Fire and Fuels Management, Landscape Dynamics, and Fish and Wildlife Resources: Study Design for Integrated Research on the Plumas and Lassen National Forests July 20, 2004

1. Project Identification

Title: Fire and Fuels Management, Landscape Dynamics, and Fish and Wildlife Resources: Study Design for Integrated Research in the Northern Sierra Nevada

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Identification Number: 4202-02-01

Overview: This document summarizes an integrated set of studies designed to evaluate the response of key forest elements to land management strategies for reducing wildland fire hazard, promoting forest health, and providing economic benefits across a managed forest landscape. The detailed plans for the five studies are each separate documents. The impetus for these studies comes from the Records of Decision (RODs) for both the Sierra Nevada Forest Plan Amendment (SNFPA) and the Herger-Feinstein Quincy Library Group (HFQLG) Forest Recovery Act Pilot Project. The HFQLG Pilot Project is designed to demonstrate how

fuel breaks, group selection, individual tree selection, avoidance or protection of sensitive areas, and riparian restoration can be applied to promote healthy forests that provide both suitable habitat conditions for an array of wildlife species as well as a sustainable local economy. The SNFPA ROD (January 2001, revised January 2004) establishes a comprehensive adaptive management strategy to investigate uncertainties regarding these and similar management approaches; the Decision specifically calls for a study related to the HFQLG Pilot Project to examine the effects of management-induced changes in vegetation on California spotted owls, their prey base, and their habitat. The Sierra Nevada Forest Plan Amendment, including the revisions included in the 2004 Final Supplemental EIS and attending Record of Decision, sets forth direction for an integrated management strategy for Sierra Nevada national forests to reduce fuel conditions that pose significant fire hazards as well as protect and enhance old forest habitat conditions.

The original intention of this integrated research strategy was to develop an experimental design at a landscape scale in which certain key questions could be tested using traditional experimental methods. Over two years of preparation was devoted to creation and refinement of an experimental design that would maximize our ability to directly address several key research questions that bear on the most pressing management problems in Sierran forests. The research program was originally organized around four principal issues:

1. efficacy of various combinations of defensible fuel profile zones (DFPZs) and area fuel treatments to reduce the extent and severity of wildland fires;
2. effects of group selection on various forest elements and conditions;
3. cumulative effects of management regimes on landscape dynamics, such as forest structure, composition, and succession across time and space; and
4. species-specific responses to habitat changes resulting from different forest management regimes.

The overarching objective of the proposed research was to address an array of related ecological questions in a coordinated, integrated effort, thereby providing empirical data to inform future management decisions. The landscape scale of this design was both the driving force addressing the key questions as well as the largest impediment to successful construction of a scientifically credible experimental design. Our research team believes that assessing many of the key elements of forest ecosystems should be done over larger spatial and temporal scales than has typically been investigated in past research. The compelling management questions pertain to how the contemporary fuels management strategies manifest over broad spatial and temporal scales. The important difference from past research efforts is that we are investigating response to changes in forest structure and composition over space and time rather than simply site specific and immediate response. We believe this difference is especially relevant to forest management practices that are designed for large landscapes and executed over relatively long time frames, such as fuels treatment strategies.

Experimental design challenges for landscape level research are formidable. Experimental and analytical approaches at a landscape scale are complicated by the large land areas involved. Working with treatment units of large size creates difficulties in identifying spatial replicates and controlling potentially extraneous variables. Furthermore, it is difficult to identify homogenous landscape units at the outset of the experiment. Intrinsic landscape variability and land-use histories (over 100 years) create significant difficultly in identifying

and delineating suitable homogeneous sample units. Moreover, even in the absence of treatment it is unlikely that existing landscape characteristics would be maintained throughout the duration of the research project.

Some response variables are necessarily studied over very large geographic domains, e.g. what many refer to as the landscape level, other response variables are appropriately examined using smaller geographic domains, which will enable use of more standard experimental designs. Our original intention was to employ large geographic sampling units that are most appropriate for investigating variables such as spotted owl population demography in response to fuels treatments. While this enables directly addressing some important questions it does pose significant design challenges.

Although such experimental design problems could be managed, ultimately the Forest Service concluded that it could not manage to support a study of this geographic scope and still be able to address other mandates of interest, most notably implementation of the HFQLG Pilot Project. Thus the decision was made to drop efforts to develop a purposefully crafted landscape experiment where treatments were to be specifically placed in space and time to test response over entire landscapes. However, the Forest Service remains supportive of the fundamental objectives of the study and thus they asked PSW to re-examine the research opportunities in light of the fundamentally different conditions for treatments. Now the treatments are to be planned and implemented with the sole purpose of implementation of the HFQLG Pilot Project on the schedule anticipated for this program. Placement, size, intensity, and timing of vegetation management projects (i.e. fuels management and silviculture) will be dictated by the Pilot Project. There will be no way to specifically direct the location, size, intensity, or timing of projects in order to facilitate an experimental design. Thus this re-designed research effort has had to re-examine the research opportunities using a backdrop of treatment conditions that is driven by entirely different purposes. This has required a modification in the kinds of questions that can be addressed, however the integrated research agenda remains as faithful as possible to the original objectives.

Under the current conditions of this study we will be relying largely upon observational studies. We believe it is important to continue to focus most of our effort towards observing the response of key forest elements to treatments at a landscape scale. Basically this will entail observing a population (e.g. spotted owls) or a feature of the forest (e.g. surface fuels) over space and time and describing what is observed through estimation of various attributes. In this case we have no opportunity to manipulate the system of interest with the intent to test a hypothesis. However this does not preclude the ability to learn from what is observed. If something is suspected to have an impact on the response variable of interest recording its value allows for the possibility of controlling for it in the subsequent analyses. By collecting data on a variety of potential explanatory variables can allow for exploration using various analytical methods. Although observational studies do not allow for the strength of inference that true experimental studies can provide, such efforts will make the most of extremely difficult experimental conditions (particularly at a landscape scale) and can provide important insights to allow for better understanding of the variables of interest. Results can also lead to a basis for designing more controlled studies if ultimately deemed necessary and feasible.

