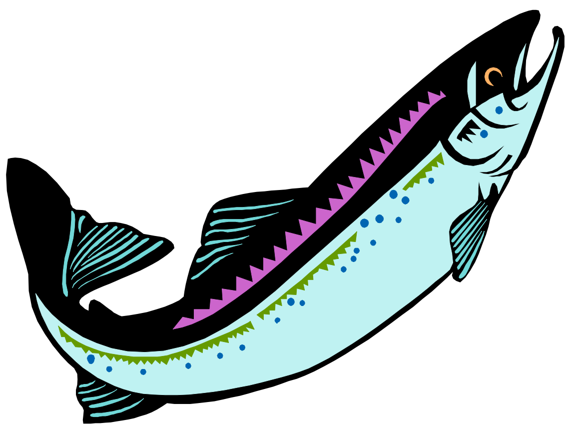
Monitoring the Effectiveness of Road System Upgrading and Decommissioning at the Watershed Scale

Final Report



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INTRODUCTION

Until recently, most fish habitat restoration projects were site-specific, focusing at the habitat unit or at most, the stream reach level (Elmore and Beschta 1987). Over the past few years, efforts to restore anadromous fish habitat on the California coast have shifted to improving watershed conditions mainly through remediation and prevention of upland erosion and/or sediment delivery from road systems. This shift is reflected in project types funded by the Fisheries Restoration Grant Program (FRGP) (Figure 1).

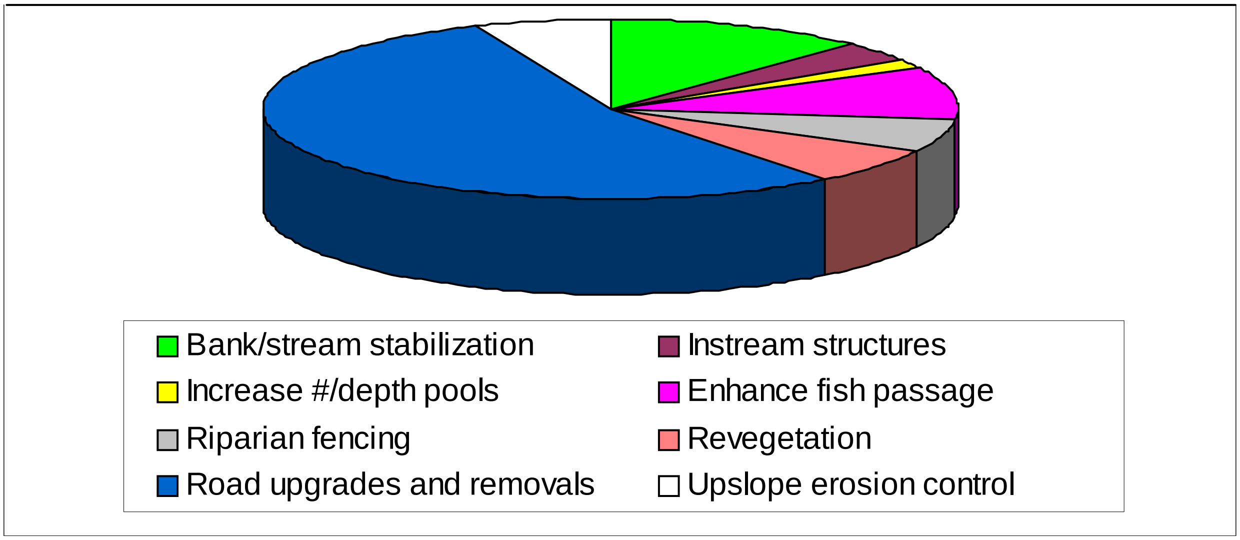

Figure 1. FRGP Funding, 1998-2000.

Many of these projects have been justified on the basis of expected improvements to stream conditions and fish habitat. For example, the following excerpt from a proposal to the FRGP for funding a road assessment is typical:

> Unlike many watershed improvement activities, erosion prevention and "storm proofing" (roads) has an immediate benefit to the streams and the aquatic habitat of the basin; they help to ensure that the biological productivity of the watershed's streams is not impacted by future human-caused erosion, and that future storm runoff can cleanse the streams of accumulated coarse and fine sediment.
>
> The (proposed) project will lead to a reduction in chronic sediment delivery that degrades spawning gravel quality and causes high and frequent turbidity associated with road surface erosion. The project will also lead to a reduction in coarse sediment delivery that causes a loss of rearing habitat through pool filling and channel aggradation by reducing the risk of catastophic stream crossing failures, stream diversions and road-related fill failures.

Many proposals make similar claims. The issue is that to date, there are no quantitative data for the California coast indicating that these practices have substantially improved instream water quality or salmonid habitat conditions. Theoretically, upslope restoration should help prevent chronic and episodic deliveries of sediment to streams and reduced sediment delivery to streams should improve water quality and fish habitat. Although it can be said with some confidence that measures aimed at reducing erosion and sediment delivery to streams have been successful at the site scale, it is not known how these site-level effects translate into benefits to water quality and stream habitat at the stream reach or watershed scales. Little is known about the temporal scale at which improvements may occur and how long term sediment budgets in watersheds may be affected by restoration. Moreover, recent studies have shown that restoration in upper watershed locations on or near non-fish-bearing streams causes short-term impacts on local water quality due to post-construction adjustments (Klein 2003). It is unknown how long these impacts persist or whether they create adverse conditions in downstream locations where fish are present. This particular issue is of importance not only to the FRGP but also to Regional Water Quality Control Boards and the US Army Corps of Engineers who issue permits for the FRGP.

Monitoring the Effectiveness of Upland Restoration provides approaches for evaluating these treatments at the site and road reach scales. This report provides a generic study design and methods for monitoring effectiveness at the watershed scale. There are three phases of potential impacts and effectiveness: 1) initial post-implementation adjustments (i.e., short-term erosion and sediment delivery due to construction practices which may last a few years after construction); 2) short- to intermediate-term effectiveness (i.e., improvements in water quality occurring after the post-implementation adjustment phase); and 3) long-term effectiveness (i.e., improved response to stressing events) (Figure 2).

Primary effects from post-implementation adjustments include elevated turbidity in watercourses near construction sites, local channel erosion due to replacement of crossings and erosion from exposed construction sites. These effects have been studied at several locations (Redwood National Park, Hopland Field Station, Pacific Lumber Company lands) over the past few years. After construction sites stabilize and re-vegetate, the short-term effectiveness phase should last until a stressing event occurs which is large enough to test the restoration treatment. During this phase, there should be measurable reductions in chronic sediment delivery from treated areas resulting in improved water quality and improved instream habitat. Effectiveness will depend on the nature of treatments (i.e., upgrading versus decommissioning) and the nature of erosion

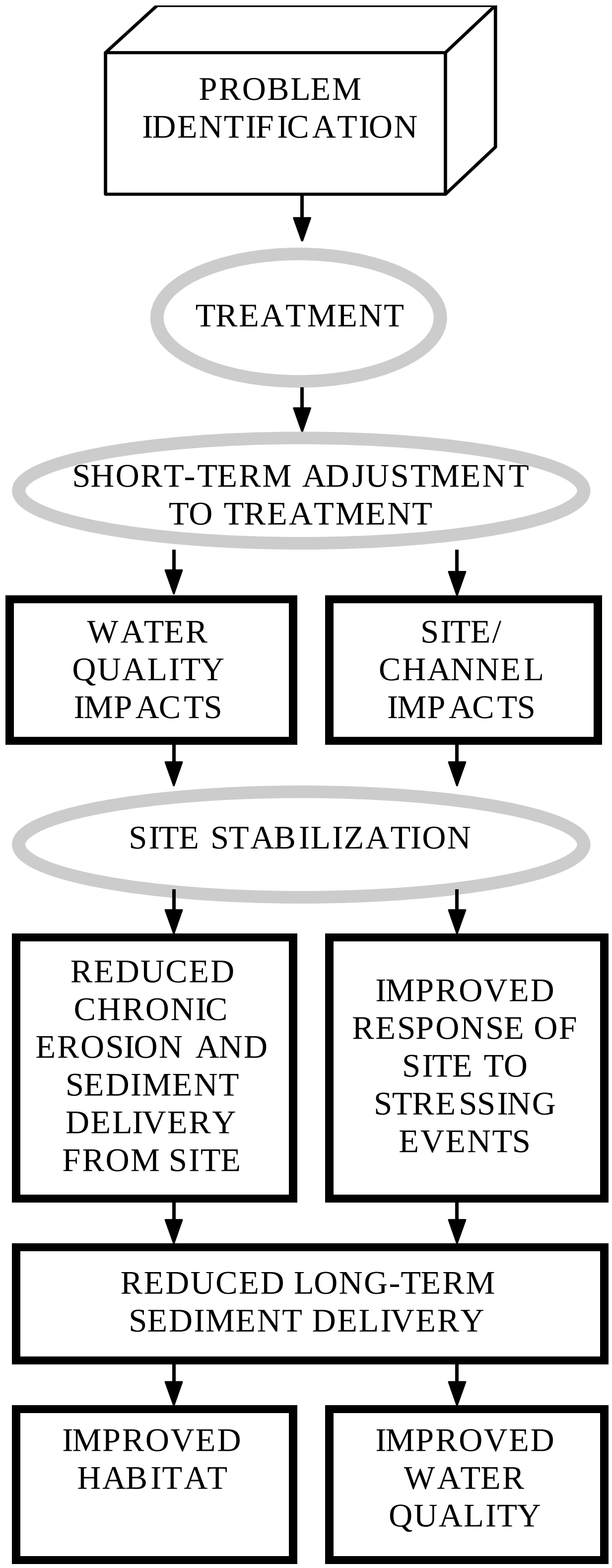

Figure 2. Conceptual Model of Upland Restoration Effects.

sources (e.g., traffic levels, gullies, etc.). Initiation of the long-term effectiveness phase cannot be predicted since it is a response to a stochastic climatic event. Responses of upslope restoration projects to stressing events have been studied by Mary Ann Madej (2001) at Redwood National Park. If restoration is effective, treated sites should have a lower frequency or volume of failure during stressing events than untreated sites. Over the long term, improved watershed conditions should result in improved instream and fisheries habitat conditions.

There are no existing monitoring studies that are addressing the entire process and sequence of events described above. Those studies that do exist typically focus on short-term responses, on physical or biological responses alone or at one but not all relevant spatial scales. This method for watershed monitoring describes an approach that has the following attributes:

- It utilizes a paired watershed before-after-control-impact (BACI) design
- It is of sufficient duration to encompass pre-treatment data collection, post-implementation adjustments and effectiveness
- It uses systematic monitoring methods at the site, stream/road reach and watershed scales
- It combines intensive field surveys with automated monitoring of water quality and stream discharge.

REPORT OBJECTIVES

This report's objectives are: 1) to provide guidelines for the development of projects for effectiveness monitoring at the watershed scale; 2) to indicate what field methods may be used for watershed monitoring; and 3) to provide a proposal screening procedure that can be used by the FRGP to evaluate proposals for watershed-scale projects. Procedures outlined here have been adopted at some locations in coastal California and elsewhere. Some were tested during a pilot study at the University of California Hopland Field Station in Mendocino County. Although the report focuses on road-related water quality improvement projects, the strategy (paired watershed BACI design) may be applied to other restoration treatments at this scale. Moreover, the proposal screening procedure, with modifications, may be useful for screening other types of monitoring proposals.

Some of the field methods that would be used for watershed monitoring are presented in other reports and are incorporated here by reference. The proposal evaluation procedure is included as Attachment A. Attachment B provides some tips on quality control and assurance for watershed monitoring. Attachment C is an example table of contents for a quality assurance project plan. The commitment and complexity involved with undertaking a watershed monitoring project should not be taken lightly either by funding agencies or by project applicants.

RESTORATION OBJECTIVES

This report applies to watersheds where the emphasis is on reducing erosion and sediment delivery to streams. Project types that may be undertaken include:

Road System Upgrading: Measures taken to reduce road surface erosion and hydrologic connectivity of roads to streams.

Road System Decommissioning: Obliteration and storm-proofing of dysfunctional or unneeded roads.

Stream Crossing Upgrading: Replacement of stream crossings deficient either in size or design.

Stream Crossing Decommissioning: Removal and excavation of stream crossings to restore natural channel characteristics.

Primary objectives of these projects are to:

- Reduce erosion at the source
- Reduce chronic sediment delivery to streams
- Prevent catastrophic failures and sediment delivery during stressing events
- Reduce hydrologic impacts on streams (peak flows, intercepted groundwater)
- Improve instream habitat conditions (reduce fine sediment deposition in streams)

Improvement of habitat conditions for fish is the ultimate goal of all upland erosion control projects.

MONITORING QUESTIONS AND EFFECTIVENESS CRITERIA

Monitoring the effectiveness of upland erosion control treatments at the *site* and *road reach* scales focuses on local effects, e.g., at restored crossings, at road drainage outlets, on fill slopes, etc. *Watershed-scale* monitoring seeks to determine the cumulative effects of these treatments on streams at the outlets of restored watersheds. Three general questions frame the problem:

- Did restoration improve hydrologic conditions in streams?
- Did restoration improve water quality in streams (suspended sediment and turbidity)?
- Did restoration have beneficial effects on instream habitat?

Within the framework of these three questions, the conceptual model presented in the Introduction (Figure 2) suggests six potential hypotheses that may be tested:

1. Decommissioning and upgrading roads using standard FRGP implementation techniques initially causes increased turbidity and channel changes in nearby streams, and local erosion as compared to pre-treatment conditions and control watersheds. These effects persist for 1-2 years.
2. After the initial adjustment phases, turbidity in streams draining treated watersheds will be significantly lower than it was prior to treatment. It will also be significantly lower than turbidity in control (untreated, but with similar road patterns) watersheds.
3. After the initial adjustment phases, reductions in sediment delivery to streams due to upslope treatments will be reflected in improved physical stream conditions (reduced fine sediment deposition in pools and riffles and increased channel bed complexity).
4. Improvements in hydrologic functions due to restoration will reduce the magnitude of storm-driven peak flows in streams. Storm-driven hydrographs will also have more gently sloping ascending and recession limbs. The yearly hydrograph for streams will reflect reduced magnitude of peak flows and increased magnitude and duration of baseflows.
5. In response to stressing climatic events, the frequency and magnitude of full and partial failures of road-related features will be significantly lower in treated watersheds than in control watersheds.
6. During and after stressing climatic events, the duration and magnitude of turbidity values in streams will be lower in treated watersheds as compared to control watersheds.

