WATER QUALITY MONITORING IN THE FORESTED WATERSHEDS OF CALIFORNIA: STATUS AND FUTURE DIRECTIONS

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Monitoring and Tracking Subcommittee of the
State Board of Forestry and Fire Protection's Monitoring Study Group

The ability to reframe situations is one of the most powerful capacities of great artists. It can be equally powerful for managers. (Bolman and Deal, 1991)

EXECUTIVE SUMMARY:

Effective monitoring is necessary for the protection and restoration of aquatic resources, and is a critical step for refining management practices in the presence of uncertainty. Despite the increase in forestry-related water quality monitoring in recent years, there is relatively little information regarding the type, distribution, and cost-effectiveness of monitoring in the forested watersheds of California. To fill in these data gaps the Monitoring and Tracking Subcommittee (MTS) of the Monitoring Study Group (MSG) sent out a 9-page Monitoring Evaluation Form (MEF) questionnaire to the various stakeholders tasked with water quality-related monitoring in California.

The MTS received 72 completed or partially completed questionnaires. Forest industry and state regulatory agencies were responsible for 66% and 22% of submitted monitoring studies, respectively. The remaining 12% of studies were submitted by federal agencies, environmental non-governmental organizations (ENGOs), universities, and consultants. Approximately 60% of monitoring studies were conducted in the Coast Ranges geomorphic province, with the majority of these studies in Humboldt and Mendocino Counties. The Klamath Mountain, Cascade Range, Sierra Nevada, and Modoc Plateau geomorphic provinces contained 19%, 13%, 5%, and 3% of the monitoring studies, respectively.

The most common rationales for monitoring were for adaptive management, research monitoring, voluntary monitoring, and as a regulatory requirement. The common types of monitoring could generally be described as effectiveness monitoring, trend monitoring, baseline monitoring, and research monitoring. Most monitoring was performed in-channel (i.e., 78% of studies), although hillslope monitoring was more common in the Cascade Range, Modoc Plateau, and Sierra Nevada provinces. Monitoring was typically done at the project (i.e., Timber Harvesting Plan) and watershed scale.

Sediment was the most common parameter measured, accounting for 61% of the submitted studies. Common sediment-related monitoring focused on erosion control Best Management Practice (BMP) implementation and effectiveness, hillslope erosion, in-channel sediment transport, and channel morphology monitoring. Studies related to the distribution, abundance, and diversity of aquatic organisms (e.g., fish, amphibians, and benthic macroinvertebrates) were also common in the Coast Range province. Overall, results and conclusions are available for 46% and 13% of studies, respectively. Forty-nine percent of studies have reports documenting study methods, results, and/or conclusions.

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It was difficult to evaluate the cost-effectiveness of the various monitoring activities due to the relative lack of cost data submitted by respondents, and the inability to define monitoring benefits across a range of stakeholders. There was limited evidence of overlapping monitoring requirements by state regulatory agencies, although some overlap may occur for companies monitoring under a Habitat Conservation Plan (HCP). Monitoring overlap may also occur when state agencies require implementation and effectiveness monitoring for the same suite of BMPs. Data did not provide clear evidence of a consistently effective feedback loop between monitoring data and decision-making except at relatively small organizational and spatial scales. An explicit set of criteria – dealing with spatial and temporal scale, dimensions of uncertainty, the evaluation of costs, benefits, and risks, and institutional and stakeholder support – should be met before applying results and conclusions from the various studies in an adaptive management setting. The data suggests that these criteria are seldom met for most studies.

Implementing a statewide adaptive management program in California will be difficult without an integrated political, social, and scientific framework to address the various adaptive management implementation criteria. The Washington State Adaptive Management Program offers the best template for implementing a statewide adaptive management program in the future. However, “groundrules” dictating science-policy interactions among the diverse, and often competing stakeholders, will have to be developed before a statewide adaptive management program can be successfully implemented. Strong leadership and facilitation will likely be necessary to lay the foundation for an integrated adaptive management framework.

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1.0. INTRODUCTION

> *Can it be that the vast labor of characterizing these systems, combined with the vast labor of analyzing them, once they are adequately characterized, is wholly disproportionate to the benefits that could conceivably follow? – (Philip, 1980)*
>
> *The collection of data without the benefits of a unifying conception … may submerge us in an ever deepening sea of seemingly unrelated facts - (Hillel 1987)*

Functional and integrated monitoring programs are necessary for ensuring the protection and restoration of aquatic ecosystems (Wissmar, 1993; Ralph and Poole, 2003). Monitoring can be used for: ensuring compliance with regulatory requirements; assessing management effects on water quality and aquatic ecosystems; justifying the costs of pollution cleanup, resource restoration, or the implementation of more restrictive management practices or regulations; and increasing understanding of the resources of concern (MacDonald, 1994). Monitoring resource outcomes is also essential for optimization of our management practices and regulatory processes in the presence of uncertainty (Ralph and Poole, 2003).

The amount of forestry-related water quality monitoring in California has increased significantly in the past ten years (Harris et al., 2007; Cafferata et al. 2008). Factors leading to the rise in monitoring activities include federal and state listings of fish species (i.e., coho salmon, chinook salmon, steelhead trout) as threatened or endangered, listing of watershed in northwestern California as sediment impaired under Section 303(d) of the federal Clean Water Act, and new requirements by the State's Regional Water Quality Control Boards for monitoring of Timber Harvesting Plans (THPs) (Cafferata et al., 2008). Additionally, aquatic Habitat Conservation Plans (HCPs) are becoming more frequent in the Coast Range of California, and monitoring is typically a requirement within HCPs. They often require an adaptive management component (see Box 1) to address scientific uncertainties that arise during the HCP development process.

Despite the increasing resources dedicated to monitoring, there is still a paucity of information regarding the type, distribution, cost, and effectiveness of water quality related monitoring activities implemented throughout the forested watersheds of California.[1] In order to fill in these key data/knowledge gaps and to help increase the efficacy of future monitoring activities, the Monitoring and Tracking Subcommittee (MTS) of the Monitoring Study Group (MSG) created a 9-page questionnaire Monitoring Evaluation Form (MEF). The MEF was sent to various stakeholders to inquire about a number of monitoring-related questions in the Spring

[1] Earlier, Krieter (1996) conducted a survey of aquatic resource monitoring in coastal watersheds of California on privately owned timberlands. Harris et al. (2007) provides detailed information on turbidity monitoring occurring throughout California and Lewis et al. (2000) provides broad data on water temperature monitoring in this state.

of 2008. The scope of the questions within the MEF includes: general monitoring description; monitoring rationale and objectives; monitoring methods; the utilization of monitoring data; data availability; other monitoring inquiries; and monitoring costs.

Box 1. A brief history and overview of adaptive management (from Kepkay, 2003).

Adaptive management was originally developed within the tradition of applied systems analysis for optimization, specifically under the leadership of C.S. Holling at the University of British Columbia and International Institute for Applied Systems Analysis. The team's work built on the key insight that, due to high uncertainty in our models of resource management systems, almost all management actions are properly described as experiments with uncertain outcomes. That is, rather than implementing "best management practices," resource managers are actually acting on a "working hypothesis" – whether they realize it or not.

The objective of this report is to summarize the findings of the completed Monitoring Evaluation Forms with the respect to the following broadly defined questions:

1) What types of water quality related monitoring activities are being implemented throughout the forested watersheds of California?
2) What is the statewide distribution of these monitoring activities?
3) What are the objectives of the various monitoring activities?
4) Are monitoring objectives being achieved and is data being utilized for management/regulatory purposes?
5) Are monitoring data accessible to other stakeholders and/or the general public?
6) Are the various monitoring activities cost effective?
7) Is there overlap between monitoring required by state or federal agencies?
8) What can be done to improve the feedback between monitoring and management/policy decisions (i.e., adaptive management)?

The collective answers to these questions will help to fill in existing data and knowledge gaps regarding the influence of timber harvest operations on aquatic resources, and should be considered a crucial step for implementing an effective adaptive management process in the forested watersheds of California.

2.0. METHODS

All too often, monitoring projects are initiated with a minimum of forethought, and result in a collection of poorly-documented data which are never analyzed, provide little or any feedback to resource managers, and contribute

little or nothing to our understanding of the systems being monitored. – (MacDonald, 1994)

… Old beer cans do not make good infiltrometers! – (Bouwer, 1986)

An analysis of statewide monitoring activities requires an understanding of how monitoring activities should be designed and implemented. To provide a conceptual basis for the assessment, a brief literature review was undertaken on the subjects of monitoring project development and execution, in addition to commonly reported problems associated with monitoring projects (see Figures 2 and 3). Literature on adaptive management was also reviewed, since an adaptive management approach may be included by the State Board of Forestry and Fire Protection's proposed Research and Science Committee (RSC) (BOF, 2008).

2.1. BACKGROUND

The likelihood of success for a given monitoring project increases by following an explicit and iterative process for project design and implementation (MacDonald, 1994) (Figure 1). The most important step in the design phase is to determine the monitoring objectives (MacDonald, 1994). Initially, the objectives should be generally defined, with the objectives becoming increasingly specific as personnel, budgetary, and technical constraints are identified. A review of the literature and previous monitoring projects is helpful during this phase, and can help to increase understanding of the monitored resource. By developing specific objectives and increasing understanding of the resource of concern, participants will be able to further focus the design of the monitoring project (MacDonald, 1994).

Once the specific monitoring objectives have been chosen, the next step is to select the appropriate monitoring variables, sampling locations, sampling frequency, and analytical methods (MacDonald, 1994). Linking study objectives to this phase is vital and can cause problems with the monitoring project if neglected (Figures 1 and 2). The selected monitoring variables should be sensitive indicators of the monitored resource and provide the data necessary to meet the study objectives. Knowledge of the spatial and temporal variability of the monitored resource should be an important factor in selecting sampling locations and sampling frequency (Montgomery, 1999). Quality assurance and quality control (QA/QC) procedures should also be created so that sampling variability is kept to a minimum and data is properly entered, stored, and analyzed. Once these steps are taken, a monitoring plan can be developed and ideally circulated for peer review (MacDonald, 1994). A peer review process can greatly decrease the likelihood of serious problems, and can help to maximize the usefulness and efficiency of the monitoring project (MacDonald, 1994; Reid, 2001). Once monitoring has started, data should be rapidly analyzed to determine if field methodologies or study objectives need to be revised or changed (MacDonald, 1994). This is considered the pilot phase of the

monitoring project, and this step can increase monitoring relevancy and efficiency (MacDonald, 1994).

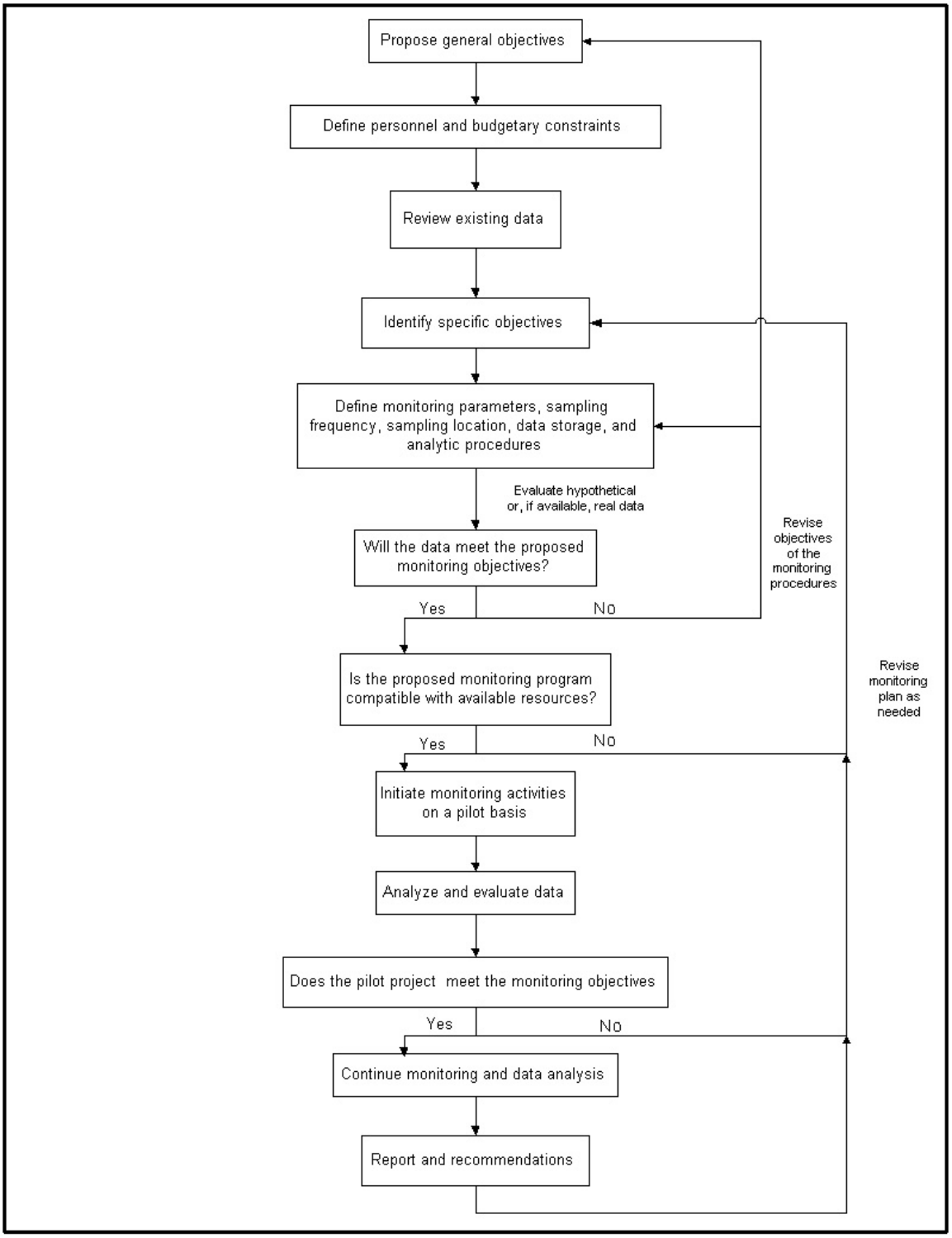

Figure 1. A flowchart illustrating the explicit and iterative steps for developing a monitoring project (modified from MacDonald, 1994).