2. Management Context

The Record of Decision for the HFQLG Pilot Project describes the background and purpose of the pilot project as follows:

> *The Quincy Library Group Community Stability Proposal of 1993 is an agreement developed by a coalition of representatives of fisheries groups, environmental organizations, the forest products industry, citizens, elected officials, and local communities in northern California. The intent of the Proposal was to develop a resource management program promoting ecological health on certain Federal lands and economic health for communities in the northern Sierra Nevada, in Sierra, Plumas, and Lassen counties. Discussions about a pilot project began in 1992 when the Quincy Library Group formed. The Proposal was subsequently introduced to Congress in 1997 and was enacted as the Herger-Feinstein Quincy Library Group Forest Recovery Act of October 21, 1998 (Act).*
>
> *The Forest Service proposes to establish and implement a pilot project not to exceed 5 years to demonstrate and test the effectiveness of management activities described in the Herger-Feinstein Quincy Library Group Forest Recovery Act of October 21, 1998, by amending, as needed, management direction in the Land and Resource Management Plans for the Lassen, Plumas, and Tahoe National Forests. The total acreage on which management activities are implemented is not to exceed 70,000 acres each year.*
>
> *The purpose of and need for a pilot project is to test and demonstrate the effectiveness of certain resource management activities designed to meet ecologic, economic, and fuel reduction objectives on the Lassen, Plumas, and Sierraville Ranger District of the Tahoe National Forests. The Act requires the Secretary (of Agriculture) to conduct a pilot project for a period of up to 5 years from the initiation of the pilot project (Title IV, Section 401(g)(2)). To accomplish the purpose of the Act, resource management activities that include fuelbreak construction consisting of a strategic system of defensible fuel profile zones, group selection and individual tree selection harvest, and a program of riparian management and riparian restoration projects are required.*

From its inception, the HFQLG Pilot Project has been viewed as an adaptive management experiment in which landscape-level treatments would be rigorously monitored to determine their efficacy. Concerns about potential impacts on California spotted owls led to the following mitigation language in the HFQLG Pilot Project Decision:

> *In order to reduce the risk to the California spotted owl, the following mitigation measure will be applied to all resource management activities conducted under [the selected alternative], until a new spotted owl habitat management strategy for the Sierra Nevada is released:*
>
> ***Mitigation:*** *At the site-specific project level, defensible fuel profile zones, group selection harvest areas, and individual tree selection harvest areas will be designed and implemented to completely avoid suitable California spotted owl habitat, including nesting habitat and foraging habitat.*

The SNFPA Decision provides the California spotted owl habitat management strategy anticipated in the HFQLG Decision. The revised SNFPA direction (described in the 2004 ROD) for spotted owl habitat management enables execution of the HFQLG Pilot Project as it was originally envisioned. Certain protective measures are prescribed including no vegetation treatments (except for light underburning) in PACs and SOHAs and outside of these areas all tree greater than or equal to 30 " will be retained. Changes to canopy cover are limited and basal area retention standards apply to all mechanical thinning.

The 2001 ROD, reaffirmed in the 2004 ROD, included direction for examining the uncertainty around response of CA spotted owls and their habitat to the combination of treatments called for in the Pilot Project:

> *Under the procedures of the adaptive management strategy in this decision, the National Forest System Region 5 will cooperate with the Pacific Southwest Research Station to design and implement an administrative study to examine the relationship between management-caused changes in vegetation and their effects on spotted owl habitat and spotted owl population dynamics. I would expect the group selection provisions of the HFQLG pilot project as well as other treatments to be used in carrying out the study. The administrative study is intended to investigate the response of the California spotted owl and its habitat, particularly populations of prey species and features of their habitats, to various silvicultural treatments.*

The Regional Forester's decision provided the Pacific Southwest Research Station (PSW), working with National Forest System managers, discretion for designing the administrative study. This intent led to a decision by the PSW team of scientists to incorporate multiple scientific objectives into the study, each linked to the theme of California spotted owl response to forest treatments. Direction in the SNFPA Decision for an administrative study focuses on California spotted owls (and related resources); however, answering questions about this species requires that we consider various other interactions between owls and their environment. Indeed, both the HFQLG Pilot Project and the SNFPA adaptive management strategy challenge us to consider a host of management and ecological interactions at a variety of spatial and temporal scales. An integrated, inclusive examination of multiple issues at multiple scales is needed to begin answering these questions. The research program described here is designed to meet this goal.

3. Research Objectives

The need for the proposed research project is to resolve persistent questions about the effects of vegetation-management actions upon wildland fire behavior, silvicultural goals, landscape dynamics, and old-forest-dependent species viability. The purpose of the proposed research project is to gather needed scientific data to resolve these key ecological and forest-management questions and thus inform future management decisions.

The current proposed research program is designed to address four principal issues described below. These issues are specifically addressed through research questions and attending

hypotheses for five different research components of this research program. These specific questions, and our ability (or lack thereof) to address these questions in an experimental manner, will be detailed in attending documents as the five research modules are discussed. Here we simply highlight the main objectives of the integrated research program.

- ***Wildland Fire Behavior and Protection.*** How do landscape level fuels and silvicultural treatments affect potential fire behavior and effects? Are specific combinations of defensible fuel profile zones (DFPZs) and subsequent area fuel treatments effective in reducing the extent and severity of wildland fires? (These two types of actions are defined in the subsequent Proposed Action section.) Are realized fire management benefits consistent with hypothesized results in reducing fire risk and altering fire behavior?

- ***Silvicultural Goals.*** Vegetation management activities applied across landscapes on the Plumas National Forest will include both fuels reduction thinnings and regeneration group selection silviculture. These management activities are anticipated to result in changes to forest structure in terms of stand density and canopy cover. Several basic questions arise from these management prescriptions. What kinds of ecological conditions were associated with shade-intolerant pine establishment? What is the growth response of remaining large trees to fuels reduction thinnings? How do microclimate conditions change in areas where there were fuels reduction thinnings and resulting canopy cover reductions?

- ***Landscape Dynamics.*** How do combinations of DFPZs, area fuel treatments, group selection, riparian protection standards, and species-specific protection measures affect landscape dynamics such as forest structure, composition, and succession at multiple scales of space and time?

- ***Species Viability.*** How will old-forest-dependent species, particularly the California spotted owl and its prey base comprised of various species of small mammals, respond to changes in vegetation composition, structure, and distribution induced by a forest management regime? How is response to treatments manifested at the individual and population levels of biological organization?

These are clearly ambitious objectives. We do not expect to address every aspect of these broad questions however we do believe that the planned research will make important contributions to our understanding of these issues.

The above four issues all entail a dynamic forest ecosystem that is subject to natural processes of growth and mortality as well as vegetation manipulation through management and uncontrollable forces of weather and climate. All components of a forest respond to the dynamic nature of a forest ecosystem (both natural processes and human-induced changes) through continual adaptation across the landscape over space and time. Thus these questions are inextricably linked; one question cannot be answered adequately without consideration of one or more other questions. Similarly, addressing each major issue requires addressing multiple component issues or questions. For example, the issue of DFPZ efficacy can be addressed by considering such questions as initial treatment levels, maintenance, or location in the landscape. These are constituent questions that are limited to the area directly within

the DFPZs. A complete understanding of DFPZ efficacy, however, requires a larger view that encompasses fuel conditions across the broader landscape, prevalent weather conditions, potential ignition sources, and the placement of other DFPZs within a landscape. Adding to the complexity is the simple fact that no two DFPZs are identical; each requires unique design standards under which it is constructed and maintained, and depending on the properties and history of its location. This is one of many examples that points to the need for concurrent lines of research at multiple scales of investigation, to quantify important relationships of interest in this research program.

