A Proposal to the Joint Fire Science Program—Amended March 2000

Submitted as the final deliverable of a 1998 JFSP grant entitled "Developing a standard experimental design and protocol for a national study of the consequences of fire and fire surrogate treatments."

Title: A national study of the consequences of fire and fire surrogate treatments

Estimated starting date: March 20, 2000

Duration of study: 60 months

Funding support requested:	FY 2000	$2,362,135
	FY 2001	$3,023,742
	FY 2002	$2,621,653
	FY 2003	$2,619,075
	FY 2004	$2,699,796
	TOTAL	**$13,326,401**

Principal investigators:

__/s/ Phil Weatherspoon________________________________
PHIL WEATHERSPOON
PSW Research Station, USDA Forest Service
Project Coordinator (proposal preparation)

__/s/ Jim McIver ________________________________
JIM McIVER
PNW Research Station, USDA Forest Service
Network Coordinator (study implementation)

Other principal investigators: See names and affiliations on following page.

A Proposal to the Joint Fire Science Program

A NATIONAL STUDY OF THE CONSEQUENCES OF FIRE AND FIRE SURROGATE TREATMENTS

Principal Investigators—Members of Project Steering Committee:

Jim Agee
University of Washington

Jim Baldwin
USDA, FS, PSW Station

Jamie Barbour
USDA, FS, PNW Station

Frank Beall
University of California,
Forest Products Laboratory

Ralph Boerner
Ohio State University

Tim Brown
University of Nevada, Reno

Matt Busse
USDA, FS, PSW Station

Carl Edminster
USDA, FS, RM Station

Gary Fiddler
USDA, FS, Region 5

Carl Fiedler
University of Montana

Sally Haase
USDA, FS, PSW Station

Kathy Harcksen
USDA, FS, PSW Station

Mick Harrington
USDA, FS, RM Station

Ron Hodgson
California State University, Chico

Jon Keeley
USDI, USGS,
Sequoia-KC NPs

Mike Landram
USDA, FS, Region 5

Bill Laudenslayer
USDA, FS, PSW Station

John Lehmkuhl
USDA, FS, PNW Station

Jim McIver
USDA, FS, PNW Station

Bill Otrosina
USDA, FS, SO Station

Roger Ottmar
USDA, FS, PNW Station

Martin Ritchie
USDA, FS, PSW Station

Kevin Ryan
USDA, FS, RM Station

Patrick Shea
USDA, FS, PSW Station

Carl Skinner
USDA, FS, PSW Station

Scott Stephens
California Polytechnic State
University,
San Luis Obispo

Nate Stephenson
USDI, USGS,
Sequoia-KC NPs

Elaine Kennedy Sutherland
USDA, FS, RM Station

Bob Vihnanek
USDA, FS, PNW Station

Dale Wade
USDA, FS, SO Station

Tom Waldrop
USDA, FS, SO Station

Phil Weatherspoon
(project coordinator)
USDA, FS, PSW Station

Dan Yaussy
USDA, FS, NE Station

Andy Youngblood
USDA, FS, PNW Station

Steve Zack
Wildlife Conservation Society
(New York);
Humboldt State University
(California)

TABLE OF CONTENTS

-

--

EXECUTIVE SUMMARY

Introduction

Many U.S. forests, especially those with historically short-interval, low- to moderate-severity fire regimes, are too dense and have excessive quantities of fuels. Widespread treatments are needed to restore ecological integrity and reduce the high risk of destructive, uncharacteristically severe fires in these forests. Among possible treatments, however, the appropriate balance among cuttings, mechanical fuel treatments, and prescribed fire is often unclear. For improved decisionmaking, resource managers need much better information about the consequences of alternative management practices involving fire and mechanical/manual “fire surrogates.”

Long-term, interdisciplinary research thus should be initiated to quantify the consequences and tradeoffs of alternative fire and fire surrogate treatments. Both ecological and economic aspects must be included as integral components. The research needs to be experimental, rather than retrospective or correlative, to permit stronger inferences about cause-and-effect relationships. Only through such research will it be possible to determine which ecosystem functions of fire can be emulated satisfactorily by other means, which may be irreplaceable, and the implications for management. The human dimensions of the problem are also important. Treatment costs and utilization economics, as well as social and political acceptability, strongly influence decisions about treatment alternatives. Such research must be a cooperative effort, involving land managers, researchers, and other interested parties.

A team of scientists and land managers has designed an integrated national network of long-term research sites to address this need, with support from the USDA/USDI Joint Fire Science Program (http://www.nifc.gov/joint_fire_sci/index.html). The steering committee and other participants in this national “Fire/Fire Surrogate” (FFS) study represent a number of federal and state agencies, universities, and private entities, as well as a wide range of disciplines and geographic regions. The study will use a common experimental design to facilitate broad applicability of results.

Objectives

Objectives of the project are as follows:

1. Quantify the initial effects (first five years) of fire and fire surrogate treatments on a number of specific core response variables within the general groupings of (a) vegetation, (b) fuel and fire behavior, (c) soils and forest floor (including relation to local hydrology), (d) wildlife, (e) entomology, (f) pathology, and (g) treatment costs and utilization economics.
2. Provide an overall research design that (a) establishes and maintains the study as an integrated national network of long-term interdisciplinary research sites utilizing a common “core” design to facilitate broad applicability of results, (b) allows each site to be independent for purposes of statistical analysis and modeling, as well as being a component of the national network, and (c) provides flexibility for investigators and other participants responsible for each research site to augment—without compromising—the core design as desired to address locally-important issues and to exploit expertise and other resources available to local sites.
3. Within the first five years of the study, establish cooperative relationships, identify and establish network research sites, collect baseline data, implement initial treatments, document treatment costs and short-term responses to treatments, report results, and designate FFS research sites as

demonstration areas for technology transfer to professionals and for the education of students and the public.

4. Develop and maintain an integrated and spatially-referenced database format to be used to archive data for all network sites, facilitate the development of interdisciplinary and multi-scale models, and integrate results across the network.
5. Identify and field test, in concert with resource managers and users, a suite of response variables or measures that are: (a) sensitive to the fire and fire surrogate treatments, and (b) both technically and logistically feasible for widespread use in management contexts. This suite of measures will form much of the basis for management monitoring of operational treatments designed to restore ecological integrity and reduce wildfire hazard.
6. Over the life of the study, quantify the ecological and economic consequences of fire and fire surrogate treatments in a number of forest types and conditions in the United States. Develop and validate models of ecosystem structure and function, and successively refine recommendations for ecosystem management.

Research Approach

Experimental Design

The benefits of an integrated study with multiple experimental sites located around the country clearly can be enhanced if a common or “core” experimental design is utilized. The core experimental design for the FFS study—i.e., those elements of the design common to all research sites in the network—consists of common (1) treatments, (2) replication and plot size, and (3) response variables.

1. **Treatments.** The following suite of four FFS treatments will be implemented at each research site:
   1. untreated control
   2. prescribed fire only, with periodic reburns
   3. initial and periodic cutting, each time followed by mechanical fuel treatment and/or physical removal of residue; no use of prescribed fire
   4. initial and periodic cutting, each time followed by prescribed fire; fire alone also could be used one or more times between cutting intervals

   These four treatments span a useful range both in terms of realistic management options and anticipated ecological effects. The non-control FFS treatments (treatments 2, 3, and 4) must be guided by a desired future condition (DFC) or target stand condition. The DFC will be defined mainly in terms of the tree component of the ecosystem—specifying such targets as diameter distribution, species composition, canopy closure, and spatial arrangements—and live and dead fuel characteristics. The following fire-related minimum standard will serve as a starting point for DFCs throughout the FFS network:

   > Each non-control treatment shall be designed to achieve stand and fuel conditions such that, if impacted by a head fire under 80th percentile weather conditions, at least 80 percent of the basal area of overstory (dominant and codominant) trees will survive. (See full proposal for further details.)

   Given that this starting point is met for a given research site, however, the DFC can and should incorporate any additional management goals appropriate to the site and stand conditions and the expectations of resource managers and other stakeholders. Beyond the fire-related minimum standard for DFCs and the general treatment definitions given above, it is neither feasible nor desirable to prescribe detailed definitions of a core DFC or detailed treatment specifications that would apply across all research sites. Participants at each research site must provide this detail to ensure consistent application of treatments at that site.

2. **Replication and Unit Size.** Each treatment will be replicated at least 3 times at each research site, using either a completely randomized or randomized block design as appropriate to the research site. The core set of 4 treatments thus will be represented in 12 treatment units at a research site. Each of the 12 core treatment units at a research site will be 10-ha, within which core variables will be measured, surrounded by a buffer. The buffer, which is to be treated in the same way as the treatment unit it surrounds, will have a width at least equal to the height of a best site potential tree. Where feasible, the replicated units will be supplemented by much larger (200 to 400 ha or more), generally unreplicated areas treated to the same specifications, to facilitate the study of larger-scale ecological and economic/operational questions.
3. **Response Variables.** A major aspect of the common design proposed for this study is a set of core response variables to be measured at all the research sites. Core variables encompass several broad disciplinary areas, including vegetation, fuel and fire behavior, soils and forest floor, wildlife, entomology, pathology, and treatment costs and utilization economics. (A social science component probably will be linked to the study through no-cost cooperative arrangements and/or non-JFSP funding.) A corresponding set of disciplinary groups has had the responsibility for developing the core variables and associated measurement protocols, including coordinating across groups to ensure consistency, compatibility, and non-duplication of data collection efforts. Within-unit sampling of all variables will be keyed to a 50-m square grid of permanent sample points to be established and maintained in each treatment unit. Spatial referencing of all data to the grid will facilitate both spatial and cross-disciplinary analyses.

As suggested in Project Objective #2, the overall study is designed to balance the values of an integrated national network of research sites having a common design against the needs for each site to retain flexibility in addressing important local issues and in exploiting expertise and other resources available to that site. Accordingly, at the discretion of investigators, managers, and other participants involved in a given site, the core design may be augmented (provided it is not compromised) at that site by adding FFS treatments, adding one or more DFCs, adding replications, increasing treatment unit size (by increasing buffer width; the 10-ha treatment unit and core data collected within it would remain unchanged), and/or adding response variables. Except where additions to the core design are specifically justified for a given research site, we are requesting support through the Fire Science Program only for implementing the core design at each site.

Research Site Locations

In selecting research sites we developed and used the following set of criteria:

1. Site is representative of forests with a historically short-interval, low- to moderate-severity fire regime and a currently high risk of uncharacteristically severe fire.
2. Site is representative of widespread forest conditions (site characteristics, forest type and structure, treatment history) that are in need of, and likely to benefit from, fire or fire surrogate treatments, and in which such treatments are feasible.
3. Site contributes significantly to balancing the overall network in terms of regional representation and/or land ownership type.
4. Partners and cooperators are committed to and capable of participating in the program. This involves several factors, including: active support and interest in involvement on the part of partners/cooperators; available land base for the study; ability and willingness of land managers

to implement the full suite of experimental treatments successfully within required time frame, repeat treatments over time as appropriate, commit selected sites for long-term research uses, and document these commitments in amendments to long-term land management plans.
5. On federal lands, treatment costs are borne by lead agency or partner.
6. Partnerships exist across agencies and with universities, and between researchers and managers.

The proposed initial network comprises 10 main sites and 1 satellite site (satellite will have less than the full suite of core treatments):

1. Mission Creek, north-central Washington, Wenatchee National Forest.
2. Hungry Bob, Blue Mountains of northeast Oregon, Wallowa-Whitman National Forest.
3. Lubrecht Forest, University of Montana, northern Rockies, western Montana.
4. Klamath Mountains, northwestern California, one or more national forests, possibly other ownerships.
5. Blodgett Forest Research Station, University of California-Berkeley, central Sierra Nevada, California.
6. Sequoia National Park, southern Sierra Nevada, California (satellite to Blodgett Forest Research Station site).
7. Southwest Plateau, Coconino and Kaibab National Forests, northern Arizona.
8. Jemez Mountains, Santa Fe National Forest, northern New Mexico.
9. Ohio Hill Country, lands managed by the Wayne National Forest, the Ohio Division of Forestry, Mead Paper Corporation, and The Nature Conservancy, southern Ohio.
10. Southeastern Piedmont, Clemson Experimental Forest, northwestern South Carolina.
11. Florida Coastal Plain, Myakka River State Park, southwest Florida.

All of these initial sites represent forests with a historically short-interval, low- to moderate-severity fire regime. Eight sites are in western coniferous forests, ranging from the Pacific Northwest to the Southwest. These sites share the fact that ponderosa pine is an important tree component, but sites vary in composition of other conifers and differ substantially in topographic and soil parameters. Two sites are in the southeastern U.S.—one in the Piedmont and one on the Coastal Plain—and are dominated by mixtures of southern pines with hardwood understories. Rounding out the network is a site in the midwestern oak-hickory type of Ohio. Collectively, these sites comprise a network that is truly national in scope. Depending on the level of interest and support available, future sites in the same or other fire regimes may be added to the network.

For more information about the study, see: http://ffs.fs.fed.us/

BACKGROUND AND JUSTIFICATION

Introduction

Current forests in many fire-dependent ecosystems of the United States are denser and more spatially uniform, have many more small trees and fewer large trees, and have much greater quantities of forest fuels than did their presettlement counterparts (Bonnicksen and Stone 1982; Chang 1996; Harrod et al. 1998; Parker 1984; Parsons and DeBenedetti 1979). Causes include fire suppression, past livestock grazing and timber harvests, farm abandonment (especially in the south), and changes in climate (Arno et al. 1997; Skinner and Chang 1996). The results include a general deterioration in forest ecosystem integrity and an increased probability of large, high-severity wildfires (Dahms and Geils 1997; Patton-Mallory 1997; Stephens 1998; Weatherspoon and Skinner 1996). Such conditions are prevalent nationally, especially in forests with historically short-interval, low- to moderate-severity fire regimes (Agee 1991, 1993, 1994; Arno 1980; Barden 1997; Caprio and Swetnam 1993; Cowell 1998; Dieterich 1980; Guyette and Cutter 1997; Kilgore and Taylor 1979; Mutch and Cook 1996; Phillips 1999; Swetnam 1990; Taylor and Skinner 1998; Sutherland 1997; Touchan et al. 1996; Van Lear and Waldrop 1989; Waldrop et al. 1987; Wills and Stuart 1994; Wright 1996; Yaussy and Sutherland 1993). The report of the Sierra Nevada Ecosystem Project highlighted these problems and explained the need for large-scale and strategically-located thinning (especially of small trees), fuel treatment, and use of prescribed fire (SNEP 1996; Weatherspoon and Skinner 1996). A recent speech by Interior Secretary Babbitt (1997) pointed out that similar problems and the need for similar solutions are now being acknowledged by national policymakers.

The need for widespread use of restorative management practices is clear (e.g., Hardy and Arno 1996). There is broad agreement that these management practices should reduce excessive fuel accumulations and move forests more in the direction of historic structures and disturbance regimes. Less agreement exists, however, about the appropriate balance among cuttings, mechanical fuel treatments, and prescribed fire (SNEP 1996; Stephens 1998; van Wagtendonk 1996; Weatherspoon 1996). Economic and technical feasibility of various treatments across different stands and landscapes, as well as social and political acceptability, are important considerations in managers' decisions about tools to use. However, to achieve goals for ecosystem integrity and sustainability, we also need much better information about the ecological consequences and tradeoffs of alternative management practices. The frequent, low- to moderate-severity fires that characterized presettlement disturbance regimes in many of our forests affected not only overall forest structure, composition, and fuel levels, but also a wide range of other ecosystem components and processes (Agee 1993, Chang 1996). What components or processes are changed or lost, and with what effects, if “fire surrogates" such as cuttings and mechanical fuel treatments are used instead of fire, or in combination with fire? For the most part, information necessary to answer such key questions is anecdotal or absent.

Long-term, interdisciplinary research thus should be initiated to quantify the consequences and tradeoffs of alternative fire and fire surrogate treatments. Both ecological and economic aspects must be included as integral components. The research needs to be experimental, rather than retrospective or correlative, to permit stronger inferences about cause-and-effect relationships. Only through such research will it be possible to determine which ecosystem functions of fire can be emulated satisfactorily by other means, which may be irreplaceable, and the implications for management. The human dimensions of the problem are also important. Treatment costs and utilization economics, as well as social and political acceptability, strongly influence decisions about treatment alternatives. Such an effort must be collaborative, involving land managers, researchers, and other interested parties.

We propose to establish and maintain a national “Fire/Fire Surrogate” (FFS) study to quantify the ecological and economic consequences of alternative fire and fire surrogate restorative treatments in a number of forest types and conditions in the United States. (We have begun to pursue opportunities to link a social science component to the study through no-cost cooperative arrangements and/or non-JFSP funding.) The study is designed as an integrated network of long-term interdisciplinary research sites utilizing a common “core” design to facilitate broad applicability of results.

Fire Effects and Fire Regimes

This study proposes to examine alternative treatments in forests at high risk of uncharacteristically severe fires—those fires that produce effects outside the historic range of variability. First order fire effects are a direct result of exposure to fire, including both the initial flaming front of a fire and smoldering combustion after the fire has passed. The severity of fire effects is not necessarily linked to the apparent intensity of the fire, such as the height of the flames, and is rarely linked to the rate at which the fire moves. In forests having short-interval, low- to moderate-severity fire regimes, historic fire behavior was variable, but mostly consisted of surface fire that burned dead leaves, twigs, limbs and other small fuels on the surface of the ground along with herbaceous and woody vegetation. Under current conditions, which generally include altered arrangements of fuels and vegetation, many of these same forests are likely to burn with extreme fire behavior (involving torching, spotting, and crown fire), as well as higher intensity surface fire and consumptive ground fire (involving often-prolonged smoldering of accumulations of litter, duff, and large diameter fuels). Like fire behavior, fire effects have changed from those of historic fire regimes to greater severity, with excessive mortality of overstory trees and damage to soils more common. As compared with forests having long-interval, high-severity natural fire regimes, forests with low- to moderate-severity regimes experience more adverse ecological effects from high-intensity and/or highly-consumptive wildfires because these forests are not adapted to such fires. In general, such forests have been more adversely affected by fire suppression and other human influences since European settlement than forests in other fire regimes, and are in greater need of treatments to restore ecological integrity and reduce wildfire hazard.

The proposed study thus has a focus on short-interval, low- to moderate-severity fire regimes as a matter of priority. A series of recent large-scale analyses and policy papers (SNEP, Sierra Nevada RDEIS, Columbia River Basin, various WO papers, federal wildland fire policy) have asserted that the most marked changes in fire behavior and fire effects have been in forests characterized historically by frequent fire. These areas have missed more fire cycles than longer interval fire regimes. Not only do wildfires in these areas cause more detrimental ecological effects, as discussed earlier, but they also pose hazards to fire fighters and the public. Analyses of expenditures indicate that recent wildfires in forests of these types are large and costly, and are difficult or impossible to control under extreme weather conditions or during periodic droughts. Active fire seasons occur at more frequent intervals than in long-interval types, due to longer fire seasons, greater drying of fuels during the fire season (higher average temperatures) and exposure to more potential ignitions during a given fire season.

For these reasons, all of the research sites in our proposed initial FFS network represent forests with a short-interval, low- to moderate-severity natural fire regime. We feel that these are strong reasons for continuing to give these forests highest priority in the study. We recognize, however, that there may be other reasons to include some sites with long-interval fire regimes in the FFS network. Such an expansion should not be done at the expense of research sites in the high-priority fire regime.

We have also considered the possibility of further enlarging the FFS study to include non-forested vegetation types. The general approach and some aspects of the design of the FFS study might be useful if a comparable study in other vegetation types is established. However, a study in non-forested types would involve such fundamental differences in key elements to be addressed—e.g., nature of management issues and problems, nature of treatments to be evaluated, and nature of many of the response variables—that combining it with the FFS study would be difficult.

