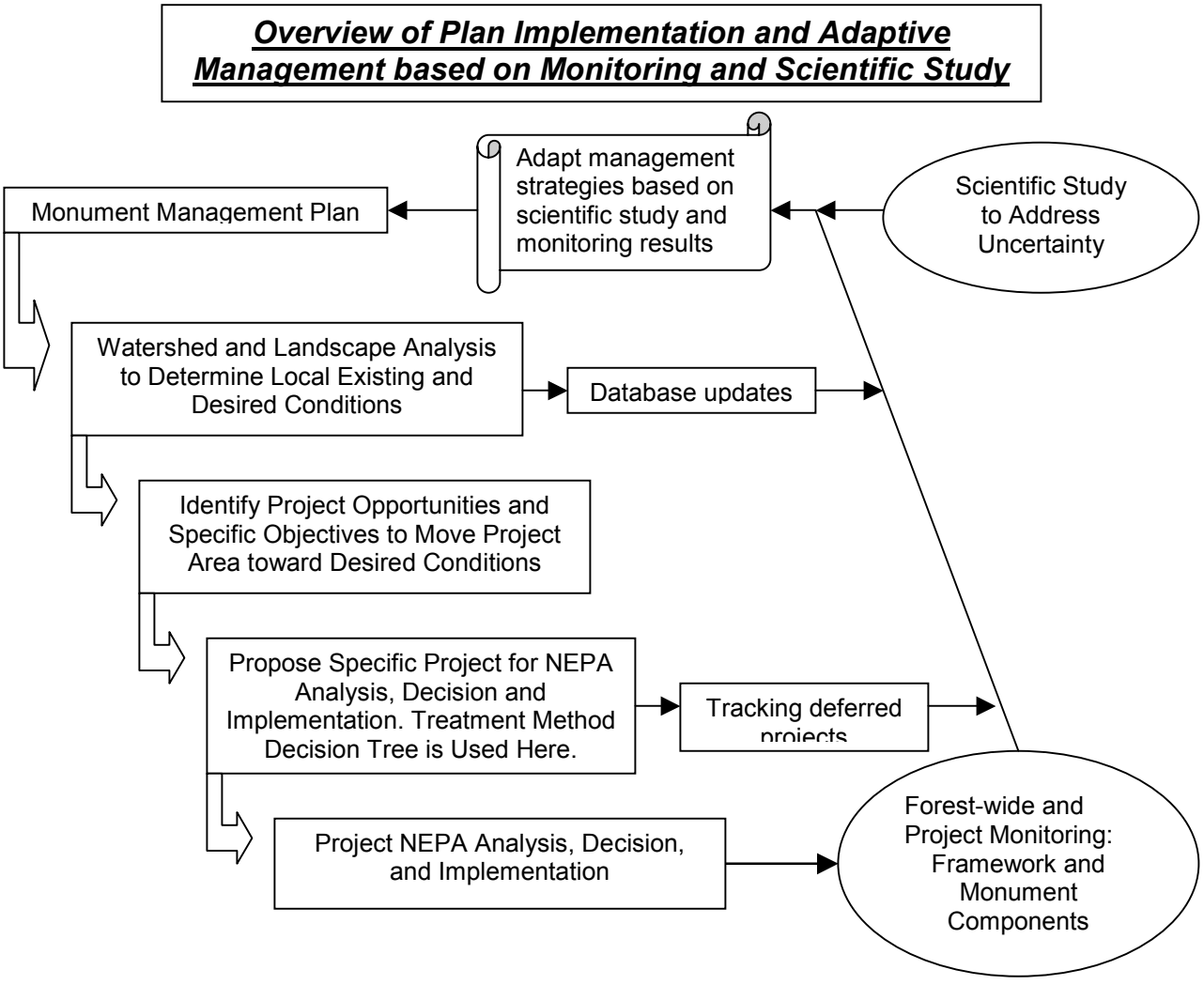
Appendix G

Monitoring, Scientific Study, and Adaptive Management

G. Monitoring, Scientific Study, and Adaptive Management

1. Relationship of Monitoring and Scientific Study to Adaptive Management

It is important to understand how management practices are adapted, based upon results from monitoring and scientific study. Monitoring occurs at multiple levels: the project level, the Forest Plan level, and bioregional or regional levels. The Sequoia National Forest assesses new information annually and makes a determination as to whether or not changes to current management practices are warranted. Changes to management practices can be documented in a wide variety of ways, depending on the timing, degree and nature of the changes. The following graphic displays the relationship of plan implementation (on the left side) and the feedback loop of monitoring and scientific study (on the right side).



2. Adaptive Management

Adaptive management is the process of continually adjusting management in response to new information, knowledge, or technologies. Adaptive management recognizes that unknowns and uncertainty exist in the course of achieving any natural resource management goals. Uncertainties can create barriers to effective decision-making, particularly where management concerns and scientific uncertainties are both high. The evolution of the study of ecology and, more specifically, large-scale systems, has indicated a continually growing appreciation of the complexity of the natural world and the importance of spatial and temporal scales. More thorough understanding of these complex relationships, particularly as past and present human disturbances are factored into what we observe, is essential for future land management decisions. This information will lead to more effective efforts in developing a balance between meeting human needs, addressing the reality that ecological systems have limits, and recognizing what management activities are needed to enable maintenance of ecosystem function in perpetuity.

The complexity and interconnectedness of ecological systems, combined with technological and financial limitations, makes a complete understanding of all the components and linkages virtually impossible. Not only is our knowledge incomplete, but the systems themselves are constantly changing through both natural and human caused mechanisms, making the effort to comprehend ecosystems dynamics and foretell their trajectories even more challenging (Gunderson, et al, 1995).

Monitoring and research are our primary mechanisms of information acquisition. Thus, the success of an adaptive management strategy is dependent upon a well designed, transparent, adequately funded, and carefully implemented monitoring and research program. Adaptive management is ultimately dependent upon the ability of institutions to integrate new information into management decisions and approaches.

The adaptive management strategy for the Framework is incorporated into this FEIS. Many cause-and-effect and status-and-change questions that are posed in the Framework strategy are particularly appropriate for the Monument, including the questions regarding important forest structure and process in old forests, wildlife habitat and population changes for species at risk, and aquatic habitat.

New information gain and institutional response can be characterized in one of three ways.