Table 1 indicates parameters, effectiveness criteria and methods appropriate for studies based on the above questions and hypotheses. These were derived through a combination of expert judgment, literature review and consultation with scientists involved in similar work.

Table 1. Effectiveness Monitoring Questions, Parameters, and Field Method.

Monitoring Question	Parameters	Effectiveness Criteria	Field Methods
Did restoration practices reduce the connectivity of roads to streams?	Connectivity length and surface area of contributing road reaches	Less than 15 percent of road length or contributing area drains directly to streams.	Field Method 1: Map and characterize road lengths and/or sub-watersheds draining to stream(s).
Did restoration practices improve hydrologic conditions in streams?	Streamflow discharge during peak flow events and baseflow	Storm hydrographs indicate reduced magnitude of peak flows and reduced steepness of hydrograph ascending and recession limbs. Yearly hydrograph indicates increased duration and magnitude of baseflows.	Field Method 2: Automated stream discharge gaging.
Did restoration practices improve water quality in streams?	Suspended sediment load and/or turbidity	Suspended sediment and turbidity levels are reduced below pre-treatment levels. Water quality thresholds important to fish and other aquatic organisms are not exceeded.	Field Method 3: Automated turbidity and/or suspended sediment sampling.
Did restoration practices contribute to beneficial effects on instream habitat?	Fine sediment deposition in pools and/or response reaches (<2 percent gradient). Channel bed complexity in response reaches.	Levels of fine sediment in pools and other sensitive habitats are reduced below pre-treatment levels. Channel bed complexity (residual pool depths and mean bed elevation) is improved relative to pre-treatment conditions.	Field Method 4: Longitudinal profiles (other methods in select locations)

As discussed later in the Monitoring Design section of this report, answering these questions will require data collection before and after treatments in both control and treated watersheds and stream reaches. These are extremely difficult questions and there are many constraints and issues associated with addressing them.

DATA QUALITY CONTROL AND ASSURANCE

Attachment B provides some detail on data quality and quality assurance. It is anticipated that any watershed monitoring project funded by the FRGP will be undertaken by experienced consultants or practitioners. It is further expected that collaborative watershed monitoring involving cooperative agencies and landowners will be required. Study designs funded by the program should explicitly address the qualifications and training of monitoring personnel.

The Salmon Forever citizen's monitoring program in Humboldt County provides an excellent example of a quality assurance project plan. The table of contents is included in Attachment C. The quality, detail and depth of this plan is indicative of what would be required for a watershed monitoring program funded by FRGP.

GUIDELINES FOR DEVELOPING A WATERSHED MONITORING PROJECT

Process

Dr. Robert Ziemer of the US Forest Service Redwood Sciences Laboratory directed the Caspar Creek watershed study for over 20 years. He provides an excellent discussion of the realities associated with monitoring at the watershed scale (Ziemer 2003). He cites four reasons why these projects fail to achieve expectations: 1) the monitoring question to answer is not defined clearly enough; 2) the inability to find adequate locations to install instruments to fit the defined objective; 3) the inability to collect relevant data (for example during very large storm events): and 4) the inability to analyze the data collected. The State of Washington has developed a process for selecting "intensively monitored watersheds" that addresses Ziemer's concerns and provides a helpful guide (WSRFB 2003b)

The State of Washington strongly emphasizes biological monitoring in the context of intensively monitored watersheds (WSRFB 2003b). Biological monitoring is not covered here. Approaches to biological monitoring of restoration projects are currently under development at Humboldt State University. Coupling restoration effectiveness monitoring with validation monitoring of fish and other aquatic organisms will ultimately determine if restoration is having the desired effects and contributing to population recovery (Botkin et al. 2000). Ideally, monitoring the response of physical conditions in a watershed to restoration should be accompanied by a complementary biological monitoring component.

Sources of Information

There have been several long-term experimental studies at the watershed scale. Monitoring to detect the effects of restoration is not fundamentally different than “monitoring” watershed responses to land use change. There have been classic studies of this type at Hubbard Brook (Likens et al. 1977), Coweeta Hydrological Laboratory (Swank and Crossley 1988) and in California, Caspar Creek (Ziemer 1998). The methods for these types of studies are well documented (Molden and Cerny 1994). In addition, there are texts and manuals that can serve as guides for developing monitoring programs at the watershed scale (Haan et al. 1994, MacDonald et al. 1991, Mulder et al. 1999).

Some watershed monitoring programs have recently been developed and implemented in coastal California and may serve as models for FRPG proposals. These include programs funded by the California Board of Forestry Monitoring Study Group at Wages Creek and the Garcia River (see http://www.bof.fire.ca.gov/board/msg_archives.html). The Wages Creek proposal, in particular, is a model for the monitoring contemplated here. It includes monitoring the responses of small watersheds to road upgrading and timber harvesting over a 10-year period. It is currently (as of 2004) in the three-year, pre-treatment data collection phase.

General Principles

The first general principle for watershed-scale monitoring is to **think small**. Natural systems are inherently dynamic and spatially heterogeneous. As a result, the ability at the watershed scale to detect change from restoration that is above and beyond this dynamic and heterogeneous background is difficult at best. Since heterogeneity and complexity increase with watershed size, the chances for change detection are greatest at the small (<1000 acres; preferably much less) watershed scale. This is the scale at which virtually all the experimental watershed studies have been done (Figure 3). For example, in the Caspar Creek watershed study, significant hydrologic effects from timber harvesting were only detectable at the sub-basin (<100 acres) scale (Ziemer 1998).

There are inherent difficulties in linking upslope treatments to instream responses even at the small watershed scale. For example, monitoring instream conditions such as sediment deposition usually involves measurements in “response reaches” of relatively gentle gradient (<2 percent) where sediment naturally accumulates. These may be absent in small watersheds that typically have steeper streams. One recently initiated study in Oregon addressed this issue by nesting smaller watersheds suitable for physical response monitoring within a larger watershed suitable for biological and geomorphic response monitoring (Figure 4).

The second general principle is to **think extensive**, in terms of the proposed restoration. That is, unless the restoration effort encompasses a large proportion of a watershed or treats things that are dominating natural processes, it is unlikely that a response will be detected. Detection of impacts to instream water yield from timber harvest for example, may not be possible unless at least 20 percent of the watershed has been harvested (Stednick 1996). There may be a threshold of impact from restoration or from other activities, below which watershed scale monitoring may not be able to detect change (MacDonald 1992). In watersheds that are dominated by large-scale erosional processes unrelated to roads, restoration activities may not have significant effects and perhaps should not even be attempted.

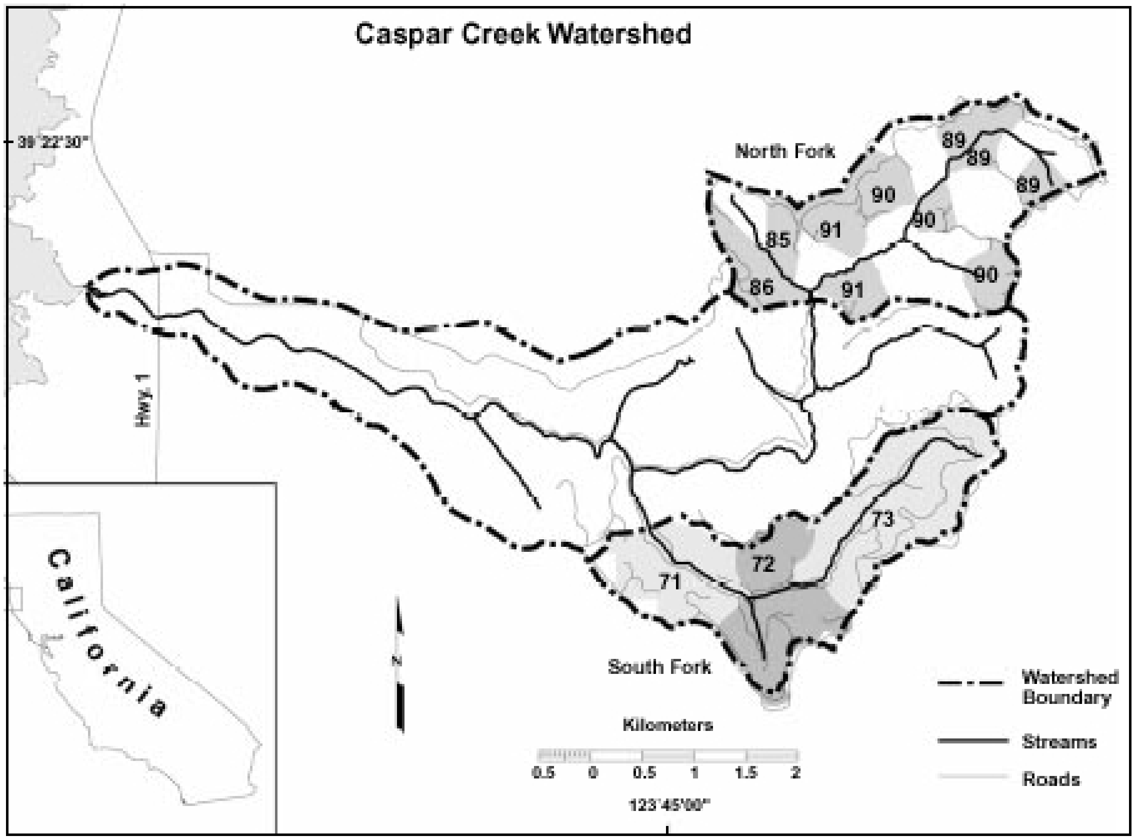

Figure 3. The Caspar Creek Experimental Watershed in Northern California—Treated and Control Subwatersheds.
Source: Ziemer 1998.

One crucial element of a watershed monitoring program is a sediment source inventory or sediment budget that quantifies the relative importance of restoration targets (e.g., roads) as a source of sediment. This information should be available not only for monitoring but should also be a prerequisite for planning and prioritizing restoration.

The third general principle is to **think long term**. Existing studies that have successfully detected changes due to land uses at the small watershed scale have required years, sometimes decades of monitoring to see the whole picture. In relation to upland erosion control restoration projects, time is required for collecting pre-project information, for short-term adjustments to treatments and for exposure to stressing climatic events. This has a bearing on pre-treatment data collection since it may take some time to adequately characterize pre-treatment conditions, calibrate treated and control watersheds (if that is an objective) and experience stressing events.

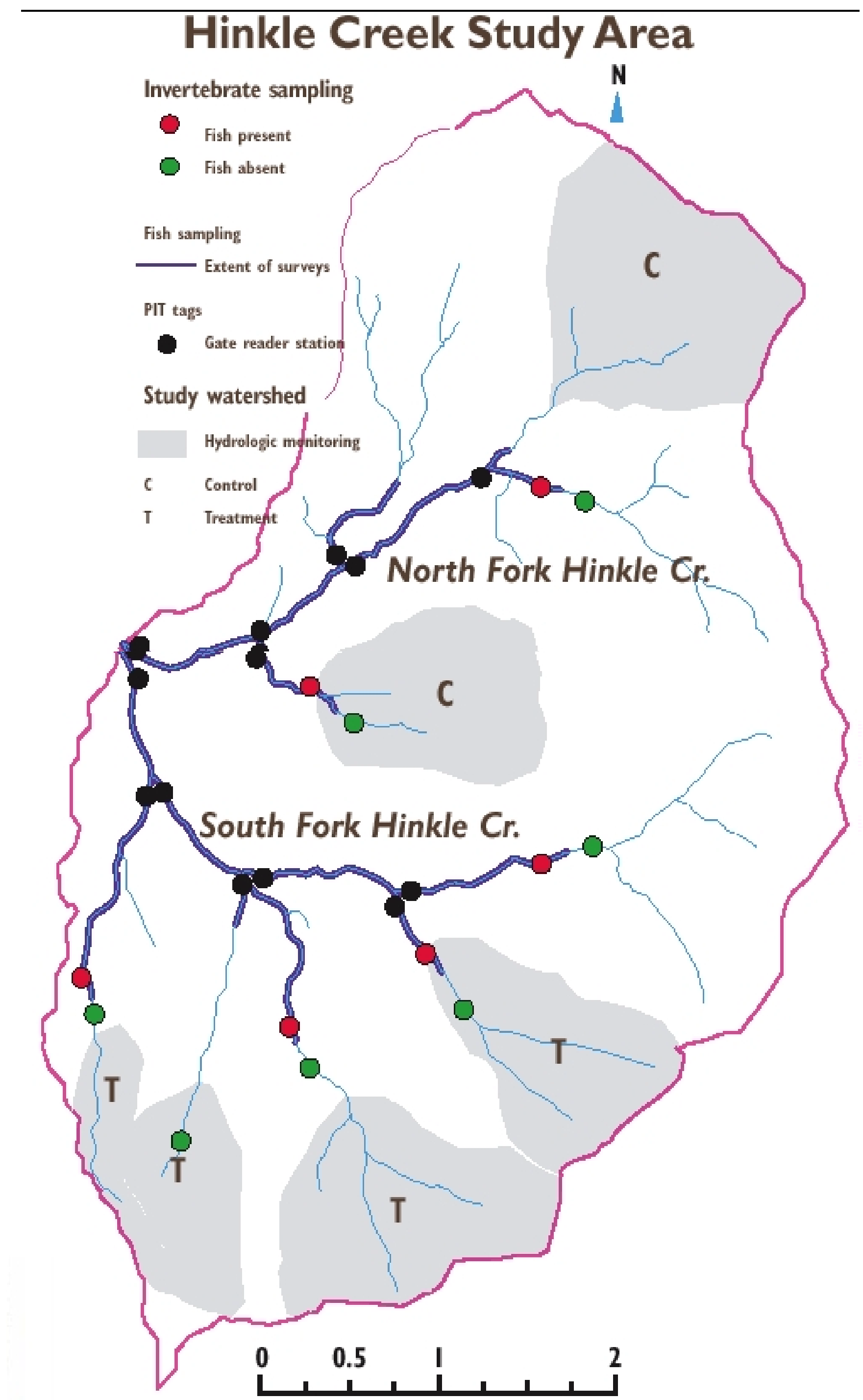

Figure 4. Hinkle Creek Paired Watershed Study Area.
Source: Watershed Research Cooperative, no date. http://www.odf.state.or.us/ DIVISIONS/ protection/forest_practices/fpmp/hinklecreek/hinkle_creek_study.asp?id=3060101

Most successful watershed monitoring or research projects have lasted at least 10 years. We estimate that at least seven years of monitoring are required to adequately evaluate short-term adjustments and reductions in chronic sediment delivery.