We have developed individual research modules that address these primary research objectives. They are discussed under Response Variable Modules below and are described in detail in separate documents. They include:

- Forest structure.
- Fuels, fire behavior, and fire effects.
- Spotted owl responses.
- Small mammal distribution, abundance, and habitat relationships.
- Landbird distribution, abundance, and habitat relationships.

Other possible research modules that not been developed at the present time include:

- Northern goshawk responses.
- American marten responses.
- Aquatic, riparian, and meadow systems.
- Socioeconomic interests.

Adaptive Management

The work imbedded in this study is hoped to be part of a larger adaptive management program. Adaptive resource management, pioneered by C.S. Holling and Carl Walters, is management by experiment (as opposed to the lack of the ability to "experiment" by simply taking a survey). The use of the term "experiment" implies the ability to assign treatments with some flexibility. We are limited in the degree to which active adaptive management might be practiced because of the limitations we have in designing and implementing treatments. We do intend to maximize the value of what is learned through primarily what scientists refer to as passive adaptive management where we examine response to treatments using a case study or survey method. A strict "survey" will not have the ability to address the questions in an experimental manner. Current management circumstances constrain our ability to impose experimental conditions, particularly at the landscape scale. However, we will work with the National Forests to design true experimental conditions (i.e. some control over the assignment of treatments) wherever possible; specific questions at smaller geographic scales that will have experimental conditions designed in cooperation with National Forest System managers. This will be discussed further under methods.

In this vein, we will be investigating portions of the Sierra Nevada's westside coniferous forest ecosystem that will be subject to management actions (i.e. fuels treatments and silviculture) and examining a set of alternative predictive models that represent competing hypotheses about how the system will respond. This approach acknowledges that the

relationship between the chosen management action and the mechanism that affects the system is not perfectly precise. We know there will be sources of variation within the measured response variables that will be unexplained by the models. But with some ability to assess an array of predictive or explanatory variables control we will learn about ecosystem functioning by monitoring a selection of response variables and evaluating alternative ecosystem models to determine which ones provide the best fit to the observed responses.

Holling and Walters suggest that a key feature of adaptive management is that actions be studied at the same scale as management is conducted. Some of the important National forest management activities today are carried out at the landscape scale. Moreover, certain key response variables cannot be addressed without adopting a landscape level of inquiry. Variables such as spotted owl population response (e.g. density of owls) across time and space, or fire behavior response to alternative landscape configurations of fuel treatments, are not possible to investigate without using large land units. To the extent that we can we will continue to try and understand how responses observed are manifested at different spatial scales including these large geographic units of interest.

This integrated program also provides an opportunity to address some significant components of the SNFPA Adaptive Management Strategy, and as such, it is intended to address key questions and uncertainties identified during development of the SNFPA. We will work closely with Region 5 and local Forest and District personnel to maximize the value of what is learned and applied to the Sierra Nevada Adaptive Management Program.

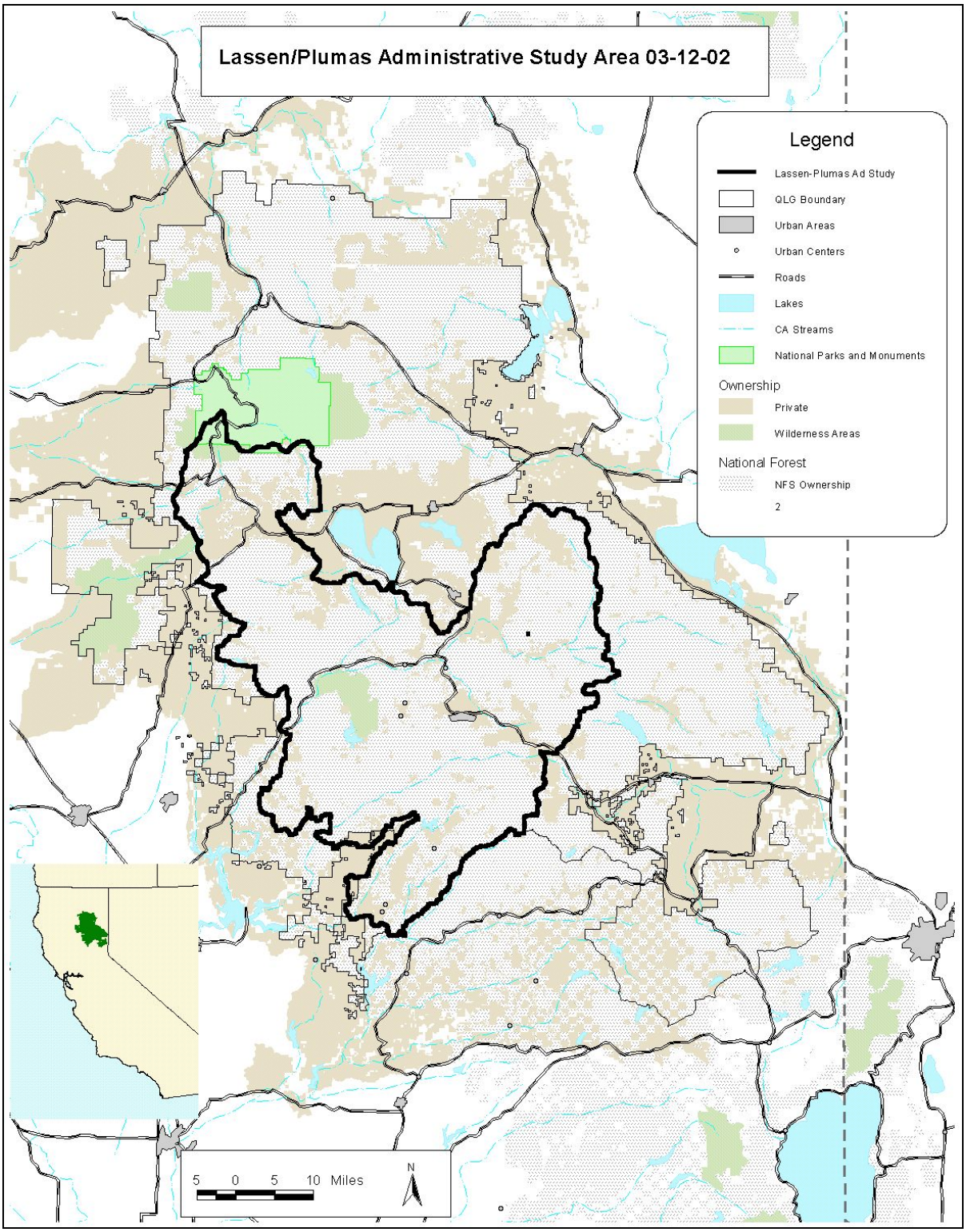
4. Study Area

The location for this study is on portions of the Plumas and Lassen National Forests, including much of the land base for the HFQLG Pilot Project within the westside coniferous forests. Figure 1 displays the original study area boundaries (in blue/thick line) and the boundary of the HFQLG Pilot Project Area (in black/thin line). The HFQLG Pilot Project includes approximately 2.5 million acres within the Lassen, Plumas, and Tahoe National Forests. The current study area initially includes selected watersheds within the Plumas National Forest. The target population of forest conditions is intended to be west slope conditions in the northern Sierra Nevada. Additional locations within the Plumas, Lassen and perhaps other locations in the northern Sierra will be added, as needed and as funding can enable.