- **Trial and error learning** occurs when information is gained by chance. No structured information acquisition effort exists, but learning does occur.
- **Passive adaptive management** occurs when new information is gathered in a structured manner, questions are pursued in a linear, sequential manner, and the information is incorporated into decision-making. Passive adaptive management approaches are applied primarily in status and change, and management effectiveness monitoring

- **Active adaptive management** occurs when new information is pursued through multiple hypotheses testing, with strong reliance on experimentation. Active adaptive management approaches are applied primarily in validation monitoring.

Adaptive management in the Monument will be guided by two important components: scientific study and monitoring of both on-going programs and projects that implement the management strategies of the Monument Management Plan. This document describes these two components.

3. Scientific Study and Research

Implementation of the Monument Management Plan will include the development and execution of a Research Strategy. The management objectives and activities for the Monument involve a number of scientific uncertainties. As management proceeds, Forest Service managers will require further guidance on a number of key scientific questions.

The Presidential Proclamation that created the Monument encourages research. “These giant sequoia groves and the surrounding forest provide an excellent opportunity to understand the consequences of different approaches to forest restoration…Outstanding opportunities exist for studying the consequences of different approaches to mitigating these conditions and restoring natural forest resilience (Appendix B, Proclamation, page B-4).” The need to develop such a strategy is clear; this is a first step in doing so.

Identification of research needs and prioritization of these needs has not yet been formalized. However, we set forth here a summary of the currently recognized research needs and a process for establishing the research agenda. It is our intention to work directly with the Sierra Nevada Research Center of the Pacific Southwest Research Station of the Forest Service to establish an integrated research program for the Monument, in cooperation and collaboration with a number of research institutions.

In addition to the general reasons for crafting a research strategy to deal with uncertainty in decision-making, there are also some specific reasons why a research strategy will be developed for the Monument. These include, but are not limited to:

- There are many areas of uncertainty regarding the potential impacts of management actions and public use in the Monument.
- Research is needed to identify the most effective treatments for restoring the Monument.
- Research will support change through adaptive management.
- There is public support for research focused on key resources within the Monument, such as the giant sequoias and Pacific fisher.
- The Scientific Advisory Board for the Monument encouraged development of a research unit to focus on key questions concerning management of the Monument.
- There are limestone outcrops, noted for their caves, which may contain evidence of vegetation change and the roles of prehistoric peoples over the last 50,000 years.

a. Characteristics of the Research Program

1) Integrated Research Program

The array of research questions that we expect to address involves a diverse set of disciplines and issues. Such issues will include addressing pressing ecological and social/economic questions. We will encourage collaboration and coordination across disciplines to maximize the synergistic value of learning that is possible. The Sierra Nevada Research Center of the Forest Service, in collaboration with the Monument, will facilitate this integrated program.

2) Tiered to the Framework Adaptive Management Strategy

The Framework FEIS of January 2001 includes a comprehensive Adaptive Management Strategy intended to accomplish the following objectives:

- Assist the forests in meeting local and bioregional monitoring responsibilities and information needs by providing an efficient mechanism for pooling resources, collecting data, and evaluating results
- Be based on well-defined questions
- Identify both mechanistic and relational links between observed change and hypothesized causal factors
- Contain measures of change that are scale-appropriate, information-rich, and sensitive to management issues of greatest concern
- Outline how monitoring information will be evaluated and interpreted
- Outline a procedure for responding to monitoring results, including how they will be incorporated into future decision making

The issues contained in this Framework Adaptive Management Strategy are incorporated into the Monument Research Strategy by reference. Some of these issues are more relevant to the Monument than others, but research and monitoring being executed for the Sierra Nevada bioregion will be, by extension, incorporated into the Monument's Research Strategy.

3) Include Facilities, Staffing, and Funding

The Monument will encourage and facilitate a research strategy for the Monument through coordinated efforts to develop and/or maintain facilities and field staff to execute the desired work. It is recognized that active research requires significant logistical support and the Monument will work towards identification of the necessary facilities and other support or resources needed. Funding support will be pursued through intra-agency, inter-agency, and outside support as needed.

4) Coordination with Other Agencies and Land Managers

As referenced above, the Monument intends to coordinate research activities in the Monument with other interested agencies and organizations. Many of the key

research needs of the Monument are issues shared by other organizations. As the research activities move forward, explicit efforts will be made to ensure coordination and maximize efficiency in addressing common questions. Coordination with National Park Service, Bureau of Land Management, U.S. Geological Survey, will be pursued.

5) Continuous and Long-Term Commitment to a Research Strategy

The issues facing the management of the Monument are formidable and complex. Development and implementation of a research strategy will require a long-term commitment. Many issues will require long time periods to develop the necessary design for data collection, execute the fieldwork, and understand the results. The richness of our understanding and application of findings will grow as we learn more of the complex nature of ecosystem processes within the Monument. Thus we expect to make a long-term commitment to the activities of a research agenda.

b. Research Already Underway

A number of important steps are already underway that will contribute to the research strategy for the Monument. Neighboring Sequoia Kings Canyon National Park and, more recently, their cooperators within the U.S. Geological Survey, have a long history of important research studies and findings, much of which is relevant to needs within the Monument. The emerging research program for the Monument will benefit greatly from access to and collaboration with this effort.

There are a number of other ongoing activities that are pertinent to what is needed from a research strategy for the Giant Sequoia National Monument. Coordination with these efforts is important:

- **The Giant Sequoia Cooperative.** This is an inter-organization group, established through a Memorandum of Understanding that includes representatives from the Pacific Southwest Research Station (PSW), Sequoia National Forest, the Sequoia and Kings Canyon National Parks, the Bureau of Land Management (BLM), Mountain Home State Demonstration Forest (California Department of Forestry), Cal Poly University, University of California, and U.S. Geological Survey. The purpose of this Cooperative is to provide leadership in applied research on the ecology of giant sequoia mixed conifer forests.
- The Giant Sequoia National Monument is conducting ongoing integrated resource inventories in the sequoia groves in partnership with **California Polytechnic University, San Luis Obispo. The National Park Service, Bureau of Land Management, and State Parks** all have resource data collection within sequoia groves.
- Adjacent research in the **Kings River Administrative Study (Sierra National Forest), Sequoia and Kings Canyon National Parks (executed by the U.S. Geological Survey) and Mountain Home State Demonstration Forest (State Department of Forestry).** Active research is ongoing in all these locations.