The fourth general principle is to think **cooperative landowner.** Although not generally true, there will be cases in which local watershed groups or coalitions of landowners may wish to develop and implement restoration effectiveness monitoring plans (Harris et al. 2000). Successful monitoring programs involving complex social relationships are the exception rather than the rule. If programs of this type, perhaps involving citizen monitoring, are to be funded by public agencies, there should be ample evidence that stakeholder commitment is strong and will remain so for the duration of the monitoring program. Single owner watersheds (especially public) are probably most favorable for long-term monitoring.

In summary, any serious proposal for monitoring restoration effectiveness at the watershed scale should be initially justified according to watershed size, amount of treatment and long-term commitment.

Monitoring Plan Contents

Generally the scope, complexity, and magnitude of proposed monitoring will vary on a case-by-case basis. A proposal submitted to the FRGP for funding should include, at a minimum, the information listed below. Although there is no "cookbook" for effectiveness monitoring, these requirements are applicable and necessary in most cases. They form the basis for Attachment A for preparing or evaluating proposals for restoration effectiveness monitoring at the watershed scale. Using this procedure will ensure that proposals contain at least the minimum amount of information to warrant advancement to the next review stage. Due to the expense, difficulty and complexity inherent in setting up a monitoring program, it is probable that few should be funded. Those that are funded should provide replicated studies spanning the geographical range of the FRGP.

Minimum information requirements are:

- Clear feasible monitoring objectives (hypotheses) linked to restoration project objectives (ask the right questions and do not attempt to answer too many questions)
- Description of watershed characteristics and condition
- Location maps for restoration treatments and proposed monitoring
- Description of available data
- Landowner or stakeholder commitment
- Watershed selection justification
- Coordination with other research and monitoring projects
- Plans for scientific peer review and oversight (e.g., technical advisory committee)
- Restoration project(s) description
- Monitoring study design, including pre-project data collection, sampling strategy, field methods selection and description, and duration of program
- Field data collection including data collection methods, sampling locations and timeframe, and field data forms
- Data management procedures

- Statistical and other analysis methods to be employed
- Qualified staff available
- Quality control approach
- Cost estimate
- Description of equipment and instrumentation required
- Accessibility for the duration of the program
- Reporting

As mentioned previously, any watershed monitoring proposal should either be accompanied by a watershed sediment source inventory or include provisions for conducting one. A sediment source inventory quantifies the relative importance of roads or other features targeted for restoration as compared to other sources in the watershed. These other sources include mass wasting, fluvial erosion, surface erosion and sediment stored in channels. Without this information, it is not possible to evaluate upland restoration effectiveness. Sediment source inventories should be done during the assessment of restoration potential in a watershed.

Pilot Studies

In some cases, the FRGP will be asked to fund the pilot testing of a watershed monitoring approach. Any serious long-term monitoring project should probably have a pilot study before full implementation. Pilot projects can serve as a proving ground for new ideas or methods. They also offer opportunities to test whether the appropriate approaches are being taken, with less stress on budgets. They are used to refine and improve selected monitoring methods, indicators, sampling designs, or data evaluation techniques (Mulder et al. 1999). In the case of road and

upland erosion control projects, pilot watershed monitoring efforts can indicate the level of restoration that may be detectable. In addition, they provide examples of potential products from monitoring, such as databases and reports that will help cultivate the support (funding) and understanding required to make long-term monitoring successful. Pilot studies funded by the FRGP may evolve into long-term projects with funding from other sources.

Monitoring Study Design

The information presented here on monitoring study design cannot substitute for a specific study design. The intent is to simply provide a conceptual basis for watershed monitoring based on the general questions and hypotheses previously presented.

Simultaneous effectiveness monitoring at the site, road reach, stream reach and sub-watershed scales provides the opportunity to establish linkages between practices that are done on a local scale and monitoring signals in streams. The difficulties of making these linkages are extreme because of natural variability, lag times between treatments and effects, and measurement issues. As with the study design proposed in other reports, the general approach recommended is a before-after-control-impact design (BACI) (Stewart-Oaten et al. 1986). In this case, however, controls will be necessary at all scales, including sub-watershed. This has important implications for both the selection of study watersheds and the required duration and intensity of sampling. Other possible study designs exist and may be used (e.g., Walters et al. 1988), but a BACI is theoretically the most powerful for detecting impacts of restoration.

In a BACI design, measurements are taken before and after treatment of control and treated areas at the site, road reach, stream reach and sub-watershed scales. At the watershed scale, the concentration is on stream discharge, water quality and stream geomorphology. The differences between the controls and treatments before treatment are compared pair-wise to the differences between the controls and treatments after treatment.

The selection of paired watersheds for study is extremely important (Figure 5). Criteria for selection include:

- Similarity in size, historical land use, climatic, geologic and vegetation conditions
- Similarity in the amount and types of roads
- Accessibility and suitability for installation of monitoring stations
- Presence of anadromous salmonids
- Similarity in future land management

In addition to these criteria, there is a requirement that treatments (road upgrading and/or decommissioning) be deferred for at least two to three years in the treated basins and for the duration of the monitoring in control basins.

To fully evaluate the fundamental questions and the hypotheses underlying them, it is necessary to think on a longer-term basis than is typical for a FRGP grant. A minimum of seven years of monitoring is recommended for pre-treatment data collection, assessment of initial post-implementation adjustments and detection of short-term effectiveness. Decades may be needed to determine responses of restoration treatments to stressing events.

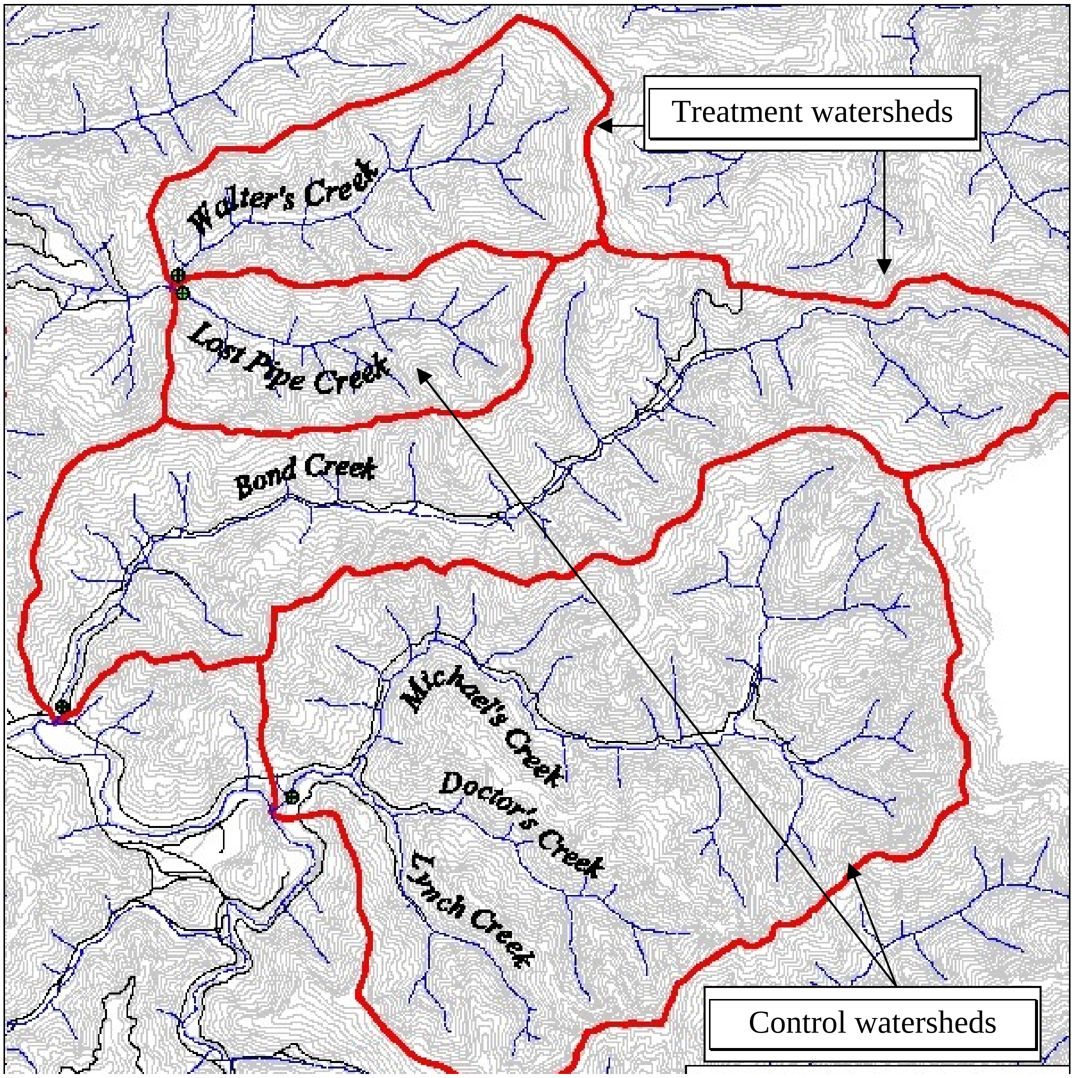

Figure 5. Road Treatment Effectiveness Monitoring Study Design Utilizing Paired Watersheds.

To enable inference, paired watershed studies of this nature should be installed in several locations, representing the entire coastal region. There are already a few similar studies underway. Using consistent methods and data collection methods in all studies would facilitate comparisons and analysis. In the states of Washington and Oregon, several "intensively monitored watersheds" have either been proposed or implemented for restoration effectiveness monitoring (Figure 6).

Reporting

Watershed monitoring funded under the FRGP will be required to file quarterly progress and completion reports. Since a watershed monitoring project will probably span more than one grant cycle, or may be continued using other funding sources, annual reporting may continue for several years. Since the long-term effectiveness of upland erosion control is presently unknown, it will be important that the results of any watershed scale monitoring be widely disseminated, preferably through peer-reviewed journal articles.

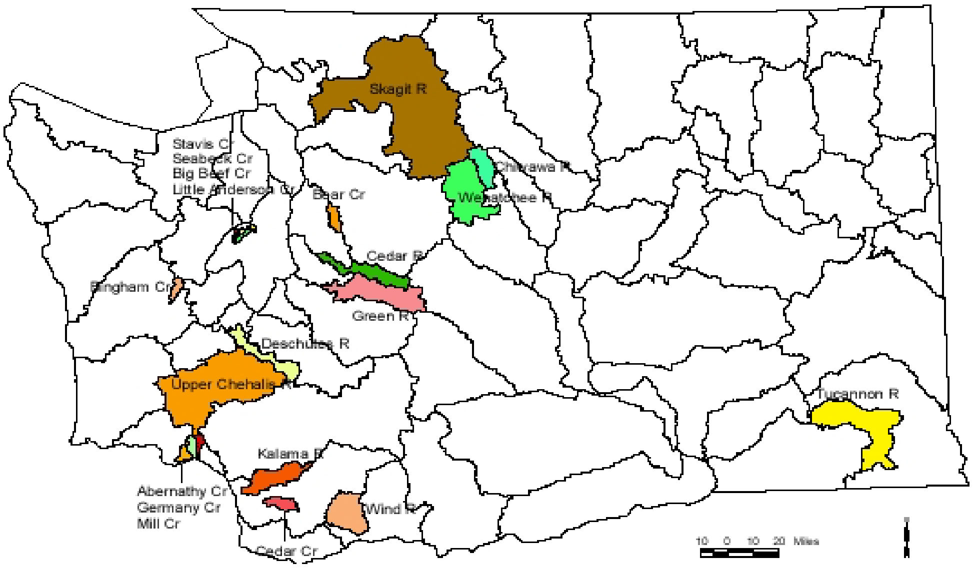

Figure 6. Proposed Locations of Intensively Monitored Watersheds, Washington State.
Source: Salmon Index Watershed Monitoring Redesign Group 2003.

FIELD METHODS

Field methods for monitoring at the site and stream/road reach scales are presented in *Monitoring the Effectiveness of Upland Restoration*. They include methods such as grab sampling of water quality above and below treated stream crossings, manual measurement of stream and road ditch discharge, void measurements on fill slopes, use of sediment basins for collecting road surface erosion products and gully dimension monitoring. These methods are not discussed here. Please refer to that report for further information.

There has been explosive growth in both technologies and methods for watershed monitoring in recent years. Agencies, private companies, and watershed organizations throughout the Pacific Northwest have all developed procedures for monitoring water quality and stream geomorphology. Although study objectives are often quite similar, there is much variability in the specific approaches used. Efforts have been made to coordinate amongst agencies and others to develop consistent approaches. The difficulties lie not in the methods per se, but in their actual application to a field setting.

In the context of this watershed monitoring report, the focus of field methods is on monitoring the following conditions in treated and untreated control watersheds before and after treatment:

- Water quantity: the quantity of runoff draining from road prisms and surfaces directly to streams and streamflow at the outlets to treated and control watersheds.
- Water quality: turbidity and suspended sediment concentrations at the outlets to treated and control watersheds.
- Stream geomorphology: channel bottom complexity and residual pool depth in low-gradient response reaches in fish-bearing streams either draining treated and untreated watersheds or downstream.

