APPENDIX E - TABLE OF CONTENTS

Appendix E –
Adaptive Management Strategy

EXECUTIVE SUMMARY

1. Introduction

1.1. Adaptive Management

The Sierra Nevada Framework Project seeks to ensure the biological integrity and ecological sustainability of multiple ecosystems on Forest Service lands in the Sierra Nevada. Sustainability is defined here as "development or resource use that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987; see also Hunsaker et al. 1999). Strong economies are dependent on healthy ecosystems to provide the basic services and functions upon which societies ultimately depend (Lubchenco et al. 1991, Perring 1995, Costanza et al. 1997).

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. 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 ecosystem dynamics and foretell their trajectories even more challenging (Gunderson et al. 1995). Uncertainty will always be a part of the management of ecosystems, and adaptive management provides a mechanism by which uncertainty can become, "the currency of decision making instead of a barrier to it" (Walters 1986).

1.2. Monitoring Requirements

Establishment of monitoring and evaluation plan requirements is one of the 6 decisions made in a Forest Plan (Table E-1). Forest Plan monitoring and evaluation is conducted to determine how well objectives established in the Plan have been met and how closely management standards and guidelines have been applied. The National Forest Management Act (1976) regulations (36 CFR 219) provide guidance on the monitoring and evaluation requirements to be included in the Forest Plan. Monitoring strategies are to contain implementation, effectiveness, and validation monitoring activities (Forest Service Manual 1922.7, MacDonald et al. 1991, Noss and Cooperrider 1994). Implementation monitoring determines if plans, prescriptions, projects, and activities are implemented as designed and in compliance with Forest Plan objectives and requirements. Effectiveness monitoring determines if plans, prescriptions, projects, and activities are effective in meeting management objectives, standards, and guidelines (Ibid). This type of monitoring has stated specific objectives and questions that monitoring is designed to answer. Validation monitoring is designed to ascertain whether initial assumptions and coefficients used in development of the Forest Plan are correct or if there is a better way to meet Forest planning regulations, policies, goals, and objectives (Ibid). This type of monitoring determines if the initial data, assumptions, and coefficients used in the development of a management plan were correct.

Table E-1. The six decisions made in a Forest Plan.

DECISIONS
Multiple-use goals and objectives
Forest-wide management requirements, standards and guidelines
Management areas and management area direction
Suitable timberland and ASQ
Non-wilderness allocation and wilderness designation recommendations
Monitoring and evaluation requirements

The new planning regulations (36 CFR 219) call for the development of a monitoring plan in association with the development, revision, or amendment of a Land Management Plan. The new planning regulations emphasize ecosystem sustainability, and place greater emphasis on evaluating resource conditions and monitoring trends over time. As noted by the Committee of Scientists (COS 1999), "monitoring procedures need to be incorporated into planning procedures and should be designed to be part of the information used to inform decisions. Adaptive management and learning are not possible without effective monitoring of actual consequences from management activities." Under the new rule, monitoring and evaluation will be used to determine if actions are being implemented in accordance with applicable plan direction; if the aggregated outcomes and effects of actions are sustainable and are achieving desired conditions; if key assumptions underlying management direction are valid; and if plan or site-specific decisions need to be modified. Further, monitoring and evaluation are expected to aid in identification of new topics of general interest or concern, the development of new assessments, and the selection process for site-specific projects. These monitoring and evaluation requirements will provide important feedback information that would continuously link planning to plan implementation. Under the new planning rule, a national forest or grassland, like a business or other large organization, would always be ready to respond quickly to new information or changed conditions.

The SNFP monitoring plan requires reliable, geographically comprehensive information on status and trends ecosystem condition, and the effectiveness of management activities at the Sierra Nevada-wide scale. Many forest level monitoring plans identify monitoring information needs that cannot be obtained at the scale of a single national forest. These often include data on the status, trends, and viability of a wide-ranging species or the characteristics and trends the fire regime at the landscape or subregional level. Through this multi-forest monitoring plan, the Forest Service will be able to address information needs identified by this EIS. The results of the proposed monitoring will inform decision-making through adaptive management at the Forest and bioregional scales.

1.3. Historical Context

A relatively recent GAO (1997) review of National Forest Service monitoring planning and accomplishments promoted monitoring as a means to improve the decision-making process; however, they found the Forest Service remiss in their monitoring obligations. The review identified that the Forest Service 1) has historically given low priority to monitoring during annual competition for scarce resources; 2) continues to approve projects without an adequate monitoring component; 3) generally does not monitor the implementation of its plans as regulations require; and 4) has a difficult time reconciling the administrative boundaries of the National Forests with boundaries of natural ecological systems.

The desire for a comprehensive and standardized monitoring strategy for the Sierra Nevada National Forests was prompted by the California Spotted Owl (CalOwl) Environmental Impact Statement

(EIS) drafted in 1995 and was scheduled to be re-released as a revised draft in 1996. The beginnings of a monitoring plan were to be published in the revised draft EIS. In 1996, release of the RDEIS for public comment was deferred to accommodate its review by a scientific committee chartered under the Federal Advisory Committee Act (FACA), named the California Spotted Owl Federal Advisory Committee (the Owl Committee). The Owl Committee was chartered to review the RDEIS to assess if all available scientific information, including the recent SNEP Report, was adequately considered in the analysis.

The Owl Committee issued a number of findings and recommendations, including some that pertained to monitoring and adaptive management. The Owl Committee found that, lacking full development and description in the EIS, "the monitoring plan could be strengthened by a more detailed consideration and explanation of the process by which the detailed monitoring plan will be developed and some indication of the measures that would be tracked." The Owl Committee also stressed the importance of the "consideration of how and what monitoring information will be fed back into the management process. How can the relevant institutions ensure rapid processing and management of monitoring data? What organizational structures need to be established to ensure that managers are informed of monitoring results? By what decision criteria will data be used to modify management practices?" The Owl Committee concluded that the Region should consider implementation of adaptive management processes that help assure appropriate shifts in direction based on new information, improved techniques, monitoring feedback, and public values. They further stated that adaptive management should include specific consideration for project design that facilitates learning from management actions.

The original Sierra Nevada Framework Project proposal requires a monitoring plan and adaptive management strategy, developed concurrently with the development of proposed new management direction. As with the RDEIS of 1996, the monitoring team consisted of both National Forest System and Forest Service Research employees. The details of the monitoring plan and adaptive management strategy are provided here.

2. Conceptual Basis for Adaptive Management

2.1. Existing Foundation

Past monitoring efforts provide valuable information relevant to the development of large-scale monitoring strategies (e.g., NRC 1994, 1995, Noon et al. 1999). To date, there are few examples of scientifically credible large-scale multi-resource monitoring plans that have been developed, implemented, and validated (Noon et al. 1999). Large-scale monitoring efforts were developed and implemented for the Northwest Forest Plan (re: managing late-seral forests and aquatic-riparian ecosystems in the Pacific Northwest). These efforts are newly completed, and in some cases still in progress, and our ability to learn form these efforts is limited to reviewing their approaches and incorporating innovations where relevant. The U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) is a rare example of a large-scale multi-resource monitoring effort that has been implemented. It strengths and weaknesses have been assessed in great detail (NRC 1994, 1995), and these assessments provide a valuable source of information on how to proceed with meeting similar monitoring objectives.

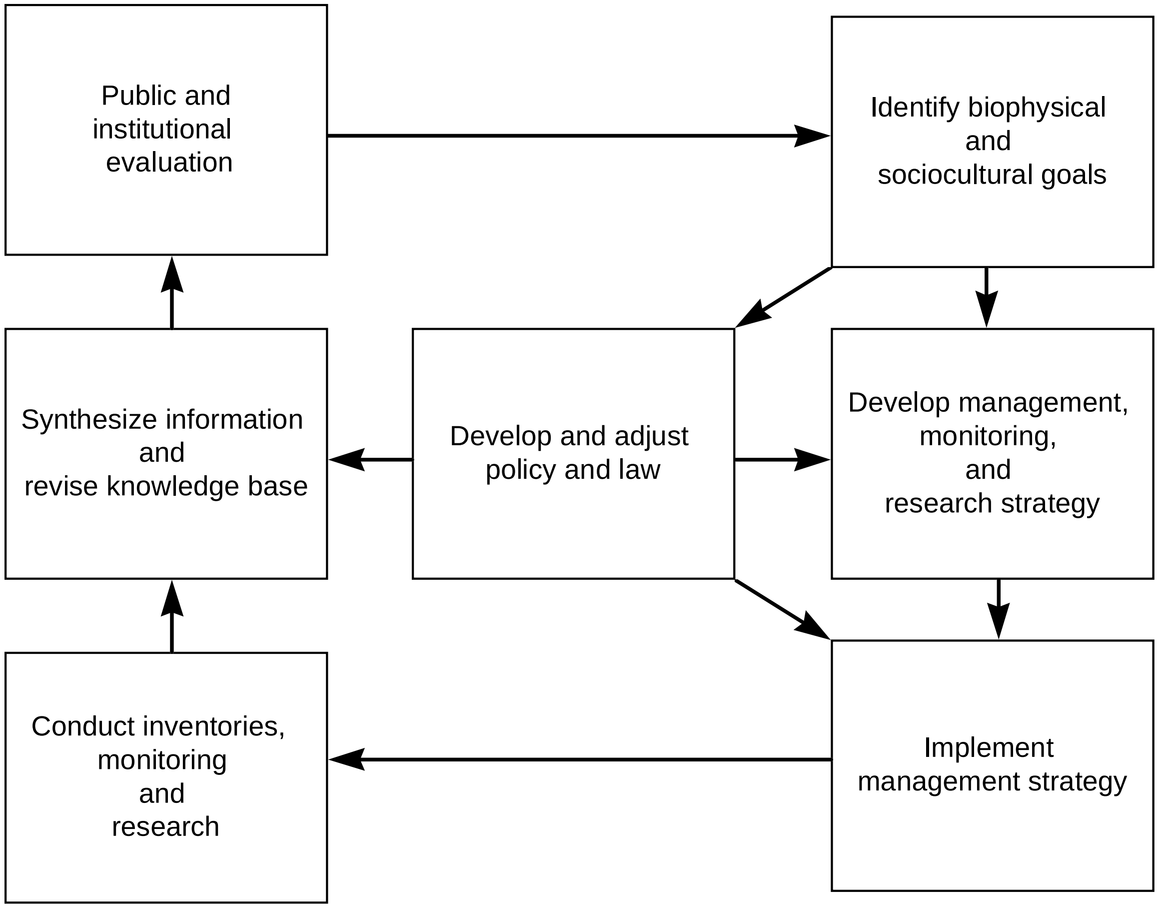
2.2. Adaptive Management Strategy

The SNFP adaptive management strategy is founded on the following six elements, grounded in the works of Barber (1994), Montgomery et al. (1995), and Noon et al. (1999):

1. it will 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;
2. it is based on well-defined questions;
3. it is based on both mechanistic and relational links between observed change and hypothesized causal factors;
4. it contains measures of change that are scale-appropriate, information-rich, and sensitive to management issues of greatest concern; 5) it outlines how monitoring information will be evaluated and interpreted; and 6) it outlines a procedure for responding to monitoring results, including how they will be incorporated into future decision making.

Adaptive management is often portrayed as a cycle; the cycle represents the flow of information acquisition, evaluation, and integration. The adaptive management cycle is portrayed here as a series of steps or stages (Figure E-1) that can be engaged at any point or stage. There is no particular starting point or sequence to the course of knowledge or information through the cycle—some portions of the cycle may be repeated and revisited more frequently than others. Figure E-1 identifies some of the "nodes" in the development of new ideas and their application in a fully integrated adaptive management strategy. Each node represents an investment of time, thought, and resources on the part of participating agencies and the public.

Figure E-1. Adaptive management cycle as constructed for the Sierra Nevada Framework Project.



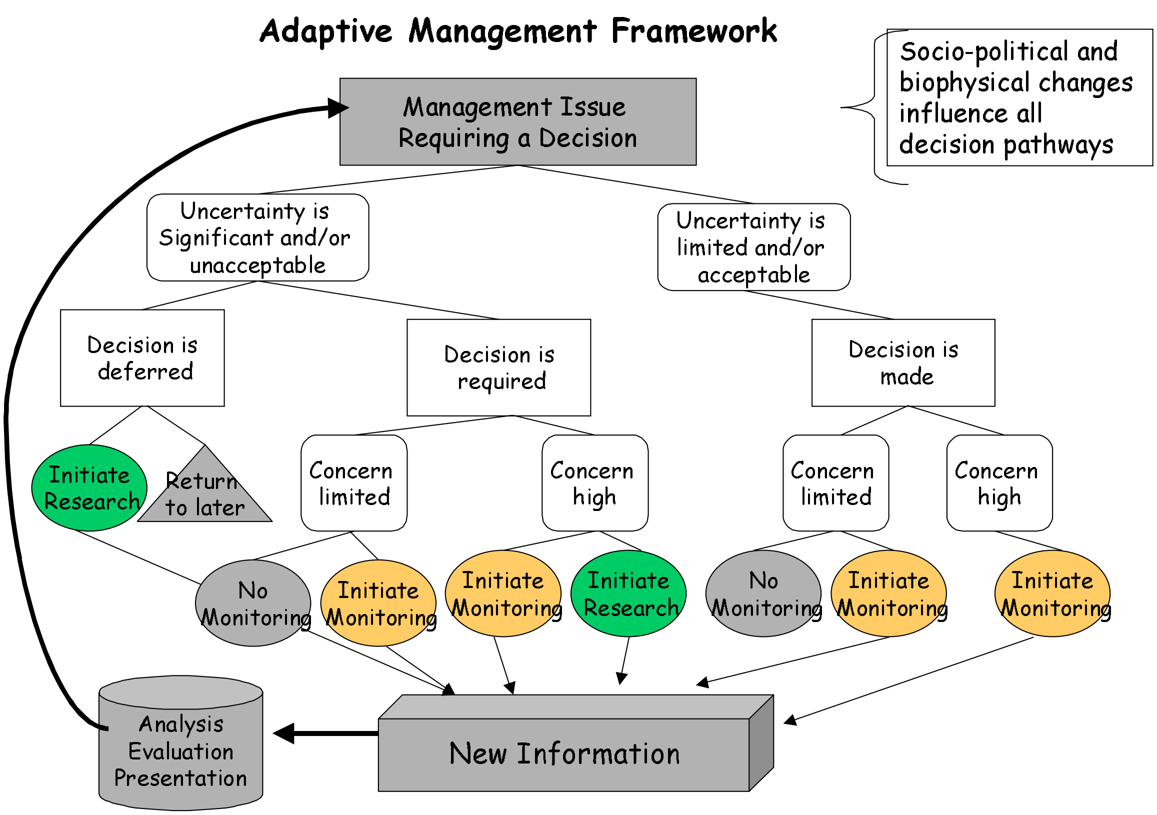
Monitoring and research are our primary mechanisms of information acquisition. Thus, the success of adaptive management is dependent upon a well-designed, adequately funded, and carefully implemented monitoring and research program. Adaptive management is ultimately dependent upon the ability of institutions to integrate new information into management decisions and approaches. New information gain and institutional response can be characterized in one of three ways.

1. **Trial and error learning** occurs when information is gained by chance. No structured information acquisition effort exists, but learning does occur.
2. **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.
3. **Active adaptive management** occurs when new information is pursued through multiple hypothesis testing, with strong reliance on experimentation.

The monitoring strategy incorporates both passive and active adaptive management approaches, as recommended by the Committee of Scientists report (COS 1999). Passive adaptive management approaches are applied primarily in status and change, and management effectiveness monitoring, whereas active adaptive management approaches are applied primarily in validation monitoring.

Uncertainties can create barriers to effective decision-making, particularly where concerns and uncertainties are both high. Figure E-2 depicts the role of adaptive management in managing uncertainty and concern in decision-making. Where uncertainty is relatively low (right hand portion of figure) and concern is high, monitoring is a strong tool for providing assurances that concerns are being addressed. Where uncertainty and concerns are both low, monitoring may or may not be warranted, depending on the situation (e.g., legal requirements may still dictate monitoring). Where uncertainty is relatively high (left hand portion of figure), and yet a decision is required despite high concerns, monitoring and research are effective tools for reducing uncertainty over time and addressing concerns. Where concerns are lower, monitoring alone may be sufficient to address uncertainties and concerns. In some cases, uncertainty is so high that the decision is deferred until a later time when additional, critical information is made available through research. Uncertainty and concern vary among the topic areas and by alternative. The location of each topic area in this decision-making framework is discussed in their individual sections later in the appendix.

Figure E-2. The role of adaptive management in managing uncertainty and concern in decision-making.



2.3. Ecosystem Approach

Monitoring Large-scale Systems

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 (O'Neill et al. 1986). Current scientific thinking recognizes that in order to understand system structure and function it is important to recognize the spatial and temporal scales relevant to the specific ecological process under consideration. System structure and function develop under particular disturbance conditions, and the ability of a system to absorb the effects of a disturbance and maintain system function within a local stability state is a measure of the resilience of a system. Traditionally, human management has resulted in systems that have reduced resilience to change as a result of reductions in spatial and functional heterogeneity (Folke et al. 1996). Humans are recognized as central components within the concept of ecosystem management and sustainability (Manley et al. 1995, Christensen et al. 1996, Folke et al. 1996, Holling and Meffe 1996). These concepts are the initial efforts in developing a balance between meeting human needs, addressing the reality that ecological systems have limits, and recognizing that maintaining system function in perpetuity must be a primary objective of management.

Monitoring is a critical tool for dealing with uncertainty in the management of large-scale systems (Hellawell 1991, Noon et al. 1999). Monitoring at large geographic scales presents many challenges, including identifying clear goals and selecting attributes to monitor based on a thorough evaluation of theory and concepts. Recent reviews of large-scale monitoring plans have identified failures in both process and content. Frequently, monitoring efforts have had poor foundations in ecological theory, little consideration of cause-effect relationships, and inadequate or uninformed approaches to selecting, justifying, and evaluating the specific indicators to monitor (Hellawell 1991, National Research Council 1995, Bricker and Ruggiero 1998, Noon et al. 1999). Monitoring at large geographic scales requires a framework for understanding relationships between components and processes of an ecosystem and the human activities that affect them.

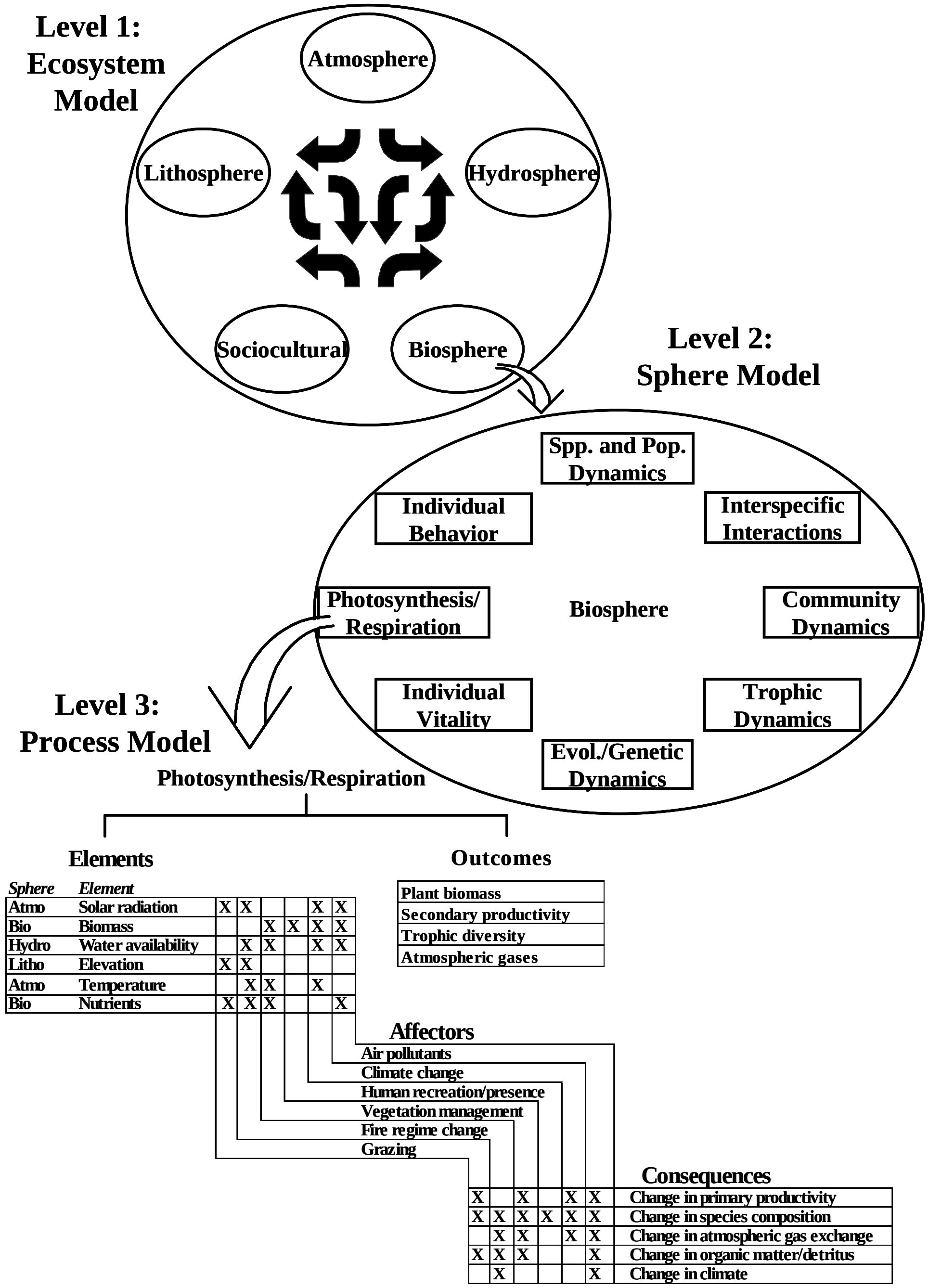
Ecosystem Process Conceptual Model

Conceptual models are increasingly recognized as playing a critical role in defining and documenting our understanding of the form and function of the system to be monitored. We created a conceptual model that is centered on ecosystem processes, considers humans as part of ecosystems, and serves as a framework for selecting attributes for monitoring ecosystems in the Sierra Nevada (Manley et al. 2000). The model has three levels: (1) an ecosystem model that identifies five spheres (Atmosphere, Biosphere, Hydrosphere, Lithosphere, Sociocultural), (2) sphere models that identify key ecosystem processes (Table E-2), and (3) key process models that identify the ‘essential elements’ that are required for the process to operate (e.g., solar radiation), the human activities (‘affectors’) that have negative and positive effects on the elements (e.g., air pollution), and the ‘consequences’ of affectors acting on essential elements (e.g., change in primary productivity) (Figure E-3).

Table E-2. Key processes identified in the Ecosystem Process Conceptual model.

Sphere	Key Processes
Atmosphere	Hydrodynamics Radiative Transfer Transport and Dispersion Chemical Reactions
Biosphere	Photosynthesis and Respiration Individual Vitality Individual Behavior Species and Population Dynamics Interspecific Interactions Community Dynamics Trophic Dynamics Evolution and Genetic Dynamics
Hydrosphere	Infiltration Evapotranspiration Surface Water Movement and Storage Surface Water Chemical Reactions Surface Water Thermal Dynamics Subsurface Movement and Storage Subsurface Chemical Reactions Cryologic Dynamics
Lithosphere	Physical and Chemical Weathering Erosion and Sediment Dynamics Volcanism Tectonics
Sociocultural Sphere	Human Population Dynamics Land and Resource Transactions Economic Activity Human Social Structure Dynamics Technological Innovation and Diffusion Human Communication Dynamics of Attitudes, Beliefs, Values, and Behaviors
(Metaprocesses)	Hydrologic cycling Nutrient cycling

Figure E-3. Illustration of the levels of the Ecosystem Process Conceptual Model.



2.4. Retrospective vs. Predictive Monitoring

For large-scale monitoring efforts, two general approaches have been defined: retrospective and predictive. Retrospective monitoring seeks to detect changes in status or condition. It is based on detecting an effect after it has occurred as the result of including a wide array of attributes in the monitoring program (NRC 1995). This inductive approach is valuable for a variety of management and conservation uses, but is not helpful in understanding why observed changes are occurring. The weakness of retrospective monitoring is that the potential cause of observed changes is often unknown.

Predictive monitoring seeks to detect indications of undesirable effects before they have a chance to occur or become serious (NRC 1995). It focuses on detecting changes expected to result from actions or activities. It assumes a cause-effect relationship between affectors and expected changes, and it is an efficient monitoring approach where there is a high level of confidence in regard to particular cause-effect relationships. The weakness of this approach is that assumptions about cause-effect relationships may be inaccurate, effects may have multiple causes, or unforeseen changes may go undetected.

In this plan, retrospective and predictive monitoring are considered complementary such that a balance of these two approaches, combined with affector monitoring, constitutes a strong approach to monitoring large-scale systems. Integrating predictive, retrospective, and affector monitoring increases the probability of detecting and interpreting important changes in ecosystem sustainability.

3. The SNFP Monitoring Plan

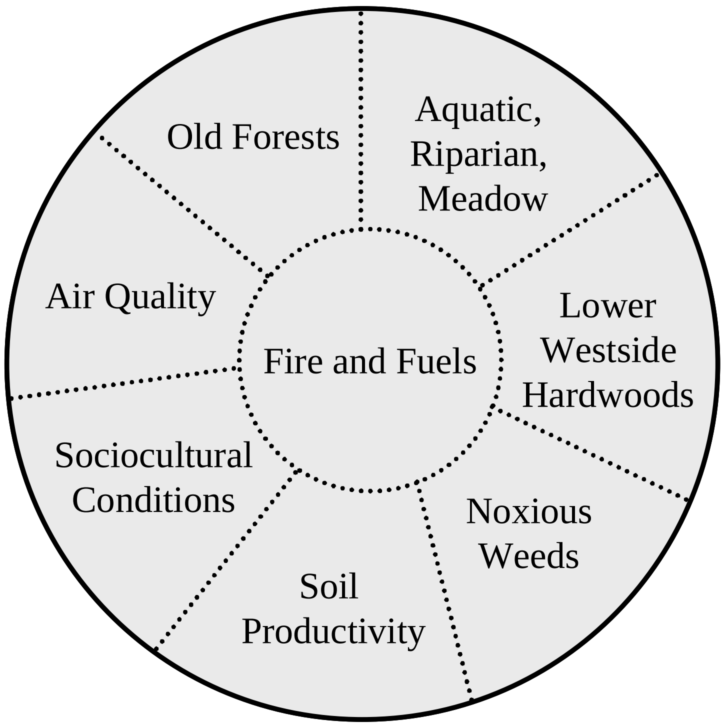
3.1 Primary Topic Areas

The Adaptive Management strategy addresses the five problem areas addressed in the EIS: old forest ecosystems; fire and fuels; aquatic, riparian, and meadow ecosystems; lower westside hardwoods; and noxious weeds. These problem areas are closely linked to three additional topic areas (as determined through the Sierra Nevada Science Review of SNEP USDA 1998] and public scoping): air quality, soil productivity, and sociocultural conditions. The adaptive management strategy identifies questions and attributes for these eight topic areas.

The interrelationship of these eight topic areas is key to understanding their relationship to and importance in the adaptive management strategy. The fires and fuels topic area interfaces with all seven of the other topic areas, and is the primary integrator (Figure E-4). The level of concern regarding threats posed by wildfire and the effects of fire and fuels management on the other topic areas, particularly habitat for species at risk, is the highest among the topic areas. Lower, but still substantial, levels of concern and uncertainty exist within each topic area, and they are addressed in the adaptive management strategy as well.

The interface of fire and fuels management with the other seven topic areas is briefly outlined here. Fire and fuel treatments are intended to reduce the severity and threat of wildland fire, but they have the potential to have detrimental effects on ecosystem conditions (amount and condition of each of the three ecosystems, air quality, soil productivity, and the spread of noxious weeds) and habitat for species-at-risk. Wildland fires can also have detrimental effects on these systems and habitats, and the impacts of wildland fires are expected to change as a result of fire and fuel treatments. Activities related to fire and fuels management, specifically salvage and hazard tree removal, also have the potential to degrade ecosystem conditions (e.g., number of large trees per acre) and habitat conditions for species-at-risk (e.g., snag densities). Restoration activities associated with fire also have the potential to promote the spread of noxious weeds.

Figure E-4. Diagram illustrating the highly interactive nature of the eight topic areas addressed in the adaptive management strategy.



3.2 Monitoring and Research Questions

Management outcomes cannot be assured where there is great uncertainty. Monitoring and research are our primary mechanisms of information acquisition and new understanding. Coupling research and management in a disciplined and transparent adaptive management strategy is the most coherent and efficient means to reduce uncertainty wherever possible. Thus, the success of adaptive management is dependent upon a well-designed, adequately funded, and carefully implemented monitoring and research program. Monitoring describes changes in actions, conditions, and relationships over time and space. Research in support of land management generates new information to address key information gaps in various areas, such as: (1) the fundamental workings of ecosystem processes, (2) the interrelationships of key ecosystem components, structures, and processes, (3) the development and testing of various management approaches, (4) the development and validation of habitat relationships of focal species and species at risk, and (5) the development and validation of ecological indicators, checkpoints and thresholds.

Monitoring questions address three main categories of information needs: implementation, status and change of ecosystem conditions and management activities, and cause and effect relationships between management actions and ecosystem conditions. In addition, we identified a fourth category of questions, research questions directed toward filling key information gaps. The adaptive management monitoring strategy consists of a balance of questions across the categories of questions to form complementary lines of inquiry. The Committee of Scientists suggests that this combination of routine monitoring and active adaptive management is the strongest approach to meeting the scientific information needs of land management. Each category of monitoring is described in more detail below.

Implementation Monitoring

Implementation monitoring records what, when, where, and how management direction has been followed, including legal requirements and agency policies. The objective of implementation monitoring is to determine the degree and extent to which application of standards and guidelines met management direction and intent. Tracking and reporting on implementation of management activities provides a record of accomplishment to the public and documents the extent and distribution of activities conducted by the Forests. Managers can compare the results of implementation monitoring (observed actions) with management direction (expected actions) to assess performance. Managers can respond to results of implementation monitoring quickly, and make necessary changes in management through training and improvements in management approaches and prescriptions. Interagency evaluation of activity implementation at the project level can provide the opportunity for collaborative field review of activities authorized by the EIS. Implementation monitoring is based on the standards and guidelines, as well as existing laws and regulations that must be followed. Implementation monitoring data will provide information on the level of compliance (e.g., exceeded, met, not met, not capable of meeting) associated with each question.

Status and Change Monitoring

Status and change monitoring provides a description of the resources, landscape, sociocultural elements, and management activities of focus in this plan amendment. Status and change monitoring provides information on whether desired conditions are achieved as well as providing an early warning of unanticipated impacts from management or other activities. Status and change monitoring consists of two emphasis areas: (1) condition monitoring, which describes important biophysical and sociocultural conditions to gauge if desired conditions are being achieved, and (2) affector monitoring, which describes management actions plus biological and physical processes that have the potential to rapidly alter sociocultural processes.

In addition to describing the status and trends in conditions and affectors, this monitoring is intended to describe correlative relationships between affectors and conditions to assist in the identification of potential causal factors for observed changes. Implementation and status and change monitoring represent routine monitoring, as defined by the Committee of Scientists (COS 1999), and they serve a critical role in determining if desired outcomes are being achieved. However, they cannot elucidate cause and effect relationships.

Cause and Effect Monitoring and Research

Cause and effect monitoring and research seeks a better understanding of how components, structures and processes respond to management activities, and how ecosystem components interrelate. Cause and effect monitoring and research consists of (1) management effectiveness questions to describe the effect of specific management actions on a desired condition, and (2) validation questions to determine whether assumptions made at any stage of planning or management are sound, particularly assumptions associated with management strategies, desired conditions, and the application of scientific knowledge.

Cause and effect monitoring and research entails testing hypotheses directly related to the effectiveness and underlying bases of management direction and actions. Thus, cause and effect monitoring and research requires careful consideration of the experimental design and analysis of the data to provide meaningful feedback to management. Cause and effect questions were formulated based on key areas of uncertainty and risk associated with management approaches, assumptions, and legal requirements related to the development and implementation of management direction. Cause and effect questions require companion implementation and status and change questions to provide a context for acting on information gained through cause and effect monitoring and research.

Standards and guidelines are a primary focus of cause and effect questions. Standards and guidelines have the force of a legal contract, and will be subject to scientific and legal challenge. But more importantly, the standards and guidelines reflect important assumptions about ecosystem behavior and response. Where there is uncertainty regarding the basis of these assumptions, cause and effect monitoring and research can be applied to reduce uncertainty and lower the risk of unintended negative effects. The level of uncertainty will determine whether the cause and effect question addresses the effectiveness of the standard and guideline as written (uncertainty moderate) or it validates the standard and guideline by testing a range of options to determine the most effective approach.

Given that standards and guidelines reflect important assumptions about ecosystem behavior and response, one of the primary areas of focus for active adaptive management will be reducing uncertainty in the weaker assumptions used as a basis for standards and guidelines. The adaptive management strategy is intended to provide greater assurance that key conservation objectives will be met by prescribed and future management actions. In order to validate the efficacy of some standards and guidelines, flexibility will be required such that a range of treatments or alternative techniques may be applied and evaluated. This flexibility needs to carefully considered, and occur only through well-crafted collaborative efforts between science, management and the concerned public (see Implementation section below).

Filling Key Information Gaps

The complexity of the mosaic of ecosystems in the Sierra Nevada, combined with our relatively immature understanding of these systems, suggests a wide array of information needs. However, this adaptive management strategy focuses upon those issues where the information is most crucial to management. Certain issues requiring a decision now involve high levels of uncertainty where concern over the decision is also high. This combination of conditions, high degree of uncertainty and high degree of concern, suggest a need for prompt attention. For these issues initiation of focused projects to fill information gaps is warranted.

Key information gaps constitute the absence of basic scientific information that is creating a barrier to decision making or creating uncertainty about the foundation of desired conditions. Like cause and effect questions, key information gaps are associated with key areas of uncertainty and risk, but in this case, uncertainties and risks are associated with goals and desired conditions for each problem area, and basic information about the resources being managed. For example, key information gaps would include the habitat relationships of species at risk, the true potential for various fire regimes, the role of fire in contributing to nitrogen deposition in sensitive ecosystems, the historic fire regime, and the validation of existing and proposed focal species as ecosystem indicators. These key information gaps, combined with other uncertainties linked to management direction in the selected alternative, highlight the need for this adaptive management strategy in order to develop new information and reduce uncertainty over time.

Priorities

A carefully considered set of key questions in each of the 4 categories of information was derived through team discussions, interagency meetings, and public scoping. These questions were further reviewed and considered to identify those that had the highest priority to be addressed during the planning period. In sections 6 to 13 below, we present the highest priority questions which will be addressed during the planning period, and we also present the remaining key questions which are recognized as important and will be pursued by the Forest Service or through collaborative efforts if at all possible.

3.3. Attribute Selection

The Conceptual Model served as a tool to facilitate the selection of attributes to answer monitoring questions and consider the key affectors that may be affecting the conditions of interest. We define attributes broadly, in the sense of Noon et al. (1999), as "any biotic or abiotic feature of the environment that can be measured or estimated." We recognize the history of referring to attributes in this sense as "indicators" (Hunsaker and Carpenter 1990, Noss and Cooperrider 1994). However, because many attributes may be species, and the indicator concept has been challenged with regard to species (e.g., Landres et al. 1988), we have avoided the term.

The EPC Model served as a guide to the attributes of processes, essential elements and outcomes that should be considered in a monitoring plan. Candidate attributes were selected from the full suite of attributes identified for key processes in the Ecosystem Process Conceptual determined to be associated with the desired condition. Candidate attributes were viewed as tractable attributes that were "information rich" reflections of conditions based on their associated key processes. Attributes generally consisted of a set of specific descriptors that reflect one or more aspects of the process through direct measures or measures of its elements or outcomes.

Once the candidate attributes were collated for each goal, candidate attributes were rated by five criteria: response time, directness of the measure, existence of monitoring methods, ability to interpret the data, and signal-to-noise ratio (Table E-3). Based on the ratings for these five criteria, we selected attributes that had the strongest overall rating, and sets of attributes that combined were strong across all the criteria.

Table E-3. Criteria used to evaluate candidate attributes for monitoring desired conditions.

		Rating		
Criterion	**Definition**	**Low**	**Moderate**	**High**
Response time	The length of time to detect a response of an attribute to a cause or forcing function and/or to complete its process cycle	Response time is slower than required period of observation (10 years)	Response time moderately matches the period of observation	Response time is sufficiently encompassed by a relevant period of observation or measurement
Direct measure	The relationship between the condition of interest and what the attribute describes	Describes a surrogate or proxy condition that is distantly related to the condition of interest	Describes a surrogate or proxy that is closely related to the condition of interest	Describes the condition of interest
Monitoring methods	Possesses a generally accepted, standardized, and precise measurement method that can be applied on a regional scale	Method is not accepted, standardized, or precise	Method is either accepted and standardized or precise, but not both	Method is accepted, standardized and precise
Ability to interpret	The degree to which results (metrics) have a strong relationship with the condition of the resource, as determined by documented or identifiable thresholds, patterns, or trends	Indirect measures whose relationship with the condition are poorly established.	Indirect measures whose relationship with the condition are well established for some other geographic area.	Direct measures, or indirect measures whose relationship with the condition are well-established
Signal-to-noise ratio	Signal to noise ratio reflects the ability to detect/distinguish change given temporal and spatial background variability of an attribute within a specified period of time	Cannot detect within 10-15 yr time period	Intermediate signal-to-noise ratio	High confidence that change can be detected within 10-15 year period

3.4. Plant and Animal Monitoring

Species Addressed

Species are an integral component of old forest, hardwood, and aquatic/riparian/meadow ecosystems and are essential to their function. Goals and desired conditions for each of the three ecosystems included maintaining habitat sufficient to support viable populations of associated species, with particular emphasis on species-at-risk. Existing regulations guiding compliance with NFMA specify the identification of Management Indicator Species (MIS) for assessment and monitoring as indicators of species diversity and population viability. The new proposed planning regulations closely follow the recommendations of the Committee of Scientists (1999) where MIS are replaced by focal species (i.e., indicators) and species-at-risk for assessment and monitoring. The EIS identified and assessed species-at-risk, as well as some of the MIS identified in one or more of the Land Management Plans of the 10 National Forests. In the adaptive management strategy, we commit to monitoring each MIS, as well as each species-at-risk for which the EIS determined the need for a full viability analysis (Table E-4). Ten species-at-risk are of particular concern: California spotted owl, Northern goshawk, American marten, Pacific fisher, Sierra Nevada red fox, wolverine, foothill and mountain yellow-legged frogs, Yosemite toad, and willow flycatcher. These 10 species receive individual issue treatments under their associated topic areas. In addition, three fish species federally listed as threatened or endangered and they also received individual treatments under the aquatic, riparian, and meadow topic area.

MIS and species-at-risk were assigned to one of the three ecosystems based on their habitat associations, and lists of these species, along with the type of monitoring proposed, are outlined in the

"MIS and Species-at-Risk" issue in each of the ecosystem topic areas. In addition to MIS and species-at-risk, monitoring will address the noxious weed species assessed in the EIS. The list of noxious weeds and the type of monitoring proposed are outlined in the Noxious Weeds topic area.

Table E-4. Species to be addressed through monitoring.

Species group	MIS	Species at risk	Shared	Recovery plan	Total to be addressed
Non-fish vertebrates	29	53	7	5	75
Fish	16	20	9	6	28
Vascular plants	0	143	0	0	143
Invertebrates	0	7	0	0	7
Non-vascular plants	0	4	0	0	4
Lichen	0	1	0	0	1

Focal species were not identified and assessed in the EIS, but when the new planning regulations are enacted, it is clear that the Forests will need to select focal species and address them in planning and monitoring efforts. Ideally, a coordinated effort across Forests would be mounted to identify focal species that function as indicators at the bioregional scale. The Committee of Scientists acknowledges that our knowledge and understanding of ecological systems is poor, and that the selection of focal species is an experimental approach that should be treated as a hypothesis that is tested and validated through monitoring and research. Thus, one of the contributions identified for research during the first phase of the adaptive management strategy is to identify candidate focal species and test them as representatives of ecosystem function and integrity.

Population and Habitat Monitoring

Since the enactment of NFMA, application and case law have refined our understanding of the appropriateness of using the status and change of environmental conditions as a surrogate for the status and change of populations. In short, case law suggests that using habitat as a surrogate for populations may be ruled as inadequate, and the circumstances under which it is appropriate are not entirely clear. The new planning regulations (36 CFR 219.11) identify the consideration of the following factors in determining when population monitoring is warranted: degree of risk to the species, the degree to which a species life history characteristics lend themselves to monitoring, the reasons that a species is included in the list, and the strength of association between ecological conditions and population dynamics. Where risks to species viability are high or there is great uncertainty about ecological conditions needed for viability, monitoring should estimate population trends. Where risks to species are lower or there are well-established relationships between population status and environmental conditions, environmental monitoring alone may be used to infer species status. Habitat conditions and trends are to be monitored for all focal species and species at risk.