- Active research is ongoing in the **Whittaker Forest (U.C. Berkeley)** that is located within the Monument.
- The **Framework monitoring program** has located teams on the Sequoia National Forest for fisher and meadow monitoring. Although these are intended to be regional efforts, a good portion of the work (especially for the fisher) will be focused on Monument lands.

c. Some of the Pressing Questions in the Monument

As referenced above, the Monument Research Strategy will incorporate, by reference, the elements of the Framework Adaptive Management Strategy (USDA, January 2001, Appendix E). In particular, the cause and effect questions addressing old forest elements and fire and fuels elements are relevant to the research information needs of the Monument. These questions are directed at the Sierra Nevada as a region but they may have direct applicability to management actions on the Monument.

In addition to those questions addressed in the Framework Adaptive Management Strategy, there are more specific information needs particular to management problems on the Monument. This list of information needs will be developed further at a later date. However, these are likely to be the key features of an initial research strategy for the Monument:

1) **What are the effects of using a variety of treatment methods (prescribed fire vs. mechanical treatment vs. prescribed fire with mechanical treatment) to meet specific short-term and long-term restoration objectives? In other words, if we want to create a range of gap sizes and distribution in a specific stand or grove, what are the ecological trades-offs by accomplishing this work via prescribed fire only, mechanical only, or by a combination of fire and mechanical?**

    - Key attributes are: changes in structure; species composition (reproduction of under-represented species – Ponderosa Pine, Jeffery Pine, Giant Sequoia, Sugar Pine); impacts to monarch Giant Sequoia (root damage, bole damage, crown damage); introduction of non-native species.

2) **What are the effects on giant sequoia regeneration from applying various fuel reduction treatments (defense and threat zone prescriptions) that are designed primarily to reduce fire behavior? There are numerous groves within the wildland-urban interface where fuel treatments are our highest priority for implementation.**

    - Key attributes: establishment and survival of giant sequoias and other species.

3) **What are the effects to surface and sub-surface water profiles in giant sequoia groves from up-slope vegetation treatments? These up-slope treatments would vary by either the method (fire vs. mechanical) or the changes in structure (different intensities of treatments**

   - Key attributes are: available water; rooting depth and/or capacity; survival and growth of seedlings; in-stream water flow.

4) **What are the effects of the management activities on the level of trust that stakeholders have in the Forest Service as managers of the Monument? Key attributes have not yet been identified that might provide a quantifiable indication of the level of support the public has for Monument management activities?**

5) **What did the pre-1875 groves and mixed conifer forests look like in terms of vegetation structure and natural processes? The Scientific Advisory Board for the Monument advised that these conditions be used as reference conditions. General public view on this topic is that the understanding of such conditions is inadequate.**

   - Key attributes: species composition, age and tree size distributions; canopy cover; key natural disturbance regimes (fire frequencies especially).

6) **What are the effects on local fisher habitat and populations from implementation of fuels reduction strategies in defense or threat zones? The only fisher den sites identified in the Sierra Nevada are within the Monument, and they are part of a giant sequoia grove/wildland urban interface/den site complex. Managers need to better understand the degree to which fishers can tolerate disturbances to their habitat, particularly reduction in canopy cover, so that a reasonable and effective overall short and long-term vegetation management strategy can be devised and implemented in the Monument that restores natural fire regimes as well as provides suitable habitat for old forest-dependent wildlife species.**

7) **What are the direct and indirect effects of different permitted management practices on giant sequoia ecology? Some activities include livestock grazing and recreation facilities and uses.**

8) **What are the ecological tradeoffs when different treatment methods are used within giant sequoia groves? For example, what are the effects on soil properties, tree-rooting capacity, and risk of noxious weed introduction when mechanical methods are used as compared with using prescribed fire only?**

d. How We Will Develop and Implement a Research Strategy for the Monument

The discussion above provides a starting point for a research strategy for the Monument: purposes, vision, collaborative opportunities, and priority issues. This direction will be developed further and executed through a collaborative approach between staff of the Monument, the Sierra Nevada Research Center of the Pacific Southwest Research Station of the Forest Service, and other agencies and interested publics. The process for accomplishing this may involve the following steps:

- Using the information presented above, develop an initial draft of a research agenda for discussion purposes.
- Hold a workshop, inviting interested managers, researchers, and the public to review the initial draft and scope out a comprehensive research agenda for the first 10 years of the Monument.
- Through the results of this workshop, draft a complete written research strategy that encompasses the ideas discussed above as well as ideas gleaned from the workshop.
- Circulate the draft to interested participants, including members of the Giant Sequoia Ecology Cooperative, and seek comments.
- Finalize a 10-year research strategy.
- Include a plan for logistical support for conducting research within the Monument.
- Complete this within one year of signing the Record of Decision.

4. Forest Monitoring Plan

a. Monitoring and Evaluation Requirements

1) Purpose

The purpose of monitoring and evaluation is to provide information on the results and progress of Forest Plan implementation so that:

- Necessary changes in the management practices can be instituted, and
- Indicated plan amendments/revisions can be made.

2) Monitoring and Evaluation System

The total monitoring system on the Monument consists of a wide variety of actions that are closely linked to the Adaptive Management Strategy found in the Framework. Data collected for this monitoring plan is expected to be compatible with the protocol and objectives of the Framework plan. Data will be able to be aggregated "upward" in order to support monitoring from stand level up to bioregional levels. The monitoring plan presented in this document consists of those special activities that focus on evaluating the broad aspects of plan implementation. Other monitoring consists of reports, reviews and records that occur as a routine part of Forest management. Actions not duplicated in this plan include such things as: individual and annual fire reports; management attainment reports; annual vegetation management action plans, reviews and reports; budget and financial management documents; recreation information management reports; environmental analysis reports; activity reviews; audits; and general management reviews.

Monitoring and evaluation are separate, sequential tasks. Monitoring is designed to observe and record the results of both natural processes and actions permitted by forest land and resource management plans. Evaluation looks at those results, determines how well those results meet forest plan direction, and identifies measures to keep the plan viable.

There are three distinct levels of monitoring: 1) implementation monitoring, 2) effectiveness monitoring, and 3) validation monitoring. Each is defined as follows:

(a) Implementation Monitoring:

Implementation monitoring determines if plans, prescriptions, projects and activities are implemented as specified in the project level environmental document (e.g., EAs). Implementation monitoring answers the question: "Was the required measure performed on the ground as specified in the project environmental document?"

