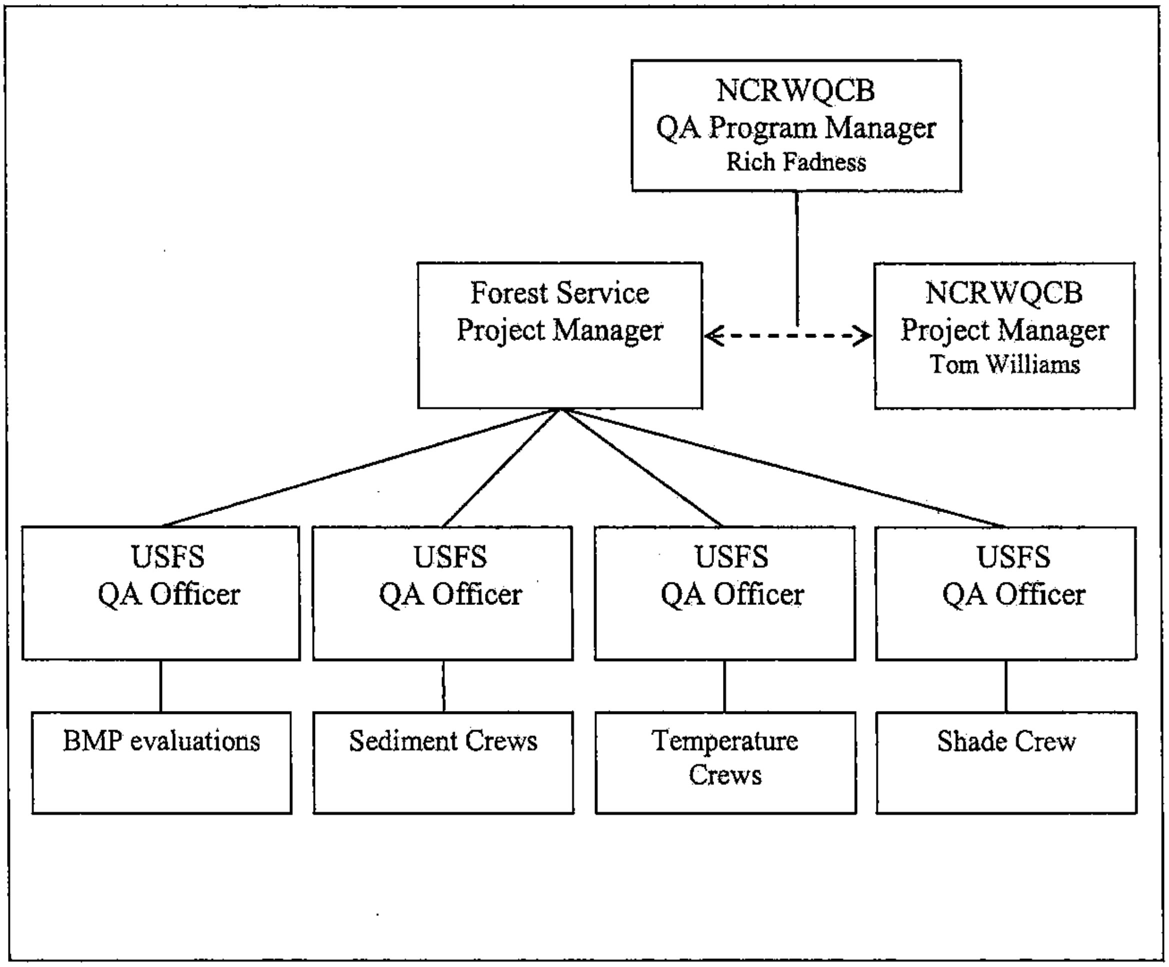
The North Coast Regional Water Board has regulatory authority for water quality in the waters of the state. The Regional Water Board's Project Manger and Quality Assurance (QA) Manager are responsible for reviewing and approving the Forest Service QAPP to assure that the plan meets all of the stated data quality objectives.

The U.S. Forest Service is responsible for conducting monitoring as required in the Scott, Salmon, Shasta, and Klamath River TMDLs, and the Categorical Waiver for Timber Harvest on Federal Lands. The Forest Service Project Manager is responsible for analysis and reporting to the Water Board. There are four Forest Service Quality Assurance Officers, one each for sediment, temperature, shade, and BMP evaluations. The Forest Service Quality Assurance Officer's role is to provide oversight for all quality control procedures in this QAPP including field sampling, training of crews, and data management. The Quality Assurance Officers will communicate directly with the field crews and have the authority to stop all monitoring activities if there are significant deviations from required practices or if there is evidence of a systematic failure. The QA Officers will keep the Project Manager informed of any problems as they arise.

Other partners such as local watershed councils may participate in data collection. All parties participating in the Forest Service monitoring program will be approved by the Project Manager must comply with all provisions in this QAPP.

Changes and updates to this QAPP may be made by the Project Manager and Quality Assurance Officers, and with the concurrence of Regional Water Board Project Manager. The Project Manager and Forest Service Quality Assurance Officers will be responsible for making the changes, submitting drafts for review, and submitting the final for signature.

Figure 1. Organizational chart



5. PROBLEM STATEMENT/BACKGROUND

5.1 TMDL Monitoring Requirements

Every stream on the Klamath National Forest has been identified on the 303(d) list as impaired for sediment or stream temperature. Total Maximum Daily Load (TMDL) allocations have been developed for the Scott, Salmon, Shasta, and Klamath Rivers that require the Forest Service to repair existing sediment sources and implement best management practices (BMPs) to protect stream shade and prevent future sediment discharge to streams. The Forest Service relies on multiple polices and guidelines to achieve the water quality objectives for stream sediment and temperature. Water quality protection is achieved through the application of BMPs, project design standards, standards and guidelines in the Land and Resource Management Plan, and watershed restoration. The Klamath National Forest has had an active restoration program to reduce sediment discharges since at least 1992. The focus of the program is on stormproofing or decommissioning roads to control road-related sedimentation, and to prevent debris flows that can impact stream temperature by removing riparian vegetation and stream shade. The purpose of the monitoring plan outlined in this document is to evaluate the combined effectiveness of these multiple water quality protection measures at protecting in-stream beneficial uses. The monitoring program evaluates the effectiveness of individual BMPs at the site scale, and the cumulative effects of multiple BMPs and TMDL actions at the watershed scale.

6. Monitoring Goals and Objectives

6.1 Goals

The goals of the Forest Service monitoring program are specified in two memorandums of understanding (MOUs) between the Forest Service and Regional Water Board (NCRWQCB 2009c, d), and in a Waiver of Waste Discharge Requirements for Timber Harvest Activities on Federal Land ((NCRWQCB 2004). The following clauses from the MOUs describe the monitoring goals on National Forest System lands.

> "The KNF Water Quality Monitoring Plan shall be designed to monitor the condition and trends of stream shading, implementation and effectiveness of sediment control practices, and trends in instream sediment and habitat conditions."
>
> The monitoring plan will "determine if existing grazing management practices and monitoring activities are adequate and effective at preventing, reducing, and controlling sediment waste discharges, increasing stream shading, and lowering elevated water temperatures."
>
> "Data generated through implementation of the KNF Water Quality Monitoring Plan will also be used to assess whether or not a stream is achieving water quality standards and, through the use of reference conditions and other lines of evidence, as appropriate, is no longer impaired under section 303(d) of the Clean Water Act."

6.2 Monitoring Objectives and Questions

Objective 1: Are BMPs implemented as prescribed in the project NEPA documents?

Objective 2: Are BMPs effective at preventing an excess discharge of sediment to streams?

Objective 3: What is the reference condition for in-stream sediment on the Klamath National Forest?

Objective 4: Which streams are attaining reference conditions for sediment?

Objective 5: Which streams are not attaining reference conditions due to management-related sediment sources?

Objective 6: Identify management thresholds for the Forest Service cumulative watershed effects models that predict attainment of reference conditions for stream sediment.

Objective 7: Have management-related disturbances reduced stream shade below the site-potential shade?

Objective 8: Which streams have temperatures that currently support the beneficial uses?

Objective 9: What is the natural variability of temperatures in reference streams?

Objective 10: Are there trends in stream temperature?

7. COMPLIANCE CRITERIA AND ASSUMPTIONS

7.1 Compliance Criteria and Assumptions for In-Stream Sediment

Water quality objectives for sediment and temperature are specified in the *Water Quality Control Plan for the North Coast Region*, referred to as the Basin Plan (Table 1). The Basin Plan also has a prohibition against the discharge of sediment associated with logging, construction, and associated activities. However, the Basin Plan objectives for sediment, suspended material, and settleable material are narrative and are not directly measurable. In order to measure attainment of the narrative objectives, the North Coast Regional Water Board has established numeric values for in-stream sediment indices that are expected to meet the water quality objectives for sediment (Table 2, NCRWQCB 2006). The indices apply to 3rd order streams and larger, so they reflect the cumulative effect of all management in the watershed.

There is a concern that the sediment criteria in Table 2 may not be attainable in the most erosive geologic parent material on the Klamath National Forest. The sediment values in Table 2 were derived from watersheds underlain by the Franciscan Formation and may not reflect the size and volume of sediment produced from the parent material on the Klamath National Forest. Many of the values were developed from literature documenting the habitat needs of salmonids and do not necessarily represent the potential condition of streams on the Forest. In order to monitor whether sediment has been altered in managed watersheds, there is a need to develop local values for unmanaged conditions using data from reference streams.

To help identify more appropriate sediment targets, this monitoring program will collect data from reference streams to develop local values for the sediment indices in Table 2. The effect of management on stream sediment will be evaluated by comparing values measured at individual managed streams to the 75th percentile of the distribution of reference values (Stoddard et al, 2005). The hypothesis tested is:

$$H_0: S_m \leq S_r +$$

Where: S_m = Value of sediment indicator in a managed stream
S_r = 75th percentile of values in reference streams
= Survey error (see section 13)

This approach relies on the assumptions listed below to evaluate whether human-caused sediment has had an adverse effect on beneficial uses. These assumptions are compatible with the SWAMP recommendations for reference reach management (Ode 2009), and guidance from the U.S. Environmental Protection Agency on establishing natural background conditions (USEPA 1999 and 2003):

1. Conditions in reference streams represent the range of natural conditions, and deviations from this range can help to determine if beneficial uses are adversely affected by human activities.
2. Reference streams meet the SWAMP definition for minimally disturbed conditions (Ode 2009, pg 5). Reference streams represent the most attainable conditions considering the variability due to channel type, geology, and natural disturbances (fire, flood, drought, etc).
3. In managed watersheds where in-stream sediment values are within the measurement error of the 75th percentile of reference conditions, the Forest Service water quality protection program will be considered cumulatively effective at protecting in-stream beneficial uses.
4. Managed streams outside the range of reference conditions may be altered and should be the focus of follow-up investigations and on-site BMP evaluations to determine the source of excess sediment.