OBJECTIVES

Objectives of the project are as follows:

1. Quantify the initial effects (first five years) of fire and fire surrogate treatments on a number of specific core response variables within the general groupings of (a) vegetation, (b) fuel and fire behavior, (c) soils and forest floor (including relation to local hydrology), (d) wildlife, (e) entomology, (f) pathology, and (g) treatment costs and utilization economics.
2. Provide an overall research design that (a) establishes and maintains the study as an integrated national network of long-term interdisciplinary research sites utilizing a common "core" design to facilitate broad applicability of results, (b) allows each site to be independent for purposes of statistical analysis and modeling, as well as being a component of the national network, and (c) provides flexibility for investigators and other participants responsible for each research site to augment—without compromising—the core design as desired to address locally-important issues and to exploit expertise and other resources available to local sites.
3. Within the first five years of the study, establish cooperative relationships, identify and establish network research sites, collect baseline data, implement initial treatments, document treatment costs and short-term responses to treatments, report results, and designate FFS research sites as demonstration areas for technology transfer to professionals and for the education of students and the public.
4. Develop and maintain an integrated and spatially-referenced database format to be used to archive data for all network sites, facilitate the development of interdisciplinary and multi-scale models, and integrate results across the network.
5. Identify and field test, in concert with resource managers and users, a suite of response variables or measures that are: (a) sensitive to the fire and fire surrogate treatments, and (b) both technically and logistically feasible for widespread use in management contexts. This suite of measures will form much of the basis for management monitoring of operational treatments designed to restore ecological integrity and reduce wildfire hazard.
6. Over the life of the study, quantify the ecological and economic consequences of fire and fire surrogate treatments in a number of forest types and conditions in the United States. Develop and validate models of ecosystem structure and function, and successively refine recommendations for ecosystem management.

While objectives 1 through 4 are attainable within a 5-year period, objectives 5 and 6 emphasize the need to develop commitments that persist for longer periods. We believe that many of the most significant results of this study will be achieved when long-term data are analyzed.

Four broad hypotheses that link to the basic design of the study are given in the Experimental Design/Treatments subsection. A detailed study plan for each of the research sites in the FFS network will provide more specific objectives and hypotheses pertinent to that site concerning effects of the specific treatments on core variables and their interactions.

RESEARCH APPROACH

The first two sections that follow, which explain the benefits of two key elements of the proposed study—the experimental approach and the national network—set the stage for the subsequent sections on Experimental Design and Research Sites.

Benefits of the Experimental Approach

A long-term experimental study, especially one with the scope and complexity of the proposed FFS study, is expensive and time-consuming. A logical question is, “Why not learn what you need to know by examining previously-treated areas?” In other words, why not do a retrospective study?

We can and should exploit opportunities for learning from retrospective and anecdotal observations. Such observations can provide first approximations of needed information, and can help to fine-tune hypotheses and approaches for experimental studies. In some disciplines (e.g., paleoecology), retrospective research is the only option. However, for most of the kinds of questions being considered here—especially ecological effects of fuel management and other restorative treatments—an experimental study has significant advantages over a retrospective approach.

A retrospective study typically will involve choosing a set of treatment levels, or different treatments, at some time after treatment, and matching after the fact untreated areas to serve as a “control”. Usually there is little evidence that the controls were in fact similar to the treated areas before they were treated. Likewise, different treatments may have been applied because of initial differences in site or stand conditions, thereby confounding treatment effects. Sometimes different treatments will have been applied at widely varying times, and this can further confuse apparent treatment effects, particularly in ecological studies, if there are temporal variations in population dynamics or climate. Legitimate treatment replications are seldom available, and treatments may be largely undocumented. The lack of randomness in study design also leads to questionable inferences from parametric statistical analysis.

An experimental approach matches all potential plots before treatment, and assigns treatments randomly, or with acceptable and defined restrictions on randomization. The experiment is synchronized across space and time, and much stronger inferences can be made about cause-and-effect relationships. An additional advantage of the experimental approach within a national network is that a number of simultaneous studies are being completed within and among sites, enabling scientists to make quantitative comparisons with other studies within sites and qualitative comparisons with similar studies across sites. This is further explained in the following section.

In brief, retrospective studies are rarely as rigorous as well-designed experimental studies and may reach equivocal conclusions (Powers 1989). Considering the immense importance and likely debate over the questions addressed in this study, there is a need for rigorous experiments that offer the hope of drawing firm scientifically-based conclusions.

Benefits of a National Network of Interdisciplinary Research Sites

Network Products

Each of the study sites proposed here as part of the FFS network will address managerially important sites and forest conditions, and will use desired condition prescriptions and treatment definitions that are meaningful regionally. Each of these sites will be able to stand on its own statistically, so that valid conclusions can be reached concerning these regionally-important issues.

However, the great strength of the national network of FFS research sites is being able to draw broad inferences that transcend the boundaries of individual sites. An additional crucial value of the network approach is the synergy created by the interaction of scientists from many disciplines, backgrounds, and geographic areas. This benefit accrues at several levels, including project planning, implementation of site installations, and reporting of results. The synergistic effect of the national network is already apparent in the output of the ensemble of scientists who designed this project, but the best evidence of the value of a truly integrated network is the kind of products proposed here. At least four distinct kinds of products will result, three of which can be described as "integrated," in that they are either interdisciplinary or interregional. Such integration would not be possible from analysis of a disarticulated group of studies (Figure 1).

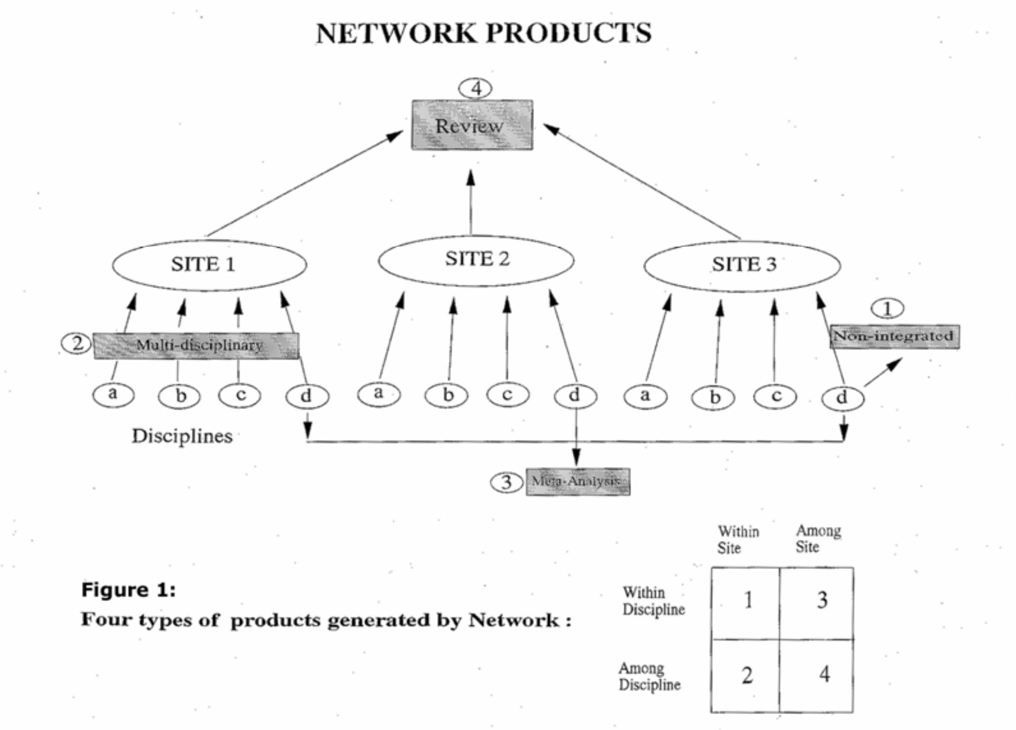

Figure 1:
Four types of products generated by Network :

The simplest product is non-integrated, being publications or other outputs from disciplinary studies at individual sites. The remaining three products are integrated, but in different ways. First, results from disciplinary studies across sites can be compared more effectively and confidently because sites share common core variables and protocols. These comparisons are most important for disciplines in which a national or regional perspective is desired. Second, results from the various disciplinary studies at each site can be analyzed together because all data at each site will be collected from a common sampling grid, at both the treatment unit and plot level. This interdisciplinary product is essential for identifying interactions among key ecological variables, such as the functional linkages among fire, bark beetles, dead trees, and cavity nesting birds. Interdisciplinary products also allow us to evaluate the effectiveness of alternative fuel reduction treatments, their ecological effects, associated costs, and consequent tradeoffs. Finally, the commonality of treatments and core variables across sites allows the periodic review, interpretation, and synthesis of all information. This will facilitate opportunities to identify and characterize emerging interdisciplinary patterns common across all sites. The network structure permits a more powerful synthesis at the national scale than cobbling together results from a group of independent studies. Because the network will emphasize monitoring, we have the potential for identifying those variables that are key to forest sustainability, and for developing more efficacious protocols to measure them.

Value of Interdisciplinary Analysis at the Site Scale—Examples

This section provides examples for one of the four products described above—interdisciplinary analysis at a given site. At the site scale, we know that numerous ecological links will be found among variables, and so we expect that treatments will cause changes not only in the individual variables, but in their relations to other variables as well. Hence for a complete elaboration of treatment effects, it will be essential to conduct interdisciplinary analysis at the site scale.

A simple example is the effect of fuel reduction treatments on down woody material used by various organisms. While fuel reduction may lower fire hazard and risk, removing down woody material will also reduce foraging habitat for birds and numerous macroinvertebrate species. Measuring both the extent of fuel reduction and its effect on biodiversity may help identify thresholds that would be useful for fine tuning management to achieve more holistic objectives. In addition, measuring belowground variables within a fuel reduction context should help us better understand the interplay between rotting wood and the soil environment. Because decomposing wood plays an obvious role in ultimately providing nutrients for plants, measuring the extent of fuel reduction, as well as soil chemistry and plant growth, should help identify ecological tradeoffs inherent in the application of management activities.

Another example that illustrates the interplay of differences in temporal effects is the expected response of bird communities to treatment. As trees are killed or injured through thinning or burning, immediate changes can be expected to occur in the quality of habitat for foraging and nesting birds. Root death or injury due to the same treatment can be expected to set into play a cascade of belowground effects including changes in N-mineralization through microbial activity, which may affect nitrogen availability and, ultimately, understory composition, density and biomass. Changes in the complexion of the understory habitat will tend to influence bird feeding and nesting in the intermediate term, and these may run counter to the immediate changes in bird habitat relations set up by the original treatment itself.

These examples illustrate only a small subset of potential links that are bound to emerge as we simultaneously investigate the response of numerous variables to fuel reduction and thinning treatments. The common core treatment and variable design of the FFS network will provide critical information on how generally applicable ecological linkages are across many similar but distant sites.

Experimental Design

The benefits of an integrated study with multiple experimental sites located around the country clearly can be enhanced if a common or "core" experimental design is utilized. The core experimental design for the FFS study—i.e., those elements of the design common to all research sites in the network—consists of common (1) treatments, (2) replication and unit size, and (3) response variables.

Treatments

The proposed FFS treatments consist of various combinations of the most common manipulative management activities utilized in forested ecosystems: cutting trees or other vegetation, using prescribed fire, and mechanically treating residues or scarifying the soil. Treatments include those that address widely-shared concerns about forest health and wildfire hazard, those that deal with environmental concerns, and those most practical from an operational standpoint. Consistent with the long-term focus of the study, treatments will be repeated periodically to represent real management approaches.

The following suite of four FFS treatments will be implemented at each research site:

1. Untreated control
2. Prescribed fire only, with periodic reburns
3. Initial and periodic cutting, each time followed by mechanical fuel treatment and/or physical removal of residue; no use of prescribed fire
4. Initial and periodic cutting, each time followed by prescribed fire; fire alone also could be used one or more times between cutting intervals

These four treatments span a useful range both in terms of realistic management options and anticipated ecological effects. They are also grounded in the four most common hypotheses for forest ecosystem restoration and management currently being discussed in both the scientific community and the broader environmental community:

> Hypothesis 1: Forest ecosystems are best conserved by passive management, with no active manipulation of ecological processes (i.e., fire) or forest structure (i.e., cutting), except for a continuation of fire suppression. Operationally this hypothesis leads to treatment 1, our untreated control.
>
> Hypothesis 2: Forest ecosystems are best conserved by restoring ecosystem processes—i.e., by reintroducing frequent, low intensity fire. This hypothesis leads to treatment 2, our prescribed fire only treatment.
>
> Hypothesis 3: Forest ecosystems are best conserved by restoring ecosystem structure—i.e., by using judicious thinning to restore density, species composition and spatial pattern of the tree component. This hypothesis leads to treatment 3, our periodic cutting treatment.
>
> Hypothesis 4: Restoration of sustainable forest ecosystems requires both structural and process

> restoration. This hypothesis leads to treatment 4, our combined burning and cutting treatment.

Cuttings in treatments 3 and 4 will be repeated at intervals appropriate to the forest type and site conditions—e.g., 20 years. Periodic prescribed burns in treatments 2 and 4 normally will be based on the best available information about presettlement fire intervals on the kinds of sites represented by the research site. Irregular rather than fixed burn intervals are preferable where supported by fire history evidence, since it seems likely that important elements of ecosystem diversity were promoted historically by natural variability in fire intervals (Agee 1993; Skinner and Chang 1996).

Definitions of the 4 FFS treatments are necessarily rather generic, and can encompass considerable variability in both cutting/mechanical and fire treatments that may significantly affect ecological responses of interest. More precise definitions would be helpful from the standpoint of reducing treatment variability among research sites. Applying uniform treatment specifications across so diverse an array of sites, however, is neither feasible nor desirable. The real world of forest ecosystems and resource management would not be represented appropriately with such a "one-size-fits-all" approach. This does, however, increase the need for (1) local replication to allow each research site to stand on its own statistically, and (2) good characterization of treatments actually applied at each research site to help explain observed differences among sites.

The non-control FFS treatments (treatments 2, 3, and 4) must be guided by a desired future condition (DFC) or target stand condition. The DFC will be defined mainly in terms of the tree component of the ecosystem—specifying such targets as diameter distribution, species composition, canopy closure, and spatial arrangements—and live and dead fuel characteristics.

There were two alternative routes we could have taken in designing the DFC characteristics. First, we could have prescribed a common set of DFCs to be implemented across the nationwide network. Such an approach would have maximized the value of the network for developing process-based ecological models. However, this approach to defining DFCs would also have resulted in our applying treatments that were well outside the reasonable range of management options in many of our network sites. Thus, such an approach would have maximized scientific elegance at the cost of management applicability.

The second alternative was not to prescribe a core DFC with any level of specificity for application across all research sites, but rather to delegate the development of DFCs for each network site to the co-operative management and science team that would be guiding the implementation of the FFS project at that site. This, we felt, would produce the best compromise between scientific elegance and management utility.

Within this management-driven framework, we agreed on a fire-related minimum standard or "least common denominator" to will serve as a starting point for DFCs throughout the FFS network. That standard is based on predicted effects of a hypothetical wildfire occurring on the site after treatments have been implemented:

> Each non-control treatment shall be designed to achieve stand and fuel conditions such that, if impacted by a head fire under 80th percentile weather conditions, at least 80 percent of the basal area of overstory (dominant and codominant) trees will survive. The definition of 80th percentile weather conditions will be based on an analysis of fire season conditions, calculated for mid-afternoon, over a period of 10 to 20 years at the closest fire weather station. The

prescription to implement the treatment will be developed based on fire behavior modeling (e.g., FARSITE) and predicted fire effects. Effects will be predicted using techniques such as FOFEM (First Order Fire Effects Model) and/or other modeling efforts that may include expert opinion.

The standard presumes the retention of a viable residual stand following treatment. Thus, clearcutting would not be an acceptable treatment option. In many cases, early treatments may take the form of some variation of thinning from below (or the equivalent via a series of burns), since this often addresses the greatest short-term restoration need. In the long-term, however, provisions will need to be made for recruitment of tree regeneration and development of a sustainable age-class structure.

Because of vegetation growth and fuel accretion, treatments will need to be repeated periodically for the standard to continue to be met. In most cases, surface fuels will require retreatment—by fire or mechanical techniques, as appropriate to the treatment type—more often than stand structure.

Participants at each research site will define a DFC (and associated treatment prescriptions and retreatment schedules) that meets this fire-related standard. Given that this standard is met, however, the DFC can and should incorporate any additional management goals appropriate to the site, to stand conditions, and to the expectations of resource managers and other stakeholders. For sites that employ a randomized block design with blocks that differ significantly in site or stand conditions, DFC could vary somewhat among the experimental blocks within a research site. It is important for a DFC to be well-defined, and implemented using a specific prescription to ensure consistency among treatment plots.

Although the common link of DFC's across all research sites is fire-related, the consequences that the study is designed to investigate are broadly ecological. Assuming the same starting point of stand and fuel conditions, moving toward a given DFC using FFS treatment 2 (fire only) clearly will be a much less precise process than using FFS treatments 3 and 4 (cuttings) and will also require a number of successive burns. Some desired changes in stand structure—e.g., "thinning" relatively large trees without doing excessive damage to the overall stand—may not be feasible. However, skilled and innovative use of prescriptions, firing techniques, and other methods such as stage burning should, over several successive burns, permit considerable progress toward most DFCs using prescribed fire alone. It should be noted that opportunities for significant reshaping of stand structure—e.g., killing groups of trees to create openings—may be greater with initial relatively heavy fuel loads than after most fuels have been consumed.

Replication and Plot Size

Replication at each research site is necessary to allow each site to be analyzed independently. As part of the core experimental design, each treatment will be replicated 3 times at each research site, using either a completely randomized or randomized block design as appropriate to the research site. The core set of 4 treatments thus will be represented in 12 treatment units at a research site.

The decision to adopt 3 replications as one element of the core (minimum) design was part of an overall compromise balancing several aspects of experimental design against costs. We recognize that 3 replications may prove to be marginal or even inadequate for some variables with large variance. Each site, therefore, should take necessary measures to maximize the probability of keeping all 3 replications intact. These should include, for example, (1) providing for appropriate amendments to management plans to ensure that future incompatible management activities do not impinge on the research site, and (2) providing an adequate fuel treatment buffer around treatment units or the entire research site to minimize chances of losses from wildfire. Site participants also should be aware of the option for replacing or adding replications in the future if the need exists and funding is available. One or more additional replications can be analyzed statistically along with the original replications provided that all of them sample the same population (see Research Sites/Site and Unit Location subsection). Ideally, treatment units constituting any later replications would be drawn from the same pool of potential units used to select the original units.

Each of the 12 core treatment units at a research site will be 10-ha, within which core variables will be measured, surrounded by a treated buffer. The 10-ha size is a compromise between advantages of smaller units (e.g., reduced costs, reduced within-unit variability) and those of larger units (e.g., need to represent natural variability in stands and in DFC(s) at a more nearly operational scale, need to accommodate some larger-scale ecological responses). Size of treatment units and appropriate core response variables are closely related and interdependent. To keep the perimeter-to-area ratio low and reasonably consistent, the length-to-width ratio should not exceed 1.5.

The buffer, which is to be treated in the same way as the treatment unit it surrounds, will have a width at least equal to the height of a best mature site potential tree. A 30-m treated buffer, for example, would bring the total size of the treatment unit to about 14 ha. Local participants may decide to adopt wider buffers than the minimum specified. Furthermore, it is left to participants at each research site to determine appropriate separation of treatment units and the nature of treatment (or nontreatment) in the matrix between units.

We recognize that many aspects of wider-ranging wildlife species, fisheries, watershed-scale hydrology, other landscape-level responses, and some economic and social questions can be studied at the 10-ha scale only indirectly—e.g., via habitat attributes and modeling methods. Where feasible at a given research site, two additional approaches may help in addressing larger-scale issues: (1) Larger replicated treatment units (i.e., larger buffers) can be used, provided that the core 10-ha units are embedded within them and are utilized for measurement of core response variables. Additional, larger-scale variables could then be measured on the larger treatment units. (2) The 10-ha replicated units can be augmented with much larger (200 to 400 ha or more), generally unreplicated areas nearby treated to the same specifications. These large treatment areas could provide useful information concerning operational-scale economics and practicability, as well as larger-scale ecological responses, especially if linked to the smaller replicated units via appropriate models.

Response Variables

A major aspect of the common design proposed for this study is a set of core response variables to be measured at all network sites, using common measurement protocols to the extent possible and a consistent within-unit sampling approach. Other responses certainly can be studied at one or more sites, depending on interests and available expertise and resources. The proposed research is designed to be open-ended in terms of scientific disciplines and associated response variables that can be accommodated. For example, we have begun to pursue opportunities to link a social science component to the study through no-cost cooperative arrangements and/or non-JFSP funding.