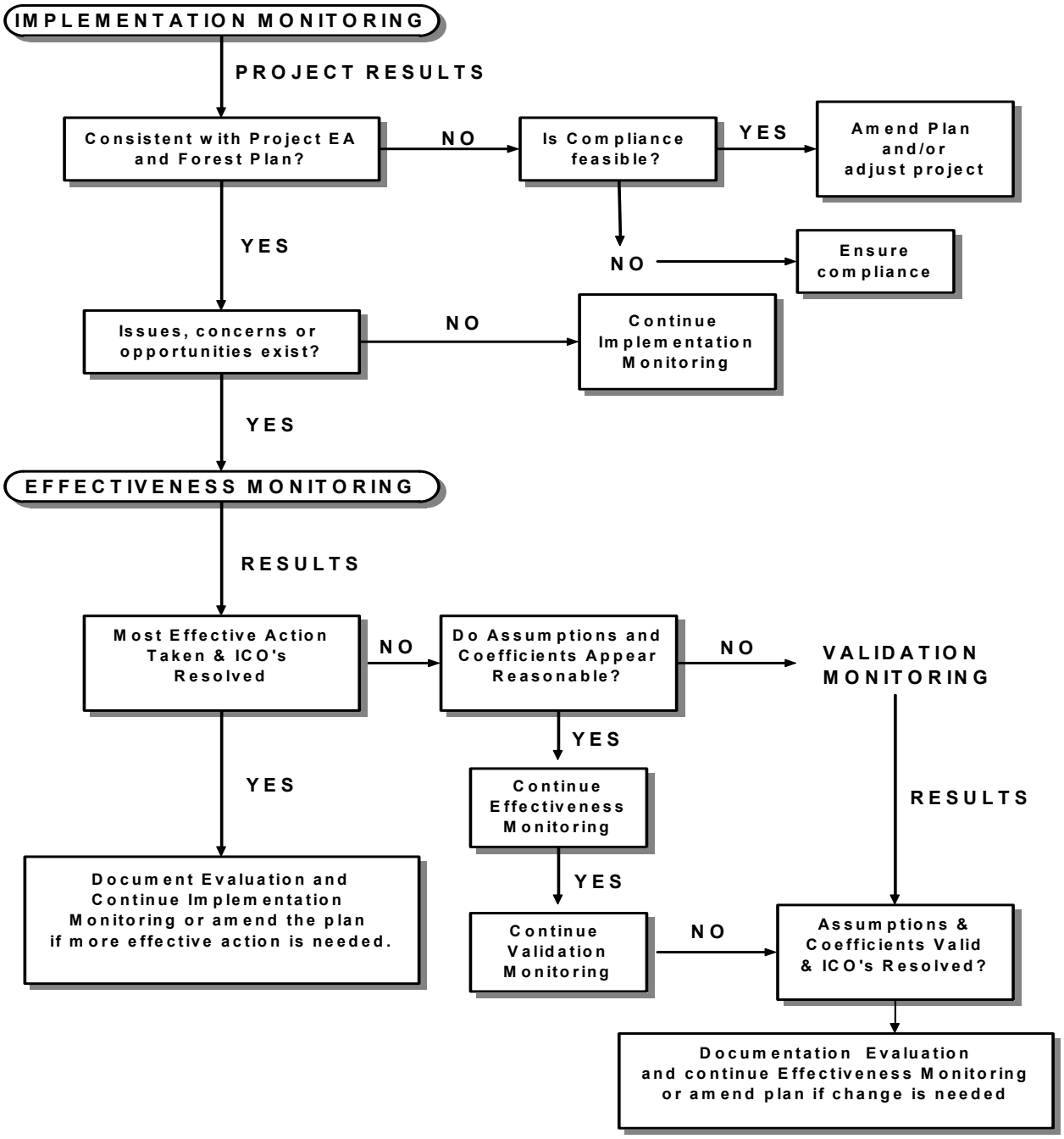
(b)Effectiveness Monitoring:

Effectiveness monitoring determines if prescriptions and management activities meet management direction, objectives, and the standards and guidelines. This level of monitoring is conducted on a limited basis as determined by resource values and risks, and public issues. Effectiveness monitoring is done only after determining that the plan, prescription, project, or activity to be monitored has been implemented according to the plan's direction. Effectiveness monitoring answers the question: "Did the required practice actually work?" If the answer is "yes", no further monitoring need be done. If the answer is "no", the appropriateness of the mitigation must be evaluated. Until that determination is made, other activities in the same watershed may or may not be halted, depending on the characteristics and scope of the problem and its context.

(c)Validation Monitoring:

Validation monitoring determines whether the initial data, assumptions, and coefficients used in development of the plan and required practices are correct; or if there is a better way to meet forest planning regulations, policies, goals, and objectives. Validation monitoring is generally done only when effectiveness monitoring results indicate that a given practice may not be working. The primary exceptions are in fields such as wildlife, where broad population trends must be evaluated. Figure E-1 displays the process for evaluating monitoring results from each monitoring level. There is a direct, sequential relationship between the levels. This relationship is designed to focus initial attention at the implementation monitoring phase.

Evaluation of Monitoring Results for Forest Plan Implementation



b. The Two-Part Approach to Monitoring

A two-part approach to monitoring and evaluation is adopted for the Giant Sequoia National Monument Management plan.

1) Project Monitoring

The major part and centerpiece of the monitoring effort focuses on in-the-field project monitoring.

The District Ranger is responsible for ongoing and post-project review of all projects. All projects are monitored to ensure that prescribed activities were implemented as planned (see Figure E-2, Phase 1). He/she performs implementation monitoring and coordinates effectiveness monitoring. The ranger files a monitoring report on each project that is kept at the district office. Copies are filed in the Supervisor's Office, as well, to facilitate public review of them. Annually the forest management team selects a sample of completed projects drawn from each district to review the management results on the ground (see Figure E-2, Phase 2). Projects are to be selected with an emphasis on soil productivity and water quality. At year's end, the management team reports on both the monitoring effort and on-the-ground results. Evaluation of results and recommendations for Plan amendment, or changes in practices and policies, are made at this time.