Table 1. Narrative water quality objectives for sediment and temperature from the Basin Plan (NCRWQCB 2007).

Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses
Sediment	The suspended sediment load and suspended sediment discharge rate of surface water shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
Temperature	The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses. At no time or place shall the temperature of any COLD water be increased by more than 5° F above natural receiving water temperature.

7.2 Compliance Criteria and Assumptions for Potential Shade/Temperature

The North Coast Regional Water Board and USEPA have identified effective shade as a surrogate for stream temperature. The TMDL load allocations for stream temperature are expressed as site potential effective shade, which is the naturally occurring stream shade in the absence of human disturbance. Site potential effective shade is defined in the Klamath TMDL as:

"the shade provided by topography and full potential vegetation conditions at a site, with an allowance for natural disturbances such as floods, wind throw, disease, landslides, and fire".

The four TMDLs on the Klamath National Forest estimate potential shade differently, and apply them at different scales. The load allocation in the Salmon TMDL requires an average shade of

69.7% for all streams in the watershed (Table 2). The Scott TMDL uses a distribution of percent shade by the length of all streams in the watershed (Table 3). The shade allocation in the Shasta TMDL does not provide an estimate of potential shade. The targets in the Klamath River TMDL are site-specific shade curves that predict the shade expected for late-seral conditions and a given type of vegetation, aspect, and stream width (Figures 2 to 7).

There is a concern that the estimates of potential shade in Figures 2 to 7 are not attainable at all sites because they do not account for the variability of natural disturbance at the site scale. To estimate the site potential shade that accounts for the natural variability of site conditions, this monitoring program will evaluate vegetation at individual sites using air photos, field data, and modeling. The monitoring design relies on the following assumptions to determine the potential shade at the site scale:

1. At sites where the existing vegetation lacks signs of human-caused alteration, the existing vegetation and stream shade is a product of natural disturbances such as fire, windthrow, disease, and earth movements, and the spatial variation in site factors such as soils and precipitation. The existing shade at these sites is equal to the potential shade and conditions are attaining the TMDL shade targets and water quality objectives for stream temperature.
2. At sites where the existing vegetation show signs of significant human disturbance, a site-specific estimate of the potential shade can be determined by measuring shade in nearby reference sites (see methods section 11.2 and 11.4).

Attainment of the stream shade targets at the watershed scale can be demonstrated using any of the four compliance pathways identified by Regional Water Board staff (McFadin 2009). Each pathway will be evaluated using the site-scale data collected from aerial imagery and field sampling:

Pathway #1. "Demonstrate that TMDL load allocations (Tables 2 and 3) are met".
Compliance in the Salmon River is attained if the watershed-average of all measurements of the current shade is greater than the TMDL load allocation in Table 2. Compliance in the Scott River is attained if the cumulative distribution of all measurements of current shade is greater than the distribution in Table 3. The Klamath and Shasta TMDLs do not have a watershed scale load allocation and attainment can only be demonstrated using pathways #2 or #3.

Pathway #2. "Demonstrate that the TMDL shade targets are met (Figures 2 to 7)".
Compare the number of sites in the watershed where the current shade is less than the potential shade in Figures 2-7 with the numeric water quality objectives in section 4.2 of the State-wide 303(d) listing policy (CWQCB 2004). The state-wide objectives are attained and the watershed meets the criteria for delisting if the number of measured exceedances supports rejection of the null hypothesis as shown in Table 4. Because Figures 2 to 7 do not account for natural disturbance or the variability of local site factors, it is expected that pathway #3 will be used in most cases.

Pathway #3. "Demonstrate that the current shade conditions reflect the unaltered shade conditions".
Compare the number of sites in the watershed where the current shade is less than the potential shade estimated from air photos and field measurements with the numeric water quality objectives in section 4.2 of the State-wide 303(d) listing policy (CWQCB 2004). The state-wide objectives are attained and a watershed meets the criteria for delisting if the number of measured exceedances supports rejection of the null hypothesis as shown in Table 4.

Pathway #4. Demonstration of compliance is applicable for watercourses in which the existing stream temperatures are cold enough to support the beneficial uses. In such a case, measured temperatures can be compared to the biological requirements to assess the support of beneficial uses. If temperatures are sufficiently low to fully support beneficial uses, and haven't been increased by 5 F° or more, the waterbody is meeting the objective.

8. Parameters

Table 2. Parameters used to measure attainment of water quality standards. Parameters and compliance criteria are from the TMDL targets, load allocations, and desired conditions.

Parameter	Compliance Criteria	Criteria Source	Survey Method
	In-Stream Sediment Criteria		
Fraction of Pool Volume filled with Sediment (V*)	≤ 0.21 (21%)	Scott River TMDL (NCRWB 2006)	Hilton and Lisle 1993
Subsurface Sediment Percent < 0.85mm Percent < 6.4mm	 ≤ 14% ≤ 30%	 Scott River TMDL (NCRWB 2006)	 Schuet-Hames 1999 Valentine 1995
Surface Sediment Percent < 2.0mm	≤ 15%	USFS 1994	USFS 2003, Cover 2008
	Shade Criteria		
Site Potential Effective Stream Shade	• 69.7% (watershed average) • Percent of stream length in the watershed shadier than a given shade value (Table 2a below) • 90% of site potential shade • Site potential shade from curves (Figures 2, 3, and 4)	Salmon River TMDL (load allocations, NCRWB 2005) Scott River TMDL (load allocations, NCRWB 2007) Shasta River TMDL (load allocations, NCRWB 2005) Klamath River TMDL (numeric targets, NCRWB 2009b)	Aerial Imagery; NCRWQCB 2009
Channel Alteration	0 miles of substantial human caused sediment-related channel alteration	Klamath River TMDL (numeric targets, NCRWB 2009b)	Aerial Imagery
	Project BMP Criteria		
On-site BMP Implementation	Pass / Fail	Categorical Waiver for Timber Harvest of Federal Lands	USFS 2002
On-site BMP Effectiveness Inspections	Pass / Fail	Categorical Waiver for Timber Harvest of Federal Lands	USFS 2002
	Stream Temperature		
	Mean Weekly Maximum Temperature (C°)		
Adult Migration	20	EPA (2003), McFadin 2010	
Adult Migration plus Non-Core Juvenile Rearing [1]	18	EPA (2003), McFadin 2010	
Core Juvenile Rearing [2]	16	EPA (2003), McFadin 2010	
Spawning, Egg Incubation, and Fry Emergence	13	EPA (2003), McFadin 2010	

Source: EPA Region 10 Guidance for Pacific Northwest State and Tribal Water Quality Standards (2003)

1. The Adult Migration plus Non-Core Juvenile Rearing designation is recommended by USEPA (2003) for the "protection of migrating adult and juvenile salmonids and moderate to low density salmon and trout juvenile rearing during the period of summer maximum temperatures," usually occurring in the mid to lower part of the basin.
2. The Core Juvenile Rearing designation is recommended by USEPA (2003) for the "protection of moderate to high density summertime salmon and trout juvenile rearing" locations, usually occurring in the mid to upper reaches of the basin.

Table 3. Scott River Temperature TMDL load allocations

Shade Class	Stream Length - Current Vegetation Conditions				Stream Length - Potential Vegetation Conditions			
(%)	(miles)	(km)	% Shadier	% of Total	(miles)	(km)	% Shadier	% of Total
0-1	141	227	77.9%	22.1%	33	53	94.8%	22.1%
>1-2	73	117	66.6%	11.3%	29	46	90.3%	4.5%
>2-3	57	91	57.7%	8.8%	26	43	86.2%	4.1%
>3-4	78	126	45.4%	12.3%	36	58	80.5%	5.7%
>4-5	97	157	30.2%	15.2%	43	69	73.9%	6.7%
>5-6	127	204	10.3%	19.9%	76	122	62.0%	11.9%
>6-7	52	83	2.3%	8.1%	103	165	45.9%	16.0%
>7-8	10	17	.6%	1.6%	177	284	18.3%	27.6%
>8-9	3	5	.2%	0.5%	116	186	.2%	18.1%
>9-10	1	2	.0%	0.2%	1	2	.0%	0.2%
Total:	639	1028			639	1028		

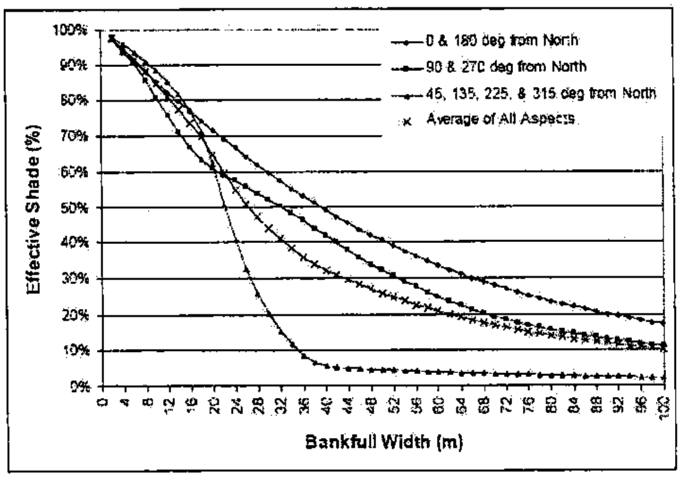


Figure 2 Potential shade for Douglas Fir / Mixed Hardwood & Conifer, height = 40 m, density = 80%, buffer width = 30m. From: NCRWQCB 2009b fig. 5.4