Field methods should be developed in application to the specific watersheds proposed for monitoring. The field method descriptions provided below are of necessity, relatively general.

Field Method 1: Hydrologic Connectivity of Roads to Streams

Hydrologic connectivity between roads and streams is a primary means by which sediment delivery occurs. Sediment from road prisms and ditches is delivered via road drainage facilities to streams. Consequently, upland erosion control efforts often focus on disconnecting road drainage from direct entry into streams. Techniques used may include installation of rolling dips, ditch relief culverts, road shaping and other treatments. All such methods generally aim at dispersing runoff and sediment onto vegetated slopes.

In addition to measures aimed at diverting road runoff from streams, projects such as road decommissioning often involve practices that de-compact the road surface. The goal of these measures is to increase infiltration rates.

Diversion of road runoff from direct discharge to streams along with increased infiltration may together have the effect of reducing the rate of runoff thereby lowering peak flows and changing their timing. At the watershed scale, the primary means by which changes in stream discharge may be monitored is continuous streamflow gauging.

Monitoring changes in infiltration of road surfaces is described in *Monitoring the Effectiveness of Upland Restoration*. Measuring infiltration rate on treated and untreated road surfaces can provide data on site and road-reach level effectiveness. Because the proportion of a watershed treated to increase infiltration may be relatively small, it is not likely that changes in infiltration rate alone can be detected at the watershed scale.

The emphasis of this field method is on quantifying changes in hydrologic connectivity of roads to streams. In many coastal watersheds, from 30-65 percent of either road length or contributing watershed area drains directly into streams. A common restoration goal may be to reduce connectivity by 80-90 percent. Measuring connectivity focuses on two elements: 1) quantifying the total area or length of road connected to the stream at given points (e.g., ditch outlets) and 2) quantifying the proportion of that total area that is exposed soil (the source area of the runoff and eroded sediment). The simplest technique for quantifying connectivity is to directly measure the length of road and/or ditch which is delivering runoff and fine sediment to the stream channel. Figure 7 and Figure 8 demonstrate the results of using this method. In Figure 7, the amount of road length directly connected to streams is 1.4 miles. In Figure 8, after treatment, the amount of road remaining connected to streams is 0.3 miles. The total reduction is 80 percent.

A more time-consuming option is to map, usually in the field, the area of watershed draining to each reach of road connected to a stream. The latter is preferable if the contributing area is a major source of sediment. Figures 9 and 10 demonstrate the use of this method. In Figure 9, 78.2 acres of watershed area are directly draining to streams. In Figure 10, after treatment, only 17.2 acres remain directly connected to streams. The total reduction in contributing watershed area is 78 percent.

The length of road or contributing area is likely to change (shrink) dramatically when restoration work is first performed, assuming that achieving reduced connectivity is a restoration goal. These benefits can be reversed by poor maintenance practices or if road surface drainage structures are altered or removed. Monitoring hydrologic connectivity over time will disclose the effects of maintenance as well as the effectiveness of practices used initially to achieve disconnection.

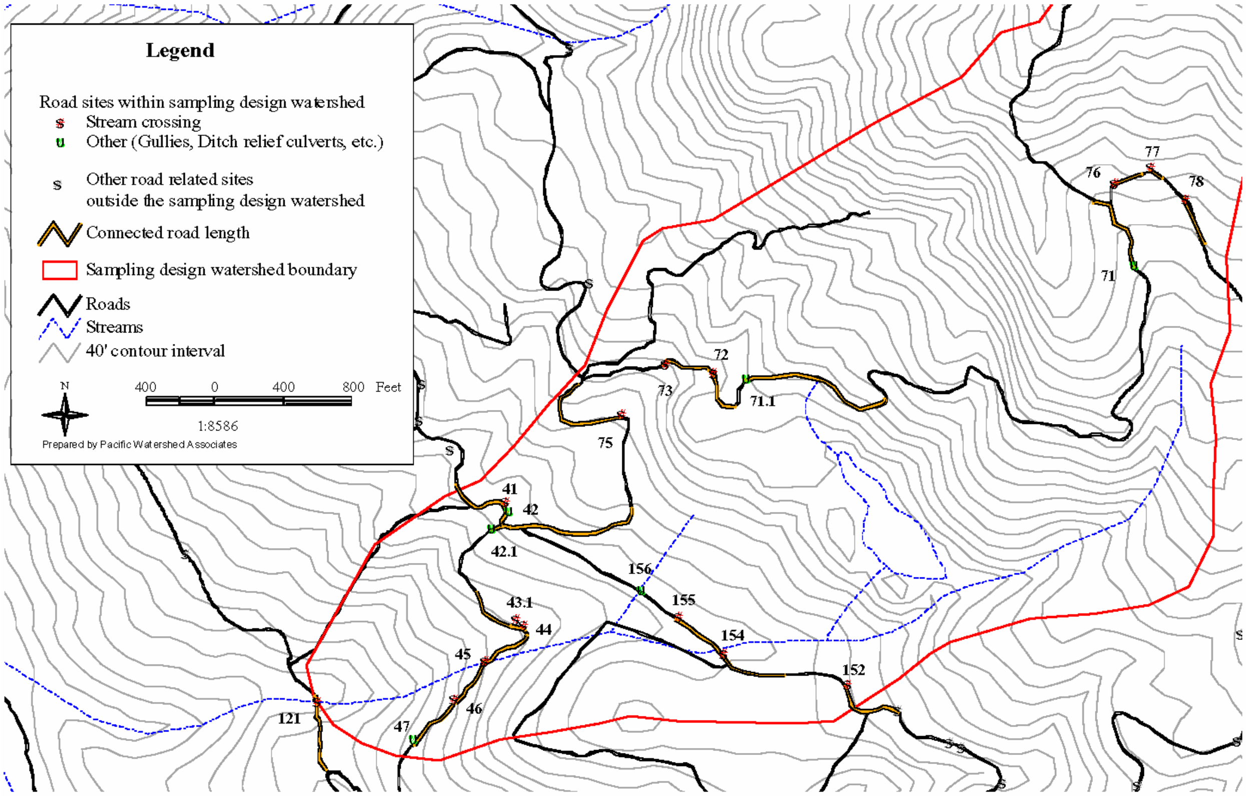

Figure 7. Pre-Treatment Road Connectivity to Streams, Experimental Watershed, Hopland Field Station.

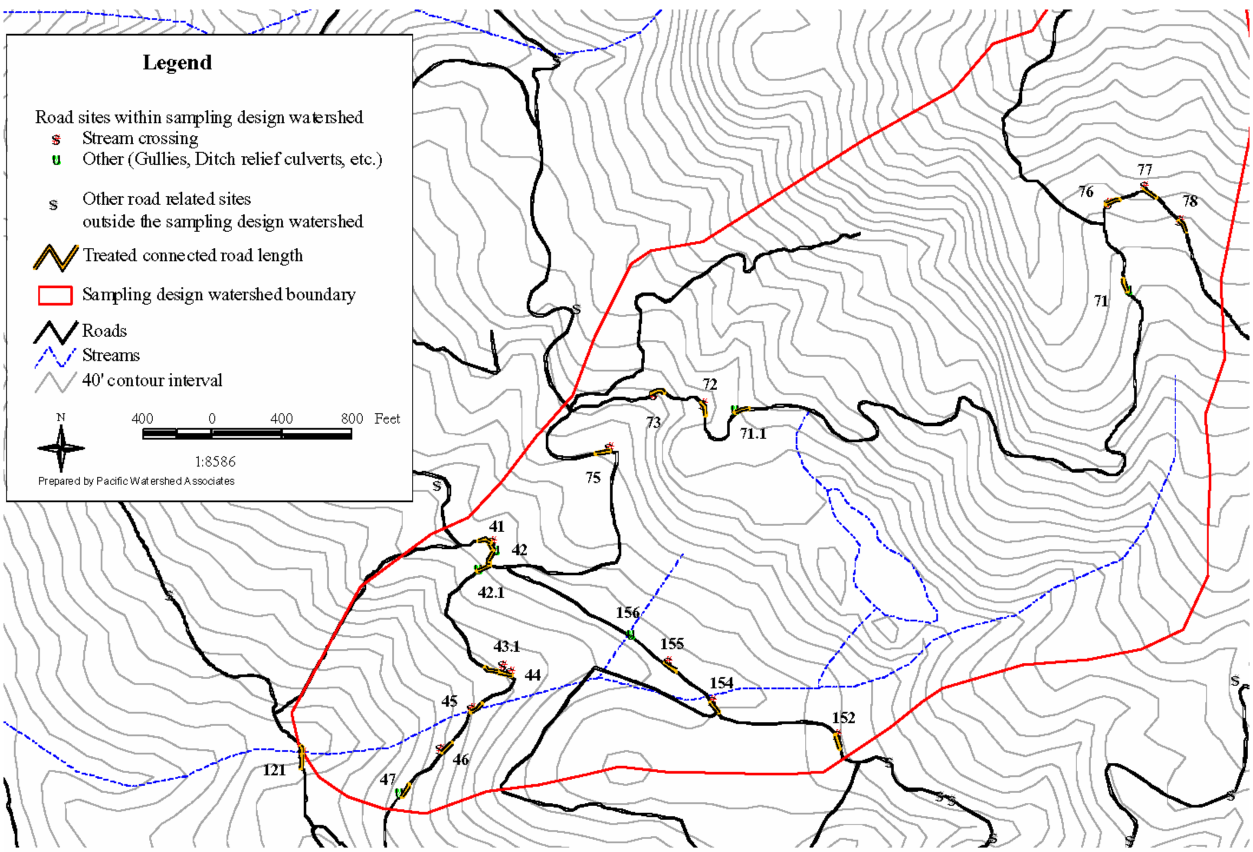

Figure 8. Post-Treatment Road Connectivity to Streams, Experimental Watershed, Hopland Field Station.

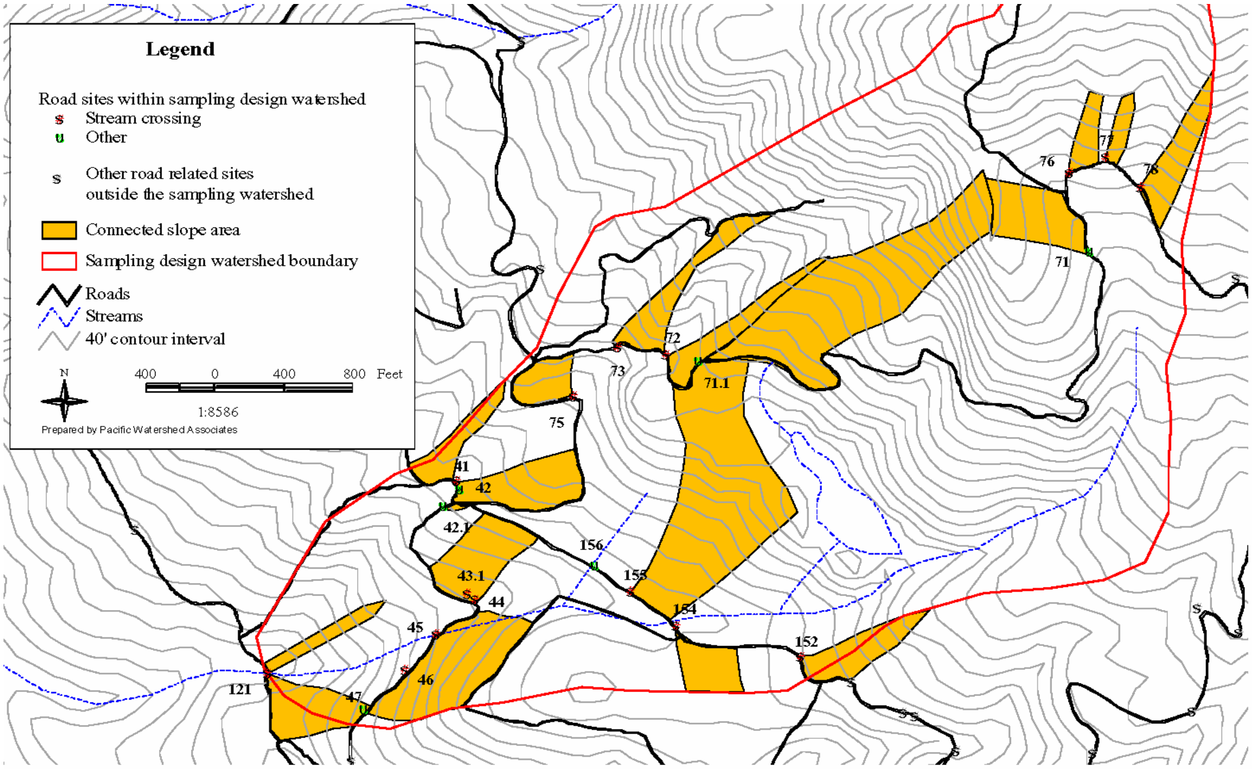

Figure 9. Pre-Treatment Watershed Area Draining to Streams, Experimental Watershed, Hopland Field Station.