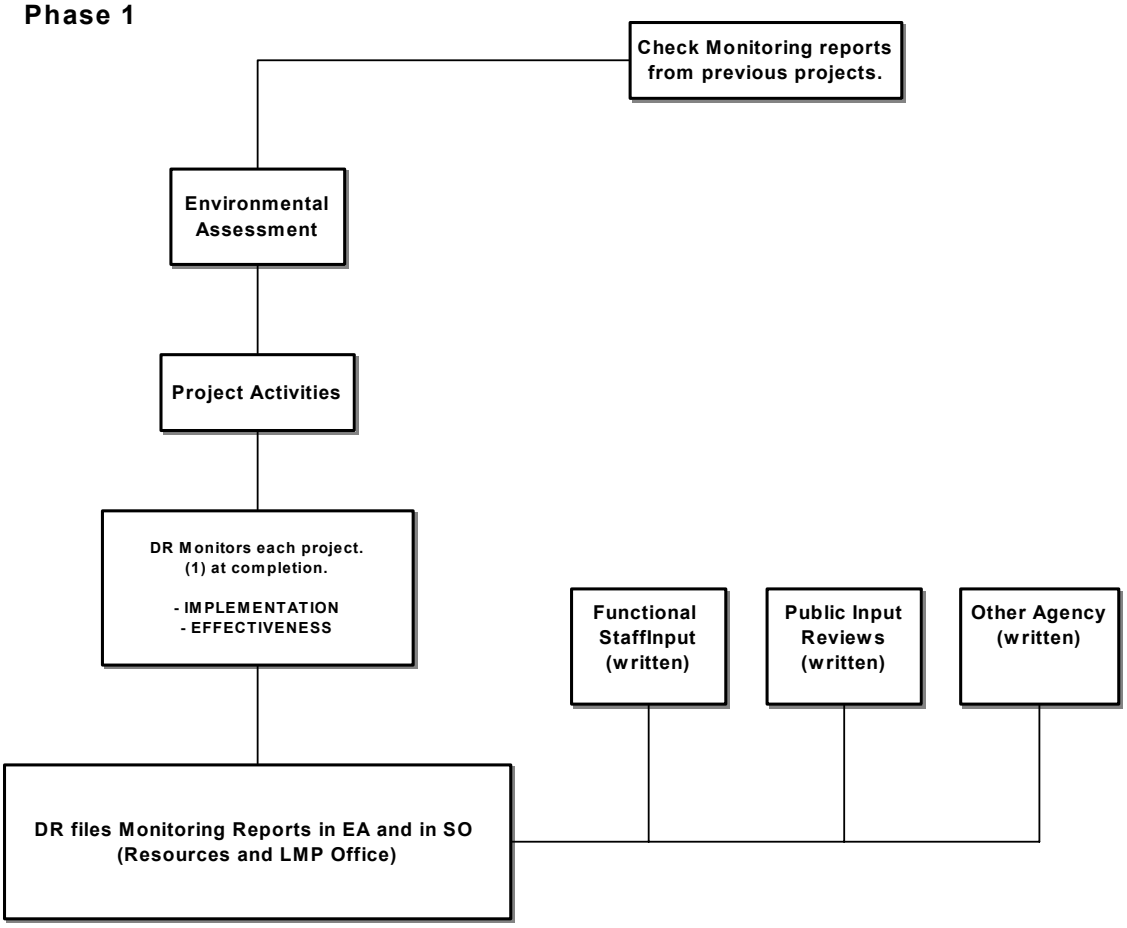
Table G-1 shows in detail those items that shall be monitored as appropriate to a given sample project. The heading "Assessment Process" identifies the monitoring process to be followed at each of the three phases of monitoring. Precision is the exactness or accuracy of measurement techniques. Validity is the expected probability that information acquired through sampling will reflect actual conditions. Both precision and validity are qualitatively rated as high, moderate, or low. The expected accuracies for precision and validity levels are:

Level of Precision/Validity	Expected Accuracy
High (H)	Within + 10%
Moderate (M)	Within + 33%
Low (L)	Within + 50%
N/A	Cannot be established.

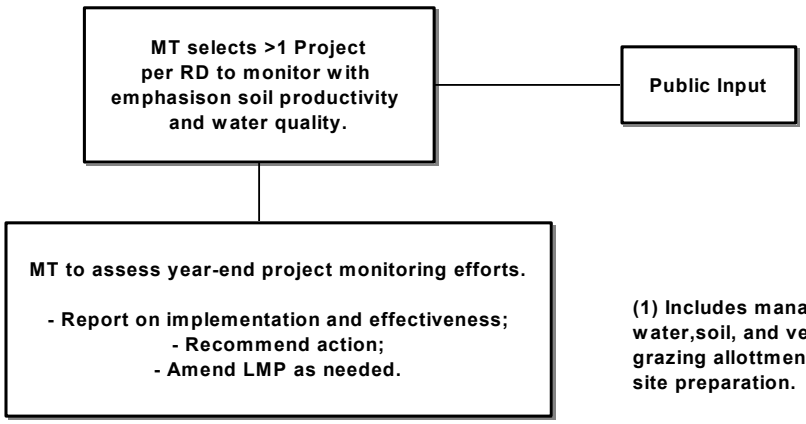
Minimum monitoring frequency specifies how often and at what sample size the assessment will be made. The responsible staff is, in each case, the member of the forest management team who is responsible for the assessment. The standard indicating further action is the "trigger" for further monitoring procedures. Estimated average annual costs are shown for each assessment process. If a practice is already part of ongoing forest management and thereby already budgeted, it is labeled "SOP" for "standard operating procedure".

Diagram of Two Phases of Monitoring

Project Monitoring (100% Projects)
Phase 1



LMP Monitoring (Sample of Projects)
Phase 2



(1) Includes management activities affecting air, water,soil, and vegetation such as timber sales, grazing allottment management, fuels management, site preparation.

2) Program Monitoring

The second part of the monitoring process responds to the need to monitor some aspects of the program on a landscape or forest-wide basis (see below). The following results of this monitoring will occur:

- Improve our ability to develop cost-effective program.
- Implement our plans.
- Gain efficiency and consistency in achieving our agreed-upon objectives.
- Carry out congressional direction.

5. Monitoring Objectives and Approach

The following section lists the monitoring objectives and approaches by resource area. It describes the required monitoring with the scale, frequency, precision and validity, responsible staff, and estimated annual cost.