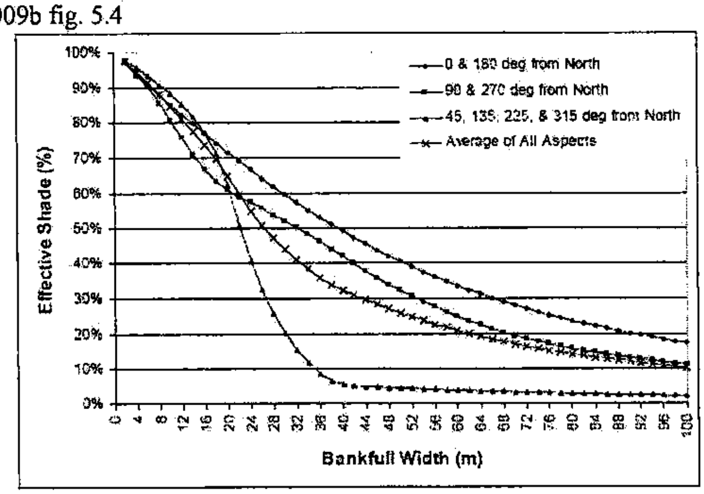


Figure 3. Potential shade for Klamath Mixed Conifer, height = 35 m, density = 80%, buffer width = 30m. From: NCRWQCB 2009b fig. 5.5

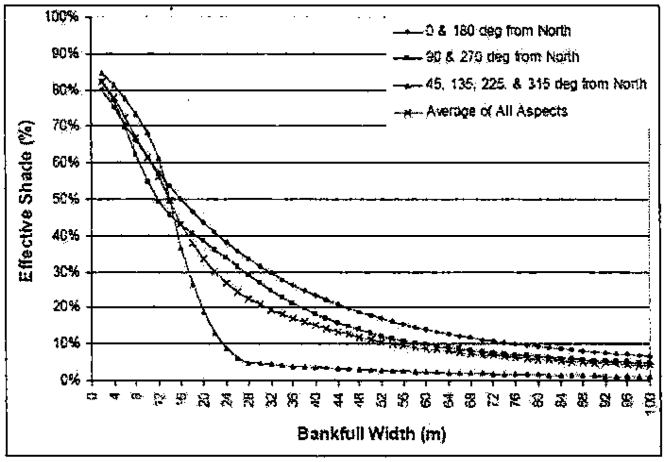


Figure 4. Potential shade for Black Cottonwood, height = 24 m, density = 50%, buffer width = 15 m. From: NCRWQCB 2009b fig. 5.6

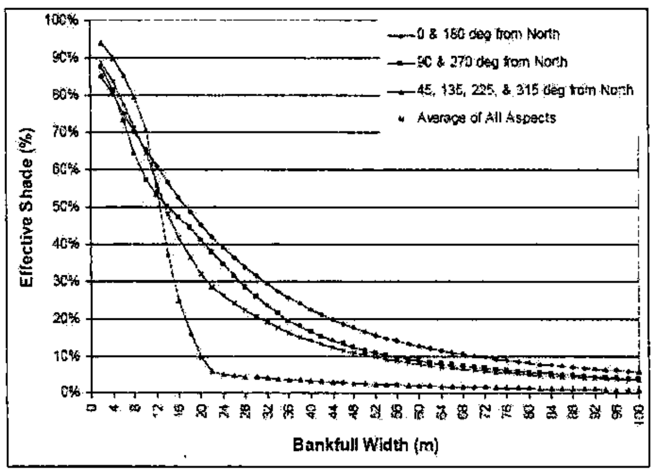


Figure 5. Potential shade for Oak Woodland, height = 20 m, density = 50%, buffer width = 30 m. From: NCRWQCB 2009b fig. 5.7

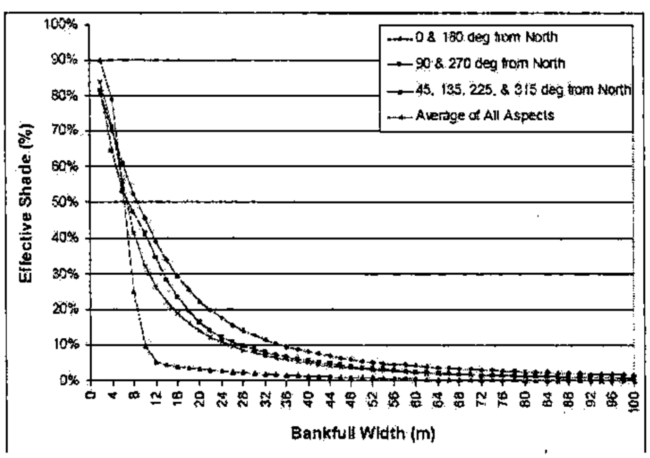


Figure 6. Willow, height = 10 m, density = 50%, buffer width = 15 m. From: NCRWQCB 2009b fig. 5.8

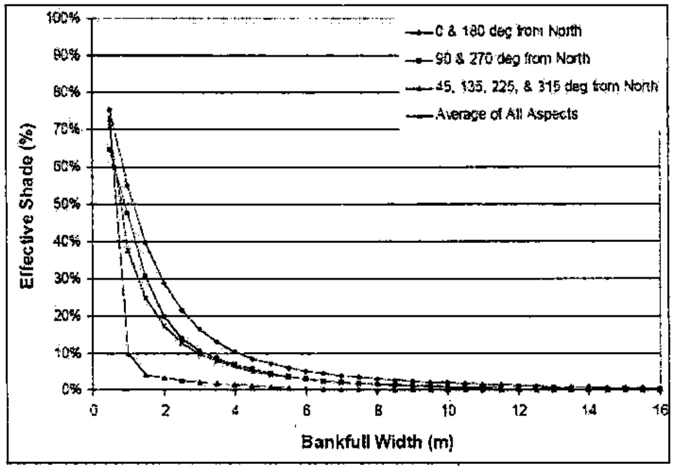


Figure 7. Potential shade for Grass / Sedge, height = 1 m, density = 75%, buffer width = 15 m. Note the scale of the x-axis is not the same as figures 2-6. From: NCRWQCB 2009b.

Table 4. Maximum number of exceedances allowed to remove a water segment from section 303(d) list for conventional or other pollutants. From Table 4.2 in *Water quality control policy for developing California's Clean Water Act section 303(d) list* (CWQCB 2004).

Null Hypothesis: Actual exceedance proportion > 25 percent.
Alternate Hypothesis: Actual exceedance proportion < 10 percent.
The minimum effect size is 15 percent.

Sample Size	Delist if the number of exceedances equal or is less than
26 – 30	4
31 – 36	5
37 – 42	6
43 – 48	7
49 – 54	8
55 – 60	9
61 – 66	10
67 – 72	11
73 – 78	12
79 – 84	13
85 – 91	14
92 – 97	15
98 – 103	16
104 – 109	17
110 – 115	18
116 – 121	19

For sample sizes greater than 121, the maximum number of exceedances allowed is established at α and $\beta < 0.2$ and where $|\alpha - \beta|$ is minimized.

α = Excel® Function BINOMDIST(k, n, 0.25, TRUE)
β = Excel® Function BINOMDIST(n-k-1, n, 1 – 0.1, TRUE)
where n = the number of samples,
k = maximum number of measured exceedances allowed,
0.10 = acceptable exceedance proportion, and
0.25 = unacceptable exceedance proportion.

9. SAMPLING DESIGN FOR IN-STREAM SEDIMENT

9.1 Sample Pool of Response Reaches and Watersheds

A network of long-term stream monitoring sites was developed to monitor sediment impacts across the entire Forest. A Forest-wide pool of possible sample streams was created by identifying a "response reach" for every 6^{th} field watershed on the Forest (Figures 8 and 9, Table 6). Response reaches usually have the lowest stream gradient in the watershed, and are the locations most likely to accumulate fine sediment in response to increased sediment supply. Response reaches are typically located near the mouth of the stream and reflect the cumulative effect of sediment input from all sources in the watershed. Meadow streams with silt or clay beds were avoided due to inapplicability of the sediment parameters in those streams. The minimum length of response reaches was set at 500 meters with a channel gradient less than 6 percent. In watersheds that do not have a stream with a slope less than 6 percent, the sample site was located at the first reach downstream that meets the minimum length and gradient requirements. In this case the response reach may reflect the cumulative sediment input from two 6^{th} field watersheds. Several response reaches are located in 7^{th} field watersheds that are not captured by one of the 6^{th} field sites. The resulting pool contains 85 response reaches that drain 80% of total drainage area on the Forest. The remaining 20% of the Forest area cannot be monitored with stream surveys because it drains into intermittent streams, streams located on private land, or is located in areas on the east side that do not have surface streams.

The Forest-wide pool of response reaches should be viewed as a master list of all possible sites from which sites are selected for each management activity that has a monitoring requirement (section 9.3). The pool of response reaches is used only for measuring sediment and is different than the pools used for on-site BMP evaluations (section 10) and stream shade measurements (section 11).

9.2 Watershed Stratification by Geology

Each watershed in the Forest-wide pool of response reaches is stratified by the ability of the dominant parent material to produce sandy sediment. Chief determining criteria is the relative abundance of silica ($SiO2$) in the rock (Table 5). Silica-rich rocks typically erode to produce sand-sized particles, while silica-poor rocks generate silt and clay-sized sediments. Watersheds are stratified by the percentage of their drainage area underlain by sand-producing parent material (silicic bedrock map units plus geomorphic landforms). This stratification is based on guidelines from Hilton and Lisle (1993) who predicted that watershed geology would result in two distinct populations of V* data, one for sandy watersheds (with higher V* values) and another for non-sandy watersheds (with lower V* values).

Table 5. Bedrock units used to stratify watersheds into sandy and non-sandy geologies.