It is possible that we will examine treatments at similar spatial and temporal scales in other parts of the Sierra Nevada. As we begin to evaluate results from this study on the Plumas National Forest, and consider the opportunities presented by the variation in certain environmental factors across the Sierra Nevada, we may consider examining similar forest treatments in other locations. Several research efforts within the Kings River Administrative Study and the Teakettle Experimental Forest on the Sierra National Forest are designed to examine similar questions over smaller geographic areas, at both watershed and forest stand

scales. The similarities between research in the southern Sierra Nevada and the proposed work for this administrative study offer important opportunities for evaluating scale-dependent responses of different landscapes, as well as geographic variation.

Figure 1



5. Methods

Experimental Design Considerations

The basic objectives of the scientific method are intended to lead to description, prediction, explanation, and understanding. Principally, we are interested in being able to ascribe cause and effect to link responses measured with treatments applied. This ultimately leads to the most specific insights for informing future management actions. Understanding is achieved when the causes of a phenomenon are identified. This requires that evidence be provided for covariation of occurrences and that other potential causes can be eliminated.

The scientific method for testing a cause and effect relationship typically involves posing and testing a hypothesis. Hypotheses are tentative explanations of events. Testing the cause and effect relationship between a dependent variable, for example the feature of interest such as owl survivorship, and an independent variable, for example a vegetation structure resulting from a treatment such as a DFPZ, requires some control over the assignment (i.e. intensity, location, timing, etc.) of the independent variable, in this example the treatments. This is relatively easy in a laboratory but conducting such work in natural systems creates many design difficulties (e.g. ecological homogeneity of sampling units, differences in land use history, uniformity of treatments applied, etc.). As one attempts to look at larger and larger geographic sampling units, the difficulties increase further.

Our current overall research strategy is constrained by the lack of controlled treatment assignments at the landscape scale. Some questions that we otherwise would have liked to address through a hypothesis testing manner, in order to maximize the strength of inference that could be drawn, we will not be able to do. Alternatively we will have to employ a more case history or observational approach, what some refer to as passive adaptive management, where we monitor response to the treatments that will be implemented over space and time as governed by typical land management operations conducted outside of a rigorous control-treatment experimental design. Such approaches are not without scientific value, they just limit the degree to which we can answer certain questions and draw inferences. Under this method, pre-treatment data are collected, predictions of anticipated responses to treatment are generated, and the post-treatment response is assessed to test model predictions and evaluate treatments effects. While inferences are not as strong as those generated from an active adaptive management approach or BACI (Before/After/Control/Impact) study design, this method still allows for formalized learning through assessment of each case study. Additionally, it provides some degree of flexibility for responding to changing management direction over time.

However, there are some issues that we believe can still be addressed with more rigorous scientific method, where we can experiment through the assignment of treatments. Under current circumstances this will be restricted to smaller geographic domains and questions that are suitable at that scale. This will require collaboration with Forest and District staff. We will seek to design experiments with independent variables (i.e. changes in forest vegetation structure resulting from treatments) where we can control the assignment of treatments for experimental purposes. The section on the specific research modules and their attending research plans (see attached) will elaborate on specific questions and design considerations.

Proposed Vegetation Treatments

Plumas National Forest Anticipated Program of Work FY03-09 in the Northern Sierra Nevada Administrative Study Area June 10, 2003 (All subject to modification)

Caveats: *The 2003-2009 program of work for vegetation management on the Plumas National Forest is subject to change, and should be expected to change as time passes. The tentative program characterization here should be considered to be a "snapshot in time" as of mid June, 2003. A more definitive version is expected to be available in July, 2003.*

Some of the specific prescriptions for vegetation management noted below may be subject to change. In particular, if the Sierra Nevada Forest Plan Amendment (SNFPA) is revised in some way as is currently proposed, some prescriptive elements may require modification or clarification. Consistency of HFQLG design criteria for DFPZs and SNFPA-Revision standards and guidelines would need to be clarified.

Program Elements:

The focus of the program of vegetation-management work in the Administrative Study Area in the remaining years of this decade will be to implement provisions of the Herger-Feinstein Quincy Library (HFQLG) Act, specifically, the HFQLG pilot project, consistent with provisions of the SNFPA or SNFPA Revision, if a revision is adopted.

Three vegetation-management program elements are proposed:

- Defensible fuel profile zone (DFPZ) construction
- Group selection silviculture for production of wood products
- Fuels treatments in SNFPA *defense zones*, and possibly *threat zones*, at the wildland-urban interface (WUI)

A table ***under development*** will show all projects for FY1999-2009 and for each will give project name, Ranger District, type of project (i.e. DFPZ, group selection, or WUI), contract award date or planned program-of-work date, Administrative Study treatment unit (as per modified treatment units), and project acreages in various Calwater planning watersheds (CPWs).

The three elements can be tentatively characterized as follows:

DFPZs

Where: A network as generally described in the HFQLG FEIS. Locations and configurations have been revised during the planning of the original Administrative Study and may be further revised during individual project planning.

What: Each DFPZ will be constructed according to management direction in effect during the planning period for each project. Two possible prescriptions are presently foreseen:

- Prescription 1 – SNFPA provisions (current requirements)
- Prescription 2 – HFQLG/SNFPA-Revision provision (possible future requirements)

These two possible prescriptions are shown on Table 1.

When: Final year of scheduled contracting is FY 2009. Actual construction must be completed within a reasonable period of time, generally considered to be no more than 3 years thereafter.

Group Selection

Where: Distributed throughout the HFQLG available land base in the study area, except in spotted owl protected activity centers and habitat areas, and focused upon Region-5 Size Class 3 stands (stands with preponderance of 12-24" dbh trees).