Table G-1: Specific Monitoring Items

1. Vegetation – Landscape and Stand/Project Level					
Monitoring Objective: Determine the status and change of the following key ecological attribute in the giant sequoia-mixed conifer, brush, and hardwood ecosystems: tree sizes and/or ages of vegetation; species composition; gaps.					
Assessment Process	***Expected Precision/Validity***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost/yr***
Implementation Perform Integrated Inventory and Monitoring data collection and other monument-wide or landscape level inventories to identify change in status of key ecological indicators and other attributes. Stratify data collection for specific stands as needed for special areas such as giant sequoia groves, communities, or key wildlife habitat. Collect and store data in forest-wide databases.	M/H	Annually, in conjunction with of each completed project and/or Landscape Analyses	District Rangers, Forest Ecosystem Management Officer, and Fire Management Staff Officer	Identification of data gaps in post-project data collection or in landscape analysis, sufficient to quantify changes in existing conditions or changes in landscape trends. .	$3,000
Effectiveness **Determine if changes resulting from prescribed activities created desired changes in forest structural characteristics. Evaluate both quantified changes in acreages treated and overall trends.**	M/M	5 years	Forest Ecosystem Management Officer and Fire Management Officer	Data analysis indicates that conditions are not trending toward desired future conditions.	
Validation Evaluate the following: projections and assumptions made in EIS, accuracy and validity of data describing existing conditions, desired conditions, and modeling protocol.	L/H	5 years	Forest Ecosystem Management Officer and Fire Management Officer	Significant discrepancies in predicted effects vs. quantified effects.	

2. Fire and Fuels – Landscape and Project Level					
Monitoring Objective: Determine the reduction in fire susceptibility in stands treated by fuels reduction projects. (Data collected at the project scale will be input to FLAMMAP modeling to measure status and change of this objective at the landscape level).					
Assessment Process	***Expected Precision/Validity***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost/yr***
Implementation Perform Integrated Inventory and Monitoring data collection to identify current status of key ecological indicators and other attributes. Stratify data collection from projects for specific stands as needed for special areas such as communities or special resource features. Determine whether or not prescribed activities were implemented consistent with project requirements.	M/H	In conjunction with Landscape Analysis and associated projects	District Ranger	When project-level changes in fuel loadings do not meet expected reductions in fire susceptibility.	**$2,700**
Effectiveness Determine fire susceptibility using analytical tools (such as FLAMMAP modeling) and other methods to determine fire susceptibility. Document and track fire susceptibility at the landscape or Monument scale.	M/M	Every 5 years	Forest Fire Management Officer	When trends in treated landscapes do not meet expected trends in desired fire susceptibility conditions (reduce areas of high and moderate to low over 30 to 40 percent of the landscape).	$2,700
Validation Review assumptions that went into projections for changes in fire susceptibility, including computer modeling, treatment methods, and desired conditions.	M/H	5 years	Forest Fire Management Officer	Modeling projections are different from predicted effects.	$2,000

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Assessment Process	***Expected Precision/Validity***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost/yr***
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Validation Review assumptions that went into projections for changes in fire susceptibility, including computer modeling, treatment methods, and desired conditions.	M/H	5 years	Forest Fire Management Officer	Modeling projections are different from predicted effects.	$2,000

4. Air Quality – Project Scale					
Monitoring Objective: To detect smoke impacts (public nuisance or health standards) contributed by prescribed fire in smoke-sensitive areas.					
Assessment Process	***Expected Precision/Validity***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost/yr***
Implementation Determine if all projects exceeding 250 acres in size received complete monitoring.	H	Annually	Forest Fire Management	Less than 100% compliance	$2,000
Effectiveness Ambient instrumentation and plume tracking	M	By project	Forest Fire Management and Air Program Manager	* 150 mg/m3 24 hour health * 30 ug/m3 hourly nuisance * 30 ug/m3 hourly validity	$20,000
Validation Examine data in consultation with PSW	H	Bi-annually	Forest Air Program Manager	Any project not maintaining effectiveness guidelines	$10,000

5. Air Quality – Bioregional Scale					
Monitoring Objective: To determine the status and trend of emissions and air quality conditions associated with prescribed fire, wildfire, and wildland fire use in the Monument.					
Assessment Process	***Expected Precision/Validity***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost/yr***
Implementation Determine if the Sequoia National Forest accomplished monitoring as needed to allow Framework monitoring program the ability to characterize smoke trends.	H	Annually	Forest Air Program Manager	If data within the Monument and forest do not allow the Framework monitoring to detect changes of 10% in smoke sensitive areas at 90% confidence level.	$2,000
Effectiveness Sierra-wide network of IMPROVE monitors with analysis of organic carbon, CALPFIRS emissions tracking, Wildfire Emissions Estimation System	M	I MPROVE – every third day CALPFIRS – annually EES - annually	Forest Air Program Manager	IMPROVE- 5% increase in light extinction for Rx fire seasonal values or in annual average values above the 2001 baseline attributed to organic carbon	$10,000 for Monument portion
Validation Examine data with PSW	H	Bi-annually	Forest Air Program Manager	Discrepancies between emissions tracking and trends in organic carbon	$10,000

6. Caves					
Monitoring Objective: To determine the nature and scope of changes to caves and associated resources.					
Assessment Process	***Expected Precision/Accuracy***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost***
Implementation Inventory and survey caves to determine the general condition of caves and their resources. Determine if cave resources were considered in landscape analyses and project NEPA documents, and that approved project mitigation measures were used to protect cave resources, if appropriate.	M/M	Post-project	District Ranger	Cave resources were not inventoried and/or properly considered in landscape analyses and project environmental assessments.	To be determined
Effectiveness Inventory special cave features where specific mitigation measures were used to protect those features (cave entrances, etc.) Determine if project mitigation measures were effective to protect cave resources.	M/M	After each project	District Ranger	If mitigation measures are not effective or if post-project effects indicate that mitigation measures were not properly designed.	To be determined
Validation Determine if caves are unaffected by management activities because of their approximate location to management activities and assumptions in effects analysis.	M/M.	Every 3 years	District Ranger	If caves deemed unaffected by management activities are affected, modify analysis model for future projects and/or activities.	To be determined