We used the language of the new planning regulations to guide our determination as to the appropriate monitoring investment for each species. The specific considerations are described in the MIS and Species-at-Risk issue in each topic area. However, here we describe the different population and habitat monitoring levels that were assigned to each species.

Types of Population Monitoring Data

We identified seven basic types of monitoring data as options for describing the status and change of populations (Table E-5). Population data range from describing changes in distribution based on presence-absence data to describing changes in population structure (e.g., age structure, survivorship). Two additional options are noted: establishing presence in the Sierra Nevada (re: species for which current populations are in question), and no population monitoring (re: species for which concern is low and habitat relationships are known). We identified one or more of these types of monitoring data as appropriate for each species based on the current (e.g., Federal and State designations) and predicted future risk (based on viability analyses). They are intended to serve as a starting point for more detailed descriptions of monitoring data needs and the development of specific measures to be used to describe changes in populations over time.

In general, as the level of risk rises, a greater level of investment in monitoring is warranted. A total of 16 non-fish vertebrate species and one fish species were determined to have a lower level of risk because their only designations were moderately vulnerable or Federal or State special concern. Thus, these species may be monitored based on habitat conditions alone. MIS that are not species-at-risk constitute species of lower risk, and their populations will be monitored based on changes in their distribution. The remaining species are considered of higher risk, and their population monitoring consists of a range of population data types. Population monitoring for plant species consists primarily of distribution and relative abundance measures. Relative abundance is commonly identified for plant species because the size of a subpopulation of these rare plants, once encountered, is quickly and easily obtained. Population monitoring identified for each species is described in its associated topic area issue.

Table E-5. Types of population monitoring data ordered by increasing level of investment and data resolution.

Monitoring Data	Definition
None	It is not appropriate to invest in monitoring populations of some species based on the range of the species or the feasibility of obtaining monitoring data relative to the level of interest or concern.
Presence	A few species are suspected to be extirpated from part or all of their range in the Sierra Nevada study area. Detecting the presence of these species is the first priority in a monitoring scheme to address their status.
Distribution	Distribution data consist of changes in the presence of species across a number of sample locations. Distribution is a spatially explicit version of frequency of occurrence data. At a spatial scale as large as the Sierra Nevada study area, changes in the distribution of species represent ecologically significant information on the status and change of populations.
Relative Abundance	Relative abundance is an index of abundance that can be derived a myriad of ways depending on the sampling method. Typically it is based on a count of individuals, but it can also be based on a count of occupied sites in a given sample area. For plants, it is the occurrence size—the number of individuals in or the area inhabited by a population or sub-population.
Population Size	Population size is a direct estimate of number of individuals. For very rare species, it could be an absolute count (census) of the population size (vs. an estimate).
Apparent Recruitment	A qualitative or semi-quantitative measure of key stage classes for plants, often including an assessment of the proportion of the population appearing to be composed of juveniles.
Reproductive Success	Reproductive success can be measured a variety of ways, depending on the species and sampling method. Reproductive success is most often pursued for bird species, where the number of eggs and fledglings can be readily enumerated to calculate number of young produced per adult. It is also described for some taxa in terms of the proportion of females reproducing. However, an index of the number of young produced per adult or breeding pair can be derived for most species.
Population Structure	Many measures of population growth and structure are available for use in monitoring. They range from individual attributes of a population (e.g., age ratios, sex ratio) to derived rates of change (e.g., mortality rates, fecundity rates, growth rates).

Types of Habitat Monitoring

Non-fish Vertebrates

Knowledge of the habitat relationships of species in the Sierra Nevada is limited. The California Wildlife Habitat Relationships (CWHR) database provides basic habitat relationship information (i.e., vegetation type, seral stage, and canopy cover class) for each non-fish vertebrate in California, including those with populations in the Sierra Nevada. This habitat relationship information offers a basis for coarsely tracking changes in suitable habitat for every non-fish vertebrate. However, these coarse habitat relationships constitute a relatively insensitive index to the status of populations, and would only be appropriate for species with a lower level of concern or for which the status of the population were also being monitored. Such species include the 17 lower risk species discussed under population monitoring, as well as MIS that are not species-at-risk (see individual issues for species identification). Specifically, habitat monitoring for these species will consist of tracking changes in habitat characteristics as derived from remotely sensed data, validated by field-plot data.

Non-fish vertebrate species of higher risk and concern warrant a more detailed description of the status and trends in habitat conditions than can be obtained from remotely sensed data. In general, habitat conditions for the remaining species-at-risk will be monitored based primarily on field-plot data, and augmented by remotely sensed data. A set of habitat elements that encompasses the basic environmental features associated with most species-at-risk has been developed to characterize habitat conditions at each site where monitoring will be conducted (Table E-6). This approach, in addition to providing an adequate description of habitat trends, will also facilitate the development and improvement of habitat relationships models for species-at-risk.

Table E-6. Examples of habitat features that would be monitored at each terrestrial and aquatic site for non-fish vertebrates.

TERRESTRIAL ECOSYSTEMS	AQUATIC ECOSYSTEMS
Canopy cover by life form	**Cover types**
Canopy gap characteristics	Substrate types and cover
Canopy cover layers	Channel characteristics and type
Cover by species	Pool depths
Diameter distribution of trees by species	Barriers to movement
Basal area by tree species	Water quality characteristics
Snag and log density by decay class	Water temperature
Decadent tree characteristics	Water velocity
Microclimatic characteristics	Hydrologic condition indicators (e.g., plants)
Soil types and characteristics	Shoreline vegetation and cover
Broken top live trees	Submergent and emergent vegetation and cover
Trees with loose bark	Presence of in-water wood
Stumps by decay class	Presence of downed wood in riparian zone
Presence of small, medium, large slash piles	Openings in shoreline cover
Presence of talus	Presence of litter
Presence of rock	Condition of riparian vegetation
Presence of caves	Evidence of disturbance
Presence of cliffs	Riparian vegetation canopy cover
Slope	Presence of undercut banks (streams)
Density stumps by decay class	Presence of emergent and submergent veg
Litter depth	Water depth and size (lentic habitats)
Substrate types and cover	Presence of vernal pools
	Presence of non-native fish
	Invertebrate community characteristics

Fish

Habitat relationships models for fish species are very limited, and no standardized database of habitat relationships, such as CWHR, exists for fish. However, key habitat components can and will be identified for each species based on published literature regarding life history and habitat requirements, and these key habitat components will be described and monitored concurrently with population monitoring.

Plants

Habitat monitoring for plants is restricted to trends in the condition of associated major ecosystem types. The spatially and temporally defined guilds identified in the EIS constitute the extent of habitat relationships developed for plant species-at-risk. The spatially defined guilds consist of associations with major ecosystem types, including meadows and seeps, vernally wet areas, riparian woodland, riparian forest, bogs and fens, non-forested lakeshore and streamsides, rock outcrops, cliffs, and unusual edaphic conditions. General trends in the conditions of many of these ecosystem types will be provided through monitoring aquatic-riparian-meadow ecosystems as part of the Aquatic Conservation Strategy, and thus general references to habitat conditions for the associated plant species can be made. Not all plant species-at-risk are associated with spatially defined guilds (see Appendix R), and thus they will not have associated trends in general habitat conditions.

Other Taxa

The habitat relationships of invertebrate, non-vascular plant, and fungi species-at-risk are poorly known. Thus, population monitoring will be conducted for these species. Habitat relationships models for these species constitutes a key information gap, and their development would be a valuable contribution of research.

A Multi-species Approach to Population and Habitat Monitoring

A multi-species monitoring approach will be used to address the majority of species that require distribution and relative abundance population data. Such an effort will consist of a breadth of standardized, well-established multi-species monitoring protocols conducted at a number of representative sample points located across the bioregion. Based on preliminary analysis (Manley et al. in prep.), this approach is likely to be a highly efficient and effective approach to monitoring a diversity of species. Specifically, we evaluated the multi-species monitoring approach through a series of steps. First, we identified a set of multi-species protocols that were known to be effective at detecting the identified MIS and species at risk (Table E-7). We then estimated the probability of detection (based on these protocols) and the frequency of occurrence for each species of vertebrate (non-fish) in the Sierra Nevada. We then evaluated the ability of the multi-species monitoring approach to provide adequate data on each species of interest. We judged the efficacy of the multi-species monitoring approach based on sample size needs relative to the density of the nationwide Forest Inventory and Analysis (FIA) systematic grid (approximately 2800 grid points in the Sierra Nevada) already in place for monitoring forested conditions across the United States. The number of MIS and species-at-risk with sufficient sample sizes to detect $\geq$ 20% reductions in distribution with $\geq$ 80% confidence were tallied (Manley et al. in prep). In summary, approximately 50% of the target vertebrate species (n > 45 out of 93 species) are likely to be adequately sampled with the array of multi-species monitoring protocols assessed.

Table E-7. Multi-species monitoring protocols proposed and evaluated for monitoring of MIS and species-at-risk.

Protocol	Target species
Track stations with cameras	Mid-sized carnivores
Live trapping (Sherman-long)	Small mammal species
Live-trapping (tomahawk)	Mid-sized mammal species
Mist netting	Bats
Point counts (terrestrial and aquatic)	Terrestrial and aquatic birds and a few vocal mammals and amphibians
Sign surveys	Mid-sized mammals, such as beaver, muskrat, porcupine, mountain beaver, badger, and ungulates
Timed area searches (terrestrial)	Amphibians and reptiles
Timed area searches (aquatic)	Amphibians
Gill-netting and snorkeling	Aquatic vertebrates

The efficiency of the multi-species monitoring approach is predicated on ability to characterize the occurrence of many species at each of many locations, and the co-location of this monitoring with monitoring associated with other topic areas (e.g., old forest conditions, air quality, fire and fuel treatments). In short, the attributes of composition and structure identified for monitoring the status and change of the condition of old forests, lower westside hardwoods, aquatic environments, riparian areas, and meadows, combined with attributes to be monitored to address soil productivity and air quality, would provide a strong set of basic habitat descriptors for vertebrates and vascular plants.

The ready availability of habitat attributes not only facilitates the potential analysis of trends in habitat conditions for many species, but also provides an empirical basis for defining habitat. Habitat attributes for focal species need to be identified prior to data collection to ensure that data collection is adequate to describe their conditions, and then this approach facilitates the verification and improvement of habitat relationships models based on the presence and absence of each species. A major advantage of this empirically-based approach to habitat monitoring and model validation is that it will enable us to address prospects for the viability of species based on trends in populations and their habitats, using empirically derived data for a large number of species-at-risk. Habitat relationships and baseline distributions can be established in the first 5 years of monitoring, and trends in populations and habitat can be described by the end of the 10-year planning period.

4. Design and Analysis Considerations

The new planning regulations require monitoring of appropriate plan decisions, characteristics of sustainability, and site-specific actions. Additionally, the monitoring information must be used to determine one or more of the following: (1) if site-specific actions are completed as specified; (2) if the outcomes and effects are achieving or contributing to the desired conditions; (3) if key assumptions remain valid; and (4) if plan or site-specific decisions need to be modified. The monitoring program would develop methods for measuring all selected indicators of ecosystem integrity and designate critical values that would trigger reviews or possible amendments to management direction. This is the essence of adaptive management. The primary elements of design and analysis are discussed below.

4.1 Measures, Experimental Design, and Data Analysis

The process of answering a particular monitoring question involves many steps, from selecting a measure (or measures) that address the question to developing a statistically sound sampling design for estimating the status or trend of the measure(s) (Table E-8).

Table E-8. Quantitative descriptors for each question in the adaptive management strategy.

DESCRIPTORS	EXPLANATION
Question	A description of the question.
Measure	A description of the measure(s).
Spatial Scale	The spatial scale to which inferences would be made from the data collected.
Temporal Scale	The time period required to collect the information to answer the question; many times this reflects an assessment mid-way through the planning period to facilitate mid-course corrections.
Experimental Design	The target and sampled population, possible statistical models, sampling design (including what, where, when how many, how frequently), sampling techniques (tools and techniques for measuring things), and sampling protocols to be used.
Metric and Effect Size	The specific measures that will be used for analysis.
Null Hypothesis	The condition we are trying to disprove with the monitoring data; in most cases, this will reflect the condition we are trying to avoid or move away from (cause and effect questions only)
Alternative Hypotheses	The condition we are trying to achieve (cause and effect questions only)
Data Analysis	A description of the analysis that includes a verbal accounting (versus formulas) of the analytical approach and statistical technique to be used and why the technique is appropriate to answer the question.
Data Interpretation	How the measure(s) will be interpreted to answer the question, particularly a question is answered by gathering information on more than one measure. In addition, how the measures will be interpreted in terms of process integrity.
Emphasis Areas	Areas within the geographic range of the target population that may require additional sampling or more detailed measurements to enable an analysis of their status.
Cost	Estimated annual cost.
Responsibility	Individuals, groups, and/or organizations responsible for conducting the monitoring activity.
Data Management	Individuals, groups, and/or organizations responsible for collecting, managing, and analyzing the monitoring data
Comments	Caveats, ideas, connections to other approaches, etc.

Identifying Differences in the Value of Measures

Estimating the status and change of a measure is a problem in estimating the unknown value of a parameter within some bound of precision. Most authors stress the importance of formal "confirmatory" statistical methods, such as tests of null hypotheses or confidence intervals and regions, to assess environmental change (e.g., Green 1979, Carney 1987, Stewart-Oaten 1996). However, there is some debate over whether hypothesis testing or parameter estimation (confidence intervals) is the appropriate framework for monitoring (Stewart-Oaten 1996). Hypothesis tests appear to be most appropriate for detecting an effect, while confidence intervals are most appropriate for assessing the magnitude of the effect (Stewart-Oaten 1996, Steidl et al. 1997).

Null hypotheses are usually the neutral position that we seek to reject in favor of alternative hypotheses that state outcomes more specifically. For example, we could test the null that “tree mortality rates do not change” against the alternative that “tree mortality rates have changed” (either increased *or* decreased; a 2-tailed test) or that “tree mortality rates have increased” or that “tree mortality rates have decreased” (one-tailed tests). One-tailed alternatives are specified if there is an expected direction of change, or if a particular direction is more important to detect. One-tailed tests are more efficient in terms of sample size requirements, but sampling designs committed to test one-tailed alternatives are powerless to address unexpected results in the opposite direction. If we develop a test of the null hypothesis that there has been no change in the index of the population of species ‘A’ that includes the one-tailed alternative that the population has declined, our design will usually be inadequate to determine if the population index has increased, if this was the survey result. In summary, a variety of considerations and options exist in designing a statistical approach to answering a question.

Challenges of Temporal Variation

Temporal variation is the primary focus of monitoring, but carries with it sampling challenges. A time series has 4 components: 1) trend or directional change; 2) cycles or periodicity; 3) seasonal variation; and 4) irregular fluctuations or noise (Dagum and Dagum 1988). In addition, time series often include temporal lags between the induction of some signal and its manifestation in the measure. Trend is the temporal “signal” we seek to detect but it is frequently difficult to discern from the other distracting components, especially when the onset of change in the measure can lag some unknown period of time from the onset of the affector.

In addition, there are temporal considerations to the mechanics of collecting data. Duration of sampling and the duration of the monitoring effort itself should be related to the temporal dynamics of the measure of interest. If the measure is expected to change rapidly over time then the sampling should also occur over a short period of time. A number of sampling designs permit partial sampling over short time intervals (say, one year) that are then summed to represent a longer period (say, a 5 year period) (Goldsmith 1991). However, the expected rate of change of the measure should be slow to permit this kind of flexibility. It may also be necessary, for administrative reasons, to time the sampling so as to produce estimates immediately prior to the need for a management decision.

Sampling Design Considerations

Regardless of the sampling framework, there are many practical statistical issues that need to be addressed. A number of these have been outlined in Noon et al. (1999), and much of what follows is drawn from that paper. One of the fundamental concerns in hypothesis testing is the choice of type I (α) and type II (β) statistical error rates. A type I error occurs when the sample data indicate that the null hypothesis should be rejected, when in fact the null hypothesis (usually no change in the measure) is true. A type II error - which is potentially more costly to a monitoring program - occurs when the sample data lead to a failure to reject the null hypothesis when in fact it is false (and therefore the alternative is true). A monitoring program must have sufficient statistical power ($1 - \beta$) to detect meaningful change in the measure. Statistical power should be estimated for various sampling schemes prior to implementing a survey (Peterman 1990, Zielinski and Stauffer 1996) and afterwards to interpret the results of surveys that failed to detect the null hypothesis (Steidl et al. 1997). This exercise should include simulations of re-sampling frequency to determine how often a measure should be sampled to have sufficient power to estimate change or trend over time.

Serious consideration needs to be given to the mechanics of the collection, entry, and storage of the data for each measure. After protocols and sampling designs are complete and integrated in the most efficient manner, the first decision to be made is who will collect the data. Options available for data collection hinge in part on the sensitivity of the data to observer variability. Some data collection techniques are complex to learn, require much training, and/or are imprecise to the degree that the number of observers needs to be limited to the extent possible (e.g., counting birds by sight and sound). Other methods are much more robust (e.g., measuring tree DBH), and with minimal training, observer bias is negligible.

Data Entry and Storage

Regardless of who collects the data, it is essential that prior to these activities a carefully organized plan for data entry and storage have been established. A central location for data storage with multiple locations throughout the Sierra Nevada where data could be entered into databases ensures version control and reduces duplication of records. Proofed hard-copy and electronic data must be reconciled between regional centers and the central location for storage. Data proofing and entry may be conducted by personnel other than field staff, but it should occur under the direct supervision of personnel that are intimately familiar with the field collection methods. This is a key institutional and administrative process that requires thorough advanced planning and sufficient funding to be successful over time. Finally, ready access to data by collaborators and interested parties will be facilitated.

Data Analysis

The analysis of monitoring data will require constant attention to the link between the measure and the question the measure is intended to address. The relationships that were established between measures, questions, and processes during the course of developing the conceptual model will also need to be adhered to during the course of the analysis. It will probably be necessary to integrate more than one measure to answer a monitoring question. For example, answering the question “Is there change in the abundance and quality of breeding habitat for pond-breeding amphibians?” may require measures of the numbers and dispersion of breeding ponds, oviposition substrates within the ponds, and the pH of the pond water, among other factors. Similarly, detecting change in primary productivity may require a composite index that includes measures related to solar insolation, plant biomass, diversity of plant functional form, and atmospheric gases. Analytical processes that require the aggregation and disaggregation of data must be supported by well-designed data storage and retrieval routines.

4.2. Evaluation and Management Checkpoints

The evaluation of attributes requires the identification of evaluation “checkpoints.” Checkpoints serve to inform management as to institutional performance, environmental conditions, and insights gained relative to competing hypotheses. In terms of implementation questions, checkpoints will represent the proportion of projects associated with various levels of compliance with standards and guidelines. In terms of status and change questions, checkpoints represent desired conditions, undesirable conditions, legal requirements, and standards and guidelines. In terms of management effectiveness questions, checkpoints may represent the proportion of projects or sites or landscapes associated with various levels of achievement regarding desired conditions or outcomes. Alternatively, thresholds may be established which indicate the more plausible of competing hypotheses. For any type of question, multiple checkpoints are likely to be identified along a gradient of values for individual attributes or groups of attributes. Checkpoints for implementation and status and change questions serve to draw attention to current conditions relative to desired conditions. Finally, in terms of validation questions, checkpoints could represent levels of confidence in competing hypotheses. At time periods of evaluation, the results of monitoring and research would be reviewed and checkpoints would provide a context for evaluating institutional performance, environmental conditions relative to desired conditions, and the management relevance of new information gained.

Some environmental features are quite variable, such as channel flow fluctuations, and reselecting meaningful checkpoints is difficult, if not impossible. The concept of reference conditions has been useful in developing a basis for checkpoints. Reference conditions consist of temporal and spatial variation in composition, structure, and function of ecosystems under conditions of minimal human disturbance. The terms “reference variability,” “range of natural variability,” “benchmark,” and “historic range of variability” have often been used synonymously to describe reference conditions (Manley et al. 1995, Landres et al. 1997, USDA Forest Service 1997). Reference conditions describe the temporal and spatial variation in measures under conditions of minimal human disturbance, and in lieu of predetermining checkpoints, the relative variations in reference and non-reference sites. Checkpoints can then be established based on the magnitude of difference between reference and non-reference sites.

5. Implementation of the Adaptive Management Strategy

5.1. Steps

The benefits of adaptive management cannot be realized without well-orchestrated and timely implementation and appropriate institutional arrangements to ensure transparency and broad participation. Implementation of the strategy consists of the further refinement of the pursuit of information on topics, issues, and associated questions, commitments to evaluation and reporting, a strategy for forming collaborative partnerships, and a mechanism by which the Region and the Forests will respond to new information generated by the adaptive management strategy. Specifically, the monitoring and key information gap questions in this adaptive management strategy will require additional development before data collection and evaluation can commence.

Further development will entail a number of steps, including, (1) identifying specific measures for selected attributes, (2) determining the experimental design and sampling protocols, (3) determining sample size requirements to achieve desired levels of confidence and statistical power, (4) description of data analysis and evaluation techniques, (5) identification of management "checkpoints" that indicate the need for review or the achievement of a goal, (6) development of data bases and information management and sharing strategies, and (7) institutional response and collaboration mechanisms.

The following criteria will guide further refinement (i.e., design and implementation) of the adaptive management strategy:

- **Cost efficiency -** getting the most information for the least cost should be a high priority;
- **High yield of useful information -** information is useful for as many applications and across as broad a range of spatial scales as possible;
- **Engagement of management leadership -** the leadership and the staff of the Region need to be directly engaged in the process of implementation as possible to facilitate ownership, education, and timely application of information to management direction;
- **Quality control -** data collection and management should be designed so that quality control standards are applied evenly and effectively across all data collection points and efforts;
- **Scientific defensibility and credibility -** designs for data collection, quality control efforts, and data analysis techniques meet rigorous research standards, have the involvement of research, and should be peer-reviewed;
- **Timely yield of information -** he monitoring program must yield information for management in a timely manner

A successful adaptive management process that is scientifically responsible, publicly transparent and accessible, and focused on areas of major public concern and scientific uncertainty, requires five key processes:

1. Establishment of the institutional venues and means through which key areas of uncertainty and public concern can be readily identified and tied to management direction;
2. Investment in a balanced relationship between management decision-makers, diverse public interests and the scientific community;

3. Investment in the means to address the assumptions and uncertainties inherent in the goals of the Standards and Guidelines by designing, funding and implementing adaptive management;
4. Determination of criteria for legitimate adaptive management proposals that will allow management actions to vary from the default requirements stated in the Standards and Guidelines;
5. Closure of the loop between new information generated by adaptive management and monitoring activities and changes in management direction through a disciplined and collaborative interpretation of results.

5.2. Commitments to Collaboration

The Record of Decision will provide details about institutional design and processes. Other, large-scale planning and adaptive management programs – such as CalFed in California, the Tongass Land Management Plan in Alaska, and the Northwest Forest Plan in the Pacific Northwest – have successfully established new institutions to provide effective public participation and scientific oversight. While ecological, political and institutional conditions vary broadly in each region, the processes share important common elements:

- A formalized advisory capacity that reviews management activities and monitoring results in order to formulate recommendations to management decision makers;
- An increased scientific capacity that bridges the boundaries between research and application;
- A highly developed monitoring program with structure reporting requirements, including review with the advisory bodies; and
- A collaborative, multi-agency technical advisory body that ensures programmatic consistency among management activities, public process, scientific review and legal requirements.

New institutional commitments will be developed after the Record of Decision is signed. However, recent historical experience suggests that solutions to region-wide problems, and requirements to monitor large-scale effects, require adjustments and innovations in institutional arrangements and governance processes.

The new planning regulations anticipate this need, and require the Forest Service to establish both public advisory councils and science advisory boards (36 CFR 219). Given the complexities and uncertainties involved in this plan amendment decision, strong public advisory and scientific capacities are critical to successful change in management strategies. Protection of the public advisory process under the provisions of the Federal Advisory Committee Act will ensure that a broad range of public interests have access to the process in a timely and informed manner.
The Forest Service has regularly articulated its commitment to collaborative processes in the development and implementation of management direction. The Chief's natural resources agenda, as well as the new planning regulations for implementation of NFMA, emphasize the need for "early and frequent" involvement of a broad array of interests, representing various geographic scales of concern. This commitment is intended to augment and strengthen the public involvement requirements of NEPA.

Collaboration is successful only in the degree to which there is a "human architecture" to support it. Dialogue without connection to decisions is often an important phase in the development of trust and the adumbration of the general nature of problems. However, this "weak" form of collaboration is less useful in the Sierra Nevada context where many of the issues are well understood, science and scientific uncertainty are at the core of decision processes and public interests already have a

sophisticated understanding of both process and content. In most problem contexts in the Sierra Nevada, a "stronger" form of collaboration is called for, which requires explicit agreements about the scope and nature of the problems to be solved, clear lines between dialogue and decisions and meaningful engagement of well-prepared representatives of diverse public interests.
In order to fulfill this commitment in the Sierra Nevada, the Forest Service has worked aggressively with other state and local representatives to develop a proposed institutional framework that will ensure successful and timely implementation of the forest plan amendments. Moreover, the institutional framework under development is intended to serve as a foundation for longer-term planning and adaptive management that integrates a broad range of local, state and federal agency regulatory and management responsibilities.

This institutional framework will be elaborated in the Record of Decision. Its broadest outlines are:

1. Establishment of a regional executive body through a memorandum of understanding, the purpose of which is to coordinate and integrate current and future management and regulatory actions in the Sierra Nevada region.
2. Chartering of a public advisory committed under the provisions of the Federal Advisory Committee Act, with the charge to oversee implementation of the forest plan amendments, to provide advice and recommendations for solving conflicts among standards and guidelines, and to create a forum for sharing of information and wider education and learning among public interests.
3. Ensuring an ongoing technical and scientific capacity will be available to the policy and management bodies to evaluate, review and assist in design of adaptive management strategies where appropriate.

Adaptive management and collaboration are inextricably connected in this process. Adaptive management strategies must "close the loop" between new information and management direction changes. Collaboration helps to ensure that new information is appropriately developed and guided without bias into the hands of management. Transparency and access are key to successful collaboration, and increase the likelihood that management changes will in fact occur when new information suggests a review of current management commitments. Collaboration also helps to strengthen constituencies for change, and often provides support for managers who must challenge agency culture and received knowledge in order to alter the course of management direction.

Full implementation of the adaptive management strategy will occur within 5 years of the implementation of this plan amendment. The adaptive management strategy will be phased-in over the 5-year period, with at least some elements to be fully implemented by year 2. Implementation will be jointly executed and managed by Region 5 and the Pacific Southwest Station, in collaboration other agencies, governments, and interests.

NFMA requires an annual monitoring and evaluation report, including the following:

1. a list or reference to monitoring required by the plan;
2. a summary of the results of monitoring and evaluation performed during the preceding fiscal year and appropriate results from previous years a summary of the results of monitoring performed during the previous fiscal year;
3. a description of achievement toward desired conditions and sustainability as identified in the land and resource management plan;
4. identification of any new topics of general interest or concern arising from monitoring and evaluation;

5. a list of amendments made to the plan in the previous year;
6. a summary of outputs, outcomes, and budgetary trends related to the achievement of desired conditions; and
7. a description of the activities and results of efforts to address key information gaps.

Thus, a monitoring and evaluation report will be produced each year, starting at the end of the first year. At the end of the first 5 years of implementation, an in-depth analysis and evaluation of the strategy and its results and findings will be conducted. At that time, the strategy should be able to provide information on the status of many resource conditions, implementation performance, status and potentially results of cause and effect monitoring and research or the pursuit of key information gaps. After 10 years of implementation, results for all of the questions in the strategy will again be provided, evaluated, and interpreted. This adaptive management strategy will also review the effectiveness of associated monitoring and research. Further monitoring and research will be revised as needed following each 5-year review.

At each of these time steps, a process will be undertaken to assess the implications of results to management and adjust management accordingly. The individual national forests will review the information gained and produce a report on management response to the new information. Evaluations with poor results will be addressed through management action at the appropriate scale, depending on known or suspected causal factors. The Forest Service will need and want collaboration with publics and other agencies with shared interests in Sierra Nevada resources to orchestrate this component of the adaptive management strategy. One key is to identify checkpoints (i.e., triggers or milestones) at various geographic scales for species and ecosystem conditions and acceptable ranges of variation that would inform publics and decision makers of the need for course corrections.

5.3. A Management and Research Partnership

The pursuit of adaptive management requires a strong working relationship between research and management. Region 5 and the PSW Station are committed to pursuing an integrated approach to facilitate monitoring and research in support of adaptive management in the Sierra Nevada. The Pacific Southwest Research Station will work with Region 5 of the Forest Service to develop, design and coordinate all data collection efforts of this adaptive management strategy, and execute the necessary field experiments. Specifically, the objectives of a partnership between research and management include (1) forming strong ties between science and management in implementation, analysis, and evaluation, (2) working toward the strengths of each branch of the agency, (3) speeding the integration of science into management through more seamless technology/information transfer, (4) rendering greater benefits from the work accomplished by each branch, and (5) strengthening the agency's credibility in management decisions and approaches. Through a carefully designed strategy of collaboration with interested parties, and with a strategic plan for data management, analysis, and dissemination, the results of new research will play a pivotal role in adaptive management, informing management direction with data that reduces uncertainty to more acceptable levels.

6. Fire and Fuels

6.1. Introduction

Goals and Objectives

Monitoring Forest Service fire management allows managers to examine management accomplishment, changes in fire behavior and forest ecosystems at multiple spatial and temporal scales, and causal relations between management actions and results of management. Managing fire under this EIS strives to attain desired future conditions for fire and fuels. These include conditions for fire behavior, wildlife habitat, air quality, and community safety. Monitoring will determine whether the US Forest Service attains these conditions. In addition, the Forest Service must account for the effects of its fire and fuels management on other resources and on communities. Requirements for monitoring and evaluating these effects under the National Forest Management Act include:

- "Consideration of the effects of National Forest management on… communities adjacent to or near the area being planned" (36 CFR Part 219.7(f)).
- "A quantitative estimate of performance comparing outputs and services with those projected by the forest plan" (36 CFR Part 219.12(k)(1)). Outputs include "nonmarket items, such as… preservation of aesthetic values" (36 CFR Part 219.12(g)(1)).
- "Documentation of costs associated with carrying out the planned management prescriptions as compared with costs estimated in the Forest Plan" (36 CFR Part 219.12(k)(3)).

Requirements under the Clean Air Act for mitigating the effects of fire and fuels management on air quality include "remedying impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution" (Clean Air Act Visibility Protection, Subpart II, 42 U.S.C. & 7491 et seq.).

The National Historic Preservation Act of 1966 (NHPA) establishes a program for the preservation of historic properties, which includes, in part: (Sec. 101) (1) the requirement that Federal agencies take into account the effects of any undertaking on National Register properties and to afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such undertakings; and (Sec. 110) (2) the requirement that the heads of all Federal agencies shall assume responsibility for the preservation of historic properties and establish a program to locate, inventory, and nominate historic properties eligible to the NRHP. Forest Service responsibilities under Sections 106 and 110 of the NHPA also include protecting heritage resources from adverse effects of management activities.

Monitoring questions are designed to accord with the overall heritage resource management program of the Sierra Nevada recommended by the Framework for Archaeological Research and Management (FARM), which has been incorporated into the Sierra Programmatic Agreement. Provisions of the Sierra Nevada Programmatic Agreement, the purpose of which is to establish optimally efficient HRM programs in compliance with the NHPA include the establishment of a program of monitoring "designed to identify and assess the effects that may be associated with" forest use and management activities.

Background

To be successful, Forest Service management of fire and fuels must be ecological sustainable, socially acceptable and economical feasible (Firey 1960). The monitoring strategy is designed to provide information that is critical in managing for these conditions. Eight issues stand out as key areas of concern and uncertainty: (1) wildland fire, (2) fire, vegetation, and habitat, (3) smoke and air quality, (4) fire and Sierra Nevada communities, (5) scenery and visual quality, (6) fire and heritage resources, (7) fire and soil productivity, and (8) implementation costs.

Wildland Fire: The management of and threat posed by fire and fuels in the Sierra Nevada comprised a primary problem area in the EIS. The design and implementation of treatments, their effectiveness in reducing the severity and threat of wildfire, and better understanding trends in wildfire are high priority information needs to be addressed through monitoring and research.

Fire, Vegetation and Habitat: The desired conditions of reducing fire threats may be in conflict with the desired conditions of maintaining and restoring the 3 ecosystems (i.e., old forests, aquatic-riparian-meadow ecosystems, and lower westside hardwoods) and their associated species-at-risk. The interaction of the effects of a *known* quantity of management activities - with uncertain effects on ecosystems and habitat - and an *unknown* probability of wildfire degrading ecosystem condition and destroying habitat in the future is at the heart of the current dilemma.

Smoke and Air Quality: Fire and fuels management has the potential to adversely affect the health and welfare of both resident and visitor populations in the Sierra Nevada. Air quality in the Sierra Nevada varies, but is at times as good as that found anywhere in the world (Cahill et al. 1996). Proposed increases in prescribed fire will in turn increase the amount of smoke emissions. Smoke includes a number of regulated air pollutants and pollutant precursors, including particulate matter, nitrogen oxides, volatile organic compounds, and carbon monoxide. Of the regulated pollutants contained in smoke, particulate matter is of greatest concern due to its adverse impacts on public health. Populations at greatest risk include children and the elderly. Smoke from prescribed fire also combines with local and transported air pollution sources to reduce visibility and diminish scenery values. Air quality directly affects visibility, and thus visual quality. Prescribed fire and wildland fire use are likely to affect the scenic quality of large areas of the landscape and reduce visual quality through smoke emissions.

Sierra Nevada Communities: The population of the Sierra Nevada more than doubled between 1970 and 1990. The area’s rapid growth is forecast to continue. Land conversion to development has been extensive. Preferences for improved quality of life and for an enhanced sense of personal safety are among the factors driving growth (Duane 1996a). Increasing fuel hazard is increasing the probability of impacts to people from wildfire. Assuming an effective fire and fuels management program, continuing development and concurrent risk in property values in the urban-wildland intermix will nevertheless continue to magnify fire risks to human health, safety, property, and quality of life. As the population grows, the public will be increasingly likely to voice concerns about the possible effects of fire and fuel treatments. Efforts to promote cummunity fire safety in the Sierra Nevada rely in part on public awareness of appropriate public and agency roles in such efforts.

Fire and Heritage Resources: Heritage resources are cultural legacies from our past, preserved as a vital part of our community life and enrichment in order to give a sense of orientation and place to the American people. Heritage resource information, combined with prehistoric environmental data, can explain past relationships between people and the land and help us to understand how human culture changes, how culture has affected and been affected by the environment, and to plan for the future. National Forests in the Sierra Nevada contain some of our nation's best-preserved archaeological, historical, and American Indian sacred sites. The potential number of sites on National Forest system lands, including those not yet discovered, is estimated at 156,000, approximately five times the number of known sites.

Fire and Soil Productivity: Fire and fuels management has the potential to adversely affect soil productivity. The effect of fire and fuels management on soil productivity is dependent on the burn severity, soil type, and the site history. Findings in the Sierra Nevada Ecosystem Project (Poff 1996) indicate that fires can affect soil physical, chemical, and biological properties. Physical effects include loss of soil organic matter, loss of soil structure, hydrophobicity or water repellant soils, and accelerated erosion. Chemical effects include change in soil pH, loss of cation exchange capacity, and loss of nutrients by volatilzation. Biological effects include direct mortality of soil organisms and loss of their habitat.

Implementation Costs: In addition to holding expectations of quality of life in the Sierra Nevada, the public expects, consistent with NFMA regulations, that Forest Service management of fire and fuels under the selected alternative will provide the most cost-efficient management possible to meet planning objectives.

Overview of Approach

Each of the eight issues discussed above is treated individually below.

6.2. Description of Fire and Fuel Issues

Wildland Fire Issue

Description

This issue addresses the application of fire and fuel strategies and treatments across the landscape, their influence on the effects of unplanned and uncontrolled ignitions in stands and landscapes, and their influence on fire regimes at the bioregional and subregional scales.

Uncertainties

It is uncertain if the occurrence of high severity wildfires has increased over the past 10 to 25 years. It is uncertain as to the specific location, number, and character of fire and fuel treatments that will be placed in the landscape. It is also uncertain that fire and fuel treatments, as designed and implemented, will be effective in changing the severity of wildfires, and reducing threats to life, property, and ecosystem conditions.

Approach

The highest priority status and change monitoring will address assess whether our subregional strategies and stand/landscape treatments create fire regimes that reduce fire severity and risks to people and to species populations in an environment where wildland fire behavior may be changing. The highest priority status and change questions track smoke emissions and air quality conditions associated with prescribed fire, visibility, the fire regime by vegetation type, and fuel levels. The highest priority cause and effect questions focus on fire and fuel treatments in achieving the desired fire behavior, fuel levels, and reduce threat and severity of wildland fire. A lower priority cause and effect question relates to the relative cost effectiveness of fire and fuel treatments.

Affectors: Fire exclusion, vegetation treatments, grazing, funding, urban development, wildland fire use, prescribed fire

Expected Results and Benefits

Status and Change Monitoring: We expect to find whether our subregional strategies and stand/landscape treatments create fire regimes that reduce fire severity and risks to people and to species populations in an environment where wildland fire behavior may be changing.

Cause and Effect Monitoring: Improved knowledge of how wildland fire behavior has changed at different spatial and temporal scales in the Sierra Nevada and Modoc Plateau; and increased fire suppression effectives and reduced resources losses in the wildland urban-intermix areas.

Monitoring and research results will provide detailed information on fire behavior and improve predictions of fire threat. Managers can then use their enhanced understanding of the multiple characteristics of wildland fire to predict fire behavior. Predictions can help identify forest stands in need of fuels reduction.

Vegetation and Habitat Issue

Description

Species-at-risk addressed here include six old-forest associates (California spotted owl, northern goshawk, Pacific fisher, American marten, Sierra Nevada red fox, and wolverine), and four aquatic-riparian-meadow associates (foothill and mountain yellow-legged frogs, Yosemite toad, and willow flycatcher). Fire and fuel treatments (i.e., prescribed fire and mechanical treatments) have the potential to result in near-term reductions in the quantity and quality of old forests and lower westside hardwoods (e.g., loss of large trees), and the quality of aquatic-riparian-meadow ecosystems (e.g., loss of canopy cover in riparian). These reductions relate to habitat suitability for species-at-risk associated with these ecosystems. If the treatments are successful in reducing the severity of wildfires, there may be a net benefit to the quality and quantity of these systems and associated habitat values assuming that, untreated, wildfires would have resulted in greater losses than were lost due to fire and fuel treatments. Conversely, if fire and fuel treatments are unsuccessful or only marginally successful, there may be a net loss to the quantity and quality of these systems and associated habitat values as a result of treatments. In either case, the quantity and quality of suitable habitat needs to be sufficient to support viable populations. Habitat for all 10 species are considered here, but direct population effects are not a primary concern for Sierra Nevada red fox or wolverine, given that it is uncertain if they are currently extant in the Sierra Nevada.

Uncertainties

The driving uncertainty associated with this issue is if and how we can meet the desired conditions of reducing the threat of wildfires and of maintaining and restoring the quality and quantity of the 3 ecosystems of concern and associated habitat values for species-at-risk. In addition to the uncertainties identified issue 1, it is uncertain whether unaltered wildland fires would have a greater or lesser impact (spatial and temporal) on ecosystem integrity and habitat for species-at-risk compared to fire and fuel treatments. Uncertainty regarding the implementation and effectiveness of fire and fuel treatments translates into uncertainty as to the risk these treatments pose to goals for the three ecosystems, including functional integrity (e.g., nutrient cycling, species diversity, hydrologic function), the quality and quantity of habitat for species at risk, and direct impacts on individuals of species-at-risk (re: occupancy, reproductive success, or survivorship). Uncertainties regarding the habitat requirements of species-at-risk are addressed in their associated ecosystem topic areas.

Approach

The highest priority status and change focus on the fuel levels following fires, i.e., vegetation composition and structure, surface fuel, and crown-loading. Within the vegetation and habitat issue, the high priority cause and effect questions address fire and fuel treatments on vegetation structure and composition, old forest community and species diversity, riparian zones, and on the quality and quantity of suitable habitat, site occupancy and reproductive success of species-at-risk. If additional monitoring funding becomes available, a lower priority cause and effect questions relating to hardwood recruitment rate, survival rates, and retention of mature trees would be addressed.