Several members of our steering committee have been serving as disciplinary group leaders with responsibility for developing major groups of response variables (Table 1). Each group leader has worked with a team of people with appropriate expertise to identify a core set of response variables that would be measured consistently across all research sites. Their activities also have included cross-group coordination to ensure consistency, compatibility, and non-duplication of data collection efforts. We anticipate that their responsibilities will continue into the implementation phase of the project to ensure that data collection protocols are followed consistently at all the sites. (Where deviations from common measurement protocols are necessary for specific variables, they will be documented and justified.) This may include training, oversight of field crews, or other measures as appropriate.

Table 1. Disciplinary groups and group leaders.

Vegetation
Jon Keeley, USGS, Sequoia-Kings Canyon National Parks

Fuel and Fire Behavior
Sally Haase, PSW Station, and Bob Vihnanek, PNW Station

Soils and Forest Floor
Ralph Boerner, Ohio State University

Wildlife
Steve Zack, Wildlife Conservation Society

Entomology
Patrick Shea, PSW Station

Pathology
Bill Otrosina, SO Station

Treatment Costs and Utilization Economics
Jamie Barbour, PNW Station

Details of the core response variables and measurement protocols are included as Appendices A-1 and A-2, respectively.

Within-unit sampling of all variables will be keyed to a 50-m square grid of permanent sample points to be established and maintained within each treatment unit. Any number of grid points in a treatment unit may be utilized for a given variable depending on the nature and appropriate intensity of sampling for that variable. Spatial referencing of all data to the grid will facilitate spatial analyses in conjunction with planned acquisition and analysis of high-resolution digital orthophotography and utilization of a GIS-based data base. Co-location (or consistent proximity) of multi-disciplinary data facilitated by use of the grid also will promote analyses that should elucidate cross-disciplinary relationships and suggest interdisciplinary hypotheses.

Augmenting the Core Design

As suggested in Project Objective #2, the overall study is designed to balance the values of an integrated national network of research sites having a common design against the needs for each site to retain flexibility in addressing important local issues and in exploiting expertise and other resources available to that site. Accordingly, at the discretion of investigators, managers, and other participants involved in a given site, the core design may be augmented (provided it is not compromised) at that site by adding FFS treatments, adding one or more DFCs, adding replications, increasing treatment unit size (by increasing buffer width; the 10-ha treatment unit and core data collected within it would remain unchanged), and/or adding response variables. Except where additions to the core design are specifically justified for a given research site, we are requesting support through the Fire Science Program only for implementing the core design at each site.

Research Sites

Criteria for Site Selection

As discussed earlier, a network of research sites using a common experimental design has the potential for synergistic output far exceeding what could be accomplished by a series of separate, uncoordinated studies. In selecting research sites we have developed and used a set of criteria (Table 2). All sites identified in this proposal—the initial sites in the network—have met or will meet the criteria given in Table 2.

Table 2. Criteria used in site selection.

1. Site is representative of forests with a historically short-interval, low- to moderate-severity fire regime and a currently high risk of uncharacteristically severe fire. (See Appendix B-1: Representative Land Base, Fire History.)
2. Site is representative of widespread forest conditions (site characteristics, forest type and structure, treatment history) that are in need of, and likely to benefit from, fire or fire surrogate treatments, and in which such treatments are feasible. (See Appendix B-1: Contemporary Fire Hazard.)
3. Site contributes significantly to balancing the overall network in terms of regional representation and/or land ownership type. (See Appendix B-1: Introduction to Site Descriptions.)
4. Partners and cooperators are committed to and capable of participating in the program. This involves several factors, including: active support and interest in involvement on the part of partners/collaborators; available land base for the study; ability and willingness of land managers to implement the full suite of experimental treatments successfully within required time frame, repeat treatments over time as appropriate, commit selected sites for long-term research uses, and document these commitments in amendments to long-term management plans. (See Appendix B-1: Prior Work, Level of Long-Term Interest.)
5. Partnerships exist across agencies and with universities, and between researchers and managers. (See Appendix B-1: Partnerships.)

Proposed Initial Sites

The network comprises 10 main sites and 1 satellite site (Table 3). Summary descriptions of all sites are provided in Appendix B-1. The main sites are all located on forest types with a prior cutting history and will implement the full suite of treatments (see Experimental Design section). The satellite site is in "old growth" forest with no historical cutting, and will limit treatments to different seasons of prescribed burning plus untreated control. The satellite site, Sequoia National Park, is linked to the Blodgett Forest Research Station site, which is implementing the full experiment on a similar forest type.

Seven of the main sites plus the satellite site are in western coniferous forests, ranging from the Pacific Northwest to the Southwest. These sites all share the fact that ponderosa pine is an important tree component, but sites vary in composition of other conifers and differ substantially in topographic and soil parameters. Two sites are in the southeastern U.S.—one in the Piedmont and one on the Coastal Plain—and are dominated by mixtures of southern pines with hardwood understories. Rounding out the network is a site in the midwestern oak-hickory type of Ohio. Collectively, these sites compose a network that is truly national in scope. Represented in this network is a mixture of land ownerships, including federal, state, university experimental forests, and private holdings.

All sites are similar in that the lead agency and site coordinator are committed to interdisciplinary research of the type proposed here and have expressed enthusiasm for continuing the program beyond the expected timeframe of JFSP funding.

The status of planning and implementation vary significantly among sites. One site (Hungry Bob, Oregon) is already established, and is compatible in design with this proposal. Some sites are prepared to implement (or begin) treatments as soon as late 2000 or early 2001, whereas others will be phased in 1 to 3 years later (see Appendices B-1 and B-2 for site timelines). This has important budget implications as it will stagger the initial and annual costs for the sites, thereby reducing average per-site costs over the 5-year proposal period.

We recognize that the proposed initial network does not represent all forest types and conditions with serious fire hazard and forest health problems. However, its composition is a reasonable compromise considering the widespread need for the information, anticipated availability of funding, and available expertise and commitment. It is our expectation that the network will provide us with widely applicable results. We see the possibility that additional sites will be included in the network as other agencies or landowners see the value of this approach. Possibilities for using the FFS study as a model for similar international studies have been discussed.

Table 3. Proposed initial research sites and principal contacts.

Mission Creek, north-central Washington, Wenatchee National Forest.
Contact: James K. Agee, University of Washington.

Hungry Bob, Blue Mountains of northeast Oregon, Wallowa-Whitman National Forest.
Contacts: James McIver, Andy Youngblood, PNW Research Station.

Lubrecht Forest, University of Montana, northern Rockies, western Montana.
Contacts: Carl Fiedler, University of Montana; Michael Harrington, RM Research Station.

Klamath Mountains, northwestern California, one or more national forests, possibly other ownerships.
Contacts: Carl Skinner, Gary Fiddler, and Phil Weatherspoon, PSW Research Station.

Blodgett Forest Research Station, University of California-Berkeley, central Sierra Nevada, California.
Contacts: Scott Stephens, California Polytechnic State University, San Luis Obispo; Bob Heald, Blodgett Forest Manager.

Sequoia National Park, southern Sierra Nevada, California (satellite to Blodgett Forest Research Station site).
Contacts: Jon E. Keeley and Nathan L. Stephenson, USGS, Sequoia-Kings Canyon Field Station; Anthony C. Caprio, NPS, Sequoia-Kings Canyon National Parks.

Southwest Plateau, Coconino and Kaibab National Forests, northern Arizona.
Contact: Carl Edminster, RM Research Station.

Jemez Mountains, Santa Fe National Forest, northern New Mexico.
Contact: Carl Edminster, RM Research Station.

Ohio Hill Country, lands managed by the Wayne National Forest, the Ohio Division of Forestry, Mead Paper Corporation, and The Nature Conservancy, southern Ohio.
Contacts: Daniel A. Yaussy, Todd Hutchinson, NE Research Station; Elaine Kennedy Sutherland, RM Research Station.

Southeastern Piedmont, Clemson Experimental Forest, northwestern South Carolina.
Contact: Thomas A. Waldrop, SO Research Station.

Florida Coastal Plain, Myakka River State Park, southwest Florida.
Contacts: Thomas A. Waldrop, SO Research Station; Robert Dye, Park Manager; Dale D. Wade, SO Research Station.

Site and Treatment Unit Location

Given that the criteria in Table 2 are met, several factors have been or will be considered in selecting specific locations for long-term research sites and treatment units. Land managers, scientists, and other collaborators involved with a particular site have the responsibility for deciding specifically where it should be located. The process of coming to agreement on the characteristics and location of the research site, in fact, should be a major opportunity for the various stakeholders to initiate a productive partnership.

The first step in the process is to describe the area and range of conditions to which inferences from that site are desired—the *target population.* The target population, which will be defined uniquely for each research site, generally should consist of widespread forest conditions (site characteristics, forest type and structure, treatment history) that are in need of fire or fire surrogate treatments, and in which such treatments are feasible (Table 2). The target population will be defined in terms of acceptable ranges of site and forest attributes such as slope, aspect, elevation, geology and soils, and vegetation condition. Riparian zones as defined locally should be excluded to the extent (e.g., for various stream classes and riparian zone widths) that they would not be (presently or in foreseeable future) available in that region for at least a modified version of all of the FFS treatments. Formally designated roads should be excluded, although poorly defined tracks, skid trails, etc. probably would be included.

The subset of the target population that is actually available for installing experimental treatments is the *sampled population.* One reason that the sampled population normally will be much smaller than the target population has to do with commitment and capability of land managers and other partners (Table 2). Potential treatment units (see Experimental Design section) will be identified within the sampled population. Each potential unit must be capable of accepting any of the proposed treatments, not just a particular treatment and not just a control. Finally, units will be randomly drawn from the available pool of potential units, and then randomly assigned to treatments. If unit locations need to be balanced with respect to some factor such as aspect, blocking should be considered. If blocking is used, unit selection and treatment assignment will be done randomly within blocks, and subsequent data analyses must account for the blocking factor.

Where the target population is characterized by a preponderance of submerchantable, low-value trees needing treatment, site and unit locations should not be biased toward less common stand conditions in which removal of merchantable trees will pay for the overall treatment. Similarly, research sites in physiographic provinces characterized mainly by steep slopes should be located on such slopes, despite the additional costs and complexities involved. Treatments and site locations should reflect "real world" constraints that often include treatments with a net negative financial return. Land managers for most sites (Table 3) have agreed to contribute the costs of planning and implementing treatments. On federal lands, appropriated fuel treatment funds (the better-informed use of which the Fire Science Program is designed to support) may be nationally earmarked to cover the costs of treatments with a net negative financial return. In this regard, the study will include a component to investigate utilization options, treatment costs, and overall economics.

Statistical Analysis

The basic analysis for the experiment is the oneway analysis of variance using an F-test for overall treatment differences. Tukey's test for all possible pairwise comparisons could be used irrespective of the outcome of the F-test. Presenting confidence intervals will allow readers to make their own decisions about interpretation of results.

The whole treatment unit, not the plot, is the unit of replication for making inferences about treatments. However, grid system-based subplots may provide opportunities for evaluating effects of "degrees of severity" of treatments—e.g., differences in localized severity of prescribed burns—assuming such treatment severity is characterized for each grid point or plot. Having many variables from several disciplines keyed to the same grid points may also facilitate cross-disciplinary analyses and may help to account for effects of local site variability. Spatial referencing of all data offers many possibilities for analyses using the still-developing techniques of spatial statistics. Use of more advanced statistical techniques needs to be carefully thought out and reviewed on a case-by-case basis.

Network Management

Oversight and Administration

Given the substantial benefits of a national FFS network, it is essential that the network be maintained over time and that its integrity not give way to a collection of separate, uncoordinated studies. A network-wide oversight and management function is needed for this purpose. We propose the following two-tiered structure.

The project will be managed under a structure comprising two committees. The first is the Science/Management Integration Committee (SMIC), which consists of site managers and disciplinary group leaders (Table 4).

Table 4. The Science Management Integration Committee

Site Managers	
Mission Creek	James Agee, University of Washington, Seattle, WA
Hungry Bob	Andy Youngblood, PNW Station, La Grande, OR
Lubrecht	Carl Fiedler, University of Montana, Missoula, MT
Klamath Mts.	Carl Skinner, PSW Station, Redding, CA
Blodgett	Scott Stephens, Cal-Poly, San Luis Obispo, CA
Sequoia	Jon Keeley, USGS, Three Rivers, CA
SW Plateau	Carl Edminster, Rocky Mt. Station, Flagstaff, AZ
Jemez Mts.	Carl Edminster, Rocky Mt. Station, Flagstaff, AZ
Ohio Hill Country	Dan Yaussy, NE Station, Delaware, OH
SE Piedmont	Tom Waldrop, Southern Station, Clemson, SC
Florida Coastal Plain	Ken Outcalt, Southern Station, Athens, GA
Discipline Group Leaders	
Vegetation	Jon Keeley, USGS, Three Rivers, CA
Fuels	Sally Haase, PSW Station, Riverside, CA
Soils	Ralph Boerner, Ohio State University, Columbus, OH
Wildlife	Steve Zack, Wildlife Conservation Society, Portland, OR
Pathology	Bill Otrosina, PSW Station, Athens, GA
Entomology	Patrick Shea, PSW Station, Redding, CA
Economics	Jamie Barbour, PNW Station, Portland, OR

The second is a five-member Executive Committee (EXEC), selected by the SMIC and consisting of a network manager, two disciplinary group leaders, and two site managers. The first EXEC consists of the network manager (Jim McIver), the soils group leader (Ralph Boerner), the wildlife group leader (Steve Zack), the SE Piedmont site manager (Tom Waldrop), and the Klamath site manager (Carl Skinner). Each EXEC member will serve 2 years, with one disciplinary group leader and one site manager rotating in each year. The Executive Committee is responsible for project oversight, distribution of funds, and reporting to the Joint Fire Science Program Governing Board. This will require a close working relationship with both the Science/Management Integration Committee and the Governing Board. The Executive Committee will be responsible for approving release of funds by the Governing Board or JFSP Program Manager to individual sites, based on recommendations from the SMIC. In addition, the Executive Committee will serve in an outreach or liaison role communicating the importance, uniqueness, and substantive outcomes of the FFS project to members of government, industry, non-governmental organizations, and the general public. As part of its outreach function, the Executive Committee will investigate the potential benefits of adapting for the FFS project the kind of successful support structure developed by the "Silvicultural Systems Project," established in the mid-1980s in the Australian state of Victoria (Powers 1999, Squire et al. 1991).

At the outset of the project, the Science/Management Integration Committee will be responsible for soliciting from the site managers comprehensive study plans that will guide study implementation and document details of the study at each site. Each study plan will include specific objectives and hypotheses pertinent to that site, detailed descriptions and justifications of each treatment and of the DFC for that site, and specifics on implementing the sampling protocols for the core variables. SMIC will review the study plans and work with site managers as needed to bring the study plans into conformance with FFS guidelines. The SMIC will be responsible for recommending sites to the Executive Committee for initial and continued funding. In addition, over the course of the funding period SMIC will be responsible for ensuring that: (1) site-level studies are progressing according to project guidelines, (2) data collection protocols and analysis remain consistent and state-of-the-art, (3) data are properly archived and managed, and (4) integration is occurring at all levels.

This organizational structure reflects the integrated nature of the proposed network. The responsibilities outlined above are critical to guaranteeing that the network functions as a whole, in terms of both interactions among participants at all scales, and in terms of the three types of integrated products planned (Fig. 1). Furthermore, this structure ensures continuity of the network through time, as participants come and go.

Quality control is the province of all participants in the study. Disciplinary group leaders and field personnel have the responsibility to develop and implement standardized methods across sites and across time based on appropriate study plans. Site managers have the responsibility to ensure that data are collected appropriately and are effectively entered and maintained in local databases. Oversight of data collection may be entirely by the site manager or through interaction with disciplinary team leaders if national data teams are used by a discipline. The SMIC and Executive Committee ensure final oversight to the data collection and storage process. They also have the responsibility to recruit replacement personnel as necessary to ensure the viability of each discipline and site through the life of the experiment.

Annual Network Meetings

To ensure network cohesiveness and foster interchange of data and ideas, an annual network meeting will be held at one of the network research sites. All site managers and disciplinary team leaders are expected to attend these meetings, with other project scientists, local forest managers, and members of the public invited as appropriate. The annual meetings will include updates on progress from the site managers, presentation of research results from selected sites, technical consultation sessions in which disciplinary team leaders will share information on emerging methodologies, and a field trip to the host research site. The results of these annual meetings will be disseminated to the entire FFS network community by the network database manager.

Database Management

As with network-wide project management, database management is also a requirement for the long-term integrity and viability of the project. A database manager will be designated to coordinate development of a common, uniform, corporate database structure to be used at all sites. This structure will include definition of necessary metadata. The SMIC (previous section) will have oversight responsibility for the work of the database manager and the integrity and management of the corporate database.

All data entered into the database will be spatially registered. Spatial referencing of data facilitates multi-scale spatial and temporal analyses to reveal important relationships not otherwise detectable at the scale of the core unit size. Using a spatial database will allow integration of data and findings across scientific disciplines. The use of a spatially referenced database also makes additional low-cost data such as orthophotos, satellite imagery, and digital elevation models more readily accessible. Relocation and remeasurement of units will be facilitated with geo-referenced coordinates.

Site managers will be responsible for updating the database within one year of data being collected. The SMIC will control access to the data within the database. Public access will be limited until there has been opportunity for site-specific and network-wide analysis of the data. Network access to the data will be handled by the site managers. The site managers will make summary statistics available to the network as they become available or are requested by the executive committee. All data will be released to the network within five years of collection and be made available for network-wide analysis and modeling. Source code for models developed under the FFS network will be treated like data for purposes of release to the network.

SUMMARY BUDGET

The budget proposed below (Table 4) covers a 5-year period—FY 2000 through FY 2004. Given the scope of the FFS project and the several years required for site-specific planning (including NEPA work on federal sites), unit establishment and layout, pretreatment data collection, treatment implementation, and early post-treatment data collection, reasonable assurance of continued funding for 5 years is necessary to proceed with the project. (We recognize, however, that funding is likely to come 1 year at a time, assuming that the Governing Board approves the proposal.) We anticipate that needs for JFSP funding beyond the initial 5 years will decrease significantly (assuming no additional sites) because (1) data collection frequency for core variables will lessen, and (2) the network should be in a position to attract more non-JFSP funds.

The budget consists of two parts. Part A, the larger of the two, is a summary of individual site budgets. Detailed budgets for the sites are shown in Appendix B-2. Contributed costs for each site are also indicated. Most of the sites, including all of those on federal land, are not requesting JFSP funds for treatment implementation. We are assuming that arrangements can be made to have federal appropriated fuel treatment funds earmarked to cover treatment costs on FFS research sites on federal land, where needed.

Each site budget in Appendix B-2 includes indirect costs. Indirect cost calculations for the sites are based first on the assumption that funds for each site will go directly to the primary performing organization at that site (following approval by the FFS Executive Committee, as described in the previous section), with no prior overhead assessment. If funds are distributed in a different manner, so that this assumption does not hold, some adjustment in funding may be necessary to accommodate a different indirect assessment environment. The last page of Appendix B-2 shows more specific assumptions for each site, based on JFSP guidelines on indirect costs and policies of the various organizations involved in the work at each site.

Part B consists of network-wide costs incurred to establish and maintain the integrity of the network and not attributable to individual sites. Indirect costs of 15% are added to the Part B budget in Table 4.

The JFSP salary policy is strictly followed. No funding is requested for salaries of permanent full-time federal employees or university faculty on 12-month appointments.

Table 5. Proposed budget.