Bedrock units producing abundant SAND	Bedrock units producing modest or little SAND
Granitic rocks, quartz-bearing schistose rocks, shale, siltstone, sandstone (greywacke), conglomerate, chert, quartzite, diorite, unconsolidated materials (e.g., glacial deposits, stream terraces, outwash deposits), tuff, pyroclastic rocks, cinders, rhyolite, rhyodacite, pumice	Slate, gabbro, undifferentiated metamorphic, undifferentiated metasediments, mudstone, ultramafic rocks, limestone, mélange units, undifferentiated volcanic rocks (including basalt, andesite, dacite), undifferentiated metavolcanic rocks

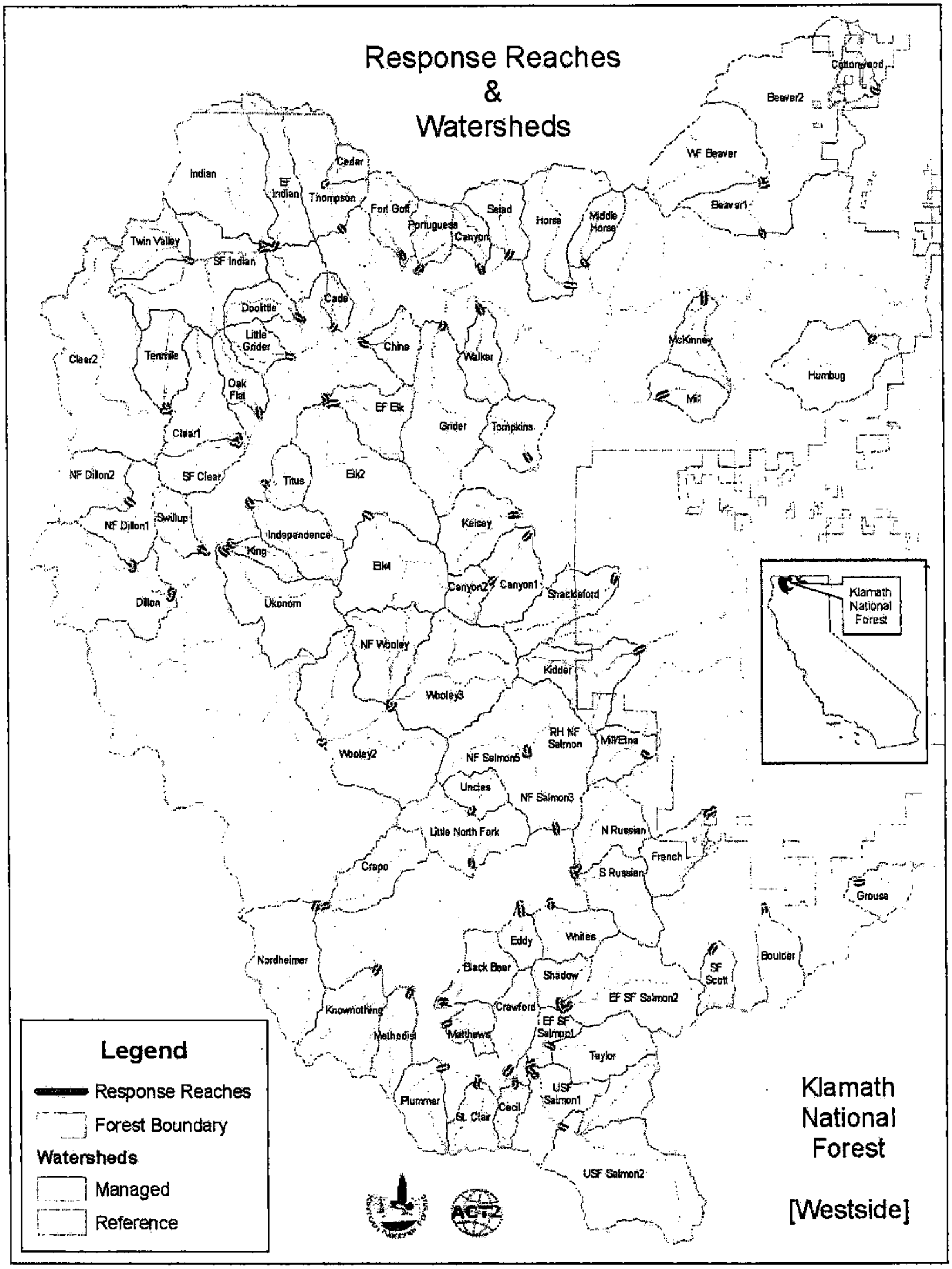


Figure 8. Sediment monitoring sites and watersheds on the west side Klamath National Forest.

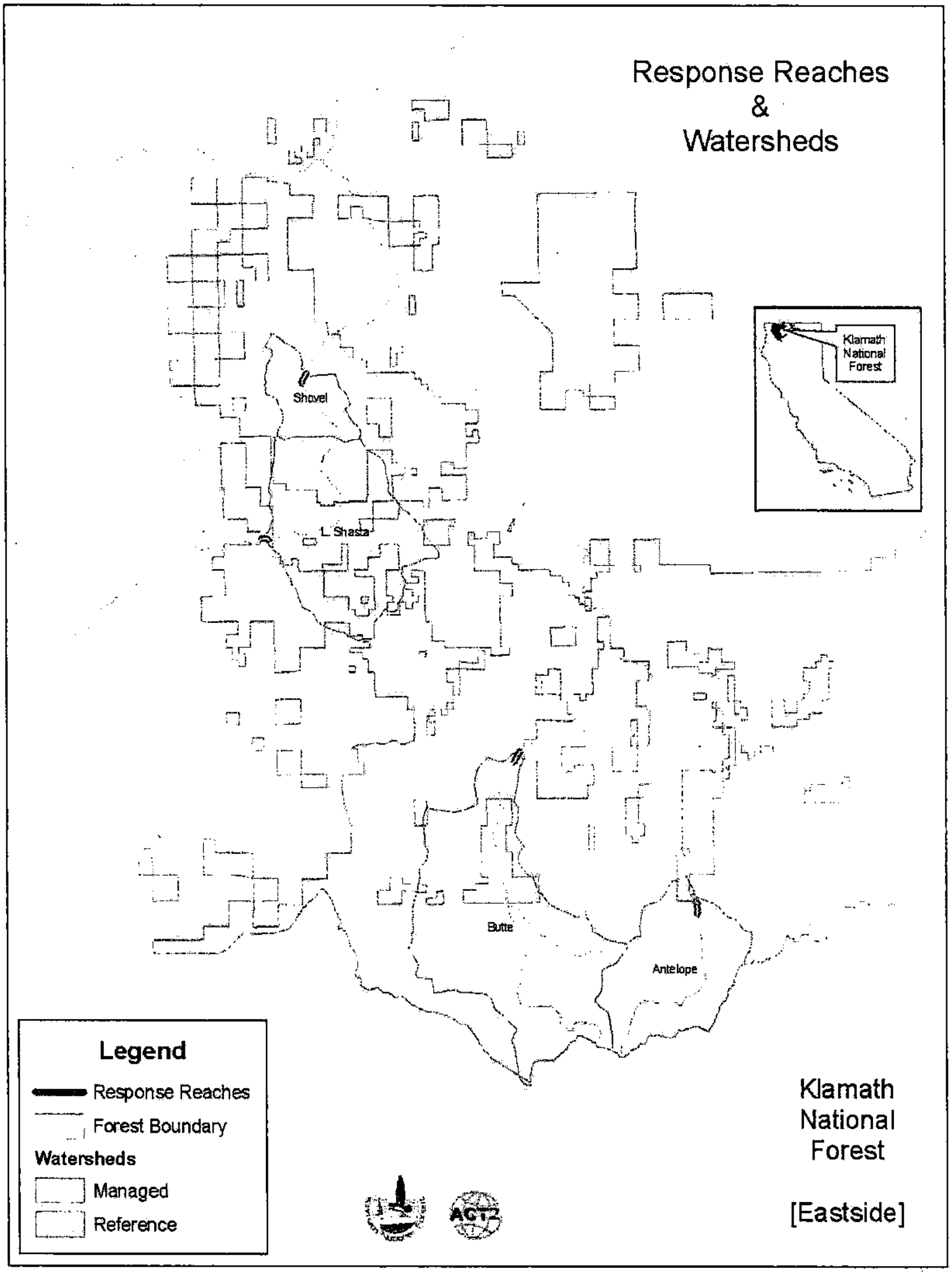


Figure 9. Sediment monitoring sites and watersheds on the east side (Goosenest Ranger District).

Table 6. Sediment and temperature monitoring sites in tributary streams. Parameters: S = sediment, W = water temperature, A = air temperature. Additional temperature sites in main river channels are listed in Table 13.

Stream	Managed or Reference	Parameters	Channel Gradient (%)	Watershed Mean Elevation [m]	Drainage Area [km2]	Average Precip [in/yr]	Road Density [km/ km2]	% of Drainage with Sandy Geology
Canyon Scott 2	Reference	S, W, A	4.1%	1,738	20.95	74.4	0.13	39.4
Canyon Seiad	Reference	S, W	4.6%	1,233	17.31	67.4	0.03	94.5
Cedar	Reference	S, W, A	5.1%	1,278	12.54	74.6	0.00	22.9
Clear 2	Reference	S, W	1.9%	1,293	159.54	100.2	0.00	19.2
Elk 4	Reference	S, W, A	2.4%	1,443	82.88	74.2	0.00	76.0
Fort Goff Creek 1	Reference	S, W	3.8%	1,138	33.52	69.9	0.01	81.7
Mill / Etna	Reference	S, W, A	5.5%	1,685	27.40	57.4	0.06	30.5
North Fork Dillon 2	Reference	S, W, A	2.6%	1,243	44.12	92.4	0.15	26.0
N.F. Salmon River 3	Reference	S, W	1.1%	1,540	164.22	68.6	0.04	15.0
N.F. Salmon River 5	Reference	S, W	1.9%	1,671	47.50	76.5	0.00	32.2
North Fork Wooley 1	Reference	S, W, A	4.1%	1,294	57.00	71.1	0.00	46.5
Plummer	Reference	S, W	2.9%	1,321	37.08	60.6	0.00	13.0
Portuguese 1	Reference	S, W	3.3%	1,150	22.63	69.9	0.06	88.4
Right Hand Fork N.F. Salmon River	Reference	S, W, A	1.9%	1,658	51.46	66.4	0.00	12.6
Tenmile	Reference	S, W, A	4.1%	1,136	40.67	78.0	0.00	49.6
Twin Valley	Reference	S, W	5.3%	1,319	35.54	92.3	0.00	22.1
Uncles	Reference	S, W	6.5%	1,588	21.18	73.3	0.00	54.0
Upper South Fork Salmon River 2	Reference	S, W	1.1%	1,695	156.40	52.8	0.19	94.8
Wooley 2	Reference	S, W	1.5%	1,365	290.65	70.1	0.02	40.3
Wooley 3	Reference	S, W	2.1%	1,456	104.67	78.0	0.00	20.9
Rush Creek	Reference	W, A	-	1,645	31	55.0	0.00	1645
Antelope 2	Managed	S, W, A	2.9%	1,977	66.34	36.7	2.28	58.0
Black Bear	Managed	S, W	3.9%	1,183	37.24	40.1	1.63	26.2
Beaver 1	Managed	S, W	1.7%	1,423	272.44	55.0	3.18	66.2
Beaver 2	Managed	S, W, A	3.3%	1,488	151.71	50.2	3.20	64.7
Boulder	Managed	S, W	3.9%	1,701	32.85	47.6	1.48	89.6
Butte 2	Managed	S, W	1.0%	1,999	140.79	29.1	2.35	14.1
Cade	Managed	S, W, A	3.4%	878	11.62	59.2	2.78	72.0
Canyon Scott 1	Managed	S, W	3.6%	1,624	64.20	64.1	0.66	32.3
Cecil	Managed	S, W, A	4.1%	1,317	14.85	47.1	2.36	73.4
China	Managed	S, W	3.9%	879	25.08	54.2	3.46	1.0
St Clair	Managed	S, W	1.9%	1,254	27.49	54.9	0.69	38.6
Clear 1	Managed	S, W	0.5%	1,218	256.11	85.9	0.14	25.7
Cottonwood 4	Managed	S, W, A	3.8%	1,550	19.48	44.5	2.04	97.2
Crapo	Managed	S, W, A	4.9%	1,193	44.79	57.6	0.56	67.8
Crawford	Managed	S, W	4.6%	1,308	33.81	39.7	1.92	73.5
Dillon 1	Managed	S, W, A	1.3%	1,032	189.62	86.6	0.47	30.1
Doolittle Indian	Managed	S, W	3.5%	965	23.75	65.1	2.87	35.2
Eddy Gulch	Managed	S, W	4.7%	1,313	17.91	49.5	2.75	43.5
East Fork Elk	Managed	S, W	2.5%	1,145	41.69	55.5	1.98	3.0
East Fork Indian	Managed	S, W	3.6%	1,144	47.60	73.5	1.58	72.3
Elk 2	Managed	S, W	1.4%	1,291	191.80	66.8	0.86	51.0
East Fork South Fork Salmon River 1	Managed	S, W	1.0%	1,521	174.54	51.5	1.21	74.1