What: Patch cuts ½ to 2 acres. All conifers and snags removed, except that rust-resistant sugar pine of any diameter and other conifers larger than 32-42" dbh (i.e. older than approximately 175 yrs) would be retained, unless they have advanced stages of root disease or are substantially infected with mistletoe. Larger oaks (>24" dbh) would be retained.

When: Beginning in FY-04, up to 4,000 acres/yr. Group selection in the entire HFQLG pilot project area would average 0.57% of the available land base per year, or 8,700 acres/yr, resulting in an average rotation age of 175 years.

WUI Projects

Where: In some or all of the defense zones established by SNFPA, as summarized by Sierra Nevada Research Station GIS staff (Sean Parks) by CPWs. Total program is currently in the planning phase.

What: Fuel treatment as per *Defense Zones* in Table 1.

When: Scheduling is currently in the planning phase.

Related Actions on the Lassen National Forest

It is anticipated that the program of work for areas of the Administrative Study within the Lassen National Forest (LNF) (i.e. portions of the Almanor Ranger District) may be similar to that described above for the Plumas National Forest. However, the district is currently deferring planning of DFPZ projects under existing SNFPA direction.

Table 1. Alternative Prescriptions for DFPZs

For both prescriptions, DFPZs shall be designed to achieve desired fuels conditions using the most cost-effective means practicable. Other provisions not listed here apply to snag and down wood retention and areas designated as special habitats or riparian zones.

Rx 1 – SNPFA Provisions

This prescription varies by SNFPA land allocation, as indicated below.

• Remove surface and ladder fuels to meet desired fuel condition, and do not include trees <6" dbh in estimation of canopy-cover.

Old-Forest Emphasis and Related Areas

• Adhere to UDL of 12" dbh.

• Subject to a maximum reduction in canopy cover of dominants and co-dominants of 10%, thin 6-12" dbh trees to retain canopy closure of at least 50%. [a]

• Do not treat at least 25% of existing stands. [a]

General Forest and Threat Zones

• Adhere to UDL of 20" dbh.

• Subject to a maximum reduction in canopy cover of dominants and co-dominants of 20%, thin trees 6-20" dbh to retain canopy closure of at least 50%. [a]

• Do not treat at least 25% of existing stands in General Forest and at least 15% of existing stands in Threat Zones. [a]

Defense Zones

• Adhere to UDL of 30" (12" for hardwoods).

• Remove smaller trees as needed to achieve desired fuels condition.

• Do not treat at least 10% of existing stands. [a]

Spotted Owl Protected Activity Centers

• Outside of defense zones, treat fuels with hand thinning and prescribed fire.

• In defense zones, treat fuels with hand thinning and prescribed fire within 500' of nests; apply General Forest provisions elsewhere.

Rx 2 – HFQLG / SNFPA-Revision Provisions

This prescription varies by Region 5 size class and SNFPA land allocation, as indicated below.

- In all areas (including Defense Zones), adhere to a general UDL for conifers of 30” dbh and for hardwoods of 12”, and in LSOG 4 & 5 areas do not treat old-growth patches larger than 1 acre (i.e. CWHR classes 5M, 5D, and 6).

- Remove surface and ladder fuels to meet desired fuel condition, and do not include trees <6” dbh in estimation of canopy-cover or basal area.

R-5 Size Classes 4, 5, and 6, except Defense Zones

- Retain 40% of existing basal area in largest trees,.[a]

- Thin 12-24” dbh trees if needed to achieve canopy closure of 40%.

R-5 Size Classes 2 and 3, except Defense Zones

- Retain 30% of existing basal area in largest trees, retaining basal area of at least 50 sq. ft.[a],

Defense Zones

- Remove trees smaller than general UDL as needed to achieve desired fuels condition.

Spotted Owl Protected Activity Centers and Habitat Areas

- DFPZs excluded.

Notes:

SNFPA = Sierra Nevada Forest Plan Amendment

UDL = upper diameter limit

CWHR = California Wildlife Habitat Relationships

[a] Areas of roads and group selections are not counted in applying these standards.

Response Variables/ Research Questions

The foundation of this research strategy is the articulation of the questions being asked. Each of the research modules is oriented around a set of one or more research questions that are an outgrowth of management information needs. The questions give rise to a research hypothesis and thus lead to an experimental design and anticipated analytical methods. Each module, summarized below and detailed in the attached study plans, describes this information for its own module.

Under the previous study strategy, most elements of this study were structured to fit within a landscape level design, using treatment units of 50,000 to 70,000 acres in size. These treatment units were to be the basic sampling unit. Nested within this design smaller geographic units would be utilized as sampling units for specific components of the study. We no longer are using large landscapes as sampling units because we will not be able to structure a treatment design that tests different landscape management strategies. Now we are employing a more passive adaptive management approach (see above). Individual research modules will describe the questions being addressed and the methods being used.

Currently-Planned Research Modules

We have developed 5 response-variable modules to address the first 3 of the 5 potential research topic groups listed above. They include

- forest structure;
- fuels, fire behavior, and fire effects;
- California spotted owl responses;
- small mammal distribution, abundance, and habitat relationships; and
- landbird distribution, abundance, and habitat relationships.

These response variable modules are briefly described below. One or more principal investigator(s) has been assigned to each module. The principal investigator(s) have developed the module's specific sampling designs and protocols and prepared a complete study module. The attached study plans provide more detailed summaries of the specific research objectives for the five response-variable modules. These summaries describe specific questions that are being posed, what variable(s) need to be measured to address these questions, how the variable(s) will be measured within the context of the overall study design presented here, and the proposed analytical methods.

A. Forest Structure Module

This module serves dual purposes. Vegetation structure and composition measurements are basic data requirements for all research modules. To facilitate maximum within and across modules value of such data, we are developing a common vegetation data protocol for all research modules that 1) facilitates data integration and cross-discipline analysis, 2) provides for different sampling intensities and time limitations, and 3) is nested around a set of common methods and protocols with additional measurements added at each higher level.

This protocol will have three levels of detail appropriate to the study of different organisms and processes. All three sampling systems are organized around a common set of measurements and categories which will be standardized between crews through common training by the vegetation module. All data will be entered and maintained with the same data fields and categories.

The vegetation module also has specific research objectives of its own. Specifically this module will examine the following ideas and test specific hypotheses for each:

1) The relationship between canopy cover and microclimate is linear (Weatherspoon 1996): alternatively, there may be a canopy cover threshold where rapid changes in microclimate occur, or an asympototic approach to maximum levels

2) Changes in understory plant communities, and rates of recovery, are proportional to changes in canopy cover and stem density from thinning and restoration treatments. Alternatively, there may be disturbance thresholds which when exceeded result in new, enduring plant communities.