A. Summary of Site Budgets

Site	FY00	FY01	FY02	FY03	FY04	Site Totals
Mission Creek	469,169	209,196	52,275	401,333	199,181	**1,331,154**
Hungry Bob	164,186	189,681	74,186	111,113	196,424	**735,590**
Lubrecht Forest	175,542	249,371	316,648	219,234	197,986	**1,158,781**
Klamath Mountains	35,947	241,653	402,490	186,459	305,452	**1,172,001**
Blodgett Forest Research Sta.	54,505	355,966	296,605	344,653	239,532	**1,291,261**
Sequoia National Park	11,903	335,477	246,732	149,385	266,996	**1,010,493**
Southwest Plateau	261,800	99,000	313,500	27,500	302,500	**1,004,300**
Jemez Mountains	22,000	290,400	104,500	347,600	33,000	**797,500**
Ohio Hill Country	322,822	274,773	131,022	111,421	261,096	**1,101,134**
Southeastern Piedmont	255,356	241,664	171,655	214,602	210,346	**1,093,623**
Florida Coastal Plain	296,920	263,060	236,150	223,964	199,375	**1,219,469**
Totals	**2,070,150**	**2,750,241**	**2,345,763**	**2,337,264**	**2,411,888**	**11,915,306**

Summary of Contributed Costs by Site

Site	FY98/99	FY00	FY01	FY02	FY03	FY04	Site Totals
Mission Creek		118,000	103,100	39,000	103,750	66,300	**430,150**
Hungry Bob	233,860	106,000	95,640	33,293	33,959	34,638	**537,390**
Lubrecht Forest		74,260	96,828	109,167	77,753	72,240	**430,248**
Klamath Mountains		47,099	150,513	92,216	62,772	87,828	**440,428**
Blodgett Forest Research Sta.		64,155	95,665	58,703	59,775	68,379	**346,677**
Sequoia National Park		19,100	34,300	32,370	26,050	28,205	**140,025**
Southwest Plateau		357,500	93,600	230,000	42,000	294,700	**1,017,800**
Jemez Mountains		42,000	229,600	85,000	231,800	42,000	**630,400**
Ohio Hill Country		244,718	244,671	234,470	240,826	257,722	**1,222,407**
Southeastern Piedmont		112,658	115,658	69,403	87,139	76,031	**460,889**
Florida Coastal Plain		141,604	178,850	127,684	175,706	119,624	**743,468**
Totals	**233,860**	**1,327,094**	**1,438,425**	**1,111,306**	**1,141,530**	**1,147,667**	**6,399,882**

B. Network Coordination and Administration Budget

	FY00	FY01	FY02	FY03	FY04
<u>Network Manager and Database Manager</u>					
Salary and Benefits					
Network manager (GS-14, 50% time)	48,000	49,440	50,923	52,451	54,024
Database manager (GS-11, 50% time)	29,000	29,870	30,766	31,689	32,640
Travel, Equipment, Supplies, and Network Services	40,000	35,000	20,000	20,000	20,000
Total	**117,000**	**114,310**	**101,689**	**104,140**	**106,664**
<u>Annual Network Meeting</u>					
Travel (3-day meeting, 20 participants)	**18,000**	**18,540**	**19,096**	**19,669**	**20,259**
<u>Network-Level Disciplinary Expenses</u>					
Vegetation	**0**	**0**	**0**	**0**	**0**
Fuel and Fire Behavior					
Travel for training and oversight	**15,000**	**10,000**	**10,000**	**10,000**	**10,000**
Soils and Forest Floor	**0**	**0**	**0**	**0**	**0**
Wildlife					
Salary, PI (Wildlife Conserv. Soc., 33% time)	20,000	20,600	21,218	21,855	22,510
Salary, national crew leader (50% time)	19,200	19,776	20,369	20,980	21,610
Travel for training and oversight	25,000	20,000	12,000	12,000	12,000
Computer and software	8,000	0	0	0	0
Data analysis (collab. with Humboldt State Univ.)	0	8,000	8,000	8,000	8,000
WCS overhead (additional needed to provide 11.51% after 10% on pass-through from FS)	4,700	4,451	4,009	4,091	4,174
Total	**76,900**	**72,827**	**65,596**	**66,926**	**68,294**
Entomology					
Travel for training and oversight	**7,000**	**7,000**	**7,000**	**7,000**	**7,000**
Pathology					
Travel for training and oversight	**15,000**	**10,000**	**10,000**	**10,000**	**10,000**

	FY00	FY01	FY02	FY03	FY04
Treatment Costs and Utilization Economics (analyses done centrally)					
Coordinate site level economic analysis (PNW Station)	0	0	26,523	27,318	28,138
Coordination among discipline group and outside groups performing regional economic analyses	5,000	5,150	0	0	0
Total	**5,000**	**5,150**	**26,523**	**27,318**	**28,138**
Total	**118,900**	**104,977**	**119,119**	**121,244**	**123,432**
Total Direct Costs—Part B	**253,900**	**237,827**	**239,904**	**245,053**	**250,355**
Indirect Costs (15%)	**38,085**	**35,674**	**35,986**	**36,758**	**37,553**
Total Funding Requested—Part B	**291,985**	**273,501**	**275,890**	**281,811**	**287,908**
Total Funding Requested—Part A	**2,070,150**	**2,750,241**	**2,345,763**	**2,337,264**	**2,411,888**
TOTAL FUNDING REQUESTED BY YEAR	**2,362,135**	**3,023,742**	**2,621,653**	**2,619,075**	**2,699,796**
TOTAL FUNDING REQUESTED FOR 5 YEARS	**13,326,401**				

DELIVERABLES

By the end of calendar year 2000, we will develop a communications plan that will provide details of technology transfer for each site and for the network as a whole. The communications plan will identify each relevant audience, describe messages to be sent, and identify a medium for delivering each message. Among other things, this process will help insure that messages delivered to managers in particular are packaged in the most useful format. To develop the communications plan, each site manager will first brainstorm ideas at the site level, and will then participate in an integrated process of communication plan development at the 2nd annual SMIC meeting (fall 2000). Examples of site level technology transfer products include a radio talk show (Mission Creek), public field tours (Hungry Bob), a public demonstration area (Ohio Hill Country), and a video for SC-ETV (SE Piedmont). For the network as a whole, we have already developed a web site and slide show, and will add a brochure and video as well. We also plan to invite USFS, BLM, NPS managers and state foresters to each of the annual SMIC meetings, to participate in any information exchange, including a planned field trip. For accountability purposes, the Network Manager will present a yearly report to the Governing Board, describing progress and accomplishments of each site, and of the network as a whole. The first annual accomplishment report to the Governing Board will include as appendices the latest draft of the overall project study plan, and the communications plan.

Additional short-term and long-term deliverables are derived from the project objectives identified earlier. Some key deliverables for the short-term ($\leq$3 years post-treatment) and mid- to long-term (3-10 years post-treatment) are indicated below. Since the primary audience for deliverables in forest managers, we also include a section on current management contacts for the sites coming on line in fiscal year 2000.

Short-Term

Within three years of implementation of treatments across all sites, the disciplinary groups and site representatives will meet to share data at a workshop centered on main treatment effects detected in the short-term. At this point each of the disciplines will have summarized core variable information from each site and so have the opportunity to compare and contrast patterns across sites and with other disciplines. This workshop will allow the team to identify those emerging interdisciplinary patterns common across all sites. It will also represent an opportunity to recognize those issues (variables) that are not amenable to generalization, and instead are affected more by the particulars (e.g., latitude, topography, site conditions, plant communities) of each site. Examples of potential general patterns might include correlations between bark-beetle infestation and woodpecker community response, common effects on ground-nesting bird productivity following prescribed fire relative to controls or fire surrogates, change in the relative cover of grass and forbs as a function of treatment, and efficiency of alternative fuel treatments in meeting stated objectives.

Other short-term deliverables include: (a) establishment of collaborative relationships, (b) identification and establishment of network research sites, (c) collection of baseline data, (d) application of initial experimental treatments, (d) documentation of treatment costs and short-term responses to treatments (see workshop described above), (e) reporting of results, (f) designation of research sites as demonstration areas for technology transfer to professionals and for the education of students and the public, and (g) a georeferenced network database. We expect treatment cost data and the demonstration value of plots with alternative fire and fire surrogate treatments to be particularly useful short-term outputs.

Mid- to Long-Term

Within this time frame a wide range of ecological and economic consequences of fire and fire surrogate treatments will emerge. All four kinds of network products discussed earlier (Fig. 1) will be produced, including a range of models elucidating ecosystem structure and function. Relevance of the research results to resource managers will be emphasized in these products, and successively refined recommendations for ecosystem management will be provided as appropriate. This information will be documented and provided to users in publications, workshops, and a variety of other technology transfer modes.

Monitoring of operational treatments designed to improve forest health and reduce wildfire hazard is necessary for evaluating their effectiveness in meeting management objectives and identifying other changes in ecosystems brought about by the treatments. Developing standard monitoring protocols that can be used across agencies, geographic areas, and vegetation and fuel types would facilitate regional or national assessments of responses to fuel treatments. One of the planned products of the FFS study is the development of such monitoring protocols, in cooperation with managers and users, for forested areas to which the FFS network is applicable. We will derive monitoring protocols from a suite of field-tested response variables or measures that are: (a) sensitive to the fire and fire surrogate treatments, (b) cost-efficient, and (c) both technically and logistically feasible for widespread use in management contexts.

The FFS network will provide a unique integrated set of experimental studies whose value may increase with time. The sound, common experimental design, together with a geo-referenced database of many layers of interdisciplinary, interrelated data, should attract the participation of a variety of future scientists and managers. Once the study is established and productive, these same factors also should attract funding from a variety of sources, thereby multiplying the early investment by the JFSP.

Management Representation

From its inception, we have developed the Fire-Fire Surrogates Study as a national ‘management experiment’, in which realistic management treatments are implemented, and variables important to managers are measured. Thus the primary audience for the project is forest managers, and they will be involved at every level during each step of project development. At the present time, we can present a list of key management contacts for each site that is planning to begin work in fiscal year 2000:

Key Management Contacts

Mission Creek

Glenn Hoffman, Richy Harrod, Bill Gaines (Leavenworth District)
Sonny O’Neal (Wenatchee Forest Supervisor)

Hungry Bob

Mike Piazza, Bill Smergut (Wallowa Valley District)
Karen Woods (Supervisor), Jimmy Roberts, John Szymoniak (Wallowa-Whitman NF)
Steve Howes (Region 6)

Lubrecht Forest

Rolan Becker (Salish and Kootenai Tribes)

Tom Daer (BLM-Missoula District)
Tim Love (Seeley Lake Ranger District)
Steve Martin (Lewis and Clark National Forest)
Craig Nelson (Clearwater State Forest)
Gordy Sanders (Montana Tree Farmers)

SW Plateau

Jim Golden (Supervisor, Coconino National Forest)
Gene Waldrip (Ranger, Peaks District)
Conny Frisch (Supervisor, Kaibab National Forest)
Susan Skalski (Ranger, Williams/Chalender District)

Ohio Hill Country

Ron Abraham (Zaleski and Tar Hollow State Forests)
Don Karas (State Forests Land Manager)
Wayne Lashbrook (Land Steward), Walt Smith, Steve Mathey (Mead Paper Company)

SE Piedmont

Skip Burdette (SC State Commission of Forestry)
Mary Strayer, Hugh Still (SC Department of Natural Resources)
Steve Perry, Knight Cox (Clemson University Forest Management)
Jeff Allen (Strom Thurmond Institute)

Florida Coastal Plain

Robert Dye (Myakka State Park Manager)

The line officers identified at each site comprise a “contact committee” of managers, to whom relevant information will be passed as sites develop. Other key contacts include those managers whose services are critical to the establishment and maintenance of sites.

LITERATURE CITED -- TEXT

Agee, J.K. 1991. Fire history along an elevational gradient in the Siskiyou Mountains, Oregon. Northwest Science 65: 188-199.

Agee, James K. 1993. Fire ecology of Pacific Northwest forests. Washington, D.C. Island Press; 493 p.

Agee, J.K. 1994. Fire and other disturbances of terrestrial ecosystems in the eastern Cascades. USDA Forest Service General Technical Report PNW-GTR-344.

Arno, S.F. 1980. Forest fire history of the northern Rockies. J. Forestry 78: 460-465.

Arno, S.F., Smith, H.Y., and M.A. Krebs. 1997. Old growth ponderosa pine and western larch stand structures: Influences of pre-1900 fires and fire exclusion. USDA For. Serv. Intermtn. Res. Sta. Res. Pap. INT-RP-495. 20 p.

Babbitt, Bruce. (A coordinated campaign: fight fire with fire). 1997. Unpublished speech by U.S. Secretary of the Interior Bruce Babbitt at Boise State University, Idaho, February 11, 1997.

Barden, Lawrence S. 1997. Historic praries in the Piedmont of North and South Carolina, USA. Natural Areas Journal. 17(2):149-152.

Bonnicksen, Thomas M.; Stone, Edward P. 1982. Reconstruction of a presettlement giant sequoia-mixed conifer forest community using the aggregation approach. Ecology 63: 1134-1148.

Caprio, A.C., and T.W. Swetnam. 1993. Historic fire regimes along an elevational gradient on the west slope of the Sierra Nevada, California. USDA Forest Service GTR INT-320. pp. 173-179.

Chang, Chi-ru. 1996. Ecosystem responses to fire and variations in fire regimes. In: Sierra Nevada Ecosystem Project: Final report to Congress. Vol. II Assessments and Scientific Basis for Management Options. Wildland Resources Center Report No. 37. Davis: Centers for Water and Wildland Resources, University of California; 1071-1099.

Cowell, C. Mark. 1998. Historical change in vegetation and disturbance on the Georgia Piedmont. American Midland Naturalist. 140:78-89.

Dahms, C.W.; Geils, B.W., tech eds. 1997. An assessment of forest ecosystem health in the Southwest. General Technical Report RM-GTR-295. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 97 p.

Dieterich, J.H. 1980. Chimney Spring forest fire history. Research Paper RM-220. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p.

Guyette, R. P., and B. E. Cutter. 1997. Fire history, population, and calcium cycling in the Current River watershed. 11th Central Hardwood Forest Conference. S. G. Pallardy, R. A. Cecich, H. G. Garrett, and P. S. Johnson, 355-72. St. Paul, Minnesota: USDA, Forest Service, North Central Forest Experiment Station.

Hardy, Colin C.; Arno, Stephen F. (eds.). 1996. The use of fire in forest restoration: a general session at the annual meeting of the Society for Ecological Restoration. General Technical Report INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station; 86 p.

Harrod, R.J., B.H. McRae, and W.E. Hartl. 1998. Historical stand reconstruction in ponderosa pine forests to guide silvicultural prescriptions. Forest Ecology and Management 96.

Kilgore, B.M., and D. Taylor. 1979. Fire history of a sequoia mixed conifer forest. Ecology 60(1): 129-142.

Mutch, Robert W.; Cook, Wayne A. 1996. Restoring fire to ecosystems: methods vary with land management goals. In: Hardy, Collin C.; Arno, Stephen F., technical coordinators. The use of fire in forest restoration. General Technical Report INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station; 9-11.

Parker, Albert J. 1984. A comparison of structural properties and compositional trends in conifer forests of Yosemite and Glacier National Parks, USA. Northwest Science 58: 131-141.

Parsons, David J.; DeBenedetti, Steven H. 1979. Impact of fire suppression on a mixed-conifer forest. Forest Ecology and Management 2: 21-33.

Patton-Mallory, M. 1997. Southwest wildland/urban interface fire risk reduction workshop, Flagstaff, AZ, August 4-5, 1997. Unpublished summary report on file. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

Phillips, C. 1999. Fire return intervals in mixed-conifer forests of the Kings River Sustainable Forest Ecosystem Project area. USDA Forest Service PSW GTR (in press).

Powers, R. F. 1989. Retrospective studies in perspective: strengths and weaknesses. p. 47-62. In: Dyck, W. J.; Mees, C. A., eds. Research strategies for long-term site productivity. Proceedings, IEA/BE A3 Workshop, Seattle, WA, August, 1988. IEA/BE A3 Report No. 8. Forest Research Institute, New Zealand, Bulletin 152.

Powers, Robert F. 1991. If you build it, will they come? Survival skills for silvicultural studies. Forestry Chronicle 75: 367-373.

Skinner, Carl N.; Chang, Chi-ru. 1996. Fire regimes, past and present. In: Sierra Nevada Ecosystem Project: Final report to Congress. Vol. II Assessments and Scientific Basis for Management Options. Wildland Resources Center Report No. 37. Davis: Centers for Water and Wildland Resources, University of California; 1041-1069.

SNEP. 1996. Sierra Nevada Ecosystem Project: Final report to Congress. Vol. I, Assessment summaries and management strategies. Wildland Resources Center Report No. 36. Davis: Centers for Water and Wildland Resources, University of California; 209 p. +plates.

Squire, R. O.; Flinn, D. W.; Campbell, R. G. Silvicultural research for sustained wood production and biosphere conservation in the pine plantations and native eucalypt forests of south-eastern

Australia. p. 3-28. In: Dyck, W. J.; Mees, C. A., eds. Long-term field trials to assess environmental impacts of harvesting. FRI Bull. No. 161, IEA/BE T6/A6 Rep. No. 5. Ministry of Forests, Forest Research Inst., Rotorua, NZ.

Stephens, S.L. 1998. Effects of fuels and silvicultural treatments on potential fire behavior in mixed conifer forests of the Sierra Nevada, CA. Forest Ecology and Management 105: 21-34.

Sutherland, E. K. 1997. The history of fire in a southern Ohio second-growth mixed-oak forest. Proceedings, 11th Central Hardwood forest conference, Editors S. G. Pallardy, R. A. Cecich, H. E. Garrett, and P. S. Johnson, 172-83. St. Paul, MN: USDA Forest Service North Central Forest Experiment Station.

Swetnam, T.W. 1990. Fire history and climate in the southwestern United States. p.6-17. In: Krammes, J.S., tech. coord. Effects of fire management of southwestern natural resources. Proceedings of the symposium, Nov. 15-17, 1988, Tucson, AZ. General Technical Report RM-191. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 293 p.

Taylor, A.H.; Skinner, C.N. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management 111: 285-301.

Touchan, R.; Allen, C.D.; Swetnam, T.W. 1996. Fire history and climatic patterns in ponderosa pine and mixed-conifer forests of the Jemez Mountains, Northern New Mexico. p. 33-46. In: Allen, C.D., tech. ed. Fire effects in southwestern forests: Proceedings of the second La Mesa Fire symposium, 1994 March 29-31; Los Alamos, New Mexico. General Technical Report RM-GTR-286. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 216 p.

Van Lear, David H.; Waldrop, Thomas A. 1989. History, use, and effects of fire in the Appalachians. Gen. Tech. Rep. SE-54. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 20 pp.

Van Wagtendonk, J.W. 1996. Use of a deterministic fire growth model to test fuel treatments. In: Sierra Nevada Ecosystem Project, Final Report to Congress. Vol. II Assessments and Scientific Basis for Management Options. Wildland Resources Center Report No. 37. Davis: Centers for Water and Wildland Resources, University of California; 1041-1069.

Waldrop, Thomas A; Van Lear, David H.; Lloyd, F. Thomas; Harms, William R. 1987. Long-term studies of prescribed burning in loblolly pine forests of the Southeastern Coastal Plain. Gen. Tech. Rep. SE-45. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 23 pp.

Weatherspoon, C.Phillip. 1996. Fire-silviculture relationships in Sierra forests. In: Sierra Nevada Ecosystem Project, Final Report to Congress. Vol. II Assessments and Scientific Basis for Management Options. Wildland Resources Center Report No. 37. Davis: Centers for Water and Wildland Resources, University of California; 1167-1176.

Weatherspoon, C.Phillip; Skinner, Carl N. 1996. Landscape-level strategies for forest fuel management. In: Sierra Nevada Ecosystem Project: Final report to Congress. Vol. II Assessments and Scientific Basis for Management Options. Wildland Resources Center Report No. 37. Davis: Centers for Water and Wildland Resources, University of California; 1471-1492.

Wills, R.D.; Stuart, J.D. 1994. Fire history and stand development of a Douglas-fir hardwood forest in northern California. Northwest Science 68: 205-212.

Wright, C.B. 1996. Fire history of the Teanaway Valley, Washington. M.S. thesis, University of Washington, Seattle.

Yaussy, D. A., and E. K. Sutherland. 1993. Fire history in the Ohio River Valley and its relation to climate. 12th Conference on Fire and Meteorology: Fire, Meteorology, and the Landscape, 777-86. Bethesda, MD.: Society of American Foresters.

APPENDIX A-1
Core Variables

Introduction

The overall goal of this project is to establish a national network of research sites in which the ecological and economic consequences of different forest fuel treatments (fire and fire surrogates) will be determined. For such a network to function in a manner that facilitates cross-ecosystem, integrated research, a common set of core variables must be measured at each site using a common sampling protocol and set of methods. In this section, we list and justify the core variables to be measured in each of the seven disciplinary areas we have identified.