East Fork South Fork Salmon River 2	Managed	S, W, A	4.6%	1,584	86.27	56.2	0.99	71.5
French	Managed	S, W	2.8%	1,649	35.25	37.2	1.96	95.1
Grider 1	Managed	S, W, A	2.7%	1,277	102.41	56.6	0.88	31.1
Grouse Scott	Managed	S, W	2.7%	1,537	26.89	46.8	2.33	43.9
Horse 1	Managed	S, W, A	2.3%	1,342	73.91	54.7	2.82	95.7
Humbug 1	Managed	S, W, A	1.8%	1,269	74.42	39.6	1.63	31.2
Independence 1	Managed	S, W	3.1%	1,144	46.59	68.1	0.95	40.2
Indian 3	Managed	S, W	1.3%	1,137	108.41	74.3	2.25	9.1
Kelsey	Managed	S, W	6.6%	1,449	46.01	57.5	0.72	37.5
Kidder 1	Managed	S, W, A	1.9%	1,615	59.01	55.1	0.90	36.9
King	Managed	S, W	5.5%	965	14.76	62.0	0.79	7.8
Knownothing	Managed	S, W	3.1%	1,181	58.85	58.6	1.43	27.5
Little Grider	Managed	S, W	3.0%	946	21.40	68.3	1.71	0.6
Little N.F. Salmon 1	Managed	S, W, A	2.7%	1,405	84.27	67.4	0.38	57.3
Little Shasta River 2	Managed	S, W, A	5.3%	1,836	93.06	32.9	2.19	4.7
Matthews	Managed	S, W	3.6%	1,057	18.71	35.0	1.65	32.6
McKinney	Managed	S, W	4.9%	1,126	29.48	38.0	2.66	34.5
Methodist	Managed	S, W, A	2.9%	1,186	32.90	50.2	1.62	5.4
Middle Horse	Managed	S, W	3.2%	1,276	32.56	51.0	3.58	99.9
Mill Ck Lower Scott 1	Managed	S, W	2.4%	1,168	57.87	42.7	2.62	15.7
North Fork Dillon Ck 1	Managed	S, W	3.7%	1,125	85.83	85.7	0.23	30.2
Nordheimer 1	Managed	S, W	2.1%	1,205	80.19	63.5	0.20	20.9
North Russian	Managed	S, W, A	3.1%	1,550	47.12	53.0	1.18	33.8
Oak Flat	Managed	S, W	6.0%	982	22.80	64.6	0.96	1.0
Seiad 2	Managed	S, W, A	2.8%	1,162	32.65	72.3	1.14	94.0
South Fork Clear	Managed	S, W	1.9%	930	31.64	64.7	1.46	11.8
South Fork Indian 1	Managed	S, W, A	1.0%	1,289	128.75	83.2	1.04	17.3
South Fork Scott River 4	Managed	S, W	5.6%	1,796	19.75	52.5	1.95	65.0
Shackleford	Managed	S, W	3.9%	1,696	48.39	58.7	1.13	37.2
Shadow	Managed	S, W	4.4%	1,449	23.03	48.1	1.71	95.1
Shovel 3	Managed	S, W, A	1.7%	2,052	23.42	34.9	2.20	40.9
South Russian	Managed	S, W	4.2%	1,598	47.86	54.2	0.86	89.1
Swillup	Managed	S, W	6.0%	885	22.59	65.9	1.09	29.3
Taylor	Managed	S, W	3.4%	1,555	47.50	48.8	1.39	74.4
Thompson 2	Managed	S, W	2.9%	1,194	71.40	73.7	0.56	31.1
Titus Creek	Managed	S, W	5.9%	684	20.77	55.0	1.83	0.0
Tompkins 1	Managed	S, W	6.1%	1,356	37.73	50.6	1.78	61.4
Ukonom 1	Managed	S, W	4.3%	1,160	84.85	68.5	0.60	76.7
Upper S.F. Salmon River 1	Managed	S, W	1.2%	1,641	203.88	50.3	0.49	94.6
Walker 1	Managed	S, W	4.9%	1,242	30.83	52.8	2.37	70.6
West Fork Beaver 1	Managed	S, W	2.1%	1,422	81.31	67.8	3.42	77.4
Whites Gulch	Managed	S, W	4.2%	1,521	34.72	55.0	1.38	65.8
Clear Bridge	Managed	W, A	-	1,129	289	83.0	0.29	-
Indian Creek	Managed	W	-	1,127	309	78.0	1.61	-
Middle Creek	Managed	W	-	1,414	18	50.0	1.80	-
South Fork Scott River	Managed	W, A	-	1,763	73	48.5	1.82	-

9.3 Stratification by Managed and Reference Watersheds

Each watershed in the Forest-wide pool of response reaches is designated as either a managed or a reference watershed. Managed watersheds are divided into the management activities that have a specific monitoring requirement in the TMDLs and Categorical Waiver (NCRWQCB 2010, 2009c, d, 2004).

1. Managed Watersheds

a. Watersheds with Category B projects:
   Watersheds with category B activities are added to the long-term monitoring pool if the Regional Water Board notifies the Forest Service in writing that the watershed must have in-stream monitoring as a condition for approving a waiver application (NCRWQB 2010). Sites will be removed from the sample pool by agreement with the Forest and the Regional Board staff. This group also contains watersheds with in-stream monitoring required under the previous waiver (NCRWQB 2004).

b. Grazing:
   Watersheds are placed in this group if they contain sites that fail on-site BMP evaluations, or if required by the Regional Water Board as a condition for waiver coverage. Some grazed watersheds were not included in this pool because they are included in other categories. It should be recognized that most grazed watersheds have a history of multiple management activities and in-stream conditions reflect the cumulative effect of all past and current management.

c. Sediment Control:
   Watersheds in this group have had sediment control projects completed in a significant portion of their watershed. On average, about 42% of the road miles in these watersheds have been treated. Ideally, these are watersheds where all of the road stormproofing and decommissioning work identified in a restoration plan has been completed.

d. General:
   This group contains all managed streams not included in the other groups. None of these watersheds have specific monitoring requirements under the TMDLs, MOUs, or waiver and are sampled at the discretion of the Forest Service.

2. Reference Watersheds:

Reference streams are located in watersheds with the least amount of human influence and represent the natural range of conditions resulting from environmental variation. Reference watersheds are used to define desired conditions and serve as benchmarks to measure effects in managed watersheds. References watersheds on the Klamath National Forest were identified using the SWAMP guidance for establishing and managing reference streams (Ode 2009). Human disturbance in each watershed was evaluated using Forest Service GIS layers for roads, timber harvest, grazing, and mines. Watersheds are considered a candidate reference if they meet the criteria in Table 7. Candidate reference streams that meet these criteria were screened by local biologists and hydrologists to validate watershed conditions using field observations and best professional judgment. A total of 20 reference streams were identified. Of these, 11 are considered near-pristine because they have no roads and most are located in wilderness areas. The other 9 are considered minimally disturbed with road densities less than 0.19 km/km^2 (Table 6). Several reference watersheds have light grazing, but have no history of BMP problems. References watersheds that contain grazing allotments will be reevaluated once in-stream data is available. Most of the reference watersheds have a history of disturbance by wildfire and floods and are included in the reference pool as of component of natural variability. Reference streams are well distributed across the forest except for the east side (Goosenest) where no streams met the minimum criteria. The characteristics of the reference watersheds have a similar range as managed streams, and are representative of the background condition of the managed watersheds (Table 8).

Table 7. Reference watershed criteria

Disturbance	Criteria
Road density	Less than 0.19 km/km^2 (0.30 mi/mi^2) with no significant road failures.
Grazing	On-site BMP evaluations show no significant discharges from areas disturbed by grazing. Most have no grazing.
Mining	No significant sediment input or point sources (metals or pH). Most have only prospects.
Timber harvest	A road density of less than 0.16 km/km^2 is used as surrogate for past harvest intensity.
Wildfire and other natural disturbance	Natural disturbance must be included in the reference pool as of component of natural variability. Steams may be temporarily removed from the reference pool in extreme circumstances where a significant portion of a watershed is severely burned.

Table 8. Characteristics of reference and managed watersheds for sediment surveys.