3) Across the PLAS landscape, fuel treatments will produce a greater change and slower recovery in forest composition and structure in ecotones between forest types. Alternatively, the greatest changes may occur in areas where abiotic stress is high – for example, areas of serpentine soils or steep, southwest aspect sites.

The attached study plan provides more detailed information about the forest-structure module.

B. Fuels, Fire Behavior, and Fire Effects Module

The goal of this component is to determine how landscape level fuels and silvicultural treatments affect potential fire behavior and effects. Data will be used to characterize fuels, forest structure, and fire behavior and effects prior to and after landscape fuel treatments. Our methods include remote sensing, extensive field sampling, and fire behavior and effects modeling.

This module has two primary questions, each containing several aspects to those questions:

1) How do current fuels conditions affect potential fire behavior and effects?

- What are current fuel loads and ladder fuel conditions prior to treatment?
- What is the range of potential fire behavior given current conditions?
- What are likely effects of fire behavior on these landscapes as determined by simulation models?

2) How will fuels treatments (i.e. DFPZs and other management applications) change fire behavior and effects?

- How do Defensible Fuel Profile Zones (DFPZs) affect fuel loading?
- How does the placement of DFPZs affect potential fire behavior? Do they reduce the risk of catastrophic fire under extreme weather conditions?

- What effect would DFPZs have on resulting fire effects? Would the reduction in total fire extent and intensity reduce the severity and extent of canopy fires?
- And, in the very long-term, how do SPLATs affect fuel loads and potential fire behavior?

The extensive data to be collected will provide, a) plot-sampled fuels data and ladder fuel hazards in a range of conditions; b) forest canopy and structure information across the same area; and c) detailed ground reference data for the fine-scale remote imagery used to assess continuous forest cover. Data collection will be coordinated with other research modules at several different scales and intensities.

Extensive but limited data will be collected in "tier 1 plots": 24 watersheds with 3 transects per watershed and 12 plots per transect. Data will include rapid assessments of forest basal area by species (using prisms), ladder fuel hazard assessments (LaFHAs), and fuel photo series analysis (as per Blonski and Schramel 1981). There will be approximately 720 such data points (864 minus 144 the moderately extensive plots described next).

More intensive data ("tier 2") will be collected in two 12.6m radial plots on each transect (144 plots). These will include measures of forest structure (height, diameter, species, canopy closure), fuel loads (modified Brown's transects) and LaFHAs. Additional sites with the same layout will be identified through stratified random sampling of areas not represented in other sampling efforts. These sites will include steep and non-forested areas (montane meadows and chaparral).

Intensive data ("tier 3") on forest structure and fuels will be collected in owl nesting areas and small mammal plots. For details, please see the vegetation crew protocols.

The attached study plan provides more detailed information about the fire and fuels module.

C. California Spotted Owl Response Module

Knowledge regarding the effects of fuels and vegetation management on California spotted owls (***Strix occidentalis occidentalis***)(CSOs) and their habitat is a primary information need for addressing conservation and management objectives in Sierra Nevada forests (Verner et al. 1992). Current fuels management concepts propose treatments at the landscape spatial scale, such as DFPZs and SPLATS within WUIs, designed to modify fire behavior and facilitate suppression efforts. Landscape fuels treatment strategies are implemented at large spatial scales and will be the dominant management activity affecting CSOs and the forest landscape. Resulting changes in vegetation structure and composition from treatments may affect CSOs and their habitat at multiple spatial and temporal scales. Key uncertainties regard the effects of landscape-scale fuels treatments strategies that thin large areas of forest on CSO density, population trends, and habitat suitability at the landscape scale and how thinning effects habitat quality at the core area/home range scale. The goal of this module is to assess the effects of fuels and vegetation treatments on CSOs and important resources, such as vegetation and prey, at the core area/home range of a CSO pair and landscape spatial scales.

It is necessary that research address management effects on CSOs at the appropriate scales at which management is being conducted. Proposed landscape treatments may have effects at either, or both, the individual territory or owl site scale as expressed through change in occupancy, diet, use of vegetation patches, survival or reproduction, or at the population level as expressed through change in the density or spatial distribution of territorial breeding pairs at the landscape-scale. The individual site scale and population level perspectives are complementary in that the population level provides context for interpreting change at the site scale. Most importantly, both perspectives are required by managers concerned with managing for high habitat quality sites, as well as, well-distributed, viable populations across landscapes while implementing management strategies to deal with large-scale fire and fuels issues.

CA Spotted Owl Study Objectives

The CSO module is designed to provide as much information as possible on the association between treatment effects and CSO population and habitat response. Within a passive adaptive management framework, our objective is to develop predictive models that project the effects of proposed treatments on CSOs and their habitat, directly monitor CSO response, and subsequently evaluate model predictions and reiterate model development or refinement as necessary. We focus on CSO response variables and habitat associations at two levels of biological organization: population and individual pair. Current information on vegetation and CSO demography and distribution is available from ongoing research and recent inventory work in the study area. A photo-interpreted vegetation map based on 1999 air photos was completed in 2002 for a large portion of the overall HFQLG project area and will form the base vegetation information for the development of predictive habitat models. Vegetation polygons have a minimum mapping unit of less than 5 acres and are attributed by vegetation type, trees size class, cover class (10% cover increments), and the presence/absence and proportion of the polygon supporting large trees. Information on CSO stage-specific survival, fecundity, and population trends is available from an ongoing demographic study started in 1990 being conducted on the Lassen National Forest within the HFQLG project area. Additional CSO density and distribution information is available from approximately 270,000 continuous acres collected during 2002-2004 from the Plumas National Forest immediately adjacent to the Lassen demography study. These data sources provide a rich and extensive baseline of information and provide an opportunity to develop predictive habitat models, monitor future change in CSOs in response to treatments, and advance scientific knowledge of CSO habitat associations.

Five specific research questions will be addressed. The first three questions address associations among treatments and CSO response at the population and individual pair levels. These three questions address each of the primary information needs proposed in the previous section required to understand the range and types of possible CSO responses. The fourth and fifth questions address important additional stressors that may have significant negative impacts on CSO population trends and population viability in the Sierra Nevada. It is imperative to have this information in order to assess the relative contribution of potential causative factors that may affect CSO populations. The five questions are as follows:

1) What is the association among landscape fuels treatments and CSO density, distribution, population trends and habitat suitability at the landscape-scale?

2) What is the association among landscape fuels treatments and CSO reproduction, survival, and habitat fitness potential at the home range scales?

3) What is the association among landscape fuels treatments and CSO habitat use and home range configuration at the core area/home range scale?

4) Are barred owls increasing in the northern Sierra Nevada, what factors are associated with their distribution and abundance, and are they associated with reduced CSO territory occupancy?

5) Does West Nile Virus affect the distribution and abundance of California spotted owls in the study area?