Affectors: fire exclusion, wildland fire use, prescribed fire, vegetation treatments, urban development, funding

Expected Results and Benefits

The status and change questions identified here look at trends in the occurrence and threat posed by wildfires in areas designated for these ecosystems and associated species-at-risk (e.g., old forest emphasis areas, riparian conservation areas, southern Sierra fisher conservation area, critical aquatic refuges). Designated areas for species-at-risk (e.g., include protected activity centers, home range areas, and willow flycatcher emphasis areas. Changes in the fire regime are difficult to predict and will not be uniform across the landscape. It is important to understand what changes in the fire regime translate to in terms of geographic areas of critical importance to species conservation so that management can adjust management direction and emphasis as necessary. Overall shifts in the fire regime are monitored in the wildland fire issue above.

Cause and effect questions address 3 primary areas of uncertainty and risk: (1) changes in community characteristics (vegetation and species), (2) changes in habitat quantity and quality, and (3) direct, near-term effects on populations of species-at-risk. Habitat includes biotic and abiotic features that have a substantial influence on the occupancy, survival, or reproductive success of the species. Addressing the high priority cause and effect questions will provide early indications as to the successes and failures of various types, features, and timings of treatments in meeting multiple objectives regarding fire threats, community integrity, stream condition, and species viability. This information can then be used to increase our successes in meeting these multiple and potentially conflicting objectives. This information would be extremely valuable for assessing the effect of individual fuel-reduction projects and as part of a larger cumulative effects analysis on vegetation and habitat suitability for species-at-risk.

The composite of these questions represents the key questions and uncertainties associated with the interface between fire, ecological communities, and habitat for species at risk. This information, combined with status and change information of the quantity and quality of the ecological communities and habitat for associated species-at-risk, and the implementation of related standards and guidelines, will fully inform management decisions regarding the interface among these goals. The status and change questions will tell us if the conditions are trending toward desired condition and at what rate. Status and change questions will also provide information on management activities, and correlative relationships between trends in management activities and trends in conditions can be made. The cause and effect questions will help us understand how fire and fuel treatments are affecting desired conditions at the project scale, and provide a valuable context for interpreting the potential contribution of fire and fuel treatments to bioregional trends in the conditions. Implementation questions will inform us as to how well we are implementing related management direction, and if desired conditions are not being achieved. Together, the suite of implementation, status and change, and cause and effect questions will help us understand why trends might be occurring, and if they are unfavorable trends, help point toward the source of the problem, be it related to implementation, effectiveness, unrelated management activities, or other environmental factors.

Smoke and Air Quality Issue

Description

Air Quality Issue 1 is targeted to the effects that proposed increases in prescribed burning would have on air quality in the Sierra Nevada. Smoke includes a number of regulated air pollutants and pollutant precursors, including particulate matter, nitrogen oxides, volatile organic compounds, and carbon monoxide. Recent and pending changes in the air regulatory environment include revisions to California's Title 17 Agricultural Burning Guidelines and the issuance of a Visibility State Implementation Plan, or SIP. Both will change the way that smoke and its air quality effects are managed by the State. Following is a brief summary of changes relevant to the fire and fuels program;

Title 17 (Amendment to California's Agricultural Burning Guidelines)

- Title 17 was recently updated by the California Air Resources Board, with the goal of allowing for increases in prescribed fire while minimizing or preventing smoke impacts to public health and visibility.
- The State has the authority to exercise enforcement powers when land managers are found to have ignited the fire in violation of the requirements of the rule, or not to have appropriately responded to air quality impacts caused by naturally ignited fires.
- Title 17 expands air quality protection requirements for prescribed burning in wildland and wildland/urban interface areas**.** Monitoring will be mandatory for burns meeting specific size, timing, location, and duration criteria. Implementation of Title 17 is currently underway.

Regional Haze

- Haze obscures the clarity, color, texture, and shape of what we see. Some haze-causing pollutants (mostly fine particles) are directly emitted to the atmosphere by a number of activities, including burning related to forestry and agriculture.
- The State and local air quality agencies will implement the regional haze program through state implementation plans, which will include emission reduction measures.
- In identifying the emission reduction measures to be included in the long-term strategy, States will address all types of manmade emissions contributing to impairment in Class I areas, including those from prescribed fires. The California haze control strategy plan will be submitted to EPA no later then 2008.

Of the regulated pollutants contained in smoke, particulate matter is of greatest concern due to its adverse impacts on public health and visibility. The selected alternative expects to increase the use of prescribed fire as a tool to reduce the threat of wildfire. Emissions projections indicate a doubling of PM emissions from the proposed treatments.

Uncertainties

Uncertainties are associated with the need to attain fuels management objectives while fulfilling legal obligations pertinent to smoke and air quality.

- Potentially incompatible goals for air quality and fire and fuels management. The fire and fuels program proposes a large increase in prescribed fire use. However, air quality concerns and regulations may limit the programs ability to implement the desired level of treatment.
- The long term "tradeoffs" between increased uses of prescribed fire, wildland fire use, wildfire, and associated trends in PM emissions are not fully understood. However, management direction is based on the assumption that increased prescribed fire results in decreased emissions over the long term.
- Smoke adversely affects human health through the inhalation of particulate matter. Particulate matter is regulated through federal and state standards designed to protect public health. The extent to which the proposed fuels program would contribute to standard violations and harmful short-term exposures is unknown.
- Visibility is a public welfare value that is also affected by smoke. However, the degree to which visibility would be affected by the proposed fuels management program is uncertain.
- Fire produces regulated pollutants and pollutant precursors in addition to PM. The degree to which fire emissions contribute to potentially harmful levels of these other substances (e.g., ozone) is not currently known.

Approach

The only identified high priority cause and effect question determines the effects from prescribed fire, wildfires and transported urban air pollutions contribute to visibility impairment.

Affectors: Emissions (urban air pollution, prescribed fire, wildland fire use, wildfire, fire exclusion)

Expected Results and Benefits

The status and change monitoring questions will track the extent to which circumstances approach desired conditions for smoke, provide early warning of adverse air quality, and allow for a timely response in the event harmful conditions do occur. The cause and effect information provided will serve as a tool in (1) evaluation of smoke management plan effectiveness, (2) assessing smoke impacts on sensitive receptors, and (3) validation of smoke dispersion models used during planning.

The proposed set of monitoring questions for smoke will benefit management by 1) meeting legal requirements for smoke monitoring at both the project and bioregional scales, as required by Title 17; 2) validating EIS smoke emission projections. Proof of overall emissions reductions will support increases in prescribed fire and wildland fire use, as the state goes through the process of developing the haze control strategy plan; 3) responding to concerns expressed by air regulatory agencies regarding the proposed increase in the use of prescribed fire as a management tool; 4) providing a systematic and coordinated approach to smoke monitoring in the Sierra, increasing efficiencies, and reducing costs; 5) balancing the need to restore fire as a process while minimizing its threats, by providing feedback on the risks of smoke to public health and visibility; 6) helping to achieve consistency with the Federal Wildland Fire Policy, by incorporating public health and environmental quality considerations into fire management plans and activities; and 7) supporting adaptive management through the validation of planning assumptions, models, and management strategies.

Sierra Nevada Communities Issue

Description

Rapid population growth and increasing fuel hazard in the Sierra Nevada result in impacts to people from wildfire increasingly likely. The rapid growth of human populations in the range of concurrent rise in property values in the urban-wildland intermix will magnify fire threat to human health, safety, property, and quality of life. As people continue to move to the area based on perceptions of higher quality of life and enhanced personal security (Duane 1996a), concerns voiced by the public about the effects of fuels management are likely to increase. The amenity value of scenery will rise with increasing local populations and recreational visits (Duane 1996b, Stewart 1996). Thus, public concerns about alterations to the visual landscape may increase. Smoke releases may precipitate public concerns about air quality and smoke exposure. This risk is increased as some communities within and adjacent to the planning area are already burdened by poor air quality (Cahill et al. 1996).

Uncertainties

The degree to which implementation of the selected alternative will affect the quality of life in the Sierra Nevada is uncertain. The effectiveness of hazardous fuel reduction treatments in and adjacent to the urban intermix areas in changing fire behavior to create a safer fire suppression environment remains to be established. The level of concern expressed by Sierra Nevada communities about fire and fuels management may vary during the course of the program. The degree to which fire prevention and public education programs will improve fire fighter and public safety is also uncertain.

Approach

Identified as the highest priority status and change questions are the threat of fire to communities and the access and egress issues for fire suppression. The one identified high priority cause and effect monitoring question addresses the effectiveness of fire and fuel treatments to achieve the desired condition of reduced threat to communities. A lower priority cause and effect question if funded, would determine if the fire and fuels management is effective in meeting scenic integrity and landscape character.

Affectors: road management, fire exclusion, wildland fire use, prescribed fire, mechanical treatments, fire threat, fire occurrence, smoke exposure, air quality, scenic integrity, landscape character, visibility, knowledge of the ecological role of fire

Expected Results and Benefits

The status and change monitoring will allow managers and communities to assess changes in fire threats to communities and the ability of fire fighters to protect areas.

The cause and effect information allow managers and communities to understand the effectiveness of treatments and adjust predictions and perceptions of fire threats as appropriate.

Heritage Resources Issue

Description

Under the selected alternative, prescribed fire and mechanical treatment may directly damage or destroy heritage resources (prehistoric and historic archaeological sites, historic structures, traditional plant gathering areas) and adversely affect the setting of historic sites. Standard and Guideline F18 provides EIS direction.

Uncertainties

Uncertainty about adequate protection of heritage resource values comes from: (1) implementation of an extensive, long-term program of fuels reduction; (2) changing scales, intensities, and locations of wildfire due to a changing fire regime; and (3) lack of information about specific effects and site locations outside inventoried land creates.

Approach

The highest status and change monitoring will address changes in the condition, integrity, and disturbance risk on various heritage resources in terms of prescribed fire and mechanical treatment. The highest priority cause and effect questions address the effects of natural wildland fire and prescribed fire on heritage resources. The questions focus on the standard protection measures and the quality of information that is available for planning fire and fuels treatments.

Affectors: Vegetation management, air/chemical pollution, fire management, roads and landings, fuelwood harvest

Expected Results and Benefits

Monitoring will provide knowledge of the status and change of heritage resources in areas treated for fuels reduction, and the effectiveness of protective measures employed during fire and mechanical treatment in the vicinity of various heritage resources. Monitoring can help protect significant heritage resources. The data obtained will assist managers in (1) evaluating and improving heritage resource inventory records, protective measures, and project planning information, (2) understanding the nature of fire and mechanical treatment effects on different classes of heritage resources, (3) formulating and applying protective measures for different classes of heritage resources under varying fuel management treatments and conditions, (4) identifying baseline conditions, (5) tracking variation in heritage resource condition across many locations and through time, and (6) identifying and assessing effects from fire and fuels management projects, and determining inadvertent impacts.

Soil Productivity Issue

Description

This issue is centered on the effect of high severity burn areas that may result in volatilization of soil nitrogen and the loss of soil cover and subsequent erosion.

Uncertainties

Uncertainties are associated with the degree to which ecosystems throughout the Sierra are exposed to prescribed burning, and the effects of the amount and severity of the burning on the soil resource.

Approach

No status and change questions were identified. However, a high priority cause and effect question will address the changes in the rate of erosion and affect of soil health and productivity. Additionally, a lower priority cause and effect questions if funded would addressing the use of mechanical fuel treatments to meet soil quality standards for maintaining long-term soil productivity.

Affectors: prescribed fire, mechanical treatment, vegetation cover, recreation

Expected Results and Benefits

The proposed set of questions will benefit management as they, (1) support legal requirements for resource protection, (2) identify ecosystems at risk from prescribed burning, (3) target effects monitoring to soil resources at greatest risk, (4) support decision-making and adaptive management by contributing to forest managers' knowledge of National Forests stressors. When combined with effects information, the current intensity and distribution of prescribed burn impacts to the soil resource within National Forests may be accurately assessed. The information will also provide a basis for predictive model development, allow development of soil resource effects predictive models that will reduce future monitoring costs, and provide better linkages between management activities and research.

Implementation Cost Issue

Description

This issue centers on Forest Service costs for managing fire and fuels under the selected alternative. The identification of cost-efficiencies in implementing treatment programs and attaining desired conditions is an important consideration.

Uncertainties

Uncertainty remains about actual costs and cost efficiency in reducing fire threat and increasing fire suppression efficiency on National Forest system lands. An associated uncertainty is the optimal spatial application of budgets for fire and fuels treatments in order to enhance ecosystem function and protect Sierra Nevada communities.

Approach

Monitoring costs consists of one implementation question and a lower priority cause and effect question regarding cost effectiveness of various treatment options.

Affectors: funding, roads, access to appropriate technology

Expected Results and Benefits

The spatially explicit monitoring of costs will allow managers to identify settings and approaches that best meet planning objectives and to modify implementation methods or schedules accordingly. With this information, program managers can more easily discern where institutional efficiency can be gained and program costs reduced without compromising human safety.

6.3. Fire and Fuels Monitoring Questions

Implementation Monitoring

1. Is the implementation of fire use (prescribed fire and wildland fire use) and exclusion consistent with planning expectations?
2. Is the annual area of mechanical (surrogate) treatments consistent with planning expectations?
3. Are the requirements of Title 17 being implemented during the planning process?
4. Are conformity determinations being completed in federal nonattainment areas?
5. Are smoke emissions and emission savings consistent with planning projections?
6. Are urban interface zones being established at the rate called for in the selected alternative?
7. Are heritage resources identified, located, and incorporated into management fire response and the Computer-Aided Dispatch process (F18)?
8. Are heritage resources adequately considered and protected in planning fire and fuels management actions?
9. Are erosion hazard ratings for soil cover being implemented during the planning process?
10. Are soil quality standards for erosion control being implemented during the activity?
11. Are the costs of fire and fuels treatments, wildland fire use, pre-suppression, and suppression on Sierra Nevada National Forests consistent with projections used in decision-making?
12. Are the effects of fire and fuels treatments, in terms of changing fire threat, fire regime, and fire behavior, consistent with projections used in decision-making?
13. Are fire fighter exposures to CO, PM, and aldehydes at or below OSHA and NIOSH requirements?

Status-and-Change and Cause-and-Effect Monitoring

High priority questions will be addressed during the planning period, and lower priority questions will be addressed if possible.

High Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
What is the status and change of…			
1. Smoke emissions and air quality conditions (project and ambient) associated with prescribed fire, wildland fire use, and wildfire on NFS lands?	PM10, PM2.5, NOx, O3, emissions (e.g. tons/unit time)	110	Air quality program
2. Visibility in the Sierra Nevada?	PM10, PM2.5.	5	Air quality program
3. Wildland fires during the planning period?	number and source of ignitions, extent, location, and distribution of severity	15	
4. The fire regime by vegetation type or series?	frequency, intensity, extent, type of fires	10	
5. Fuel levels following fires?	vegetation composition and structure, surface fuel, crown-loading (actual and predicted)	8	Contributed data from fire monitoring
6. Wildland fires in areas designated for the conservation of the 3 ecosystems and associated species-at-risk of greatest concern?	number and source of ignitions, extent, location, and distribution of severity	1	
7. Threat (risk and hazard) of fire to communities?	fuels, ignitions, climate, community attributes, losses	30	Fire management program
8. Access and egress to areas for fire suppression?	proportion of communities with emergency plans for evacuation, number of people informed about evacuation plans	15	Fire management program
9. The condition, integrity, and disturbance risk of prehistoric and historic archaeological sites, historic sites, and traditional American Indian sites in terms of prescribed fire and mechanical treatment?	fire effects on soil, stone artifacts and features, wood structures, rock art, culturally valued plants; vehicle tracks and roads, dislocation of features and artifacts	136	Existing forest heritage resource monitoring reports

High Priority Cause and Effect Monitoring Questions	Attributes	Total cost ($1000s)	Contrib. from linked questions or other NFS programs
Fire Regime:			
1. Do fire and fuel treatments (e.g., DFPZs, SPLATs) in the urban intermix and in the general forest reduce threat and severity of wildland fire?	treatment characteristics (location and type), ground fuels, ladder fuels, crown bulk density, and tree density	15	
2. Are the fire and fuel strategies and treatments effective in achieving the desired fire behavior and fire regime within vegetation types or series?	severity, rate of spread, fire type, intensity, frequency, spotting; crown bulk density, tree density	15	
3. How effective are fuel treatments (prescribed burning, mechanical treatments) and wildfire in achieving desired fuel levels at treatment sites through time?	vegetation composition and structure, surface fuel, crown-loading	1	Fuels data for treated areas provided by status and change question #6. Estimated contribution: 8 (retrospective approach)
Fire X Vegetation and Habitat:			
4. What is the effect of a variety of fire and fuel treatments on vegetation structure and composition at the stand scale, and thus its quality of suitability as habitat for species-at-risk?	vegetation structure and composition (e.g., density and abundance of large, old trees; snag and log characteristics, plant species composition; canopy cover; canopy layering), duff and topsoil characteristics	200	
5. What is effect of a range of fire and fuel treatments on old forest community and species diversity?	treatment characteristics (e.g., burn intensity, burn duration, timing of treatment, tree removal, equipment use), fuel loading and characteristics, vegetation type, species composition	0	Covered by cause and effect question #4
6. What is the effect of fire and fuel treatments in riparian zones and near ephemeral streams on the riparian and stream physical, chemical, and biological conditions?	treatment characteristics (see question #5), fuel loading characteristics, water quality, channel morphology, invertebrate composition, sediment, vegetation characteristics	0	Covered by cause and effect question #5
7. What is the effect of treating various proportions of watershed or home range-scale areas on the quality and quantity of suitable habitat, site occupancy, and reproductive success of species-at-risk?	same as question #5, plus presence and reproductive success	28	Population and environmental data obtained from status & change monitoring; (retrospective approach)
8. What is the effect of treating various proportions of landscapes (multiple watersheds or home ranges) on the quality and quantity of suitable habitat, site occupancy, and reproductive success of species-at-risk?	same as question #5, plus presence and reproductive success	28	Population and environmental data obtained from status & change monitoring; (retrospective approach)
9. How do the effects of prescribed fire differ from the effects of wildland fire on vegetation structure and composition (including noxious weeds), and its suitability as habitat for species-at-risk of greatest concern?	same as question #5	15	Control and prescribed fire data from cause and effect question #4. Estimated contribution: 90

High Priority Cause and Effect Monitoring Questions	Attributes	Total cost ($1000s)	Contrib. from linked questions or other NFS programs
Fire X Smoke and Air Quality:			
10. How does smoke from prescribed fire, wildfires, and transported urban air pollution contribute to visibility impairment in the Sierras?	PM10, PM 2.5	78	Use data from existing monitoring networks with some additional validation monitoring. Estimated contribution: 300 per year
Fire X Sierra Nevada Communities:			
11. Does the change in fire behavior resulting from fire and fuel treatments in urban intermix zones achieve desired conditions of reduced threat to communities?	acreage affected by fires originating from NFS lands and passing through the urban interface zone, dollar value of property damaged	1	Fire behavior data provided by status and change monitoring questions 3, 4, and 7. Estimated contribution: 35
Fire X Heritage Resources:			
12. How effective are standard protection measures for preventing damage from fire and fuel management activities to heritage resources?	presence or absence of effects and type of effect	1	Data provided by status and change question #9. Estimated contribution: 136 (retrospective approach)
13. What are the effects of natural wildland fire and prescribed fire on heritage resources?	fire effects on soil, stone artifacts and features, wood structures, rock art, culturally valued plants	10	Data on prescribed fire provided by status and change question #9. Estimated contribution: 136 (retrospective approach)
14. Is the quality of information on heritage resources that is available for planning fire and fuels management actions effective in providing protection for heritage?	heritage resource inventory and descriptions	1	Data provided by status and change question #9. Estimated contribution: 136 (retrospective approach)
Fire X Soil Productivity:			
15. Does the use of prescribed fire increase or decrease the rate of erosion (long term versus short term) and affect soil health and productivity?	soil cover, actual erosion, water repellency	20	

Lower Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
What is the status and change of …..			
1. Suppression efficiency on National Forest system lands within the urban-wildland intermix?	per-acre costs, per-fire costs, number of acres burned, value of property and resource losses for each fire passing through the urban intermix	2	
2. Community perceptions of the public's and the Forest Service's roles in promoting community safety from wildland fire?	perceptions	10	
3. The level of concern in Sierra Nevada communities about fire related conditions (i.e., fire threat to human life and property, community smoke exposure, effects on National Forest scenic quality, effects on visibility due to Sierra Nevada National Forest fire and fuels management)?	level of concern expressed	0	Cost included in status and change question #2
4. Scenic integrity and landscape character on Sierra Nevada National Forests?	patterns of scenic character including evidence of burns, vegetation structure, species composition	1.9	Existing remote sensing data
Lower Priority Cause and Effect Monitoring Questions	**Attributes**	**Total cost ($1000s)**	**Contrib. from linked questions or other NFS programs**
1. How are prescribed fire and mechanical thinning designed to reduce fuel loading affecting hardwood recruitment rate, survival of seedlings and saplings, retention of mature trees, and other demographic parameters of interest?	distribution and rate of burning and mechanical thinning, recruitment rate, species composition, survival of seedlings and saplings, age/stage structure, fecundity/mast production	45	
2. Is fire and fuels management effective in meeting objectives for scenic integrity and goals for landscape character?	patterns of scenic character including evidence of burns, vegetation structure, species composition	0.6	
3. Does the use of mechanical fuel treatments meet soil quality standards for maintaining long-term soil productivity?	soil porosity, soil cover, soil organic matter, and large woody debris	20	
4. What is the relative cost effectiveness of fire and fuels treatment on different site types using various techniques?	costs in dollars per acre treated, fire hazard, fire frequency, fire intensity, fire duration, flame length, implementation methods	1.8	Most data from high priority cause and effect question #18

6.4. Key Fire and Fuels Information Gaps

The following are research questions that were identified as key information needs in relation to the topic areas addressed in the FEIS.

1. How accurate are the characterizations of current and future fuels (surface, ladder, and crown-loadings, models and distribution)?
2. Is the fire return interval changed in response to the use of prescribed fire?
3. What is the role of fire (prescribed, wildland, wildland fire use) in contributing to nitrogen deposition and ozone formation?
4. What are "natural background" conditions for smoke and particulate matter in the Sierra Nevada?
5. How accurate are the models used to predict smoke concentrations?
6. Do mechanical treatments serve as ecological surrogates for wildland fire?

7. What is the near-term effect of the timing, extent, and type of fire and fuel treatments on site occupancy by pacific fisher?
8. What is the near-term effect of the timing, extent, and type of fire and fuel treatments on site occupancy by California spotted owl?
9. What is the near-term effect of the timing, extent, and type of fire and fuel treatments on site occupancy by the foothill yellow-legged frog?

7. Old Forests and Associated Species

7.1. Introduction

Goals, Objectives, Background

Old forest ecosystems perform important ecological functions (e.g., nutrient cycling, hydrologic cycling, support of biological diversity) and provide critical habitat for a host of plant and animal species. Old forests are one of the most altered ecosystems in the Sierra Nevada, and they have declined in quality, quantity, and distribution over the past hundred years (Franklin and Fites-Kaufman 1996). Habitat for and populations of animals associated with old forests, including forest carnivores, northern goshawk, and California spotted owl, have suffered significant declines as well. The decline in quality and quantity of old forests and changes in their distribution in the Sierra Nevada have also been detrimental to overall ecosystem integrity. The desired goal is to increase the density of large trees, increase structural diversity of vegetation, and improve the continuity and distribution of old forests across national forest landscapes.

The National Forest Management Act (NFMA) of 1976, CFR title 36 Part 219, mandates monitoring of species populations and their habitats (see previous discussion). In addition to NFMA, other legislation that specifically requires monitoring includes the Endangered Species Act, National Environmental Policy Act, Fish and Wildlife Conservation Act, Executive Orders, Forest Service Handbook, Forest Service Manual, OGC opinion and court decisions, and the Natural Resource Agenda announced by the Chief.

Overview of Approach

The monitoring plan for old forests was developed to address community and ecosystem management goals of the old forest topic area. The goals include (1) community and ecosystem integrity, and (2) maintaining viable populations of associated species. Thus the monitoring plan addresses issues of the amount and condition of old forests, and the vegetative structures characteristic of old forest function and habitat suitability for associated species. Maintaining the habitat needs of old forest-associated species, species diversity, and viability of species are addressed, with an emphasis on those populations of species that are most at risk. The plan was designed to assess the achievement of those goals as well as to reflect relevant issues, public concerns, and management uncertainties regarding the goals.

7.2. Description of Old Forest Issues

Amount and Condition of Old Forests Issue

Description

The Sierra Nevada Science Review (USDA 1998) indicated that management strategies that allocate large blocks of land to the restoration of old forest conditions are most effective at conserving all important ecological elements, and that all issues concerning old forests and associated species should be addressed in an integrated ecosystem context. Old forest stands in the Sierra Nevada exist in a landscape mosaic, and their emergent properties shift as one moves up through successively larger geographic scales. Characteristics of landscape mosaics, including adjacent patches of vegetation, distances between patches, and distribution of different aged and structured stands across the landscape affects ecosystem function, as well as habitat quality for old forest associated species. Monitoring to describe old forest ecosystems includes both stand-scale and landscape-scale features. Stand-scale attributes describe the general structure and components of old forest communities, as well as vegetative structures characteristic of old forests and important to ecosystem function. Landscape-scale attributes describe the distribution and abundance of old forest gradient classes, and will include number, spatial extent, and spatial arrangement. Habitat for old forest associated species is addressed in species-specific issues and in the MIS and Species-at-Risk issue in this topic area.

Uncertainties

One of the primary uncertainties resulting from management activities is the adequacy of the specifications prescribed for achieving desired conditions and the effectiveness of prescribed mechanisms to achieve desired conditions. Specifically, it is uncertain whether the structural specifications prescribed in the standards and guidelines will result in functional old forests that support their inherent biological diversity. The effects of fire and fuel treatments are addressed in the fire and fuels topic area; thus, this issue addresses silvicultural treatments and other types of forest treatments. It is also uncertain if mechanical or silvicultural treatments will result in desired old forest conditions. It is also uncertain whether the pace of restoring old-growth ecosystems will offset losses to old-forest ecosystems in the coming years from changes caused by the combination of management activities, global trends, and natural disturbances (fire, disease)—each of which works at multiple spatial scales to affect vegetation structure and ecosystem functions. Finally, it is uncertain whether the modeled estimates of large tree densities for the proposed action are accurate. Uncertainty associated with the ability of old forests to support species at risk is addressed in the species issues.

Approach

Many standards and guidelines existed for the management of old forests and associated species, so the monitoring includes many implementation questions. Status and change questions address amount and condition of old forests at a range of scales. Cause and effect questions address the effectiveness of silvicultural treatments and other timber harvest activities.

Affectors: Fire and fuel treatments, silvicultural treatments, salvage and hazard tree removal, exotic species, roads, grazing, and recreation and recreational development.

Expected Results and Benefits

Status and Change Monitoring: The combination of stand and landscape scale monitoring will allow managers to assess the amount, condition, distribution, and integrity of old forest ecosystems, how they are changing over time, and whether or not stated desired conditions are effective. Affector monitoring will provide information on potential causal factors contributing to those changes. Remote sensing data will increase understanding on how management actions appear at broad spatial scales and how well the results of management activities conform to intended results for forest ecosystems.

Cause and Effect Monitoring: Monitoring the effects of silvicultural and mechanical treatments in old forest stands will provide information to forest managers about the effectiveness of current strategies to protect and expand the amount of old forests in the Sierra Nevada, and to provide for the integrity and function of old forest ecosystems. If activities do not move the amount, condition, and distribution of old forests toward the stated desired conditions, or are detrimental to ecosystem function, managers can make course corrections in a timely manner.

The issue of community and ecosystem integrity in old forests is critical because land managers believe that management activities within and around old forest patches can have a positive effect on old forest amount, condition, distribution, and integrity. The cause and effect questions will help determine if management activities are having the predicted effects, and if they are different from natural disturbances. This information is essential to validate the assumptions associated with the desired condition and the stated goals of management for old forests and associated species. Monitoring the implementation of old forest standards and guidelines will assess if management direction is accomplished and/or achievable. The information from status and change monitoring will help determine if old forest ecosystems are trending toward desired condition and at what rate. Information on possible causes of change will be provided by monitoring affectors, as well as analyzing relationships with explanatory variables such as air quality, air/chemical pollution, climate change, and urbanization/land development. The composite information provided by this suite of monitoring questions will help determine if management activities are cumulatively accomplishing the changes designed to expand and protect old-forest ecosystems and improve their functional integrity to conserve biological diversity, as stated in the desired conditions.
California Spotted Owl Issue

Description

The California spotted owl (*Strix occidentalis occidentalis*) is of current management and conservation focus in the Sierra Nevada because of concern regarding declines in habitat and populations. California spotted owls are top-trophic level predators that occur in relatively low population densities and nest and forage in mature forests (Verner et al. 1992). Current demographic studies suggest that owl populations are declining in the Sierra Nevada (Blakesley and Noon 1999, Steger et al. 1999, Gutierrez et al. 2000). California spotted owl habitat is characterized by large trees, dense canopy cover, and complex canopy structures (Verner et al. 1992). Reductions in the quantity and quality of late-seral/old-growth forests and changes in forest structure and composition resulting from timber harvest and fire suppression policies (McKelvey and Johnston 1992) are hypothesized to have led to declines in California spotted owl populations. The subspecies was recently petitioned for federal protection under the Endangered Species Act. California spotted owls are “Sensitive Species” in the Pacific Southwest Region (R5) of the USDA Forest Service, a “Management Indicator Species” on nearly all National Forests in the Sierra Nevada, and a “Species of Special Concern” as designated by the state of California.

Uncertainties

Key uncertainties related to California spotted owl viability in the Sierra Nevada and the selected alternative are 1) uncertainty about the factors driving current population trends, 2) uncertainty about habitat relationships and habitat quality, 3) uncertainty about the current distribution, amount, and quality of habitat, and 4) uncertainty about treatment effects (e.g., fuels and silvicultural treatments) on habitat and populations at multiple spatial scales (e.g., stand, home range, landscape, forest type). Information suggesting that owl populations are declining dictates a conservative approach to management and highlights the need to continue to monitor population trends and address potential causal factors. Uncertainty about habitat relationships and habitat quality, or how habitat structure and composition affect survival and reproduction, make it difficult to assess current conditions and project how future scenarios may affect owl populations. Finally, the uncertainty related to the effects of treatments within Protected Activity Centers, home ranges, and across the landscape on habitat and populations render it difficult to evaluate the efficacy of management and conservation efforts to provide for viability.

Approach

Developing the knowledge necessary to address viability issues and the effects of USDA Forest Service management on California spotted owls in the Sierra Nevada will require information derived from a comprehensive set of complementary monitoring approaches. Cause and effect monitoring is needed to address the effects of management activities (e.g., fuels and silvicultural treatments) and assess the effectiveness of conservation measures on California spotted owl populations. Fire and fuel treatment effects are addressed in the Fire and Fuel topic area. Status and Change monitoring is required to address population trends of California spotted owls at the scale of the Sierra Nevada. That is, are California spotted owl populations continuing to decline as suggested by available studies? This type of monitoring will be extensive across the Sierra Nevada Bioregion. It is possible that, after a period of annual population monitoring (distribution and demographic), we will have sufficient understanding of important habitat characteristics that we can confidently monitor habitat without annual monitoring of owl distribution and demographics. This is contingent, however, on a dedicated program of population monitoring and careful analysis and testing of habitat models along the way. Ultimately these habitat models may make it unnecessary to monitor owl populations directly, or at least to conduct population monitoring much less frequently. In this respect the approach mimics that proposed to monitor the effectiveness of the Northwest Forest Plan on recovery of the northern spotted owl (Lint et al. 1999).

Affectors: roads, fire and fuels management, dams/diversions (including hydroelectric), recreation, timber harvest (salvage, hazard tree, site prep)

Expected Results and Benefits

The viability of California spotted owls in the Sierra Nevada is uncertain. A comprehensive monitoring and research strategy that addresses the various components of our uncertainty regarding the effects of management activities, habitat relationships and population trends is warranted. The information generated from this strategy will provide managers and interested publics with the information necessary to address viability concerns and adapt management as knowledge is collected on the strengths and weaknesses of the various management treatments and strategies prescribed in this plan amendment. Information on habitat and population trends garnered through status and change monitoring will provide managers with sensitive and informative measures of risk to viability. Information from cause and effect monitoring and research will address how and why management activities affect California spotted owl habitat and populations. Key information gap questions will provide much needed data on habitat requirements to better manage for suitable habitat at the appropriate range of scales to support a viable population. Finally, implementation monitoring completes the picture by assessing whether management standards and guidelines have been applied in a rigorous and consistent manner across the Sierra Nevada. Together the information generated from these comprehensive and integrated approaches will inform management decisions and adaptive management regarding the application of treatments to achieve ecosystem goals and human safety while at the same time minimizing the potential negative effects, or documenting potential positive effects, on California spotted owls.

Northern Goshawk Issue

Description

The northern goshawk (*Accipiter gentilis*) is of current management and conservation focus in the Sierra Nevada because of concern regarding declines in habitat and uncertainty regarding population trends. Northern goshawks are top-trophic level predators that occur in relatively low population densities and that nest in mature forests (Reynolds et al. 1992, Squires and Reynolds 1997, Keane 1999). No information is available on goshawk population trends in the Sierra Nevada, though the species still appears to be distributed throughout its historic range in the Sierra Nevada (Grinnell and Miller 1944, Keane and Woodbridge in prep.). Northern goshawk nest sites are characterized by large trees, dense canopy cover, and open understories (Hargis et al. 1994, Keane 1999). Reductions in the quantity and quality of late-seral/old-growth forests and changes in forest structure and composition resulting from timber harvest and fire suppression policies (McKelvey and Johnston 1992) are hypothesized to have lead to reductions in northern goshawk populations. The species has been petitioned for federal protection under the Endangered Species Act, with the current listing proposal under court appeal. Northern goshawks are “Sensitive Species” in the Pacific Southwest Region (R5) of the USDA Forest Service, a “Management Indicator Species” on all National Forests in the Sierra Nevada, and a “Species of Special Concern” as designated by the state of California.

Uncertainties

Key uncertainties related to northern goshawk viability in the Sierra Nevada and the Preferred Alternative are 1) uncertainty about current population trends, 2) uncertainty about habitat relationships and habitat quality, and 3) uncertainty about treatment effects (e.g., fuels and silvicultural treatments) on habitat and populations at multiple spatial scales (e.g., stand, home range, landscape, forest type). Uncertainty about population trends means that we do not know if northern goshawk populations are declining, stable, or increasing, thereby making it difficult to identify more fully the level of risk to viability. Uncertainty about habitat relationships and habitat quality, or how habitat structure and composition affect survival and reproduction, make it difficult to assess current conditions and project how future scenarios may affect northern goshawk populations. Finally, the uncertainty related to the effects of treatments on habitat and populations render it difficult to evaluate the efficacy of management and conservation efforts to provide for viability.

Approach

Developing the knowledge necessary to address viability issues and the effects of USDA Forest Service management on northern goshawks in the Sierra Nevada will require information derived from a comprehensive set of complementary monitoring approaches. Cause and effect monitoring and research will address the effects of management activities (e.g., fuels and silvicultural treatments) on habitat. Fire and fuel treatment effects are addressed in the Fire and Fuels topic area. Status and Change monitoring will address population trends of northern goshawks at the scale of the Sierra Nevada. It is possible that, after a period of annual population monitoring, we will have sufficient understanding of important habitat characteristics that we can confidently monitor habitat without annual monitoring of northern goshawk distribution and demographics. This is contingent, however, on a dedicated program of population monitoring and careful analysis and testing of habitat models along the way. Ultimately these habitat models may make it unnecessary to monitor northern goshawk populations directly, or at least to conduct population monitoring much less frequently. In this respect the approach mimics that proposed to monitor the effectiveness of the Northwest Forest

Plan on recovery of the northern spotted owl (Lint et al. 1999). Implementation monitoring is required to determine if management Standards and Guidelines are implemented as prescribed.

Affectors: roads, fire and fuels management, dams/diversions (including hydroelectric), recreation, timber harvest (salvage, hazard tree, site prep)

Expected Results and Benefits

The viability of northern goshawks in the Sierra Nevada is uncertain. A comprehensive monitoring strategy that addresses the various components of our uncertainty regarding the effects of management activities, habitat relationships and population trends is warranted. The information generated from this strategy will provide managers and other interested publics with the information necessary to address viability concerns and adapt management as knowledge is collected on the strengths and weaknesses of the various management treatments and strategies prescribed in this plan amendment. Information on habitat and population trends garnered through status and change monitoring will help managers to determine if northern goshawk populations are declining across the Sierra Nevada and to gauge the level of risk to viability. Information from cause and effect monitoring and research will address how and why management activities affect northern goshawk habitat and populations. Key information gap questions will provide much needed data on habitat requirements to better manage for suitable habitat at the appropriate range of scales to support a viable population. Finally, implementation monitoring completes the picture by assessing whether management standards and guidelines have been applied in a rigorous and consistent manner across the Sierra Nevada. Together the information generated from these comprehensive and integrated approaches will inform management decisions and adaptive management regarding the application of treatments to achieve ecosystem goals and human safety while at the same time minimizing the potential negative effects on northern goshawks.

Fisher Issue

Description

Fishers (*Martes pennanti*) appear to occupy less than half of their known historical range in the Sierra (Grinnell et al. 1937, Zielinski et al. 1995, Zielinski et al. 1999) and are absent north of Yosemite National Park. Moreover, annual mortality rates of adult females appear to be relatively high (Truex et al. 1998). The restricted range of the fisher population in the Sierra Nevada and its low potential growth rate place it at risk of extirpation (Lamberson et al. 2000). Fishers find daily refuge in large diameter conifers and hardwoods (Truex et al. 1998). In the southern Sierra Nevada they select resting sites that have an abundance of large woody structures, have dense canopy closure, and are close to water (Zielinski et al. in prep.). The loss of structurally complex forests, the reduction in large-diameter trees (conifers *and* hardwoods) (McKelvey and Johnson 1992), and the fragmentation of habitat by roads and residential development are most likely responsible for the loss of fishers from the central and northern Sierra and the failure of dispersing animals to recolonize the area. Roads are more common throughout the Sierra Nevada today than historically and are a source of mortality and a potential impediment to fisher movements.

The western fisher has been petitioned twice, since 1990, to be listed under the Endangered Species Act and a third petition is in preparation. The fisher is also a ‘Sensitive Species’ in the Pacific Southwest Region (R5) of the US Forest Service, a “Species of Special Concern’ as designated by the state of California, and a Management Indicator Species on various national forests within R5.

Uncertainties

Of primary concern is the effect of activities that are necessary to address the perceived threat of catastrophic fire. These 'area treatments' pursue the goal of reducing the canopy, basal area, and density of trees, snags and logs in patches that occupy about 30% of the forest area in fire-prone elevations. At particular risk from both wild fire and prescribed fire are the large, rare and slowly-renewing elements of the forest (large diameter trees, snags and logs) that are important rest sites for fishers. Moreover, the loss of canopy closure can increase the depth of snow on the forest floor, which interferes with the movement of fishers (Krohn et al. 1995, 1997). The potential impact of fire and fuel treatments on the quantity and quality of habitat for fisher is addressed in the Fire and Fuels topic area.

Other forest management activities, besides fire and fuel treatments, have a high potential to degrade habitat conditions for fisher. Specifically, salvage and hazard tree removal activities have the potential to reduce the number of large trees and reduce the number of large logs, degrading habitat suitability. The effects of these activities on vegetation structure are addressed in the Old Forest topic area, and here we address the interpretation of those effects in terms of habitat suitability for fisher.

The conservation strategy proposed for the fisher includes standards and guidelines that focus on limited operating periods near natal dens, the retention of large snags and logs, minimizing the effects of treatments on large trees, snags and logs, the maintenance of large oaks in conifer stands, management of minimum proportions of old forest conditions in landscapes, the creation of management buffers around existing and new detection locations and around den sites, the recognition of roadkill as a threat, the restriction of some OHV activities and the creation of a Southern Sierra Fisher Conservation Area where fisher conservation would be the goal.

Approach

We will monitor the status and change in the distribution, reproductive success, and survivorship of fishers and we will compare these features with habitat to determine which habitats favor the growth of the Sierran fisher population and its recolonization of previously occupied habitat. Monitoring the presence/absence of fishers and their demographic parameters in large areas that are differentially affected by treatments will provide information that will inform future decisions about management activities. Monitoring survival and reproduction is necessary because, when related to habitat, these data will provide a better understanding of the current status of the fisher population than presence/absence (distribution) monitoring alone. Furthermore, survival/reproduction information will help predict the future growth of the fisher population and will be the most sensitive metric of population viability. It is possible that, after a period of annual population monitoring (distribution and demographic), we will have sufficient understanding of important habitat characteristics that we can confidently monitor habitat without annual monitoring of fisher distribution and demographics. This is contingent, however, on a dedicated program of population monitoring and careful analysis and testing of habitat models along the way. Ultimately these habitat models may make it unnecessary to monitor fisher populations directly, or at least to conduct population monitoring much less frequently. In this respect the approach mimics that proposed to monitor the effectiveness of the Northwest Forest Plan on recovery of the northern spotted owl (Lint et al. 1999). Because there are no dominant prey species that comprise the fisher diet in the southern Sierra, and because fishers are not affected by particular species of predators, the direct monitoring of species that directly interact with fishers is not warranted.