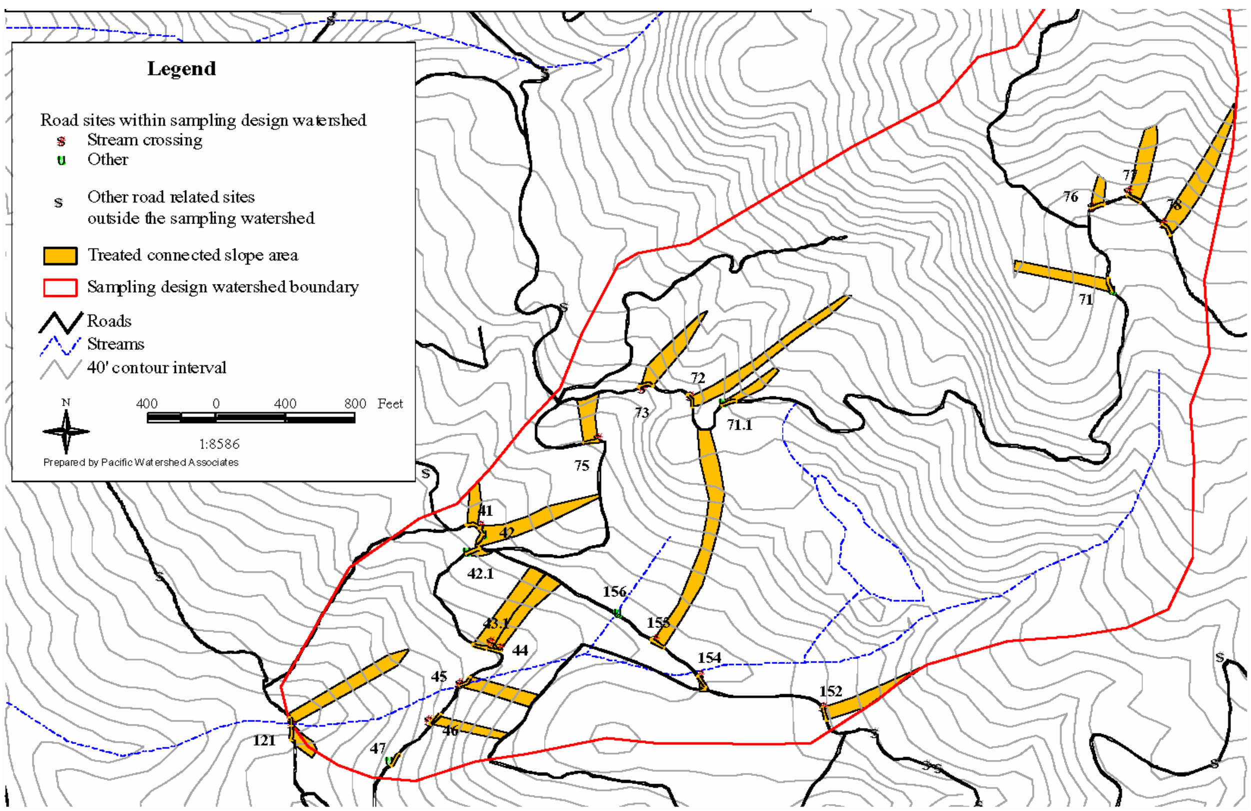

Figure 10. Post-Treatment Watershed Area Draining to Streams, Experimental Watershed, Hopland Field Station.

The following step-by-step procedure can be used for quantifying hydrologic connectivity.

1. Select measurement method—Select the type of monitoring desired to characterize or quantify the contributing area and the exposure of soils subject to surface erosion. The measurements may be linear or spatial. For example, for roads these connectivity measurements might include: 1) connected road length (linear), 2) connected road surface (area), 3) connected bare soil (area) (e.g., exposed road, ditch and cutbank areas), or 4) connected road surface area and contributing hillslopes (that drain to the connected road segment).
2. Identify and map points of connectivity—Identify the specific locations where runoff from disturbed or managed areas is being delivered to the natural drainage network. Plot the connected point on a topographic map or aerial photo of the project site and describe the location (see Location Report).
3. Measure contributing area or length—Measure the contributing area to each point of connectivity, or measure an analog (such as road length), prior to restoration treatment (Figures 7 and 9). Enter the lengths in the Connectivity Data Table. Flow paths of runoff immediately after or during a runoff event can help in clearly defining the boundaries of the connected area. Measurements can be made using pace, tape, hip chain, measuring wheel, vehicle distance measurer, or a survey instrument. Areas can be calculated by taking average spatial measurements, by mapping on aerial photos, by mapping on scaled low-level vertical photos, by mapping from digital elevation data, or from detailed instrument surveys (level, plane table, theodolite, or total station) of the small contributing subwatershed area that is draining to each point of connection. They can also be estimated using random sampling or aerial grids that identify areas as being “in” or “out” of the contributing area adjacent to the restoration site. Sampling reduces the measurement requirements, but lowers the accuracy of the area measurement. Selection of the appropriate measurement technique for monitoring contributing areas will depend on the objective of the monitoring project.
4. Measure bare soil within connected area or length—Map and measure the area of exposed bare soil within the contributing area. Exposed bare soil must consist of erodible soils that are subject to surface erosion. Exposed non-erodible bedrock, lag deposits of stony materials, vegetated surfaces or mulched (protected) areas are not considered subject to surface erosion. Bare soil areas can be estimated, measured, sampled, mapped or surveyed using the same techniques described for measuring contributing areas (see #3, above).
5. Remeasure (monitor) connectivity—Remeasure the contributing area following restoration treatment using the same measurement techniques (Figures 8 and 10), and intermittently thereafter if conditions change as a result of maintenance, management actions or natural events.

The data form presented below may be used to record data collected with Field Method 1.

<table>
<tr><td colspan="7">ROAD AND BARE SOIL CONNECTIVITY DATA FORM
Contract #:__________ Date (mm/dd/yy):______ Implementation (mm/dd/yy):________
Watershed: ________________ Road name: _________________ Crew: ____________
Measurement method(s): ____
(Left and right are determined when viewing downhill or downstream at the site)</td></tr>
<tr><td rowspan="2">Connected site #</td><td colspan="2">Left connectivity</td><td colspan="2">Right connectivity</td><td colspan="2">Total connectivity</td></tr>
<tr><td>Length (ft)</td><td>Area (ft^2)</td><td>Length (ft)</td><td>Area (ft^2)</td><td>Length (ft)</td><td>Area (ft^2)</td></tr>
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</table>

Field Method 2: Stream Discharge and Water Quantity

At the watershed scale, the hydrologic parameters that are most likely to be affected by upland restoration include the magnitude, timing and frequency of peak flows and the magnitude and duration of low flows. There have been no studies on this subject. This supposition is based on research concerning the effects of urbanization including roads, on hydrographs (Dunne and Leopold 1978). Theoretically, restoration would reverse the effects.

For example, efforts at disconnecting road drainage from streams and/or increasing infiltration capacity should slow the rate of runoff during a precipitation or snowmelt event. Road ditches are extremely efficient at moving water (and sediment), much more so than vegetated slopes. Compacted road surfaces resist infiltration and also tend to increase the rate of runoff. Slowing the rate of runoff during a precipitation event will mean that it takes longer for the discharge to peak. Reducing the absolute amount of runoff (e.g., increasing soil storage) will tend to reduce the size of peak discharge. During extreme precipitation or snowmelt events these effects will be less noticeable, especially if soils are at field capacity. Consequently, restoration effects should be most noticeable during moderate-sized floods (2-10 year recurrence intervals). Events of this scale are the ones that most land use effects are noted (Jones and Grant 1996).

If restoration efforts effectively disperse runoff from roads onto more permeable slopes, overland flow may be reduced. In most forested settings, overland flow is nearly absent because of soil and depression storage (Dunne and Leopold 1978). Increased soil and groundwater storage in turn, will tend to prolong stream baseflows because water discharges slowly to the stream over a longer period. Therefore, another measure of effectiveness will be the magnitude and duration of low flows during the summer and fall.

These effects on peak and low flows can directly benefit streams and aquatic life. For a restored watershed, the yearly hydrograph and individual storm hydrographs should approach a natural range of variability, absent other factors such as streamflow diversions.

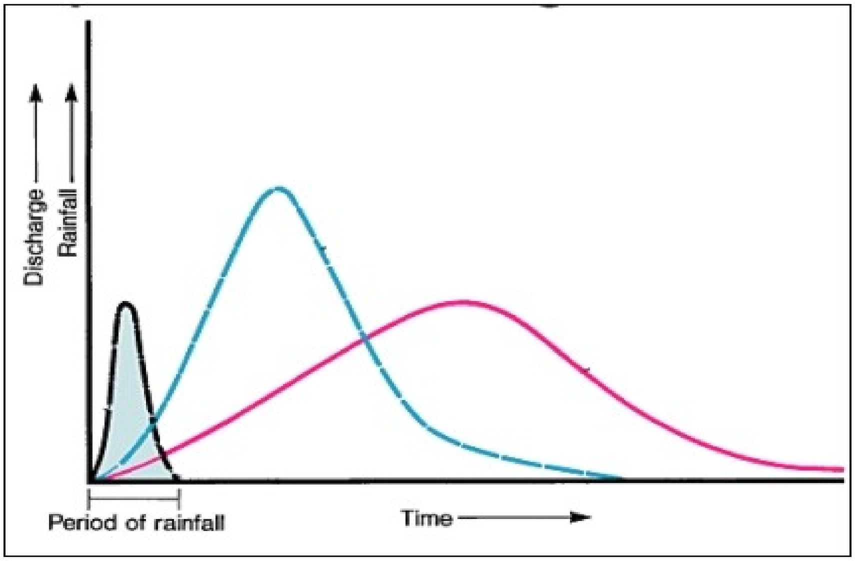

Figure 11. Hypothetical Storm Hydrographs for Untreated (dashed line) and Treated (solid line) Watersheds.

Figure 11 represents a potential theoretical basis for examining watershed-level hydrologic effects. It originates from research on the hydrologic effects of urbanization (Dunne and Leopold 1978). Comparable effects have not been demonstrated for upland restoration in undeveloped watersheds. There have been studies in forested watersheds indicating that land use effects may be confounding (Ziemer 1998) or that hydrologic responses in “natural” watersheds are extremely complex (Bowling and Lettenmaier 1997). The potential responses indicated in Figure 11 should therefore, not be considered expectations of restoration effects.

Because information on streamflow is needed virtually all year-round in order to detect changes due to restoration, there are no options for automated stream gauging to obtain the necessary data. The frequency of discharge sampling should be defined in the monitoring study design. Gauging stations should be installed at the mouths of treated and control sub-watersheds. Automated stream discharge (and water quality) measurement requires the installation of a permanent facility, sometimes including a weir or flume. Standardized methods for installation may be reviewed in USGS publications on the subject (USGS 1999a, 1999b, 2000). The duration of required stream gauging may be reduced if long-term records are available for similar nearby watersheds. Hydrologic analysis methods can be used to correlate short-term gauging records to long-term records, thereby extending them (Maidment 1993).

Streamflow data may be analyzed graphically or statistically to determine differences between pre- and post-restoration hydrology at treated and control sub-watersheds. Statistical analysis of streamflow records should be emphasized. The principle constraint on analysis is having sufficiently long records that include a wide range of flows.

Field Method 3: Water Quality

There are three main processes of erosion operating on the California coast: 1) mass movement (landslides), 2) fluvial erosion (gullies, road crossing failures, and stream bank erosion), and 3) surface erosion (rills and sheetwash). These three processes can deliver sediment to stream channels both naturally and as a result of land use. Upland restoration practices seek to interrupt the delivery of sediment to streams from roads via culverts, inboard ditches, and gullies (fluvial erosion). Other treatments (e.g., stream crossing upgrading, slope stabilization) attempt to reduce the catastrophic failure (mass movement) of roads and drainage facilities during stressing events. Some treatments may attempt to reduce surface erosion (e.g., road surfacing) but more often the focus is on preventing the transport of surface erosion products to streams (sediment delivery).

On California's coast, many watersheds are naturally subject to mass wasting and bank erosion completely unrelated to roads. These sources may be of such magnitude as to completely dwarf road-related erosion and sediment delivery. The relative importance of natural versus human sources of erosion and sediment delivery must be considered in designing a monitoring program (Figure 12). That is the main reason why a sediment source inventory is an essential component of a watershed monitoring program. Provisions should be made for conducting follow-up inventories during the progression of the monitoring.

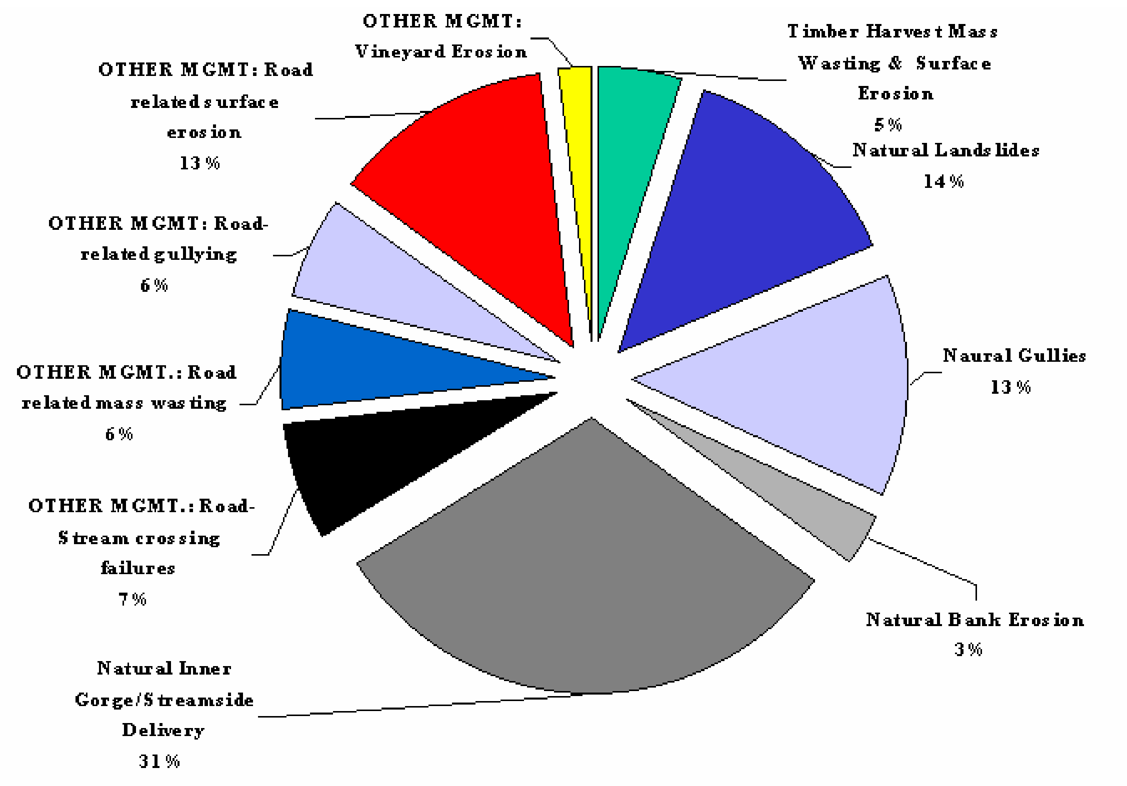

Figure 12. Sediment Contributions to the Navarro River, 1975-1998.
Source: USEPA 2000.