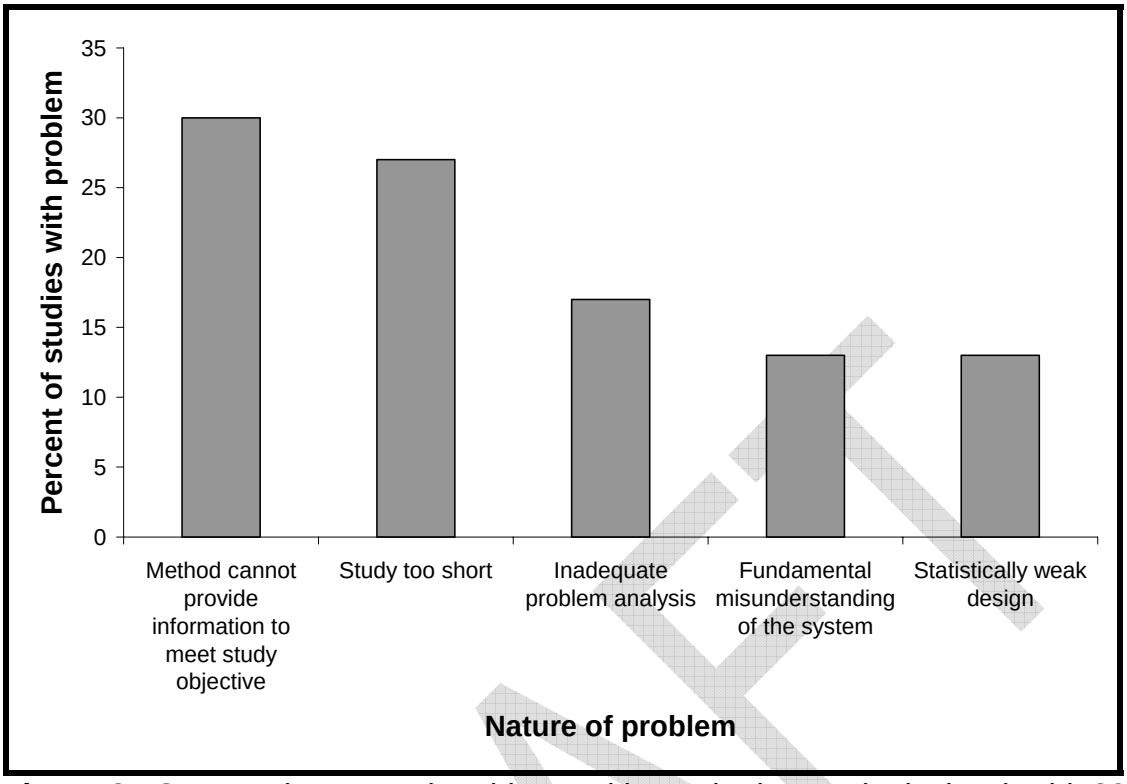

Figure 2. Commonly reported problems with monitoring study design (Reid, 2001).

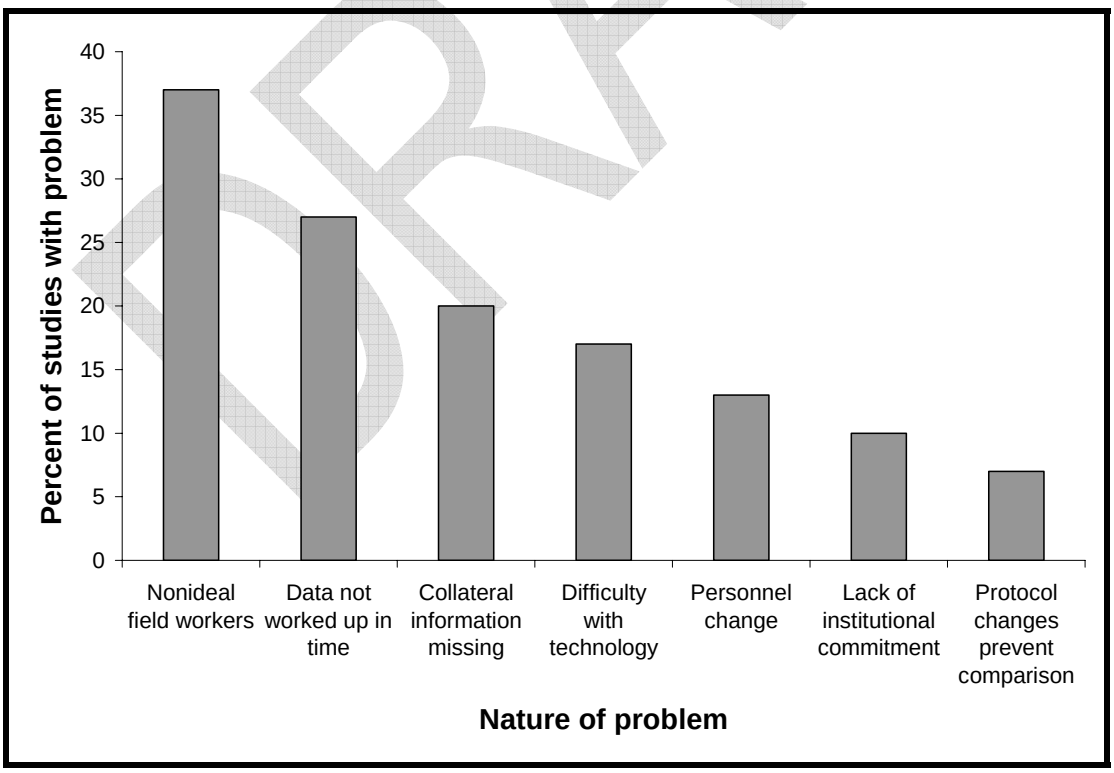

Figure 3. Commonly reported problems with monitoring study implementation (Reid, 2001).

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The successful implementation of a monitoring project depends on several factors (Figure 3). The most important component is to have enthusiastic, well-trained personnel carry out the data collection (Reid, 2001) (Figure 3). Rapid data entry, data annotation, and error checking is essential for avoiding problems, especially if monitoring personnel changes (MacDonald, 1994; Reid, 2001) (Figure 3). After sufficient data is collected, monitoring results, conclusions, and recommendations should be summarized into a written report. Peer review of the report helps to ensure that the conclusions and recommendations are consistent with the data (MacDonald, 1994).

2.2. Monitoring and Evaluation Form

Given the aforementioned conceptual framework, the Monitoring and Evaluation Form (MEF) was created to inquire about statewide monitoring efforts in forested watersheds (Appendix 1). Initially, respondents were asked to provide basic contact information as well as the title of the monitoring project. From here, the MEF was broken into 7 sections: 1) monitoring description; 2) monitoring rationale and objectives; 3) monitoring methods; 4) utilizing monitoring data; 5) data availability; 6) monitoring inquiries; and 7) monitoring costs.

Respondents were asked to describe their monitoring projects by selecting from one or more of the following categories (MacDonald et al., 1991):

1. **Implementation monitoring** – Monitoring that determines whether management activities were carried out as intended.
2. **Forensic monitoring** – Monitoring that determines whether water quality impacts are occurring during storm events.
3. **Compliance monitoring** – Monitoring used to determine whether regulatory requirements or specific water quality criteria are being met.
4. **Baseline monitoring** – Monitoring used to characterize existing water quality conditions and to establish a data set for planning or future comparisons.
5. **Trend monitoring** – Monitoring done at regular intervals to determine the long-term trend in a particular parameter.
6. **Validation monitoring** – Monitoring done to determine if regulatory or management models are adequate for achieving desired resource conditions.
7. **Project monitoring** - Monitoring done to determine the effect of a particular project on the resource of concern.
8. **Research monitoring** – Monitoring done to increase knowledge regarding biologic, hydrologic, or geomorphic pattern, process, or function.
9. **Other** – Other types of monitoring not included in the above descriptions.

Respondents were then asked to provide the rationale for monitoring by selecting one or more of the following choices:

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1. **Regulatory requirement** – Is monitoring done because of a regulatory requirement? If so, what federal, state, or local agencies are requiring the monitoring, and what regulatory program is it under (e.g., Timber Harvest Waiver; Waste Discharge Requirements; Habitat Conservation Plans)?
2. **Informing agency rulemaking** – Is the monitoring intended to address uncertainties regarding the current Forest Practice Rules (FPRs) or other policies related to forested watersheds?
3. **Informing numeric targets** – Is the monitoring intended to test the effectiveness or validate the metrics within the FPRs (e.g., buffer widths) or other regulatory frameworks?
4. **Informing narrative targets** – Is the monitoring intended to assess narrative targets for water quality objective such as "significant", "nuisance", or "adverse effects" from sediment?
5. **Voluntary** – Is monitoring intended to inform landowners on the efficacy of management practices or whether they're achieving resource objectives?
6. **Adaptive management** – Is monitoring intended to adjust management activities in response to results?
7. **Research** – Is the monitoring intended for research purposes?
8. **Other** – Other reasons not listed.

The MEF asked respondents to provide both general and specific objectives for their monitoring projects. General monitoring objectives refers to the broad objectives developed jointly by management and technical staff. An example of this might be, "are buffer strips sufficient to protect water quality?" Specific objectives refer to the more detailed objectives formulated once personnel, budgetary, and technical constraints are identified. An example of a specific objective might be, "is a 100 foot buffer strip sufficient to filter sediment derived from surface erosion?" Respondents were also asked whether their objectives were structured as specific hypotheses, so that statistical inferences could be drawn from a monitoring project.

The MEF contained several questions about study locations. Since the location of monitoring drives the basic monitoring approach, respondents were also asked whether monitoring was done on hillslopes, instream, or in some other type of waterbody (e.g., ponds, wetlands, reservoirs, etc). Respondents were asked whether monitoring was done at the project, watershed, ownership, regional, or statewide scale. Furthermore, respondents were also asked whether monitoring studies were nested within a multiscale hierarchical monitoring framework. A question was also asked about how monitoring sites were chosen.

Several questions were asked about monitoring methods. First, respondents were asked whether their monitoring methods were primarily quantitative, qualitative, or a combination of both. Respondents were also asked what types of parameters were being monitored. An example response to this question might be sediment production, BMP effectiveness, or V-star. Respondents were then asked how the parameters were being monitored. For example, if turbidity was being measured, was it measured with a single grab sample or through the much more intensive

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turbidity threshold sampling (TTS) method? An additional question was asked about the frequency and timing of monitoring measurements.

A number of questions were asked about sampling site selection, statistical considerations, and the duration of the monitoring study. For instance, were the monitoring sites chosen through best professional judgment, or were they chosen as part of a random, stratified-random sample, or other statistical sampling scheme? Respondents were asked whether statistical considerations (e.g., statistical power) were given to the sample size of the monitoring study. Respondents were also asked about the proposed duration of the monitoring study, and how many years of data have been collected.

The MEF contained several questions related to quality assurance and quality control (QA/QC). Respondents were asked whether QA/QC measures were applied to the monitoring studies, and if the monitoring methods were consistent with those proposed in the State Water Resources Control Board's Quality Assurance and Project Plans (http://www.swrcb.ca.gov/water_issues/programs/swamp/qapp.shtml). Furthermore, respondents were asked to explain or attach QA/QC plans. A question was asked about the qualifications of the field personnel tasked with collecting monitoring data. For instance, were the field personnel trained, certified, or licensed in a discipline relevant to the study? Another question also asked whether the monitoring approach had been internally reviewed, independently reviewed by experts in the field, anonymously reviewed by experts in the field, or had no review.

A variety of questions were asked about the utilization of monitoring results and conclusions. Respondents were asked to briefly describe the results and/or conclusions of their monitoring study. In addition, respondents were asked whether the conclusions had been internally reviewed, independently reviewed by experts in the field, anonymously reviewed by experts in the field, or whether there had been no review. A question was asked about whether monitoring objectives were being achieved. If not, respondents were asked why. For example, did the monitoring methods not provide the necessary data to meet the monitoring objectives? Did inadequate funding prevent the monitoring objectives from being achieved? Another question was asked about whether the results and conclusions were utilized to adjust management or regulatory activities, and respondents were asked to explain how the data was being utilized, or why it was not being utilized.

Several questions were asked about data availability and monitoring costs. For example, is the data available to the public? Is the data available in accessible databases or summarized reports? Respondents were also asked whether the data was available online. To determine the cost effectiveness of the various monitoring activities, respondents were asked to provide cost data for their monitoring studies. If possible, respondents were asked to itemize costs for staff, training, equipment, and laboratory testing.

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2.3. Data Analyses

Data was generally stratified by geomorphic province (CGS, 2002), as this is considered a broad spatial scale where the driving controls on water quality are similar (Montgomery and Bolton, 2003). As such, this stratification can provide an initial basis for knowledge transfer from a discrete study area to a broader spatial scale. However, since the process regimes that control water quality can vary considerably within a geomorphic province (Montgomery, 1999), more in-depth process analyses should be required before data is transferred from one area to another. Studies were counted more than once if they overlapped multiple geomorphic provinces, and this is why sample size exceeds the number of submitted studies.

3.0. RESULTS

Data, Data, Data! He cried impatiently. I can't make bricks without clay. – Sherlock Holmes in "The Adventure of the Copper Beeches" (Doyle, 1892)

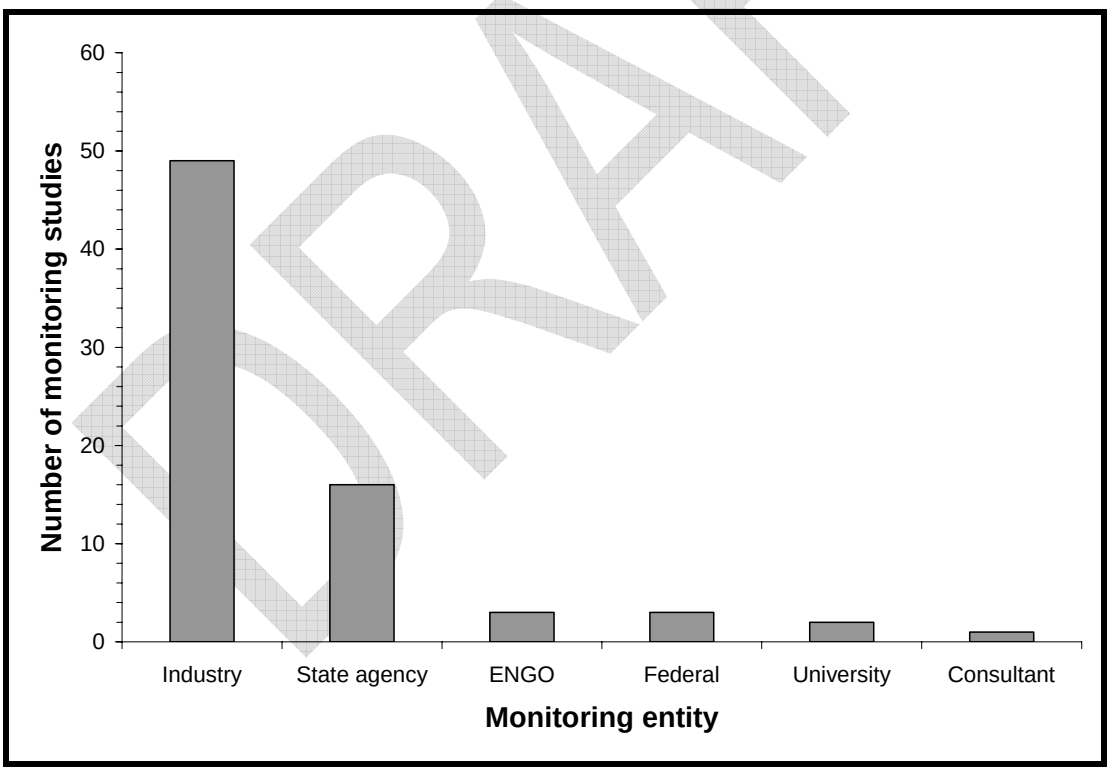

Figure 4. Number of studies by lumped monitoring entity.