	Reference Streams (n = 20)			Managed Streams (n = 64)		
Watershed Characteristics	Average	Maximum	Minimum	Average	Maximum	Minimum
Drainage Area (km^2)	70	291	13	66	272	12
Mean Elevation (m)	1437	1754	1147	1311	1946	760
Maximum Elevation (m)	2179	2715	1811	2080	2715	1286
Minimum Elevation (m)	711	1286	393	639	1791	231
Precipitation (Mean Annual) (in)	73	100	53	56	87	29
Road Density (km/km^2)	0.03	0.19	0.00	1.62	3.58	0.14
Sandy geology (%of drainage area)	44	95	13	47	100	0
Channel Gradient (%)	3.3	6.5	1.1	3.4	6.6	0.5
Reach Length (m)	790	1811	405	767	1622	457

9.4 Sample Size and Frequency

In-channel sediment is sampled from a rotating set of sites selected from the pool for each management activity (Table 9). The sample size allows all sites in each activity group to be re-sampled on a 5 year rotation, except for reference streams which are sampled on a 2 year rotation. The number of streams in each pool is expected to change over time as new projects are proposed in over-threshold watersheds, and as sediment control work is completed. A total of 23 streams must be sampled each year in order to measure all 85 streams in the Forest-wide pool over a 5 year period. A total of 18 streams must be sampled each year if the general pool is omitted.

9.5 Methods for Measuring In-Stream Sediment

A full description of methods and field forms for measuring in-stream sediment parameters are located in Appendix A.

Table 9. Sample size and frequency for long-term sediment monitoring.

Management Pool	Monitoring Requirement	Current Number of Streams in Pool	Sample Frequency
Category B watersheds	Waiver	10	5 years
Grazing	TMDLs	9	5 years
Sediment Control	TMDLs	18	5 years
Reference Watersheds	Desired Condition	20	2 years
General Pool (includes grazing, timber and recreation)	TMDLs	28	5 years
	Total =	85	

10. Sampling Design for On-Site BMP Implementation and Effectiveness Evaluations

10.1 Methods for On-Site BMP Evaluations

The Forest Service Region-5 Best Management Practice Evaluation Program (BMPEP) will be used to monitor the implementation and effectiveness of individual BMPs at the project scale (U.S. Forest Service 2002). The Klamath National Forest monitoring plan tiers to the regional program and incorporates any future amendments or revisions to the regional plan.

The regional protocol has 29 different evaluation procedures, each designed to assess a specific BMP or set of closely related BMPs. Both implementation and effectiveness are evaluated. Each evaluation procedure has a different method for selecting sites, timing of sample collection, and criteria for rating effectiveness. A complete description of the methods used for each BMP is located on page 18 in Appendix D: *Best Management Practices Evaluation Program (BMPEP) User's Guide, USDA Forest Service Pacific Southwest Region (2002).*

10.2 Pools for On-Site BMP Evaluations - Random Sampling

A Forest-wide pool for random sampling is created annually for each BMP category using all projects on the Forest. Each of the 29 BMPs has different criteria to qualify for the sample pool. See the criteria under "Developing the Random Sample Pool" on page 20 of Appendix D, and the instructions for each BMP beginning on page 29 of Appendix D. The sample size is dictated by budget targets assigned by the Forest Service regional office. The randomly identified sites are used to draw statistical conclusions on the overall implementation and effectiveness of the BMP program.

11. Sampling Design for Stream Shade

11.1 Development of Sample Pools for Stream Shade

A pool of possible stream shade sample sites was developed by plotting points every 100 meters along all perennial streams in the Forest Service GIS stream layer. The result is a dataset of 42,165 points that represents the entire perennial stream network on the Klamath National Forest.

11.2 Methods for Estimating Stream Shade from Aerial Imagery

1. Identify the existing canopy cover and tree diameter for all sites in the sample pool by overlaying the 100-meter sample sites onto the Existing Vegetation layer (EVEG). The EVEG layer is a GIS layer of vegetation characteristics derived from Landsat imagery, developed by the U.S. Forest Service Remote Sensing Lab (http://www.fs.fed.us/r5/rsl/projects/mapping/). All sites in the pool will be assigned one of the diameter/canopy cover categories in Table 10 based on the data from EVEG. The tree diameter and canopy cover from EVEG is then converted to the tree height and density classes used in the shade model. Canopy cover is assumed to equal tree density as shown in Table 10. Tree diameter is converted to tree height according to Table 11. The shrub and open categories in Table 10 may be further subdivided after photo interpretation and field verification.

2. Check for errors in the EVEG layer by overlaying the sample sites onto aerial photographs and comparing the canopy cover values to the canopy cover visible in the photos. Typically, errors can occur where large EVEG polygons extend upslope and represent vegetation on hillslopes rather than along streams. If photos show gross inaccuracies in the EVEG canopy cover, the canopy cover value will be adjusted using either 1) EVEG cover values from adjacent polygons that have similar cover in the photos, or 2) The photo template and visual method in appendix B (Swiecki 2001). Any adjustments will be noted and available for review by the Water Board staff.

3. Estimate the current channel width and aspect from air photos, or from the bankfull width and drainage area relationship in Figure B-5 in Salmon River TMDL (NCRWQCB 2005). This information will be used to estimate potential shade from the TMDL shade curves as described in section 7.2, compliance pathway #2.

4. Determine if the existing canopy cover or tree height has been altered by human disturbance using air photo interpretation. Look for evidence such as harvest units, skid trails, roads, debris flows, or mine tailings. If evidence of past debris flow is present, identify any upslope contribution from human activities. If channels are scoured by both natural and human-caused debris flows, identify the source as "mixed". The disturbance assessment may require interpretation of older historic photographs to determine if past disturbance is due to human or natural causes. At sites that have been altered by human activity, identify the contributing factors and the potential for restoration.

5. Identify the site-potential canopy cover tree height, or channel width at each site using air photo interpretation. At sites where the canopy cover has not been altered by human activity, the potential canopy cover is equivalent to existing canopy cover in EVEG. At sites where the vegetation has been altered by human activity, the potential canopy cover is estimated using EVEG data at nearby reference sites where the vegetation meets the SWAMP criteria for minimally disturbed conditions (Ode 2009). Reference sites for shade must have the same valley type, channel type, and potential vegetation as the altered site. Historic photos taken prior to the human activity may be used to estimate predisturbance conditions.

6. Estimate the current and potential stream shade for all sites in the pool using the shade-a-lator model developed by the Oregon Department of Environmental Quality (http://www.deq.state.or.us/wq/tmdls/tools.htm), and the inputs for tree height, density, channel width, and aspect assigned to each point. The current shade will be compared to the site-specific potential shade to evaluate compliance pathway #3 as described in section 7.2.

Table 10. Conversion of the EVEG categories for tree diameter and canopy cover to the height and density classes used in the shade model. All sites on the sample pool will be evaluated.

Diameter / Canopy Cover Categories from EVEG	Model Inputs		Number of Sites in Pool
	Vegetation Height (m)	Vegetation Density (%)	
large / 10-50% tree cover	40	30	550
large / 50-60% tree cover	40	55	922
large / 60-70% tree cover	40	65	2701
large / 70-80% tree cover	40	75	6850
large / 80-100% tree cover	40	90	11617
medium / 10-50% tree cover	25	30	760
medium / 50-60% tree cover	25	55	759
medium / 60-70% tree cover	25	65	1496
medium / 70-80% tree cover	25	75	2247
medium / 80-100% tree cover	25	90	4474
Open	10	10	2401
poles / 10-50% tree cover	10	30	438
poles / 50-60% tree cover	10	55	447
poles / 60-70% tree cover	10	65	753
poles / 70-80% tree cover	10	75	974
poles / 80-100% tree cover	10	90	2257
seed-sap / 10-50% tree cover	3	30	176
seed-sap / 50-60% tree cover	3	55	114
seed-sap / 60-70% tree cover	3	65	94
seed-sap / 70-80% tree cover	3	75	136
seed-sap / 80-100% tree cover	3	90	234
Shrub	3	40	1765

Table 11. Conversion of EVEG tree diameter classes to the tree height classes in the shade-a-lator model.

Tree Class	Diameter (inches DBH)	Assumed Tree Height (m)
Seedlings	0 to .9	3
Saplings	1 to 4.9	3
Poles	5 to 9.9	10
Medium	10 to 19.9	25
Large	20 to 29.9	40
Large to giant	30 inches +	40

11.3 Selection of Sites for Stream Shade Measurement in the Field

Stream shade will be measured in the field to verify a sub-sample of the shade values estimated by the shade-a-lator model. All sites in the sample pool will be stratified into 10 shade categories: 0-10% shade, 10-20% shade, etc. A random sample will then be selected from each category for field sampling. Initially, a total of 200 random sites will be selected with a minimum of 5 sites per category. The exact number of field samples in each shade category will not be determined until we estimate shade with the model. The sample size in each category is dependent in part on the number of sites in each category, but also on the expected variability of stream shade in the category. The 90-100 % stream shade category will likely have little variability whereas the lower stream shade categories will likely have larger statistical variances. Actual variances and sources of error in estimating stream shade will not be known until data has been collected. Re-evaluation of sample size and re-categorization of shade-a-lator inputs may be needed following initial field sampling.

11.4 Methods for Measuring Stream Shade in the Field

At each site selected for field sampling in section 11.3, stream shade will be measured at 5 transects spaced 20 meters apart. The total number of measurements depends on the bankfull channel width (Table 12).

Table 12. Sample points along stream shade transects.

Channel Width (m)	# of sample points per transect	Location along transect (portion of bankfull width)
0 to 6	1	0.5
7 to 12	2	0.33 and 0.66
>13	3	0.25, 0.5, and 0.75

The following data will be collected at each sample point:

1. Existing Stream Shade:
   a. Measure the existing shade using Hemispherical Canopy Photography and the Hemiview camera system. Protocols for equipment, setup, taking photographs, and the analysis software are described in Appendix C.
   b. Visually estimate tree height and density to verify the values derived from EVEG and air photos. A clinometer and densitometer may be used check estimates.

2. TMDL Target Shade:
   a. Estimate the potential shade using the shade curves from Figures 2 to 7 and the site-specific vegetation type, channel width, and aspect.