Vegetation

The vegetation component of the larger project has been designed for the long term because forest response to treatment occurs at four levels that demand long-term research and monitoring (Franklin 1989): (i) slow processes, such as forest succession; (ii) sensitivity to rare episodic events, such as weather extremes and insect outbreaks; (iii) high intra- and inter-annual variability, such as changes in reproduction, growth, and death driven by both "normal" and changing climatic regimes; and (iv) complex phenomena where multivariate analysis is required to separate pattern from noise, a consequence of the interactions of the preceding three characteristics. Within this context, each network site team will measure and project the consequences of the different treatments on the following:

Stand Structure and Composition, both because trees are keystone life forms which create or greatly influence habitat for all other forest organisms, and because trees have great amenity and commodity value to humans.

Stand Function (e.g., aboveground productivity) because productivity tells us the rate at which future forest products are produced, the rate at which carbon and other elements are being sequestered, and the rate at which new fuels are being generated.

Stand Stability and Resilience, because forests have great amenity and commodity value to humans. Forest stability and resilience can be viewed as components of the vaguer term "forest health." Stability and resilience are more easily inferred from stand structure and function than directly measured.

Shrub and Herb Layer Structure and Composition, because understory vegetation is important as habitat and food sources for other forest organisms, and because the understory plants are important components of the aesthetics for which humans often visit such sites.

Shrub and Herb Layer Function, because the plants that comprise these understory strata are important in the fuel complex and in fixing atmospheric nitrogen that subsequently supports productivity in the tree layer.

The specific core variables that will be sampled in order to meet those needs will be:

Forest Structure

Tree (>1.37 m height) and seedling/sapling density by species
Tree status (live or dead)
Tree height
Tree dbh
Tree crown cover and condition
Tree height to live and dead crown
Snag and log distribution
Bole scarring and crown condition
Product age
Shrub and herb cover
Shrub and herb biomass (where it contributes to fuels)

Forest Composition
Species density at 0.1 ha scale

Forest Function
Change in tree dbh

Landscape Pattern
Gap/patch distribution

NOTE: For practical reasons, species-level resolution of shrub and herb layer plant taxa usually will be limited to vascular plants. Taxonomic expertise in non-vascular species is usually more difficult to come by, and non-vascular species are a minor component of many forested ecosystems. However, non-vascular plants may be important components of the understory of some forested ecosystems, requiring identification to the species level when possible.

Fuel and Fire Behavior

The primary goals of the fuel and fire behavior analysis are to characterize the changes in fuel loading resulting from fire and fire-surrogate treatments at each research site, and to document fire behavior during the fire treatment applications. Ground, surface, understory, and overstory fuels will be measured before and after treatment and at specified times throughout the length of the study. In addition, fuel moisture content, fire behavior measurements, and fire weather data will be collected at the fire treatment application sites.

The fuel components to be measured are:

Ground Fuels: These are the L, F, and H forest floor layers, often called litter and duff. The forest floor is a vital element in relating effects of the fire treatment to soil, vegetation, smoke production, and other components of the study. Fire severity and behavior are directly related to the consumption of this fuel component.

Surface Fuels: This includes down dead woody fuels, herbaceous vegetation, and low shrubs. This component constitutes a large fraction of the biomass available for fire consumption. Not only will some of the woody fuel component be consumed by the fire treatment, but additional woody fuel will also be generated by both the fire and fire surrogate treatments. One measure of success of the treatments in reducing wildfire risk will be the amount of woody fuel remaining on the site after the application of the treatments.

Understory Fuels: This includes standing shrubs and saplings (both live and dead). The significance of the live fuel contribution to fire spread and degree of consumption of this fuel component will vary among ecosystems.

Overstory Fuels: This includes the standing live and dead trees and tall shrubs. These fuels are important in determining crown fire potential. Changes within this fuel component among treatments will determine the success or failure of the treatment application in reducing wildfire risk.

Other Fuel-related Variables: Fuel moisture content, fire behavior, and fire weather parameters are not fuel bed components, but have a direct relationship to potential fire effects on the fire treatment sites.

The specific fuels variables to be measured are:

Ground Fuels
- L-layer (newly cast litter),
- F-layer (litter beginning to break down yet still identifiable)
- H-layer (humus consisting of unidentifiable organic material)

Surface Fuels
- Coarse woody debris
- Ground-level plant biomass

Understory Fuels
- Live and dead shrub and sapling biomass

Overstory Fuels
- Standing live and dead biomass of trees and tall shrubs
- Vertical and horizontal distribution of overstory fuels

Fire Behavior
- Fuel moisture
- Fire weather
- Flame length
- Rate of spread
- Smoldering duration

Note: We acknowledge that other variables, such as smoke emissions and soil heating, are of value in assessing effects of treatments that include prescribed fire. These are not included as core variables in this study, however, because of their cost and/or complexity. Smoke emissions models are available for many of the ecosystems proposed in this study, and they can be used to estimate the smoke factor. Individual site managers may want to include such additional variables if warranted by local importance and availability of expertise and other resources.

Soils and the Forest Floor

The forest floor and soils component of the larger study has been designed to determine the consequences of different fuel management treatments on key aspects of forest floor and soil structure, function, biogeochemistry, and biodiversity. Fuel accumulates on the forest floor as a consequence of the balance between detrital production by the vegetation, and decomposition and mineralization by organisms in the soil, and oxidation of fuels by fire. The chemical, physical, and biological status of the soil determines to a great extent the rate of primary production, and feedbacks among vegetation, forest floor, and soil processes determine the rates at which dead plant materials are recycled. In addition, the forest floor protects the underlying soil from compaction and erosion and moderates runoff during snowmelt and heavy precipitation events. Thus, one cannot expect to predict the long term effects of various fuel reduction treatments on the forest ecosystem without understanding the direct effects of those treatments on the forest floor and soil as well as the manner in which the feedbacks among vegetation and soil components are altered. Within this context, each network site team will measure and project the consequences of the different treatments on the following:

Forest Floor Mass, Depth, and Organic Matter/Nutrient Capital: Not only does the organic matter comprising the forest floor mass supply a significant part of the fuel for wildfire, this organic material plays a number of other keystone roles in the forest ecosystem, including: insulating the soil from extremes of moisture and temperature, storage and recycling of essential macronutrients (e.g. Ca, P, Mg, K, N), sequestering C and N derived from the atmosphere through primary production, determining the potential range of "safe site" conditions for seed germination and seedling growth, and supplying habitat for a range of vertebrate and invertebrate animals.

Mineral Soil C, N, and Macronutrients: Nutrient availability is one of the major controls on plant productivity. Understanding how the various fuel treatments will affect both standing pools of key nutrients and the rates at which they are made available through the activities of the soil biota are both critical to the prediction of the long term effects of the fuel treatments. The quantity and quality (e.g. C:N ratio) of soil organic matter regulates many of the microbial processes that determine nutrient availability, either directly or through its effect on other soil organisms. Finally, in many cases, a significant proportion of the organic C and N in soils is found in compounds that are highly recalcitrant. Thus, these pools may represent important and long-term mechanisms for the sequestering of C and N from the atmosphere.

Mineral Soil Physical and Hydrologic Properties: The physical properties of surface soils help determine whether precipitation that penetrates the canopy will infiltrate into the soil and be available for biological processes or run off the surface and impact on water quality. The physical properties of the soil also affect root growth, seedling germination, microbial activity, and soil faunal activities, and an understanding of how the treatments affect these properties is important to understanding the long term impact on the vegetation. In particular, the degree of compaction of the soil surface caused by harvesting equipment and the proportion of the mineral soil surface that is directly exposed to the atmosphere by harvesting and fire must be measured to determine the impacts on soil physical properties. These soil physical properties are also closely linked to local hydrology as the physical properties of the mineral soil and forest floor determine to a great extent the balance between infiltration, evaporation, and surface runoff. Although it is not logistically feasible to monitor hydrology at a watershed scale in this project, we anticipate that an understanding of the effects of the various treatments on these forest floor and soil physical properties will yield considerable insight into their likely effects on hydrology at the local scale.

Forest Floor and Soil Biodiversity: It is clear that soil microbes (e.g. bacteria, fungi, actinomycetes) and soil fauna (e.g. microarthropods, nematodes) play key roles in the organic matter and nutrient dynamics of the forest floor and soil, and thereby, help regulate primary production and fuel accumulation. Although there are some insights into how the abundances of these broad groups affect ecosystem processes, little is known about the importance of their biodiversity to ecosystem function and few links have been established between taxonomic biodiversity of soil organisms and ecosystem processes. As an alternative, one might adopt a functional approach to the measurement of soil biodiversity by assessing how the treatments affect the abundance of groups of organisms with clearly identifiable functional roles (e.g. nitrifying bacteria, plant pathogenic nematodes, lignin-degrading fungi), the by-products of the activity of those organisms (e.g. stable exoenzymes), or the diversity of carbon sources that can be degraded by the resident microbial community (i.e. BIOLOG plates). Given the wide diversity of ecosystem types in the network and the broad range of existing studies of one or more of these biodiversity indicators already on-going in network sites, we have opted not to specify any one core variable for soil biodiversity as a strict requirement for all sites..

Initial Site Characterizations: In addition to those core variables directly related to the fuel management treatments, we must also conduct initial site characterizations in each of the plots within each study area, including the full range of standard taxonomic and morphological measurements.

The specific core variables that will be sampled in order to meet those needs will be:

Forest floor and soil organic matter and nutrient capital
- Mass
- C, N by forest floor horizon

Mineral soil chemistry (sampling by depth or horizon, depending on specific site characteristics)
- C, N
- Macronutrients and pH

Soil nutrient availability
- Nitrogen mineralization in forest floor and mineral soil
- Nitrification in mineral soil

Soil physical properties
- Bulk density of the top 20 cm
- Exposure of mineral soil

Soil biodiversity assessment

Initial site characterization
- Standard morphological and taxonomic survey methods
- Texture measured by depth

Note: Many other soil and forest floor variables could be measured in order to gain greater insight into the ecological effects of the fuel treatments on these ecosystems. Those which were discussed seriously, but which did not make the core variable list because of financial or logistic constraints included •soil water movement and leaching, using lysimetric analysis; •semi-permanent instrumenting for soil moisture and temperature; analysis of hydrophobicity; and decomposition of forest floor materials.

Wildlife

It is important to the overall goal of this project to complete a qualitative and, where possible, quantitative assessment of the effect of fire and fire surrogates on the bird and mammal fauna across the network. Evaluating potential general patterns of the avian, small mammal, and herpetofaunal community responses to fire and fire surrogate treatments is especially central to the needs of National Forests when undertaking environmental impact assessments in support of plans for active management of forests. Further, evaluating the fire and fire surrogate treatments in relation to snag generation and sustainability is critically important to wildlife management concerns in coniferous forests.

We are particularly interested in how populations respond numerically (the abundance issue from above) and, among birds, how a particular foraging guild responds functionally ("bark-gleaners" and how they forage on trees in response to the treatments). Among the birds, our emphasis will be on the foraging "guilds" (woodpeckers, "bark-gleaners", "leaf-gleaners", etc.) that seem to have phylogenetic coherence across the coniferous forests of North America. We will evaluate possible cause-effect relationships of abundance, diversity, nest productivity, and the functional response of bark-gleaners to the fire and fire-surrogate treatments relative to controls.

Among the mammals, *Tamias* chipmunks, *Tamiasciurus* tree squirrels, *Sciurus* squirrels, and *Spermophilus* ground squirrels should be regular diurnal species interacting directly (in cavities, in coarse woody debris, feeding on mast) with forest trees across all sites. The nocturnal mammals should be dominated by *Peromyscus* (and in particular *P. maniculatus*) deer mice. We expect the abundance and diversity of these groups to reflect closely the effects, indirect and direct, of fire.

The herpetofauna is not expected to be phylogenetically consistent among the network sites, nor do we anticipate strong community fidelity among this group of organisms. At this time, it is less clear how this group of animals will respond to the fire and fire surrogate treatments.

Within this context, each network site team will measure and project the consequences of the different treatments on the following:

Vertebrate species diversity: Emphasis will be on species which colonize sites in response to fire/fire and those that tend to disappear following treatment

Changes in vertebrate abundance:: Shifts in abundance of each species in response to the treatments will be assessed both over the short term (1-2 yr) and longer term (5+ yr).

Bird nest productivity: Knowing how the production of avian young/nest changes in response to the fire/fire surrogate treatments is key to predicting longer term demographic effects.

Bird Functional responses: How will the "bark-gleaners" respond to trees as foraging substrates as a response to treatments? Fire will inevitably contribute to mortality in some trees. Evaluating how woodpeckers respond to fire (and how other bark-gleaners choose among trees) is one direct way of evaluating wildlife response to prescribed fire across coniferous forests. As dying and dead trees are those excavated for cavities by woodpeckers, understanding the spatial and temporal aspects of this process of decay and cavity-generation by woodpeckers is important for sustainable management of wildlife in forests.

Note: The approach used for analyzing the bird functional responses will be coordinated with that used for assessing bark beetle dynamics (detailed in the next section). The sampling protocol will be designed to match the status (time since infection, source of infection) of bark beetle-infected trees with woodpecker foraging patterns and drilling patterns in order to closely correlate tree mortality with onset of cavity excavation. For woodpeckers and the other bark-gleaners, the tag number of the individual tree utilized during foraging observations to later correspond bird utilization patterns with tree characteristics will be noted. Sampling for micro-habitat variables associated with nest-site choice in birds and the micro-habitat near our small mammal and herp trapping sites will be coordinated with those designed to establish overall plant community composition and structure on a per site basis.

Entomology

Invertebrates are also key elements in the forest ecosystem, and have what are typically considered as positive factors (e.g. facilitating wood decay, pollinator service) and negative factors (e.g. bark beetles) for forest management. Prescribed fire is commonly viewed as the most commonly-used management tool for improving forest health and reducing wildfire risk. Although wildland fires have been shown to predispose residual trees to attack by bark beetles (Amman and Ryan 1991), little research has been done on the effect of different types of prescribed fire or on combinations of fire and other treatments on predisposition to attack by bark beetles and secondary insects. In addition, virtually no detailed research has been done on the effect of prescribed fires and/or thinning on populations of insect (numbers of species or individuals) inhabiting coarse woody debris (CWD). Thus, the goal of this segment of the overall fire and fire surrogates study is to develop an understanding of how the various treatments are likely to affect both the positive and the negative roles that these insects play in ecosystem processes.

To achieve this goal, each site team will measure the following:

Bark beetle-caused tree mortality: Determine whether there is a significant increase or decrease in percent mortality/ha/year, by insect species and tree species. This will also involve determining the degree of cambial injury/bark scorch, because of the importance of these as indicators of susceptibility of trees to infestation.

Interactions between bark beetles and secondary insects, and between bark beetle activity and cavity dependent wildlife species: This involves determining the suitability and acceptability of fire killed trees and bark beetle killed trees to cavity dependent wildlife species

Abundance and Diversity of entomofauna that utilize down coarse woody debris (CWD): We need to determine if the various treatments induce an increase or decrease in populations (numbers of individual or numbers of species) of insects dependent on CWD, as well as the effect on biodiversity of entomofauna in CWD. We will also evaluate possible interactions between CWD entomofauna and birds and small mammals

Pathology

The primary goal of the pathology component of the larger study is to determine pathological dynamics and their impact on forests resulting from fuel management treatments. Fire can affect the soil fungal community and forest pathogens in a number of ways. Fire influences on pathogen epidemiology range from direct effects on inoculum density, inoculum viability, and wound/fire scar infection to indirect effects such as influences on stand composition, vigor, changes in soil microbial communities, and changes in woody debris and litter accumulation.

Reintroduction of fire or fire surrogate treatments to fire suppressed forest ecosystems may result in novel pathological and entomological problems due to what is defined as an “exotic ecosystem” effect (Otrosina 1998). Such an effect arises from disturbances, previous cultural practices, soil degradation, or altered fire periodicity (suppression). In relation to the incidence and severity of pathogens, exotic ecosystems are often characterized by increased mortality associated with root infecting fungi not normally regarded as primary pathogens. Because forest tree root pathogens are powerful drivers of forest ecosystems, influencing stand dynamics and succession in various forest types, knowledge of fire effects on below ground pathological processes are essential for predicting long-term effects of various fuel reduction treatments on forest ecosystems (Piirto et al. 1998). Therefore, given budget constraints, the following key pathological component is identified as critical to meeting the goals of this proposal.

Assessment of root disease incidence and impact: Root disease fungi, as key drivers of conifer forest ecosystems, can influence productivity and stand composition both directly and indirectly. Recent research suggests that prescribed burning may lead to increased incidence of root infecting fungi (Otrosina 1998).

Fungi involved in root disease and associated mortality and productivity losses belong to diverse taxonomic groups and are likely to vary considerably among the network sites. These taxa have various modes of pathogenicity, ranging from opportunistic colonizers to primary pathogens.

Some root infecting fungi, such as the Ophiostomoid complex fungi, may be indicators of stress or abnormal ecosystem function (Otrosina et al. 1997). This group of fungi is isolated with increasing frequency in longleaf pine ecosystems of the eastern U.S. where prescribed burning is conducted following longer than normal periods of fire absence (Otrosina, 1998). Another aspect of importance relative to Ophiostomoid fungi is they are generally associated with insects, which directly vector them or are incidentally associated with infection by these fungi through wounding.

A devastating root disease in east-side ponderosa and Jeffrey pine ecosystems is caused by a fungal species, *Leptographium wageneri*, belonging to this group. Little is known of fire effects on this disease and the insects associated with its spread. It is therefore essential to assess presence of poorly understood insects such as root feeding bark beetles (e.g., *Hylastes* sp.) that may vector this and similar fungi. Understanding these relationships will enable a pro-active approach to be taken relative to fuel treatment effects in various ecosystems, both from a disease risk assessment perspective and from its use as indicators of ecosystem function. Study of these insects and the fungi they may carry can be coupled to the Entomology Sub-component.

Yet other fungi, such as *Heterobasidion annosum*, are woody root pathogens that cause mortality in conifer ecosystems worldwide (Otrosina and Cobb 1989). In most ecosystems, effects of fire and other disturbances on incidence of root disease caused by these fungi are unknown. Because root diseases predispose trees to bark beetle attack, it is especially imperative we gain an understanding of the effects fuel treatments have on the fungi that cause root diseases.

Note: The earlier version of this proposal included studies of fine root damage and fungal biomass/productivity as keystone core variables. The mandate to drastically reduce the budget resulted in these core variables being deleted from the proposal. The steering committee believes that studies of fine root production, function, and damage should be parts of both the pathology component and the forest floor/soil component, and the hope that scientists involved in this project will seek funding outside FFS to complete this work was expressed at several steering committee meetings.

Treatment Costs And Utilization Economics

There are economic costs and benefits associated with reducing fuel loadings whether this happens through uncontrolled wildfires, prescribed natural fire, prescribed burning, mechanical removals of coarse fuels, or some other means. If silvicultural cutting (thinning, improvement cuts, regeneration harvest, etc.) is part of the management strategy then materials removed might help offset treatment costs. Information developed under the Treatment Cost and Utilization Economics discipline area will help policy makers and resource managers choose alternatives that balance ecological and social concerns with the budgetary realities of implementing treatments. Integrating this work with the other discipline areas included in the FFS study strengthens the analysis by allowing comparisons that are not possible when cost and revenue data are collected in separate studies.

Questions associated with reduction of fire hazard, improved forest health, or efficient utilization of the types of materials removed in fuels reduction treatments must ultimately be addressed at scales larger than those studied by the FFS project. We intend to structure our data to make them useful for analyses that aggregate treatments across larger land areas. This regional analysis will not be conducted under the FFS Project. Stand level data collected under the FFS Project will, however, make these regional analyses possible by generating information usable by separately funded projects aimed at these broader regional or national questions. Mechanisms to transfer this information are rapidly developing or are already in place. For example, members of the Treatment Cost and Utilization Economics Group have established sources of support for this work including separate JFSP funding (Barbour et al., 1999), cooperative projects with the USDA Forest Products Laboratory (Ince and Blattner, 1999), and several other relationships between universities and government agencies (e.g., California FPL Biomass Project). We will not attempt to explicitly evaluate tradeoffs between the treatments implemented on the various sites and other values, e.g., hunting, recreation, water, etc. Barbour et al. (1999) does, however, include an assessment of the capabilities within the profession to conduct research in this topic area and results from that assessment will be used in the analysis of costs associated with treatments on the FFS study sites.