The attached study plan provides more detailed information about this module for the California spotted owl.

D. Small Mammal Distribution, Abundance, and Habitat Relationships Module

We currently know relatively little about the basic ecology of the array of small mammal species found in the Sierra Nevada. The primary species of interest will include taxa in the genera *Peromyscus* (deer mice, etc.), *Reithrodontomys* (harvest mice), *Neotoma* (wood rats), *Microtus* (meadow voles), *Zapus* (jumping mice), *Sciurus* (tree squirrels), *Tamiasciurus* (Douglas squirrel), *Spermophilus* (ground squirrels including golden-mantle ground squirrel), *Glaucomys* (flying squirrels), and *Tamias* (chipmunks). These species play pivotal roles as seed consumers and dispersers in forest ecosystems and as prey for carnivores, including the California spotted owl.

The goal of this component is to build basic understandings of small mammal ecology, focused on three main objectives.

1) What are the habitat associations of the different taxa of small mammals found in coniferous forests in the northern Sierra (objective of developing refined yet functional models of habitat associations)? What is the relative abundance and distribution of these taxa with respect to forest structure and composition?

2) Estimate values of the demographic parameters (for example, population size, reproductive output, survivorship, and mortality rates) of these taxa.

3) Estimate values for spatial patterns (for example, home range area and configuration) for these taxa.

Small mammals often are penultimate members of food webs, providing a critical food source for many carnivores, including marten, fisher, northern goshawk, and California spotted owl. As such, their dynamics may have cascading effects (e.g., trophic cascades) through ecosystems, and understanding their demography and community dynamics is central to holistic management of natural systems.

Alteration of habitat structure and quality through forest management will have some kind of direct effects on the demography of small mammal populations. Specifically, improvement in habitat quality should be reflected in enhanced demographic performance (higher density, greater reproduction and survival) and changes in spatial distribution (leading to higher densities and possibly to spatially predictable levels of clumping), with consequent influences on social structure.

Determining which components of habitat structure (for example, vegetation height, density, and species composition) most strongly influence small mammal communities requires an analysis of habitat associations. Variation in habitat quality typically is reflected in spatial patterns, with individuals in poor quality habitat occupying larger home ranges (or leaving altogether).

The attached study plan provides more detailed information about the small mammal distribution, abundance, and habitat relationships module.

E. Landbird Distribution, Abundance, and Habitat Relationships Module

The objective of the land bird module has three primary components. The overall objective is to better understand how bird communities respond to dynamic environments that are constantly in flux due to both natural and human-induced processes. Will these dynamic landscapes that include forest management practices intended to manage fuels accumulations and provide some timber commodities sustain healthy songbird communities?

We have three primary questions that we are attempting to address with the bird module of this research work.

1) Is the relative abundance and overall distribution of the avian community stable in northern Sierran forests in response to the suite of forest management practices that affect these forests?

We intend to monitor the distribution and abundance of birds across the landscape in response to changes in forest structure and composition as determined by vegetation growth/succession and by human-induced treatments. Forests in the northern Sierra Nevada grow rapidly (Powell et al. 1992) and growth rates (characterized, for example, by changes in tree size class and canopy cover) will presumably impact habitat conditions. Treatments, such as forest thinning for fuels management or group selection for timber harvesting, will also impact habitat conditions on the site of treatments and surrounding areas in some way. When analyzed over time and across the spatial extent of a watershed, what is the response of bird communities? Will forest structure and composition resulting from a combination of continuous vegetative growth and specific management regimes create conditions capable of sustaining stable avian communities?

This study is distinguished by its geographic domain or scale. We are principally interested in measuring response of variables over relatively large geographic areas and over relatively long time periods. The reason for this is rooted in the rate and extent of treatments combined with the rate and extent of vegetation growth. This watershed-scale study endeavors to incorporate spatial and temporal factors that might influence the response variables.

2) How do bird communities respond/change to landscape level fuels treatments such as defensible fuel profile zones or strategically placed area treatments at and in the vicinity of site-specific treatments?

In addition to assessing responses of birds to forest management and succession integrated over time (10 to 20 years) and space (throughout a watershed) we plan to simultaneously address the short-term, localized responses of birds to specific forest treatments. What are the site-specific changes in bird community composition and abundance in response to treatments and how does this change over time following treatments?

Fuels treatments are intended to remove or reduce surface fuels, ground fuels and ladder fuels to the extent that fire behavior would be significantly different in treated areas compared with untreated areas. Fire should move significantly more slowly and with less intensity through treated areas. Habitat conditions after treatment will be different. Percent canopy cover will be lower, there will be less ground vegetation, and there will be fewer trees per acre. However, there will still be a forest with some amount of large trees. Basic vegetation composition may not change significantly and the habitat type will still be similar.

How do bird communities respond to these changes in vegetation structure? How far from treated locations do effects influence bird community composition and species' relative abundance? Are these changes significant enough to affect certain species but not others? Is the effect short term or does it persist over longer periods of time?

These questions can also be applied to SPLATS at a later date when such treatments are scheduled and implemented.

This multi-scale approach allows us to understand both the effects of specific management practices and the integrated effects of treatments and vegetation succession.

3) What are the specific habitat affinities of birds species in northern Sierran forests?

We also intend to build predictive models that can associate habitat conditions with expected avian species abundance. These habitat relationships models will enable us to predict how habitat changes measured in response to vegetation growth and management will influence the overall distribution and abundance of bird species across a landscape. In a modeling context, treatments will be assessed in terms of how effective they are at moving stand and landscape vegetation structure and composition toward a desired condition.

We can use these habitat association models to develop covariates to help explain variability and gain more power to detect treatment effect changes.

We propose to measure the relative abundance, spatial distribution, and community composition of landbirds as response variables over space and time. In a modeling context, treatments will be assessed in terms of how effective they are at moving stand and landscape vegetation structure and composition toward a desired condition. Key questions to be addressed include the effects of treatments on: (a) snag dynamics and associated snag-

dependent species, such as black-backed woodpeckers; and (b) species associated with forest openings and early-seral vegetation, such as olive-sided flycatchers.

The attached study plan provides more details about the landbird distribution, abundance, and habitat relationships module.

Potential Additional Modules

Four other response-variable modules have been identified that could be developed to enhance the research project, if additional funding becomes available. They include:

- Northern goshawk responses;
- American marten responses;
- Aquatic, riparian, and meadow systems; and
- Socioeconomic interests.

Northern Goshawk Responses Potential Module

The density of goshawks within each treatment unit could be estimated annually using dawn courtship, broadcast calling, and intensive stand searches following standard survey protocols. Follow-up visits could be conducted following all detections to determine status (nonterritorial single, territorial single, pair, reproductive pair) and reproductive success. Density could be expressed in terms of crude density (number/total area of treatment unit), ecological density (number/area of habitat), and breeding pair density (number of breeding pairs/total area of treatment unit). These data would be used to: (1) assess the effects of treatment regimes on the number and reproductive success of goshawks and (2) validate and refine the first-generation habitat models at home range and landscape scales.