3. Site Potential Shade:
   a. Field verify the air photo interpretation of whether riparian vegetation has been altered by human activity. Look for evidence such as stumps, skid trails, roads, debris flows, or mine tailings. If evidence of past debris flows are present, aerial photos will be reviewed to identify any contribution from human activities. At sites where the riparian vegetation lacks signs of human-caused disturbance, record the site potential shade as the existing shade.
   b. At sites where vegetation has been altered by human activity, estimate the potential shade using the following methods:
      i. Measure stream shade using Hemiview pictures or a Solar Pathfinder at a reference site located outside of the disturbed area that has similar soils, valley type, channel width, aspect, and natural disturbance history as the altered site. If possible this should be the same reference site used in the air photo analysis in section 11.2.5.
      ii. Estimate the potential tree height, density, and channel width and enter these values into the shade-a-lator model to estimate the potential shade. The site-potential tree height and density will be estimated for both the pre-disturbance soil condition and the current soil condition. Mine tailings, road cuts, or borrow pits are examples of sites where the current potential may be irreversibly reduced from historic conditions due to changes in soils. The current site-potential may be estimated by observing vegetation at similar sites that have recovered.

11.5 Sampling Frequency for Stream Shade

An assessment of stream shade will be conducted for the entire stream network as described in section 11.2 as new aerial photography becomes available and the USFS Remote Sensing Lab produces a new EVEG layer. The expected frequency is approximately 5 to 10 years. Special flights and assessment may be considered after flood events.

12. Sampling Design for Stream Temperature

12.1 Selection of Temperature Sample Sites

Temperature will be measured in tributary streams at the locations in Table 6, and in the main river channels at the locations in Table 13. Most of the tributary streams are measured at the same location as stream sediment. The monitoring network is designed to monitor Klamath National Forest lands at the 6^{th} field watershed scale, but include several 7^{th} field watersheds that are not captured by one of the 6^{th} field sites. Tributary streams are divided into either managed or reference watersheds using the criteria described in section 9.3. Temperature monitoring sites in the main river channels are selected to include most of the historic monitoring locations and represent a longitudinal gradient downstream. No reference streams are available for the main river channel sites.

12.2 Methods and QA/QC

Prior to deployment and after retrieval of data, water and air temperature logging instruments are tested for accuracy and precision following the Klamath National Forest temperature monitoring protocol (USFS 2010, appendix E). This protocol also gives the general procedures for deploying the instrument and for retrieving, handling the data, and QA/QC procedures.

Table 13. Stream temperature monitoring sites in main river channels. Parameters: W = water temperature, A = air temperature. Tributary temperature sites are listed in Table 6.

Stream	Parameters
Klamath River downstream of Iron Gate Dam	W
Klamath River upstream of Shasta River	W, A
Klamath River upstream of Scott River	W, A
Klamath River upstream of Grider Creek	W
Klamath River at Happy Camp above Elk Creek Bridge	W
Klamath River upstream of Oak Flat Creek	W
Klamath River at persido bar	W
Scott River at USGS gauge	W, A
Scott River above Boulder Creek	W
Scott River at Bridge Flat	W, A
Scott River at Townsend Gl.	W
Scott River at Sugarpine Gl.	W
Scott River at Roxbury Bridge	W
Salmon River upstream of Nordheimer Creek	W
N.F. Salmon above Forks	W
N.F. Salmon above Little N.F.	W
S.F. Salmon above Forks	W
S.F. Salmon River upstream of Knownothing Creek	W
S.F. Salmon above Black Bear Ck.	W

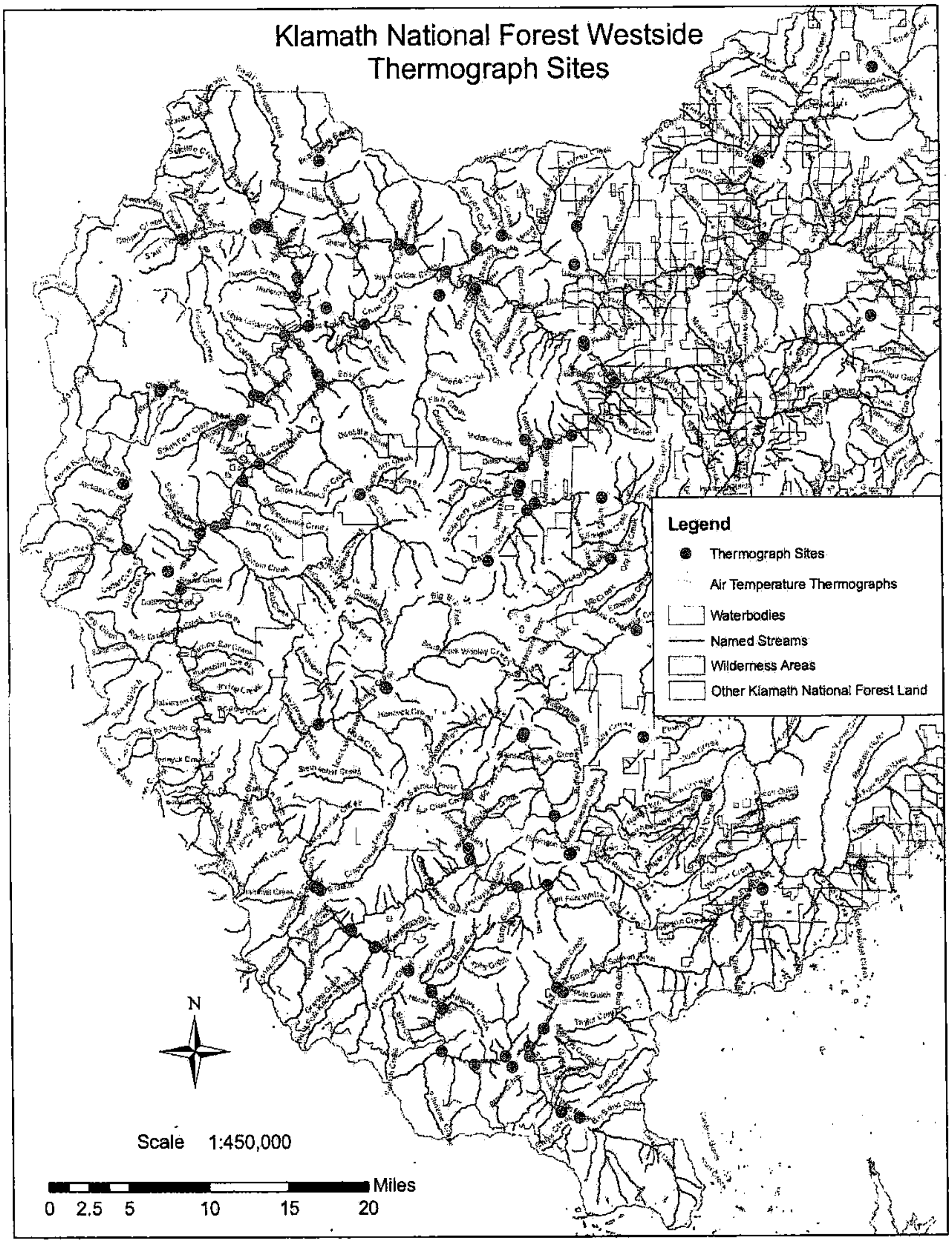


Figure 10. Stream temperature monitoring sites on the west side of the Klamath National Forest

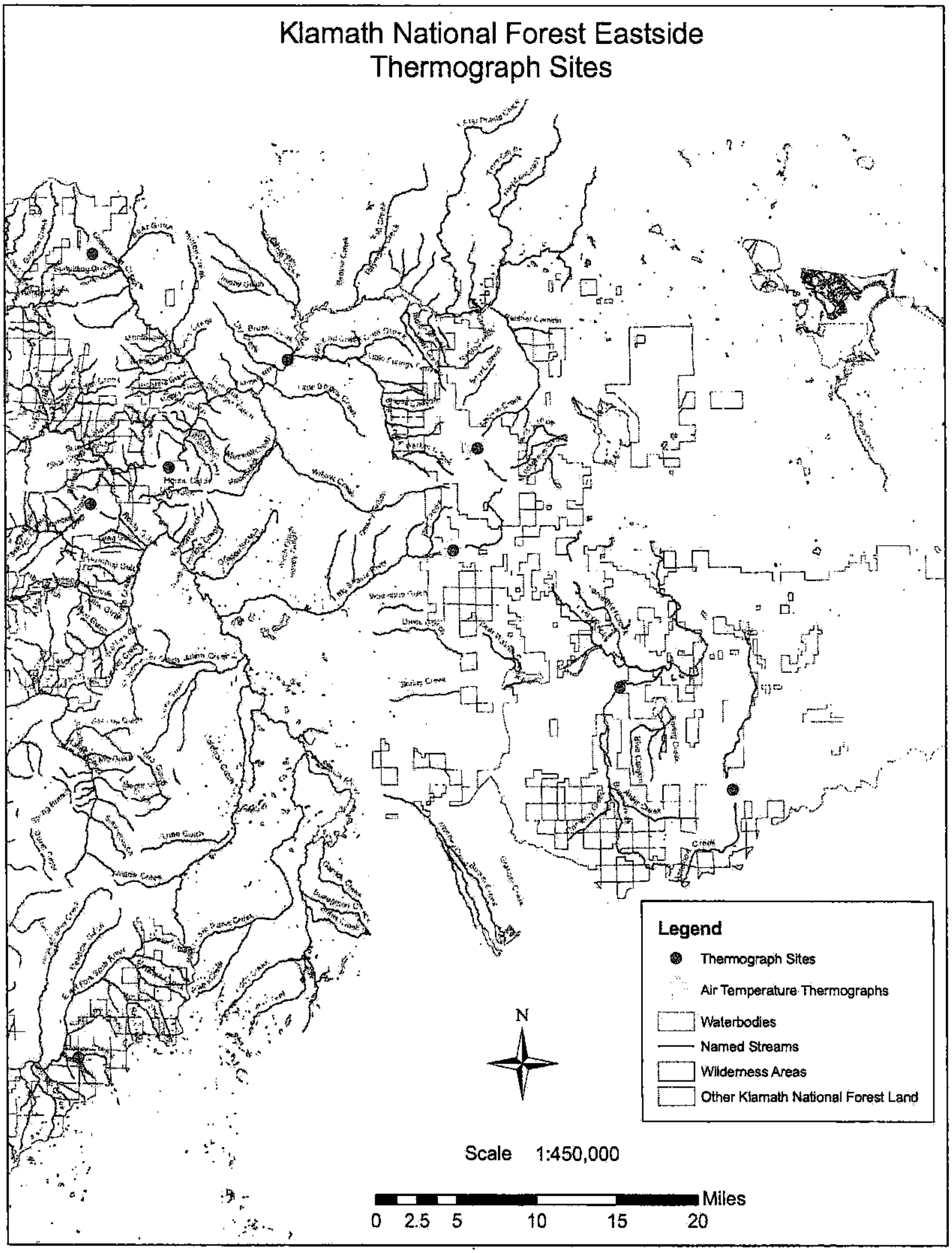


Figure 11. Stream temperature monitoring sites on the east side of the Klamath National Forest.