Responses to the monitoring questionnaires varied in detail and completeness. Overall, information on 72 different monitoring studies was submitted to the Monitoring and Tracking Subcommittee by 24 different monitoring entities (Table 1). When stratified by lumped monitoring entity, sixty-six percent of studies were

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submitted by forest industry, 22% by California State agencies, 4% by environmental non-governmental organizations (ENGO), 4% by federal agencies, 3% by universities, and 1% from environmental consultants (Table 1; Figure 4).

Table 1. Number of monitoring studies submitted by landowner.

Landowner and/or Affiliation	Number of Monitoring Studies Submitted
Big Creek Lumber Company	1
CALFIRE	4
Campbell Timberland Management	8
Central Coast Regional Water Quality Control Board	7
Central Valley Regional Water Quality Control Board	1
Colorado State University	2
Crane Mills	1
Department of Fish and Game	3
FGS	5
Green Diamond Resource Company	7
Gualala Redwoods	1
Hearst Forests	1
Mattole Restoration Council	3
Mendocino Redwood Company	9
North Coast Regional Water Quality Control Board	2
O'Connor Environmental Inc.	1
Redwood National Parks and State Parks	2
Roseburg Resources Company	1
Scotia Pacific Ltd (now Humboldt Redwood Company)	1
Sierra Pacific Industries	4
Soper-Wheeler Co.	1
Timber Products Company	5
U.S. Forest Service – PSW Research	1
W.M. Beaty and Associates	1
Total:	**72**

Monitoring studies commonly overlapped geomorphic provinces, county lines, and watershed boundaries. Approximately 60% of monitoring studies were conducted in the Coast Ranges geomorphic province (Figure 5), with the majority of these studies in Humboldt and Mendocino Counties (Figure 6). Nineteen percent of monitoring studies were conducted in the Klamath Mountain province, with the majority of these studies located in Siskiyou county (Figure 5; Figure 6). The Cascade Range, Sierra Nevada, and Modoc Plateau provinces contained 13%, 5%, and 3% of the monitoring studies, respectively (Figure 5).

When asked about why monitoring was being done, responses were varied and typically plural in nature. The most common rationale for monitoring was adaptive management, and this comprised 47% of responses (Figure 7). Monitoring was also done for research (43%), on a voluntary basis (36%), and as a regulatory requirement by State agencies such as the Department of Fish and Game and the Regional Water Quality Control Boards (30%). A small percentage of monitoring studies were being performed specifically to inform narrative targets (7%) (e.g., quantifying "nuisance" or "adversely affect" as it relates to sediment), numeric

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targets (4%) (e.g., TMDLs), or to inform rule making activities (3%). Approximately 13% of respondents listed “other” as the reason for monitoring, and 16% did not answer the question.

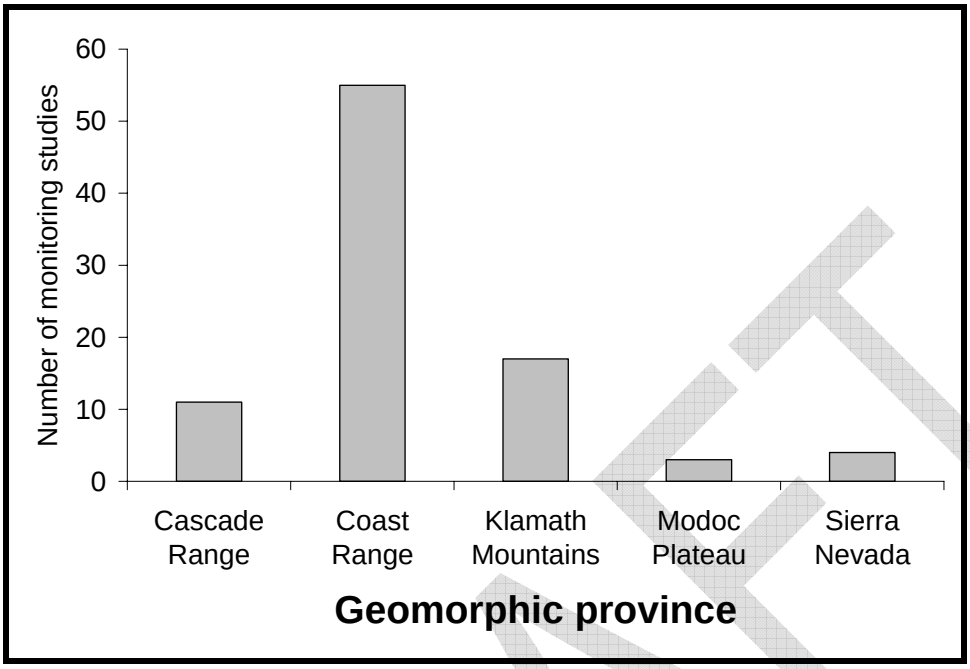

Figure 5. Number of monitoring studies within a geomorphic province.

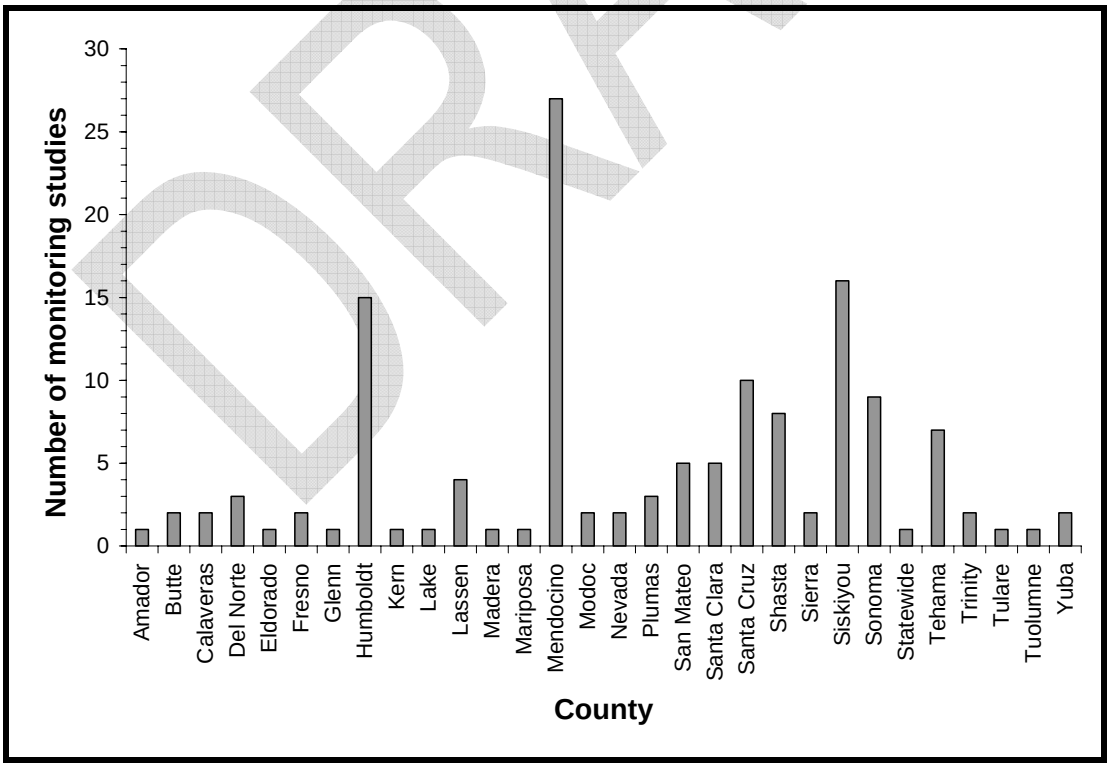

Figure 6. Number of monitoring studies by county. Studies were counted once for each county they overlapped.

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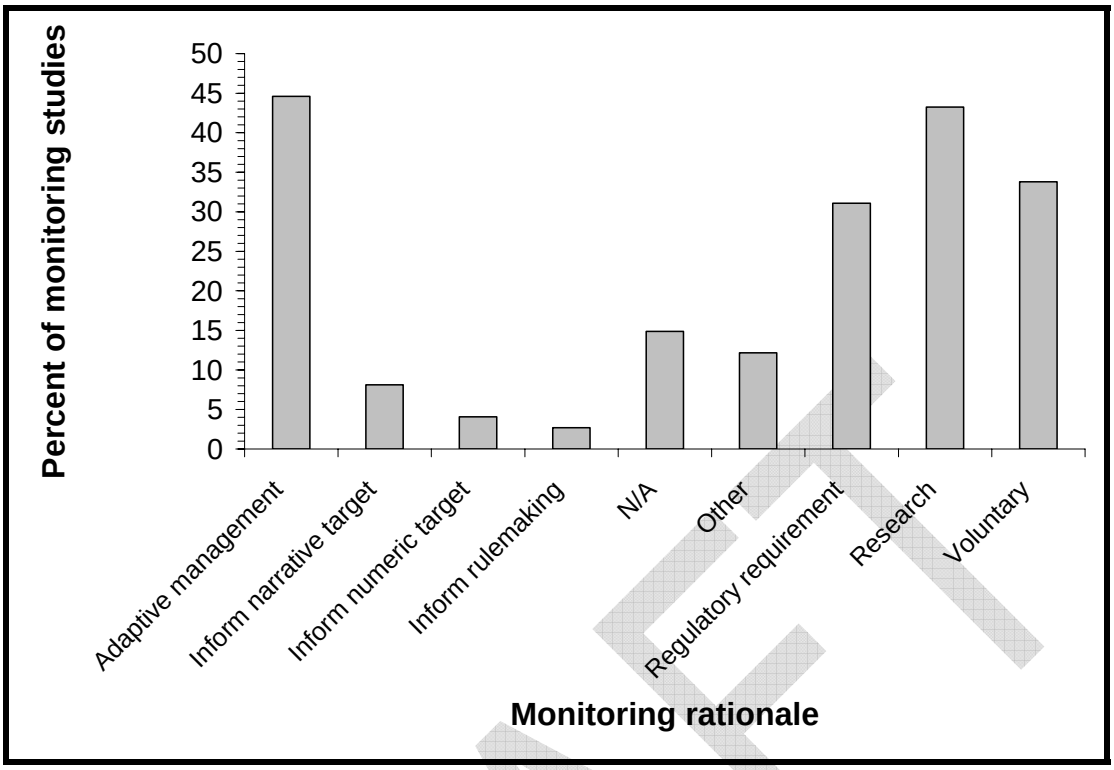

Figure 7. Percent of monitoring studies with following monitoring rationale. Studies could state more than one type of monitoring rationale.

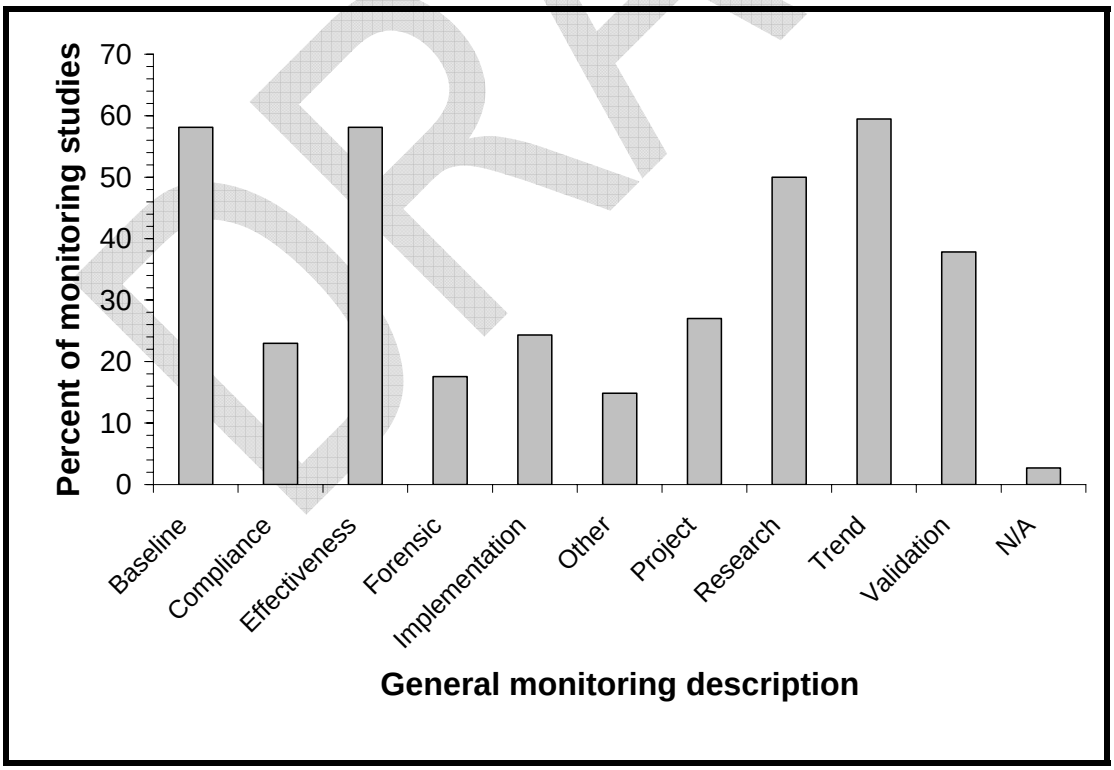

Figure 8. Percent of monitoring studies with the following monitoring description. Studies could state more than one type of description.

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When asked to characterize the type of monitoring study, responses were varied and typically included a combination of various monitoring types (Figure 8). Respondents most commonly described their monitoring as effectiveness monitoring (61%), trend monitoring (61%), baseline monitoring (60%), and research monitoring (51%). Other common responses included validation monitoring (40%), project monitoring (29%), implementation monitoring (26%), compliance monitoring (24%), and forensic monitoring (18%) (Figure 8). Three percent of respondents did not answer the question.

Monitoring objectives were stated for 91% of monitoring studies (Table 2). Only 43% of monitoring studies had specific monitoring objectives, while many monitoring studies did not differentiate between general and specific monitoring objectives, or did not directly answer the question. When asked if monitoring objectives were defined as testable hypotheses, 60% of respondents stated no, 20% stated yes, while 20% did not answer the question.

Monitoring entities were asked to provide a general description of their monitoring methodology. Approximately 53% of monitoring studies relied on quantitative monitoring methodologies, while 29% of studies used a combination of quantitative and qualitative methodologies. Only 11% of studies relied solely on qualitative methods, while 7% of respondents did not answer the question.