Transported sediment load has two general components: suspended and bed load (Maidment 1993). These may be further distinguished as wash load, suspended load, intermittent suspended load and bed load (M. O'Connor personal communication). Watershed monitoring focuses on suspended load for a number of reasons. Chronic erosion from road surfaces and gullies tends to be dominated by fine particles, which are mostly transported as suspended load. Fine suspended sediments in the water column that contribute to turbidity along with organic and dissolved material have a clear link to fish foraging efficiency (Madej et al. 2004) (Figure 13). Thus, measurement of suspended load provides a conceptual linkage between chronically generated sediments from roads and fish condition. Finally, the technology for continuously recording suspended load is far more advanced than for measuring bed load.

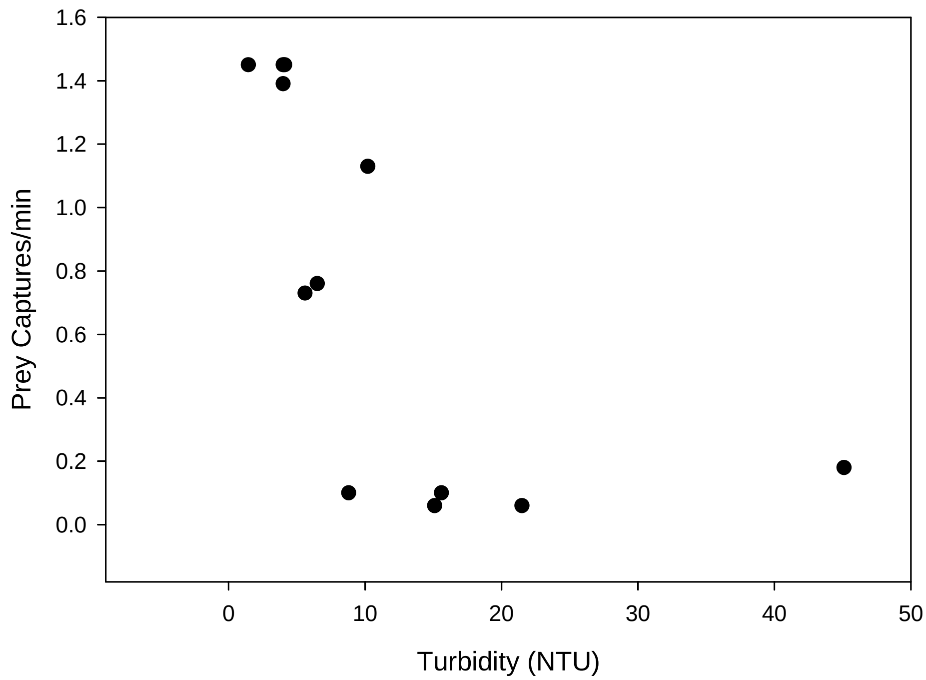

Figure 13. Biomass of Prey in Salmonid Foreguts Collected Under a Range of Field Turbidities. Although feeding may occur at relatively high field turbidities (>50 NTU), there is a general reduction at turbidities around 15-20 NTU). *Source:* Madej et al. 2004.

Episodic deliveries of sediment to the stream channel via road or crossing failures are relatively rare and are more likely to generate size classes and quantities of sediment that will be transported as bed load. Since methods for measuring bedload transport are relatively crude and the probability of correctly timing sampling to observe transport due to management activities is low, data regarding bedload transport may be best captured with channel geometry and substrate measurements in depositional stream reaches (Field Method 4).

Measuring suspended load may be done directly through analysis for Total Suspended Solids (TSS). TSS is a parameter used to measure water quality as a concentration (weight of solids/volume of water; mg/L) of mineral and organic sediment. In general, it is assumed that most suspended solids are inorganic and therefore results from this analysis represent the concentration of suspended sediment. Recent research on the North Coast suggests that organics can contribute greatly to turbidity and suspended loads (Madej et al. 2004), especially as peak flows rise and fall (Figure 14). Consequently, in some watersheds, this assumption may not be accurate and would require verification in a pilot program. TSS is determined by measuring the weight of dry solid material remaining after vacuum filtration of a known sample volume (50 to 100 mL). Samples are filtered through a 0.45-micron filter in accordance with standard procedures (Clesceri et al. 1998). Analytical laboratories provide this service for a fee. It is assumed that watershed monitoring under this method will utilize equipment that collects TSS data automatically.

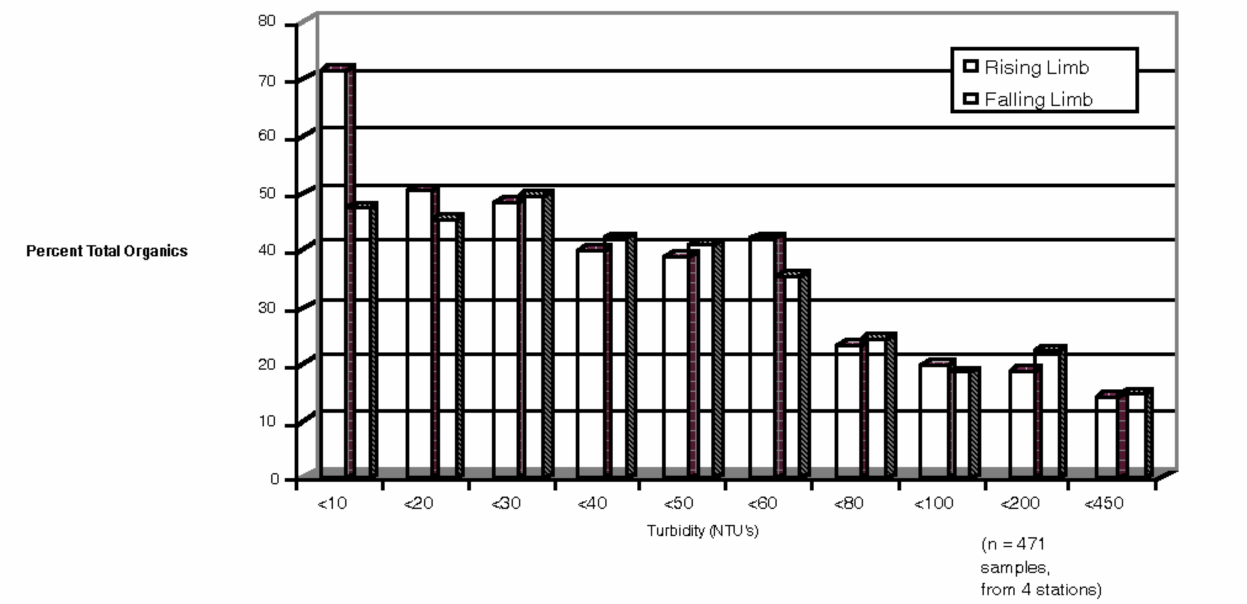

Figure 14. Relationship of Percent Total Organics in a Sediment Sample to Turbidity Readings and Hydrograph Limb.
Source: Madej et al. 2004

Turbidity is the measurement of the amount of light that is scattered and absorbed as it passes through a water sample. It is measured with nephelometry methodology and recorded in nephelometric turbidity units (ntu) (MacDonald et al., 1991). The amount of light scattered or absorbed changes as a function of the size, shape, surface characteristics, and quantity of particles within the sample (Clifford et al. 1995, Gippel 1995). Samples are analyzed according to American Public Health Association procedures (Clesceri et al. 1998). Analytical laboratories provide this service for a fee or an easy to use turbidity meter can be purchased for several hundred dollars. Automatic turbidometers will normally be required for watershed-scale monitoring. They are costly (up to $4000, depending on the model, including a data logger). Additional information is available at the USDA-Forest Service, Redwood Sciences Laboratory website. Turbidometers are installed at sub-watershed outlets in permanent facilities that also include stream gages (Figure 15).

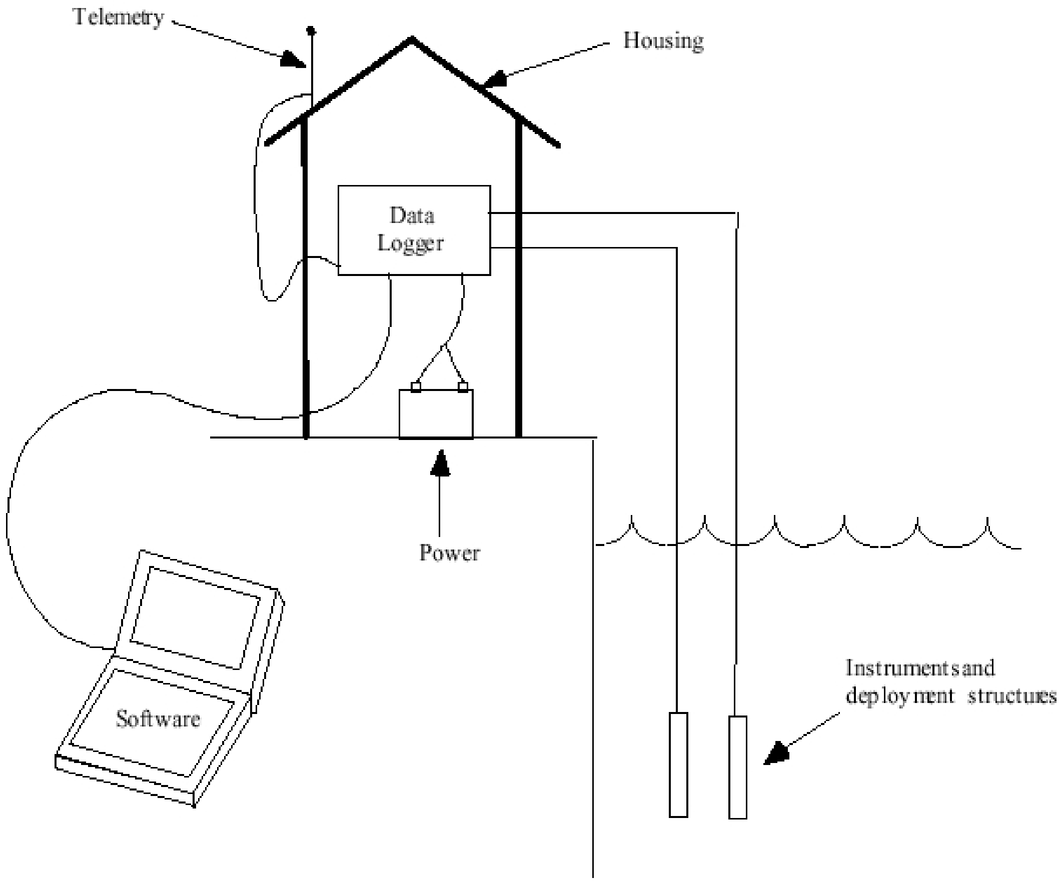

Figure 15. Components of Automated Water Quality Sampling System.
Source: Resources Inventory Committee 1999.

Automated sampling of discharge and water quality is timed according to study objectives (USGS 2000). Concentrations of sediment in surface waters are variable at the storm event, seasonal (within year), and inter-annual (between year) time scales (Tate et al. 1999) (Figure 16). For example, during a storm total suspended solid concentrations will increase and decrease in direct response to the rise and fall of stream flow. Over the duration of one season, total suspended solid concentrations will generally decrease. Differences in total suspended solid concentrations from one year to the next result from annual differences in rainfall. Higher rainfall years will generally have greater total suspended solid values in comparison to lower rainfall years.

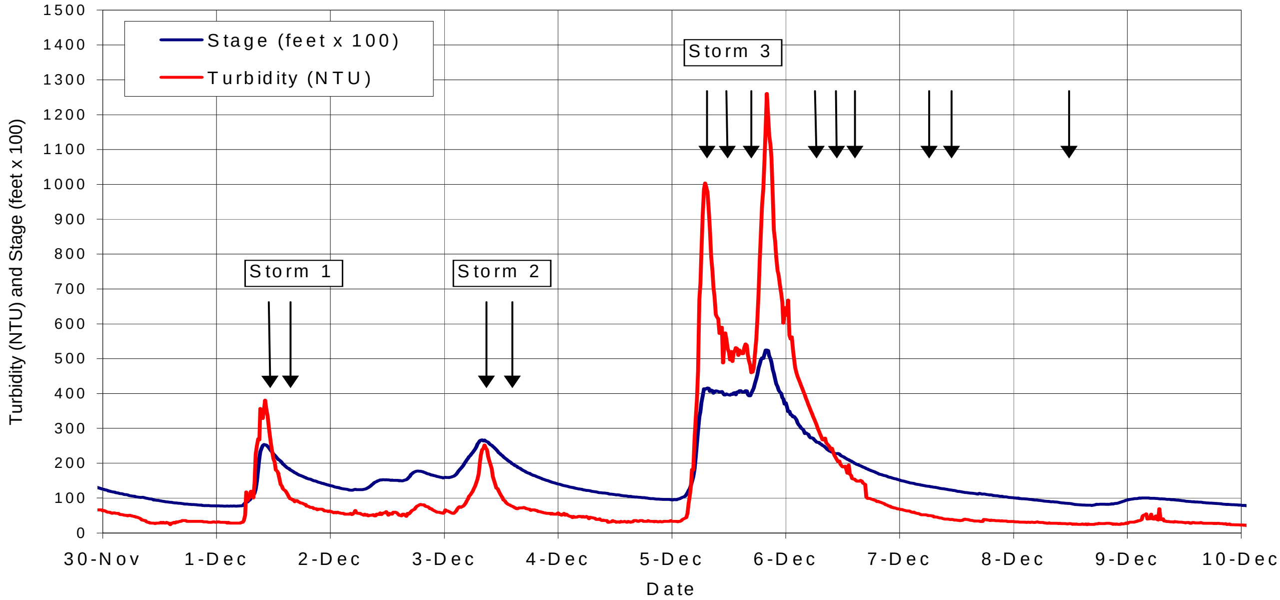

Figure 16. Continuous Turbidity and Discharge Measurements, Redwood Creek, 2003.
Source: Randy Klein, Redwood National Park, unpublished data.