We seek information on the status and potential changes in the geographic distribution and the demographics of fishers as well as the status and changes in the quantity and quality of their habitat. Because we do not yet have a habitat model that can distinguish suitable from unsuitable habitat, it is necessary to monitor fishers directly. The most economical way to accomplish this is with an array of detection devices that determine presence/absence at survey points throughout the bioregion. The presence/absence of fishers at each location will be related to the habitat characteristics to understand, and then to monitor, fisher habitat.

Affectors: roads, fire and fuels management, dams/diversions (including hydroelectric), recreation, timber harvest (salvage, hazard tree, site prep)

Expected Results and Benefits

The combination of population and habitat monitoring will help determine whether the conservation strategy is effective in increasing the fisher population and in increasing the amount, quality and distribution of fisher habitat. We will use the monitoring data to determine whether the selected alternative has (1) increased the geographic extent and abundance of the fisher population in the Sierra Nevada, and (2) increased the amount and proper distribution of fisher habitat. The result will be an assessment of whether fisher habitat has been improved at various spatial scales (stand, home range, and landscape). This plan will also help determine whether changes in fisher populations or habitat are associated with actions taken by the Forest Service. If future monitoring determines that the population has declined, but the habitat has improved, then there may be no need for change in policy. It is possible that after a period of annual population monitoring (distribution and demographic) that we will have sufficient understanding of important habitat characteristics that we can confidently monitor habitat without annual monitoring of fisher distribution and demographics.

Our approach to monitoring geographic distribution is indirect, in that we assume that a change in the pattern of occurrence across the range is indicative of a change in population. We do not know, however, what relationship truly exists between our index of geographic distribution and population size. Therefore, direct monitoring of survival and reproduction in selected study areas is viewed as essential. We anticipate achieving some economies of scale by conducting these studies on the same study areas where demographic rates and densities are estimated for spotted owls (and perhaps other species). The habitat would be described, at multiple scales, in each of the study areas with the goal of developing a habitat model that could be used to predict—and to monitor over time—the habitats that result in the highest survival and reproduction. We can use the association between high survival and reproduction and particular habitat characteristics to understand and monitor important habitat, similar to the way that presence/absence from distribution monitoring will be used.

Critical to evaluating the effectiveness of the selected alternative is the consideration of all elements of the monitoring package presented here. The set of questions (status and change, cause and effect, implementation, key information gaps) is interdependent in that our interpretation of the results of one set (e.g., status and change) hinges on quality information from one or more other sets (e.g., implementation). Only with full implementation of this monitoring package will we be able to determine whether the actions taken will have influenced the status of fisher and their habitat. If data are collected immediately we will have very useful information in the first 5 years on the status of the fisher population, the habitat requirements of the fisher, and the distribution of fisher habitat. We will also have information on the effects of fire and fuels treatments on the habitat elements (i.e., large trees, snags and logs) that are important to fishers. It will take longer, perhaps 10 years, before we will have the monitoring data to determine whether we will be able to monitor habitat as a surrogate for monitoring the fisher population directly. Full synthesis of the information necessary to answer most of the 'cause and effect' questions (most of which are included in the 'fire' topic area) will require more than 5 years.

The status and trend of the fisher population and habitat are useful indices but until the information is linked, via experimentation or adaptive management, it will be difficult to specify the causes for any changes. This is why the 'cause and effect' questions and key information gaps are essential to progress. They take the solid information that is collected about fishers and their habitat and relate it to the potential agents of change in the Sierra Nevada. Most of these questions are included in the fire topic area, but their answers require monitoring effects on individual species such as the fisher.

Marten Issue

Description

Martens (*Martes americana*) appear to occupy much of their historical range in the Sierra (Kucera et al. 1995, Zielinski et al. 1997); however, our understanding of their distribution is less precise than for fishers. The marten's association with mature and old-growth forests (Buskirk and Powell 1994, Ruggiero et al. 1994) makes it vulnerable to the loss of large trees, and large patches of mature, high-elevation true-fir forest. The marten occurs in higher elevation forests (generally above 6,500') than the fisher. Large snags and large downed woody material provide protection from predators, sources of prey, access to subnivean (below snow) spaces, and protective thermal micro-environments (Spencer et al. 1983; Buskirk and Powell 1994). Martens do not appear capable of maintaining residence within home ranges that have lost more than 30% loss of mature forest cover (Chapin et al. 1998, Hargis et al. 1999, Potvin et al. 2000). The conservation of martens in the Sierra Nevada will require a better understanding of the current extent of fragmentation of true fir (*Abies* sp.) forests and sensitivity to additional fragmentation by management activities. The marten, like the fisher, occurs at the southernmost portion of its North American range in the Sierra and populations may be more vulnerable than those closer to the center of the species' range. Although classified as a furbearer in California, the marten has been protected since 1954. The marten is a 'Sensitive Species' in the Pacific Southwest Region (R5) of the US Forest Service, a "Species of Special Concern' as designated by the state of California, and a Management Indicator Species on various national forests within R5.

Uncertainties

Because martens that occur on the westside occupy high-elevation forests, these forests are less vulnerable to severe fires and are therefore less likely to be treated for fuel reduction. Although this is not the case on the drier, more fire-prone eastside pine habitats, there are far fewer human settlements and consequently less area designated as urban intermix where the treatments would affect habitat elements that are important to martens. However, all high-elevation habitats—west and eastside—tend to exhibit less ecological resilience to disturbance, requiring longer recovery times than more productive middle elevation sites. The potential impact of fire and fuel treatments on the quantity and quality of habitat for fisher is addressed in the Fire and Fuels topic area.

Protections exist for trees greater than 30" in westside forests and greater than 24" in eastside forests. However, it is uncertain whether this would lead to a loss of trees in the next smallest tree size classes (e.g., 20-29" in the true fir). Similarly, the reduction in canopy closure, in the interest of fire protection or fuel hazard reduction, may render stands less suitable to martens. The uncertainty of this effect is greatest in the HFQLG area where large areas of eastside pine forest habitat will be treated creating openings that will probably be avoided by martens. Martens in the Sierra Nevada also select habitats for foraging that are in close proximity to meadows and riparian areas (Spencer et al. 1983). Lack of spatially-explicit information for grazing allotments, pack stations and Important Bird Areas necessitates some caution in interpreting any cost/benefit that may result from their overlap with marten distribution. Trade-offs exist between allowing fire into riparian and meadow areas to reduce ladder fuels, the risk of catastrophic fire, and forest encroachment on meadows, versus the retention of snags and logs in these areas. Finally, the development of winter recreation areas such as ski resorts and snow parks may generate openings and fragment dense forest cover. These developments often require new roads and increase vehicular traffic. Management direction proposed in the EIS includes standards and guidelines that focus on limited operating periods near natal dens, the retention of large snags and logs, minimizing the effects of treatments on large trees, snags and logs, management of minimum proportions of old forest conditions in landscapes, the creation of management buffers around existing and new detection locations and around den sites, the recognition of roadkill as a threat, and the restriction of some OHV activities.

Approach

We will monitor the status and change in the geographic distribution of martens and we will compare the occurrence of martens to habitat features that are also monitored at various scales. Monitoring the presence/absence of martens, across large areas that are differentially affected by treatments, will provide information that will inform future decisions about management. If the results of monitoring geographic distribution suggest that a decrease in distribution, and in occupied habitat, is occurring then we propose that demographic study areas—similar to those proposed for fishers—be initiated and that we monitor survival, reproduction and density. Information on survival and reproduction will help predict the future growth of the population and will be the most sensitive metric of population viability. It is possible that, after a period of annual population monitoring (distribution and demographic), we will have sufficient understanding of important habitat characteristics that we can confidently monitor habitat without annual monitoring of marten distribution and demographics. This is contingent, however, on a dedicated program of population monitoring and careful analysis and testing of habitat models along the way. Ultimately these habitat models may make it unnecessary to monitor marten populations directly, or at least to conduct population monitoring much less frequently. In this respect the approach mimics that proposed to monitor the effectiveness of the Northwest Forest Plan on recovery of the northern spotted owl (Lint et al. 1999). Because there are no dominant prey species that comprise the marten diet in the Sierra, and because martens are not exposed to significant predation by any particular species, focused monitoring of species that directly interact with martens is not warranted at this time.

We seek information on the status and potential changes in the geographic distribution of martens as well as the status and changes in the quantity and quality of their habitat. Because we do not yet have an empirical habitat model that can distinguish suitable from unsuitable habitat, it is necessary to monitor martens directly. The most economical way to accomplish this is with an array of detection devices that determine presence/absence at survey points throughout the bioregion. The presence/absence of martens at each location will be related to the habitat characteristics to understand, and then to monitor, marten habitat.

Affectors: roads, fire and fuels management, dams/diversions (including hydroelectric), recreation, timber harvest (salvage, hazard tree, site prep)

Expected Results and Benefits

The combination of population and habitat monitoring will help determine whether the conservation strategy is effective in maintaining the distribution of martens throughout the planning area and in increasing the amount, quality and distribution of marten habitat. We will use the monitoring data to determine whether the selected alternative has (1) maintained the geographic extent of the marten population in the Sierra Nevada, and (2) maintained the quantity, quality and proper distribution of habitat and how trends in populations relate to trends in habitat. The result will be an assessment of whether marten habitat has been maintained at various spatial scales (stand, home range, and landscape). This plan will also help determine whether changes in marten populations or habitat are due to actions taken by the Forest Service. If future monitoring determines that the population has declined, but the habitat has improved, then there may be no need for change in policy. However, a decline in the distribution will trigger the need for developing more intensive monitoring of marten survival and reproductive rates in selected study areas. Should this occur, we would have the opportunity to understand the habitat features that are associated with healthy and growing marten populations and, in the future, to consider monitoring the habitat as a surrogate for monitoring the marten population itself.

Our approach to monitoring geographic distribution is indirect, in that we assume that a change in the pattern of occurrence across the range is indicative of a change in population. We do not know, however, what relationship truly exists between our index of geographic distribution and population size. This is why direct monitoring of survival and reproduction will be required if the distribution begins to decline. If monitoring these demographic parameters becomes necessary, we will achieve some economies of scale by conducting these studies on the same study areas where demographic rates and densities are estimated for other old-forest associated species for which these studies may be necessary. We would use the relationship between high survival and reproduction and particular habitat characteristics to understand and monitor important habitat, similar to the way that presence/absence from distribution monitoring will be used.

Critical to evaluating the effectiveness of the selected alternative is the consideration of all elements of the monitoring package presented here. The set of questions (status and change, cause and effect, implementation, key information gaps) is interdependent in that our interpretation of the results of one set (e.g., status and change) hinges on quality information from one or more other sets (e.g., implementation). Only with full implementation of this monitoring package will we be able to determine whether the actions taken will have influenced the status of marten and their habitat. If data are collected immediately we will have very useful information in the first 5 years on the status of the marten population, the habitat requirements of the marten, and the distribution of marten habitat. We will also have information on the effects of fire and fuels treatments on the habitat elements (i.e., large trees, snags and logs) that are important to martens. If it becomes necessary to monitor survival and reproduction (triggered when a significant decline in distribution is noted), it may take as long as 10 years before we will have the monitoring data to determine whether we will be able to monitor habitat as a surrogate for monitoring the marten population directly. Full synthesis of the information necessary to answer most of the ‘cause and effect’ questions (most of which are included in the ‘fire’ topic area) will require more than 5 years.

The status and trend of the marten population and habitat are useful indices, but until the information is linked—via experimentation or adaptive management—it will be difficult to specify the causes for any changes. This is why the ‘Cause and Effect’ questions are essential to progress. They take the solid information that is collected about martens and their habitat and relate it to the potential agents of change in the Sierra Nevada. Most of these questions are included in the fire topic area, but their answers require monitoring effects on individual species such as the marten.

Wolverine Issue

Description

Wolverines (*Gulo gulo*) were part of the early fur harvest in California and were distributed at low densities throughout most of the Sierra Nevada (Grinnell et al. 1937). In the early 1900s their populations were already viewed as declining, due largely to trapping (Dixon 1925, Seton 1929), and as of 1933 no more than 30 animals were thought to occur in California (Grinnell et al. 1937). It has been over 50 years since verifiable evidence (i.e., track, photograph, carcass) has been collected in California. There have been no regular surveys for wolverines since trapping was prohibited in the mid-1900s, and surveys specific to wolverine have not yielded positive results (Kucera and Barrett 1993). Each year, however, there are several reputable sightings in California. Wolverines use coniferous forest types predominately (Hornocker and Hash 1981, Copeland 1996), but their significant use of non-forest alpine habitats (Banci 1994, Copeland 1996) distinguishes them from the fisher and marten. There are two elements of their habitat for which they appear to be particularly selective. The first is their natal dens, which are associated with either high-elevation rocky or woody substrates on north and east slopes in cirque basins (Grinnell et al. 1937, Copeland 1996, Magoun and Copeland 1998) or large woody debris piles often associated with avalanche chutes (Krebs and Lewis 1999). The second ‘habitat’ element for which wolverines appear selective is for areas that are free from significant human disturbance, especially during the denning period of late winter and early spring. Wolverine occurrence in the Rocky Mountains is strongly associated with low human population and low road density (Carroll et al., in press). Hornocker and Hash (1981) believed that the seasonal shift to higher elevations in the summer in Montana was due to avoidance of human recreational activity.

Uncertainties

Because wolverines may only occur at very low densities in the Sierra Nevada, the uncertainties are related to how Forest Service activities will affect the dispersal of wolverines into the Cascades and Sierra Nevada from the north and the reproduction of animals that occur, or will occur, in the state. Wolverines are expected to occur at the highest elevations in the Sierra Nevada and, as a result, will usually reside above the zone where fire is a risk or where fuels treatments will be prescribed. The exception is the northern Sierra Nevada and Cascades where the highest elevations are forested and where treatments, especially in the HFQLG area, are likely to affect the highest elevations. There is risk to disrupting, via intensive fuel-hazard reduction activities, the avenue by which wolverines will travel from north to south to recolonize the Sierra Nevada.

An increasing amount of evidence and observation by wolverine biologists suggests that human disturbance, especially by snowmobile, during the late winter or early spring can affect wolverine use of wilderness high country (B. Kennedy, USFS, pers. comm., J. Copeland, Idaho Fish and Game, pers. comm., Copeland and Kucera 1997). New, more powerful, snowmobiles have an increasing effect on wolverine habitat elsewhere in the United States but the potential effect of alpine recreation on wolverines or their habitat has not been evaluated in California. The increasing popularity of high country recreation (vehicular and non-vehicular) and the burgeoning population of California (Duane 1996a) are well documented, but the effects of these activities on wolverine recovery in California are uncertain. The EIS does not propose new recreational activities that directly disturb wolverines or affect their habitat. However, the effects of existing backcountry activities—vehicular and non-vehicular - on the potential for wolverine recovery have not been considered. Management direction proposed in the EIS includes one standard and guide that is specific to wolverine. It restricts activities from January 1 – June 30 within 5 miles of valid sightings (presumed to apply also to verified tracks or photographs).

Approach

Because the presence of wolverines has not recently been documented in California, 'Status and Change' monitoring for this species amounts to conducting periodic searches to verify its existence within the planning area. Until we verify the existence of wolverines in the Sierra Nevada, there is no basis for 'Cause and Effect' monitoring and research. However, if a sighting with merit or tracks/photographs are collected as a result of our searches, we will monitor also the implementation of the single standard and guide (FC01 (6,8): restrict activities around location from January – June).

To determine the status of wolverines in the Sierra will require conducting searches using protocols that have been established for other western states. Determining changes in the number of wolverine detections that occur will be difficult until the number of detections increases. Assessment of wolverine habitat will be accomplished by routine assessment of habitat potential using CWHR and by applying to the Sierra Nevada the model that predicts the occurrence of wolverine den locations (Hart et al. 1997).

Affectors: recreation, fire and fuels management, dams/diversions (including hydroelectric), roads, timber harvest.

Expected Results and Benefits

The monitoring proposed above will help determine whether wolverines occur on Forest Service managed lands. The approach will guarantee that wolverine occurrence will not be overlooked. Until wolverines are verified in the planning area and until we can determine the effects of various management activities on their behavior and on their numbers, it will be difficult to know how best to regulate activities to encourage the growth of the wolverine population.

Monitoring wolverines is unlike that for many other species because we do not know whether wolverines currently occur in the Sierra Nevada. The information that is gained from the monitoring program will help determine when and where wolverines occur in the future and, therefore, will guide management actions to protect these animals from disturbance.

Sierra Nevada Red Fox Issue

Introduction

Historically, the Sierra Nevada red fox (SNRF) (*Vulpes vulpes necator*) maintained a continuous, high-elevation distribution in the Sierra Nevada and occurred at low densities (Grinnell et al. 1937). They were seldom sighted below 5,000 feet, and most often above 7,000 feet. The current distribution and population status of the SNRF is uncertain (California Department of Fish and Game 1990) but there has not been a documented SNRF occurrence in over 50 years. California is home both to the indigenous SNRF and to an introduced population of non-native red fox that occurs primarily in lowland areas in the state, though its range may be expanding into the Sierra Nevada (Burkett and Lewis 1992, Lewis et al. 1993). Unfortunately, there is currently no way to distinguish the SNRF from the non-native red fox (Lewis et al. 1993). The most recent California locations of high elevation red fox (of unknown subspecies) center around Lassen National Park. A recently initiated study has trapped and radio-collared several red foxes (Perrine pers. comm.) but until genetic testing is conducted we cannot be certain whether these are the introduced eastern or the Sierra Nevada subspecies. Martin (1989) noted that SNRF might be on the extreme edge of its range, existing in marginal habitat. However, the SNRF is potentially distributed across all 11 National Forests covered in this EIS, is a USDA Forest Service 'Sensitive Species', and is listed as 'Threatened' by the state of California.

Uncertainties

A key uncertainty, which is shared with the wolverine, is whether the Sierra Nevada subspecies currently occurs in the Sierra Nevada. The population of foxes in the high elevation Sierra Nevada is assumed to be small and probably declining (Schempf and White 1977) and the subspecific identity of red foxes known to occur in the Lassen region (Kucera 1995) is unknown. This aside, red foxes that once occurred throughout the Sierra were associated with elevations and habitats that protect them from fire and fuels management activities. The exception is the northern Sierra Nevada and Cascades where the highest elevations are forested and where fire and fuels treatments, especially in the HFQLG area, are likely to affect the highest elevations. More likely to affect the establishment and recovery of the SNRF are the activities proposed in the EIS that will affect alpine meadow systems. In addition to the frequent human disturbance (to which the native SNRF is intolerant) associated with grazing management, domestic livestock can reduce the vegetation height that influences cover for the fox's small mammal prey (Grinnell et al. 1937). It is also uncertain to what degree the encroachment of conifers into meadow and riparian areas affect meadow-associated species like the SNRF.

The increasing popularity of high country recreation (vehicular and non-vehicular) and the burgeoning population of California (Duane 1996a,b) are well documented, but the effects of these activities on SNRF recovery in California are uncertain. The EIS does not propose new recreational activities that directly disturb SNRF or affect their habitat. However, the effects of existing backcountry activities—vehicular and non-vehicular—on the potential for SNRF recovery have not been considered. Dispersed recreation such as trail use by hikers and livestock, pack stations, and alpine campgrounds can increase human presence in remote high country areas favored by SNRF and may concentrate use in meadow areas. Concentrated recreation such as at ski resorts and snow parks increase road density, traffic and access to high elevation habitats by humans. Road construction and increased human settlement in the Sierra Nevada provide access to areas previously unavailable and may facilitate the dispersal of the non-native red fox, which is capable of long-distance dispersal (Zeiner 1990, Lewis et al. 1993), into SNRF habitats. Competition may already be occurring with the introduced red fox for prey, den sites, and habitat (Lewis et al. 1993). Contact with the non-native fox may also result in interbreeding and disease transmission or increased mortality from rabies outbreaks (Lewis et al. 1993).

Management direction proposed in the EIS includes 1 standard and guideline that is specific to SNRF. It requires a Limited Operating Period to restrict activities from January 1 – June 30 within 5 miles of valid sightings (presumed to apply also to verified tracks or photographs).

Approach

Because the presence of SNRF has not been verified in California, 'Status and Change' monitoring for this species amounts to conducting periodic searches to verify its existence within the planning area. This should occur in association with a program to determine the subspecific identity of the foxes using genetic samples. Until we verify the existence of SNRF in the Sierra Nevada and determine their distribution, there is no basis for 'Cause and Effect' monitoring. However, if a sighting with merit or tracks/photographs is collected as a result of our searches, we will monitor the implementation of the standard and guidelines associated with the FEIS.

To determine the status of SNRF in the Sierra will require conducting searches using a combination of protocols that have been established for other species (e.g., lynx and wolverine) in other western states. Determining changes in the number of SNRF detections that occur will be difficult until the number of detections increases. Assessment of SNRF habitat will be accomplished by routine assessment of habitat potential using CWHR with the assumption, however, that this is currently based on very little empirical information and will need to be revised as detections and new habitat information accumulates.

Affectors: grazing, recreation, fire and fuels management, dams/diversions (including hydroelectric), roads, timber harvest (salvage, hazard tree, site prep)

Expected Results and Benefits

The monitoring proposed above will help determine whether SNRFs still occur on Forest Service managed lands. The approach will guarantee that SNRF occurrence will not be overlooked and that this information will be used to protect from disturbance during the denning period those SNRFs that are discovered in the Sierra. Addressing the habitat questions would be helpful, if added, because monitoring the quality and quantity of habitat via CWHR would help determine whether activities that are regulated by the Forest Service are not inhibiting the recovery of SNRF in the Sierra Nevada. However, until SNRF are verified in the planning area and until we can determine the effects of various management activities on their behavior and on their numbers—and develop empirical habitat models—it will be difficult to know how best to regulate activities to encourage the growth of the SNRF population.

Monitoring SNRFs is unlike that for many other species because we do not know whether *bona fide* SNRFs continue to occur in the Sierra Nevada. The information that is gained from the monitoring program will help determine when and where SNRFs occur in the future and, therefore, will guide management actions to protect these animals from disturbance. If we begin to implement search protocols immediately we will have in 5 years the best information that has ever been collected on the distribution of SNRFs since the trapping season closed. After 5 years we will also have completed several annual assessments of habitat quality via CWHR and will know the current status of habitat for SNRF. However, we will not understand the effects of grazing and recreation on SNRF habitat until we can address some of the information needs specified above.

Management Indicator Species and Species at Risk Issue

Description

This issue addresses population and habitat monitoring of Management Indicator Species (MIS) and species at risk. Species of highest concern—the California spotted owl, northern goshawk, fisher, marten, wolverine, and Sierra Nevada red fox—are treated as separate issues in the old forest topic area.

Management Indicator Species. The National Forest Management Act (NFMA) of 1976 dictates that MIS will be identified and monitored by each forest to yield information about the effects of management practices on native and desired nonnative vertebrate species. MIS are meant to represent groups of species with similar habitat requirements; management of these species to maintain viable population levels is intended to provide for viable populations of the remaining species in the group they represent. All 13 of the old forest associated MIS on the Sierra Nevada National Forests are vertebrates and include federal and state listed special concern species, Forest Service sensitive species, harvest species, and cavity-nesters (Table E-8).

Species at Risk. Species at risk are those with a high level of concern whose ranges are not peripheral to the Sierra Nevada and that occur in old forest ecosystems. This list includes those species given a full viability treatment in this EIS: all Federally Threatened, Endangered, and Special Concern species, Forest Service sensitive species, species in the High Vulnerability group, and those Moderate Vulnerability species with small populations and known declines. In addition, other federal threatened and endangered species and Forest Service sensitive species are included except if 1) their range occupies less than 5% of the Sierra Nevada bioregion, and 2) 50% or more of their entire range falls outside the Sierra Nevada. Some vertebrates are of lower concern than others; we identify species at lower risk as those that are federal special concern or moderate vulnerability and have no higher designations. These 11 species receive habitat monitoring only. Twenty-one vertebrate species (including four that are also MIS) and 86 vascular plant species are associated with the old forest topic area (Table E-8). Two of these are federally listed vertebrates for which a recovery plan that addresses monitoring exists (northern spotted owl and Sierra Nevada bighorn sheep); no additional monitoring is proposed for these species.

Management Direction. Standards and guidelines relevant to species at risk (beyond those addressing the species of highest concern) includes the establishment of Limited Operating Periods (LOPs) for listed and sensitive species, and requirements for surveys of sensitive plant species.

Uncertainties

Many uncertainties exist about the status and fate of MIS and species at risk. Basic information on distribution, population status, and habitat relationships is lacking for most MIS and species at risk, creating uncertainties about the adequacy and effectiveness of various conservation measures. Habitat for invertebrates, nonvascular plants, and fungi is particularly poorly understood. In addition, some MIS are intended to serve as indicators of ecosystem condition and the status of other species. Uncertainty exists as to if and how these species can serve this role, because they have not been tested or validated. Monitoring will serve as an early warning of declines in populations and habitat condition to address some of these uncertainties.

In addition to the above, the same uncertainties exist for MIS and species-at-risk as were identified for old forest conditions and the individual species, namely the effects of management activities directed at other values (e.g., fuel reduction) and the effectiveness of silvicultural treatments in creating desired conditions. However, the risks associated with these uncertainties were not deemed high enough to merit reduction through cause and effect monitoring and research.

Approach

Species and their associated population monitoring levels are shown in Table E-9. Population and/or habitat monitoring will be conducted for all MIS and species at risk. Varying levels of monitoring will be conducted depending on the level of concern associated with each species; as the level of concern about a species increases, the investment in monitoring data increases. Vascular plants will all receive population monitoring, ranging from presence to population demography (Table E-9) depending on the level of concern. Multi-species monitoring will be employed as an efficient way to obtain population and habitat data on the bulk of vertebrate MIS and species at risk. Those species not captured by multi-species monitoring will be monitoring through changes in habitat conditions.

It is possible that, after a period of annual population monitoring (distribution and abundance), we will have sufficient understanding of important habitat characteristics that we can confidently monitor habitat without annual monitoring of species' distribution and abundance. This is contingent, however, on a dedicated program of population monitoring and careful analysis and testing of habitat models along the way. Ultimately these habitat models may make it unnecessary to monitor species' populations directly, or at least to conduct population monitoring much less frequently. In this respect the approach mimics that proposed to monitor the effectiveness of the Northwest Forest Plan on recovery of the northern spotted owl (Lint et al. 1999).

Affectors: Fire suppression, vegetation management, roads, urbanization, exotic species, human recreation, livestock grazing

Expected Results and Benefits

This package of monitoring will provide managers with information about the status and change in populations and habitats of species at risk. This information will be useful in determining potential impacts of projects on sensitive species and will provide an early warning system for species known to be at risk, yielding information that may aid in preventing listing. In addition, this monitoring package meets the legal requirement to monitor MIS. Finally, multi-species methods employed to monitor MIS and species at risk will provide data on the habitat relationships of these species, enabling the validation of species as indicators and the potential to monitor habitat as a surrogate for populations. Multi-species monitoring protocols will also yield data on non-target species, providing the opportunity to test the effectiveness of candidate focal species.

Table E-9. Management Indicator Species (MIS) and species at risk (SAR) associated with old forest ecosystems. FSS = Forest Service sensitive; Other status: FSC = Federal special concern; CE = California Endangered; CT = California Threatened; CSC = California special concern. Monitoring level: Dist = distribution; Relab = relative abundance; Aprec = apparent recruitment; Demog = population demography. Vulnerability ratings (Vul): H = high, M = moderate, L = low, blank = not included in analysis because of their weak association with old forest ecosystems. Checkmarks (✓) in the population monitoring column indicate species for which population trend data is expected to be obtained.

CWHR ID	Common name	Scientific name	MIS	SAR	FSS	Other status	Vul	Monitoring level	Population monitoring
Vertebrates:									
B134	Blue grouse	*Dendragapus obscurus*	X				M	Dist	✓
B141	Mountain quail	*Oreortyx pictus*	X				L	Dist	✓
B270S2	Northern spotted owl [1]	*Strix occidentalis caurina*	X		X		M	Recovery plan	
B300	Williamson's sapsucker	*Sphyrapicus thyroideus*	X				L	Dist	✓
B304	Hairy woodpecker	*Picoides villosus*	X				L	Dist	✓
B308	Pileated woodpecker	*Dryocopus pileatus*	X				L	Dist	✓
M077	Western gray squirrel	*Sciurus griseus*	X				M	Dist	✓
M151	Black bear	*Ursus americanus*	X				M	Dist	✓
M177	Elk	*Cervus elaphus*	X				M	Dist	✓
M182	Pronghorn	*Antilocapra americana*	X				L	Dist	✓
B129	Peregrine falcon	*Falco peregrinus*	X	X	X	CE	L	Dist	✓
B137	Sage grouse	*Centrocercus urophasianus*	X	X		CSC	M	Dist	✓
B251	Band-tailed pigeon	*Columba fasciata*	X	X			M	Dist	✓
B271	Great gray owl	*Strix nebulosa*	X	X	X	CE	M	Dist	
AOXX1	Relictual slender salamander	*Batrachoseps relictus*		X	X	FSC, CSC		Dist,Relab	
AOXX2	Kern Plateau slender salamander	*Batrachoseps* sp.	X	X				Dist	
A016	Pacific slender salamander	*Batrachoseps pacificus*		X	X		M	Dist,Relab	✓
B309	Olive-sided flycatcher [2]	*Contopus cooperi*		X			M	Dist	✓
M025	Long-eared myotis [2]	*Myotis evotis*		X		FSC	M	Dist	✓
M026	Fringed myotis [2]	*Myotis thysanodes*		X		FSC	M	Dist	✓
M027	Long-legged myotis [2]	*Myotis volans*		X		FSC	M	Dist	✓
M029	Small-footed myotis [2]	*Myotis ciliolabrum*		X		FSC	M	Dist	✓
M030	Silver-haired bat [2]	*Lasionycteris noctivagans*		X			M	Dist	✓
M034	Hoary bat [2]	*Lasiurus cinereus*		X			M	Dist	✓
M036	Spotted bat [2]	*Euderma maculatum*		X		FSC, CSC	M	Dist	✓
M037S1	Pacific western big-eared bat	*Corynorhinus townsendi townsendi*		X	X	FSC, CSC		Dist,Relab	✓ (species level)
M037S2	Pale townsend's big-eared bat	*Corynorhinus townsendi pallescens*		X	X	FSC, CSC		Dist,Relab	✓ (species level)
M042S1	Greater western mastiff bat [2]	*Eumops perotis californicus*		X		FSC, CSC		Dist, CSC	
M044	Pygmy rabbit	*Brachylagus idahoensis*		X		FSC, CSC	H	Dist	✓
M049S1	Sierra Nevada snowshoe hare [2]	*Lepus americanus tahoensis*		X		FSC, CSC		Dist	✓
M050	White-tailed hare	*Lepus townsendii*		X		CSC	H	Dist	✓
M183S1	Sierra Nevada bighorn sheep [1]	*Ovis canadensis californiana*		X	X	CE	H	Recovery plan	

CWHR ID	Common name	Scientific name	MIS	SAR	FSS	Other status	Vul	Monitoring level	Population monitoring
Vascular plants:									
	Coville's dwarf abronia	*Abronia nana* ssp. *covillei*			X		H	Dist,Relab	✓
	Three-bracted onion	*Allium tribracteatum*			X	FSC	M	Dist,Relab	✓
	Yosemite onion	*Allium yosemitense*			X		L	Dist,Relab	✓
	Bodie Hills rock cress	*Arabis bodiensis*			X	FSC	M	Dist,Relab	✓
	Constance's rock cress	*Arabis constancei*			X		L	Dist	✓
	Pinzl's rock cress	*Arabis pinzlae*			X	FSC		Dist,Relab	✓
	Carson Range rock cress	*Arabis rigidissima* var. *demota*			X	FSC	L	Dist	✓
	Nissenan manzanita	*Arctostaphylos nissenana*			X	FSC	L	Dist	✓
	Troubled milk-vetch	*Astragalus anxius*			X	FSC	L	Dist	✓
	Walker Pass milk-vetch	*Astragalus ertterae*			X	FSC		Dist,Relab	✓
	Lens-pod milk-vetch	*Astragalus lentiformis*			X	FSC	M	Dist,Relab	✓
	Mono milk-vetch	*Astragalus monoensis* var. *monoensis*			X	FSC		Dist,Relab	✓
	Raven's milk-vetch	*Astragalus monoensis* var. *ravenii*			X	FSC		Dist,Relab	✓
	Pulsifer's milk-vetch	*Astragalus pulsiferae* var. *pulsiferae*			X		M	Dist,Relab	✓
	Suksdorf's milk-vetch	*Astragalus pulsiferae* var. *suksdorfii*			X	FSC	M	Dist,Relab	✓
	Shevock's milk-vetch	*Astragalus shevockii*			X		M	Dist,Relab	✓
	Webber's milk-vetch	*Astragalus webberi*			X	FSC	H	Dist,Demog	✓
	Western goblin	*Botrychium ascendens*			X	FSC	H	Dist,Relab	✓
	Western goblin	*Botrychium montanum*			X		H	Dist,Relab	✓
	Pleasant Valley mariposa lily	*Calochortus clavatus* var. *avius*			X	FSC	L	Dist,Relab	✓
	Shirley Meadows star-tulip	*Calochortus westonii*			X	FSC	L	Dist,Relab	✓
	Butte County morning-glory	*Calystegia atriplicifolia* ssp. *buttensis*			X		M	Dist,Relab	✓
	Mono Hot Springs evening-primrose	*Camissonia sierrae* ssp. *alticola*			X	FSC	L	Dist,Relab	✓
	Jaeger's caulostramina	*Caulostramina jaegeri*			X	FSC		Dist,Relab	✓
	Small's southern clarkia	*Clarkia australis*			X		L	Dist,Relab	✓
	Lake Almanor fairyfan	*Clarkia stellata*			X		L	Dist,Relab	✓
	Flaming trumpet	*Collomia rawsoniana*			X	FSC	L	Dist,Aprec	✓
	Bristlecone cryptantha	*Cryptantha roosiorum*			X	FSC		Dist,Relab	✓
	Clustered lady's-slipper	*Cypripedium fasciculatum*			X	FSC	H	Dist,Aprec	✓
	Mountain lady's-slipper	*Cypripedium montanum*			X		H	Dist,Aprec	✓
	Unexpected larkspur	*Delphinium inopinum*			X		M	Dist,Relab	✓
	Tulare County bleeding heart	*Dicentra nevadensis*			X		M	Dist,Relab	✓
	Tahoe draba	*Draba asterophora* var. *asterophora*			X			Dist,Relab	✓
	Cup Lake draba	*Draba asterophora* var. *macrocarpa*			X	FSC		Dist,Relab	✓
	Gilman's goldenbush	*Ericameria gilmanii*			X			Dist,Relab	✓
	Hall's daisy	*Erigeron aequifolius*			X		L	Dist,Relab	✓
	Starved daisy	*Erigeron miser*			X		L	Dist	✓
	Limestone daisy	*Erigeron uncialis* var. *uncialis*			X			Dist,Relab	✓
	Breedlove's buckwheat	*Eriogonum breedlovei* var. *breedlovei*			X	FSC	L	Dist,Relab	✓
	Kettle Dome buckwheat	*Eriogonum prattenianum* var. *avium*			X		L	Dist,Relab	✓
	Prostrate buckwheat	*Eriogonum prociduum*			X	FSC	L	Dist	✓
	Twisselmann's buckwheat	*Eriogonum twisselmannii*			X	FSC	L	Dist,Relab	✓
	Green buckwheat	*Eriogonum umbellatum* var. *glaberrimum*			X		M	Dist,Relab	✓
	Donner Pass buckwheat	*Eriogonum umbellatum* var. *torreyanum*			X	FSC	H	Dist,Relab	✓

CWHR ID	Common name	Scientific name	MIS	SAR	FSS	Other status	Vul	Monitoring level	Population monitoring
	Olancha Peak buckwheat	*Eriogonum wrightii* var. *olanchense*			X			Dist,Relab	✓
	Yosemite woolly sunflower	*Eriophyllum nubigenum*			X		M	Dist,Aprec	✓
	Hocket Lakes fawn lily	*Erythronium pusaterii*			X			Dist,Relab	✓
	Pilot Ridge dawn lily	*Erythronium taylori*			X		L	Dist,Relab	✓
	Warner Mtns. bedstraw	*Galium serpenticum* ssp. *warnerense*			X		M	Dist,Relab	✓
	Heterotheca monarchensis	*Heterotheca monarchensis*			X			Dist,Relab	✓
	White Mtns. horkelia	*Horkelia hispidula*			X		M	Dist,Relab	✓
	Kern Plateau horkelia	*Horkelia tularensis*			X	FSC	L	Dist,Relab	✓
	Short-leaved hulsea	*Hulsea brevifolia*			X		M	Dist,Relab	✓
	Baker's globe mallow	*Iliamna bakeri*			X		M	Dist,Aprec	✓
	Ash Creek ivesia	*Ivesia paniculata*			X	FSC	L	Dist,Relab	✓
	Webber's ivesia	*Ivesia webberi*			X	FSC	H	Dist,Aprec	✓
	Yosemite lewisia	*Lewisia disepala*			X		M	Dist,Relab	✓
	Long-petaled lewisia	*Lewisia longipetala*			X	FSC	L	Dist	✓
	Saw-toothed lewisia	*Lewisia serrata*			X	FSC	L	Dist	✓
	Stebbins's lomatium	*Lomatium stebbinsii*			X	FSC	M	Dist,Relab	✓
	Orange lupine	*Lupinus citrinus* var. *citrinus*			X	FSC	H	Dist,Relab	✓
	Quincy lupine	*Lupinus dalesiae*			X		L	Dist,Aprec	✓
	Father Crowley's lupine	*Lupinus padre-crowleyi*			X	FSC	H	Dist,Demog	✓
	Kelso Creek monkeyflower	*Mimulus shevockii*			X		M	Dist,Relab	✓
	Sweet-smelling monardella	*Monardella beneolens*			X			Dist,Relab	✓
	Follett's monardella	*Monardella follettii*			X		M	Dist,Aprec	✓
	Flax-like monardella	*Monardella linoides* ssp. *oblonga*			X	FSC	L	Dist,Relab	✓
	Stebbins's monardella	*Monardella stebbinsii*			X		H	Dist,Demog	✓
	Baja navarretia	*Navarretia peninsularis*			X		M	Dist,Relab	✓
	Twisselmann's nemacladus	*Nemacladus twisselmannii*			X	FSC	M	Dist,Relab	✓
	Purple mountain-parsley	*Oreonana purpurascens*			X		L	Dist,Relab	✓
	Inyo beardtongue	*Penstemon papillatus*			X		M	Dist,Relab	✓
	Closed-throated beardtongue	*Penstemon personatus*			X	FSC	L	Dist,Aprec	✓
	Playa phacelia	*Phacelia inundata*			X		M	Dist,Relab	✓
	Mono County phacelia	*Phacelia monoensis*			X	FSC	M	Dist,Relab	✓
	Nine Mile Canyon phacelia	*Phacelia novenmillensis*			X	FSC	M	Dist,Relab	✓
	Stebbins's phacelia	*Phacelia stebbinsii*			X	FSC	M	Dist,Relab	✓
	Mason's sky pilot	*Polemonium chartaceum*			X			Dist,Relab	✓
	Sticky pyrrocoma	*Pyrrocoma lucida*			X		H	Dist,Demog	✓
	Muir's raillardella	*Raillardiopsis muirii*			X		L	Dist,Relab	✓
	Feather River stonecrop	*Sedum albomarginatum*			X		L	Dist,Relab	✓
	Western campion	*Silene occidentalis* ssp. *longistipitata*			X	FSC	M	Dist,Demog	✓
	Piute Mtns. jewel-flower	*Streptanthus cordatus* var. *piutensis*			X	FSC	M	Dist,Relab	✓
	Tehipite Valley jewel-flower	*Streptanthus fenestratus*			X			Dist,Relab	✓
	Masonic Mtn. jewel-flower	*Streptanthus oliganthus*			X	FSC	M	Dist,Relab	✓
	Grey-leaved violet	*Viola pinetorum* ssp. *grisea*			X		M	Dist,Relab	✓

[1] *Federally Endangered species*
[2] *Species at lower risk*

7.3. Old Forest Monitoring Questions

Implementation Monitoring

1. Were standards and guidelines relating to reintroducing fire into old forest ecosystems met? (OF18)
2. Were standards and guidelines relating to retention of live trees met? (OF02, OF04)
3. Have all hardwood tress and snags 10 inches dbh or greater been retained during mechanical vegetation treatments, including salvage operations, except where trees pose an immediate threat to human life or property? (OF24)
4. Were standards and guidelines relating to live tree and snag retention following stand replacing events met? (B52)
5. Were old forest emphasis areas managed as prescribed in the standards and guidelines?
6. Were California spotted owl protected activity centers (PACs) delineated and were activities within them restricted according to standards and guidelines in the selected alternative? (B01, B02, B07, B08)
7. Were Limited Operating Periods for California spotted owl PACs established and implemented according to the standards and guidelines in the selected alternative? (B11)
8. Were California spotted owl foraging habitats delineated and were activities within them restricted according to standards and guidelines in the selected alternative? (B20D)
9. Were circular home range polygons delineated around each California spotted owl activity center detected since 1987 and were habitat standards met inside and outside individual home ranges? (B18, B22, B51)
10. Were nesting and roosting habitats maintained in conditions suitable for continued use by California spotted owls in PACs according to standards and guidelines? (B07B, B08, B10)
11. Were northern goshawk protected activity centers (PACs) delineated and were activities within them restricted according to standards and guidelines in the selected alternative? (B04, B05)
12. Were westside standards met for down woody debris in relation to prey for northern goshawks? (B30)
13. Were Limited Operating Periods provided when and where necessary for all Federally listed or proposed threatened and endangered species and Forest Service sensitive species? (TES1)
14. Were westside standards met for down woody debris in relation to prey for fishers? (B30)
15. Were verified Pacific fisher birthing and kit rearing dens protected from March 1 - June 30 with 700-acre buffers consisting of the highest quality habitat in a compact arrangement surrounding the den site and was a Limited Operating Period established and implemented? (FC01G, FC01H)
16. Was a 7,500 acre home range established around known and future Pacific fisher detections, with home range selection being the best habitat available around or adjacent to the detection in accordance with standards and guidelines, and detections defined as a photo of the species, a verified track-plate fisher paw print, or a carcass? (FC50A)
17. Have management activities within fisher detection buffers been in accordance with standards and guidelines? (FC50C)
18. Have snags been retained according to standards and guidelines in the selected alternative? (FC25, FC25A, FC33)
19. Have roads that were open to public travel, but were in conflict with objectives of the area, been considered for decommissioning or closure, with priority given to roads that run along streams or that fragment forest carnivore habitat (e.g. loop roads)? Have roads been managed to minimize animals killed on roads? (RD07B)

20. Has coarse woody debris for fishers been retained in accordance with standards and guidelines? (FC40A)
21. In the Southern Sierra Fisher Conservation Area (SSFCA) were fuels treatments limited to mechanical methods and hand-clearing until more knowledge is gained regarding the effects of prescribed fire on fishers and fisher habitat, and were mechanical methods in accordance with standards and guidelines? (FC92, OF16)
22. In the SSFCA were planning watersheds managed to support fisher habitat requirements? (OF14A)
23. Have all stand-altering activities been excluded from all known and future fisher den site buffers until more knowledge is gained regarding the effects of treatments on fishers and fisher habitat? (PC01N)
24. In areas of mixed ownership have standards and guidelines relative to habitat quality and connectivity been met? (FC91, FC95)
25. Were westside standards met for down woody debris in relation to prey for marten? (B30)
26. Has coarse woody debris been retained in accordance with standards and guidelines? (FC40A)
27. Was a 2,500-acre home range established around known and future American marten detections, with home range selection being the best habitat available around or adjacent to the detection, and detections defined as a photo of the species or a verified track-plate marten paw print? (FC50)
28. Have snags been retained according to standards and guidelines in the selected alternative? (FC25, FC25A, FC33)
29. Have management activities within marten detection buffers been in accordance with standards and guidelines? (FC50C)
30. In areas of mixed ownership have standards and guidelines relative to habitat quality and connectivity been met? (FC91, FC95)
31. Have roads that were open to public travel, but were in conflict with objectives of the area, been considered for decommissioning or closure, with priority given to roads that run along streams or that fragment forest carnivore habitat (e.g. loop roads)? Have roads been managed to minimize animals killed on roads? (RD07B)
32. Were Limited Operating Periods provided when and where necessary for all Federally listed or proposed threatened and endangered species and Forest Service sensitive species? (TES1)
33. Upon a detection, was an analysis performed to determine if activities within five miles of the detection had the potential to impact wolverines, and for a period of two years following the detection, were activities restricted from January 1 to June 30 that were determined to have an adverse impact? (FC01M)
34. Were field surveys for TEPS plant species conducted in accordance with standards and guidelines? (P01)
35. Were management prescriptions from completed (signed by line officer) species management guides or recovery plans for threatened, endangered, proposed and sensitive plants incorporated into Forest Plans? (P03)
36. Was an LOP provided when and where necessary for all TEPS species? (TES1)

Status and Change and Cause and Effect Monitoring

High priority questions will be addressed during the planning period, and lower priority questions will be addressed if possible.

High Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
WHAT IS THE STATUS AND CHANGE OF…			
1. Key within-stand vegetation structural components of old forest ecosystems?	species composition, canopy cover, hardwood basal area by species, canopy layers, tree diameter, plant biomass, leaf area index, down woody debris density, litter volume, snag density, decadent tree characteristics, gap number, gap size, distribution of forest gaps	20	FIA, approximately $1.5 million per year
2. The distribution and abundance of forest communities at the landscape scale, and how is it changing during the planning period?	abundance and proportion of forest communities by type and age distribution, number of patches, patch size, spatial distribution, distance among patches, fragmentation, connectivity	3	FIA and remotely sensed data
3. The geographic distribution, abundance, and reproductive success of the California spotted owl?	presence, number, and reproductive success of owls at each in an array of monitoring stations throughout the planning area	50	
4. The quantity, quality, and distribution of California spotted owl habitat?	distribution of large trees, snags and logs within stands, vegetation composition, structure and spatial arrangement within home ranges, vegetation indices from remote sensing, prey species, special habitat elements, spatial arrangement of important habitat areas at the landscape scale	40	
5. The abundance and reproductive success of the northern goshawk in the Sierra Nevada?	presence, number, and reproductive success of goshawks at each in an array of monitoring stations throughout the planning area	50	
6. The quantity, quality, and distribution of northern goshawk habitat?	see question 4	50	
7. The geographic distribution, abundance, reproductive success, and survivorship of the fisher population?	presence of fishers at each in an array of monitoring stations throughout the planning area, reproductive status of captured females, recapture rates of marked individuals	110	
8. The quantity and quality of fisher habitat at the stand, home range and landscape scales?	see question 4	10	
9. What is the status and change in the geographic distribution and relative abundance of the marten population?	presence of martens at each in an array of systematic survey points throughout the planning area	60	Fisher monitoring covers about ½ costs of marten
10. The quantity and quality of marten habitat at the stand, home range and landscape scales?	see question 4	10	
11. The occupancy of the Sierra Nevada and southern Cascades by wolverines and Sierra Nevada red fox?	Presence of verified wolverine tracks, photographs or sightings; collection of hair or tissue from individuals that are determined to be red foxes via searches for tracks, photographs or sightings	40	
12. Populations and habitats of MIS and vertebrate species at risk?	Presence, distribution, relative abundance, amount and distribution of suitable habitat	660	Covers MIS and species at risk monitoring (other than the top 13 species) for all topic areas. An estimate of 50 species monitored (habitat and/or population).
13. Populations of vascular plant species at risk?	Presence, distribution, relative abundance, apparent recruitment, and population demography	100	Covers all 135 FSS plant species

High Priority Cause and Effect Monitoring Questions	Attributes	Total cost ($1000s)	Contrib. from linked questions or other NFS programs
1. Do silvicultural treatments in stands cumulatively enhance the ecosystem function of existing old forests, including habitat for species at risk (owl, goshawk, fisher, marten), and accelerate development and recruitment of old forests?	silvicultural treatments, vegetation structure and composition (e.g., large trees density, canopy characteristics, vegetative layering), plant biomass, leaf area index, down woody debris, litter volume, snag density, distribution and fragmentation of old forests across the landscape	135	
2. How does salvage logging affect vegetation structure and composition and the suitability of habitat for old forest species at risk (owl, goshawk, fisher, marten)?	salvage and hazard tree removal operations, attributes for question 1	203	Natural resource program
3. How are natural disturbances influencing the amount and condition of old forests?	natural disturbances (insects, fungal infections, drought, meteorological events), plus attributes from question 1	1	
Lower Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
1. The quantity and quality of wolverine habitat?	distribution of CWHR index values within the historical range of wolverine and SNRF	3	
2. The quantity and quality of wolverine denning habitat?	proportion of predicted wolverine den sites that do not receive human disturbance during the denning season (January – June)	5	
3. The quantity and quality of Sierra Nevada red fox habitat?	distribution of CWHR index values within the historical range of SNRF	3	

7.4. Key Old Forest Information Gaps

The following are research questions that were identified as key information needs in relation to the topic areas addressed in the FEIS. The first three questions listed here were identified as a high priority for the Pacific Southwest Station, and every effort will be made to address these first three questions during the planning period.

1. What are the habitat relationships of the California spotted owl at the stand, home range, and landscape scales?
2. What are the habitat relationships of the fisher at the stand, home range, and landscape scales, particularly in relation to den sites? Do existing data on habitat relationships accurately represent habitat of fishers?
3. What are the reproduction and mortality rates of fishers and what environmental features are potentially influential?
4. What habitats produce the greatest rates of reproduction of the California spotted owl and the least mortality and how do these habitats change over time?
5. What insights can be gained from a more in-depth analysis of California spotted owl demographic study data across the 4 historic study areas as to the driving factors behind observed population trends?
6. What are the habitat relationships of the Northern Goshawk at the stand, home range, and landscape scales?
7. What habitats produce the greatest rates of reproduction and the least mortality for the Northern Goshawk and how do these habitats change over time?
8. What are the effects of OHV use on the abundance and distribution of fishers?
9. What are the habitat relationships of old forest associated MIS and species at risk?

10. How effective are associated MIS at indicating old forest ecosystem conditions and the status of other species?
11. What species might be strong indicators of old forest ecosystem conditions and the status of other old forest associated species? What are the habitat relationships of the marten at the stand, home range, and landscape scales? Do existing data on habitat relationships accurately represent habitat of martens?
12. What are the effects of OHV use on the abundance and distribution of martens?
13. What are the effects of increasing ski-resort and snow-park developments on marten habitat?
14. What are the effects of increasing ski-resort and snow-park developments on wolverine habitat?
15. What are the effects of ski-resort and snow-park developments on SNRFs habitat?
16. What genetic markers best distinguish the SNRF from the non-native red foxes and what means are best for collecting DNA to conduct such analysis?

8. Lower Westside Hardwood Forests

8.1. Introduction

Background

Mature hardwoods of the lower conifer zone are critical components of Sierra Nevada ecosystems as elements of biological diversity and as habitat for some old forest associated species. They provide cavities that are used for roosting, resting, and reproduction for many wildlife species, and energy to animal communities in the form of acorns and foliage. Increasing urban development in lower elevations in the Sierra Nevada has fragmented and decreased the amount of hardwood forests. The public has expressed a desire to maintain the remaining hardwood forests for their ecological roles in processes such as fire, soil building, and nutrient cycling, biodiversity, aesthetics, cultural resources, and for resource uses such as firewood and forage.

There is significant variation across forests for retention of hardwoods in managed and un-managed conifer stands. Introduction and spread of non-native species like yellow star thistle and scotch broom are affecting biodiversity. Also, oak regeneration is not widely addressed in Forest Plans. Trends in hardwood ecosystem distribution indicate that hardwoods are declining on public lands, and rapidly being lost on private lands. This loss on private lands puts a greater responsibility on the Forest Service to maintain and enhance portions of hardwood ecosystems on national forest lands. The purpose of the proposed action is to provide a strategy and standards and guidelines that will result in sustaining desired conditions of hardwood forest ecosystems, including structure, composition and function to maintain biological diversity.

The National Forest Management Act (NFMA) of 1976, CFR title 36 Part 219, mandates monitoring of species populations and their habitats (see previous discussion). In addition to NFMA, other legislation that specifically requires monitoring includes the Endangered Species Act, National Environmental Policy Act, Fish and Wildlife Conservation Act, Executive Orders, Forest Service Handbook, Forest Service Manual, OGC opinion and court decisions, and the Natural Resource Agenda announced by the Chief.

Overview of Approach

The monitoring plan for lower westside hardwoods was developed to address community and ecosystem management goals of the lower westside hardwood topic area. The goals include, (1) community and ecosystem integrity, and (2) maintaining habitat to support viable populations of associated species. Thus the monitoring plan addresses issues of the amount and condition of hardwood forests, and vegetative structures characteristic of hardwood forests, and important to ecosystem function and habitat for associated species. Maintaining the habitat needs of hardwood-associated species, species diversity, and viability of species are addressed through monitoring MIS and species-at-risk. Monitoring is designed to assess the achievement of those goals as well as to reflect relevant issues, public concerns, and management uncertainties regarding the goals.

8.2. Description of Lower Westside Hardwood Issues

Amount and Condition of Lower Westside Hardwoods Issue

Description

Monitoring to describe hardwood ecosystems includes both stand-scale and landscape-scale features. Stand-scale attributes describe the general structure and components of hardwood communities, as well as vegetative structures characteristic of hardwood forests and important to ecosystem function. Landscape-scale attributes will monitor the distribution and abundance of hardwood forests, and will include number, spatial extent, and spatial arrangement.

Uncertainties

One of the major uncertainties for managing hardwoods is basic information on the extent of original and existing hardwood forests, and the basic condition of hardwood ecosystems. Another uncertainty is the effectiveness of the fuels treatments on reducing the extent and severity of wildfire, and the effects of this management on habitat for wildlife species associated with hardwood ecosystems, and the ecological function of these ecosystems. There is a risk of prescribed fire escaping and spreading and adversely affecting hardwood habitat.

Approach

Monitoring will address changes in stand and landscape scale vegetation features. Status and change monitoring questions and attributes were selected because they are direct measures or indicators of the status and change of amount, condition, distribution, integrity of hardwood forests, at the stand and landscape scale. No cause and effect questions were identified as high priority, however the effectiveness of grazing standards was identified as a priority cause and effect monitoring question.

Affectors: Fire and fuel treatments, mechanical vegetation treatments, salvage and hazard tree removal, exotic species, roads, grazing, and recreation and recreational development

Expected Results and Benefits

Monitoring the implementation of hardwood forest standard and guidelines will assess if management direction is accomplished and /or achievable. The information from status and change monitoring will help determine if hardwood forest ecosystems are trending toward desired condition and at what rate. The combination of stand and landscape scale monitoring will allow managers to assess the amount, condition, distribution, and integrity of hardwood ecosystems, how they are changing over time, and whether or not stated desired conditions are appropriate and achievable. Remote sensing data will increase our understanding on how management actions appear at broad spatial scales and how well the results of management activities conform to intended results for hardwood forest ecosystems. Information on potential causes of changes will be provided by monitoring affectors, as well as available data on explanatory variables such as air quality, air pollution/chemical pollution, climate change, urbanization/land development. If the effectiveness of grazing standards in hardwood forest stands is monitored (lower priority) the results will inform forest managers as to the effectiveness of current strategies to protect and sustain hardwood forests in the Sierra Nevada, and to provide for the integrity and function of hardwood forest ecosystems. If results indicate that grazing standards are not adequate to achieve desired conditions, managers can make course corrections quickly.

The information gained through this monitoring is essential to validate the assumptions associated with the stated goals and prescribed management for hardwood forests and associated species. The composite information provided by this suite of monitoring questions will help determine if management activities are cumulatively accomplishing the changes designed to protect and sustain hardwood forest ecosystems and improve their functional integrity to conserve biotic diversity, as stated in the desired conditions.

Management Indicator Species and Species at Risk Issue

Description

This issue addresses population and habitat monitoring of Management Indicator Species (MIS) and species at risk.

Management Indicator Species. Six MIS are associated with the lower westside hardwood topic area (Table E-10). See Old Forest topic area MIS section for a discussion of the role of MIS in forest management.

Species at risk. Seven vertebrate species (including one that is also a MIS) and 28 vascular plant species are associated with the lower westside hardwood topic area (Table E-10). One of these is a federally listed vertebrate for which a recovery plan that addresses monitoring exists (California condor); no additional monitoring is proposed for this species. See Old Forest topic area species at risk section for a description of the criteria used to identify species at risk.

Management Direction. Standards and guidelines relevant to species at risk (beyond those addressing the species of highest concern) includes restrictions on salvage logging for snag-dependent species, establishment of limited operating periods for listed and sensitive species, and requirements for surveys of sensitive plant species.

Uncertainties

Many uncertainties exist about the status and fate of MIS and species at risk. Basic information on distribution, population status, and habitat relationships is lacking for most MIS and species at risk, creating uncertainties about the adequacy of and necessity for various conservation measures. Habitat for invertebrates, nonvascular plants, and fungi is particularly poorly understood. In addition, some MIS are intended to serve as indicators of ecosystem condition and the status of other species. Uncertainty exists as to if and how these species can serve this role, because they have not been tested or validated.

There is a high degree of risk that silvicultural and fuels treatments (including salvage harvest and hazard tree removal) could damage hardwood ecosystem function and will not produce the desired condition of habitat for hardwood associated species, and that the short term impact of these management activities on species' occupancy, reproduction, and survival could exacerbate risks to population viability even if habitat goals were eventually met. It is uncertain if mechanical treatments will render the desired conditions for hardwood habitat or damage resource values, including hardwood ecosystem function. Uncertainty also exists regarding how each of the different vegetation management treatments affects the distribution, abundance, and availability of prey for at-risk species. Because the populations of many sensitive plant and animal species are already in decline, the risk of management damaging the resource has to be balanced with the risk of losing habitat to the threat of high severity wildfire. One of the major uncertainties for managing hardwoods is basic information on the extent of original and existing hardwood forests, and thus the location and abundance of hardwood habitat for associated species. Hardwood ecosystems have high biodiversity, which is reflected by MIS and species at risk associated with these ecosystems. Additional uncertainties include 1) whether efforts to restore the quantity, quality, and distribution of hardwood ecosystems in Sierra Nevada National Forests are sufficient to support viable populations of at-risk associated species; 2) whether management directed toward improving hardwood ecosystem condition provides habitats that support a diverse array of species, including species at risk; and 3) whether environmental processes at regional or global scales may override efforts at landscape scales to provide suitable habitat for species associated with hardwood ecosystems. Monitoring will serve as an early warning of declines in populations and habitat condition to address some of these uncertainties.

Approach

Species and their associated population monitoring levels are shown in Table E-10. Population and/or habitat monitoring will be conducted for all MIS and species at risk. Varying levels of monitoring will be conducted depending on the level of concern associated with each species; as the level of concern about a species increases, the investment in monitoring data increases. Vascular plants will all receive population monitoring, ranging from presence to population demography (Table E-10) depending on the level of concern. Multi-species monitoring will be employed as an efficient way to obtain population and habitat data on the bulk of vertebrate MIS and species at risk. Those species not captured by multi-species monitoring will be monitoring through changes in habitat conditions.

It is possible that, after a period of annual population monitoring (distribution and abundance), we will have sufficient understanding of important habitat characteristics that we can confidently monitor habitat without annual monitoring of species' distribution and abundance. This is contingent, however, on a dedicated program of population monitoring and careful analysis and testing of habitat models along the way. Ultimately these habitat models may make it unnecessary to monitor species' populations directly, or at least to conduct population monitoring much less frequently. In this respect the approach mimics that proposed to monitor the effectiveness of the Northwest Forest Plan on recovery of the northern spotted owl (Lint et al. 1999).

Expected Results and Benefits

This package of monitoring will provide managers with information about the status and change in populations and habitats of MIS and species at risk. This information will be useful in determining potential impacts of projects on sensitive species and will provide an early warning system for species known to be at risk, yielding information that may aid in preventing listing. In addition, this monitoring package meets the legal requirement to monitor MIS. Finally, multi-species methods employed to monitor MIS and species at risk will provide data on the habitat relationships of these species, enabling the validation of species as indicators and the potential to monitoring habitat as a surrogate for populations. Multi-species monitoring protocols will yield data on non-target species, providing the opportunity to test the effectiveness of some candidate focal species.

Table E-10. Management Indicator Species (MIS) and species at risk (SAR) associated with lower Westside hardwood ecosystems. FSS = Forest Service sensitive; Other status: FSC = Federal special concern; CE = California Endangered; CT = California Threatened; CSC = California special concern. Monitoring level: Dist = distribution; Relab = relative abundance; Aprec = apparent recruitment; Demog = population demography. Vulnerability ratings (Vul): H = high, M = moderate, L = low, blank = not included in analysis because of their weak association with lower westside hardwood ecosystems. Checkmarks (✓) in the population monitoring column indicate species for which population trend data is expected to be obtained.

CWHR ID	Common name	Scientific name	MIS	SAR	FSS	Other status	Vul	Monitoring level	Population monitoring
Vertebrates:									
B126	Golden eagle	*Aquila chrysaetos*	X			CSC	L	Dist	✓
B131	Prairie falcon	*Falco mexicanus*	X			CSC	L	Dist	✓
B138	Turkey	*Meleagris gallopavo*	X				L	Dist	✓
M181	Mule deer	*Odocoileus hemionus*	X				M	Dist	✓
B109	California condor [1]	*Gymnogyps californianus*	X	X		CE	H	Recovery plan	
B121	Swainson's hawk	*Buteo swainsoni*	X		X	CT	M	Dist,Relab	
B260	Greater roadrunner	*Geococcyx californianus*		X			H	Dist	
B272	Long-eared owl	*Asio otus*		X		CSC	H	Dist	✓
B338	Purple martin	*Progne subis*		X		CSC	H	Dist	
M033	Western red bat	*Lasiurus blossevillii*		X	X		H	Dist,Relab	
M038	Pallid bat	*Antrozous pallidus*		X	X	CSC	M	Dist	✓
A012S1	Yellow-blotched ensatina	*Ensatina eschscholzii croceator*			X	FSC		Dist	
A017	Kern Canyon slender salamander	*Batrachoseps simatus*			X	CT	M	Dist,Relab	
A018	Tehachapi slender salamander	*Batrachoseps stebbinsi*			X	CT	M	Dist,Relab	
A025	Limestone salamander	*Hydromantes brunus*			X	CT	L	Dist,Relab	
R043	California legless lizard	*Anniella pulchra*			X		M	Pres	

CWHR ID	Common name	Scientific name	MIS	SAR	FSS	Other status	Vul	Monitoring level	Population monitoring
Vascular plants:									
	Jepson's onion	*Allium jepsonii*			X	FSC	L	Dist,Aprec	✓
	Kaweah brodiaea	*Brodiaea insignis*			X	CE	H	Dist,Relab	✓
	Butte County calycadenia	*Calycadenia oppositifolia*			X		M	Dist,Relab	✓
	Mariposa pussypaws [2]	*Calyptridium pulchellum*			X		H	Dist,Relab	✓
	tree-anemone	*Carpenteria californica*			X	ST	L	Dist,Aprec	✓
	Mariposa clarkia	*Clarkia biloba* ssp. *australis*			X		L	Dist,Relab	✓
	Brandegee's fairyfan	*Clarkia biloba* ssp. *brandegeae*			X		L	Dist,Relab	✓
	white-stemmed clarkia	*Clarkia gracilis* ssp. *albicaulis*			X		L	Dist,Relab	✓
	Merced clarkia	*Clarkia lingulata*			X	CE	L	Dist,Relab	✓
	Mosquin's clarkia	*Clarkia mosquinii* var. *mosquinii*			X	FSC	L	Dist,Relab	✓
	Springville clarkia [2]	*Clarkia springvillensis*			X	CE	M	Dist,Relab	✓
	Pierpoint Springs dudleya	*Dudleya cymosa* ssp. *costafolia*			X	FSC		Dist,Relab	✓
	Kings River buckwheat	*Eriogonum nudum* var. *regirivum*			X			Dist,Relab	✓
	tripod buckwheat	*Eriogonum tripodum*			X		M	Dist,Aprec	✓
	Congdon's woolly sunflower	*Eriophyllum congdonii*			X		L	Dist,Relab	✓
	Tuolumne fawn lily	*Erythronium tuolumnense*			X	FSC	H	Dist,Relab	✓
	Butte County fritillary	*Fritillaria eastwoodiae*			X	FSC	H	Dist,Demog	✓
	striped adobe-lily	*Fritillaria striata*			X	ST	H	Dist,Aprec	✓
	Shevock's hairy golden-aster	*Heterotheca shevockii*			X		L	Dist,Relab	✓
	Parry's horkelia	*Horkelia parryi*			X	FSC	L	Dist,Relab	✓
	Cantelow's lewisia	*Lewisia cantelovii*			X		L	Dist,Relab	✓
	Congdon's lewisia	*Lewisia congdonii*			X			Dist,Relab	✓
	yellow bur navarretia	*Navarretia prolifera* ssp. *lutea*			X		L	Dist,Relab	✓
	Piute Mtns. navarretia	*Navarretia setiloba*			X		M	Dist,Relab	✓
	Hall's rupertia	*Rupertia hallii*			X		M	Dist,Demog	✓
	cut-leaved ragwort	*Senecio eurycephalus* var. *lewisrosei*			X		L	Dist,Relab	✓
	Layne's ragwort [2]	*Senecio layneae*			X			Dist	✓
	Keck's checkerbloom [3]	*Sidalcea keckii*						Pres	✓

[1] *Federally Endangered species*
[2] *Federally Threatened species*
[3] *Federal candidate species*

8.3. Lower Westside Hardwood Monitoring Questions

Implementation Monitoring

1. During or prior to watershed analysis, were distributions of existing and potential natural hardwood plant communities spatially determined and confirmed, were areas for hardwood restoration and enhancement projects located, and were hardwood stand goals and objectives for these areas developed? (H20, H21, H22)
2. Were impacts to hardwood ecosystem structure and biodiversity considered in prescribed fire planning documents and in application of mechanical fuel treatments? (H06)
3. In lower westside hardwood ecosystems, was livestock browse no more than 20 percent of annual growth on seedlings, did grazing utilization maintain at least 60 percent cover in annual grasslands, and were standards and guidelines followed regarding management of residual dry matter? (G02B, G03B, G03C)
4. Where mechanical vegetation treatments are employed, including salvage, have all hardwood snags 15 dbh or greater been retained [(except where removal is needed to address human health and safety or to meet fuels management objectives in SPLATs and in inner buffers of the urban wildland intermix zone)]? (H04, H04B)
5. Have all blue oak and valley oak trees been retained, except where National Forests have developed stand restoration strategies calling for tree removal, where they pose an immediate threat to human life or property, public health and safety, or where lost due to fire? (H05)
6. Have all large hardwood trees (as defined in standards and guidelines) been retained, except where trees pose an immediate threat to human life or property, or where losses are incurred due to prescribed or wild fire? (H10, H10A)
7. Were existing residual large hardwood trees buffered by not planting trees within 20 feet of the edge of the crown canopy and was priority given to [naturally occurring] California black oak [and pine seedlings and saplings within buffer or beneath residual tree] during plantation thinning or release? (H24, H24A)
8. Was commercial and domestic hardwood, fuelwood, and sawlog cutting in hardwood ecosystems permitted only where slopes were less than 30 percent and hardwood tree cover was greater than 60 percent, disallowing removal after stands reached an average of 40 percent hardwood tree cover and retaining hardwood trees and snags 15 inches or greater in DBH? (H11)
9. Were field surveys for TEPS plant species conducted in accordance with standards and guidelines? (P01)
10. Were management prescriptions from completed (signed by line officer) species management guides or recovery plans for threatened, endangered, proposed and sensitive plants incorporated into Forest Plans? (P03)
11. Was an LOP provided when and where necessary for all TEPS species? (TES1)
12. Was habitat for purple martins provided following wildfire and insect mortality in accordance with standards and guidelines? (B52)

Status-and-Change and Cause-and-Effect Monitoring

High priority questions will be addressed during the planning period. No lower priority questions were identified for lower westside hardwoods.

High Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
1. What is the status and change of key within-stand vegetation characteristics of hardwood ecosystems?	plant species composition, vegetation structure (e.g., canopy cover, hardwood basal area by species, canopy layers, tree diameter distribution), plant biomass, leaf area index, down woody debris characteristics, duff and topsoil layers, snag characteristics, gap number, gap size, distribution of forest gaps, crown fuel ladders, surface fuels, recruitment rate, survival of seedlings and saplings	7	FIA points adequate for all attributes but forest gaps
2. What is the status and change of the distribution and abundance of hardwood forest communities at the landscape scale?	abundance and proportion of forest communities by type and age distribution, number of patches, patch size, spatial distribution, distance among patches, fragmentation	2.5	
3. What is the status and change of populations and habitats of MIS, and vertebrate and vascular plant species of risk?	population characteristics, amount and distribution of suitable habitat	0	Covered by Old Forest topic area
High Priority Cause and Effect Monitoring Questions	Attributes	Total cost ($1000s)	Contrib. from linked questions or other NFS programs
1. Are grazing standards effective in conserving hardwood recruitment rates, survival of seedlings and saplings, and other demographic parameters of concern?	distribution and rate of grazing, recruitment rate, species composition, survival of seedlings and saplings, age/stage class structure, fecundity/mast production	225	Range program

8.4. Key Lower Westside Hardwood Information Gaps

The following are research questions that were identified as key information needs in relation to the topic areas addressed in the FEIS.

1. What are the habitat relationships of lower westside hardwood forest associated MIS and species at risk?
2. How effective are associated MIS at indicating lower westside hardwood foresecosystem conditions and the status of other species?
3. What species might be strong indicators of lower westside hardwood foresecosystem conditions and the status of other old forest associated species?

9. Aquatic, Riparian, and Meadow Ecosystems

9.1. Introduction

The purpose of the proposed action in the EIS for the aquatic, riparian, and meadow problem area (ARM), is to protect and restore aquatic, riparian, and meadow ecosystems of the Sierra Nevada national forests to ensure proper functioning of key ecosystem processes, continued supply of high quality water, maintenance of biological diversity and viability of species associated with ARM ecosystems. The desired condition is to provide sustainable ARM compositions, structures, and functions including processes within desired ranges of variability, well-distributed habitat for desired plant, invertebrate, and vertebrate species, and connectivity among watersheds (NOI 1998, DEIS 2000). Aquatic and riparian dependent species of special concern include the foothill yellow-legged frog, mountain yellow-legged frog, California red-legged frog, Yosemite toad, Cascade frog, Northern leopard frog, and willow flycatcher.

Aquatic, riparian, and meadow (ARM) ecosystems are areas of high biodiversity providing habitat for many aquatic and upland vertebrate and vascular plant species (Sierra Nevada Science Review 1998, SNFCC 1998). The Sierra Nevada is the source for much of California's water, and high quality water is considered an important commodity (Sierra Nevada Science Review 1998). Aquatic, riparian, and meadow systems are among the most degraded in the Sierra Nevada (SNEP 1996, NOI 1998, DEIS 2000). Twenty-four percent of vertebrate species dependent on riparian habitat in the Sierra Nevada are at risk, including about half of all native amphibians and fish (Sierra Nevada Science Review 1998). Aquatic invertebrates may also be in decline (Erman 1996). Degradation has resulted from numerous activities including dams and diversions, overgrazing, roads, mining, logging, introduced species, and recreation (Sierra Nevada Science Review 1998, SNFCC 1998).

An Aquatic Conservation Strategy (ACS) forms the basis of management direction for ARM ecosystems in the EIS. The fundamental principle of the ACS is to retain, restore, and protect the processes and land forms that provide habitat for aquatic and riparian species, and that provide high quality water. Desired conditions are described generally by nine ACS goals which provide a broad, comprehensive framework, and more specifically by Riparian Conservation Objectives (RCOs) which provide standards for evaluating management prescriptions to determine if a proposed activity would move an area toward the desired conditions described by the ACS goals.

The key management activities discussed in the EIS that may affect ARM systems and dependent species are livestock grazing, mining, fire and fuels management, timber management, road management, and noxious weeds management. Pesticide application is a potential problem for amphibians. Opportunities exist for collaborating with other agencies to direct policies on dams and diversions and introduced species toward improving conditions for ARM species and habitats.

Monitoring will comply with a variety of federal and state laws including Clean Water Act, National Forest Management Act, Organic Administration Act, Endangered Species Act, SAM-32, and Porter Cologne Water Quality Control Act. For example, the National Forest Management Act mandates compliance with the Clean Water Act and calls for monitoring of species, livestock grazing, and watershed condition. SAM-32 is a 1987 memorandum of understanding between the State, EPA and the Forest Service designed to clarify the role of US Forest Service for nonpoint source controls and water quality standards. This MOU resulted in the development and monitoring of Best Management Practices for Forest Service activities to maintain high quality water.

Overview of Approach

The aquatic, riparian, and meadow problem area is comprised of a variety of interrelated aquatic and vegetation ecosystem types. Appropriate attributes for reflecting condition differ among these ecosystem types. For example, sensitive attributes for measuring water quality may differ for streams and lakes. Vegetation structure in riparian areas is measured differently than for meadows. Because of these differences, we have divided ARM into four interrelated ecosystem types for the purposes of monitoring: streams and associated riparian zones, meadows, lakes, and special aquatic habitats (e.g., unique aquatic areas such as springs, seeps, bogs, fens, wetlands, and vernal pools). The conditions of these four ecosystems are addressed as issues below (see issues 1-4 below). The condition and amount of disturbance in upslope areas of surrounding watersheds is included in the issues addressing stream/riparian and lake ecosystems. Soil quality, an important component of ARM condition, is addressed as its own topic area elsewhere in this chapter.

Monitoring of species and their habitats will address species at-risk and management indicator species (see issues 5-8 below). Species-at-risk of greatest concern have more detailed monitoring plans and are divided into 3 issues: fish (Little Kern golden trout, Modoc sucker, and Central Valley winter run steelhead), frogs and toads (foothill yellow-legged frog, mountain yellow-legged frog, and Yosemite toad), and the willow flycatcher. The remaining management indicator species and species at-risk are addressed as one issue.

The four ecosystems and associated species are highly integrated and the combination of conditions and population status of dependent species in these ecosystems reflects the health of aquatic, riparian and meadow areas. For example, healthy riparian vegetation is integral to healthy streams, contributing to stable stream banks, decreased erosion, and acceptable nutrient concentrations. Similarly, streams with flows and sediment within natural ranges of variation that are connected to their floodplains are integral to healthy riparian vegetation and meadows. Healthy streams, riparian areas, lakes, and meadows constitute high quality habitat. Finally, key management activities (affectors) will be monitored coincident with ARM condition to provide insights into potential relationships between management activities and their positive and negative effects on ARM ecosystems.

Monitoring for ARM ecosystems is designed to 1) determine the degree and extent to which application of standards and guidelines meet management direction and intent outlined in the EIS; 2) determine how effective national forest activities are in meeting ACS goals; 3) provide insights on more effective strategies that might better meet ACS goals; and 4) detect potential problems before systems become degraded and problems become too expensive to resolve.

9.2. Description of Aquatic, Riparian, and Meadow Issues

Stream and Riparian Issue

Description

Streams and riparian areas provide a variety of valuable resources including high quality water, important habitat for many aquatic and terrestrial species, forage production for livestock, recreation, and simple aesthetics. Streams include perennial and seasonally flowing water ranging from low gradient response reaches to headwater source channels. Riparian zones, adjacent to the streams, are identified by hydric soil characteristics and riparian or wetland plant species that require or tolerate free water conditions of varying duration. Condition is determined by water quality, stream channel condition including floodplain connectivity, in-channel sediment, condition of stream banks, vegetation successional stages present in the riparian zone, riparian zone vegetation canopy and structural characteristics (both vertical and horizontal), stream flow patterns on regulated systems, watershed connectivity, and watershed condition.

Uncertainties

- Whether the combination of proposed management activities will be effective in moving toward the desired conditions for streams.
- Whether livestock grazing policies result in improved stream and riparian condition and whether other policies would be more effective.
- The effects of allowing prescribed fire to back into riparian areas and mechanical treatment near ephemeral streams. This is discussed under the fire and fuels problem area.

Approach

Monitoring questions and associated attributes were selected because they are either direct measures of stream condition or are strong indicators of stream condition. Each of the pertinent ACS goals is addressed. Key management activities that may influence streams and riparian areas were selected for affector monitoring. Status and change monitoring will characterize the condition of streams and riparian areas, and whether they are moving toward desired conditions. Monitoring key management activities (affectors) will provide information on potential causal factors that may be contributing to resulting stream conditions. Status and change monitoring also will provide early warning of problems that may become significant if not addressed in a timely manner.

Livestock grazing was identified as an issue with high risk and high uncertainty. Cause and effect questions address causal relationships between livestock grazing management and stream and riparian condition and will provide information on the effectiveness of grazing policies for maintaining and restoring stream and riparian condition as well as on alternative strategies that may be more effective.

Affectors: Livestock grazing, roads, mining, fire and fuels management, dams/diversions (including hydroelectric), exotic species (including fish, amphibians, noxious weeds), recreation, timber harvest, chemicals (pesticides, herbicides), restoration

Expected Results and Benefits

Monitoring will provide information on whether the condition of streams and riparian areas are improving and will help managers understand the most effective management approaches to achieve desired conditions. Data will inform issues such as maintenance of high quality water, effects of erosion and sedimentation on aquatic systems, livestock grazing practices, recreational activities associated with riparian habitats, long-term successional trends in riparian areas, and maintenance of aquatic and riparian habitat. Information on potential causes of changes will result from affector monitoring. More detailed information on the effects of grazing policies will provide managers with options to develop more effective management direction. Tracking and reporting on implementation of management activities will provide a record of accomplishment to the public and document the extent and distribution of activities conducted by the Forests. Key information gaps provide valuable data on the most effective approach to meeting multiple land management objectives, including protecting stream and riparian conditions.

Meadow Issue

Description

Meadows are among the most heavily used sites by both livestock and recreationists, and provide forage and habitat for a variety of wildlife, as well as other important ecological functions such as water storage and groundwater recharge, sediment trapping, and flow energy dissipation. Meadows vary along a moisture gradient from wet meadows with water tables less than 50 cm deep to dry meadows with water tables greater than 100 cm deep. To evaluate achievement of desired condition in meadows, monitoring will assess ecological status and hydrologic function. The desired condition is meadows with an ecological status of late seral that are hydrologically functional.

Uncertainties

- Whether the combination of proposed management activities will be effective in moving meadows toward desired conditions.
- Whether livestock grazing policies result in improved meadow condition and whether other policies would be more effective.

Approach

The high priority status and change monitoring questions and attributes are direct measures of ecological status and hydrologic function or are good indicators of meadow condition. Pertinent ACS goals are addressed. Key management activities that may influence meadow condition were selected for affector monitoring. Status and change questions will address whether the condition of meadows is maintained or improving and moving toward desired conditions. Monitoring key management activities (affectors) will provide information on potential causal relationships between the activities and resulting meadow conditions. Status and change monitoring will also provide early warning of potential problems.

Livestock grazing was identified as an issue with high risk and high uncertainty. Therefore, cause and effect monitoring will be conducted to address causal relationships between livestock grazing management and meadow condition. It is well known that improper grazing practices can adversely affect riparian and meadow sites. What is less certain is which grazing management techniques are compatible with maintaining or improving these areas and under what conditions.

Affectors: Livestock grazing, roads, dams/diversions (including hydroelectric), noxious weeds, recreation, timber harvest, restoration, fire and fuels management.

Expected Results and Benefits

Monitoring meadows will provide information on whether meadows in the Sierra Nevada are moving toward the desired conditions. The suite of information collected will provide information on whether meadows are dominated by late successional, deep-rooted plant species, are hydrologically functional with good water infiltrating capabilities, have little erosion, and are changing in size due to changes in water table level and other hydrologic factors. Information on potential causes of changes will result from affector monitoring. More detailed information on the effects of grazing will provide managers with options to develop more effective management direction. Tracking and reporting on implementation of management activities will provide a record of accomplishment to the public and document the extent and distribution of activities conducted by the Forests.

Lake Issue

Description

Lakes in the Sierra Nevada encompass a variety of values including high quality water, important habitat for many aquatic species, and simple aesthetics, and are heavily used recreation sites for activities such as boating, fishing, and camping. Lakes in the Sierra Nevada range from deep alpine lakes to shallow, seasonally wet ponds. They are unique in being the most chemically dilute group of lakes sampled nationwide in the US EPA's 1985 lakes survey (Eilers et al. 1989). In addition, thousands of dams occur in the Sierra Nevada forming reservoirs of varying sizes. For monitoring purposes, condition of lakes will be determined by major ionic chemistry, selected physical attributes (e.g., clarity), and key biological indicators of water quality and overall condition.

Uncertainties

Whether the combination of proposed management activities move lakes toward desired conditions.