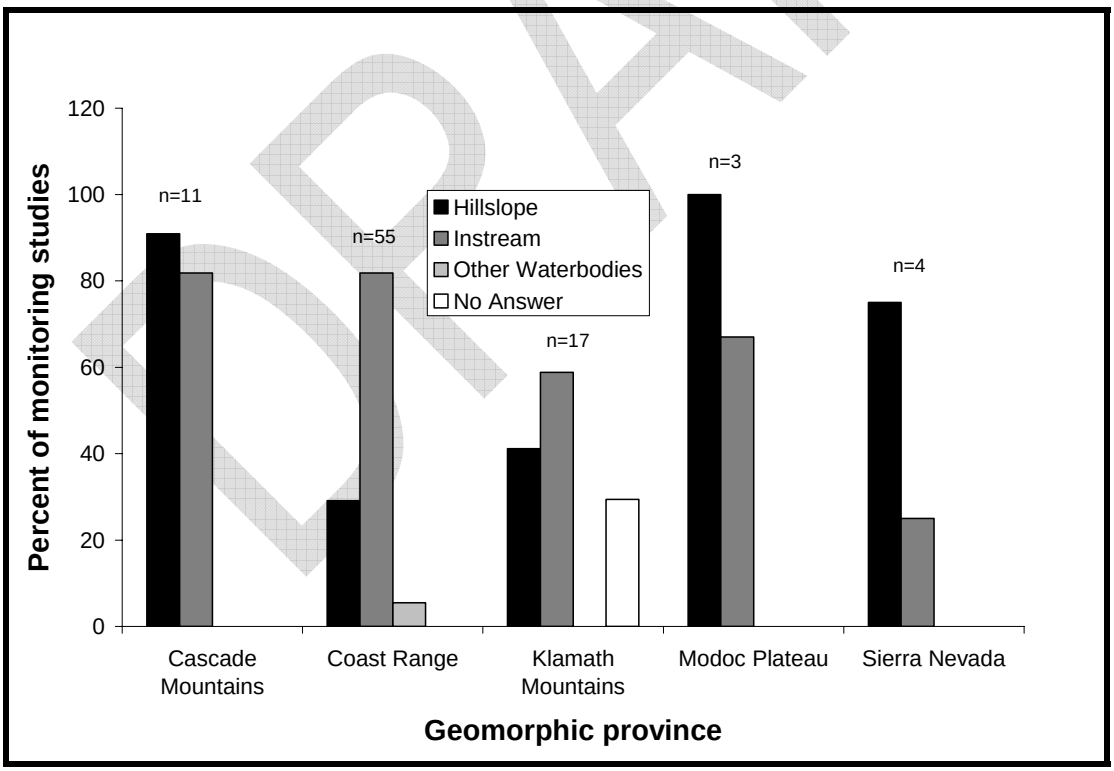

Figure 9. Generalized location of monitoring study by geomorphic province.

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Table 2. General monitoring objective by monitoring entity.

Monitoring Entity	Study Title	General Monitoring Objectives[1]
Big Creek Lumber Co.	Timber waiver monitoring and reporting	To monitor compliance using Central Coast Regional Water Quality Control Board Monitoring and Reporting Order
CALFIRE	JDSF stream surveys	Observe general trends in stream attributes including LWD recruitment, trends in canopy cover, and stream attributes.
CALFIRE	JDSF water temp	Determine background water temperature, monitor trends, have data available for retrospective or future exam of management practices, riparian zone relationships, aquatic habitat relationships
CALFIRE	FORPRIEM	Provide data on the adequacy of the implementation and effectiveness of those CA FPRs specifically designed to protect water quality and riparian/aquatic habitats.
CALFIRE (Interagency)	IMMP pilot project	The main goals of the IMMP pilot project were to: (1) collect water quality-related monitoring data primarily on higher risk watercourse crossing sites within THPs and NTMPs, and (2) more broadly, to develop a process to reach agreement with an interagency team that can be applied to other forestry-related topics. General goals of the overall IMMP program include: 1. Promoting better working relationships among the Review Team agencies. 2. Developing common understandings for issues that concern Review Team agencies (beginning with watercourse crossings in the IMMP pilot project). The pilot was focused on watercourse crossings and the road segments that drain to crossings because past monitoring work has shown that these are particularly high risk sites for sediment delivery to stream channels.
Campbell Timberland Mgt.	Basin temp water temp model	How does stream temperature vary from basin to basin and what is the affect in response to tree density and riparian vegetation.
Campbell Timberland Mgt.	SF Wages streamflow and sediment	The overall objective of the proposed monitoring project is to evaluate the relative importance of sediment generated by THP activities (i.e. road maintenance and harvesting), as currently practiced by Campbell Timberland Management, compared to legacy sources and background rates within the SF Wages Creek watershed.
Campbell Timberland Mgt.	Class I and II water drafting	Comply with USEPA regulations regarding dust abatement; Make sure streams are not adversely impacted by water drafting activities.
Campbell Timberland Mgt.	SF Ten Mile streamflow and sediment	Sediment data collection to validate the estimates of sediment delivery developed from aerial photography mapping as part of the TMDL; Establish a long-term sediment monitoring program.
Campbell Timberland Mgt.	Habitat typing	To assess present habitat conditions and to meet a regulatory requirement.

Monitoring Entity	Study Title	General Monitoring Objectives[1]
Campbell Timberland Mgt.	Pudding Ck. adult migrant	Determine adult escapement of coho salmon and steelhead trout; Identify any long term trends in the viability of the salmonid populations.
Campbell Timberland Mgt.	Pudding Ck. juvenile migration	The project has the following objectives for coho salmon and steelhead trout: 1) Estimate adult populations; 2) Estimate smolt production; 3) Characterize life history patterns in the study area; & 4) Estimate juvenile abundance during summer.
Campbell Timberland Mgt.	ECP monitoring and reporting	Have erosion control measures been installed correctly? Have they performed adequately after a stressing storm event? Have they performed adequately at the end of the winter period?
Central Coast RWQCB	Santa Cruz stream habitat and juvenile salmonid	To measure juvenile salmonid densities, habitat and streambed conditions, and fish passage; compare to previous years fisheries data; evaluate habitat quality trends.
Central Coast RWQCB	Continuous turbidity monitoring	To determine how water diversion might impact salmonid fisheries populations, to determine turbidty levels safe for drinking water.
Central Coast RWQCB	TMDL numeric target monitoring	To develop TMDLs and associated implementation actions for sediment, the Central Coast RWQCB needs better information on the linkage between sediment loads and impairment of aquatic life beneficial uses. Aquatic habitat quality will be evaluated by sampling instream invertebrate communities and calculating composite measures of community structure (such as diversity, biotic index, and taxonomic indicator groups), and through multivariate methods that consider physical habitat parameters as well as community structure.
Central Coast RWQCB	Timber waiver turbidity monitoring	To determine if newly constructed or reconstructed crossings on THP and NTMP plan areas are functioning property (i.e. is turbidity higher below the crossing than it is above. To determine if a plan area is contributing ongoing chronic inputs of sediment into the system (i.e. is the turbidity higher below the plan area than it is above). To determine if there is an event (natural or human based source) increasing the amount into the system through the forensic monitoring. This program does not aim to capture isolated events contributing a single pulse of sediment.
Central Coast RWQCB	Timber waiver summer temp. monitoring	To determine if water temperature increased to the detriment of beneficial uses.
Central Coast RWQCB	Timber waiver photo storm event	Documentation of harvest area conditions before, during, and after timber harvesting in area with the greatest potential to impact water quality.
Central Coast RWQCB	Timber waiver visual storm event	To determine if management practices are functioning properly.

Monitoring Entity	Study Title	General Monitoring Objectives[1]
Central Valley RWQCB	Timber waiver monitoring and reporting	1) Determine if BMPs, mitigations, and management measures have been properly put into place before the start of the winter period; 2) Determine if significant pollution occurs as a result of timber harvest activities during the winter period; 3) Determine if the management measures were effective in preventing significant pollution during the winter period.
Colorado State University	Sediment production - southern Sierra	The overall goal is to characterize road sediment production and delivery in the southern Sierra, and determine how this varies with elevation, road surface type, and management treatments, including grading and the installation of waterbars. Hillslope sediment production is also being measured, and the intent is to determine the overall effect of roads on watershed-scale sediment yields.
Colorado State University	Road treatment effectiveness in the Lassen NF	Quantify the effectiveness of different road and stream crossing treatments for reducing sediment production, sediment delivery, and the risk of failures at stream crossings.
Crane Mills	Water temperature monitoring on company land	To develop baseline and trend (if any) data for major and tributary watercourses on company property.
DFG	Stream temperature and microclimate	Document changes in relative humidity (one study area), air and stream temperatures to several silvicultural treatments in coastal Mendocino Coast.
DFG	SF Caspar salmonid populations	Are habitat conditions and aquatic vertebrates affected by timber harvest operations?
DFG	Streambed alteration agreements	Determine if conditions set for in agreements are being implemented.
Fruit Growers Supply	Temperature	N/A
Fruit Growers Supply	Sediment	N/A
Fruit Growers Supply	LWD	N/A
Fruit Growers Supply	Aquatic habitat	N/A
Fruit Growers Supply	Water quality	N/A
Green Diamond Resource Company	Summer juvenile salmonid population estimates	The Summer Juvenile Salmonid Population Estimates project is part of GDRCo's long term monitoring efforts as defined in the GDRCo Aquatic Habitat Conservation Plan (AHCP). The objectives of the summer population estimates are to estimate summer populations of young-of-the-year coho and age 1+ and older steelhead and cutthroat trout, and to track trends in these populations over time.

Monitoring Entity	Study Title	General Monitoring Objectives[1]
Green Diamond Resource Company	Class I channel monitoring	The monitoring objectives of the Class I channel monitoring project are to track long term trends in the sediment budget of Class I watercourses as evidenced by changes in channel morphology. The long term channel monitoring project is designed to measure the effectiveness of the conservation measures in reducing management related sediment inputs to area streams. The channel characteristics measured in each reach may include cross-sectional and thalweg profiles, and substrate size distributions (pebble counts).
Green Diamond Resource Company	Salmonid outmigrant trapping project	The outmigrant-trapping monitoring project is part of Green Diamond Resource Company's (GDRCo) long term monitoring efforts as defined in their Aquatic Habitat Conservation Plan (AHCP). The traps are designed to monitor the abundance, size, and timing of emigrating salmonid smolts. Furthermore, it is conducted to observe long term trends in any or all of these variables. The results of the outmigrant trapping are primarily used in conjunction with the summer population monitoring, which includes snorkeling and electrofishing, to estimate overwinter survival in the various watersheds. Eventually, this information will be further analyzed to correlate specific habitat conditions with summer and overwinter survival of salmonids.
Green Diamond Resource Company	Water temperature monitoring	The following objectives have been developed for water temperature monitoring: • Document the highest a) 7DMAVG (highest 7-day moving average of all recorded temperatures), b) 7DMMX (highest 7-day moving average of the maximum daily temperatures), c) seasonal temperature fluctuations for each site for both Class I and Class II watercourses. • Identify stream reaches with temperatures that have the potential to exceed the monitoring thresholds (established in AHCP) relative to the drainage area above the monitoring site for both Class I and Class II watercourses.
Green Diamond Resource Company	Turbidity threshold monitoring	Using Turbidity Threshold Sampling (TTS), GDRCo measures stage, velocity, streamflow, turbidity and suspended sediment concentration in various streams during the water year. The specifications for the construction and operation of the TTS station are based on procedures developed by the USFS Redwood Science Laboratory.
Green Diamond Resource	SF Elk WWDR Road Erosion Sampling	The objective of the road erosion monitoring outlined in this project plan is to evaluate the effectiveness of GDRCo's sediment control measures in minimizing sediment delivery from treated sites.

Monitoring Entity	Study Title	General Monitoring Objectives[1]
Green Diamond Resource Company	Class III sediment monitoring	The objectives are to monitor Class III watercourses to quantify the amount of sediment delivered from treatment channels following timber harvest relative to control channels.
Gualala Redwoods	Instream reach and temperature	Measure buffer and instream conditions.
Hearst Forests	Hearst Forests PTEIR monitoring program	Assess effectiveness of PTEIR BMPs and verify watershed impact thresholds and recovery rates.
Mattole Restoration Council	Sediment reduction implementation monitoring	Assess implementation and site-specific effectiveness of sediment reduction work (road and stream crossing upgrades, road decommissioning, slide stabilization, etc).
Mattole Restoration Council	Mattole watershed stream channel monitoring	Determine baseline conditions, trends, and variability in stream channel and aquatic habitat health. Rationale at one time was also to provide means of assessing effectiveness of sediment reduction and habitat enhancement work, but this assumed much stronger and quicker uplsope/instream link.
Mattole Restoration Council	Mattole turbidity monitoring	Determine turbidity response to sediment reduction work, using "lower-bound line" of turbidigraph.
Mendocino Redwood Co.	Long term channel monitoring & watershed study	Assess riparian and in-stream habitat conditions on Mendocino Redwood Company industrial timberlands.
Mendocino Redwood Co.	Turbidity and suspended sediment in SF Albion	Trends in turbidity and suspended sediment in the South Fork Albion planning watershed shall improve due to road management activities.
Mendocino Redwood Co.	Coastal tailed frog abundance	Monitoring the abundance of larval coastal tailed frogs ovr time to assess the effectiveness of proposed HCP/NCCP conservation strategies.
Mendocino Redwood Co.	Coastal tailed frog distribution	Assess the baseline distribution of coastal tailed frogs throughout MRC ownership and monitor the distribution over time. The presence of coastal tailed frogs dictates greater watercourse protections as per MRC policy.
Mendocino Redwood Co.	Red-legged frog breeding distribution	Assess the baseline distribution of red-legged frog breeding sites throughout MRC ownership and monitor the occupation and utility of documented breeding sites over time.
Mendocino Redwood Co.	Out-migrating smolt abundance monitoring	Track trends in out-migrant population levels to assist in asessing the effectiveness of our HCP/NCCP conservation strategies and to better understand trends in aquatic resources.
Mendocino Redwood Co.	Salmon distribution monitoring	Assess and monitor the spatial distribution of juvenile salmonids throughout MRC's watercourses.
Mendocino Redwood Co.	Stream temperature monitoring	Assess the status of stream temperature regimes in MRC owned streams and monitor trends over time. Use information to assess effectiveness of HCP/NCCP conservation measures.