This variability has important implications for successfully monitoring water quality. Incorrect conclusions will be made about TSS and turbidity if the monitoring program does not take this variability into account. Monitoring programs can achieve this by sampling before, during, and after storms, throughout the duration of the season, and across several years. This can be done with automated sampling equipment and is the main reason for using it.

In a BACI design in which paired watersheds are monitored (treated and control), several years of pre- and post-treatment data are required. Monitoring may be based on a pulsed approach (Bryant 1995), timed to coincide with restoration treatments. Pre-treatment monitoring may require a calibration period, the length of which will be determined by statistical considerations. Post-treatment monitoring must be long enough to encompass the initial phases of adjustment and short-term effectiveness. Generally, at least 1-2 years are required for most short-term adjustments to occur, e.g., erosion at improved stream crossings (Figure 17). Afterwards, an additional 1-3 years are required for short-term effectiveness to manifest, e.g., reduction in sediment delivery from improved road drainage. The ultimate test of improvements is response to a stressing event, which may not occur for decades.

The main objective of data analysis will be to determine if upland erosion control treatments have had a detectable effect on suspended sediment and turbidity. Comparisons of pre- and post-treatment measurements in treated and control watersheds will provide the basis for analysis. As with stream discharge, the primary constraint on analysis will be the length of records and the range of streamflow and climatic conditions sampled.

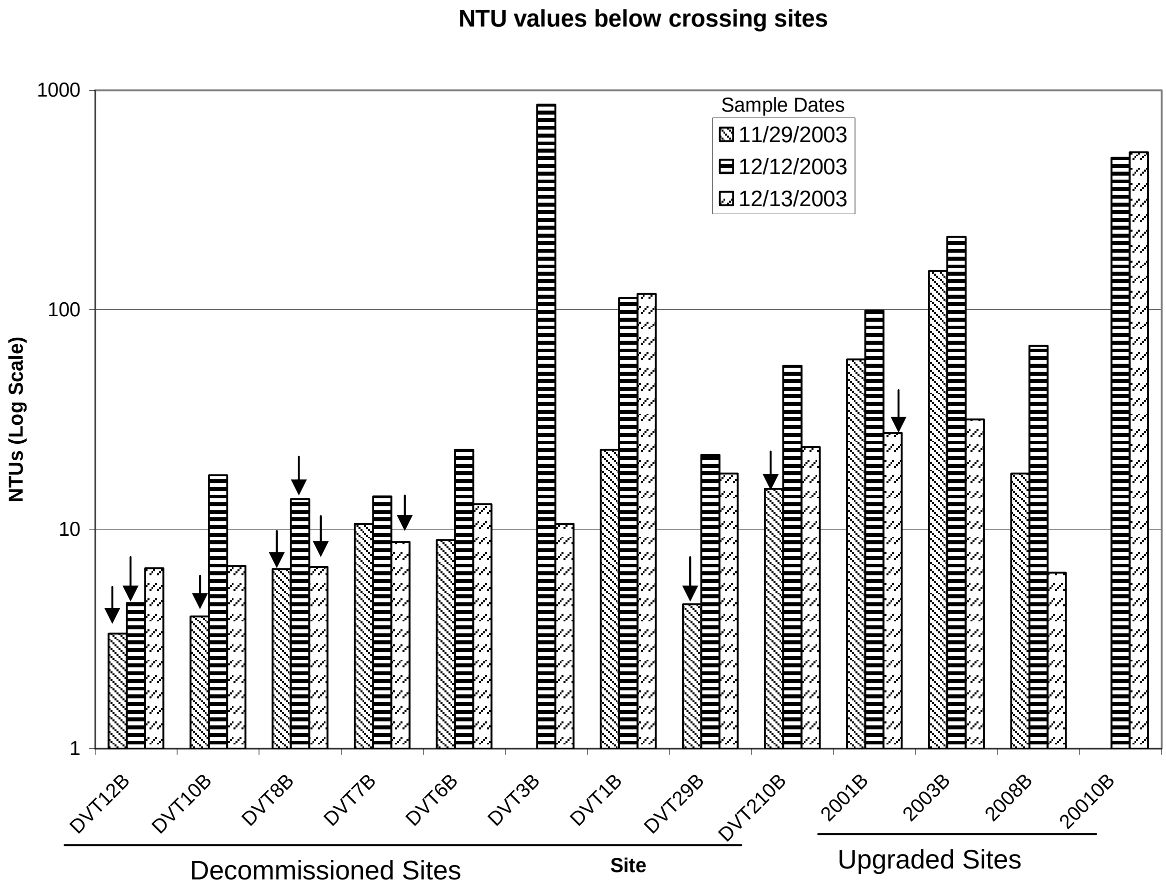

Figure 17. Measured Turbidity Above and Below Stream Crossing Treatment Sites.
Sampling was conducted during the first winter after treatment. Arrows indicate cases where downstream turbidity was >120 percent of upstream turbidity.

Field Method 4: Stream Geomorphology

The theoretical beneficial effect of upslope restoration practices on streams is reduced deposition of fine sediments in pools and other habitat units and increased channel complexity due to reduced sediment supply. There are other potential benefits such as reduced bank erosion but these are especially difficult to tie directly to restoration. At the present time, data demonstrating changes in stream sedimentation and channel complexity due to restoration are rare and monitoring projects that study this relationship should be encouraged.

Changes in stream sedimentation may be evaluated by monitoring changes in “channel bottom complexity” i.e., topography or by direct measurements in pools. Longitudinal profiles are recommended for evaluation of reach-scale sedimentation processes. These are used to obtain data on residual water depth, residual pool depth and mean bed elevation (Madej 1999) (Figure 18). For direct measurements in pools, other methods, such as V* may be appropriate in certain geologic settings (Lisle and Hilton 1992, Hilton and Lisle 1993, Lisle and Hilton 1999). In addition, surface and subsurface substrate sampling may be conducted to evaluate changes in sediment grain size over time. All of these methods are described in *Monitoring the Effectiveness* *of Instream Habitat Restoration* and *Monitoring the Effectiveness of Instream Substrate Restoration.*

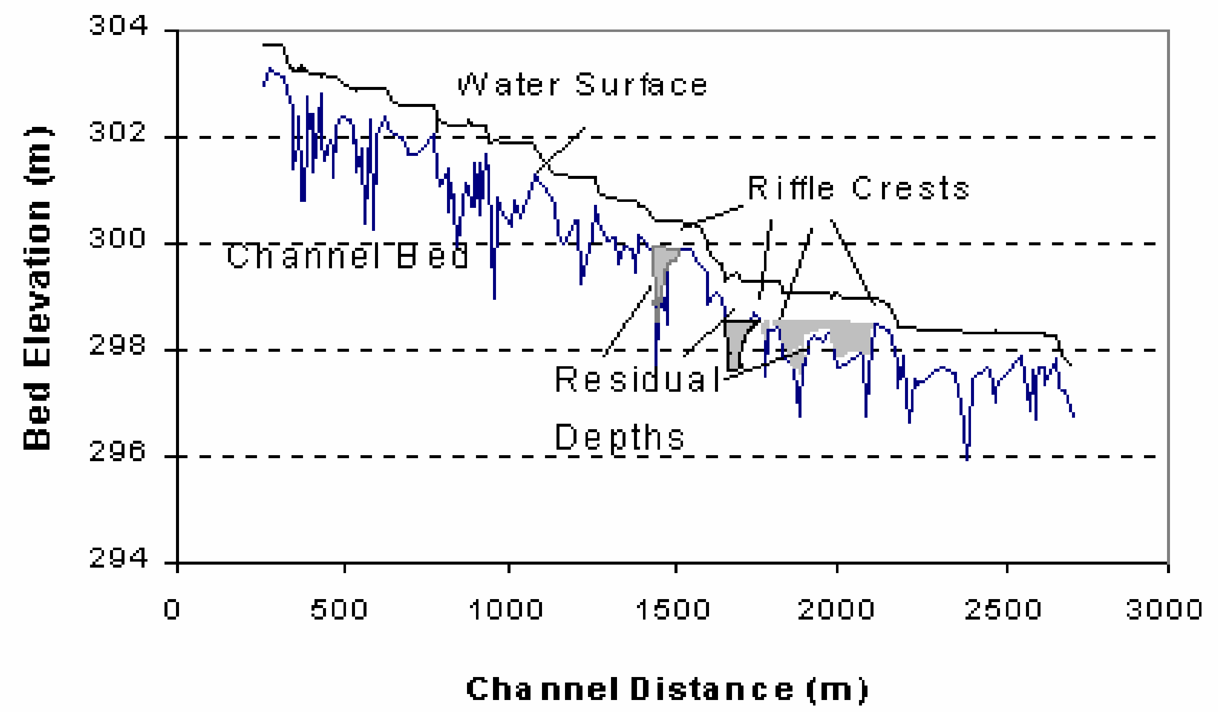

Figure 18. Redwood Creek at Weir Creek, 1997 Thalweg Profile.
Source: Madej 1999.

Under some circumstances, especially in watersheds where streams have erodible banks, there may be proposals to evaluate changes in channel cross section (i.e., width/depth). This can be accomplished with permanently monumented cross sections perpendicular to the stream (Harrelson et al. 1994) (Figure 19). Cross section installation and measurement is described in *Monitoring the Effectiveness of Instream Habitat Restoration.*

It is advisable to focus data collection on stream reaches that are most susceptible to sediment deposition i.e., low gradient response reaches (Montgomery and Buffington 1998) (Figure 20). Preliminary identification of these reaches can be accomplished through interpretation of stream profiles derived from topographic maps or digital elevation models. Field verification is necessary, especially if response reaches are small, as would be expected in small watersheds. Re-measurements should be timed to capture pre- and post-treatment conditions as well as the effects of extreme stressing events in both treated and control sub-watersheds.

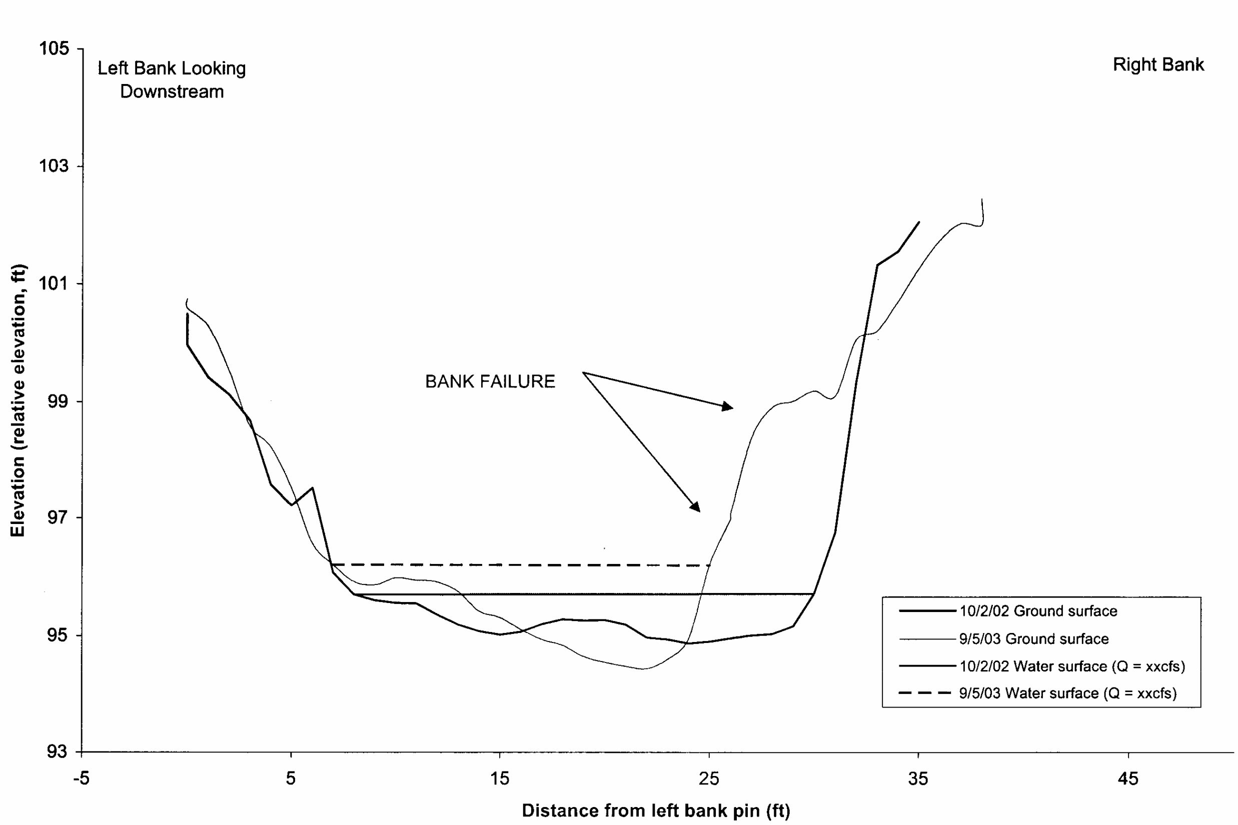

Figure 19. Sequential Cross Section Surveys from 2002 and 2003 in a Restored Reach on Lower Freshwater Creek, CA.
In this cross section a stream bank failure deposited material into the bankfull channel width on the right bank, resulting in a narrower and slightly deeper channel. *Source:* McBain and Trush 2004.