7. Aquatic Resources (Channel Stability, Riparian Health, Fish Habitat, Herpetofauna, Water Quality/Quantity and Flow)					
Monitoring Objective: To assess the current status, distribution, and location of aquatic species and aquatic species habitat and become aware of any changes to aquatic species and aquatic species habitat from natural (wildfire, floods, etc.) or management induced disturbances					
Assessment Process	***Expected Precision/ Accuracy***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost***
Implementation Perform Hydrologic Condition Assessment at the Watershed Scale to identify current status of Aquatic resources and habitat conditions	M/M	Every 5 years	District, Forest EM Staff	Identification of data gaps in required surveys or species/habitat conditions.	$4,200 per site
Perform all required habitat inventory, stream surveys condition evaluations, cumulative effects analysis and watershed/fisheries improvement inventories at the landscape level.	M/H	Every 5 years	District, Forest EM Staff	Inventories and/or analysis indicate reason for concern or presence of special species.	
Implement Stream Condition Inventory, Riparian Vegetation Plots, Identify presence or absence of life stages, perform BMPEP surveys	H/H	Prior to ground-disturbing activity	Forest EM Staff	Project Implementation would prompt evaluation of change and effectiveness of protection measures	
Effectiveness Determine if hydrologic condition assessment identify aquatic resources and habitat conditions necessary to support landscape analysis. Determine if inventory and assessment plots were placed in a location sensitive to disturbances.	M/M	Project Analysis	District	**Unexpected species and or habitat conditions are present and not identified prior to project implementation and or planning.**	$4,200 per site
Determine if all pre project surveys were performed commensurate with required protocol. Evaluate results for consistency against existing database information and local knowledge. Determine if evaluations and analysis is effective in identifying potential problems, resource conflicts or targeting mitigation responsive to concerns relative to aquatic habitat, species and/or water quality.	M/H	Project Analysis	Forest EM Staff	Inconsistent results that depart from identified trends and relationships	
Determine if there was a post project change in stream conditions, Macro-invertebrate community diversity, and water quality. Determine if BMPs are effective in protecting aquatic resources and water quality.	H/H	1-3 years	Forest EM Staff	Disequilibria (aggradation or degradation) conditions noted in habitat. Ineffective water quality protection measures	
Validation **Determine if habitat is correctly assigned. Determine if cumulative effects are correctly and reasonably evaluated. Determine if assumptions used to formulate riparian conservation strategy, habitat capability and stream stability are achieving Forest Plan and Framework objectives.**	M/M	Dependent on Effectiveness Results	Forest EM Staff	When assessment tools, riparian conservation strategy, cumulative effects analysis, etc. fail to predict effects to aquatic habitat, and water quality, quantity, and flow.	Variable

8. Soils and Geology

Monitoring Objective: To assess the current status, distribution, and location of soil resources, lands of unstable character, and assure that soil productivity is maintained while protecting these resources from catastrophic fire.

Assessment Process	***Expected Precision/ Accuracy***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost***
Implementation					
Perform Hydrologic Condition Assessment at the Watershed Scale to identify current distribution of soil complexes and location of unstable lands Identify lands sensitive to treatment through application of 4th order Ecological Unit Inventory.	M/M	Evaluate every 5 years	Province soil scientist & District staff	Identification of data gaps in soil surveys or slope stability.	$30,000/5 years
Perform all required cumulative effects analysis and soil inventories at the landscape level.	M/H	Evaluate every 5 years	Province soil scientist & District staff	Inventories and/or analysis indicate reason for concern or presence of instability.	Unknown
Implement soil quality monitoring protocol along with implementation of soil and water quality monitoring surveys (BMPEP).	H/H	In response to projects	Forest EM staff	Project Implementation would prompt evaluation of change and effectiveness of protection measures	$2,500 per site
Effectiveness					
Determine if Hydrologic Condition Assessment identify erosive soils and unstable lands. Determine if inventory and assessment plots placed in a location sensitive to disturbances.	M/M	1-3 years post-project	Province soil scientist	**Unexpected conditions are present and not identified prior to project implementation and or planning.**	Unknown
Determine if all pre project surveys performed commensurate with required protocol. Evaluate results for consistency against existing database information and local knowledge. Determine if evaluations and analysis is effective in identifying potential problems, resource conflicts or targeting mitigation responsive to concerns relative to soil quality, slope stability, and water quality.	M/H	Project level analysis	District	Inconsistent results that depart from identified trends and relationships	Unknown
Determine if there was a post project change in slope stability, soil quality, and water quality. Determine if BMPs are effective in protecting soil and water resources.	H/H	1-3 years post-project	Forest EM staff	Disequilibria (displacement or deposition) noted in soil resources. Ineffective soil and water quality protection measures	$1,500 per site
Validation					
Determine if cumulative effects are correctly and reasonably evaluated. Determine if assumptions used to formulate soil quality standards are achieving Forest Plan and Framework objectives.	M/M	Dependent on Effectiveness Results	Forest EM staff	When assessment tools such as the cumulative effects analysis, etc. fail to predict effects to soil quality and stability.	Variable

9. Erosion					
Monitoring Objective: To assess the current status, distribution, and location of mass movements, slope failures, depositional features are identified and mitigated prior to management. To maintain existing condition of these areas and not increase their frequency, remobilize and stabilized sites, or create new sites.					
Assessment Process	***Expected Precision/ Accuracy***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost***
Implementation Perform Hydrologic Condition Assessment at the Watershed Scale to identify current distribution mass movement, zones of geologic unstable lands sensitive to treatment through application of 4th order Ecological Unit Inventory.	M/M	Evaluate every 5 years	Province Geologist	Identification of data gaps in geologic surveys.	Unknown
Perform all required cumulative effects analysis and geologic assessment at the landscape level.	M/H	Evaluate every 5 years	Province Geologist and District staff	Inventories and/or analysis indicate reason for concern or presence of geologically active or potentially active areas.	Unknown
Implementation of soil and water quality monitoring surveys (BMPEP).	H/H	Post-project	Forest EM staff	Project Implementation would prompt evaluation of change and effectiveness of protection measures	$1,000 per site
Effectiveness **Determine if Hydrologic Condition Assessment identified geologically unstable lands.**	M/M	1 to 3 years post-project	District	Unexpected conditions are present and not identified prior to project implementation and or planning.	Unknown
Determine if all pre project surveys performed are commensurate with required protocol. Evaluate results for consistency against existing database information and local knowledge. Determine if evaluations and analysis is effective in identifying potential problems, resource conflicts or targeting mitigation responsive to concerns relative to slope stability and geologic hazards.	M/H	1 to 3 years post-project	District	Ineffective protection measures Land slopes display disequilibria through failure and large-scale deposition.	Unknown
Determine if there was a post project change in slope stability. Determine if BMPs are effective in protecting soil and water resources.	H/H	1 to 3 years post-project	Forest EM staff		$1,000 per site
Validation **Determine if cumulative effects are correctly and reasonably evaluated. Determine if assumptions used to formulate slope stability criteria are achieving Forest Plan and Framework objectives.**	M/M	Post-project dependent on effectiveness results	Forest EM staff	When assessment tools fail to predict unstable lands.	Variable