Monitoring Entity	Study Title	General Monitoring Objectives[1]
Mendocino Redwood Co.	Southern torrent salamander distribution	Assess baseline distribution of southern torrent salamanders throughout MRC ownership and monitor distribution over time.
North Coast Regional Water Quality Control Board	Elk River/Freshwater Creek TMDL Development Monitoring	Identify stream incision and bank erosion rates in managed forests. Identify landslide hazard area.
North Coast Regional Water Quality Control Board	Garcia River Instream Monitoring Project	To establish permanent monitoring reaches. Other objectives include collecting data to support refinement and development of Indices of Biotic Integrity (IBI) for benthic macroinvertebrates and periphyton.
O'Connor Environmental, Inc.	Flow and TTS monitoring, Preservation Ranch	Document existing conditions in relation to TMDL Current Conditions developed for the Gualala watershed.
Redwood National/ State Parks	Stream temperature monitoring in Redwood Ck.	Stream temperature monitoring proides long-term trend data for the main channel and selected tributaries of Redwood Creek.
Redwood National/ State Parks	Rainfall/streamflow/sediment in Redwood Ck.	Objectives are: 1) to elucidate management effects on stream sedimentation in Redwood Creek (complies with 92 STAT. 166); 2) to provide information for evaluating impacts to aquatic biota, 3) to provide basic hydrologic design criteria for park restoration and capital improvement projects.
Roseburg Resources Co.	Trail Gulch Ck. adaptive management project	To provide an understanding of current stream quality conditions in order to design appropriate adaptive management actions.
Scotia Pacific	Piezometric response of hillslopes to rainfall	To identify patterns of piezometric response to surface runfall to rainfall and to determine the effects of forest canopy removal.
Sierra Pacific Industries	Millseat Ck. temperature and microclimate	In general to determine the effect of 75' riparian buffers on water quality, stream temperature, near-stream microclimate, macro-invertebrates, shade producing canopy, water quality. Examine Pre and Post harvest values--determine response of forest managment- which was clear cut to 75'--leave buffer with 50% canopy under CDF site Tube and 85% angular density.
Sierra Pacific Industries	Bailey Ck. Temperature and microclimate	Determine the impact of 75' riparian buffers on the above listed response variables.
Sierra Pacific Industries	Water quality monitoring for Engebretsen THP	Determine impacts of harvest management activities on water quality, sediment production, road construction projects, general timber harvest impacts.
Sierra Pacific Industries	Southern exposure	Determine impact of various buffer widths on response variables.
Soper-Wheeler Co.	Water quality control board monitoring req.	To prevent sediment discharges from occuring.

Monitoring Entity	Study Title	General Monitoring Objectives[1]
Timber Products Co.	Stream channel and riparian assessment	To assess stream channel and riparian zone conditions.
Timber Products Co.	Monitoring alternative WLPZs in Etna Ck.	This study is focused on the cause-and-effect relationship between riparian and stream channel habitats and in stream water temperature and channel condition.
Timber Products Co.	Monitoring alternative WLPZs in McKinney Ck.	This study is focused on the cause-and-effect relationship between riparian and stream channel habitats and in stream water temperature and channel condition.
Timber Products Co.	Watershed scale road erosion inventory	Determine the amount, type, and location of erosion occuring on forest roads in a watershed.
Timber Products Co.	Stream water temperatures in Siskiyou county	N/A
USFS PSW Res. Station	Caspar Ck. experimental watersheds	Measure cumulative effects of forest practices on downstream resources.
W.M. Beaty & Associates	Various required monitoring activities	To make sure that roads are stable and watercourse crossing facilities have functioned properly and are not posing a risk of sediment delivery to a watercourse.

[1]Monitoring objectives taken directly from monitoring questionairres.

Instream monitoring was the dominant form of monitoring, with 78% of all studies having some kind of instream monitoring component. Hillslope monitoring occurred in 43% of the studies, while only 4% of studies looked at other types of waterbodies. When stratified by geomorphic province, instream monitoring was most common in the Coast Range and Klamath Mountain provinces, whereas hillslope monitoring was more common in the Cascade, Modoc Plateau, and Sierra Nevada provinces (Figure 9).

Monitoring studies were done at a variety of spatial scales, and sometimes overlapped multiple spatial scales. Overall, 71% of monitoring studies were done at the watershed scale. Approximately, 60% of studies were also done at the project scale. Twenty-eight percent of studies were done at the ownership scale, typically by large industrial landowners. Only 15% of studies were done at the statewide or regional scale, and these were typically done by state agencies. The Coast Range and Klamath Mountain provinces were dominated by watershed scale monitoring, whereas the Cascade, Modoc Plateau, and Sierra Nevada provinces were dominated by project scale monitoring (Figure 10). Nineteen percent of the studies were part of a nested study design, indicating that consideration had been given to scale linkages, while 57% of studies were not part of a nested design.

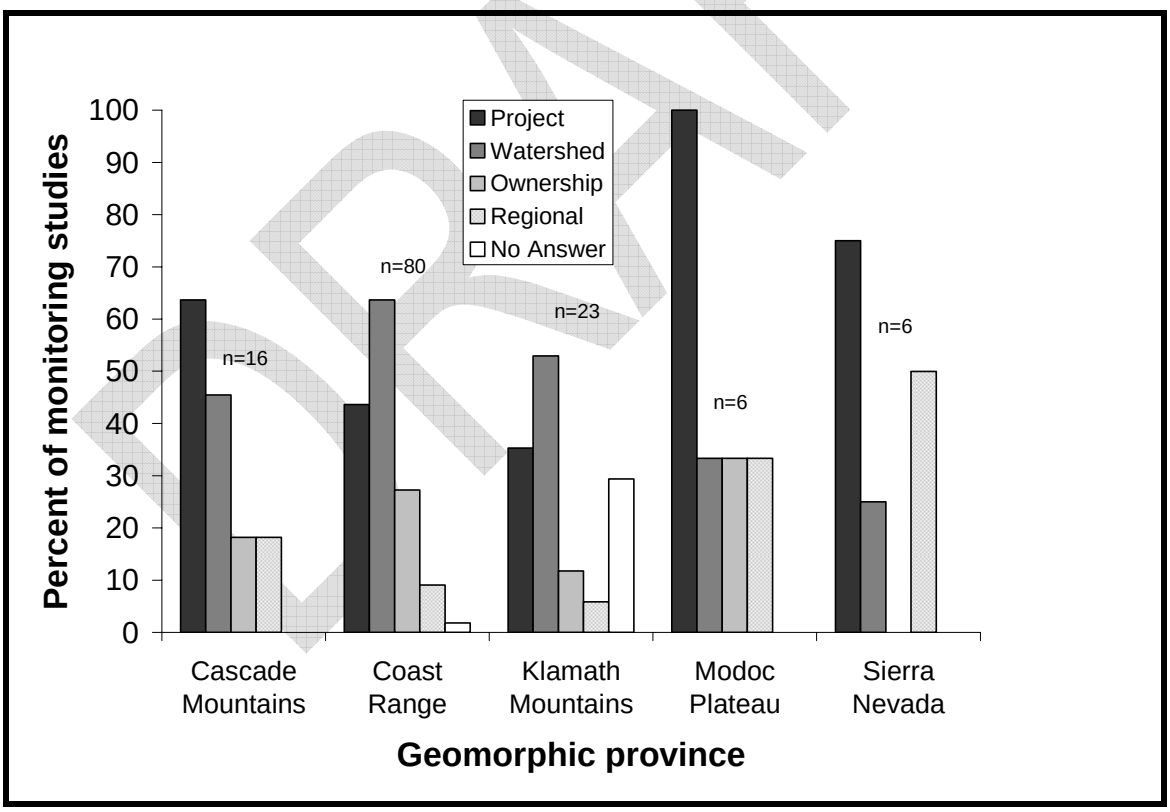

Figure 10. Spatial scale of monitoring by geomorphic province.

The types of parameters measured in a monitoring study were often quite variable. Given this variability, we lumped parameters into general monitoring parameter categories. Table 3 provides information on all the general types of monitoring

parameters measured in a study, and Figure 11 provides an even broader generalization of monitoring parameters by geomorphic province. Sediment-related monitoring was the most common monitoring parameter across all geomorphic provinces, with 61% of all studies measuring parameters related to channel morphology, hillslope erosion, in-channel sediment, and/or sediment-related BMP monitoring. The Coast Range province had the most sediment-related monitoring, with 32 projects monitoring some form of sediment-related parameter (Figure 11).

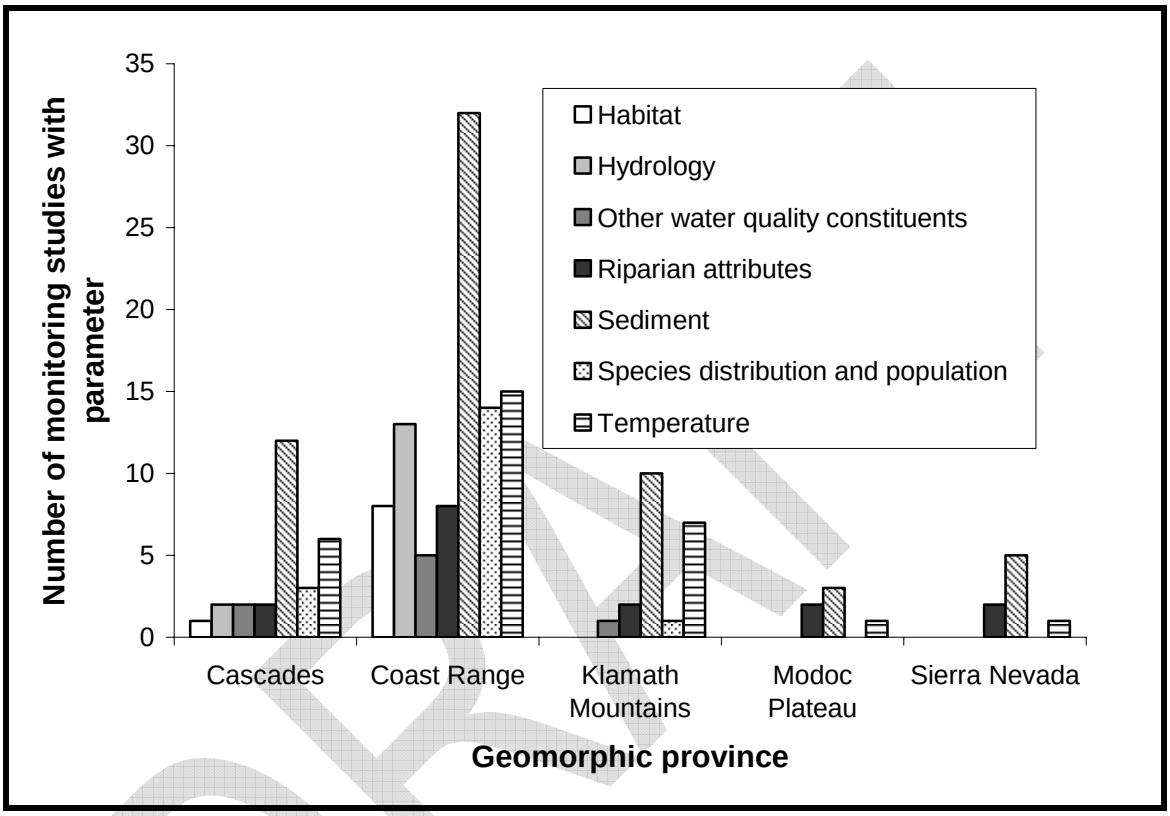

Figure 11. Lumped monitoring parameters by geomorphic province.

The next most common form of monitoring was water temperature monitoring. Approximately 31% of all studies had some sort of temperature-related monitoring. The majority of temperature monitoring was conducted in the Coast Range and Klamath province, with these provinces having 15 and 7 studies with temperature data, respectively (Figure 11). Six temperature-related studies were located in the Cascade province, whereas the Modoc Plateau and the Sierra Nevada each had one temperature study.

Projects characterizing aquatic species (i.e., amphibians, fish, and/or benthic macroinvertebrates) distribution, diversity, and/or population were the next most numerous type of monitoring study. These types of studies accounted for 24% of all monitoring studies, with more than 80% of these studies located in the Coast Range province (Figure 11). Three of these types of studies were located in the Cascade Province, and only one was located in the Klamath Mountain province. The Modoc Plateau and Sierra Nevada had no studies characterizing the distribution, diversity,

and/or population of aquatic species. Eleven percent of studies looked at habitat parameters (e.g., pool characteristics) for fish, amphibians, and/or benthic macro-invertebrates.

Studies monitoring riparian attributes (e.g., shade canopy, stocking, etc.) were the next most common type of monitoring study, with 17% of all studies having some component of riparian attribute monitoring. Sixty-six percent of these studies occurred in the Coast Range province, while the remaining studies spead evenly across the Cascade, Klamath Mountain, Modoc Plateau, and Sierra Nevada provinces (Figure 11).

Studies that monitored hydrologic parameters (e.g., streamflow; soil-water relationships for studying hillslope hydrology) were a component of 21% of all monitoring studies. Eighty-seven percent of these studies were within the Coast Range Province, with the remaining studies within the Cascade and Klamath Mountain provinces (Table 3; Figure 11). Approximately 7% of studies looked at large woody debris (LWD) loading. Eighty percent of LWD studies were located in the Coast Range, and one study was conducted in the Cascade Range.

Several questions were asked regarding statistical consideration for site selection and sample size. When asked about how monitoring sites were chosen, 35% of respondents answered “best professional judgment” and 26% percent did not reply. Ten percent of studies employed a 100% sample, and these were typically BMP implementation and/or effectiveness monitoring projects required by state regulatory agencies. Seven percent of monitoring studies utilized some form of random sampling (e.g., random; stratified random sampling; generalized stratified tessellation sampling), and the remaining answers were difficult to categorize. Only 28% of monitoring studies explicitly considered statistical issues when determining the sample size, while the remaining 72% of respondents said no or provided no answer.

Numerous questions were asked about quality assurance/quality control measures (QA/QC), and whether monitoring methodologies had been reviewed before implementation. When asked if monitoring studies employed QA/QC, 68% of respondents answered yes, whereas the remaining 32% answered no or did answer the question. Only 8% of respondents acknowledged that their methods were consistent with the State Water Resources Control Board’s Quality Assurance and Project Plans. Approximately 65% of monitoring methodologies received some sort of internal review before implementation, 39% received review from independent experts, and 30% of methodologies received no review before implementation. Seventy-four percent of respondents stated that they had qualified field personnel in charge of data collection, while 24% of respondents did not answer the question, and 2% answered “no.”

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Table 3. Monitoring information by monitoring entity. Key located at the bottom of the table.