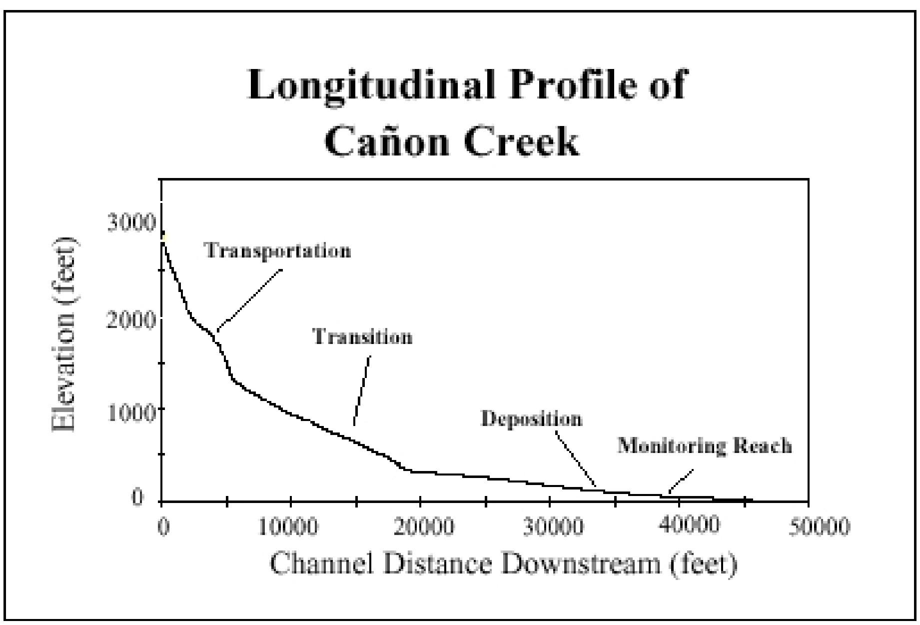

Figure 20. Longitudinal Profile Depicting Location of Response Reach.

It should be noted that there are few examples of studies definitively linking upslope management activities with instream geomorphology. Some studies that have been done on California's coast have been inconclusive (Knopp 1993). Although DFG, as well as others, have a strong desire to demonstrate positive effects from upland erosion control practices, this may be possible only after many years of data collection in several watersheds. Some streams may not ever clearly reflect improved watershed conditions as a direct result of restoration.

SUMMARY

The FRGP invests considerable energy and money into the remediation and prevention of upland erosion and sediment delivery to streams. Yet, there is little scientific evidence available that documents positive effects of these projects on fish habitat and fisheries. This report provides a framework for watershed-scale monitoring that addresses all spatial and temporal scales of upland erosion control project effectiveness. It provides guidelines for watershed monitoring projects, indicates what questions and hypotheses might be addressed with such projects and proposes a procedure for screening and selecting projects for funding. Although tailored specifically to upland erosion control effectiveness, the principles for watershed scale monitoring may apply to other projects undertaken at this scale, e.g., vegetation management, riparian restoration, etc., and some of the tools used would be the same.

Watershed monitoring has recently stimulated interest in California and other Pacific Northwestern states. This report recommends: 1) think small, because watershed size will affect the ability to detect a response from restoration; 2) think extensive, in terms of the restoration activities; 3) think long term, since it will take years to collect pre-treatment and post-treatment data of sufficient quantity and quality to evaluate response; and 4) think cooperative landowner, because without long-term landowner commitment, nothing will be possible.

Watershed monitoring should be undertaken in a range of basins representative of the coastal setting. Each project should be judged not only on its merits but also on the basis of its potential contribution to a wider understanding of restoration effectiveness.

Monitoring proposals and plans will vary but they should include a minimum amount of information in order to be competitively judged. The results of pilot studies may be used to refine and verify the monitoring approaches used.

For an evaluation of upland erosion control effectiveness, there should be data collection at the site, road/stream reach and watershed scales. There should be controls and treatments at all scales and data should be collected before and after treatment. At the watershed scale, the main field methods would include quantification of hydrologic connectivity of roads to streams, continuous streamflow gaging, automated water quality sampling and stream geomorphic studies. The methods used should be defined specifically in each watershed monitoring proposal. To be useful, any methods used should produce data similar to those being produced at other locations in California and elsewhere in the Pacific Northwest.

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ATTACHMENT A: PROPOSAL SCREENING PROCEDURE

Part 1: Preliminary Screening Questionnaire for Watershed Monitoring Proposals

This questionnaire is for use with the summary checklist provided for evaluating proposals to conduct restoration effectiveness monitoring at the watershed scale.

Clear Feasible Objectives:

- Does the proposal have a clear statement of objectives (monitoring questions to be answered)?
- Are these objectives feasible in relation to the proposed timeframe and funding?
- Is there a definite link between monitoring objectives and a scientific justification to expect results?
- Are the temporal and spatial scale(s) appropriate for answering the key questions?
- Are the objectives directly related to selected methods and proposed data analysis methods?
- Are the methods and analysis methods proposed appropriate for addressing the objectives?
- Does the proposal include a biological monitoring component?

Watershed Characteristics and Condition:

- Is adequate information on the watershed available for designing and implementing the monitoring project, e.g., sediment source assessment?
- Does the proposal contain an adequate summary of that information or cite sources?
- Are the location, size, diversity and current condition of the watershed conducive to a successful monitoring project?
- Is the watershed potentially a good demonstration site?

Location Maps:

- Is the information provided adequate to determine exactly where monitoring will occur?
- Are proposed or existing restoration sites adequately documented?

Historic Data:

- Are historic data available that will facilitate either data collection or interpretation of results?
- In cases where restoration activities have already been implemented, are pre-project data available?
- Are there any historical events in the watershed that may necessitate overly complex data collection and analysis procedures?

Landowner or Stakeholder Commitment:

- Is there evidence that the landowner(s) will commit to long term monitoring?
- If applicable, were local landowners, appropriate government agencies, and technical experts involved in the development of the proposal?

- Is there an attempt to develop long-term partnerships with other agencies and groups?

Site Selection Justification:
- Is the study area of a size that is conducive to producing monitoring results?
- Is the area accessible for a long-term study?
- Is the intensity of proposed restoration sufficient to produce a significant change?
- What other factors make the area a good candidate for monitoring?

Coordination With Other Projects:
- Are there opportunities for coordinating this monitoring project with other ongoing studies in the watershed or in nearby watersheds?
- Does the proposal exploit those opportunities?
- Is the proposed project redundant with other efforts?

Restoration Scale and Extent:
- Does the proposal provide convincing evidence that it will produce meaningful results given the type and extent of proposed restoration in the watershed?
- Is the restoration program of sufficient scale to expect a monitoring signal?

Detailed Study Design:
- Does the proposal contain adequate details on study design so that its feasibility can be assessed?
- What scientific input has there been to the study design?
- Has the design been subjected to peer review?

Pre-Project Data Collection:
- Does the project propose collection of pre-restoration implementation data?
- If so, how will that be accomplished?
- If not, what is the basis for the study design?

Sampling Strategy:
- Is there a sampling strategy in the proposal?
- If not, who will prepare one and when?
- Is the proposed sampling strategy consistent with the study objectives?
- Is it feasible given funding and time constraints?
- Are the project sponsors capable of collecting the data or will others be doing the data collection?
- Is there evidence in the proposal that the sampling strategy is statistically sound?

Selection and Description:
- What sampling methods are proposed?
- Are these consistent with adopted DFG methods?
- If not, what is the rationale for choosing different methods?
- Are methods adequately described or cited?

Duration of Program:

- Since the DFG grant program only provides funding for two years at the most, is there evidence that this program will continue (e.g., cost sharing, additional funding sources, etc.)?
- If a short-term program, is there reason to believe that meaningful results will be obtained?

Field Data Collection:

- Are field data collection procedures adequately described or cited?
- Are sampling locations and frequency documented?
- If standard DFG methods will be used, then associated field data forms should also be used. If other methods will be used, are field forms available or yet to be developed?

Data Management and Analysis:

- Is there an adequate description of how field data will be processed and archived?
- Is there a description of how the project sponsor will interact with DFG on data management?
- How will the monitoring data produced by this effort be made available to DFG?
- What analysis procedures are proposed?
- Will the project sponsors conduct analysis or retain others to do it?
- Are the monitoring objectives clearly related to the analysis methods?

Qualified Staff:

- Is the proposed staff qualified to do the work?
- Is staff competent in all phases: study design, data collection, data management and analysis?
- What is the commitment of staff to the project beyond the initial grant period (<2 years)?

Training Requirements:

- Are any staff training requirements specified?
- If so, how will training be conducted and who will do the training?
- How will skills be maintained over the life of the project in incumbent or new staff?

QAQC:

- Is quality control and assurance addressed in the proposal?
- If so, does it appear to be adequately covered?
- If not, will a quality control and assurance plan be prepared prior to project implementation?

Cost Estimate:

- Is the proposed budget commensurate with the proposed level of effort?

Equipment and Instrumentation Required:

- Does the proposal contain a list of required equipment or instruments?
- Are these presently in the possession of the project sponsor?
- If not, how will equipment or instruments be procured?

Reporting:

- Does the proposal specify a method for reporting results (in addition to reports otherwise required by the grant program)?
- How will results be disseminated?
- Will reporting be used to adapt or modify the monitoring program if the need for change is indicated?

Part 2: Summary Checklist

Preliminary Screening Checklist for Small Watershed Proposals

Checklist Criteria	OK	More Detail	Absent	Notes
Clear feasible objectives				
Watershed characteristics and condition				
Location maps				
Historic data				
Landowner or stakeholder commitment				
Site selection justification				
Coordination with other projects				
Restoration scale and extent				
Detailed study design:				
Pre-project data collection				
Sampling strategy				
Method selection and description				
Duration of program				
Field data collection:				
Data collection methods				
Sampling locations				
Sampling frequency and timing				
Field data forms				
Data management and analysis:				
Data storage and integration				
Analysis objectives				
Qualified staff available				
Training requirements				
Quality control plan (QAQC)				
Cost estimate				
Equipment and instrumentation required				
Reporting				
TOTAL =				

Proposals pass preliminary screening if 80 percent of the information is satisfactorily provided.

ATTACHMENT B: GUIDELINES FOR QUALITY ASSURANCE

A Quality Assurance (QA) approach should be included in all monitoring proposals submitted for consideration. The purpose is to provide a quality management system that will guide collecting and evaluation of monitoring data. Oversight could include implementing QA project plans, QA management reviews, and QA reports (Mulder et al. 1999). A structured QA provides a process for identifying and meeting the needs and expectations of the end user. It also ensures that data collection programs provide and document high-quality data, and ensures that analyses of these data are repeatable and defensible. Data collection techniques, data management, analysis and interpretation form the cornerstone of a QA plan. These concepts are discussed more fully below.

Quality System Specifications

A QA plan should list the specific activities contributing to project quality. This should include information on: study objectives; experimental design; procurement; measurement procedures; calibration procedures and frequency; training and certification requirements; preventative procedures; quality controls; corrective action; data collection, reduction, and verification; and data validation and reporting. Procedures for conducting accuracy (measurement-error) assessments for all monitoring data should be provided. All data analysis methods should be documented and tested.

The following format is commonly used to document quality control measures for studies funded with federal agency dollars (USDA 1996). The specific activities described above should be captured in this outline. The format serves as a template that can be used on most monitoring projects.

Quality Control Plan Outline

Introduction
Goals and objectives
Work scope overview
Expected types of data
Site information
Background and location
Data quality objectives
Data uses
Expected data quality
Data quality indicators
Data management checklist
Assessment oversight
Sampling design
Sampling methods and procedures
Field procedures
Equipment
Staffing
Calibration and maintenance
Field sampling procedures

The level of effort required will be variable, depending upon the scope, complexity and magnitude of the proposed project. For small, focused projects, this information could be covered in the proposal along with the description of methods. In a large complex project, a separate stand-alone document is probably necessary to document quality control measures. Requiring this information will greatly improve prospects that the monitoring will be implemented and that it will yield meaningful results. It also will strengthen the overall validity of a monitoring program.

Additional Considerations

Data Collection

Data collection represents the largest component of a monitoring program, usually employs the most staff, and is the most costly part. To insure that collected data meets project needs, the monitoring design is critical. A major goal of all monitoring programs should be to continually improve the quality and utility of data. This can be accomplished through periodic debriefings with field crews, review of the quality of data, reports from data analysts about the consistency and utility of the collected data, and feedback from DFG staff. Personnel responsible for collecting data over the long term should also be identified.

Data Management and Interpretation

The reporting of information has been a major problem in environmental monitoring. Two essential types of reports, data summaries and interpretive reports, should be provided to insure quality control standards are maintained. In addition, personnel required to support data summary and analysis activities should also be specified.

Data summaries are brief, comprehensive reports of essential data collected for the monitoring program. This report presents data in an organized and useful manner. Summaries should be prepared at least annually or as appropriate to the resource monitored. Preparing the summaries serves to motivate data collectors to process their data in a timely manner so that assessment and reporting needs can be met. They also provide a tangible product for which staff and DFG can be held accountable each year. Most importantly, data summaries are essential building blocks for preparing interpretive reports and for providing intermediate progress reports for assessing program objectives. Mulder et al. (1999) describe options for preparing data summary reports. Steps include quality check of the data, or data validation; data analysis, data presentation, and report preparation.

Interpretive reports present a synthesis of monitoring results and statements of their implications to management for each resource being monitored. The key task of interpretive reporting is to address the effectiveness monitoring questions by using all available data. The focus is on evaluating and interpreting the significance of trends emerging from data provided in the data summaries. This information is also critical to the adaptive management process; it will be used to change plans, direction or policies, and contribute to budgetary and other decisions that are needed. These reports are more analytical and comprehensive than data summaries. Considerable effort and planning are required to develop these reports, and they will require significant participation by knowledgeable agency scientists. Mulder et al. (1999) provide a process for preparing interpretive reports, including options for staffing, reporting frequency, and a strategy for future improvement.

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ATTACHMENT C: SALMON FOREVER QUALITY ASSURANCE PROJECT PLAN

Volunteer Monitoring of Suspended Sediment Concentrations and Turbidity in Humboldt, Mendocino and Trinity Counties, California

Quality Assurance Project Plan
September 2001

Salmon Forever
Watershed Watch

Project Director:	______________________________	Date:	____________________________
Field Manager:	______________________________	Date:	____________________________
Laboratory Manager:	______________________________	Date:	____________________________
QA Manager:	______________________________	Date:	____________________________

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