Approach

The high priority status and change monitoring questions and attributes are direct measures of lake condition or are good indicators of lake condition. Pertinent ACS goals are addressed. Major management activities that may influence lakes were selected for affector monitoring. Status and change questions will assess whether lakes are moving toward desired conditions. Monitoring key management activities (affectors) will assess potential causal factors that may contribute to resulting conditions. Status and change monitoring may also provide early warning of potential problems before they become significant to address.

Affectors: Livestock grazing, dams/diversions, exotic and introduced native fish and amphibians, recreation, timber harvest, roads, fire and fuels management, chemicals (pesticides, herbicides), air pollution.

Expected Results and Benefits

The lake monitoring will provide an early warning of acidification or eutrophication in high-elevation lakes which are currently extremely clean. Candidate causes of any changes will be identifiable through correlational associations with monitored affectors and explanatory variables like air deposition and snowpack chemistry. Monitoring of the key chemical, biological and physical indicators will help identify reasons for changes in sensitive, lake-dependent aquatic biota (e.g., mountain yellow-legged frog). Tracking and reporting on implementation of management activities will provide a record of accomplishment to the public and document the extent and distribution of activities conducted by the Forests. Filling the key information gap regarding indicators will improve the ability of monitoring to efficiently monitor lake conditions through indicators.

Special Aquatic Habitats Issue

Description

Special aquatic habitats (springs, seeps, fens, bogs, small ponds, and vernal pools) are small, irregularly distributed aquatic and riparian habitats in the Sierra Nevada. They provide important habitat for aquatic and terrestrial plant and animal species, and are particularly important for rare or endemic species. For the purposes of this monitoring program, condition is determined by plant species composition, plant community composition, measurements of ground cover, water table measurements, and measurements of the extent of each special habitat site to determine if they are shrinking or otherwise. In addition, monitoring will track the distribution, abundance, and disturbance of these habitats.

Uncertainties

Whether the combination of proposed management activities will achieve the desired conditions for special habitats, and whether livestock grazing policies result in improved special habitat condition and whether other policies would be more effective.

Approach

The high priority status and change monitoring questions and attributes are direct measures of special habitat condition or are good indicators of the condition of special habitats. Each of the pertinent ACS goals is addressed. Key management activities that influence special habitats were identified for affector monitoring. Status and change questions will characterize the condition of special aquatic habitats and assess whether they are moving toward desired conditions. Monitoring key management activities (affectors) will assess potential causal factors which may contribute to resulting conditions. Status and change monitoring may also provide early warning of potential problems before they become significant to address.

Livestock grazing in special habitats was identified as an issue with high risk and high uncertainty. Therefore, cause and effect monitoring will be conducted to address relationships between livestock grazing management and the condition of special aquatic habitats. Questions targeted at the interaction of fire and fuel treatments with the condition of special aquatic habitats are located in the Fire and Fuels topic area, Issue 2. Monitoring of livestock grazing will provide information on the effectiveness of grazing policies for improving the condition of special habitats

Affectors: Livestock grazing, dams/diversions (including hydroelectric), exotic species (including fish, amphibians, noxious weeds), recreation, restoration, roads, fire and fuels

Expected Results and Benefits

Monitoring will provide information on whether the condition of special aquatic habitats are maintained or improving. Data will inform issues such as livestock grazing practices, recreational activities associated with special habitats, long-term successional trends, and characteristics of the physical and biotic aspects of special habitats. Information on possible causes of changes will result from affector monitoring. More detailed information on the effects of grazing will policies will provide managers with options to develop more effective management direction. It is anticipated that measurements of these factors over time will lead to an improved knowledge of condition in these habitats and how these habitats respond to disturbance.

Modoc Sucker Issue

Description

The Modoc sucker (*Catostomus microps*) is a rare fish with a very limited geographic range. It is listed as endangered by both state and federal governments. Isolation, stream channelization, water diversions, grazing, Sacramento sucker (*C. occidentalis*) invasions, and predation by non-native fishes contribute to the vulnerability of this species.

The Modoc sucker is a small (15cm SL), native catostomid found only in a few tributaries of the Upper Pit River drainage system of northeastern California (majority of lands managed by USFS). It is associated with benthic pool habitat in small, often intermittent streams and is most abundant in pools with cool (<25°C), moderately clear water. Overhanging trees and shrubs and undercut banks are also desirable. It is a short-lived fish (usually < 5 yrs.) that matures at an early age (3 yrs.). Spawning occurs between mid-April and early June in small tributaries over fine gravel in the lower end of pools or in riffles. Food is mostly detritus and algae, but also includes aquatic insect larvae and crustaceans. Specific habitat associations are not well documented.

No management is proposed in the EIS specifically for the Modoc sucker. However, general management direction in the EIS is toward restoring and maintaining aquatic and riparian systems which should benefit this species. Management associated with livestock grazing, road management, timber harvest, fire and fuels management, and pesticide/herbicide application may affect the species. Also, management guidelines in Riparian Conservation Areas also should benefit this species.

Uncertainties

Whether the combined effect of management proposed in the EIS will maintain and restore Modoc sucker habitat and whether this will result in stabilization or increase of Modoc sucker population. Also, whether livestock grazing policies will result in improved Modoc sucker populations and habitat.

Approach

Monitoring for the Modoc sucker is designed to detect changes in population and habitat characteristics and will provide data for developing a more detailed understanding of habitat requirements. The status and change questions will provide information on population status reflected in changes in distribution and survivorship. Hybridization of Modoc and Sacramento suckers and predation by introduced fish, especially brown trout, also threaten the continued existence of the Modoc sucker and will be monitored. Monitoring of brown trout distribution will allow for evaluation of threat from this introduced predator; this information can further be used in deciding if eradication efforts are needed. Genetic analysis, if funded (lower priority) would aid in determining the current range of the Sacramento sucker and extent of Modoc sucker introgression that has already occurred, enabling managers to address one of the key components involved in the decline of this species. Coincident monitoring of affectors with population and habitat data will provide information on the effects of different land uses on populations and habitat conditions. Livestock grazing was identified as an issue with high risk and uncertainty for the Modoc sucker. Information on the effectiveness of livestock grazing will help managers to make informed decisions regarding range management. Information will be gained on the effectiveness of proposed policies as well as on alternative strategies that may be more effective.

Affectors: Livestock grazing, roads, fire and fuels management, water diversions/channelization, Sacramento suckers, introduced fishes, timber harvest, chemicals (pesticides, herbicides)

Expected Results and Benefits

The combination of population and habitat monitoring is essential to assessing the viability of the Modoc sucker and to inform decision-making. Although the availability and quality of habitat is a major issue for the Modoc sucker, monitoring habitat alone is not sufficient to assess viability of the species because hybridization with the Sacramento sucker is also a major threat to species survival. Monitoring distribution, habitat quantity and quality, and species interactions (with Sacramento sucker and brown trout) will provide the minimum level of information necessary for assessing the viability of the Modoc sucker. Because of the small range of this species, and the relatively low number of land use groups (majority of lands owned by USFS), the successful and economical recovery of the Modoc sucker seems very possible.

Little Kern Golden Trout Issue

Description

The Little Kern golden trout (*Onchorynchus mykiss whiteii*) is a rare fish native only in the Little Kern River drainage. It was listed as a federally threatened species in 1978 and currently retains this status. The greatest threat to this species involves loss of genetic integrity due to hybridization with rainbow trout (*Onchorynchus mykiss*). Lesser threats are posed by habitat degradation, interactions with non-native fishes, and angling pressure. Habitat concerns include livestock grazing, pack-stock use, high use trails (foot and pack-stock), and mining. Interactions with non-native fishes, especially brook trout (*Salvelinus fontinalis*) competition and brown trout (*Salmo trutta*) predation, have become less important as recent eradication efforts have eliminated these two species from the drainage, but there is still concern involving illegal reintroduction of these fishes. Heavy angling pressure is a concern, as past study has shown over-fishing to greatly reduce Little Kern golden trout population size.

The Little Kern golden trout is a small (usually <30cm) salmonid native only to the Little Kern River drainage. They are most commonly found in small streams between 6,000-10,000 feet in elevation, but also occupy a few lakes. Spawning occurs in late spring or early summer (May-July) and is limited to stream habitat in areas where substrate is composed of small gravels. Individual fish have a very limited home range, spending an entire lifetime in a short section of one stream. Food items include both aquatic and terrestrial macroinvertebrates. As with most other salmonids this species is cover-oriented, preferring to be in close proximity to undercut banks, low-lying riparian vegetation, wood debris, or other structural cover.

No management is proposed in the EIS specifically for the Little Kern golden trout. However, general management direction in the EIS is toward restoring and maintaining aquatic, riparian, and meadow systems which should benefit this species. Management associated with livestock grazing is the primary activity addressed in the EIS which may affect the Little Kern golden trout. Although recreation may affect the Little Kern golden trout, it is not a focus of the EIS. Management guidelines in Riparian Conservation Areas should also benefit this species.

Uncertainties

Whether the combined effect of management proposed in the EIS will maintain and restore Little Kern golden trout populations and habitat. Also, whether livestock grazing policies will result in improved Little Kern golden trout populations and habitat and whether other policies would be more effective.

Approach

The majority of the Little Kern golden trout population is within national parks or wilderness areas, limiting the number of land uses likely to affect their habitat. Therefore, uncertainties related to EIS management direction focus on livestock grazing. Recreation (e.g., pack-stock use, trail use by hikers and pack-stock, angling) will be monitored as an affector. Management concerning Little Kern golden trout distribution, genetic integrity, non-native fishes, and angling have been and continue to be addressed by the California Department of Fish and Game and U.S. Fish and Wildlife service. Past non-native eradication efforts in conjunction with reintroductions have been very successful in restoring the Little Kern golden trout to its historic range.

Monitoring proposed in this plan recognizes the need to ensure the maintenance of current Little Kern golden trout distribution, abundance, genetic integrity, and isolation from non-native fishes. However, it is anticipated that much of this work will be done in collaboration with ongoing programs. Because the population of the Little Kern golden trout is currently stable, and now occupies much of its historic range, monitoring will focus on population distribution, habitat conditions, presence of non-native and native introduced fish, and associations with key affectors.

Affectors: Livestock grazing, introduced fishes (native and nonnative), recreation (pack-stock, angling, hiking), mining

Expected Results and Benefits

The high priority status and change questions will provide information on whether Little Kern golden trout habitat and populations are being maintained or restored. Monitoring key affectors will inform managers on the relative effects of these activities on Little Kern golden trout populations and habitat.

Livestock grazing was identified as an issue with high risk and uncertainty for the Little Kern golden trout. Information on the effectiveness of livestock grazing strategies will help managers make informed decisions on the most effective range management practices.

Due to recent restoration efforts, the Little Kern golden trout, which was only present in 10% of its historic range just 20 years ago, currently occupies much of its historic range. The proposed monitoring will inform managers whether the current population status is being maintained. For this species, the largest threat is the presence of introduced trout species, the most immediate concern continuing to be introgression resulting from hybridization with rainbow trout. Information related to the status and change of interacting species is crucial in maintaining recent gains and preventing a reoccurrence of past problems. Recreation and angler monitoring may become more important as the species recovers and fishing interest increases. In the past, the above issues have been managed by both the California Department of Fish and Game and the U.S. Fish and Wildlife Service; it is anticipated that the monitoring proposed here will be conducted in collaboration with these agencies. Monitoring habitat conditions in conjunction with key affectors will assess the impact of land use on Little Kern golden trout habitat. More detailed data on the effectiveness of livestock grazing regulations on populations and habitat conditions will provide information on the success of range management policies. In summary, the proposed monitoring will provide managers with the information necessary to maintain this species and its habitat and increase the likelihood of de-listing or down-listing.

Central Valley Winter Run Steelhead Issue

Description

Central Valley winter-run steelhead (*Oncorhynchus mykiss*) historically widely distributed throughout Sacramento and San Joaquin Rivers, are now restricted to a few watersheds in northern California. Ninety-five percent of historic habitat is no longer accessible due to impassable dams and some of the remaining accessible habitat is threatened by out-of-stream water demands. Central Valley steelhead were listed as a threatened Evolutionarily Significant Unit (ESU) under the Endangered Species Act

(ESA) on March 19, 1998. In the Sierra Nevada, the main threats to the continued existence of this species are related to historic freshwater habitat loss and degradation including inadequate stream flows, blocked access to historic spawning and rearing areas due to dams, and human activities that discharge sediment and debris into watercourses. Another issue for this species in the Sierra Nevada is loss of genetic integrity due to hybridization with hatchery steelhead. The Central Valley steelhead is also affected by many factors that occur outside of the Sierra Nevada (e.g., water development effects in the Sacramento River and delta, urbanization, estuary pollution, ocean conditions, commercial and sport fishing, and agricultural water intakes).

All steelhead stocks in the Central Valley of California are winter-run steelhead. At the present time, naturally spawning populations of steelhead are known to occur in the upper Sacramento River and tributaries (Mill, Deer, and Butte Creeks), Dry Creek, Auburn Ravine, and the Feather, Yuba, American, and Stanislaus Rivers (Interagency Ecological Program Steelhead Project Work Team 1999). Like all anadromous fishes, steelhead are dependent on nearly all habitats of a river system, from the headwaters and tributaries, to the main channel, to the estuary, and finally the ocean. Steelhead use the Sierra Nevada for spawning and rearing. Winter-run steelhead adults typically spawn between December and June. They spawn in cool, clear, well-oxygenated, often intermittent streams with suitable depth, current velocity, and gravel size.

The EIS proposes a long-term strategy for anadromous fish producing watersheds on the Lassen National Forest. The strategy is designed to maintain or restore desired conditions described by the Aquatic Conservation Strategy (ACS) goals in the Antelope, Battle, Butte, Deer, and Mill Creek watersheds. The strategy proposes wider Riparian Habitat Conservation Areas, more restrictive standards and guidelines in these areas, watershed analysis, restoration, monitoring, and collaboration with the goal of maintaining and restoring anadromous fish populations and habitat.

Uncertainties

Whether the combined effect of management proposed by the long-term strategy will maintain or restore Central Valley steelhead spawning and rearing habitat and contribute to recovery of populations.

Approach

Only part of the steelhead's life history occurs on Forest Service land, and there currently are ongoing efforts for this species. Monitoring for this species will involve collaboration and cooperation with other agencies, particularly CDFG. Monitoring of the Central Valley steelhead in the Sierra Nevada focuses on quantity and quality of and access to spawning and rearing habitat. Population trends such as distribution and relative abundance would be useful to assess the status of the species but is difficult to obtain in the Sierra Nevada. Population sampling is problematic because adult steelhead migrate and spawn when flows are high and access is difficult. However, it would be useful to know how many fish are reaching Sacramento River tributaries. In-migration and out-migration could be monitored. Because migration would most likely be measured in lower parts of the watersheds, this will require collaboration with other agencies such as CDFG. Developing effective methods for sampling for distribution and abundance is identified as a key information gap. Hybridization with hatchery steelhead is currently under investigation by CDFG. Monitoring hybridization may be warranted in the future.

Affectors: dams/diversions (including hydroelectric), hatchery production of steelhead (introduced native species), grazing, roads, mining, timber harvest, fire and fuels management, chemical spills, urbanization.

Expected Results and Benefits

Monitoring proposed in this plan will provide information on whether management plans in the long-term strategy for anadromous fish are effective in maintaining and restoring Central Valley steelhead spawning and rearing habitat. Implementation monitoring will inform decision makers on the degree the strategy was followed. Status and change monitoring will determine whether habitat quantity, quality, and access are being maintained or restored. Further work on developing methods to obtain population distribution and relative abundance would greatly contribute to a better understanding of this species (see key information gaps below.) Monitoring of key management activities (affectors) will provide information on potential causal factors that may contribute to the observed conditions. Filling key information gaps will assist management in more effectively fulfilling monitoring requirements and producing valuable information to inform management decisions.

Amphibian Species-at-Risk Issue

Description

The following monitoring approach addresses the major threats and uncertainties for the three most at-risk amphibian species in the Sierra Nevada: foothill yellow-legged frog, mountain yellow-legged frog, and Yosemite toad**.** These species are treated as a group because the monitoring strategy is similar for all three. The Forest Service will collaborate with other agencies for monitoring the California red-legged frog.

Foothill yellow-legged frog

- **Concern:** This species apparently has disappeared from 66% of its historic range in the Sierra Nevada (Jennings 1996). It is currently listed as a California State Species of Special Concern and USDA Forest Service California Region Sensitive Species. Primary causes of their decline are not well known, but aquatic and riparian habitat alteration and changes in stream hydrology and geomorphology resulting from construction of dams, diversions, and reservoirs are primary suspects (Jennings 1996, Lind et. al. 1996).
- **Species Characteristics:** The foothill yellow-legged frog historically occurred in foothill and mountain streams from northern Baja California to southern Oregon west of the Sierra-Cascade crest, to 1830m (6000 ft). They utilize streams for egg deposition, rearing, foraging, and cover, and adjacent riparian vegetation for dispersal, cover, and foraging.
- **Management Direction:** This EIS proposes management direction in several areas that may affect this species: (1) hydropower re-licensing, (2) mining, livestock grazing, and fuels treatment in and near aquatic and riparian habitats, and (3) application of herbicides to control noxious weeds.
- **Uncertainties:** Fire and fuels treatments are likely to be the main activities conducted under the new management. The effect of these treatments on the instream and riparian habitats of the foothill yellow-legged frog could be significant. Direct (loss of individuals due to prescribed fire and ground disturbance of mechanical fuels treatments), indirect (habitat alterations), short-term, and long-term changes are expected. It is unclear if the new direction on hydropower re-licensing will result in changes to water management that will significantly improve conditions for this species.

Mountain yellow-legged frog

- **Concern:** Once the most common amphibian in high elevation aquatic ecosystems of the Sierra Nevada, this species has disappeared from 70-90% of its historic range in the bioregion (US Fish and Wildlife Service 2000a). It is currently a California Species of Special Concern, a Forest Service Sensitive Species and a recent petition to list the species as Federally endangered has been accepted by US Fish and Wildlife Service. Primary causes of their decline are the stocking of exotic fish predators in historically fishless high mountain lakes (Knapp and Matthews 2000) as well as disease, contaminants, and livestock grazing (U.S. Fish and Wildlife Service 2000a).
- **Species Characteristics:** The mountain yellow-legged frog historically inhabited ponds, tarns, lakes, and streams from 1370 to over 3650 m (4,500 to over 12,000 ft.) (Stebbins 1985). They utilize these areas for egg deposition, rearing, cover, and foraging. Adjacent riparian and meadow areas are used for dispersal, cover, and foraging.
- **Management Direction:** The EIS proposes management direction in several areas that may affect this species: (1) development of a conservation strategy for the species, (2) evaluation and alteration of fish stocking regimes with California Department of Fish and Game, (3) livestock in and near aquatic and riparian habitats, and (4) application of herbicides to control noxious weeds.
- **Uncertainties:** The major areas of uncertainty for this species are the effectiveness of the proposed conservation strategy and the effects of changes in exotic fish stocking practices. The latter area is of particular concern, because it requires cooperation with another agency (California Department of Fish and Game), which may have different objectives in the Sierra Nevada.

Yosemite Toad

- **Concern:** Yosemite toads have disappeared from more than 50% of the sites where they were known to occur historically and formerly large populations have been reduced in numbers (Jennings 1996). The Yosemite toad is currently a California State Species of Special Concern, a Forest Service Sensitive Species and a recent petition to list the species as Federally endangered has been accepted by US Fish and Wildlife Service. Primary causes of their decline are changes in meadow condition and trampling due to livestock grazing (D. Martin, pers. comm.), other changes to meadow hydrology, which may have been exacerbated by drought (Kagarise Sherman and Morton 1993), disease, exotic fish stocking (U.S. Fish and Wildlife Service 2000b) and possibly dispersed recreation activities (e.g., packstock).
- **Species Characteristics:** The Yosemite toad is endemic to the Sierra Nevada mountain range and occurs in wet montane meadows between ca. 1950 m ca. 3450m (6435 to 11,385 ft) from Alpine County south to Fresno Co. They utilize meadow streams and ponds for egg deposition, rearing, foraging, and cover, and adjacent riparian and possibly upland vegetation and springs for dispersal, cover, and foraging.
- **Management Direction:** The EIS proposes management direction in several areas that may affect this species: (1) timing and intensity of livestock grazing in meadows, (2) evaluation and alteration of fish stocking regimes with California Department of Fish and Game, and (3) evaluation and relocation of dispersed recreation sites.
- **Uncertainties:** For the Yosemite toad, the major area of uncertainty is the effectiveness of proposed livestock grazing standards. The proposed standards change the timing and intensity of meadow use but these approaches are untested with regard to the population and habitat needs of the Yosemite toad.

While research on environmental toxin effects on these species has not yet been conducted, closely related frog and toad species in other regions have shown sensitivity to numerous pesticides, herbicides, and fertilizers (Berrill et. al. 1997, LeBlanc and Bain 1997). Because these chemicals are thought to disrupt endocrine systems in amphibians at low concentrations, application of pesticides and herbicides are considered to be a risk factor for all three species. Thus, the extent of use and the effects of increased herbicide use for noxious weed control and silvicultural applications and the interaction of these two uses are a key uncertainty.

There are also several information gaps that create general areas of uncertainty common to these three amphibian species. Basic life history (e.g., longevity, fecundity), population dynamics, and metapopulation characteristics are poorly known for the three species. Habitat associations are better understood, but research is needed on seasonal and life stage variations in habitat requirements. While there is fairly good qualitative information on the historic and current distributions of these species, a quantitative range-wide analysis of their status is needed.

Approach

In order to understand the effects of Forest Service management on these species we will need information that is derived from several types of monitoring. Cause and effect monitoring will provide information on the proposed management activities that pose the greatest risk to populations and habitat for each species. This type of monitoring will require intensive information gathering and will likely only be accomplished at a few representative sites. Status and change monitoring, which here would collect information from throughout each species' range in the Sierra Nevada, is thus a complementary approach. It will provide a larger context for the results gleaned from cause and effect monitoring as well as giving and overall assessment of the condition of the species and its habitat through time. Implementation monitoring will be conducted to fill in information gaps and answer questions regarding the extent to which the standards and guidelines, adopted in the Record of Decision, were applied throughout the Sierra Nevada.

Affectors: fire and fuels treatments, flow regimes below dams, in-stream mining, exotic fish stocking, livestock grazing, dispersed recreation, herbicide use for noxious weeds and silvicultural applications

Expected Results and Benefits

The status and change questions will meet Forest Service monitoring requirements for documenting the status and change of these species and their habitat. Additional information would be required to assess the long-term viability of these species (see section on Key Information Gaps below). Monitoring will encompass several spatial scales (e.g., local population and subwatershed/meadow complex). Status and change questions will provide documentation of several aspects of populations and habitats of these species throughout their ranges in the Sierra Nevada: (1) occurrence, (2) relative abundance, (3) a detailed understanding of the population dynamics, and (4) information on habitat condition, including correlative relationships with Forest Service management through affector monitoring. If information is gathered at several spatial scales, some initial information on metapopulation dynamics could also be gleaned. Habitat associations models could also be developed as long as a portion of the areas monitored were relatively undisturbed (i.e., reference sites). Taken together, these monitoring data will provide information necessary for planning locations of land management activities at the Forest and Sierra Nevada range-wide scales.

The selected cause and effect questions reflect the areas of greatest risk and uncertainty for each species in proposed Forest Service management. Questions on affectors that have corollary influences are listed below (see Key Information Gaps). These additional questions would require substantial additional funding. Monitoring will encompass several spatial scales (e.g., local population and subwatershed for foothill yellow legged frog and meadow complex for Yosemite toad). Answering the above cause and effect questions for populations and habitat of each of the three amphibian species will provide information on the effects of key affectors on these species. Direct and indirect effects of proposed standards and guidelines can be gleaned with the appropriate monitoring design, especially if a range of management activities (varying both temporally and spatially) were implemented. Since these management actions are likely to be the most pervasive component in the implementation of the EIS and they are the key affectors on these amphibian species, addressing these questions would inform managers of both the effects of management actions and possible ways to adjust management to reduce effects.

The viability of these species is at risk in the Sierra Nevada. Thus designing a monitoring strategy that will move us toward better estimates of viability will inform managers of status of the species and their habitat in the context of Forest Service activities. Viability assessment requires integration of information on the distribution, population size and growth, recruitment rates, and survival rates of a population. This information needs to be set in the context of the various scales that are relevant to a given species (range-wide, metapopulation, and local population). The types of monitoring described act in a complementary fashion to provide information to assess the viability of these three amphibian species. Status and change monitoring that includes areas with limited management provides information on the condition of populations and habitats throughout Forest Service lands while at the same time increasing our knowledge of the natural population dynamics and habitat requirements of these species. Results from cause and effect monitoring will give details on how management activities affect species. Together these two types of monitoring can inform managers of ways to reduce impacts to these amphibian species.

Willow Flycatcher Issue

Description

In the last four decades, willow flycatcher (*Empidonax traillii*) breeding populations have been extirpated from most lower elevation habitats in California and it appears that the species no longer breeds within the lower regions of the Sierra Nevada, the Central Valley, or the western Great Basin (Gaines 1974, Klebenow and Oakleaf 1984, Zeiner et al. 1990). Historic records combined with recent survey efforts indicate a long-term decline of willow flycatchers in the higher elevations of the Sierra Nevada as well (Gaines 1992, Bombay 1999). Current estimates of the willow flycatcher population in the planning area range between 300 and 400 individuals, with 120 to 150 of these on National Forest lands (Serena 1982, Harris et al. 1987, 1988, Ritter and Roche 1999, H. Bombay pers. comm.). There are various likely causes of the willow flycatcher population decline in the Sierra Nevada, including livestock grazing, brown-headed cowbird (*Molothrus ater*) brood parasitism, and changes in meadow systems from road building, timber harvest, and fire management. The three willow flycatcher subspecies that breed in California, *E. t. adastus*, *E. t. brewsteri*, and *E. t. extimus* (Phillips 1948, Unitt 1987), are all included on the Regional Forester's Sensitive Species list in USFS Region 5 (FSM 2670). The willow flycatcher has formal listing status in the State of California as an endangered species (CDFG 1995) and the southwestern willow flycatcher (*E. t. extimus*) is listed as a Federally Endangered species (Federal Register 1995).

Willow flycatchers are associated with meadows where high water tables result in standing water and riparian shrubs (specifically willow) are abundant (Serena 1982, Harris et al. 1988, Fowler et al. 1991). Meadows in which willow flycatchers breed are usually larger than 19.8 acres (Serena 1982, Harris et al. 1987, 1988) but are occasionally much smaller (e.g., KRCD 1985). Willow flycatchers currently occur at elevations from 1200 to over 9,000 feet, although the majority of willow flycatcher sites occur between 4000 and 8000 feet (Serena 1982, Harris et al. 1988, Stafford and Valentine 1985, Bombay et al. 1998). In the Sierran bioregion, the willow flycatcher breeding season occurs from late May or early June to the middle of September (Stafford and Valentine 1985, Bombay et al. 1999).

Standards and guidelines relating to willow flycatchers in this EIS propose some specific conservation strategies intended to increase the distribution and abundance of willow flycatchers and their habitat in the Sierra Nevada. This direction includes grazing restrictions in willow flycatcher occupied habitat, creation of a network of “emphasis” meadows, prioritization of meadow restoration, and reduction of the potential for cowbird parasitism.

Uncertainties

Because only an estimated 60-70 percent of willow flycatcher sites are known, there is a risk that impacts to willow flycatchers could occur in areas where managers are unaware of their occurrence. In the selected alternative, impacts from livestock to vegetation, hydrology, and stream banks (and thus indirectly to willow flycatchers) are uncertain. It is unclear whether grazing and recreation standards and guidelines will reduce the threat of cowbird parasitism. Potential grazing impacts in occupied willow flycatcher habitat after the breeding season may reduce habitat suitability in subsequent years. Finally, uncertainty remains as to whether potential grazing impacts outside of occupied habitat will allow flycatchers to expand into new areas.

Approach

This monitoring plan addresses the key uncertainties about willow flycatchers in the Sierra Nevada. A combination of status and change, cause and effect, and implementation monitoring will address uncertainties about population and habitat trends of willow flycatchers, effects of grazing practices and cowbird parasitism, and the level of compliance with standards and guidelines. One potential approach to reduce the risk to willow flycatchers is to use other species as a surrogate for willow flycatchers when answering the cause and effect questions.

It is possible that, after a period of population monitoring (distribution and abundance), we will have sufficient understanding of important habitat characteristics that we can confidently monitor habitat without monitoring willow flycatcher populations directly. This is contingent, however, on a dedicated program of population monitoring and careful analysis and testing of habitat models along the way to determine linkages between population and habitat parameters. Ultimately these habitat models may make it unnecessary to monitor willow flycatcher populations directly, or at least to conduct population monitoring much less frequently. In this respect the approach mimics that proposed to monitor the effectiveness of the Northwest Forest Plan on recovery of the northern spotted owl (Lint et al. 1999).

Affectors: Livestock grazing, dams and diversions, dispersed and developed recreation, fire and fuels treatments, roads, pesticides, restoration.

Expected Results and Benefits

Data on the status and change of willow flycatchers and their habitat will suggest whether standards and guidelines aimed to protect this species are effective or if others may be needed. If flycatchers continue to decline despite restrictions on affectors, a shift in management strategies will be necessary. In addition, population monitoring may yield additional locations of flycatchers, which will allow standards and guidelines to be implemented in those areas. The cause and effect questions will provide information to managers about the effects of two potential threats to willow flycatcher individuals and habitat. This information will be useful in assessments of the effectiveness of standards and guidelines and will affect decisions on whether more restrictive or different management direction is warranted.

This adaptive management plan represents a strong approach to providing information that will assist the conservation of one of the Sierra Nevada's rarest birds. Determining the habitat relationships, population status, and effects of livestock grazing on flycatchers are vital for designing and implementing appropriate grazing practices to meet conservation objectives for the flycatcher. Status and change monitoring of the willow flycatcher population, habitat, and affectors will allow inferences about potential causes of observed trends. These monitoring and research data will provide a package of information that will be vital for increasing our understanding of the effectiveness of conservation measures.

Management Indicator Species and Species at Risk Issue

Description

This issue addresses population and habitat monitoring of Management Indicator Species (MIS) and species at risk. Species of highest concern—Modoc sucker, Little Kern golden trout, Central Valley winter steelhead, foothill yellow-legged frog, mountain yellow-legged frog, Yosemite toad, and willow flycatcher—are treated as separate issues in the ARM topic area.

Management Indicator Species. Twenty-six MIS are associated with the ARM topic area (Table E-11). See Old Forest topic area MIS section for a discussion of the role of MIS in forest management.

Species at risk. Forty-two vertebrate species (including 10 that are also MIS), seven invertebrate species, 29 vascular plant species, four nonvascular plant species, and one lichen species are associated with the ARM topic area (Table E-11). Six of these are federally listed vertebrates for which a recovery plan exists (bald eagle, Central Valley spring run chinook salmon, Lahontan cutthroat trout, Paiute cutthroat trout, red-legged frog, and Owens tui chub); no additional monitoring is proposed for these species. See Old Forest topic area species at risk section for a description of criteria used to identify species at risk.

Management Direction. General management direction in the EIS toward restoring and maintaining aquatic, riparian, and meadow systems should benefit MIS and species at risk. Management associated with livestock grazing, road management, timber harvest, fire and fuels management, and pesticide/herbicide application as well as management guidelines in Riparian Conservation Areas may affect these species. Management direction relevant to species at risk (beyond those addressing the seven species of highest concern) includes a long-term strategy for anadromous fish producing watersheds on the Lassen National Forest, avoidance of impacts to northern leopard frog and Cascade frog occupied sites, requirements for surveys of sensitive plant species, and establishment of Limited Operating Periods (LOPs) for federally threatened or endangered or Forest Service sensitive species.

Uncertainties

Many uncertainties exist about the status and fate of MIS and species at risk. Basic information on distribution, population status, and habitat relationships is lacking for most MIS and species at risk, creating uncertainties about the adequacy of and necessity for various conservation measures. Some MIS are intended to serve as indicators of ecosystem condition and the status of other species, and uncertainty exists as to if and how these species can serve this role, because they have not been tested or validated.

The Aquatic Conservation Strategy guides management toward maintaining and restoring populations and habitats of species in ARM ecosystems. A major uncertainty is whether the combined effects of proposed management are sufficient to support viable populations of at-risk species as well as a diverse array of species in ARM ecosystems. This includes maintaining and restoring the distribution, abundance, and connectivity of populations, the abundance, quality, and connectivity of habitat, and the distribution, abundance, and availability of prey. This is particularly pertinent for management associated with livestock grazing, fire management (e.g., prescribed fire, mechanical treatments, salvage and restoration), roads, noxious weeds, mining, herbicides and pesticides, dams and diversions, and introduced species.

Approach

Species and their associated population monitoring levels are shown in Table E-11. Population and/or habitat monitoring will be conducted for all MIS and species at risk. Varying levels of monitoring will be conducted depending on the level of concern associated with each species; as the level of concern about a species increases, the investment in monitoring data increases. Vascular plants will all receive population monitoring, ranging from presence to population demography (Table E-11) depending on the level of concern. Multi-species monitoring will be employed as an efficient way to obtain population and habitat data on the bulk of vertebrate MIS and species at risk. Those species not captured by multi-species monitoring will be monitoring through changes in habitat conditions.

It is possible that, after a period of annual population monitoring (distribution and abundance), we will have sufficient understanding of important habitat characteristics that we can confidently monitor habitat without annual monitoring of species' distribution and abundance. This is contingent, however, on a dedicated program of population monitoring and careful analysis and testing of habitat models along the way. Ultimately these habitat models may make it unnecessary to monitor species' populations directly, or at least to conduct population monitoring much less frequently. In this respect the approach mimics that proposed to monitor the effectiveness of the Northwest Forest Plan on recovery of the northern spotted owl (Lint et al. 1999).

Expected Results and Benefits

This package of monitoring will provide managers with information about the status and change in populations and habitats of species at risk. This information will be useful in determining potential impacts of projects on sensitive species and will provide an early warning system for species known to be at risk, yielding information that may aid in preventing listing. In addition, this monitoring package meets the legal requirement to monitor MIS. Finally, multi-species methods employed to monitor MIS and species at risk will provide data on the habitat relationships of these species, enabling the validation of species as indicators and the potential to monitoring habitat as a surrogate for populations. Multi-species monitoring protocols will incidentally provide data on non-target species, providing the opportunity to test the effectiveness of candidate focal species.

Table E-11. Management Indicator Species (MIS) and species at risk (SAR) associated with aquatic, riparian, and meadow ecosystems. FSS = Forest Service sensitive; Other status: FSC = Federal special concern; CE = California Endangered; CT = California Threatened; CSC = California special concern. Monitoring level: Dist = distribution; Relab = relative abundance; Aprec = apparent recruitment; Demog = population demography. Vulnerability ratings (Vul): H = high, M = moderate, L = low, blank = not included in analysis because they were exotic or because of their weak association with aquatic, riparian, and meadow ecosystems. Checkmarks (✓) in the population monitoring column indicate species for which population trend data is expected to be obtained.