Monitoring Entity	Study Title	Geomorphic Province	Monitoring Description	Monitoring Parameter	Hypo-thesis Testing	Years of Data	Report Available
Big Creek Lumber Co.	Timber waiver monitoring and reporting	CR	C	S_C, S_H, T	No	5	Yes
CALFIRE	JDSF stream surveys	CR	B, E, F, O, T	C, L, R, T	No	>1	No
CALFIRE	JDSF water temp	CR	B, C, E, F, I, P, R, T, V	T	No	2-13	No
CALFIRE	FORPRIEM	CA, CR, KL, MP, SN	C, E, I	B, R, S_H	No	4	No
CALFIRE (Interagency)	IMMP pilot project	CA, CR, KL	E, I	B, S_H	No	2	Yes
Campbell Timberland Mgt.	Basin temp water temp model	CR	R, V	Q, R, T	Yes	2	Yes
Campbell Timberland Mgt.	SF Wages streamflow and sediment	CR	B, E, F, P	Q, S_C	No	4	Yes
Campbell Timberland Mgt.	Class I and II water drafting	CR	C	Q	No	N/A	No
Campbell Timberland Mgt.	SF Ten Mile streamflow and sediment	CR	B, F, R, T, V	Q, S_C, S_H	No	5-6	Yes
Campbell Timberland Mgt.	Habitat typing	CR	B, O, P, T	C, H, R	No	7	Yes
Campbell Timberland Mgt.	Pudding Ck. adult migrant	CR	R	F	No	3	Yes
Campbell Timberland Mgt.	Pudding Ck. juvenile migration	CR	R	F	No	3	Yes
Campbell Timberland Mgt.	ECP monitoring and reporting	CR	C, E, I	B, S_H	No	3	Yes
Central Coast RWQCB	Santa Cruz stream habitat and juvenile salmonid	CR	B, R, T	C, F, H	No	1	N/A
Central Coast RWQCB	Continuous turbidity monitoring	CR	B, R, T	N/A	N/A	N/A	N/A
Central Coast RWQCB	TMDL numeric target monitoring	CR	B, C, R, T, V	C, H, I	Yes	1	N/A
Central Coast RWQCB	Timber waiver turbidity monitoring	CR	C, E, F, I, O, P, R, T, V	S_C	No	5	No
Central Coast RWQCB	Timber waiver summer temp. monitoring	CR	C, E, I, P, T, V	T	No	5	No
Central Coast RWQCB	Timber waiver photo storm event	CR	B, C, E, F, I, P, T, V	B, S_C, S_H	No	5	No
Central Coast RWQCB	Timber waiver visual storm event	CR	C, E, F, I, P, T, V	B, S_C, S_H	No	5	No
Central Valley RWQCB	Timber waiver monitoring and reporting	CA, CR, KL, MP, SN	C, E, F, I, V	B, R, S_C, S_H	No	3	No
Colorado State University	Sediment production - southern Sierra	SN	B, E, P, R	S_H	Yes	4	Yes
Colorado State University	Road treatment effectiveness in the Lassen NF	CA	E, R	B, S_H	No	4	Yes
Crane Mills	Water temperature monitoring on company land	CR, KL	B, E, P, R, T, V	T	No	13	No
DFG	Stream temperature and microclimate	CR	B, E, P, R, T, V	R, T	Yes	7	Yes
DFG	SF Caspar salmonid populations	CR	E, P, T, V	A, C, F, H	Yes	12	Yes
DFG	Streambed alteration agreements	CA, CR, KL	C, I	B	N/A	7	N/A
Fruit Growers Supply	Temperature	KL	B, T	N/A	N/A	N/A	N/A

Monitoring Entity	Study Title	Geomorphic Province	Monitoring Description	Monitoring Parameter	Hypo-thesis Testing	Years of Data	Report Available
Fruit Growers Supply	Sediment	KL	B, E, I, T	N/A	N/A	N/A	N/A
Fruit Growers Supply	LWD	KL	B, T	N/A	N/A	N/A	N/A
Fruit Growers Supply	Aquatic habitat	KL	B, T	N/A	N/A	N/A	N/A
Fruit Growers Supply	Water quality	KL	B, T	N/A	N/A	N/A	N/A
Green Diamond Resource	Samonid outmigrant trapping project	CR	O, R	F	No	9	Yes
Green Diamond Resource	Summer juvenile salmonid population estimates	CR	O, R	F	No	13	Yes
Green Diamond Resource	Class I channel monitoring	CR	E, O, R	C	No	13	No
Green Diamond Resource	Water temperature monitoring	CR, KL	B, E, O	T	Yes	14	N/A
Green Diamond Resource	Class III sediment monitoring	CR	E, O, R	C, S_C, S_H	Yes	>10	No
Green Diamond Resource	Turbidity threshold monitoring	CR	B, C, E, R, T, V	Q, S_C	Yes	7	No
Green Diamond Resource	SF Elk WWDR Road Erosion Sampling	CR	E, I, R, V	B, C,. S_H	Yes	2	No
Gualala Redwoods	Instream reach and temperature	CR	B, T	C, M, T	No	10	Yes
Hearst Forests	Hearst Forests PTEIR monitoring program	CA, KL	B, C, E, F, I, T	B, C, F, T	No	3-10	Yes
Mattole Restoration Council	Sediment reduction implementation monitoring	CR	E, I, O	B	No	N/A	Yes
Mattole Restoration Council	Mattole watershed stream channel monitoring	CR	B, T	C, H, L, R	No	1	No
Mattole Restoration Council	Mattole turbidity monitoring	CR	E, T	Q, S_C, S_H	No	0	No
Mendocino Redwood Co.	Long term channel monitoring & watershed study	CR	B, E, T, V	C, H, R, T	No	>1	Yes
Mendocino Redwood Co.	Turbidity and suspended sediment in SF Albion	CR	T	C, Q, S_C	No	N/A	Yes
Mendocino Redwood Co.	Coastal tailed frog abundance	CR	B, E, R, T, V	A, W	No	0	No
Mendocino Redwood Co.	Coastal tailed frog distribution	CR	B, E, R, T, V	A, W	No	N/A	Yes
Mendocino Redwood Co.	Red-legged frog breeding distribution	CR	B, E, T, V	A	No	N/A	Yes
Mendocino Redwood Co.	Out-migrating smolt abundance monitoring	CR	B, E, T, V	F, Q, W	No	2	Yes
Mendocino Redwood Co.	Salmon distribution monitoring	CR	B, E, R, T, B	F, W	No	10	Yes
Mendocino Redwood Co.	Stream temperature monitoring	CR	B, E, R, T, V	T	No	N/A	Yes
Mendocino Redwood Co.	Southern torrent salamander distribution	CR	B, E, R, T, V	A, W	No	N/A	Yes
North Coast RWQCB	Garcia River Instream Monitoring Project	CR	B, T	C, H, I, L, Q, R	Yes	2	No
North Coast RWQCB	Elk River/Freshwater Ck TMDL Development	CR	R	C, S_H	Yes	1	Yes
O'Connor Environmental, Inc.	Flow and TTS monitoring, Preservation Ranch	CR	B, P, T, V	Q, S_C, T	No	1.5	Yes
Redwood National/State Parks	Stream temperature monitoring in Redwood Ck.	CR	O, T	T	No	>10	Yes

Monitoring Entity	Study Title	Geomorphic Province	Monitoring Description	Monitoring Parameter	Hypo-thesis Testing	Years of Data	Report Available
Redwood National/State Parks	Rainfall/streamflow/sediment in Redwood Ck.	CR	B, R, T	P, Q, S_C	N/A	>25	Yes
Roseburg Resources Co.	Trail Gulch Ck. adaptive management project	KL	B, P, T	C, P, S_C, W	N/A	1	No
Scotia Pacific	Piezometric response of hillslopes to rainfall	CR	R	H_H, P, Q	N/A	N/A	No
Sierra Pacific Industries	Millseat Ck. temperature and microclimate	CA	B, E, P, R, T, V	I, Q, R, T	Yes	9	Yes
Sierra Pacific Industries	Bailey Ck. Temperature and microclimate	CA	B, E, P, R, T	H, Q, R, T	Yes	8	Yes
Sierra Pacific Industries	Water quality monitoring for Engebretsen THP	CA	B, C, E, F, I, P, R, T, V	P, S_C, S_H, T, W	Yes	9	Yes
Sierra Pacific Industries	Southern exposure	CA	B, E, P, R, T, V	I, L, R, S_C, S_H, W	Yes	8	Yes
Soper-Wheeler Co.	Water quality control board monitoring req.	CA, CR, SN	C, E, F, I, P	B, S_C, S_H	No	N/A	No
Timber Products Co.	Stream channel and riparian assessment	KL	B, P, R	S_H, T	N/A	N/A	N/A
Timber Products Co.	Monitoring alternative WLPZs in Etna Ck.	KL	E, R	B, S_H, T	No	N/A	N/A
Timber Products Co.	Monitoring alternative WLPZs in McKinney Ck.	KL	E, R	N/A	N/A	N/A	N/A
Timber Products Co.	Watershed scale road erosion inventory	KL	B, E, O, R	S_H	N/A	N/A	N/A
Timber Products Co.	Stream water temperatures in Siskiyou county	KL	B, R, T	T, S_H	N/A	N/A	N/A
USFS PSW Res. Station	Caspar Ck. experimental watersheds	CR	R	C, H_H, L, P, Q, S_C, S_H, T	Yes	45	Yes
W.M. Beaty & Associates	Various required monitoring activities	CA, MP, SN	B, C, E, F, I, P, T, V	B, S_C, T	No	8	N/A

Geomorphic Province:

CA - Cascade Range
CR - Coast Ranges
KL - Klamath Mountains
MP - Modoc Plateau
SN - Sierra Nevada

Monitoring Description:

B - Baseliine monitoring
C- Compliance monitoring
E - Effectiveness monitoring
F - Forensic monitoring
I - Implementation monitoring
O - Other monitoring
P - Project monitoring
R - Research
T - Trend monitoring
V - Validation monitoring

Monitoring Parameters:

A - Amphibian distribution and population
B - BMPs (e.g., erosion control)
C - Channel morphology
F - Fish distribution and population
H - Habitat
H_H - Hillslope hydrology
I - Invertebrate distribution, diversity, and population
L - Large woody debris
P - Precipitation
Q - Discharge or stage
R - Riparian attributes (shade; structure; etc)
S_C - In-channel sediment (turbidity; suspended sediment; etc)
S_H - Hillslope sediment (sediment fences; erosion voids; etc)
T - Temperature (air or stream)
W - Water quality (pH; conductivity; DO; etc)

The proposed duration of monitoring studies ranged from a year to indefinitely. The proposed duration of monitoring studies were longest for study areas such as the Caspar Creek watersheds (i.e., 100 years), and for large industrial landowners operating under Habitat Conservation Plans (i.e., 50 years to indefinitely). Approximately 37% of monitoring studies had proposed durations longer than 10 years. The duration of 24% of monitoring studies was less than 10 years. Thirty-nine percent of respondents did not answer the question. The actual duration of collected data ranged from 0 to 45 years (Table 3). The longest datasets were for companies operating under HCPs (e.g., Green Diamond Resource Company) and experimental/research watersheds such as Caspar Creek and Redwood Creek.

Overall, results and conclusions were available from 46% and 13% of the monitoring studies, respectively. The number of studies reporting results was 64% for the Cascade Range, 47% for the Coast Ranges, 29% for the Klamath Mountains, 67% for the Modoc Plateau, and 50% for the Sierra Nevada. (Figure 12). The number of studies reporting conclusions was 18% for the Cascade Range, 15% for the Coast Range, 12% for the Klamath Mountains, 67% for the Modoc Plateau, and 50% for the Sierra Nevada (Figure 12). Reports describing study methodologies, results, and/or conclusions were available from 49% of the studies (Table 3).

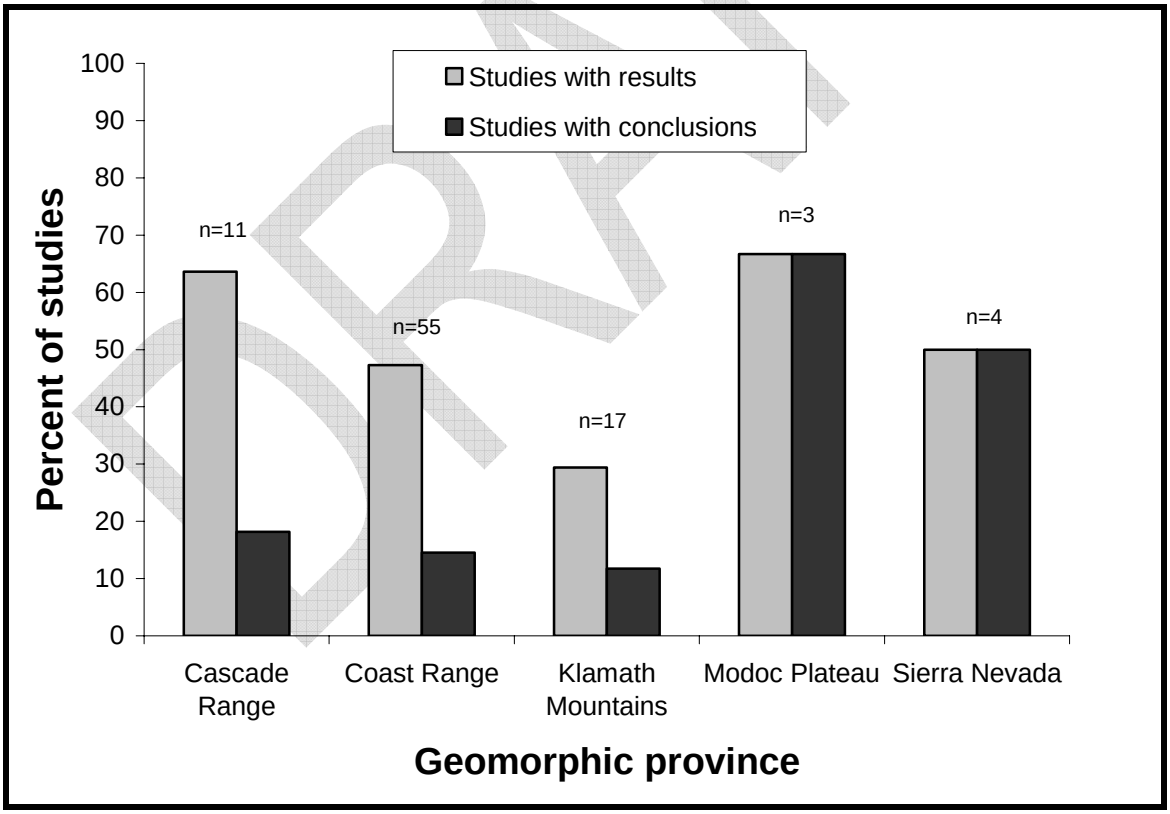

Figure 12. Percent of monitoring studies with results and/or conclusions by geomorphic province.

Respondents were asked if monitoring results and conclusions were to be used for adaptive management. Sixty-seven percent of respondents replied that results and

conclusion were being used for adaptive management, or would be used for adaptive management in the future. The remaining 33% percent of respondents replied "no" or did not answer the question.

The failure to meet study objectives is well noted in the monitoring literature (MacDonald, 1994; Reid, 2001). When asked whether their monitoring study objectives were being achieved, 51% of respondents answered yes, 7% of respondents stated no, 3% replied that it was too early to tell, and the remaining 39% of respondents did not answer the questions. Thirty-five percent of respondents stated that they had modified study objectives and/or methodologies in response to initial data collection.