10. Fire					
Monitoring Objective: To assess the current status, distribution, and location of past fires, fire susceptibility and pre and post treatment conditions from natural, man-caused, or management induced fires.					
Assessment Process	***Expected Precision/ Accuracy***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost***
Implementation Perform Hydrologic Condition Assessment at the Watershed Scale to identify current distribution, status and location of past fire, fire susceptibility and fuels loading.	M/M	Landscape Analysis	SO EM & District	Identification of data gaps in geologic surveys.	
Perform all required cumulative effects analysis to include natural, man-caused, and management induced fire.	M/H	Project Analysis	District Ranger	Inventories and/or analysis indicate reason for concern based on intensity, amount or timing of proposed management activity	
Determine if burn plans consider slope stability, soil and water concerns and provide a process for post project monitoring of Best Management Practices and Soil Quality Standards.	H/H	Project Analysis	District Ranger	Project Implementation would prompt evaluation of change and effectiveness of protection measures	
Determine if post project monitoring for soil quality standards and water quality standards (through the BMPEP) were implemented post treatment.	H/H	1-3 years after project	SO EM		
Effectiveness **Determine if those areas treated were identified in Hydrologic Condition Assessments**	M/M	Project Analysis	SO & District	Treatment of areas not identified in Hydrologic Condition Assessments.	
Determine if fuels projects considered natural resource related values, identified potential problems, resource conflicts and provided mitigation responsive to identified concerns.	H/H	Landscape Analysis	SO & District	Unacceptable impacts to natural resources. Unacceptable impacts varies by resource and area (e.g. 20% disturbance in Riparian Conservation Area)	
Determine if BMPs are effective in protecting soil and water resources and soil quality standards effective in. protecting soil resources.	M/H	1-3 years after project	SO EM	Ineffective protection measures	
Validation Determine if assumptions used to formulate fuels management projects and prescribed burning are achieving and Framework objectives and the impact of wildfires on natural resources are reduced.	M/M	1-3 years after project	SO Fire	No change in fire intensity from un-planned ignitions.	

11. Flooding Frequency					
Monitoring Objective: To assess the past and present flood history, health, stability, frequency and physiographic bankfull relationships of riparian and wetland resources.					
Assessment Process	***Expected Precision/ Accuracy***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost***
Implementation					
Perform Hydrologic Condition Assessment at the Watershed Scale to identify current distribution, status and location of flooding and bankfull relationships of channels.	M/M	Annually	Forest EM staff	Identification of data gaps.	$10,000 per year
Determine if stream systems are capable of moving bedload and sediment without causing channel alterations and damage to riparian and wetland resources.	M/H	In response to flood events	Forest EM staff	Inventories and/or analysis indicate reason for concern system displaying indicators of an unbalanced condition post project. (Aggradation/degradation as seen in changes in channel cross-sections).	Unknown
Determine if post flood monitoring for riparian and wetland damage is implemented and documented in Forest Watershed Improvement Inventory Database.	H/H	In response to flood events	Forest EM staff	Site investigations provide indications that flows have exceeded bankfull causing channel alteration.	Unknown
Effectiveness					
Determine if those areas flooded were identified in Hydrologic Condition Assessments	M/M	In response to flood events	Forest EM staff	**Past floods are not identified in Hydrologic Condition Assessments.**	Unknown
Determine extent of impacts to resources	H/H	In response to flood events	Forest EM staff	Departure from 1.5-year return interval post project. Channel cross-sections indicate stream system is out of equilibrium.	Unknown
	M/M	In response to flood events	Forest EM staff		
Validation					
Determine if regional bankfull relationships are accurate.	M/M	Dependent on effectiveness results	Forest EM staff	Determine if the 1.5-year return interval for flooding (Bankfull return interval)	Unknown
Determine if assumptions used to formulate flooding potential on life, property, or natural resources are reduced or avoided.		Dependent on effectiveness results	Forest EM staff	Post treatment of landscape results in flooding and damage to life, property or resources.	Unknown

12. Wildlife					
Monitoring Objectives: 1) To assess effects of management on fisher and provide for adaptive management, **2)** To assess the change in acres of late seral/old growth habitat.					
Assessment Process	***Expected Precision/ Accuracy***	***Minimum Monitoring Frequency***	***Responsibility***	***Guidelines Indicating Further Action***	***Cost***
Implementation * Determine if project standards and guidelines, management requirements, or mitigation measures relevant to protection of fisher habitat and late seral stage old growth habitat were properly designed and implemented. * Determine if pre- and post-project surveys of suitable fisher habitat and/or late seral stage old growth habitat were conducted to establish occupancy, and identify and protect important habitat elements and structures such as canopy cover, downed logs, snags, and clumps of large trees.	H/H	Each project within suitable habitat	District Ranger	Insufficient application of standards and guidelines or lack of proper development of S&Gs for inclusion into NEPA document or contract.	$5,000
Effectiveness * Determine if vegetation treatments affected fisher use of treated areas as predicted in the project environmental document (if applicable). * Determine if vegetation treatments retained sufficient habitat for fishers as predicted and described in the project environmental document. * Compare pre- and post-treatment fisher habitat to determine changes in fisher use.	M/M	Each project within suitable habitat	Forest Wildlife Biologist	Monitoring review indicates that: 1) project designs and predicted effects are inconsistent with actual habitat changes and population use for species of concern, or 2) forest standards and guidelines that address pace and/or design of treatments do not adequately protect use and/or habitat of species of concern.	$10,000
Validation * Conduct a peer review of completed projects and their associated monitoring results (both habitat changes and changes in use). Evaluate effects modeling protocol to ensure most current science is considered. Also evaluate the results of radio telemetry studies of fisher in response to vegetation treatments in the Kings River Demonstration Project.	M/M	Ongoing research	Forest Wildlife Biologist	Peer review indicates a need to update management strategies to ensure protection and sustainability of old forest-dependent species.	$30,000