The site level analysis conducted here will center on treatment methodology and costs, quantity of removed materials, and the value of and potential uses for removed materials. Potential trade-offs among the costs and financial benefits associated with fire, mechanical removals, and combinations of the two will be addressed at the stand level and should reflect the full cost of implementation including program administration costs incurred by the agencies.

Methods for collecting data under the FFS Project are also structured to allow a stand level meta analysis among sites within the FFS Project. This analysis will highlight areas of concern or sources of efficiency by identifying financial tradeoffs at the stand level associated with different management actions intended to reduce fire hazard and improve forest health.

Within this context, each network site team will work with members of the Treatment Cost and Utilization Economics group to develop measures of treatment costs and estimates of the types and quantity of materials removed. These data will be collected in a format suitable for both the site level and meta-analyses.

Validate existing silvicutural cutting cost simulation model using compartment-level data.
Compartment-level harvest productivity data will be collected for each function e.g., felling, skidding, forwarding, etc. Where feasible, information will be collected on multiple operational compartments at each site so that more data points will be available. The data will include operating hours for each compartment, and scale (volume and/or weight) information for all products removed from each compartment. The between-compartment variation of factors such as average tree size and slope will provide more information than would a single data point for each unit. In many cases, the area served by a single landing would make an easily identified compartment.
OR
Use an expert opinion survey approach to develop harvest and treatment costs applicable to the forest types and conditions needing treatment. This process will develop regional estimates of costs associated with implementation of operational-scale silvicultural cutting and/or prescribed burning

program. This will be the only method used to estimate the cost of prescribed burning treatments.

The decision of which of these methods for assigning silvicultural cutting costs is most appropriate for each site will be made based on consultations between Site Leaders and the Treatment Cost and Utilization Economics group. In some cases, it may be desirable to collect cost data using both methods.

Estimate amount (volumes or weight) and value of materials removed by diameter and species. The pre-treatment inventory of the overstory and understory vegetation at each site and will allow the estimation of removal proportions to be incorporated into the prescription. Data will be collected, as appropriate, on a site by site basis to validate these estimates.

Estimate the effects of burning on tree mortality and wood quality as related to salvage value. This will be done as part of the post-treatment vegetation sampling.

One of the central economic questions posed to the Joint Fire Sciences Program is whether management actions implemented today will reduce the costs associated with future management and in the process provide increased or decreased benefits to humans in the form of goods and services removed from the forest. The work proposed here under Treatment Costs and Utilization Economics will not in itself answer this question. It will, however, provide information that is essential to the development of projections of how different levels and types of treatments will influence future monetary costs and the availability of goods and services desired by people.

APPENDIX A-2
Sampling Protocols and Methodology

Overall Study Design and Site Characterization

Spatial scale plays a tremendous role in defining which tools and approaches we will use to measure our core variables. Thus, in our presentation of study design tools and approaches are organized by spatial scale, from broadest to finest. For the purposes of this project, "plot" refers to a full 10 ha area receiving a treatment application. "Subplot" refers to smaller areas nested within the larger 10 ha plot for the purpose of spatial organization of the sampling.

Aerial photography will allow us to determine changes in the forest mosaic much more cheaply than ground-based measurements. Determination of changes in the forest mosaic will be useful for several reasons, not the least of which are documenting changes in forest potential as wildlife habitat and addressing the long-simmering "structure vs. process" debate (see Stephenson 1996 and in revision). Regarding the latter, structural restorationists have argued that fire suppression has led to more uniform forest conditions, thus blurring the boundaries between formerly distinct forest patches. This increased uniformity, they have argued, will be perpetuated by fire which erases the original character of the forest mosaic. Thus, a silvicultural restoration is a necessary precursor to reintroduction of fire. Process restorationists, in contrast, have argued that a simple reintroduction of fire is likely to restore the forest mosaic. Both sides have been arguing in a near-vacuum of evidence. As in so many cases, either argument may be correct depending on local circumstances. Examination of broad-scale treatment effects on forest structure by aerial imagery can help address this issue.

As a consequence of its lower spatial resolution, satellite imagery cannot adequately address our questions of interest regarding changes in forest structure. Likewise, to obtain aerial digital multi-spectral images for determining changes in productivity at a resolution also useful for determining changes in forest structure is more expensive than separately obtaining satellite images (for determining changes in productivity) and aerial color-infrared photographs (for determining changes in forest structure).

We will obtain color infrared photographs at a resolution (approximately 1:4000) that allows individual trees and objects on the ground to be discerned easily. Images will be georeferenced to treatment plots by a combination of (1) on-board GPS, and (2) ground markings set up for the purpose. Images will be taken pre-treatment and in the 3rd or 4th post-treatment year. Analysis will proceed as described in Skinner (1995) and references therein.

Vegetation

Decades of experience by many scientists have demonstrated the value of a plot-based approach to addressing many of the questions listed earlier. A standard established by Whittaker in the 1950’s and now commonly used in North America is the tenth-hectare plot (20 x 50 m). Plots of this size form the core of many forest vegetation studies that find a reasonable balance between intensive and extensive, and precision and accuracy. In some studies the Nature Conservancy has adopted 25 x 50 m (0.125 ha) plots. Other studies have successfully utilized circular plots of various dimensions. In this study the preferred sampling design will be 10 rectangular tenth-hectare (20 x 50-m) subplots per treatment plot, but the shape and size of sample subplots may vary with local conditions as determined by site managers. Subplots will be arrayed systematically at pre-determined grid points within the treatment plot. If local site conditions merit, subplot locations may be determined by site stratification. Since different vegetation components are best measured at different spatial scales, other smaller sample size units will be used, and these will be nested within the larger subplots.

Due to the national scope of this program there is a need for maximum flexibility in sampling design in order to accommodate the wide range of conditions. The precise sampling procedure for determination of the vegetation variables listed in Appendix A-1 will be determined by individual site managers.

All variables will be measured pre-treatment and in the 3rd or 4th post-treatment year. At some network sites, herbaceous sampling may be performed twice per growing season to account for the phenology of the herbaceous flora (i.e., spring ephemeral and summer flora). In other locales, one growing-season sample will suffice.

Fuel and Fire Behavior

The L- and F-layers contribute significantly to fire behavior in the fire treatments, whereas changes in the H-layer are more important in affecting the severity and below ground consequences of the fire. Thus, the mass of the ground fuel component must be measured or accounted for on each treatment unit.

The amount of forest floor material can be determined by destructively sampling the forest floor material or by estimating the weight by developing a regression equation relating forest floor mass to forest floor depth. In order to develop a forest floor prediction equation, the site needs to have an undisturbed, well-developed forest floor. A forest floor with mostly L- and F- and little H-layer material will not usually produce a reliable prediction equation. It is desirable to use this indirect method to estimate forest floor weight with the use of duff spikes in the burn treatment units, so that less disturbance would occur and ultimately influence the fire behavior and fire effects.

Samples used to develop the prediction equations are randomly selected in areas that represent the full range of forest floor depth on the units. If blocks are used in the design of the study site, a different predictive equation may be necessary for each block if there appears to be significant differences. If total consumption is not usually obtained during the burning process, a predictive equation may also be necessary to estimate the H-layer separately since the bulk densities differ between the L- and F-layer and the H-layer. The remaining depth (H-layer) determined from the duff pin data would be applied to the more appropriate prediction equation developed with the H-layer information. Fifty samples (each 1.0 ft^2 = 929 cm^2) is the minimum number of samples needed to produce the predictive equations. A metal frame is used along with a cutter to collect each sample by layer (L, F, and H) and each layer is bagged separately. After the careful removal of the frame, each layer is measured in the center of each side of the square foot sample and recorded on the L-layer bag. The twelve depths measured are then averaged by layer for that particular sample. Often not all of the organic material is collected when trying to avoid collecting soil in the sample and this can bias the sample by each individual having different interpretations of the organic layer. Therefore to ensure the collection of all organic material, the sample is collected past the soil surface. Each sample is then washed to remove the soil and rock portion. They are then air-dried and then dried in an oven set at 85°C until a constant weight is reached. Samples are weighed after 48 hours to begin the determination of the constant weight and re-weighed in 6-8 hour intervals. This is especially important when dealing with extremely deep forest floor material. When all of the moisture has been removed, a total weight is recorded for each sample. The different size classes of woody material (0-¼", ¼-1", and 1-3") and other components (cones, bark and other vegetation parts) can then be separated out of the individual samples. The separation process supplements the woody material inventory by determining the woody component incorporated in the forest floor. All fuel weights should be based on oven-dry-weight. The complete description of the forest floor material is important in relating the fire to the different fire effects being looked at especially below ground.

The amount of forest floor material removed by the prescribed fire, is critical for defining vegetation and soil responses as well as smoke production. A series of eight duff pins will be used to determine the amount of forest floor material removed. The eight steel pins will be located on two perpendicular axes located at the far end of each woody fuel transect and marked with engineering flags to aid in relocating. Each pin will be pushed into the forest floor and mineral soil until the head of the pin is flush with the top of the litter layer. The location of the pins will have to be determined once other activities around the grid points are defined so that they are located in undisturbed areas. After the fire, each pin is relocated and the distance from the top of the pin to the top of the remaining forest floor is measured. The total distance from the top of the pin to mineral soil is also recorded for each pin. These measured depths are then applied to the prediction equation to estimate the tons per acre of forest floor material present and what amount is removed by burning. (See field sheet FFS-Fuels-C).

We expect that destructive sampling will be required to characterize the forest floor on the units being thinned due to the high level of physical disturbance anticipated. It will also be necessary to do destructive sampling of forest floor material on the control plots. Some study sites may not have a well-defined forest floor component due to species composition or as a consequence of past management activities. Such sites will also need to be destructively sampled. The destructive forest floor samples (at least two sample per grid point) will be taken in a systematic “off set” scheme at each grid point so that they do not interfere with the subplot layout or are in traffic patterns. These forest floor samples should be processed the same way as the depth-weight prediction equation samples.

The down dead woody fuels will be measured using Brown’s (1974) planar intercept method. Fuel will be classified by size class (0-1/4"=0-6mm, 1/4-1"=6-25mm, 1-3"=25-75mm, and 3+"=75+mm), decay class condition (sound and rotten), and the number of intercepts and diameters of 3+" diameter material by species. The maximum depth of elevated dead woody fuel is also measured in each one-foot section of the last three feet of the transect. This fuel inventory will need to be done prior to treatment application, after thinning activity is completed and after the application of the prescribed fire treatments. It is expected that at least 4,000 feet (1,220m) of transect will be measured on each treatment unit. The recommended number of samples would consist of two 20m transects randomly placed at each of the 36 grid points and that measurements be offset 6 feet (2 meters) from the grid point with the smaller size class fuels measured at the far end of the transect. It is imperative that these transects be permanently marked with reinforcement rod so that the same transects are measured for post treatment sampling.

One of the two or more woody fuel transect lines will be randomly selected to serve as the centerline for the course woody debris (CWD) survey strip plot. The protocol for estimating the CWD has been developed by the entomology section. Measurements should be done by the woody fuel inventory crew simultaneously with the woody fuel measurements to reduce disturbance to the sites.

If biomass of grass, forb, and dwarf shrub vegetation is considered to be an important contributor to fire behavior or effects, then biomass estimates must be made. The grass and forbs could be destructively sampled before and after treatment applications, but this is very labor intensive. A more efficient method of estimating this vegetation component would be to utilize existing allometric equations or develop new equations for the dwarf shrub species present. The measurements taken during the vegetation sampling can then be used to estimate biomass. If no equations exist, then a double-sampling method could be applied to quantify the biomass of the dwarf shrub fuel component to a lesser degree of accuracy if this fuel is not critical. This method is also applicable to estimate the grass and forbs biomass.

The overstory fuels are critical in estimating fire risk and crown fire potential on a site. Species, tree density, dbh, ladder fuel height, number of canopy layers, height to live crown, total height, and percent canopy closure are critical variables and are needed to calculate fire risk and crown fire potential. These variables will be changing during the applications of the treatments within each study site and they will reflect the differences between the different study sites. The collection of these data will be part of the basic vegetation sampling and will be incorporated into the overstory plot descriptions for each plot and subplot. After the application of the burn treatments, we recommend crown scorch data to also be collected on the overstory plots.

Samples for the measurement of fuel moisture will need to be collected just prior to the application of the burn treatments. Forest floor samples need to be collected by layer to represent the plot condition. These samples are collected in moisture proof bottles, weighed, oven-dried at 95°C until there is no more weight loss, and then re-weighed. Woody fuel moisture content samples need to also be collected by the different woody fuel size classes as defined previously. Moisture content must also be determined for the live fuel component. This should be done by vegetation class (grass, forb and shrub) and should be sampled to represent the entire plot. The moisture content is determined on an oven dry basis as defined above. We suggest that a site team collect this information prior to burning with instruction from the fuels team (See field sheet FFS-Fuels F).

It will be necessary to document fire behavior at each burn treatment plot to be able to qualify the fire intensity between fire treatment plots (See field sheet FFS-Fuels-G). Flame length should be measured and done as an ocular estimate on the flame front. Rate of spread is estimated by timing the movement of the flaming front to cover a known distance. This should be done for both heading and backing fire fronts. Flaming and smoldering stage duration should be measured during the course of the burn. The flame length and rate of spread should be taken as sets of measurements at regular intervals (i.e. every 15 minutes), throughout the lighting phase at selected grid points. In addition, flaming and smoldering duration should be ocularly estimated at the same selected grid points. It would also be prudent to have the soils team collect the flaming and smoldering stage duration times while they monitor their sample plots.

Prior to and during the burning operations on the fire treatment plots, ambient temperature, relative humidity, and wind speed and direction should be collected as fire parameters (See field sheet FFS-Fuels-G). This should be done for each burn treatment unit and should be done by the site team or teams under the direction of the fuels team.

Table 5. Information that would be measured by the fuels team.

Fuel Variable	Data collected:
Ground fuels (litter and duff)	Destructively sample forest floor material on thinned treatment plots and controls. Treatment plots would be sampled before and after the thinning and/or burn treatments. Destructively sample forest floor material to develop a depth/weight prediction equation to estimate tons/acre of material present on appropriate study units. Reinforcement rod can then be used to estimate consumption of forest floor material in relation to specific fire effects being investigated by other groups. The depth-measurements taken on the woody fuel transects can be applied to this more appropriate tons/acre estimate of fuel loading. Forest floor biomass and the average of four depth measurements of each layer (L, F, and H) will be collected for each square foot sampled. Duff depth at two points in the last 5 feet of the transect line to the nearest 0.1 inch. Consumption of forest floor material at eight pins located at the end of the woody fuel transects extended from each grid point on each burn treatment unit.
Down dead woody fuel	(1) Number of intercepts of woody fuel by diameter size class: 0-¼" diameter size class in first 6’ of transect ¼-1" diameter size class in first 6’ of transect 1-3" diameter size class in first 12’ of transect (2) Actual diameter of woody material that is in the 3+” size class of the entire transect length by species. (3) Duff depth at two points in the first 5 feet of the transect line to the nearest 0.1 inch. (4) Dead fuel depth at three 1-foot wide vertical partitions in the first 3 feet of the transect line. Slope estimate of the transect line. Course woody debris (CWD) length and diameters of woody pieces >15cm in diameter and >1meter long according to CWD protocol. Decay class is also recorded of each piece.

Table 6. Summary of data collected by other teams but shared with the fuels team.

Variable	Needed by fuels	Collected by:
Overstory Fuels		
Ladder fuel height	X	Vegetation
DBH	X	Vegetation
Species	X	Vegetation
Tree density by diameter	X	Vegetation
Crown cover	X	Vegetation
Number of crown layers	X	Vegetation
Height to live crown	X	Vegetation
Crown and bole scorch	X	Vegetation
Understory Fuels		
Live fuel biomass if allometric equations are not available to estimate biomass	X	Vegetation
Surface Fuels		
Grass/Forbs	X	Vegetation
Other Variables		
Mineral soil exposure		Soils
Fuel moisture	X	Site crew
Flame length and rate of spread	X	Site crew
Flaming and smoldering duration	X	Site crew
Fire weather: Ambient temperature Relative humidity Wind speed/direction	X	Site crew

Soils and the Forest Floor

We anticipate measuring all the soil and forest floor core variables during the pretreatment year, the immediate post treatment year, and one additional year as late in the project period as possible. For sites in which thinning and burning can be done within the first 1.5 yr of the project, this will translate to samples taken during years 0, 1, and 3 or 4. For sites in which there must be a year of curing between thinning and burning, this will translate to year 0, year 3 and year 4. If additional funding can be secured, we recommend additional sampling of a subset of the core variables may be done during the years not covered by the core sampling protocol.

.

The spatial pattern of the soil and forest floor sampling will be guided by the design of the subplots for vegetation analysis, whereas the degree of replication within and around each subplot will be determined by the magnitude of underlying variability in each site.

To determine the C and N content of forest floor, we anticipate taking 6 samples per vegetation sample plot (assuming 10 plots per treatment unit), and sorting, drying, and weighing those samples to determine mass. Depending on the characteristics of the individual site, 1-3 forest floor horizons or strata may be sampled separately.

Mineral soil will be sampled for C, N, and macronutrient content. In sites in which spatial variations in soil chemical characteristics are modest, we recommend taking one sample at each of two opposing corners and at the center of the plot, for a total of three samples per plot and 30 samples per treatment unit. For sites in which the underlying variability dictates a larger number, samples will be taken at regular intervals along the long sides of the plots. Again, this sampling protocol assumed a design based on 10 large sample plots per treatment unit; adoption of a sampling protocol based on >30 smaller plots will need to be adjusted to yield the same sampling intensity.

Mineral soil samples will be stratified as justified by the soil characteristics of the individual study site. In some sites, samples will need to be stratified by depth in 10cm increments, whereas in others a single A-horizon sampling will be sufficient. Wherever possible, given the underlying variability, samples from a given subplot will be composited prior to chemical analysis.

The extent to which the samples from a given plot are composited prior to analysis will depend on the spatial variability in nutrient content within that site. In genera, we expect most sites will be able to composite the 6 samples from a given plot down to 1-2 samples for chemical analysis without losing precision or accuracy; however, in highly variable sites or treatments (e.g. just after mechanical harvesting), analyzing all 6 samples independently may be required. Analysis of spatial autocorrelation in forest soils from the hardwood site in Ohio indicate that the chemical properties of mineral soil samples are spatially autocorrelated at ranges up to 10m (Boerner et al. 1998); thus compositing samples taken within this range does not cause the loss of ecologically-relevant information, at least in the hardwood site.

Pilot analyses of at least 6-12 individual samples from each of at least three sample plots will be required to establish the degree of acceptable compositing for a given network site. We have agreed to dopt a common criterion to determine the acceptable degree of compositing: the standard error of the mean of the composited samples from a given sample plot shall not exceed 20% of the magnitude of the mean of those samples. If the standard error does exceed 20% of the magnitude of the mean, too much compositing has been done and more individual samples must be analyzed from each sample plot. Although we recognized that this is an arbitrary standard, the adoption of a standard across the entire network will still suffice for maintaining quality assurance.

Subsamples of the composite forest floor samples and mineral soil samples will be analyzed for organic C content by Walkley-Black oxidation/titration (Nelson and Sommers 1982). In sites where carbonates are absent from the parent material, loss on ignition may be substituted (Nelson and Sommers 1982). Subsamples of forest floor will also be digested in H_2SO_4:H_2O_2 and analyzed for total:N by colorimetry on a Lachat Autoanalyzer or similar automated N analyzer. Mineral soil samples will be extracted for Ca, Mg, and K with 1M NH_4OAC (Thomas 1982), for Al with 2M KCl, and for P with 0.01M $CaCl_2$ (Olsen and Sommers 1982). Cation analysis will be done by atomic absorption spectroscopy, and P analyses by stannous chloride/molybdate or ascorbic acid colorimetric methods (Olsen and Sommers 1982). Soil pH will be determined in a 1/5 w/v slurry.