Respondents were asked to optionally submit itemized cost data for their monitoring studies. Only 36% of respondents submitted cost information in their questionnaires. Cost estimates ranged from as low as $2,521 per year for stream temperature monitoring in the Jackson Demonstration State Forest to $200,000 for the 2-year long Interagency Mitigation Monitoring Program (IMMP). Campbell Timberland Management submitted the most comprehensive cost data, and their total expenditures for monitoring were almost $700,000 to date. CAL FIRE has spent a combined $300,000 on the IMMP and FORPRIEM monitoring studies.

4.0. DISCUSSION

> *Institutions exhibit a tendency to promote competitive behavior at the expense of cooperative actions, yet often cooperation is needed to identify and implement good solutions.…It is clear that institutions will soon be forced to begin thinking about performing the "unnatural" acts of cooperating and sharing information and resources to a much greater extent than they have in the past. – (Ryan and Jensen, 2003)*

4.1. Are the Various Monitoring Activities Cost Effective?

For monitoring to be cost effective it must provide a reasonable benefit to the stakeholder relative to the cost of the monitoring activity. The majority of costs are borne by the stakeholder tasked with implementing the monitoring activity, while costs are relatively small for those stakeholders peripherally involved with the monitoring activity. Benefits may be perceived as different depending upon the stakeholder. For the regulated public, benefits may be viewed in terms of greater regulatory relief or operational flexibility. For regulatory agencies and research entities, benefits may be in the form of defining resource status or trends, or greater scientific understanding of the resource of concern. Cost effectiveness is a matter of perspective, since monitoring can be viewed as economically burdensome by those bearing the cost of the monitoring activity and beneficial by those bearing little of the monitoring costs. As such, this question was difficult to answer given the

relative lack of cost data submitted by the respondents, and the difficulty in defining what constitutes a benefit for a given stakeholder.

Despite difficulties in determining the cost effectiveness of monitoring activities, several benefits or perceived benefits from monitoring were noted. Many respondents provided brief summaries of monitoring results and conclusions, and this shows that stakeholders may benefit from increased understanding of the resource of concern. A perfect example of this is the extensive understanding of the hydrologic and geomorphic effects of timber harvest derived from monitoring studies such as those in Caspar Creek watersheds. Social learning is another benefit derived from studies such as the Interagency Mitigation Monitoring Program (IMMP), which found broad agreement among the various state agencies for issues related to the effectiveness of modern best management practices at high risk watercourse crossings (Longstreth et al. 2008).

Despite the lack of information regarding the cost-effectiveness of monitoring, information derived from the MEF shows clear optimism that monitoring results will benefit the respondents in the future. This is evidenced by the preponderance of those expressing “adaptive management” as a primary monitoring rationale. However, the questions in the MEF did not distinguish between actual benefits and the expectation of benefits in the future. Ultimately, a better evaluation of the cost effectiveness monitoring will have to wait until more results become available in the future. Evaluation of cost effectiveness will also require a better framework to assess the costs and benefits for each stakeholder involved in the process.

4.2. Are There Overlaps Between Monitoring Required by Local, State, or Federal Agencies?

Answers from the MEF provided limited evidence of overlapping monitoring requirements by the various state or federal regulatory agencies. For companies operating under HCPs, the likelihood for overlap was greater since they are subjected to monitoring from both state and federal agencies. However, most monitoring required by state regulatory agencies is done at the project scale (i.e., THP scale), whereas federal agencies are more likely to require programmatic monitoring at broader spatial scales (e.g., watershed or ownership scale).

There is some potential for overlapping monitoring requirements from the various state agencies that require the monitoring of BMP implementation and effectiveness. For example, Campbell Timberland Management is required to do Erosion Control Plan Monitoring and Reporting by the North Coast Regional Water Quality Control Board and Class I and II Water Drafting monitoring by the California Department of Fish and Game. Conceivably, this could result in overlapping monitoring requirements, since water drafting sites are generally considered erosion sources. The extent of this type of overlap might be isolated given the lack of similar information from other respondents.

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4.3. Improving the Feedback Loop Between Monitoring and Decision-Making

One of the questions this report attempts to answer is how to improve the adaptive management feedback loop between monitoring and management/policy decision-making. Collective data from the MEF did not provide clear evidence of a successful feedback loop except at the smallest organizational and spatial scales. Adaptive management at these scales is more likely to be successful because data analyses and decision-making is fairly simple. For example, BMP implementation monitoring can result in a rapid and effective feedback loop because the scale of analysis is generally discrete (e.g., a watercourse crossing), cause-and-effect is relatively easy to assess (e.g., a modification to an erosion control BMP will cause less erosion), and iterative solutions to the problem involves limited personnel (e.g., a forester and an equipment operator). As the scale of the monitoring increases to the watershed, regional, or statewide scale, more stakeholders become involved (i.e., state agencies, federal agencies, or ENGOs). In many cases, the cause-and-effect relationships between management and resource response become increasingly complex (MacDonald and Coe, 2007) and open to debate among the various stakeholders. These added social, political, and technical complexities can slow or halt the feedback loop, may result in decisions that are not equitable, or are consistently biased towards one or more of the stakeholders.

To avoid these issues and increase the likelihood that future monitoring studies can be used for adaptive management, the following topic areas must be examined (Gregory et al., 2006). These topic areas include:

1) The spatial and temporal scale of the problem;
2) The relevant dimensions of uncertainty;
3) The associated suite of costs, benefits, and risks; and
4) The degree to which there is stakeholder and institutional support.

Within each topic-area are several criteria posed as questions in Table 4 (Gregory et al., 2006). Each of these criteria should be explored to see if they: a) present no major barrier to implementing adaptive management; b) are a challenge to implementing adaptive management; or c) are a significant or insurmountable challenge to implementing adaptive management. If challenges to adaptive management are present then the monitoring study should be revised so that all or most of the criteria can be satisfied. If most of the criteria cannot be satisfied, then adaptive management is not a feasible option (Gregory et al., 2006).

Monitoring information summarized in this report could conceivably be used for adaptive management in the near future. However, I would argue that unless these studies can satisfy many of the criteria in Table 4, they have limited utility in adaptive management. Studies that can satisfy these criteria are generally already operating under an adaptive management framework (e.g., HCP monitoring), or are monitoring studies operating at limited spatial and organizational scales.

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Table 4. Summary of proposed criteria for deciding whether to use adaptive management (AM), by topic area and formulated in questions (from Gregory et al., 2006)

TOPIC-AREA CONSIDERATION	CRITERIA QUESTIONS
Spatial and temporal scale:	
Duration	Is the project timeline to obtain verified results compatible with management decision-making requirements?
Spatial extent and complexity	If spatial extent or complexity is large, are there opportunities to apply AM on a subset of the problem and scale up?
External effects	Have potential issues related to background trends and cumulative effects of management activities been addressed in the AM design?
Dimensions of uncertainty:	
Parameter uncertainty	Has the AM design been pared down to focus on only those uncertainties most likely to influence management decision?
Structural uncertainty	Are there profound structural uncertainties? If so, how will surprise outcomes be managed?
Stochastic uncertainty	How do low-probability random natural and other causal events affect the AM design and expected outcomes?
Confidence in assessments	If the confidence in the proposed AM design is low, can expert judgments or other techniques help?
Costs, benefits, and risks:	
Specifying benefits and costs	Can all costs and benefits (and risks) be documented and communicated in a manner understandable to all stakeholders?
Magnitude of effects	Will the information collected through AM have sufficient predictive ability to make a difference to managers?
Multiple objectives	Does the design and assessment of AM plans explicitly address the multiple goals of stakeholders (rather than only scientists)?
Perceived risk of failure	Can stopping rules and clear thresholds identify and/or minimize the perceived risks of failures, to species and to institutions?
Stakeholder and institutional support:	
Leadership	Is there explicit policy guidance and leadership support for AM? Will stakeholders see AM as an effective way to deal with uncertainty?
Flexibility in decision making	Is there sufficient management flexibility (and continuity) to incorporate new information in revised experimental design?
Avoidance of taboo trade-offs	Does the proposed AM design involve any trade-offs that might be considered taboo by some stakeholders?
Institutional capacity	Are sufficient analytical skills available (staff or contractors) to design, evaluate, and monitor AM plans?

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4.4. Towards an Effective Statewide Framework for Monitoring and Adaptive Management in Forested Watersheds

Implementing a statewide adaptive management process that will achieve resource objectives and is equitable for all stakeholders is a daunting task in California. The fragmentation of interests, values, responsibility, authority, information, and knowledge means that it will be very difficult to satisfy any of the criteria outlined in Table 4. Without an integrated political, organizational, and scientific framework to systematically address these criteria, adaptive management is not a feasible option except under very limited circumstances.

While several adaptive management frameworks exist for decision making in a natural resource settings, the one most applicable to California is the Adaptive Management Program (AMP) from Washington State. According to the Washington Forest Practice Rules Board Manual (WFPRMB) Section 22 (2005), the goals of Washington's AMP are to:

1. To provide compliance with the Endangered Species Act for aquatic and riparian-dependent species on non-federal forest lands;
2. To restore and maintain riparian habitat on non-federal forest lands to support a harvestable supply of fish;
3. To meet the requirements of the Clean Water Act for water quality on non-federal forest lands; and
4. To keep the timber industry economically viable in the State of Washington.

According to the WFPRBM (2005):

> The Washington AMP is divided into three functions: Policy, Science, and Implementation. The Cooperative Monitoring, Evaluation, and Research Committee (CMER) reviews existing science and contributes original research to the program. The Policy groups make recommendations to the Board for decision. As shown in Figure 13, the "Policy/Science Firewall" illustrates the intent that the Science function produces unbiased technical information for consideration by Policy and the Board. The AMP Administrator coordinates the flow of information between Policy and CMER according to the Forest Practice Board's directives. Feedback can be achieved through compliance monitoring and implementation statistics and reports that are generated from operational experience such as Interdisciplinary (ID) Teams and alternate plans.

The various stakeholders collaboratively staff the science and policy groups. These various stakeholders consist of representatives from state and federal agencies, the timber industry, small private landowners, tribal interests, and ENGOs. Since the stakeholders have varying values, goals, and responsibilities, the potentially contentious linkages between science and policy are governed by a set of

“groundrules”, which serve to minimize conflict, foster mutual respect, and encourage problem solving (see Appendix II). The “groundrules” lay the foundation for the AMP framework, and help to deal with many of the socio-political, analytical, and technical criteria outlined in Table 4.

The Washington AMP provides an integrated political, organizational, and scientific framework for dealing with uncertainty in forest-water policy issues. While regional differences and financial limitations likely preclude the adoption of the Washington approach to California, it serves as a possible template for improving statewide adaptive management in the future. In particular, the adoption of a set of groundrules is the most critical step for moving forward, as this lays the foundation for a more functional interaction between science and policy.

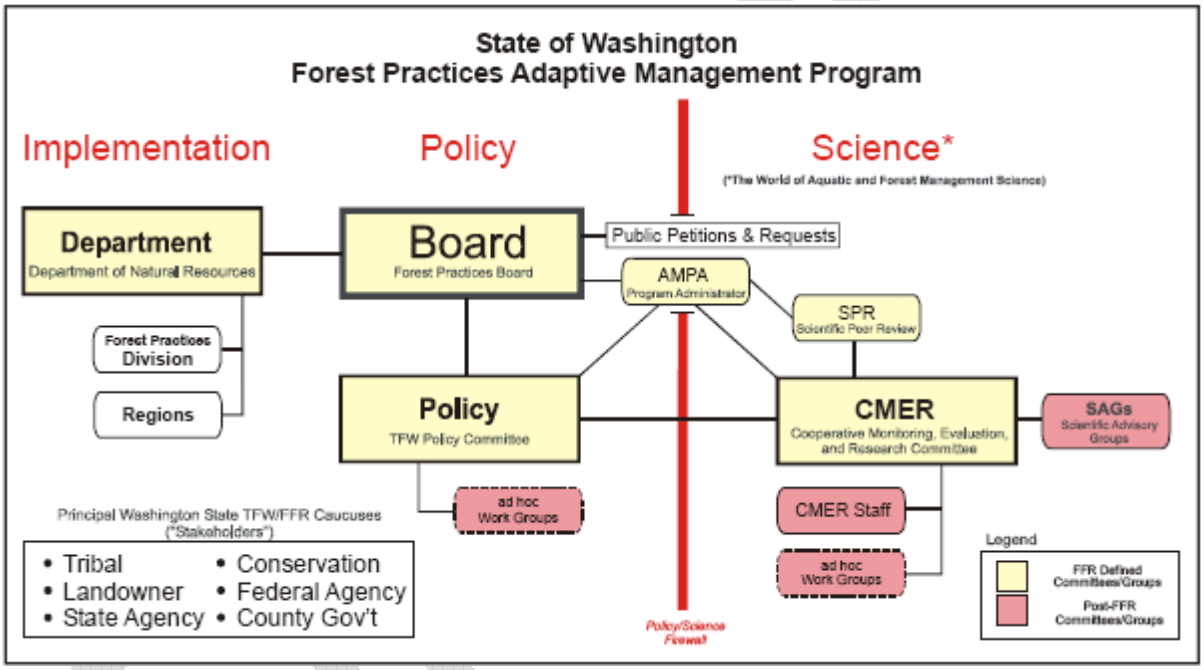

Figure 13. A schematic of Washington State’s Adaptive Management Program.

The adoption of groundrules should not be taken lightly. Strong leadership is necessary to overcome the social, political, and jurisdictional barriers associated with protecting and restoring aquatic ecosystems (Ryan and Jensen, 2003). It will also require an “unnatural” degree of cooperation, compromise, and trust on behalf of the relevant stakeholders. In California, this step may not be possible without facilitation. However, without this kind of strong foundation, adaptive management would likely fail during the implementation phase.

5.0. CONCLUSIONS

> *By expecting the scientific compass to point toward clear directions, people fail to recognize the true nature of science. Science is more about identifying directions that will not work than setting a true direction; it is better at disproving cherished ideas than proving new methods will work. – (Smith et al., 1998)*

Effective monitoring is necessary for the protection and restoration of aquatic resources, and is a critical step for refining management practices in the presence of uncertainty. Despite the increase in forestry-related water quality monitoring in recent years, there is relatively little information regarding the type, distribution, and cost-effectiveness of monitoring in the forested watersheds of California. To fill in these data gaps the Monitoring and Tracking Subcommittee (MTS) of the Monitoring Study Group (MSG) sent out a 9-page Monitoring Evaluation Form (MEF) questionnaire to the various stakeholders tasked with water quality-related monitoring in California.

The MTS received 72 completed or partially completed questionnaires. Forest industry and state regulatory agencies were responsible for 66% and 22% of submitted monitoring studies, respectively. The remaining 12% of studies were submitted by federal agencies, environmental non-governmental organizations (ENGOs), universities, and consultants. Approximately 60% of monitoring studies were conducted in the Coast Ranges geomorphic province, with the majority of these studies in Humboldt and Mendocino Counties. The Klamath Mountain, Cascade Range, Sierra Nevada, and Modoc Plateau geomorphic provinces contained 19%, 13%, 5%, and 3% of the monitoring studies, respectively.