CWHR ID	Common name	*Scientific name*	MIS	SAR	FSS	Other status	Vul	Monitoring level	Population monitoring
Vertebrates:									
B075	Canada goose	*Branta canadensis*	X				L	Dist	✓
B079	Mallard	*Anas platyrhynchos*	X				L	Dist	✓
B103	Bufflehead	*Bucephala albeola*	X				L	Dist	
B110	Osprey	*Pandion haliaetus*	X			CSC	L	Dist	✓
B298	Red-naped sapsucker	*Sphyrapicus nuchalis*	X				M	Dist	
B299	Red-breasted sapsucker	*Sphyrapicus ruber*	X				M	Dist	✓
B430	Yellow warbler	*Dendroica petechia*	X			CSC	L	Dist	✓
FI65	Colorado cutthroat trout	*Oncorhynchus clarki pleuriticus*	X					Dist	
FI66	Brook trout	*Salvelinus fontinalis*	X					Dist	✓
FI67	Lake trout	*Salvelinus namaycush*	X					Dist	
FI68	Brown trout	*Salmo trutta*	X					Dist	✓
FI89	Largemouth bass	*Micropterus salmoides*	X					Dist	✓
FN10	Resident rainbow trout	*Oncorhynchus mykiss irideus*	X				L	Dist	✓
FN49	Lost river sucker [1]	*Deltistes luxatus*	X			CE	M	Recovery plan	
FN52	Shortnose sucker [1]	*Chasmistes brevirostris*	X			CE	M	Recovery plan	
B113	Bald eagle [2]	*Haliaeetus leucocephalus*	X	X		CE	L	Recovery plan	
B150	Sandhill crane	*Grus canadensis*	X	X		CT	M	Dist	✓
FN06	Central Valley spring run chinook salmon [2]	*Oncorhynchus tshawytscha*	X	X	X	CT	H	Recovery plan	
FN08	Central Valley fall run Chinook salmon [3]	*Oncorhynchus tshawytscha*	X	X	X		L	Dist,Relab	
FN09	Central Valley late fall run chinook salmon [3]	*Oncorhynchus tshawytscha*	X	X		CSC	M	Dist,Relab	
FN13	Kern River rainbow trout	*Oncorhynchus mykiss gilberti*	X	X		FSC,CSC	H	Dist,Relab	
FN15	Volcano Creek golden trout	*Oncorhynchus mykiss aguabonita*	X	X	X	FSC,CSC	H	Dist,Relab	
FN19	Lahontan cutthroat trout [2]	*Oncorhynchus clarki henshawi*	X	X			H	Recovery plan	
FN20	Paiute cutthroat trout [2]	*Oncorhynchus clarki seleniris*	X	X			M	Recovery plan	
FN39	Hardhead	*Mylopharodon conocephalus*	X	X	X	CSC	L	Dist	
AOXX2	Breckenridge Mt. slender salamander	*Batrachoseps* sp.		X	X	FSC		Dist,Relab	
A023	Mount Lyell salamander [4]	*Hydromantes platycephalus*		X		FSC,CSC	L	Dist	✓
A040S1	California red-legged frog [2]	*Rana aurora draytonii*		X		CSC	H	Recovery plan	
A042	Cascade frog	*Rana cascadae*		X	X	FSC	H	Dist,Relab	
A045	Northern leopard frog	*Rana pipiens*		X	X	CSC	H	Pres	
B042	American white pelican [4]	*Pelecanus erythrorhynchos*		X		CSC	M	Dist	
B233	Forster's tern [4]	*Sterna forsteri*		X			M	Dist	✓
B235	Black tern	*Chlidonias niger*		X		CSC	H	Dist	✓
B385	Swainson's thrush	*Catharus ustulatus*		X			H	Dist	✓
B467	Yellow-breasted chat	*Icteria virens*		X		CSC	H	Dist	
B476	Blue grosbeak	*Guiraca caerulea*		X			H		

CWHR ID	Common name	*Scientific name*	MIS	SAR	FSS	Other status	Vul	Monitoring level	Population monitoring
B510S1	Mountain white-crowned sparrow	*Zonotrichia leucophrys oriantha*		X			H	Dist	✓
B520	Tricolored blackbird [4]	*Agelaius tricolor*		X		FSC,CSC	M	Dist	
FN01	Kern brook lamprey [4]	*Lampetra hubbsi*		X		FSC,CSC	M	Dist	
FN02	Pacific lamprey	*Lampetra tridentata tridentata*		X		FSC	H	Dist	✓
FN03	Goose Lake lamprey	*Lampetra tridentata* ssp.		X	X	FSC,CSC	M	Dist,Relab	
FN12	Eagle Lake rainbow trout	*Oncorhynchus mykiss aquilarum*		X	X	FSC,CSC	M	Dist,Relab	
FN16	Warner Valley redband trout	*Oncorhynchus mykiss* ssp.		X	X	FSC,CSC	M	Dist,Relab	
FN17	Goose Lake redband trout	*Oncorhynchus mykiss* ssp.		X	X	FSC,CSC	L	Dist,Relab	
FN22	Goose Lake tui chub	*Gila bicolor thalassina*		X	X	CSC	M	Dist,Relab	
FN23	Lahontan Lake tui chub	*Gila bicolor pectinifer*		X	X	CSC	L	Dist,Relab	✓
FN25	Owens tui chub [1]	*Gila bicolor snyderi*		X		CE	H	Recovery plan	
FN32	Sacramento hitch	*Lavinia exilicauda exilicauda*		X			H	Dist	
FN35	San Joaquin roach	*Lavinia symmetricus* ssp.		X		CSC	H	Dist	
FN45	Goose Lake sucker	*Catostomus occidentalis lacusanserinus*		X	X	FSC,CSC	M	Dist,Relab	
M002	Mt. Lyell shrew [4]	*Sorex lyelli*		X		FSC,CSC	M	Dist	
M052S1	Mono Basin mountain beaver [4]	*Aplodontia rufa californica*		X		FSC		Dist	✓
R004S1	Northwestern pond turtle	*Clemmys marmorata marmorata*		X	X	FSC,CSC	H	Dist,Relab	
A019	Inyo mountains salamander	*Batrachoseps campi*			X	CSC	L	Dist,Relab	
A041	Spotted frog [3]	*Rana pretiosa*			X		H	Pres	
R041	Panamint alligator lizard	*Elgaria panamintina*			X		M	Dist,Relab	
Invertebrates:									
	California floater	*Anodonta californiensis*			X			Dist	✓
	Great Basin rams-horn	*Helisoma newberryi newberryi*			X			Dist	✓
	Scalloped juga	*Juga acutifilosa*			X			Dist	✓
	Topaz juga	*Juga occata*			X			Dist	✓
	Montane peaclam	*Pisidium ultramontanum*			X			Dist	✓
	Owens Valley springsnail	*Pyrgulopsis owensensis*			X			Dist	✓
	Wong's springsnail	*Pyrgulopsis wongi*			X			Dist	✓
Vascular plants:									
	Ramshaw Meadows abronia [3]	*Abronia alpina*			X		L	Dist,Relab	✓
	Kern Plateau milk-vetch	*Astragalus lentiginosus* var. *kernensis*			X		M	Dist,Relab	✓
	Scalloped moonwort	*Botrychium crenulatum*			X	FSC	H	Dist,Relab	✓
	Long-haired star-tulip	*Calochortus longebarbatus* var. *longebarbatus*			X	FSC	M	Dist,Demog	✓
	Palmer's mariposa lily	*Calochortus palmeri* var. *palmeri*			X	FSC	H	Dist,Relab	✓
	Alkali mariposa lily	*Calochortus striatus*			X	FSC	H	Dist,Relab	✓
	Wilkin's harebell	*Campanula wilkinsiana*			X	FSC	H	Dist	✓
	Tioga Pass sedge	*Carex tiogana*			X		M	Dist,Relab	✓
	White Mtns. draba	*Draba monoensis*			X		M	Dist,Relab	✓
	Subalpine fireweed	*Epilobium howellii*			X		H	Dist	✓
	Kern River daisy	*Erigeron multiceps*			X	FSC	M	Dist,Relab	✓
	Shuteye Peak fawn lily	*Erythronium pluriflorum*			X		L	Dist,Relab	✓
	Sierra Valley ivesia	*Ivesia aperta* var. *aperta*			X	FSC	H	Dist,Demog	✓
	Dog Valley ivesia	*Ivesia aperta* var. *canina*			X	FSC	M	Dist Demog	✓
	Plumas ivesia	*Ivesia sericoleuca*			X	FSC	H	Dist,Demog	✓
	Red Bluff dwarf rush	*Juncus leiospermus* var. *leiospermus*			X		M	Dist,Relab	✓
	Bellinger's meadowfoam	*Limnanthes floccosa* ssp. *bellingeriana*			X	FSC	M	Dist,Relab	✓

CWHR ID	Common name	*Scientific name*	MIS	SAR	FSS	Other status	Vul	Monitoring level	Population monitoring
	Ephemeral monkeyflower	*Mimulus evanescens*			X		M	Dist,Relab	✓
	Slender-stemmed monkeyflower	*Mimulus filicaulis*			X	FSC	M	Dist,Relab	✓
	Pansy monkeyflower	*Mimulus pulchellus*			X		M	Dist,Relab	✓
	Slender Orcutt grass [2]	*Orcuttia tenuis*			X	CE	H	Dist,Relab	✓
	Plumas aster	*Oreostemma elatum*			X		M	Dist,Relab	✓
	Profuse-flowered pogogyne	*Pogogyne floribunda*			X	FSC	M	Dist,Relab	✓
	William's combleaf	*Polyctenium williamsiae*			X		M	Dist,Relab	✓
	Modoc County knotweed	*Polygonum polygaloides* ssp. *esotericum*			X		M	Pres	✓
	Columbia yellow cress	*Rorippa columbiae*			X	FSC	H	Dist,Relab	✓
	Tahoe yellow cress	*Rorippa subumbellata*			X		M	Dist,Relab	✓
	American scheuchzeria	*Scheuchzeria palustris* ssp. *americana*			X		L	Dist,Relab	✓
	Bolander's clover	*Trifolium bolanderi*			X	FSC	L	Dist,Relab	✓
Nonvascular plants:									
	Bolander's candle moss	*Bruchia bolanderi*			X			Dist	✓
	Moss	*Meesia triquetra*			X		H	Dist	✓
	Moss	*Meesia uliginosa*			X			Dist	✓
	Moss	*Orthotrichum spjutii*			X			Dist	✓
Fungi:									
	Lichen	*Hydrothyria venosa*			X		H	Dist	✓

[1] *Federally Endangered species*
[2] *Federally Threatened species*
[3] *Federal candidate species*
[4] *Species at lower risk*

9.3. Aquatic, Riparian, and Meadow Monitoring Questions

Implementation Monitoring

1. Were best management practices and other appropriate state mandates (e.g., TMDLs) implemented to protect beneficial uses including water quality? (RCA1, RCA2)
2. Were adequate landscape and project analyses completed to determine appropriate management activities in aquatic, riparian, and meadow areas? (CAR-AM11, should be other SGs on this? check out)
3. Were appropriate land allocations (RCAs, RCPZs, CARs) delineated? (?sgs)
4. Were standards and guides for management activities within land allocations (RCAs, RCPZs, CARs) enacted to protect beneficial uses including water quality, habitat, and aquatic, riparian and meadow dependent species?
5. Were restoration opportunities identified and activities implemented to maintain or restore geomorphic (including reduction of sediment delivery), floodplain, and vegetative characteristics (including LWD) of streams, riparian areas, and special aquatic features? (RCA6, RCA17-RCA21, RCA40, RCA44-46)
6. Were Soil Quality Standards implemented to reduce the risk of sediment delivery to aquatic systems? (RCA4-RCA5)?
7. Were adequate roads analyses conducted and standards and guidelines implemented to protect beneficial uses (including reduction of sediment delivery) and ensure the continuity of hydrologic flow paths? (RCA7-RCA9, RCA14-RCA15, RCA44, RCA46, RCA38)
8. Were standards and guidelines for vegetation management and fire and fuels management implemented to protect beneficial uses, ensure a renewable supply of large woody debris, and enhance or maintain physical and biological characteristics associated with aquatic and riparian dependent species? (RCA22, RCA26, RCA27, RCA30-RCA35)
9. Were adequate range management analyses conducted and standards and guidelines relevant to livestock grazing implemented to maintain or enhance streams and riparian areas and the abundance, distribution, and condition of meadows, lakes and other special aquatic features? (RCA39-43)
10. Were standards and guidelines related to mining and minerals management implemented, including the identification and implementation of reclamation of abandoned mine sites? (RCA45, and numerous General forest SGs)
11. Were standards and guidelines associated with dams and diversions implemented including cooperation with and providing input to other governments and agencies to maintain sufficient instream flows? (RCA23-25)
12. Are strategies proposed in the Long-Term Strategy for Anadromous Fish implemented?
13. Were Aquatic Conservation Strategy goals considered during F.E.R.C. re-licensing procedures? (RCA24)
14. Was a conservation strategy developed for the mountain yellow-legged frog and were fish stocking activities evaluated and changed in cooperation with California Department of Fish and Game? (RCA47-RCA49)
15. Were management guides developed for the foothill yellow-legged frogs, mountain yellow-legged frogs, and Yosemite toads? (RCA50)
16. Were grazing standards (including pack and saddle stock and limited operating periods for the Yosemite toad) implemented? (RCA41)
17. Was the application of pesticides and herbicides avoided within 500 feet of known occupied sites for foothill and mountain yellow-legged frogs and Yosemite toads? (RCA12)

18. In suitable California red-legged frog, foothill and mountain yellow-legged frogs, and northern leopard frog habitat, were aquatic conditions assessed, mitigation methods developed, and analyses on appropriate use of prescribed fire conducted prior to implementing ground disturbing or fire management activities? (RCA26-RCA28)
19. Were grazing and pack station standards and guidelines followed as prescribed in association with willow flycatcher habitat management? (RCA43)
20. Was a management guide developed for the willow flycatcher? (RCA50)
21. Were willow flycatcher “emphasis areas” identified using regionally established criteria and were these areas surveyed according to standards and guidelines? (B46A)
22. Were fish stocking policies evaluated and changed in cooperation with California Department of Fish and Game? (RCA49)
23. Were stream crossings within CARs upgraded to provide unimpaired passage to aquatic species? (RCA44)
24. Was pesticide application prohibited within 500 feet of sites known to be occupied by California red-legged frogs, northern leopard frogs, or Cascade frogs? (RCA12)
25. In suitable California red-legged frog and northern leopard frog habitat, were aquatic conditions assessed, mitigation methods developed, and analyses on appropriate use of prescribed fire conducted prior to implementing ground disturbing or fire management activities? (RCA26-RCA28)
26. Were screening devices attached to all water drafting pumps that are designated with low entry velocity to prevent removal of egg masses and tadpoles? (RCA29)
27. Were management activities conducted to improve or maintain pertinent habitat requirements of aquatic, meadow, and riparian species including temperature, shade, streambanks, flow floodplain inundation, and large woody debris? (RCA11, RCA18, RCA22, RCA25, RCA37)

Status-and-Change and Cause-and-Effect Monitoring

High priority questions will be addressed during the planning period, and lower priority questions will be addressed if possible.

High Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
WHAT IS THE STATUS AND CHANGE OF …			
1. Water quality in streams? (Goal 1)	water chemistry, temperature, sedimentation, macroinvertebrate assemblages	261	
2. Stream channel condition? (Goals 6, 8, 9)	channel morphology, sedimentation, channel stability, floodplain connectivity, large woody debris	0	Cost included in status and change question #1
3. Riparian vegetation condition and community diversity? (Goal 3)	plant successional stage, vegetation structure including canopy cover, canopy layers, life form diversity, downed wood, snags, extent of riparian area riparian plant diversity, noxious plants, introduced-native and exotic fish	300	
4. Watershed condition? (Goal 7)	disturbance, erosion and sedimentation indicators	70	Clean water action plan
5. Vegetation condition and bird species composition in meadows? (Goal 3)	plant and bird species composition, ground cover, soil hydrologic characteristics, meadow area	54	MIS and species at risk monitoring. Estimated contribution: 100

High Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
WHAT IS THE STATUS AND CHANGE OF …			
6. Water quality and community composition in lakes? (Goal 1,3)	major ionic chemistry, water clarity, key indicator taxa such as zooplankton, macroinvertebrates, and algae	162	Water quality program
7. Vegetation conditions and disturbance in special aquatic habitats? (Goal 5)	plant community composition, plant species composition, ground cover	50	Regional meadow program
8. Abundance and distribution of special aquatic habitats? (Goal 5)	width, depth, shape, size, disturbance, number, location	36	
9. The distribution, relative abundance, and survivorship of the Modoc sucker? (Goal 2)	distribution (based on presence/not found data), relative abundance measured by frequency of occurrence#fish/age class calculated from age-at-length data (scale collection)	40	Ongoing efforts are collecting some data.
10. The quantity and quality of habitat for all life history stages of the Modoc sucker? (Goal 2)	stream habitat characteristics such as elevation, average/ maximum depth, width, pool and riffle area, migration barrier identification, substrate composition, riparian vegetation, undercut banks, bank stability, in-stream cover, adjacent land use, stream miles of suitable habitat. Water quality indicators such as temperature regimes, pH, dissolved oxygen, salinity, alkalinity, and turbidity	0	Cost included in status and change question #9
11. Overlap in distribution between the Modoc sucker and the Sacramento sucker, hybrid sucker, and introduced fish (especially brown trout, Salmo trutta)?	distribution of Sacramento suckers and hybrid suckers within the range of the Modoc sucker; presence of introduced fishes within the range of the Modoc sucker; number and location of physical barriers limiting the distribution of Sacramento suckers and brown trout, number and distribution of populations of Modoc suckers that are isolated from Sacramento suckers and brown trout.	0	Cost included in status and change question #9
12. The distribution of the Little Kern golden trout?	distribution (based on presence/not found data)	10	Ongoing efforts are collecting some data.
13. Habitat quality for the Little Kern golden trout?	riparian vegetation, substrate composition, water quality (e.g., temperature)	40	
14. Distribution of rainbow trout, Little Kern golden trout/rainbow trout hybrids, brown trout, and brook trout within the range of the Little Kern golden trout?	presence of rainbow trout, brown trout, brook trout and Little Kern golden trout/rainbow hybrid within the range of the Little Kern golden trout	0	Cost included in status and change question #12
15. Quantity and quality of and access to spawning and rearing habitat for the Central Valley steelhead?	amount and quality of spawning and rearing habitat (e.g., substrate, large woody debris, water temperature, number of barriers to spawning and rearing habitat, number of stream miles accessible to steelhead)	15	Ongoing efforts may contribute data
16. The distribution and relative abundance by life stage of foothill yellow-legged frogs, mountain yellow-legged frogs, and Yosemite toads (larvae, metamorph, juvenile and adult)?	distribution (i.e., presence/not found data), abundance	90	
17. The condition of aquatic and riparian habitats for all life stages of foothill yellow-legged frogs, mountain yellow-legged frogs, and Yosemite toads?	in stream/pond and riparian/meadow habitat characteristics (e.g., measures of hydrologic regimes, fine and course sediments, water temperature, and riparian vegetation/woody debris structure, composition, and microclimate)	90	

High Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
WHAT IS THE STATUS AND CHANGE OF …			
18. The distribution, relative abundance, nest success, and fecundity rate of willow flycatchers?	distribution, relative abundance, nest success, and fecundity rate of willow flycatchers	75	
19. The quality, quantity, and distribution of suitable willow flycatcher habitat?	characteristics of meadow and riparian ecosystems such as meadow size, water depth, herbaceous layer and shrub vegetation structure and composition, grazing intensity, and brown-headed cowbird abundance	0	Covered by status and change questions for meadows. Estimated contribution: 54
20. Populations and habitats of MIS, and vertebrate and vascular plant species at risk?	(see Old Forests topic area)	0	Costs shown in Old Forest topic area
21. Populations of invertebrate species at risk?	distribution	14	
22. Populations of nonvascular plant and fungi species at risk?	distribution	5	
High Priority Cause and Effect Monitoring Questions	**Attributes**	**Total cost ($1000s)**	**Contrib. from linked questions or other NFS programs**
1. What livestock grazing standards are most effective in maintaining and restoring physical, chemical, and biological conditions in stream, riparian, and meadow ecosystems?	water quality, channel morphology, riparian plant successional stage, vegetative structure (horizontal and vertical), various grazing practices (e.g., livestock grazing utilization, method, duration, season) plant species composition, ground cover, soil hydrologic characteristics, meadow area	80	Assumes some overlap with status and change monitoring
2. What livestock grazing standards are most effective in maintaining and restoring the physical and biological condition of special aquatic habitats?	plant community composition, plant species composition, ground cover, water table measurements, area of special habitats, various grazing practices (e.g., livestock grazing utilization, method, duration, season of use)	28	
3. Are livestock grazing standards effective in protecting Little Kern golden trout populations and habitat?	relative abundance, habitat condition (e.g., riparian vegetation, substrate composition, water quality); various livestock grazing practices (e.g., grazing utilization, method, duration and season)	29	
4. Does the timing and location of mechanical fuels treatments and prescribed burning in and near riparian habitats affect populations (distribution, abundance, population structure) and habitat (in-stream and riparian) of the foothill yellow-legged frog?	distribution, abundance, and demographic characteristics (e.g., reproductive and survival rates) ; in-stream and riparian characteristics (e.g., measures of hydrologic regimes, fine and course sediments, water temperature, and riparian vegetation/woody debris structure, composition, and microclimate); various mechanical fuel treatments	77	
5. Does the implementation of a conservation plan that includes strategic reduction/elimination of exotic fish stocking in high elevation lakes result in positive changes in the distribution (at both small and large scales), abundance, and population structure of mountain yellow-legged frogs?	distribution, abundance, and demographic characteristics (e.g., reproductive and survival rates) of mountain yellow-legged frogs at several spatial scales (e.g., local population and lake basin)	85	
6. Do livestock grazing standards, including limited operating periods, result in improvements in population status (e.g., distribution, abundance, and population structure) and habitat conditions (meadow and riparian) for Yosemite toads?	distribution, abundance, and demographic characteristics (e.g., reproductive and survival rates); in-stream, pond, and meadow characteristics (e.g, measures of hydrologic regimes, water depth, fine and course sediments, water temperature, and meadow vegetation composition and microclimate); various livestock grazing practices (e.g., grazing utilization, method, duration and season)	85	

High Priority Cause and Effect Monitoring Questions	Attributes	Total cost ($1000s)	Contrib. from linked questions or other NFS programs
7. What are the direct and indirect effects of various livestock grazing practices on willow flycatchers and their habitat?	grazing practices (e.g., utilization, method, duration, and season); willow flycatcher population parameters (e.g., occupancy, site fidelity, density, nest success, fecundity rate, nest tipping); habitat parameters (e.g., ; herbaceous layer and shrub vegetation characteristics; meadow hydrology; incidence of cowbird parasitism)	0	Data on habitat conditions provided by cause and effect question # 1
8. What are the effects of brown-headed cowbird parasitism on willow flycatcher populations?	frequency of cowbird parasitism; willow flycatcher population parameters (e.g., occupancy, site fidelity, density, nest success, fecundity rate, nest tipping)	0	Data provided by status and change monitoring of reproductive success
Lower Priority Status and Change Monitoring Questions	**Attributes**	**Cost per year ($1000s)**	**Contrib. from linked questions or other NFS programs**
What is the status and change of ….			
1. Watershed connectivity? (Goal 5)	regulated flow, human-created barriers	16	
2. Stream flow patterns in regulated streams? (Goal 8)	regulated flows	8	
Lower Priority Cause and Effect Monitoring Questions	**Attributes**	**Total cost ($1000s)**	**Contrib. from linked questions or other NFS programs**
1. Are livestock grazing management practices effective in protecting Modoc sucker habitat and populations?	distribution and survivorship of the Modoc sucker; various grazing practices (e.g., livestock grazing utilization, method, duration, season of use)	29	
2. Does using ACS goals in the FERC re-licensing process result in changes to flow regimes and stream channels that are less detrimental to foothill yellow-legged frogs and their habitat?	changes in flow regimes in relation to re-licensing	5	

9.4. Key Aquatic, Riparian, and Meadow Information Gaps

The following are research questions that were identified as key information needs in relation to the topic areas addressed in the FEIS. The first three questions listed here were identified as a high priority for the Pacific Southwest Station, and every effort will be made to address these first three questions during the planning period.

1. What width and range of treatments for riparian buffers (including those proposed in the S&Gs) are most effective in maintaining and restoring aquatic, riparian, and meadow physical, chemical, and biological conditions?
2. What are the habitat characteristics of the willow flycatcher at the local, territory, and landscape scale and how do they relate to abundance and reproductive success?
3. What are the habitat requirements (including biological factors such as introduced fish) of foothill yellow-legged frogs, mountain yellow-legged frogs, and Yosemite toads at multiple scales (local population and subwatershed/meadow complex) and what is needed to maintain or restore the population and genetic structure of these species?
4. What are effective methods for monitoring stream flow on unregulated streams and sediment?

5. What zooplankton, macroinvertebrates, and algae are the most sensitive and informative indicators of water quality and overall condition in lakes and ponds?
6. What are the most sensitive and informative indicators of overall condition for each type of special aquatic habitat?
7. What are the most effective methods for monitoring changes in the distribution and abundance of Central Valley steelhead?
8. What is the current genetic status of native Central Valley steelhead, and what is the extent of hybridization? (CDFG is currently working on this)
9. What is the population and genetic structure (e.g., dispersal and interactions among populations, extinction/recolonization, reliance on one "mainland or source" population) of foothill yellow-legged frogs, mountain yellow-legged frogs, and Yosemite toads in the Sierra Nevada and what implications does this have for management?
10. How do disease (e.g., chytrid fungus) and predation contribute to mortality levels in foothill yellow-legged frogs, mountain yellow-legged frogs, and Yosemite toads in the Sierra Nevada?
11. What are the effects of exotic fish stocking on the distribution, abundance, and population structure of Yosemite toads?
12. Do livestock grazing standards result in positive changes in the distribution (at both small and large scales), abundance, population structure, and habitat condition of foothill yellow-legged frogs and mountain yellow-legged frogs?
13. Does the prescribed reductions in the use of pesticides (including herbicides) near amphibian sites reduce the environmental toxin load and result in larger populations of foothill yellow-legged frogs, mountain yellow-legged frogs, and Yosemite toads?
14. Does the southwestern willow flycatcher (*E. t. extimus*) occur as a breeding bird or as a migrant on any National Forest lands within the planning area that are outside the Kern Plateau of Sequoia National Forest?
15. What is the population structure and demography of willow flycatcher in the Sierra Nevada?
16. What is the historic trend in willow flycatcher distribution, abundance, and reproduction in the Sierra Nevada over the past 50 years?
17. What are the habitat relationships of aquatic, riparian and meadow associated MIS and species at risk?
18. How effective are associated MIS at indicating aquatic, riparian and meadow conditions and the status of other associated species?
19. What species might be strong indicators of aquatic, riparian and meadow conditions and the status of other aquatic, riparian and meadow associated species?

10. Air Quality

10.1. Introduction

Goal

The goal of the air quality topic area is to protect air quality and sensitive resources on National Forests in the Sierra Nevada.

Objectives

The objectives of the air quality topic area are to, (1) minimize air pollutant impacts from prescribed fire, (2) meet legal compliance requirements, and (3) protect sensitive resources on National Forests from the adverse effects of air pollution.

Background

The National Forests in the Sierra Nevada are exposed to some of the best and worst air quality conditions in the nation (SNEP 1996). Air quality concerns have been documented in each of the previous ecological review efforts focusing on the mountain range. The Sierra Nevada Ecosystem Project (SNEP) documented bioregional scale problems with ozone and particulate matter, and identified pesticide use in the Central Valley as a potential issue. The Sierra Nevada Science Review considered air pollution (ozone and nitrogen) as a key concern for lower Westside hardwood forests, and chemical contamination as an issue for sensitive amphibian species. Other research efforts have focused on ozone and nutrient deposition as significant affectors of Sierra Nevada forests and aquatic systems. Air quality is linked to the FEIS through (1) proposed increases to prescribed fire and wildland fire use and their effects on air quality, and (2) air pollution as an affector of old forest, hardwoods, noxious weeds, and aquatic/riparian/meadow ecosystems.

Legal obligations relative to air quality originate with the Clean Air Act and various federal, state, and local rules and regulations. Legal requirements with particular relevance to fire and fuels management include Clean Air Act Conformity provisions, federal and state air quality standards, California’s revisions to Title 17 (Smoke Management Guidelines for Agricultural and Prescribed Burning), and federal Regional Haze regulations. Additional guidance on use of fire as a management tool is found in EPA’s Interim Air Quality Policy on Wildland and Prescribed Fires, and the Federal Wildland Fire Policy. Legal obligations relative to resource protection may be found in the Clean Air Act, The Forest and Rangeland Resources Planning Act, the Organic Act, and the Code of Federal Regulations. For a complete discussion of the air regulatory framework.

Overview of Approach

The approach taken to defining EIS monitoring needs for air quality is both model and issue-based. A comprehensive set of air quality monitoring questions and attributes were identified through the development of the Ecosystem Process Conceptual Model. In response to the needs of the Framework EIS, a subset of issue-based questions was developed through evaluation against a set of objective criteria. The questions were further subdivided into topic areas, (1) smoke and air quality, and (2) air pollution. The topic areas are complementary and overlap to some degree, including in their monitoring requirements. Forest Service management actions proposed in the EIS, fire and fuels management in particular, directly influences the smoke issue area. The smoke and air quality issue is addressed under the Fire and Fuels topic area. The air pollution issue area reflects outside pollution sources and their impacts to National Forest air quality, over which the agency has limited authority. The questions are intended to assist management by (1) providing a framework to address the complex issue of smoke management, and (2) providing information on air quality conditions on National Forest lands.

10.2. Description of Air Quality Issues

Air Pollution Issue

Description

This issue is centered on air quality conditions on National Forest lands, as affected by outside sources of air pollution. The Forest Service is given direction to protect air quality and related values from harmful impacts of air pollution by the following laws and regulations:

The Organic Act (16 U.S.C. &1609 (a)): Directs the Secretary of Agriculture to "make provisions for the protection against destruction by fire and depredations upon the public forests and national forests."

The Forest and Rangeland Renewable Resources Act of 1974, as amended by the National Forest Management Act (16 U.S.C. 1602): Directs the Secretary of Agricultural to "protect, and where appropriate, improve the quality of soil, water, and air resources."

The Clean Air Act (42 U.S.C. & 7470 et seq): Establishes the Prevention of Significant Deterioration program, whose purpose is to "preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value." The Act gives the Federal Land Manager an "affirmative responsibility" to protect air quality related values (including visibility) in Class I areas. The FLM is urged to err on the side of resource protection.

Planning Regulations (proposed) 36 CFR 219.20 (b) (7): Directs the Forest Service to "provide for the protection and/or restoration of air resource values, including visibility, from human-caused air pollution impacts to the extent possible given variables beyond the control of the Forest Service."

Poor air quality results in health hazards to forest users and decreased visibility in "pristine" areas. The importance of air quality conditions is also linked to its effects on ecosystems. Impacts include physical and physiological injury to sensitive plant species, elimination of sensitive species and genotypes, changes to nutrient cycling, and degradation of water quality. Forest Service management actions (such as prescribed fire) can interact with transported pollutants to multiply adverse effects to air quality. While state and air pollution control districts maintain ambient monitoring networks, the majority of sites are not well situated to determine conditions on National Forest lands.

Uncertainties

Uncertainties are associated with (1) air quality conditions on National Forests, and (2) the effects of exposure on forested lands. (Effects monitoring is addressed under the appropriate problem area.)

Approach

Monitoring consists of tracking trends in atmospheric deposition and depositional effects.

Affectors: Emissions (prescribed, wildland fire use, wildfire, urban transported air pollution).

Expected Results and Benefits

When combined with effects information, the current intensity and distribution of air pollution impacts to National Forests may be accurately assessed. The information will also provide a basis for predictive model development and a database that will support cooperative efforts with air regulatory agencies to protect forest lands.

The high priority questions will benefit management in the following ways:

- Support legal requirements for air quality and resource protection on National Forests.
- Supplement smoke monitoring by providing information on trends in pollutants that are potentially affected by emissions from prescribed fire.
- Identify ecosystems at risk from air pollution.
- Target effects monitoring to ecosystems at greatest risk.
- Improve protection of National Forests by providing information for use in the regulatory arena.
- Support decision-making and adaptive management by contributing to forest managers' knowledge of National Forests stressors.
- Allow development of air pollution/ecosystem effects predictive models that will reduce future monitoring costs.

10.3. Air Quality Monitoring Questions

Implementation Monitoring

These questions are designed to track implementation of air quality standards and guidelines.

1. Were dust abatement techniques used during timber harvest and road building activities?
2. Are conformity determinations made for projects occurring in federal nonattainment areas?
3. Are activities with the potential to affect AQRVs addressed during the NEPA process?

Status and Change Monitoring

High priority questions will be addressed during the planning period. No lower priority questions were identified.

High Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
What is the status and change of…			
1. Ambient air quality and atmospheric deposition in the Sierra Nevada?	ozone, nitrogen compounds (NO/NOx, HNO3, NH3, N deposition), PM10 and PM2.5, lichen chemistry, foliar injury, water chemistry	10	26
2. Biotic and physical air quality indicators?		40	40

11. Soil Productivity

11.1. Introduction

Goal

The goal for soil quality is to maintain and restore soil health and productivity on National Forests in the Sierra Nevada.

Objectives

The objectives of the soil quality topic area are to (1) ensure that components of soil productivity, which include soil physical, chemical, and biological processes, provide for the ecological function and integrity of the soil, (2) maintain soil hydrologic function and soil buffering capacity to prevent accelerated erosion and deterioration of soil quality, (3) provide for ecosystem health, diversity, productivity and water quality, and (4) maintain and restore watershed condition to reduce adverse cumulative watershed effects associated with reduced infiltration, altered sediment regimes, and provide for healthy hillslope and riparian ecosystems.

Background

The soil quality found within the Sierra Nevada ranges in terms of its productivity and in doing so it provides a plethora of diverse vegetation. The vegetation is an expression of the soil resource and ranges from the Giant Sequoias, hardwood forests, mixed conifer forests, riparian areas and wetlands, and unique vegetative assemblages that provide for both terrestrial and aquatic habitat. The soil can be easily viewed as the foundation from which the Sierra Nevada tapestry has formed and our management of that resource is essential to maintaining not only the soil quality but also the more tangible attributes described above.

Soil quality concerns have been documented in the Sierra Nevada. Scientific research and Forest Service records indicate that past management activities and wildfires have changed soil conditions in the Sierra Nevada. Hydraulic mining in the late 1800s dramatically affected the condition of the soil and tons of soil was washed downstream. Recent studies have linked reduced tree growth to compaction in several Sierra Nevada ecological types (Poff 1996). Changes in soil porosity in oak woodlands have been identified, as has the potential for air pollution to change nutrient cycling in soil systems. Soil quality is linked to the Framework EIS through (1) proposed increases to prescribed fire and wildland fire use, (2) the relationship between mechanized timber harvest and the impact to soil porosity, and (3) the relationship between riparian area management and accelerated soil erosion.

Legal obligations relative to soil quality protection are found in NFMA Section 102 (2) (C) and (3) (C & E). NFMA Section 6 (G) calls for protection of forest resources including watersheds and soil. The Forest and Rangeland Resources Planning Act, the National Environmental Policy Act, Executive Order 11991, and the Code of Federal Regulations.

Overview of Approach

The approach taken to defining EIS monitoring needs for soil quality is both model and issue-based. A comprehensive set of soil quality monitoring questions and attributes were identified through the development of the Ecosystem Process Conceptual Model. To respond to the needs of the EIS, a subset of issue-based questions and attributes was developed after evaluation against a set of objective criteria by a team of soil scientists. The remaining questions and attributes are intended to assist management by (1) providing a framework for addressing the complex issue of soil quality, and (2) providing information on the both the current status of the soil resource and the effects of grazing on the soil resource.

11.2. Description of Soil Productivity Issues

Soil Quality Issue

Description

This issue addresses the effects that management activities that displace topsoil, reduce soil porosity (cause compaction), reduce soil cover, and potentially increase erosion may have on soil quality in the Sierra Nevada.

Uncertainties

The risks of management activities are coupled with a fairly high level of uncertainty due to the limited knowledge of the existing condition of the soil resource. Monitoring efforts have been fragmented and lack consistency in terms of data collection protocol. Limited data from monitoring exists from these types of activities (thinning, restoration) in the region. Little on the ground knowledge or experience of monitoring large-scale treatments or in defining the effects of these treatments exists.

Approach

Monitoring centers on the implementation and effectiveness of soil quality standards, and trends in soil quality.

Affectors: Vegetation management, grazing, recreation, fire, roads, land development, hydroelectric, mining, and restoration.

Expected Results and Benefits

Cause and Effect Monitoring: The proposed set of monitoring questions supports the soil quality standards that have been developed for Regions 4 and 5. The information provided will serve as a tool in (1) evaluation of soil quality standard effectiveness in maintaining soil quality, and (2) validation of landscape and watershed analysis as a tool to identify and implement corrective measures to improve watershed and soil quality.

These questions are designed to provide baseline information on the existing condition of the soils relative to physical, chemical/nutrient and biological properties. This includes the pre-existing condition for compaction, soil cover, soil organic matter, and large woody material.

Status and Change Monitoring: The proposed set of monitoring questions provides necessary information to assess if soil quality standards are being achieved to maintain and restore soil health and productivity. When looking at soil productivity it is important to address the physical, chemical and biological properties. The three cannot be separated because they all interact and affect each other.

The high priority monitoring questions for soil quality will benefit management by 1) meeting legal requirements for soil quality monitoring at both the project and regional scales, 2) responding to public concerns regarding the current condition of the soil resource and the affects of management activities on long-term soil productivity, and 3) providing a systematic and coordinated approach to soil quality monitoring in the Sierra across National Forests and among interested agencies.

11.3. Soil Productivity Monitoring Questions

Implementation Monitoring

1. Are soil quality standards being implemented?

Status and Change and Cause and Effect Monitoring

High priority questions will be addressed during the planning period, and lower priority questions will be addressed if possible.

High Priority Status and Change Monitoring Questions	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
What is the status and change of…			
1. Soil physical properties, soil chemical/nutrient availability, and soil biological activities?	soil porosity, soil cover, soil erosion, soil cover, large woody debris, soil organic matter, soil pH, roots, wormholes, worm casts, soil organic matter	200	Soils Program
High Priority Cause and Effect Monitoring Questions	**Attributes**	Total Cost ($1000s)	**Contrib. from linked questions or other NFS programs**
1. Do grazing standards meet soil quality standards for erosion and compaction in meadows and riparian areas?	soil porosity, rooting depth, and soil cover	28	Range program
2. Does implementation of the recommendations in a landscape/ watershed analysis result in maintenance and or restoration of watersheds and soil health/productivity?	attributes are dependent on the type of restoration work performed and would be linked to soil physical, chemical, or biological properties and Regional Soil Quality Standards.	25	
Lower Priority Cause and Effect Monitoring Questions	**Attributes**	Total Cost ($1000s)	**Contrib. from linked questions or other NFS programs**
1. Does implementation of soil standards and guidelines maintain and restore soil health and productivity in relationship to the current thresholds?	soil porosity, soil cover, soil organic matter, large woody debris	40	

11.4. Key Soil Productivity Information Gaps

The following is a research question that was identified as key information needs in relation to the topic areas addressed in the FEIS.

1. What are appropriate desired conditions as informed by “natural background” conditions for soil quality in the Sierra Nevada?

12. Noxious Weeds

12.1. Introduction

Noxious weeds can pose serious threats to Sierran ecosystems. Weeds are non-native plant species that displace native species, cause erosion, and adversely affect wildlife habitat, human health, recreation, and local economies. Sixty noxious weed species have been identified in this planning process (Table E-12). Weeds spread through a variety of anthropogenic vectors, such as roads, utility corridors, vegetation management projects, recreation, livestock, fire and fuels management, and commercial nurseries. The three goals of this EIS related to noxious weeds are as follows: 1) contain or eradicate existing weed populations, 2) eradicate new weed populations, and 3) prevent the establishment of new weed populations. Management direction in this EIS that addresses noxious weeds includes a wide variety of strategies for eradicating and containing weed populations and reducing the frequency of new infestations. Standards and guidelines include the following strategies: public and agency education, incorporating noxious weed considerations in permitting, NEPA documents, restoration plans, and burning plans, requiring control measures during ground disturbing activities, and inventory and monitoring.

Overview of Approach

The noxious weed topic area addresses the need to monitor populations of noxious weeds and determine the degree to which strategies for containment and eradication are being applied across the bioregion. Two issue areas were created: 1) populations of noxious weeds and 2) noxious weed management strategies. Together, the two issues provide a package of monitoring information that will inform management about the status of noxious weed infestations and the level of compliance with existing management direction.

12.2. Description of Noxious Weed Issues

Populations of Noxious Weeds Issue

Description

This issue addresses status and change monitoring of noxious weed populations (Table E-12). Knowledge of trends in noxious weed distributions and the occurrence and residency time of new weed populations will assist managers in prioritizing areas for treatment and helping prevent further spread of weeds.

Table E-12. Noxious weed species addressed in the monitoring strategy. Each species will receive distribution monitoring.

COMMON NAME	SCIENTIFIC NAME
Russian knapweed	*Acroptilon repens*
Jointed goatgrass	*Aegilops cylindrica*
Goatgrass	*Aegilops triuncialis*
Tree-of-heaven	*Ailanthus altissima*
Black mustard	*Brassica nigra*
Cheatgrass	*Bromus tectorum*
White-top	*Cardaria draba*
White-top	*Cardaria pubescens*
Spiny plumeless thistle	*Carduus acanthoides*
Musk thistle	*Carduus nutans*
Italian plumeless thistle	*Carduus pycnocephalus*
Smooth distaff thistle	*Carthamus baeticus*
Woolly distaff thistle	*Carthamus lanatus*
Red star thistle	*Centaurea calcitrapa*
White knapweed	*Centaurea diffusa*
Iberian starthistle	*Centaurea iberica*
Spotted knapweed	*Centaurea maculosa*
Tocalote	*Centaurea melitensis*
Yellow star thistle	*Centaurea solstitialis*
Squarrose knapweed	*Centaurea squarrosa*
Rush skeletonweed	*Chondrilla juncea*
Canada thistle	*Cirsium arvense*
Yellowspine thistle	*Cirsium ochrocentrum*
Wavyleaf thistle	*Cirsium undulatum*
Bullthistle	*Cirsium vulgare*
Field bindweed	*Convolvulus arvensis*
Common crupina	*Crupina vulgaris*
Bermudagrass	*Cynodon dactylon*
Scotch broom	*Cytisus scoparius*
Russian olive	*Elaeagnus angustifolius*
Quackgrass	*Elytrigia repens*
Wolf's milk	*Euphorbia esula*
Oblong spurge	*Euphorbia oblongata*
Vulgare	*Foeniculum vulgare*
Frenchbroom	*Genista monspessulana*
Halogeton	*Halogeton glomeratus*
Waterthyme	*Hydrilla verticillata*
Klamathweed	*Hypericum perforatum*
Dyer's woad	*Isatis tinctoria*
Poverty weed	*Iva axillaris* ssp. *robustior*
Ox-eye daisy	*Leucanthemum vulgare*
Broadleaved pepperweed	*Lepidium latifolium*
Dalmatian toadflax	*Linaria genistifolia* ssp. *dalmatica*
Purple loosestrife	*Lythrum salicaria*
Horehound	*Marrubium vulgare*
Spike watermilfoil	*Myriophyllum spicatum*
Scottish thistle	*Onopordum acanthium* ssp. *acanthium*
Black locust	*Robinia pseudoacacia*
Himalayan blackberry	*Rubus discolor*
Tumbleweed	*Salsola paulsenii*
Russian thistle	*Salsola tragus*
Mediterranean sage	*Salvia aethiopis*
Milk thistle	*Silybum marianum*
White horse-nettle	*Solanum elaeagnifolium*
Johnsongrass	*Sorghum halepense*
Spanish broom	*Spartium junceum*
Medusa-head	*Taeniatherum caput-medusae*
Tamarisk	*Tamarix chinensis*
Puncturevine	*Tribulus terrestris*
Gorse	*Ulex europaeus*
Common mullein	*Verbascum thapsus*

Uncertainties

Whether noxious weed populations will decline due to management strategies; alternatively, how they might spread, both temporally and spatially.

Approach

Monitoring questions address the status and change in population characteristics. No implementation or cause and effect monitoring are identified for this issue.

Affectors: vegetation management, livestock grazing, human recreation/recreational development, fire management, agriculture

Expected Results and Benefits

The status and change questions yield important species-specific information about noxious weed populations. Managers will benefit from discoveries of new infestations and from data regarding the spread or shrinkage of existing infestations by facilitation of early responses and thus minimizing expense and increasing the success of treatments. The information gained will allow prioritization of areas and species to target for containment or eradication measures. Furthermore, decreased residency times for new infestations would indicate some success in noxious weed treatments, while increased or stable residency times would indicate the need to act more quickly or develop new strategies that eradicate infestations more quickly.

Noxious Weed Management Issue

Description

This issue addresses the degree to which standards and guidelines are being implemented across the Sierra Nevada. There is a high degree of confidence in the effectiveness of noxious weed management strategies. Therefore, this issue consists entirely of implementation monitoring.

Uncertainties

The primary uncertainty in relation to noxious weed management strategies is the ability to implement them across the Sierra Nevada.

Approach

Monitoring for this issue consists entirely of implementation questions. A high level of confidence exists in the protective measures that appear in the standards and guidelines, thus no effectiveness monitoring is prescribed. If weed populations show an increasing trend even though implementation monitoring demonstrates compliance with the standards and guidelines, then the effectiveness of the standards and guidelines may come into question.

Expected Results and Benefits

This array of implementation questions addresses Forest Service compliance with a subset of standards and guidelines relating to noxious weed planning, control, mitigation, education, and monitoring. Knowledge of levels of compliance will eventually yield improved performance. The package of information derived from implementation monitoring of noxious weed management strategies will provide indications of the ability of current management direction to accomplish the task of containing and eradicating noxious weeds.

12.3. Noxious Weed Monitoring Questions

Implementation Monitoring

1. Were all permits (including but not limited to livestock grazing, special uses, pack stock operators) amended to include noxious weed management requirements and updated weed management information? (W24)
2. Was the risk of noxious weed spread considered in prescribed fire planning documents, application of mechanical fuel treatments, and BAER treatments after consultation with appropriate resource personnel or noxious weed coordinators? (H06, W34)
3. Was the current distribution and potential for the spread of noxious weeds evaluated and were management actions that contain or eradicate existing noxious weeds and prevent the introduction of new noxious weeds recommended during watershed analysis? (W08)
4. Were prevention and control measures incorporated into all management or maintenance activities that involved ground disturbance or the possibility of spreading weeds? (W19)
5. Were national forest users, local agencies, groups, and organizations in communities near national forests informed about noxious weed management? (W01)
6. Were noxious weed control projects routinely monitored to determine success and was the need for follow-up treatments or different control methods evaluated? (W50)
7. Were follow-up inspections and, if needed, additional noxious weed treatments performed for all ground disturbing activities? (W50)

Status and Change Monitoring

High priority questions will be addressed during the planning period. No lower priority questions were identified for noxious weeds.