Analysis of nutrient availability (i.e. N mineralization and nitrification) will be done for four samples per plot during the spring or early summer of each year using aerobic, *in situ* incubations for measurement of N mineralization and nitrification. This involves the following steps: (1) taking soil samples from the corners of the plots, (2) separating each sample into two subsamples, (3) placing one of the subsamples into a polyethylene bag and returning it to the hole from which the sample came for a 20-30 day *in situ* incubation, and (4) returning the other subsample to the laboratory for immediate extraction with 2M KCl for subsequent analysis of NH_4 and NO_3 concentration by automated colorimetry (Keeney and Nelson 1982). After 20-30 days, the samples which have remained *in situ* in the polyethylene bags are recovered and extracted for inorganic N the same way. Net N mineralization is calculated as the difference in total inorganic N (NH_4+NO_3) between the initial samples and those incubated *in situ* for 20-30 days. Net nitrification is calculated as the difference between NO_3 in the initial samples and the incubated samples. Proportional nitrification is calculated as the net difference in NO_3 concentration between the initial and incubated samples divided by the total NH_4 available for nitrification (i.e. initial NH_4 + net N mineralization). Refer to Eno (1960) for basic design issues for this method, and Plymale et al. (1987) and Boerner et al. (2000) for examples from one of the network sites.

Ideally, biodiversity assessments would be done by one standard method using the same samples used to assess nutrient availability; however, in practice this may prove unfeasible. Site teams will include in their proposed study plan a specific method for soil biodiversity assessment, and just justify the method they choose based on precedent and/or on-going studies in the ecosystem type they represent. In addition, each site will do biodiversity assessments by a second method on 10-20% of their samples to facilitate cross-method and cross-site comparisons. This compromise means that different sites will likely assess soil diversity by different methods. Thus, our ability to generalize across sites will be reduced (although doing a second assessment method on a few samples may help alleviate this problem). However, using an assessment methods that fits the individual forest type best will give the greatest future management value for the dollar.

Each vegetation sample plot will be searched each spring for areas of exposed mineral soil >30 cm^2 in area. Each exposure will be measured and its position recorded for later resurvey. If feasible, each exposure should be marked for resurvey on a biannual basis. Compaction will be measured along transects just outside the boundaries of the subplots. The preferred method will be to take penetrometer readings and core samples for bulk density measurements at 5 m intervals just outside the plot boundaries, thus yielding 20 measurements per method per plot per year. For sites in which alternative methods must be used (e.g. tile spade penetration at Hungry Bob), sample size will be adjusted to a level which generated an equivalent mean:variance ratio.

Wildlife

The wildlife discipline will include measuring abundance, diversity, nest productivity, and functional response of birds, and measuring the abundance and diversity of herps and mammals.

Birds. We propose to assess the diversity and abundance to the treatments of birds in the study through the use of point count censuses. We will monitor nest productivity (number of young fledged per nest initiated) of nesting birds in a subset of sites. Finally, we will evaluate the functional response of foraging woodpeckers and other bark-gleaners to the treatments.

Point counts are a standardized method (Ralph et al., 1993) of assessing the diversity and abundance of birds by counting birds (detected by hearing and by sight) at points. As the study sites will have grid points at every 50m, wildlife teams will assess birds at every 200 m, with 50 m radii of detection. Depending on the shape of each study site, we hope to have ca. 4 to 5 points/site, assessed for five minutes per point. Each site (the three replicates of control, fire-only, fire plus mechanical harvest, and mechanical harvest-only) will be assessed six times (six replicates per sites) during the two-month spring-summer breeding season. The main output of this method will be an assessment of the kind (diversity) and number (abundance) of birds detected as a function of controls and treatments. At each study site, the following is the suggested protocol for point counting of birds:

- It is the responsibility of the crew leader to insure that the bird crew knows the site's bird species by sight and sound. This is obvious, but crucial. Crew people should be testing each other and comparing observations constantly. This should take two weeks, at least. Point counts should start as early as possible in the field season. (By mid-July in California, birds are mostly quiet). Also, estimates of distance should be jointly judged repeatedly so all crew people estimate distances similarly.
- Each unit will have a point count assessment six times each season (with 6 replicates of 12 units (72 counts), we have crews of three needing at minimum 24 days of counting)
- Depending on the shape of the unit, try for 4-6 points per unit
- Points must be at least 200 meters apart, points set at grid points
- At each point, the count (beginning at first light) is to last 10 minutes exactly (wait 2-4 minutes at each point before counting); the observer is to be quiet and move very little
- Count all individuals of all bird species detected; distinguish between those seen first, and those heard first on data form
- Detections of birds will be recorded in 10 meter segments (see data form), up to 100 meters distant (e.g., a bird detected 5 m away would be recorded as "10" for 0-10 meters, or a bird detected at ca. 45 m away would be recorded as "50"; birds detected directly flying overhead would be recorded as "10" because first detection was, for that issue, directly at (over) the point – we are measuring horizontal distance, not vertical)
- A complete replicate count of all units must be completed before the second replicate of any unit is done. Use a random number table to determine the sequence of units sampled each replicate.
- Use standardized four-letter codes for each bird species recorded (see http://www.pwrc.nbs.gov/bbl/manual/bandsize.htm
  or Pyle (1997) for the codes. (Make sure you note on the data form the AOU common name for a bird species if your code is a guess!)

Nest productivity, assessing the production of young/nest of species, can also be assessed by standardized methods (Martin and Geupel, 1993; Ralph et al., 1993; see particularly the BBIRD (Breeding Biology Research and Monitoring Database website put together by Thomas Martin et al., at http://pica.wru/umt.edu/BBIRD/protocol/protocol.htm). We are essentially following the BBIRD protocol, so all crew people should read this before they begin searching for nests.
We propose that:

- each crew leader randomly assign two replicates of each treatment (including controls) (thus 8 units of the 12) to be thoroughly searched for bird nests and monitored until the fate (fledging young or failure) has been determined.

- When finding a nest, use flagging nearby (10-15 m away) to indicate the species and nest number
- Draw a depiction of where the nest is, and to begin data entry, following BBIRD protocol.
- Nest sites will later be visited (after fledging or failing) to measure some simple vegetation variables (to be developed when vegetation protocols are established)
- Don't forget snags! Cavity nesting birds will be important to know, even if we don't obtain egg number and fledging number.

The data will be analyzed in terms of overall productivity, and analyzed by categories (cavity vs. cup-nesters vs. ground nesters) and by species. We hope for a good effort at monitoring possible nesting in snag cavities. We suggest that the crew leader monitor two units, and the other two of the crew will monitor three units each. Crew leaders, again, are responsible for uniformity in data collection.

To evaluate the "functional" response of woodpeckers and other "bark-gleaning" birds (chickadees, titmice, nuthatches, creepers), we will observe their foraging patterns on trees at each site. We will adopt, and modify, methods developed by Weikel and Hayes (1999) for this effort. To insure equal sampling across units, it would be best to invest two hours (two 1 hour sessions exactly) in this method in mornings following point counts on a given unit. The following is the proposed protocol for assessing functional response of bark-gleaning birds:

- Observations are to be made while walking the plot systematically along the grid points. Walk a different route with each sample.
- The emphasis here is on collecting data only from "bark gleaners" (Paridae: genera *Baeolophus* (titmice) and *Poecile* (Chickadees), Sittidae: *Sitta* (Nuthatches), Certhiidae: *Certhia americana* (Brown Creeper), and possibly the Black and White Warbler *Mniotilta varia* in the Eastern sites and from "bark probers", the woodpeckers (Picidae: all genera). Collect data from these species only when they are in trees.
- To avoid the statistical problems of independence, we will "sample" an individual from the above species once while foraging, then move on to another species. Thus, if you spot a candidate species, follow it until it unambiguously forages on a tree (not shrub or log).
- Only individuals clearly foraging (not singing, cavity drilling, etc.) will be sampled.
- When many species are present, choose woodpeckers first.
- After a bird foraging observation, use random number table (two numbers: one for compass direction, another for meters distant*) to find tree of same category (conifer, deciduous, snag) and take relevant data.

(*- use numbers to designate N, S, E or W; distance should be < 50 m)

Interaction with Bark Beetle Research. We will interact with this research group in order to match the status (time since infection, source of infection) of infected trees with woodpecker foraging patterns and drilling patterns in order to closely correlate tree mortality with onset of cavity excavation. This work involves visiting bark beetle infested trees once per season. This research would be conducted toward the end of the field season, after the insect crew has surveyed the units for bark beetle activity. The trees to be sampled will be those marked, and referenced to the grid system, by the bark beetle field crews. We propose the following protocol for quantifying woodpecker-beetle activity on selected snags.

Upon location of the sample snag, record the diameter at breast height (the diameter of the snag measured at 1.3 meters from the base). Using this value as the width, create a 1.0m long rectangle on the north side of the snag centered around breast-height level. Use 4 nails to mark the corners and wrap the twine around the nails to mark the perimeter (see diagram below). Within this rectangle, record the variables listed on the accompanying data sheet. Detailed descriptions of the woodpecker and beetle variables are listed below, and abbreviated definitions for the complete list of variables can be found on the sample data sheet.

Definitions:

Woodpecker Excavating: Woodpeckers foraging for subsurface bark and wood boring insects leave evidence of their activity in the form of holes punctured in the bark. These range in size from 0.5 to 6.0+ cm. They usually penetrate the bark down to the sapwood, but often times are superficial wounds. All woodpecker sign should be counted.

Woodpecker Scaling: Woodpeckers often "scale" the bark in small areas, creating patches of foraging which can be difficult to quantify by counting individual "hits" or holes. In this case, you should estimate the proportion of area within the rectangle which has been "scaled".

Dendroctonus Exit Holes: These symmetrical round holes measure between 2-3 millimeters in diameter.

Buprestid Exit Holes: These oblong shaped holes measure between 3-6 millimeters (measured on the longest side).

Cerambycid Exit Holes: These symmetrical round holes are similar to Dendroctonus holes, but are larger, usually measuring between 3-6 millimeters in diameter.

Small mammals and herps. We recommend the following protocol for assessing the abundance and diversity of small mammals and herps:

- Crews will establish 6X6 grid, with grid points spaced 40 m **or** 50m apart, on each unit (place traps away from the grid points themselves).
- Each grid point will have one Sherman XLK and one Tomahawk #201 (use duff, bark and other natural features to shade and insulate traps)
- Pitfall traps will be established at every other grid point (some sites may wish to have them at every point).
- The size of the pitfall trap will be decided by, and be defended by, each site (the logistics of soil digging will have the main role here). Cover pitfalls when not sampling (e.g., with a small piece of plywood with a weight (stone) on top).
- Traps will be inspected for nocturnal and diurnal mammals for 10 day/night periods, open before dusk, opened at mid-morning (starting at ca. 8 a.m.). This protocol rests on the assumption that there are few nocturnal species, and thus most traps are open in the morning. If there are many nocturnals, you may have to open traps again after removing nocturnals, and go through the grid again.
- With crews of three people, this means sampling two units at a time, with two crew people at one unit, one alone at the other (thus the 12 units will have 60 days of sampling total during each field season)
- Reverse the order of walking the trap grid every other day
- Weighing small mammals with a pesola or scale is important

- Individually mark (e.g., with magic markers) small mammals (e.g., red-white left (on front foot)
- Herps (amphibians and reptiles) need not be individually marked (most sites, particularly those in the north, will have few herps; southern sites may have many and should expand their effort, if resources are available)
- Look over “FFS Mammals Protocol.doc” for some suggestions on logistics

*Interaction with vegetation research: when the vegetation protocols are developed, we will develop simple complimentary vegetation measurement protocols for mammal trap sites.

Table 7. Outline of Wildlife Methods: Bird research will be conducted at each site in four of the five years of study. No bird studies will be conducted in the year after thinning and prior to prescribed fire. Mammals will be studied only two years: one pre-treatment year, and one post-treatment year.

Measurement	**Season**	**Scale**	**Effort**	**“Output”**
Bird Point Counts	May-August	Every 200 m	All plots 6 repeat visits	Density and diversity
Bird Nest Productivity	May-August	Where found on sampled plots	2 plots each treatment (= 8 plots total)	Young/nest per nesting species
Bird “Functional Response”	May-August	Sampling foraging “bark gleaners”	2 plots each treatment (= 8 plots total)	Foraging response to “treated” trees
Mammal Capture-Recapture	May-August Pre- and Post-Treatment	6X6 grid, 40 m apart, with two live traps and, at every other trap, a pitfall trap	All plots, sampled one time/yr (10day-night periods)	Density and diversity (productivity?)
Herpetofauna Pitfall Trapping	May-August Pre- and Post-Treatment	Pitfall trap at every other gridpoint in a 6X6 grid array (above)	All plots, sampled one time/yr (10day-night periods)	Density (?) and diversity

Entomology

At least one year before the applications of the treatments the study plots will be censused for bark beetle mortality. At each successive grid point we will scan 180^{o} for trees that are clearly in decline or devoid of needles. As such trees are found, the direction and distance from the grid point will be determined. For each tree, the tree species, bark beetle species responsible for mortality, tree diameter, fading stage (color i.e. lime or light green, straw colored, yellow, red, or grey {old dead}) will be recorded. These data will be collected at each grid point on each study plot. This will allow for bark beetle mortality to be spatial referenced for GIS analysis.

These data will also be collected at 2 and 4 years post-treatment. The variables of interest to be used to detect treatment effects include, but are not limited to, percent mortality/tree species/bark beetle species/year, percent of mortality represented by group kills, mean number of trees per group kill, distribution of morality by diameter class/bark beetle species, incidence (percentage) of bark beetle attacked trees also attacked by secondary insects, percent of tree mortality caused by secondary insects acting alone, and DBH distribution of tree mortality caused by secondary insects.

The sampling protocols developed for estimating large woody material for fuels management are not adequate for describing the structural aspects of course woody debris (CWD) for wildlife purposes. For example, estimating the percentage of ground covered by logs was an important variable relating to the abundance of small vertebrates and their food resource. Log density (i.e. number of pieces) and lengths have also been use to describe the foraging habitat of pileated woodpeckers. (see draft manuscript: Estimating the density, length, percent cover, and weight of logs for wildlife management. Bate, Torgersen, Garton and Wisdom 10/14/99). In addition length, diameter, and decay class appear to important aspects of CWD required by some wood boring insects. (Shea unpublished data)

The following protocols are recommended for estimating the structural aspects of CWD as potential wildlife and insect habitat. Sample plots will be established on at least every other grid point on all experimental units. At each sampled grid point, a strip-plot (4 meters by20 meters) will be established with the respective woody fuel transect line serving as the strip-plot center line. Within each strip-plot only logs or parts of logs that are at least 1m in length and have a large end diameter 15cm or greater will be measured and counted. The small end (>7.62cm) and large end diameters will be measured on all qualifying logs or parts of logs that fall within the boundaries of the strip-plot. If a piece extends outside the strip-plot, diameters are measured at the line of intercept of the strip-plot boundary and CWD piece. Piece lengths are the lengths of the CWD within the strip-plot area an are recorded. The length of the entire piece must be measured to determine the midpoint of the CWD. If the midpoint is within the strip-plot, the piece is given an additional rating of ``1" for the Indicator Variable. If the midpoint falls outside the strip-plot the piece is given a rating of ``0" for the Indicator Variable.

In addition the species (if possible) and decay class of each log will be recorded. The following 5 decay classes will be used to rate the CWD (from Thomas 1979):

Decay Class 1	Bark is intact; twigs are present; wood texture is sound; log is still round; original wood color.
Decay Class 2	Bark is intact; twigs are absent; wood texture is sound or becoming soft; log is still round; original wood color.
Decay Class 3	Bark is falling off; twigs are absent; wood texture is hard; log is still round; original color of wood is faded.
Decay Class 4	Bark is absent; twigs are absent; texture of wood is soft, blocky Pieces; shape of log is oval; wood has faded to light yellow or gray.
Decay Class 5	Bark is absent; twigs are absent; wood texture is soft and powdery; shape of log is oval; wood has faded to light yellow or gray.

Pathology

It is recognized that sites will vary with respect to preeminent disease problems, including root diseases and, in particular, above-ground diseases such as dwarf mistletoe, rusts, and various canker and foliar diseases. These above-ground diseases should be addressed, if desired, on an individual site basis because few inferences can be made on treatment effects over the entire suite of study sites with respect to these localized conditions.

The following protocol, however, addresses the need for a consistent pathological variable that can be measured across all treatments and sites, given constrained budget levels. Because all trees have roots and grow in soil, fire and other treatments can directly impact this component relative to disease causing microorganisms, notwithstanding direct above-ground effects such as crown scorch and bole scorch that are being addressed by another discipline. Furthermore, there is a critical need for information regarding below-ground pathological processes and potential effects of fire and other disturbances on these processes. Therefore, as a starting point, a rudimentary below-ground pathology protocol is presented that relies, in principal, upon above-ground symptomatology and root sampling.

The Protocol
An initial survey of all treatment plots will be conducted in order to mark trees that have pre-existing symptoms so as not to confuse these with subsequent treatment effects. This survey will follow the current entomology plan that involves 100% cruises of treatment plots. In the case of pathology, observations will consist largely of above-ground crown symptoms based upon a rating scale developed by TRB. Four symptom classes are recognized ranging from healthy to moribund. Determinants involved in these crown symptom classes are based upon foliar color, needle/leaf size, and internode length, with color being the primary character defining symptomatic trees. These symptom classes and their application to this study will be specified through on-site training by TRB personnel.

The pre-treatment data collection will include all trees over 10 cm in diameter. Symptomatic trees will be tagged with fire-resistant metal tags that are numbered sequentially. Tags will be placed on trees via aluminum nail at the highest point that can be practically and safely reached (approximately six feet) above ground level. If plot grid points are monumented, then tags should face in the direction of grid center. Data will be obtained on all treatment plots and replicates on each study site. Data collection on all symptomatic, putative root diseased trees will consist of recording the above mentioned crown symptoms, dbh, crown position, and signs of other distress agents (such as bark beetle pitch tubes, exit holes, etc.). Because hardwoods are different than conifers relative to expectations for diseases and for manifestations of symptoms, a different protocol will be developed for this ecosystem. Nonetheless, the hardwood site pre-treatment examination will be conducted for signs of *Armillaria* root disease.

Pre-treatment data collection for pathology involves woody root samples taken from symptomatic trees via careful excavation of lateral roots that are near the soil surface. A minimally invasive procedure will be used that involves the sampling of intact root tissue by means of an increment hammer. This cautionary method is crucial in that minimal tissue disruption is essential--excessive wounding will cause anomalous insect attraction. Such undesirable impacts would confound interpretation of treatment effects relating to entomological data. To minimize these potential confounding effects, the pretreatment survey will be conducted in the following manner.

Entomology crews who, following the entomology protocol and trained in this pathology protocol, will identify trees that are symptomatic (ie. potentially root diseased trees). Such trees will be identified by tagging with the above described numbered tags in addition to recording their distance and azimuth from the plot grid point. Root samples will not be taken from identified symptomatic trees until and unless the insect flight season has passed. Thus, root samples from identified, symptomatic trees will be obtained during late fall or after insect flights have ceased.

Several samples of wood per root will be obtained by coring the excavated (or exposed) root from the root collar to approximately one meter distally along the root. At least two such woody roots having a minimum diameter of about five cm will be sampled per symptomatic tree. Roots from a few (two to three) healthy, asymptomatic, randomly selected trees in each treatment plot will also be sampled. These trees will also be tagged with the above described numbered tags. While it is necessary to tag all symptomatic trees during the sampling of each treatment plot, root samples from all these trees are not necessary, particularly if there are large numbers of symptomatic trees in a plot or the disease can be readily identified by symptom characteristics (e.g., black-stain root disease). In the event of a large number of symptomatic trees, a sub-sample of trees will then be obtained that is consistent with good judgement, logistic capability, and statistical validity. As a preliminary general rule, about 20% of symptomatic trees would be sampled in such cases, although this percentage sample can vary depending upon the amount of symptomatic trees observed. Also, prior knowledge of root diseases on sites, past history, and existing conditions will also be important factors used in the interpretation of symptoms and sampling intensity. To provide consistency and analytical validity for the overall meta-analysis, these issues will be resolved on site in conference with TRB personnel.

Extracted cores from all trees will be stored in ice chests or similar thermally protected implement. Isolations will be conducted according to standard lab techniques using specific media specified by TRB. Emerging relevant fungi from wood samples will be subcultured and identified. A copy of all data will be provided to TRB for analyses.

Post treatment sampling will be similarly conducted. During the second and fourth years post-treatment, treatment plots will be observed and sampled relative to crown symptoms. Newly symptomatic trees will be tagged, noted, and root samples taken and analyzed as above.