Diets of goshawks could be determined by collecting pellets at nest sites and roosts within known territories. These data would be used to assess temporal and spatial variation in prey use and to estimate treatment effects on diet and prey use.

American Marten Responses Potential Module

The distribution of martens within each treatment unit could be determined using presence-absence surveys. Within each treatment unit, a grid of survey sites could be established at 2-kilometer intervals, consisting of track plates and remote cameras. Repeated surveys could monitor changes in marten population distribution, relate detection patterns to management activities, and validate and refine habitat models for martens. Annual live-trapping and mark-recapture techniques could be used to estimate marten density within each treatment unit and to test the use of survey data as an index of marten abundance. Scat and prey remains collected during live trapping could be used to analyze the composition of marten diets. Data would be examined for seasonal, annual, or spatial variation in diet and used to estimate treatment effects on marten diets and prey use.

Aquatic, Riparian, and Meadow Systems Potential Module

Response variables related to the effects of treatments on aquatic, riparian, and meadow systems include in-stream and terrestrial components of these systems. Response variables

include vegetation structure and composition, water quality, erosion and sedimentation, and soil hydrologic regime, measured at multiple spatial and temporal scales. In addition, localized perturbations can have both local and landscape-level effects. Changes in water quality, water temperature, hydrologic regime, and sedimentation as a result of treatments, wildland fire, or other natural disturbances could be monitored, both at small and large scales. Responses of riparian and meadow vegetation to management activities, wildland fire, or other natural disturbances could be measured using both plot-based and remote-sensing techniques. Data on the attributes of aquatic, riparian, and meadow systems would be used to assess changes in distribution, abundance, and quality of habitat for focal aquatic and riparian species at local and landscape scales under different treatment regimes.

Socioeconomic Interests Potential Module

Potential economic response variables include costs of implementing different treatments or treatment combinations at both local and landscape scales; revenue generated by removing large- and small- diameter timber during group selection, DFPZ, and thinning treatments; estimated reductions in fire suppression costs; and changes in local economies and employment opportunities.

Analysis Methods

Specific analytical methods for each of the individual research modules are discussed in appendices addressing each module. Refer to those sections for further details.

6. Data Quality Assurance and Control

The Pacific Southwest Region's Sierra Nevada Research Center will provide the core data management services for GIS data and other project-wide data requirements for this study. All GIS data will be developed and maintained at this Center in Davis, California. These data will be made available to all study team members for use in individual analyses.

Data developed for each study module will be stored and maintained by the responsible principal investigator(s). See individual response-variable modules for details.

7. Animal Care and Use Certification and Permits

See individual response-variable modules.

8. Radio Telemetry and Communications

See individual response-variable modules.

9. Data Management and Archiving

Data Entry and Processing

Data unavailable from existing Forest Service electronic data sources will be collected using hand-held field recorders wherever possible. To ensure quality of the data entry, collected data will be uploaded soon after each field visit. The data collector will be sent a printout of the data so that he or she can check for erroneous entries. In addition, various checks (summary tables, scatter plots, and so forth) will be performed to reveal and correct more subtle recording errors.

Data Availability and Archiving

Once the research has been published, data will be available on PSW's external web site, either as a complete MS Access database or as a spreadsheet constructed from a customizable request for subsets of the data.

10. Expected Products

The researchers involved in this effort will work both as a team, examining the array of response variables in an ecosystem context, and as individual principal investigators addressing specific topics. Annual meetings will be held to review recent findings and guide subsequent coordination efforts. Annual reports, summarizing information from annual meetings, will be issued.

Findings will be published in peer-reviewed journals. These products will be prepared and submitted when the principal investigator determines that the results are ready for publication.

More detailed examination of the study data will be conducted at 5-year intervals, beginning in 2008. Principal investigators will work as a team to consider study results and make recommendations on continuing the effort. The entire research team will jointly issue a formal report on the research findings of the previous 5 years. This report will include recommendations for future work.

11. Budget, Staff, and Time Requirements

See individual response variable modules for details on staff and funding requirements.

12. Opportunities for Partnership and Collaboration

This study provides significant opportunities for partnerships. Collaboration with the National Forest System, in particular the Plumas and Lassen National Forests, is imperative.

From the inception of this study, we have closely collaborated with staff at the supervisor's office and ranger district level, and we fully expect this to continue. Two members of the Forest Service's HFQLG Implementation Team have participated in developing this study design: Dave Peters (Project Manager), and Wayne Johannson, (Monitoring Team Leader). Careful coordination with District staffs is constent. We consider District and Forest staff key partners in the execution of this administrative study.

All treatments will be executed by the Forests to their specifications. The team of principal investigators will work closely with District and Forest staffs in the execution of the treatments and coordination of field plot locations. Some of them are PSW researchers, others are university scientists and researchers from the PRBO Conservation Science.

13. External Communication and Coordination

A team of interested parties will serve as a forum for communication as the study is implemented. The composition of the team will include interested resource/land managers, researchers, or individuals who have a stake in the study and could provide a scientific contribution. Possible members could come from the National Forest System employees, USDI Fish and Wildlife Service, California Department of Fish and Game, California Department of Forestry and Fire Protection, Sierra Pacific Industries, and members of the Quincy Library Group.

Composition of the team will likely vary and change over time to fit tasks at hand. Key communication and information-sharing phases will occur during detailed study-design development, fieldwork execution, and data analysis and reporting. Team participants will be expected to gain a better understanding of the study and be able to share this information with those they represent or with whom they work.

14. Statistical Review

Throughout the development of this study design, we involved the environmental statistics unit of the PSW. The statisticians provided expertise related to the sampling design and analytical methods as well as input regarding how implementation would allow us to meet our study objectives. The Forest Service Western Research Statisticians (a group of statisticians from the three western Research Stations: PSW, Pacific Northwest Research Station, and Rocky Mountain Research Station) will provide an independent statistical review of the study.

15. Health and Safety

See individual modules for details related to health and safety.

16. NEPA Compliance (40 CFR Parts 1500-1508 & FSM 1950)

Based on the current management direction and changes in the study objectives and design, no fuels treatments are being planned specifically for the purposes of the study. The Forest Supervisors of the Plumas and Lassen National Forests will plan vegetation-management actions in accordance with objectives of the HFQLG Pilot Project. Any NEPA actions required as a result will be executed by the Plumas or Lassen National Forest.

17. Expected Outcomes

See individual study modules.

18. Literature Cited

See individual study modules.