High Priority Status and Change Monitoring Questions	Attributes	COST PER YEAR ($1000S)	Contrib. from linked questions or other NFS programs
What is the status and change of…		**Total: 13**	
1. The distribution of populations of noxious weed species?	distribution of populations of noxious weeds	8	CDFA does some monitoring – potential contribution
2. The number of new weed populations?	number of new weed populations	5	
3. The residency time of new weed populations?	residency time of new weed populations	0	Covered by question 1

13. Cultural and Socio-Economic Effects

13.1. Introduction

General

The effects of management actions on communities are of concern to the Forest Service. American Indian tribes constitute one group of Sierra Nevada communities. There are approximately 54 Indian tribes and communities residing in or near the Sierra Nevada. A suite of Federal laws and Executive Orders confers a unique constitutional status upon American Indian tribes as internally sovereign nations. Tribes rely on Federal lands for exercising their rights to access and use natural resources, cultural resources, and ceremonial sites, and to seek economic well-being (Reynolds 1996). Effective tribal relations programs are necessary to facilitate the redemption of these and other rights and interests.

The FEIS decision has the potential to affect American Indian rights and interests. Of particular concern are fire protection and the condition of and access to culturally important resource areas, sacred and ceremonial areas, and Traditional Cultural Properties (TCP) on National Forest lands. Effective Forest Service management of both tribal relations programs, and potential impacts to resources of interest to tribes, will be critical to protecting tribal rights and interests under the selected alternative.

The economic effects of management on communities is also of concern. Forest outputs such as wood products, forage, and recreation, as well as payments to counties and activities such as restoration, affect jobs and wages in Sierra Nevada communities. The cumulative effects of forest outputs and actions can disproportionately affect communities of place, employment in certain job sectors, or particular socioeconomic groups.

The selected alternative describes programmatic changes that are projected to cause significant shifts in some Sierra Nevada National Forest outputs. Outputs such as large-dimension timber and forage are projected to decrease, while forest restoration service contracts, small-dimension timber, and biomass outputs may increase. These changes will take place in a context in which recreation and tourism, much of which occur on National Forest system lands, is currently the largest single employment sector in the Sierra Nevada but could change significantly (Stewart 1996, Duane 1996b). Monitoring will provide managers with a clear understanding of the effect of their actions on communities in this dynamic economic context.

The goals of the FEIS are, (1) to redeem Federal trust and other responsibilities by maintaining effective government-to-government and other formal relations with American Indian tribes, and (2) to Fulfill Forest Service obligations to monitor the effects of management on communities, consistent with the National Forest Management Act (NFMA). Associated objectives include, (1) to comply with direction found in the suite of laws and Executive Orders pertaining to tribal relations, and (2) to conduct a program of monitoring and evaluation of the effects of the selected alternative that includes:

- "A quantitative estimate of performance comparing outputs and services with those projected by the forest plan" (36 CFR Part 219.12(k)(1)). Outputs include "appropriate marketable goods and services as well as nonmarket items, such as recreation" (36 CFR Part 219.12(g)(1));

- "Consideration of the effects of National Forest management on… communities adjacent to or near the National Forest being planned" (36 CFR Part 219.7(f)).

Tribal Relations

FSM 1563.03 provides direction to monitor compliance with policies relevant to tribal relations. Compliance includes: 1) maintaining a governmental relationship with Federally Recognized Tribal Governments; 2) implementing Forest Service programs and activities honoring Indian treaty rights and fulfill legally mandated trust responsibilities; 3) administering programs and activities to address and be sensitive to traditional Native religious beliefs and practices; and 4) providing research, transfer of technology, and technical assistance to Tribal Governments. Management direction is predicated on the assumption that institution and implementation of government-to-government protocols will facilitate the development of effective tribal relations programs. Monitoring legal compliance provides a measure of the Forests' state of compliance and the status and effectiveness of their tribal relations programs.

Economic Effects on Communities

Under the selected alternative, the potential for Sierra Nevada National Forest large-diameter timber outputs will decrease significantly after year 2004. There could be major cuts in employment for current forestry worker and mill employees in the Sierra-Cascade sub-region. Loss of timber jobs may also affect economically disadvantaged, minority communities in the southern Sierra Nevada by reducing the supply of higher-paying manufacturing jobs.

Concurrent with changing trends in timber outputs, an increase in forest restoration service contracts let by the Forest Service is predicted. Service contracts will be developed largely to implement manual and mechanical fuels treatments through thinning of small-dimension timber. Thus small-dimension timber and biomass outputs may increase.

Continuing reductions in Sierra Nevada National Forest forage outputs are expected to occur under the selected alternative. These reductions may cause substantial economic impacts to ranchers and to agriculture-dependent communities in the planning area. Impacts to the wellbeing of Indian and minority communities in the eastside Sierra Nevada are also of concern.

Recreation and tourism comprise the largest single employment sector in the Sierra Nevada (Stewart 1996). Over half of all recreation occurring on public lands in the Sierra Nevada takes place on National Forest System lands (Duane 1996b). It is critical to consider recreation in monitoring the effects of Forest Service management on communities, as NFMA requires.

Overview of Approach

Monitoring of tribal relations will be accomplished using peer review, tribal review and consultation, interviews, Rapid Social Assessment, and other social science methods. Rapid Social Assessment methods are most efficient as they are designed to quickly obtain reliable information for planning or other management purposes. The data obtained will insure positive working relationships between forests and tribes and guide the design of management programs that adequately meet the needs and interests of tribes, communities, and individuals.

Wood products, forage, recreation, forest restoration service contracts, and payments to counties are critical National Forest outputs directly affecting employment in Sierra Nevada communities. The Forest Service will monitor these outputs and use the data to model impacts on jobs and wages. Monitoring will allow managers to identify where forest outputs and their economic impacts significantly deviate from planning projections. Forests will consider these findings in planning efforts. Response to monitoring may range from amending Forest Plans to reflect adjusted outputs, to mitigating economic impacts to communities through rural development initiatives.

13.2. Description of Cultural and Socio-economic Issues

Tribal Relations Issue

Description

The selected alternative has the potential to affect American Indian rights and interests. Of particular concern are fire protection and the condition of and access to culturally important resource areas, sacred and ceremonial areas, and Traditional Cultural Properties on National Forest lands. Development of forest tribal relations programs with establishment of consultation protocols, and incorporation of tribal interests and needs in management plans, as provided for in Process Guidelines NA02-NA09 and Inventory and Reporting Guideline NA03, will prevent or mitigate these effects.

Uncertainties

Uncertainties include the degree of forest commitment to establish adequate consultation protocols. The risks to tribal lands and culturally significant areas due to implementation of an extensive program of fuels reduction are also uncertain. These risks are especially unclear given the associated uncertainties as to whether and how the fuels management program will affect the extent and severity of wildfire. There is further uncertainty about which plant species are important to American Indians, about the location of traditional resource areas, and about traditional management. An additional uncertainty is the lack of knowledge about sacred and ceremonial areas and their locations.

Approach

The implementation of government-to-government protocols is the primary emphasis in monitoring tribal relations. Status and change monitoring will describe changes in culturally valued plant species. Cause and effect monitoring will address the effectiveness of government-to-government protocols and of communication efforts to accommodate tribal concerns into planning.

Affectors: access/permitting, land allocation, conflicts over management and allocation, exotic and native species, vegetation management.

Expected Results and Benefits

The information acquired from the various American Indian Tribes, communities, and individuals and from forest staff and management documents will allow the Forest Service to adjust its management actions in order to better protect American Indian rights and interests.

Socio-economic Effects Issue

Description

The selected alternative has the potential to significantly affect jobs and wages in Sierra Nevada communities. Forest outputs that contribute to jobs and wages and that are likely to be affected include large- and small-dimension timber, biomass, and forage. The value of forest restoration service contracts let by Sierra Nevada national forests affects jobs and wages, and may change under the selected alternative. Recreation on the national forests and payments to counties also may have important effects on socio-economic conditions.

Uncertainties

The degree to which planning projections for outputs will be met remains uncertain. The severity of associated impacts to jobs and wages is thus also uncertain. Future patterns of recreational use in the Sierra Nevada could change significantly and rapidly (Duane 1996b), as could the effects of such use on employment in Sierra Nevada communities. The dynamic character of the Sierra Nevada's economy creates uncertainty as to the influence of Forest management on economic conditions in Sierra Nevada communities.

Approach

Most of the monitoring for cultural and socio-economic concerns is accomplished through implementation monitoring, and centers on actual versus projected outputs. One cause and effect monitoring effort will look at the economic importance of biomass harvesting in the Sierra Nevada.

Expected Results and Benefits

These questions are central to helping the public and decision makers understand the cumulative effects of multiple management activities instituted under the selected alternative on jobs and wages in Sierra Nevada communities. The adaptive management strategy will rely on recreational use data obtained through the Forest Service National Recreational Use Sampling Pilot Project and subsequent efforts. Like the data describing other forest outputs, these data can be modeled to provide estimates of effects on jobs and wages. Analysis may be stratified using U.S. Census Bureau socio-demogrtaphic data, school district data, or other relevant information. This will allow the Forest Service to identify heavy or disproportionate impacts to groups such as people of color, gender-based groups, students and youth, the elderly poor and working-class communities, and other groups of interest, consistent with the Civil Rights Act and Executive Order 12898 on Environmental Justice.

13.3. Cultural and Socio-economic Monitoring Questions

Implementation Monitoring

1. Do Sierra Nevada National Forests consult with local tribes about tribal needs, issues, concerns, and opportunities during Forest and project planning and watershed assessments?
2. Is confidential and/or proprietary information used by Sierra Nevada National Forests protected from general public access as per management guidelines?
3. Are Sierra Nevada National Forests in compliance with Federal law, Executive Orders, and implementing regulations regarding tribal relations?
4. Are aboriginal management techniques considered for integration into fire and fuels and other management projects?

5. Are forest fire protection and fuels management plans completed and implemented in consultation with American Indian communities?
6. Has an independent review of the success of Sierra Nevada National Forest tribal relations programs and Forest compliance with legal direction and standards and guidelines been conducted?
7. Does the Forest Service consult with tribes about access to traditional use areas and resources during Forest and project planning and watershed assessments?
8. Are wood products offered, sold, and harvested from Sierra Nevada National Forests consistent with projections in the FEIS?
9. Are wages and numbers of jobs for loggers, timber haulers, and mill workers for Sierra Nevada National Forest timber operations consistent with projections in the FEIS?
10. Are annual payments to counties from Sierra Nevada National Forests consistent with projections in the FEIS?
11. Is the dollar value of forest restoration service contracts offered by Sierra Nevada National Forests consistent with projections in the FEIS?
12. Are wages and the number of jobs based on Sierra Nevada National Forest restoration service contracts consistent with projections in the FEIS?
13. Is forage offered for cattle and sheep on Sierra Nevada National Forests consistent with projections in the FEIS?
14. Is the number of jobs and the annual wages derived from cattle and sheep grazed on Sierra Nevada national forests consistent with projections in the FEIS?
15. Is recreational use on Sierra Nevada National Forests consistent with projections in the FEIS?
16. Are wages and jobs based on recreation in Sierra Nevada National Forests consistent with projections in the FEIS?

Status-and-Change and Cause-and-Effect Monitoring

High priority questions will be addressed during the planning period, and lower priority questions will be addressed if possible.

High Priority Status and Change Monitoring Question	Attributes	Cost per year ($1000s)	Contrib. from linked questions or other NFS programs
What is the status and change of …			
1. The diversity of culturally valued plant species (including herbs, shrubs, oaks and pinyon)?	species composition, seral stage distribution	3	Accomplished through Hardwood and Old Forest structure and composition monitoring. Estimated contribution: 50
High Priority Cause and Effect Monitoring Questions	**Attributes**	**Total cost ($1000s)**	**Contrib. from linked questions or other NFS programs**
Tribal Relations:			
1. How effective are government to government protocols and consultation for acquiring resource data on each Sierra Nevada National Forest sufficient to manage traditional plant resources?	traditional plant resource inventories	22.5	Implementation monitoring data. Estimated contribution: 55
2. How effective are government to government protocols and consultation for acquiring adequate knowledge of local tribal needs, issues, concerns, and opportunities on Sierra Nevada National Forests for management and planning needs?	social assessment results as expressed by Indian people	0	Covered by cause and effect question #1
3. How effective do Indian people find the processes and procedures designed to inform Forest and project planning and watershed assessments about tribal concerns and interests?	assessment of effectiveness as expressed by Indian people	0	Covered by cause and effect question #1
4. How effective do Indian people find the measures used by Sierra Nevada National Forests to monitor tribal concerns and interests?	assessment of effectiveness as expressed by Indian people	0	Covered by cause and effect question #1
5. How effective do Indian people find the Forest Service in managing National Forest system lands in the Sierra Nevada compatibly with the management objectives of adjacent and nearby tribal lands and their management plans?	assessment of effectiveness as expressed by Indian people	0	Covered by cause and effect question #1
Socioeconomics:			
1. Does biomass (small-dimension wood) harvesting in Sierra Nevada national forests create jobs and income for Sierra Nevada residents?	dollar value of annual wages, number of jobs	2.5	

13.4. Key Cultural and Socio-economic Information Gaps

The following are research questions that were identified as key information needs in relation to the topic areas addressed in the FEIS.

1. What are the appropriate uses of projected National Forest small-dimension timber outputs in rural development in the Sierra Nevada?
2. To what degree do communities in the Sierra Nevada rely on fuel wood from National Forests?

14. Literature Cited

Banci, V. 1994. Wolverine. Pages 99-127 In: Ruggiero, Leonard F., et al., tech. eds.. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the Western United States. Gen. Tech. Rep. RM-254. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 184p.

Barber, M.C. (ed.). 1994. Environmental monitoring and assessment program indicator development strategy, EPA/620/r-94., US Environmental Protection Agency, Office of Research and Development, Environmental Resources Lab, Athens, Georgia.

Berrill, M., S. Bertram, and B. Pauli. 1997. Effects of pesticides on amphibian embryos and tadpoles. Pp. 223-245 in: D.M. Green, ed. Amphibians in Decline: Canadian Studies of a Global Problem. Herpetological Conservation 1.

Blakesley, J.A., and B.R. Noon. 1999. Demographic parameters of the California spotted owl on the Lassen National Forest: preliminary results (1990-1998). Unpublished report. USDA Forest Service, Sierra Nevada Framework Project, Sacramento, CA.

Bombay, H.L. 2000. Personal communication. California State University, Sacramento.

Bombay, H.L. 1999. Scale perspectives in habitat selection and reproductive success for willow flycatchers (Empidonax traillii) in the central Sierra Nevada, California. Masters thesis, California State University, Sacramento. 225 pp.

Bombay, H.L., M.L. Morrison, and L.S. Hall. 1998. 1997 Annual report for the challenge cost-share agreement between California State University, Sacramento and USDA Forest Service, Tahoe National Forest regarding willow flycatcher survey and monitoring. January 2, 1998.

Bombay, H.L., M.L. Morrison, and L.S. Hall. 1999. 1998 Annual report for the challenge cost-share agreement between California State University, Sacramento and USDA Forest Service, Tahoe National Forest regarding willow flycatcher monitoring. February 22, 1999.

Bricker, O.P. and Ruggiero, M.A.: 1998. Toward a National program for monitoring environmental resources, Ecol. Appl. 8, 326-329.

Brundtland, G. 1987. Our common future. Oxford University Press, Oxford, England.

Burkett, E.E., and J.C. Lewis. 1992. The spread of the red fox. Outdoor California 53:1-4.

Buskirk, S.W., and R. A. Powell. 1994. Habitat ecology of fishers and American matens. Pages 283-296 in S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables, and fishers: biology and conservation. Comstock Publishing Associates, Cornell University Press, Ithaca, New York, USA.

Cahill, T.A, Carroll, J.J., Campbell, D., Gill, T.E. 1996. Air Quality. Pp. 1227-1262 In Status of the Sierra Nevada, Vol. II, Assessments and Scientific Basis for Management Options. Sierra Nevada Ecosystem Project Final Report to Congress. Wildland Resources Center Report No. 37. Centers for Water and Wildland Resources, University of California, Davis.

California Department of Fish and Game (CDFG). 1990. Annual report on the status of California state listed threatened and endangered plants and animals. Fifth Annual Report. The Resources Agency, California Department of Fish and Game, Sacramento, CA. 207 p.

California Department of Fish and Game (CDFG). 1995. Endangered and threatened animals of California. List generated from California Code of Regulations (Title 14, Section 670.5). Calif. Dept. Fish Game, Natur. Heritage Div., NDDB, Sacramento, CA. 13 pp.

Carney, R. S. 1987. A review of study designs for the detection of long-term environmental effects of offshore petroleum activities. Pp. 651-696 In D. F. Boesch and N. N. Rabalais, eds. Long-term environmental effects of offshore oil and gas development. Elsevier, New York, NY.

Carroll, C.,R. F. Noss, and P.C. Paquet. in press. Carnivores as focal species for conservation planning in the Rocky Mountain region. Ecological Applications

Chapin, T.G., D.J. Harrison, and D.D. Katnik. 1998. Influence of landscape pattern on habitat use by American marten in an industrial forest. Conservation Biology 12: 1327-1337.

Christensen, N.L.: 1997. Managing heterogeneity and complexity on dynamic landscapes, Pages 167-186 in Pickett, S. T. A., Ostfeld, R. S., Shachak, M. and Likens, G. E. (eds.), The ecological basis for conservation, Chapman and Hall, New York.

Christensen, N.L., A.M. Bartuska, J.H. Brown, S. Carpenter, C. D'Antonio, R. Francis, J.F. Franklin, J.A. MacMahon, R.F. Noss, D.J. Parsons, C.H. Peterson, M.G. Turner, and R.G. Woodmansee. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. Ecological Applications 6:665-691.

Committee of Scientists (COS). 1999. Sustaining the people's lands: recommendations for stewardship of the national forests and grasslands into the next century. U.S. Department of Agriculture, Washington, D.C.

Copeland, J.P. 1996. Biology of the wolverine in central Idaho. M.S. Thesis. Univ. of Idaho. Moscow, ID. 138 pp.

Copeland, J. 1997. Personal communication. Idaho Department of Fish and Game, Boise, ID

Copeland, J.P., and T.E. Kucera. 1997. Wolverine (Gulo gulo). Pages 23-33 In: Harris, John E., and Chester V. Ogan, Eds. Mesocarnivores of Northern California: biology, management, and survey techniques, Workshop Manual. August 12-15, 1997. Humboldt State Univ., Arcata, CA. The Wildlife Society, California North Coast Chapter. Unpublished document. 117 p.

Costanza, R., and H. E. Daly. 1992. Natural capitol and sustainable development. Conservation Biology 6(1): 37-46.

Dagum, C. and E. B. Dagum. 1988. Trend. Pp. 321-324. In Kotz, S. and N. L. Johnson,, eds. Encyclopedia of statistical sciences, Vol. 9, John Wiley and Son, NY.

Dixon, J. 1925. Closed season needed for fisher, marten and wolverine in California. California Fish and Game, 11:23-25. Sacramento, CA.

Duane, T.P. 1996a. Human Settlement, 1850-2040. Pp. 235-360 In Status of the Sierra Nevada, Vol. II, Assessments and Scientific Basis for Management Options. Sierra Nevada Ecosystem Project Final Report to Congress. Wildland Resources Center Report No. 37. Centers for Water and Wildland Resources, University of California, Davis.

Duane, T.P. 1996b. Recreation in the Sierra. Pp. 557-610 In Status of the Sierra Nevada, Vol. II, Assessments and Scientific Basis for Management Options. Sierra Nevada Ecosystem Project Final Report to Congress. Wildland Resources Center Report No. 37. Centers for Water and Wildland Resources, University of California, Davis.

Eilers, J.M., D.F. Brakke, D.H. Landres and W.S. Overton. 1989. Environmental Monitoring and Assessment. 12:3-21]

Federal Register. 1995. Final rule determining endangered status for the Southwestern Willow Flycatcher. 50 CFR Part 17; RIN 1018 AB 97.v.60, n. 38, p.10694, February 27, 1995.

Federal Register. 2000. National Forest System Land Resource Management Planning: Final Rule. 36 CFR Parts 217 and 219; vol. 65, n. 218, p. 67514. November 9, 2000.

Firey, W. 1960. Man, mind, and land. The Free Press, Glencoe, IL.

Folke, C., C. S. Holling, and C. Perrings. 1996. Biological diversity, ecosystems, and the human scale. Ecol. Appl. 6:1018-1024.

Forest Ecosystem Management Assessment Team (FEMAT). 1993. Social Assessment of Options. *In* Forest Ecosystem Management: An Ecological, Economic, and Social Assessment. Report of the Forest Ecosystem Management Assessment Team, chap. 7. Government Printing Office, Washington, D.C.

Fowler, C., B. Valentine, S. Sanders, and M. Stafford. 1991. Suitability Index Model: willow flycatcher (Empidonax traillii). Document, USDA Forest Service, Tahoe National Forest. 15 pp.

Gaines, D. 1974. A new look at the nesting riparian avifauna of the Sacramento Valley, California. Western Birds 5:61-80

Gaines, D. 1992. Birds of Yosemite and the east slope. Artemisia Press, Lee Vining, CA. 352 pp. (revised 2nd printing)

GAO. 1997. Forest Service decision-making. Government Assessment Office GAO/RCED 97-71, US Government Printing Office, Washington, DC.

Goldsmith, F. B. (ed.). 1991. Monitoring for conservation and ecology. Chapman and Hall, New York.

Green, R. H. 1979. Sampling design and statistical methods for environmental biologists. John Wiley & Sons, New York, NY.

Grinnell, J. and A.H. Miller. 1944. The Distribution of the Birds of California. Cooper Ornithological Club. Pacific Coast Avifauna Number 27.

Grinnell, J., J.S. Dixon, and J.M. Linsdale. 1937. Fur-bearing mammals of California. Univ. of California Press, Berkeley. Vols. 1 and 2. 777 p.

Gunderson, L.H., C.S. Holling, and S.S. Light, eds. 1995. Barriers and bridges to the renewal of ecosystems and institutions. Columbia University Press, New York, NY.

Gutierrez, G.I. Gould Jr., and T.W. Beck (technical coordinators) 2000. The California spotted owl: a technical assessment of its current status. Gen. Tech. Rep. PSW-GTR-133. Pacific Southwest Research Station, U.S. Forest Service, U.S. Department of Agriculture, University Press. New Haven, CT.

Hargis, C.D., J.A. Bissonette, and D. L. Turner. 1999. The influence of forest fragmentation and landscape pattern on American martens. Journal of Applied Ecology 36: 157-172.

Hargis, C.D., C. McCarthy, and R.D. Perloff. 1994. Home ranges and habitats of northern goshawks in eastern California. Studies in Avian Biology 16:66-74.

Harris, J.H., S.D. Sanders, and M.A. Flett. 1987. Willow flycatcher surveys in the Sierra Nevada. Western Birds 18:27-36

Harris, J.H., S.D. Sanders, and M.A. Flett. 1988. The status and distribution of the willow flycatcher in the Sierra Nevada: results of the survey. Calif. Dept. Fish Game, Wildlife Manage. Div., Admin. Rep. 88-1. 32 pp.

Hart, M.M., J.P. Copeland, and R.L. Redmond. 1997. Mapping wolverine habitat in the northern Rockies using a GIS. Service agreement submitted to Montana Dept. Fish, Wildl. and Parks and Idaho Dept. of Fish and Game. Unpublished document. 10p.

Hellawell, J. M. 1991. Development of a rationale for monitoring, Pages 1-14 in Goldsmith, F. B. (ed.), Monitoring for conservation and ecology, Chapman and Hall, New York.

Holling, C. S. and G. K. Meffe. 1996. Command and control and the pathology of natural resource management. Conserv. Biol. 10:328-337.

Hornocker, M.G. and H.S. Hash. 1981. Ecology of the wolverine in northwestern Montana. Can. J. Zool. 59:1286-1301.

Hunsaker, C.T. and Carpenter, D.E. 1990. Ecological indicators for the Environmental Monitoring and Assessment Program, EPA 600/3-90/060, US Environmental Protection Agency, Research Triangle Park, North Carolina.

Hunsaker, C.T., J.D. Christman, A.B. Coley, and M.A. Kane. 1999. Ecological Sustainability, Part 1: issue paper and literature review. Unpublished document. U.S. Environmental Protection Agency.

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review of Existing Programs, and Assessment of Needs. Tech. Append. VII-A-11 of the CMARP Recommendations for the Implementation and Continued Refinement of a Comprehensive Monitoring, Assessment, and Research Program, March 10, 1999 Report.).

Jennings, M.R. 1996. Status of amphibians. Pp. 921-944 in: Sierra Nevada Ecosystem Project: Final Report to Congress, vol. II, Assessments and scientific basis for management options. Davis: University of California, Centers for Water and Wildland Resources.

Kagarise S.C. and M. L. Morton. 1993. Population declines of Yosemite Toads in the Eastern Sierra Nevada of California. J. Herpetol. 27(2):186-198.

Keane, J.J. 1999. Ecology of the northern goshawk in the Sierra Nevada, California. PhD Dissertation. University of California, Davis.

Keane, J.J. and B. Woodbridge. In prep. Distribution of the northern goshawk in California.

Kennedy, B. 1999. Personal communication. USDA Forest Service, Missoula, MT.

Kings River Conservation District (KRCD). 1985. Studies on the Willow flycatcher in the central Sierra Nevada conducted during 1983 and 1984. Kings River Conservation District Res. Rep. No. 85-017. 66 pp.

Klebenow, D.A. and R.J. Oakleaf. 1984. Historical avifaunal changes in the riparian zone of the Truckee River, Nevada. Pp. 203-209 In R.E. Warner and K.M. Hendrix, (eds.), California riparian systems: Ecology, conservation, and productive management. Univ. Calif. Press., Berkeley, CA.

Knapp, R.A. and K.R. Matthews. 2000. Nonnative fish introductions and the decline of mountain yellow-legged frogs from within protected areas. Conservation Biology 14:428-438.

Krebs, J. A. and D. Lewis. 1999. Wolverine ecology and habitat use in the North Columbia Mountains. Progress Report. Columbia Basin Fish and Wildlife Compensation Program. 26 p.

Krohn, W.B., K.D. Elowe, and R.B. Boone. 1995. Relations among fishers, snow, and martens: development and evaluation of two hypotheses. Forestry Chronicle 71:97-105.

Krohn, W.B., W.J. Zielinski, and R.B. Boone. 1997. Relations among fishers, snow, and martens in California: Results from small scale comparisons. Pgs 211-232 in G. Proulx, H. N. Bryant and P. M. Woodard, editors, *Martes*: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton, Alberta Canada. 474 p.

Kucera, T.E., W.J. Zielinski, and R.H. Barrett. 1995. Current distribution of the American marten, Martes americana, in California. California Fish and Game 81: 96-103.

Kucera, T.E. 1995. Recent photograph of a Sierra Nevada red fox. Calif. Fish and Game 81(1):43-44.

Kucera, T.E. and R.H. Barrett. 1993. Cooperative wolverine study: third annual report. Department of Forestry and Resource Management, University of California, Berkeley. 21pp.

Lamberson, R.H., R L. Truex, W.J. Zielinski and D.C. Macfarlane. 2000. Preliminary analysis of fisher population viability in the southern Sierra Nevada. Unpubl. manuscript. USDA Forest Service, Pacific Southwest Research Station, Arcata, CA.

Landres, P.B., Verner, J. and Thomas, J.W.: 1988. Ecological use of vertebrate indicator species: a critique, Con. Bio. 2, 316-328.

Landres, P., P. Morgan, and F. Swanson. 1997. Evaluating the usefulness of natural variability in managing ecological systems. Ecol. Soc. Amer. Bulletin Suppl., Abstracts for the 1997 Annual Meeting, Aug 10-14, 1997.

LeBlanc, G.A. and L. J. Bain. 1997. Chronic toxicity of environmental contaminants: sentinels and biomarkers. Environmental Health Perspectives 105 (suppl.):65-80.

Lewis, J.C., K. Sallee and R. Golightly. 1993. Introduced red fox in California. California Department of Fish and Game, Nongame Bird and Mammal Section Report 93-10. Sacramento, CA. Unpublished Report. 33 p.

Lind, A.J., H.H. Welsh, Jr. , and R.A. Wilson. 1996. The effects of a dam on breeding habitat and egg survival of the foothill yellow-legged frog (Rana boylii) in northwestern California. Herpetological Review 27:62-67.

Lint, J. et al. 1999. Northern spotted owl effectiveness monitoring plan for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-440. Portland, OR. USDA Forest Service, Pacific Northwest Research Station. 43 p.

Litton, R.B.Jr. 1984. Visual Vulnerability of the Landscape: Control of Visual Quality. USDA Forest Service Research Paper WO-39. 34 p.

Lubchenco, J., A.M. Olson, L.B. Brubaker, S.R. Carpenter, M.M. Holland, S.P. Hubbell, S.A. Levin, J.A. MacMahon, P.A. Matson, J.M. Melillo, H.A. Mooney, C.H. Peterson, H.R. Pulliam, L.A. Real, P.J. Reagal, and P.G. Risser. 1991. The sustainable biosphere initiative: an ecological research agenda. Ecology 72(2):371-412.

MacDonald, L., A. Smart, and R. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. US Environmental Protection Agency, Region 10, NPS Section, WD-139, Seattle, WA.

Magoun, A.J. and J.P. Copeland. 1998. Characteristics of wolverine reproductive den sites. J. Wildl. Manage. 62(4):1313-1320.

Manley, P.N., G.E. Brogan, C. Cook, M.E. Flores, D.G. Fullmer, S. Husari, T.M. Jimerson, L.M. Lux, M.E. McCain, J.A. Rose, G. Schmitt, J.C. Schuyler, and M.J. Skinner. 1995. Sustaining ecosystems: a conceptual framework. USDA Forest Service, Pacific Southwest Region, R5-EM-TP-001. San Francisco, CA. 216 pp.

Manley, P.N., J.A. Fites-Kaufman, M.E. Barbour, M.D. Schlesinger, and D.M. Rizzo. 2000. Chapter five: biological integrity. Pages 403-598 in Murphy, D.D., and C.M. Knopp, eds. Lake Tahoe watershed assessment: volume I. Gen. Tech. Rep. PSW-GTR-175. USDA Forest Service, Pacific Southwest Research Station, Albany, CA.

Martin, D.L. 1999. Personal communication, 19 April.

Martin, S.K. 1989. Sierra Nevada red fox: report on species ecology and habitat requirements. USDA Forest Service, Pacific Southwest Region, San Francisco, CA. Unpublished Report. 4 p.

McKelvey, K.S., and J.D. Johnson. 1992. Historical perspectives on the forests of the Sierra Nevada and the Transverse Ranges in southern California: forest conditions at the turn of the century. Pgs 225-246 in Verner, Jared; Kevin S. McKelvey; Barry R. Noon; R. J. Gutierrez; Gordon I. Gould, Jr.; and Thomas W. Beck, technical coordinators. The California spotted owl: a technical assessment of its current status. Gen. Tech. Rep. PSW-GTR-133. Albany CA: Pacific Southwest Research Station, Forest Service. U.S. Department of Agriculture.

Montgomery, D. R., G. E. Grant, and K. Sullivan. 1995. Watershed analysis as a framework for implementing ecosystem management. Water Res. Bull. 31(3):369–386.

National Research Council (NRC). 1994. Review of EPA's environmental monitoring and assessment program: forests and estuaries. National Academy Press, Washington, D.C.

National Research Council (NRC). 1995. Review of EPA's environmental monitoring and assessment program: overall evaluation, National Research Council, National Academy Press, Washington, D.C.

Noon, B.R., Spies, T.A. and Raphael, M.G.: 1999. Conceptual basis for designing an effectiveness monitoring program, Pages 21-48 in Mulder, B. S., Noon, B. R., Spies ,T. A., Raphael, M. G., Palmer, C. J., Olsen, A. R., Reeves, G. H. and Welsh, H. H. Jr., The strategy and designing of the effectiveness program for the Northwest Forest Plan, USDA For. Serv. Gen. Tech. Rept., PNW-GTR-437, Pacific Northwest Station, Portland, Oregon.

Noss, R.F. and A.Y. Cooperrider, 1994, Saving nature's legacy, Island Press, Covelo, California.

O'Neill, R. V., D. L. DeAngelis, J. B. Waide, and T. F. H. Allen. 1986. A hierarchical concept of ecosystems. Princeton Univ. Press, Princeton, NJ.

Pahl-Wostl, C. 1995. The dynamic nature of ecosystems: chaos and order entwined. John Wiley and sons, New York, NY. 267 pp.

Perrine, J. 2000. Personal communication. University of California, Berkeley, CA.

Perrings, C. and B. H. Walker. 1995. Biodiversity loss and the economics of discontinuous change in semi-arid rangelands. Pp. 190-210 In C. Perrings, K. G. Maler, C. Folke, B. O. Jansson, and C. S. Holling, eds. Biodiversity loss: ecological and economic issues. Cambridge Univ. Press, New York, NY.

Peterman, R. M. 1990. Statistical power analysis can improve fisheries research and management. Canadian J. Fisheries and Aquatic Sci. 47:2-15.

Phillips, A.R. 1948. Geographic variation in Empidonax traillii. Auk 65:507-514.

Poff, R. 1996. Effects of silvicultural practices and wildfire on productivity of forest soils. Page 477-495 in Sierra Nevada ecosystem project: final report to Congress, assessments and scientific basis for management options, Vol. II. University of California, Centers for Water and Wildland Resources, Davis, CA.

Potvin, F., L. Belanger, and K. Lowell. 2000. Marten habitat selection in a clearcut boreal landscape. Conservation Biology 14: 844-857.

Reynolds, L.A. 1996. The Role of Indian Tribal Governments and Communities in Regional Land Management. Pp. 207-234 In Status of the Sierra Nevada, Vol. II, Assessments and Scientific Basis for Management Options. Sierra Nevada Ecosystem Project Final Report to Congress. Wildland Resources Center Report No. 37. Centers for Water and Wildland Resources, University of California, Davis.

Reynolds, R.T., R.T. Graham, M.H. Reiser, R.L. Bassett, P.L. Kennedy, D.A. Boyce, Jr., G. Goodwin, R. Smith, and E.L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. General Technical Report RM-217. Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Ft. Collins, CO.

Ritter, T.M. and K. Roche. 1999. Draft 1998 assessment of willow flycatcher management in R5: Sierran forests summary. Unpubl. rep. 14 pp.

Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, L.J. Lyon, and W J. Zielinski, editors. 1994. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States. USDA Forest Service, Gen. Tech. Rep. RM-254. Fort Collins, CA. 193 pp.

Schempf, P.F., and M. White. 1977. Status of six furbearer populations in the mountains of northern California. USDA Forest Service, Pacific Southwest Region, San Francisco, CA. Unpublished Report. 51 p.

Serena, M. 1982. The status and distribution of the willow flycatcher (Empidonax traillii) in selected portions of the Sierra Nevada, 1982. Calif. Dept. Fish Game, Wildlife Manage. Branch Admin. Rep. No. 82-5. 28 pp.

Seton, E.T. 1929. Lives of game animals. Garden City, NY: Doubleday, Doran & Co., Inc. 746pp

Sierra Nevada Ecosystem Project (SNEP): 1996, Status of the Sierra Nevada, vol 1, Assessment summaries and management strategies, Wildland Resources Center Report No. 36, University of California, Davis.

Sierra Nevada Framework for Conservation and Collaboration (SNFCC). 1998. Summary of existing management direction. USFS PSW.

Spencer, W.D., R.H. Barrett, and W.J. Zielinski. 1983. Marten habitat preferences in the northern Sierra Nevada. Journal of Wildlife Management 47: 1181-1186.

Squires, J.R. and R.T. Reynolds. 1997. Northern Goshawk (*Accipiter gentilis*). In The Birds of North America, No. 298 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologist's Union, Washington, D.C.

Stafford, M.D. and B.E. Valentine. 1985. A preliminary report on the biology of the willow flycatcher in the central Sierra Nevada. CAL-NEVA Wildlife Transactions 1985:66-77.

Stebbins, R. C. 1985. Western Reptiles and Amphibians. Houghton-Mifflin Co., Boston. 336pp.

Steger, G.N., T.E. Munton, G.P. Eberlein, and K.D. Johnson. 1999. A study of spotted owl demographics in the Sierra National Forest and Sequoia and King’s Canyon National Parks. Unpublished report. USDA Forest Service. Sierra Nevada Framework Project. 801 I Street, Sacramento, CA 95814.

Steidl, R. J., J. P. Hayes, and E. Schauber. 1997. Statistical power analysis in wildlife research. J. Wildlife Manage. 61:270-279.

Stewart, W.C. 1996. Economic Assessment of the Ecosystem. Pp. 973-1064 In Status of the Sierra Nevada, Vol. III, Assessments and Scientific Basis for Management Options. Sierra Nevada Ecosystem Project Final Report to Congress. Wildland Resources Center Report No. 37. Centers for Water and Wildland Resources, University of California, Davis.

Stewart-Oaten, A. 1996. Goals in environmental monitoring. Pp. 17-27 In R. J. Schmidt and C. W. Osenberg, eds. Detecting Ecological Impacts: Concepts and Applications. Academic Press, Orlando, FL.

Truex, R.L., W.J. Zielinski, R.T. Golightly, R.H. Barrett, and S.M. Wisely. 1998. A meta-analysis of regional variation in fisher morphology, demography, and habitat ecology in California. Report to the California Department of Fish & Game Wildlife Management Division. 118 p.

USDA. 1998. Sierra Nevada Science Review. USDA Forest Service, Pacific Southwest Station, Albany, California.

USDA Forest Service. 1995. Landsape Aesthetics: A Handbook for Scenery Management. USDA Forest Service Agriculture Handbook No. 701.

USDA Forest Service. 1997. Environmental Impact Statement for the Interior Columbia River Basin Ecosystem. USDA For. Serv. Pacific Northwest Region, Portland, OR.

U.S. Fish and Wildlife Service. 2000a. Endangered and Threatened Wildlife and Plants: 90 Day Finding on a Petition to List the Mountain Yellow-legged Frog as Endangered. Federal Register 65(198):60603-60605.

U.S. Fish and Wildlife Service. 2000b. Endangered and Threatened Wildlife and Plants: 90 Day Finding on a Petition to List the Yosemite Toad as Endangered. Federal Register 65(198):60607-60609.

Unitt, P. 1987. Empidonax traillii extimus: an endangered subspecies. Western Birds 18(3):137-162.

Verner, J., K. McKelvey, B. Noon, R. Gutierrez, G. Gould, and T. Beck, tech. coords. 1992. The California spotted owl: a technical assessment of its current status. Gen. Tech. Rep. PSW-GTR-133. USDA Forest Service, Pacific Southwest Research Station, Albany, CA. 285 pp.

Walters, C. J. 1986, Adaptive management of renewable resources, MacMillan, New York.

Zeiner, D.C., W. Laudenslayer, Jr., K. Mayer, and M. White. (eds.). 1990. California's wildlife, Vol. 2, Birds. Calif. Dept. Fish Game, Sacramento, CA. 732 pp.

Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White. 1990. California's wildlife, Volume III, Mammals. California Wildlife Habitat Relationships System. Calif. Dept. Fish & Game. 407 p.

Zielinski, W. J. and H. B. Stauffer. 1996. Monitoring Martes populations in California: survey design and power analysis. Ecol. Appl. 6:1254-1267.

Zielinski, W.J., R.L. Truex, C.V. Ogan, and K. Busse. 1997. Detection surveys for fisher and American martens in California, 1989-1994: Summary and interpretations. Pgs 372-392 in G. Proulx, H. N. Bryant, and P. M. Woodard, editors, *Martes*: Taxonomy, Ecology, Techniques, and Management. Provincial Museum of Alberta, Edmonton, Alberta Canada. 474 pp.

Zielinski, W.J., R.L. Truex, G.A. Schmidt, F.V. Schlexer and R.H. Barrett. in prep. Habitat ecology and home range characteristics of the fisher in California. Wildlife Monographs.

Zielinski, W.J., R.L. Truex, L.A. Campbell, C.R. Carroll, and F.V. Schlexer. 1999. Systematic surveys as a basis for the conservation of carnivores in California forests. USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, CA. 38 p.

Zielinski, W.J., T.E. Kucera, and R.H. Barrett. 1995. The current distribution of the fisher, *Martes pennanti*, in California. California Fish and Game 81:104-112.