13. ANNUAL SCHEDULE OF WORK

Table 14. Annual timeline for sediment, shade, and BMP effectiveness sampling. All activities and deliverables are contingent on funding.

Activity	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Training: Sediment / Shade	June	July	Field Session	N/A
Shade Surveys	June	October	NA	NA
Sediment Surveys	July	October	NA	N/A
On-site BMP evaluations	July	November	Field Report	December
Deploy/Retrieve Temperature Loggers	May	October	Field Data	November
Mid-Season QA/QC Check	August	September	Final report	Mid-season
Data Summary and database entry	November	December	Field Report	December
Analysis	January	February	Final Report	March

14. DATA QUALITY OBJECTIVES AND MEASUREMENT VARIABILITY

14.1 Data Quality Objectives

The expected precision of substrate and shade measurements is listed in Table 15. The estimated precision of surface fines is from Olsen (2005). The estimated V* precision is from the error reported by Kiem (2002). The precision of subsurface fines is assumed to be similar to surface fines. Stream temperature precision is from the instrument manufacturer.

Acceptable levels of precision for stream survey data have been defined by Kaufmann (1999) using a signal to noise ratio (S:N). The S:N ratio compares the variance among streams (signal) with the variance between repeat measurements of the same stream (noise). Signal to noise ratios <2.0 may not have enough resolution to answer the monitoring questions and severely limit any analysis.

Table 15. Expected precision of sediment and shade measurements

Parameter	Estimated Precision
1. % Fines, Subsurface <0.85mm and <6.4mm	15%
2. % Fines, Riffle Surface <2.0mm	15%
3. Fraction of Pool Volume with Sediment (V*)	5%
4. Stream Shade (modeled from air photos)	10%
5. Stream Shade (field)	5%
6. Stream Temperature	0.2 C°

14.2 Field Quantification of Survey Variability

The ability to detect a change in sediment depends on the precision of the measurement, or the degree to which repeated measurements under unchanged conditions show the same results. The precision of each sediment indicator is determined using repeat surveys at sites randomly selected from approximately 12% of all sites in the survey. Repeat surveys will sample two sources of error:

1. Crew variability is evaluated using two successive measurements by different crews at the same site. This metric represents the variability between crews due to differences in where and how measurements are made.

2. Observer variability is evaluated using two successive measurements by the same crew at the same site. Where possible, the same individual will take both measurements.

Each pair of repeat surveys will be measured during the same year so that differences represent variation in the measurement and not year-to-year changes in the parameter. It is recognized that the variance between successive surveys represents both the precision of an individual measurement, and changes to a parameter over the course of the summer. The total measurement variation, or survey error, for each sediment indicator is calculated using the mean difference between all repeat pairs.

14.3 Procedures to Reduce Other Sources of Error

Other sources of variation will be reduced through project design and sampling methods. Variability due to spatial differences within a reach will be reduced by resurveying permanent sites at recurring intervals. Variation among streams will be reduced by stratifying by channel gradient and percent of watershed in sandy geology. Sampling methods that help to reduce variability in surface fines include the use of sampling frames, and large sample sizes of >600 particles measured over 3 riffles.

15. Quality Control

The Forest Service QA/QC procedures consist of the following elements:

- Training (survey procedures and field test). See section 15.
- Pre-Survey Preparation (equipment, data forms, field gear). Appendix A.
- Post-Survey Evaluation (review data, maps, photos). Section 19.
- Data Entry (field data review, training, oversight, data entry check). Section 16 and 18.
- Field evaluation of measurement variability. Section 13.
- Field Oversight (crew evaluations during field season).

The Field Mangers have the responsibility for reviewing the quality of data collection and the safety of field crews. Supervisors and the QA Officer will be roving between crews to periodically observe data collection and assure consistent application of QA/QC procedures. The QA Officer will have final authority to stop work or clarify protocols.

16. Training

All personnel collecting data for the Forest Service monitoring program will attend an annual training session in June or July. Training consists of both introductory and refresher sessions. Introductory sessions for employees new to the stream surveys consist of a combination of classroom discussion and field practice over a 3-day period. Refresher sessions are for personnel who have done stream surveys but who have not measured a reach in at least two years.

Refresher sessions are usually one day in the field at an established monitoring reach. Introductory training includes office and fieldwork in field measurement, sampling strategy (reaches, passes, and systematic and random selections), and data form management. Refresher training includes fieldwork and any changes to the protocols and field forms. Forest Service range and resource staff will attend training for BMP evaluation protocols, and a 3-day training session in protocols used to monitor the effects of grazing. Trainers consist of biologists and hydrologists well experienced in stream survey measurements. The Forest Service Quality Assurance Officers will provide oversight to all training sessions.

At the end of the training session all surveyors will collect data at a test reach. Each surveyor will be evaluated on their performance so that any corrections can be made before conducting actual surveys. Any surveyor not performing to the satisfaction of the QA Officer will not be certified and will not be allowed to collect data for this program. Training is documented for each surveyor on QA/QC form.

17. Sample Handling and Custody

Shade and sediment metrics of V*, surface fines, and subsurface fines are processed on-site and do not have any handling and custody procedures. Field crews shall be required to keep a field log using methods described in USFS (2003) and Cover (2008). All data fields on the form will be completed during the field visit. The field crews shall have custody of samples during field sampling.

18. Documents and Records

The final project file will contain the following documents.

1. EXCEL spreadsheet with field data
2. Field forms and QA/QC forms (scanned)
3. Digital Hemiview Photographs
4. GIS feature class of all points used for stream shade monitoring. Data for each point will include vegetation cover category (both existing and potential) as derived from EVEG and from air photo interpretation, channel width, aspect, modeled shade (both existing and potential), and notes on cause if existing does not equal potential. Field sampled points will also contain measured shade and potential shade.
5. Field report with narrative summary of the season's data collection. Include any problems encountered, significant weather events, and suggested improvements for the next year.
6. Final analysis report

19. Data Management and Storage

<u>Sediment Data</u>

Measurements will be entered into PDRs and/or hardcopy forms in the field. At the end of each day, data from the PDRs and cameras will be downloaded onto an office computer. For survey reaches involving overnight camping, data will be downloaded immediately upon return from the field. After analysis of the data at the end of the season, the data and analysis will be transferred to the Forest Service on a CD or DVD.

The Forest Service QA Officers will permanently store all data at the Klamath National Forest Supervisors Office in Yreka. Electronic data will be entered into the Forest Service national database (NRIS), the Klamath Basin Monitoring Program (KBMP) web-based database, and backed-up on the Klamath National Forest server. The Forest Service Quality Assurance Officer is responsible for maintaining the database.

Stream Shade Data

On-site data will be entered on paper field forms. Field forms and Hemiveiw photos will be stored on file at the Klamath National Forest Supervisors Office.

On-Site BMP Evaluations

Hard copies of completed forms, comments, photographs, etc. are retained in the Forest's dedicated water quality data file in the Supervisor's Office. The data will be entered into the Best Management Practice Data Base (BMP-DB), which resides on the IBM in ORACLE. This system allows for flexible storage, retrieval and reporting. Detailed user instructions for this system are given in Section IV of the BMPEP Users Guide.

20. Verification and Validation Methods

Field personnel that collect the data should discuss the confidence of the data with the QA Officer and Project Leader and come to consensus on whether to accept, reject, or qualify parts of the resulting data. Once data have been entered into a spreadsheet, the spreadsheet should be printed out and proofread against the raw data. Errors in data entry shall be corrected. Outliers and inconsistencies will be flagged for further review and discussion. Problems with data quality will be discussed in the field report. As soon as possible after data collection, the data should be checked for accuracy and completeness. If quality objectives are not met, the cause should be evaluated and a decision made about whether to discard the data or apply correction factors. The cause should be corrected by retraining or by reassessing equipment and methods. Any limitations on data use shall be detailed in the final report.

21. Reports to Management

Field Reports for Sediment and Shade

A field report will be submitted by the field crews to the Forest Service QA Officer before December 1st. The field report will summarize the operations for the season including the sites sampled, any problems encountered such as access, weather, and safety, and any departures from the protocol. The report will include all data, field forms, and photos organized into the format specified by the QA Officer.

Final Reports for Sediment, Shade, and BMP On-site Evaluations

Final Reports for sediment, shade, and on-site BMP evaluations will be submitted on or before March 15 of each year. The shade report will only be submitted in years when new aerial imagery and EVEG data are available, approximately every 5 to 10 years. The final report will include an analysis of data and a determination of compliance with water quality standards. The report will identify the need for restoration in watersheds where the analysis indicates adverse impacts to channels from management activities. The report may also include an analysis of reference conditions and recommendations to revise the Categorical Waiver.

Forest Service Cumulative Watershed Effects Model Revision

The threshold of concern for the Klamath National Forest cumulative watershed effects models will be reviewed and possibly revised using the sediment data from reference streams. The model thresholds will be compared with the 75th percentile of reference sediment values to determine if the model adequately predicts impacts to beneficial uses. If necessary, the threshold of concern may be adjusted to reflect the desired conditions for in-stream sediment.

22. Reconciliation with Monitoring Objectives

The ability of this monitoring program to answer the monitoring questions depends on the continuance of consistent data collection over many years. The rotating panel design relies on a commitment to long-term monitoring because the power to detect trends increases dramatically with time (Larsen 2004). The ability to assess current conditions relies on an adequate sample size to detect differences between managed and unmanaged streams. The sample size of reference streams is particularly important because the goal of this analysis is to determine if an individual managed stream is a member of the reference population. It should be recognized that channel response to upslope disturbance is complicated by many interacting processes. The final assessment of watershed condition and trends must be tempered by the judgment of local professionals rather than relying solely on attainment of desired values.

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