The most common rationales for monitoring were for adaptive management, research monitoring, voluntary monitoring, and as a regulatory requirement. The common types of monitoring could generally be described as effectiveness monitoring, trend monitoring, baseline monitoring, and research monitoring. Most monitoring was performed in-channel (i.e., 78% of studies), although hillslope monitoring was more common in the Cascade Range, Modoc Plateau, and Sierra Nevada provinces. Monitoring was typically done at the project (i.e., Timber Harvesting Plan) and watershed scale.

Sediment was the most common parameter measured, accounting for 61% of the submitted studies. Common sediment-related monitoring focused on erosion control Best Management Practice (BMP) implementation and effectiveness, hillslope erosion, in-channel sediment transport, and channel morphology monitoring. Studies related to the distribution, abundance, and diversity of aquatic organisms (e.g., fish, amphibians, and benthic macroinvertebrates) were also common in the Coast Range province. Overall, results and conclusion are available for 46% and 13% of studies, respectively. Forty-nine percent of studies have reports documenting study methods, results, and/or conclusions.

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It was difficult to evaluate the cost-effectiveness of the various monitoring activities due to the relative lack of cost data submitted by respondents, and the inability to define monitoring benefits across a range of stakeholders. There was limited evidence of overlapping monitoring requirements by state regulatory agencies, although some overlap may occur for companies monitoring under a Habitat Conservation Plan (HCP). Monitoring overlap may also occur when state agencies require implementation and effectiveness monitoring for the same suite of BMPs. Data did not provide clear evidence of a consistently effective feedback loop between monitoring data and decision-making except at relatively small organizational and spatial scales. An explicit set of criteria – dealing with spatial and temporal scale, dimensions of uncertainty, the evaluation of costs, benefits, and risks, and institutional and stakeholder support – should be met before applying results and conclusions from the various studies in an adaptive management setting. The data suggests that these criteria are seldom met for most studies.

Implementing a statewide adaptive management program will be difficult without an integrated political, social, and scientific framework to address the various adaptive management implementation criteria. The Washington State Adaptive Management Program offers the best template for implementing a statewide adaptive management program in the future. However, "groundrules" dictating science-policy interactions among the diverse, and often competing stakeholders, will have to be developed before a statewide adaptive management program can be successfully implemented. Strong leadership and facilitation will likely be necessary to lay the foundation for an integrated adaptive management framework.

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APPENDIX I. The Monitoring Evaluation Form.

Monitoring Evaluation Form

Name:	Affiliation:	Date:
Address:	Phone:	Email:

Monitoring Project Title:	Counties:
Watersheds:	

1. Monitoring Description: Fill out separate form for each monitoring activity.

a. What description(s) best describes the monitoring activity (check all that apply)?

- [ ] **i. Implementation Monitoring** - Determines whether management measures and/or BMPs are being properly applied.
- [ ] **ii. Forensic Monitoring** - Determines whether management activities are generating significant pollution sources during the winter period.
- [ ] **iii. Effectiveness Monitoring** - Determines whether management measures and/or BMPs are effective at achieving desired results (e.g., minimal erosion; clean water; etc).
- [ ] **iv. Compliance Monitoring** - Determines whether regulatory requirements (e.g., water quality objectives for turbidity; waterbreak spacing) are being met.
- [ ] **v. Baseline Monitoring** - Determines the status of existing water quality conditions.
- [ ] **vi. Trend Monitoring** - Determines whether water quality conditions are changing over time.
- [ ] **vii. Validation Monitoring** - Determines whether regulatory/management models are adequate for achieving desired conditions (clean water; healthy aquatic ecosystem; etc).
- [ ] **viii. Project Monitoring -** Determines the effect of a particular project (e.g. timber harvest plan) on water quality or other resource of concern.
- [ ] **ix. Research** - Systematic investigation increasing knowledge regarding biologic, hydrologic, or geomorphic pattern, process, or function.
- [ ] **x. Other** (explain below)

2. Monitoring Rationale and Objectives:

a. Monitoring is being done for the following reasons:

☐ **i. Regulatory requirement -** e.g., Fulfilling regulatory requirements for Timber Harvest Waivers, WDRs, TMDLs, or HCPs.

Regulating agencies:

Regulatory program:

☐ **ii. Inform agency regarding rulemaking** - e.g., Addresses uncertainties with current Forest Practice Rules (FPRs) and/or FPR implementation rates.

☐ **iii. Inform numeric target** - e.g., Test the efficacy of metrics within the FPRs (e.g. buffer widths) or other regulatory frameworks.

☐ **iv. Inform narrative target -** e.g., Quantitatively assess "significant", "nuisance", or "adverse effects" from sediment.

☐ **v. Voluntary -** e.g., Informs landowner on efficacy of management practices or whether they're achieving resource objectives.

☐ **vi. Adaptive management** - e.g. Adjust management activities in response to monitoring results.

☐ **vii. Research**

☐ **vii. Other (explain below)**

b. What are the general objectives of the monitoring project? (e.g., Are buffer strips sufficient to protect water quality?)

c. What are the specific objectives of the monitoring project? (e.g. Is there an optimum buffer strip width for filtering sediment from upslope areas?)

Are the specific objectives defined as testable hypotheses? Yes ☐ No ☐
(e.g., Do 100 foot buffer strips filter more sediment from upslope areas than 50 foot buffer strips?)

3. Monitoring Methods:

a. Is monitoring method primarily: Quantitative ☐ Qualitative ☐ Combination ☐
Explain:

b. Location of monitoring: Hillslope ☐ Instream ☐ Other waterbodies ☐
(e.g. ponds; wetlands; reservoirs; etc)

c. Scale of monitoring: Project ☐ Watershed ☐ Ownership ☐
(e.g. THP)
Regional ☐ Statewide ☐ Other ☐
(e.g., geomorphic province or regulatory boundary)

Explain:

d. Is this monitoring activity a part of a nested monitoring design? Yes ☐ No ☐
If yes, list other monitoring activities included in the nested monitoring approach and explain how scale linkages are considered:

e. What parameters are being monitored? (e.g. sediment production; BMP effectiveness; turbidity; water temperature; V-star; discharge; etc)

f. How are the parameters being monitored? (e.g., erosion void surveys; turbidity threshold sampling; sediment traps; etc)

g. What is the frequency and timing of monitoring? (e.g., 15-minute intervals; once a year after a threshold precipitation amount; etc).

h. How are monitoring sites chosen? (e.g., best professional judgement; 100% sample; random sample; stratified-random sample; paired watershed/BACI design; slopes over 60%; etc)

i. Have statistical considerations (i.e., power; variability; etc) been given to sample size? Yes ☐ No ☐

Explain:

j. How many years will the monitoring project last?

k. How many years of data have been collected?

l. Are quality assurance and quality control (QA/QC) measures applied? Yes ☐ No ☐

i. Are the methods consistent with the State Water Resources Control Board's Quality Assurance and Project Plans (QAPP)? Yes ☐ No ☐

Explain or attach QA/QC plans:

m. Who collects data in the field? Are they trained, certified, or licensed?
Explain:

n. Has the monitoring approach been:

Internally reviewed		Independently reviewed by experts in the field		Anonymously reviewed by experts in the field (peer review)	
No review					

4. Utilizing Monitoring Data

a. If available, briefly describe results and conclusions of monitoring study:

b. Have the conclusions been independently peer-reviewed?

Internally reviewed		Independently reviewed by experts in the field		Anonymously reviewed by experts in the field (peer review)	
No review					

c. Are monitoring objectives being achieved? Yes ☐ No ☐

If not, why (e.g. methods not consistent with objectives; too early to analyze data; inadequate funding; inadequate statistical design):

d. Are (or will) results and conclusions utilized (or be utilized) to adjust management/ regulatory activities? If so, how? If not, why (e.g. too much uncertainty in results)? Yes ☐ No ☐

e. Are monitoring objectives/methods being revised in response to data collection or analyse Yes ☐ No ☐

If so, how?

If not, why?

5. Data Availability

a. Is the data available to the public? Yes ☐ No ☐

b. Is it available in accessible databases? Yes ☐ No ☐

c. Is it available in summarized reports? Yes ☐ No ☐

d. Have you attached a copy of the summarized report? Yes ☐ No ☐

e. Is it available online Yes ☐ No ☐

If so, where:

6. Monitoring Inquiries

a. Are you aware of other, similar monitoring projects not included in our list (see attached spreadsheet) Yes ☐ No ☐

If so, list projects and contact information:

b. Is there an opportunity to combine monitoring work to increase efficiencies. Yes ☐ No ☐

If so, explain:

7. Monitoring Costs - Filling out this section is optional, but helps us assess the cost effectiveness of each monitoring approach. Itemization is optional, so provide simplified cost data if more appropriate. If possible, itemized by monitoring type.

DESCRIPTION (e.g.)	HOURS	UNIT COST	SUBTOTAL	COMMENTS
Full time staff				
Seasonal technicians				
Consultants				
Volunteers				
Monitoring Equipment				
Maintenance and Upkeep				
Laboratory Costs				
Vehicles				
Gas				
Training				
	Total:		0	

Appendix II. Ground rules for the Washington State Adaptive Management Program. Taken from the Washington State Forest Practice Rules Board Manual Section 22 (http://www.dnr.wa.gov/Publications/fp_board_manual_section22.pdf).

I. Policy (WAC 222-12-045(2)(b)(ii))

Policy members are self-selected by participating caucuses. Each caucus selects representatives to Policy and the Adaptive Management Program. Caucuses should be mindful of how their appointed representatives are perceived by other caucuses in light of the fact that the Adaptive Management Program is a collaborative effort. Each representative should demonstrate a genuine commitment to problem solving and mutual respect among all the caucuses.

A. Ground rules concerning expectations upon appointment as an Adaptive Management Program participant.

1. Participants in the Adaptive Management Program bring with them the legitimate purposes and goals of their organizations.
2. Participants recognize the legitimacy of the goals of others and assume that their own goals will also be respected.
3. Participants agree that the purpose of the Adaptive Management Program is the effective implementation of the Forest Practices Act and rules in order to meet its four goal (see Part 1, Overview).
4. Participants provide sufficient attention, staffing and other resources.
5. Participants commit to address all aquatic resource management issues raised in the adaptive management process.

B. Ground rules concerning participation in the Adaptive Management Program.

1. Participants commit to search for opportunities to solve problems collaboratively. Participants acknowledge that solving problems or issues of other caucuses is more likely to lead to solutions for ones own problems and issues.
2. Participants commit to listen carefully, ask questions to understand, and make statements to explain or educate.
3. Participants state needs, problems and opportunities first and positions last, and avoid hidden agendas.
4. If a caucus does not agree with statements or positions by other caucuses, participants offer reasons why and alternatives.
5. Participants attempt to reach consensus on a proposal or other issue being considered in the Adaptive Management Program. Consensus means that each caucus can live with all parts of that proposal, and that all caucuses will accept implementation of all parts of that proposal. At a minimum, each participant allows its name being subscribed on consensus proposals being sent to the Board, and to refrain from taking actions opposing adoption of consensus proposals by the Board.
6. Caucuses are polled on each proposal. Caucus positions on proposals reside with the governing bodies of each caucus's

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representatives. Each caucus decides how it will govern itself in reaching caucus decisions.

7. If the dispute resolution process concludes without consensus or a resolution satisfactory to each caucus, the issue or matter is released for consideration in other forums. If a participant chooses to resort to such other processes, it notifies the other participants before taking such action.

C. Ground rules concerning relationships to outside parties and processes

1. Participants avoid use of other processes such as legislation or litigation to resolve issues being considered in the Adaptive Management Program. If a participant believes it must resort to such other processes, it notifies the other participants before taking such action.
2. A participant may leave the Adaptive Management Program after telling the other caucuses why.
3. At the conclusion of an issue, participants attempt to agree on the message that will be given, and respect the resolution and implementing actions of the other participants.
4. No participant attributes suggestions, comments or ideas of another participant in communications with the news media or other non-participants.
5. Each participant accepts the responsibility to keep friends and associates informed of the progress of the Adaptive Management Program.
6. Caucuses are free to talk to the press, but they should not negotiate their positions in the press. Everyone is mindful of the effects their public and private statements will have on the climate of this effort.

II. Cooperative Monitoring Evaluation and Research Committee (CMER) (WAC 222-12-045(2)(b)(i))

A. General CMER Ground Rules

1. Each of the participants affirmed by the Board to CMER agree to these ground rules, which were developed collectively by CMER to ensure that CMER produces credible scientific results that have a broad base of support. These ground rules are specific to CMER and do not apply to any other portion of the Adaptive Management Program.
2. CMER core values are predicated upon the agreement of each CMER participant that adaptive management is based upon sound science. It is the responsibility of every participant to follow sound scientific principles and procedures.
3. Participants will also adhere to the purpose of the Adaptive Management Program:

   . . . to provide science-based recommendations and technical information to assist the board in determining if and when it is necessary or advisable to adjust rules and

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guidance for aquatic resources to achieve resource goals and objectives. The goal of the program is to affect change when it is necessary or advisable to adjust rules and guidance to achieve the goals of the forests and fish report or other goals identified by the board. (WAC 222-12-045(1))

4. Individual Policy positions are not the basis for CMER decisions, otherwise the credibility of CMER research can be questioned, resulting in CMER having failed in its function of providing accountable results to the Adaptive Management Program.

B. Specific CMER Ground Rules

1. CMER participants will engage in actions that promote productive meetings and will encourage the active participation of each individual member. Examples of these actions are:
   a. Speak to educate, listen to understand.
   b. Pursue win/win solutions.
   c. State motivations and justifications clearly. Discuss issues openly with all concerns on the table. Avoid hidden agendas.
   d. Ensure that each individual has a chance to be heard.
   e. Help others move tangent issues to appropriate venues by scheduling a time to discuss these issues later.
   f. Start and stop meetings on time.
   g. Take side conversations outside—listen respectfully.
   h. Define clear outcomes for each conversation and appoint a conversation manager.
   i. Be trusting and trustworthy.
   j. Acknowledge and appreciate the contributions of others, even when you disagree.
2. CMER participants agree to spend the time in preparation for meetings so that their participation is both meaningful and relevant and to refrain from participation when they are unprepared.
3. CMER participants agree to participate in the Adaptive Management Program's scientific dispute resolution process when consensus cannot be reached and to make a good faith effort to resolve the dispute.
4. CMER participants recognize that information and results are preliminary until the final report is approved by CMER. Products must be clearly labeled and presented as DRAFT until approved by CMER as a final product.
5. At no time shall any potential contractor for a project be involved in the drafting of an RFP, RFQ or SOW or in the selection of contractor for that specific project.

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