Regarding other diseases that may be present in stands or diseases that are regional in nature (e.g., dwarf mistletoe, rusts), the sites having arrangements with other pathology groups can develop their protocols to address these issues. Such protocols will be incorporated into site study plans that are available for review by SMIC members upon request.

Treatment Costs and Utilization Economics

The validation of an existing harvest treatment cost simulation model with compartment-level data first requires that each site team determine the per unit area costs of associated activities at the site level, such as slashing, prescribed burning, etc. To insure accurate estimates, operational times for all equipment will be monitored with Servis recorders and collected by study personnel on each site. Study personnel will also record times for the associated activities. Agreements to allow monitoring of operating times and to provide scale records by compartment need to be built into contracts (or formally agreed upon in advance with purchasers) at the site level. To provide realistic estimates of costs, information will need to be collected from areas where an efficient operations layout is used and the treated area is large enough to be cost efficient. The compartment-level harvest productivity data will be used to validate estimates from a harvesting cost simulation model and when appropriate to validate expert opinion data collected for individual sites.

Harvesting costs depend on a number of factors including tree size, removal density, skidding distance and slope, among others. Rather than developing new cost models, data collected at the compartment level from the study sites will be used to validate existing harvest treatment cost simulations for the fuels reduction applications. Estimates of the costs of burning, with and without thinning, will be collected at each site.

A compartment is defined, for purposes of this portion of the study, as the smallest unit for which it is readily feasible to segregate gross harvesting production and operating time data. In many cases, the area served by a single landing would make an easily identified compartment, if trails into the landing are preflagged, and/or if boundaries between one landing and the next are flagged. Where feasible, information will be collected on multiple operational compartments within each unit so that more data points will be available. If this is not possible, the unit will make an acceptable compartment.

The site administrator will supply accurate topographic maps of all units, with compartment boundaries and landing locations indicated, to UC Davis. These will be used to calculate compartment areas, and to estimate average skidding, forwarding or yarding distances and ground slopes. Landing locations and skid trail locations will be indicated on these maps.

Compartment-level harvest productivity data will be collected for each stump-to-truck function e.g., felling, skidding or forwarding, etc. For mechanized functions, operating hours will be collected with electronic dataloggers mounted on each machine. When operations begin at a site, the site administrator will install a compact, self-contained datalogger on each piece of equipment. These dataloggers essentially monitor vibration level over time to indicate whether the machine is operating or not. The administrator will download information from each datalogger weekly. In addition, a paper record must be kept of the dates and approximate times each machine began and finished operating in each compartment. At the completion of operations, the dataloggers will be removed from the machines.

For thinning of small trees, it is likely that most operations will be mechanized. For manual operations such as chainsaw felling, the dates and approximate times each person began and finished operating in each compartment will be recorded on paper. For all harvesting activities information will be provided on the type of harvesting system including equipment manufacturer and specific model, average piece size, residual volume per acre, skidding or yarding distance, and where limbing and bucking is done (i.e., at the stump or roadside).

Similar records will be collected for slashing and prescribed burning activities, but at the unit level rather than for compartments within units. As was the case for mechanized harvesting, dataloggers will be used on equipment, and paper records for manual activities. To provide realistic estimates of prescribed burning costs, information will need to be collected from areas where an efficient operations layout is used and the treated area is large enough to be cost efficient.

Harvesting production from each compartment will be determined from scale (volume and/or weight) tickets and records for all products removed. Scale tickets must accurately indicate from which compartment the material was derived. If individual logs are scaled, scale records will be provided to

U.C. Davis. Most truckloads should be derived from a single compartment, but residual partial loads may be combined as long as the truck driver makes a reasonable estimate (i.e. to the nearest 10%) of what portion of the load came from each compartment. Agreements to allow monitoring of operating times with dataloggers, and to provide scale records by compartment need to be built into contracts (or formally agreed upon in advance with purchasers) at the site level.

All the data will be transmitted by the site administrator to UC Davis, within a week of when they are collected. The UC Davis group will compare the compartment-level harvesting production and time data with simulated results, to validate harvesting models that have already been developed for estimating costs of harvesting small trees.

Estimation of the amount (volume or weight) and value of materials removed by diameter and species will first require a detailed pre-treatment inventory at the site (and compartment) level to describe the existing stand. The prescription for each treatment will designate trees to be killed or removed and those having potential product values. Pre-treatment plots will be remeasured to obtain a detailed post-treatment inventory. This will verify the starting conditions for post-treatment stand growth modeling. The differences between pre- and post-treatment will further characterize the removals. Between-compartment variation of factors such as average tree size and removal density will provide more information than would a single data point for each unit.

Since much of the material to be removed is likely to be of small diameter, it is recommended that sample plots (if circular) be fixed-radius rather than variable-radius. If it is feasible to delineate compartments, the boundaries should be designated prior to the pre-treatment inventory so that a number of plots can be located at random within each compartment. A minimum of three 0.05 ha plots (five would be preferable) should be located within each compartment, and a sampling intensity of 10% or higher is recommended.

Estimation of the effects of burning on tree mortality and wood quality as related to salvage value will be important in determining longer term treatment economics. Information gathered here will allow estimation of the potential to reduce costs of treatments by salvaging mortality after burning. This analysis will require periodic stand sampling over a number of years after the treatment by the vegetation team in each site.

Estimates of burning costs will use an “expert opinion” methodology. Analysis will be based on information provide by individuals knowledgeable about burning under local conditions on similar plots of land with units sized and staffed for operational treatments. This information will be related to the treatment units.

A sample of 40 disks per major tree species (1-2 inches thick) will be provided to the California Forest Products Laboratory from each replicate at each site. This sample will include 20 disks removed from the butts of sub-merchantable size trees and 20 disks removed from the top of the first log of merchantable trees. The disks should cover the diameter range of each group. Site-specific requirements will be negotiated with the California Forest Products Laboratory. The intention here is to provide a representative sample of the wood characteristics of the major tree species at a minimum costs so sample requirements will be tailored to the capability of each site.

A sample of tree ages will be collected in a convenient manner, e.g., breast height increment cores, stump ring counts, etc., for the sub-merchantable size trees and the merchantable size trees of each major species in each replicate. The objective is to provide an estimate of tree age by species and size class at a minimum cost and site-specific sampling details should be negotiated with the PNW Station.

Literature Cited—Core Variables and Protocols Section

Amman, G.D., K.C. Ryan. 1991. Insect infestation of fire-injured trees in the greater Yellowstone area. USDA Forest Service Research Note INT-398. 9 p.

Bannwart, D. L. 1998. Blue-stain fungi associated with decline of longleaf pine. Phytopathology: (Abstract) 88(9) supplement: S5.

Barbour, R.J., Fight, R., Fiedler, C., and Keegan, C. 1999. Assessing the need, costs, and potential benefits of prescribed fire and mechanical treatments to reduce fire hazard. Project funded under the Joint Fire Sciences Program, Boise, ID. February 1999 Request for Proposals. USDA Forest Service, PNW Research Station Joint Venture Agreement 00-JV-11261975-068.

Boerner, R.E.J., A.J. Scherzer, and J.A. Brinkman. 1998. Spatial patterns of inorganic N, P, and organic C in relation to soil disturbance: A chronosequence approach. *Applied Soil Ecology* 7: 159-178.

Boerner, R.E.J., K.L.M. Decker, and E. Kennedy Sutherland. 2000. Prescribed burning effects on soil enzyme activity in a southern Ohio hardwood forest: a landscape scale analysis. *Soil Biology and Biochemistry: in press*

Boerner, R.E.J., E. Kennedy Sutherland, S. Jeakins Morris, and T.F. Hutchinson. 2000. Spatial variations in the effect of prescribed fire on N dynamics in a forested landscape. *Landscape Ecology: in press*

Brown, J. K. 1974. Handbook for inventorying downed woody material. GTR-INT-16. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 24.

Buckland, S.T. 1987. On the variable circular plot method of estimating density. Biometrika 43:363-384.

Decker, K.L.M, R.E.J. Boerner, and S.J. Morris. 1999. Scale-dependent patterns of soil enzyme activity in a forested landscape. *Canadian Journal of Forest Research* 29: 232-241

Eno, C.F. 1960. Nitrate production in the field by incubating the soil in polyethylene bags. Soil *Science Society of American Proceedings* 24: 277-299.

Franklin, J. F. 1989. Importance and justification of long-term studies in ecology. Pages 3-19 in G. E. Likens, ed., Long-Term Studies in Ecology: Approaches and Alternatives. Springer-Verlag, New York.

Ince, P. and Blattner, K.A. 1999. Comparative financial risks of small medium and large scale investments option s for utilizing small diameter timber in the us west. Cooperative Agreement between Washington State University and the USDA Forest Service Forest Products Laboratory, Madison, WI. Forest Products Laboratory Research Joint Venture Agreement 99-RJVA-3328.

Keeney, D.R.and D.W. Nelson. 1982. Nitrogen – inorganic forms. In: Page, A.L. (ed.) Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties. American Society of Agronomy, Madison, WI. Pp. 643-698.

Kirkland, G.L. Jr., and T. K. Sheppard. 1994. Proposed standard protocol for sampling small mammal communities. Pp. 277-283 *in* J.F. Merritt, G.L. Kirkland, and R.K. Rose (eds.) Advances in the Biology of Shrews. Special Publication of the Carnegie Museum of Natural History 18, pp. 1-458.

Martin, T.E., and G.R. Geupel. 1993. Nest-monitoring plots: methods for locating nests and

monitoring success. J. Field Ornithol. 64(4):507-519.
Morris, S.J. and R.E.J. Boerner. 1998. Landscape patterns of nitrogen mineralization and nitrification in southern Ohio hardwood forests. *Landscape Ecology* 13: 215-224.
Morris, S.J. and R.E.J. Boerner. 1998. Interactive influences of soil acidification and silvicultural management on microbial abundance and nitrogen mineralization. *Forest Ecology and Management*: 103: 129-139.
Nelson, D.W. and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. . In: Page, A.L. (ed.) Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties. American Society of Agronomy, Madison, WI. Pp. 539-580.
Olsen, S.R. and L.E. Sommers. 1982. Phosphorus. In: Page, A.L. (ed.) Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties. American Society of Agronomy, Madison, WI. Pp. 403-430.
Otrosina, W.J. 1998. Diseases of forest trees: consequences of exotic ecosystems? Pages 103-106 In: Proceedings 9th Biennial Southern Silviculture Research Conference (Ed. TA Waldrop), Feb. 25-27, 1997, Clemson, SC. General Technical Report, SR-20, USDA Forest Service, Southern Research Station, Asheville, NC, 678 p.
Otrosina, W.J. and Cobb, F.W. Jr. 1989. Biology, ecology, and epidemiology of *Heterobasidion annosum*. *In*, Proceedings of the symposium on research and management of annosus root disease (*Heterobasidion annosum*) in western North America; Otrosina, W.J. and Scharpf, R.F., (tech. coords). General Tech. Report, PSW-116, Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 117 p.
Otrosina, W.J., Hess, N.J., Zarnoch, S.J., Perry, T.J., and Jones, J.P. 1997. Blue-stain fungi associated with roots of southern pine trees attacked by the southern pine beetle, *Dendroctonus frontalis*. Plant Disease 81:942-945.
Peet, R.K., T.R. Wentworth, and P.S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274.
Piirto, D.D., Parmeter, J.R., Jr., Cobb, F.W., Jr., Piper, K.L., Workinger, A.C., and Otrosina, W.J. 1998. Biological an management implications of fire-pathogen interactions in the giant sequoia ecosystem. Pages 325-336 *in* Teresa L. Pruden and Leonard A. Brennan (eds.). Fire in ecosystem management: shifting the paradigm from supression to prescription. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, FL.
Plymale, A.E., R.E.J. Boerner, and T.J. Logan. 1987. Relative nitrogen mineralization and nitrification in soils of two contrasting hardwood forests: Effects of site microclimate and initial soil chemistry. *Forest Ecology and Management* 21: 21-36.
Pyle, Peter. 1997. Identification Guide to North American Birds. Slate Creek Press, Bolinas, CA
Ralph, C.J., G.R. Geupel, P. Pyle, T. E. Martin, and D.F. DeSante. 1993. Handbook of Field Methods for Monitoring Landbirds. Gen. Tech. Rep. PSW-GTR-144. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture: 41p.
Reynolds, R.T., J.M. Scott, and R.A. Nussbaum. 1980. A variable circular plot method for estimating bird numbers. Condor 82:309-313.
Skinner, C. N. 1995. Change in spatial characteristics of forest openings in the Klamath Mountains of northwestern California, USA. Landscape Ecology 10: 219-228.
Stephenson, N. L. 1996. Ecology and management of giant sequoia groves. Pages 1431-1467 in Sierra Nevada Ecosystem Project: final report to Congress, vol. II, Assessments and scientific basis for management options. Wildland Resources Center Report No. 37, Centers for Water and Wildland Resources, University of California, Davis.

Stephenson, N. L. 1999. Reference conditions for giant sequoia forest restoration: structure, process, and precision. Ecological Applications 4: 1253-1265.

Sutherland, E.K. (ed). 1999. Characteristics of mixed-oak forests in southern Ohio. USDA Forest Service GTR NE-. *In preparation.*

Thomas, G.W. 1982. Exchangeable cations. In: Page, A.L. (ed.) Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties. American Society of Agronomy, Madison, WI. Pp. 159-166.

Thomas, J.W. , Ed. 1979. Wildlife habitats in managed forests—the Blue Mountains of Oregon and Washington. Agric Handbook No. 553. U.S.D.A. Forest Service, 512p.

Weikel, Jennifer, and John P. Hayes. 1999. The foraging ecology of cavity-nesting birds in young forests of the northern coast range of Oregon. The Condor 101:58-66.

Whittaker, R.H., W.A. Niering, and M.O. Crisp. 1979. Structure, pattern, and diversity of a mallee community in New South Wales. Vegetatio 39:65-76.

APPENDIX B-1
Site Descriptions

Descriptions of the 11 study sites (10 main sites plus 1 satellite site) proposed for the national Fire/Fire Surrogate Network are provided below. Site selection criteria are listed in Table 1 and discussed further in the "Research Site Locations" section. All of the main sites are required to commit to the core experimental design (see "Experimental Design" section). The Sequoia National Park site, which serves as a satellite to the Blodgett Forest Research Station site, departs from the core design only with respect to the core suite of treatments: only prescribed burning (2 seasons) and control treatments will be included. The value of this satellite site is that it adds a missing dimension to the network by including old growth forest as a distinct structural type for the burning treatments, thereby extending our conclusions to the type of fuel reduction treatments used by the National Park Service. Site descriptions reflect the physical conditions exhibited by each site, as well as the potential for a successful study to be installed and maintained for the long term. Sites are presented beginning with the Pacific Northwest, and ending with the sites in the Southeast.

--

MISSION CREEK

Contact: James K. Agee, University of Washington, Seattle**,** WA

Cooperating host agency: USDA Forest Service, Region 6

Location: North-central Washington, 6 miles west of Wenatchee, Leavenworth Ranger District, Wenatchee National Forest

Forest type: Mixed conifer: ponderosa pine, Douglas-fir, grand fir

Total area available: 2500 acres

Topographic range: Mid-elevation forests from 2000' to 4500'

Representative land base: Several hundred thousand acres on the Wenatchee Forest alone.

Fire History: The Douglas-fir series of eastern Washington historically burned with frequent, low intensity surface fires (Agee 1993). A USGS map ca. 1900 indicated no stand replacement burns in the previous 50 years in the low to mid elevation areas that contain this forest series (Agee 1994). Nearby studies (Wright 1996, Harrod et al. 1998) suggest a fire frequency of 10-20 years for this forest type previous to about 1900.

Contemporary fire hazard: Low severity fire regimes in the Mission Creek area have fuel buildup of both dead and life fuels that have radically altered fire behavior. The forests once had classic clustered groups of ponderosa pine at stem densities of 20-40 per acre, that are now being replaced by Douglas-fir at 125-175 stems per acre (Harrod et al. 1998).

Prior work and anticipated time line: Several management projects are currently underway, treating the matrix around any potential study site. Because environmental analysis has been accomplished, we expect to be able to begin treatments by the summer of 2000.

Level of long-term interest: The Pendleton part of the Mission Creek site has already been designated as a management demonstration area for thinning and burning treatments. In a December 17, 1998 meeting, District, Forest and local PNW research staff expressed commitment to participate in the study. One research project essential to defining silvicultural prescriptions for thinning has been completed at this site (Harrod et al. 1998).

Partnerships: Wenatchee National Forest, PNW Station, and University of Washington; possibly other academic institutions, as well as BLM and the Park Service may become involved.

Site/Plot selection constraints: No constraints on random assignment of treatments.

Treatments: All four core treatments will be installed.

5th treatment: In addition to the core treatments, we may have a fifth treatment consisting of either a second yarding technique for thinning, or an alternate season of burning.

Thinning and burning prescriptions: Thinning will include either feller-buncher or cable, and for season of burn either spring or fall burning. Prescriptions for the treatments have not yet been defined, but would be in the nature of low thins (thinning from below) and low intensity fires (flame lengths < 3 ft).

--

HUNGRY BOB

Contacts: James McIver, Andy Youngblood, PNW Research Station, La Grande, OR

Cooperating host agencies: USDA Forest Service, Region 6

Location: Blue Mountains of northeast Oregon, 25 miles north of Enterprise, Wallowa Valley District, Wallowa-Whitman National Forest

Forest type: Dry mixed conifer forest: Douglas-fir, ponderosa pine/snowberry plant association (Franklin and Dyrness 1988); on mostly shallow, rocky, and loamy mollisols.

Total area available: 2500 acres

Topographic range: Experimental plots are all located on the upper slopes or tops of ridges, where the dry forests typically occur. A few plots are located on lower slopes, but none extend into riparian areas.

Representative land base: The Hungry Bob project area represents a forest type and condition found throughout about 800,000 acres in the Blue Mountains and several million acres in the Columbia River Basin.

Fire history: Frequent, low intensity fire (<25 yr return interval), typically July -- October (Hall 1980). Due to fire suppression, most areas have not experienced fire for 80 years or more (Agee 1996).

Contemporary fire hazard: Fire severity and size have increased significantly in the Blue Mountains in the past 20 years. Wildfires have burned nearly 500,000 acres in the Malheur, Umatilla and Wallowa-Whitman National Forests in the past 10 years alone. Recent fires include the 1996 Summit (40,000 acres) and Tower Fires (35,000 acres).

Prior work and anticipated time line: Hungry Bob is the first proposed FFS site that is underway. This project has identical treatments and core variables as being considered for the other sites in the FFS network. Site, plot and subplot selection and layout occurred in 1997. Pre-treatment data were collected during 1998, followed by the thinning treatments. Prescribed fire treatments will be implemented in fall 2000. The first year of post-treatment data will be collected in 2000. A USDA Competitive Grant will provide much of the funding for the project through the first post-treatment year.

Level of long-term interest: Both managers and scientists involved in Hungry Bob have expressed willingness and commitment to the project for at least 10 years.

Partnerships: Wallowa Valley Ranger District (Wallowa-Whitman National Forest), Joseph Timber Co., Zacharias Logging Co., Oregon State University, PNW Research Station

Site/Plot selection constraints: Hungry Bob was selected from 8 potential available sites in the Blue Mountains. Site selection was restricted primarily by the scope and scale of fuel reduction treatment planned by the potential Ranger Districts. No plot selection constraints occurred.

Treatments: All core treatments have been or will be installed.

5th Treatment: Spring burning treatment.

Thinning and burning prescriptions: Thinning was undertaken by single grip harvester, coupled with forwarders for log retrieval. Prescription was to lower overall basal area from overstocked to 75% stocked, and to lower fuels to less than 10 tons per acre. Fire prescription is to reduce fuels to less than 10 tons per acre, and to achieve mortality of many stems less than 3" diameter. Multiple fire entries to achieve ultimate stand objectives are likely.

LUBRECHT FOREST

Contact: Carl Fiedler, Univ. Montana; Michael Harrington, Rocky Mt. Research Station, Misssoula, MT

Cooperating host agencies: University of Montana, USFS Rocky Mountain Research Station, Montana Dept. Natural Resources and Conservation

Location: Lubrecht Forest, 30 miles east of Missoula

Forest type: Dry mixed conifer: ponderosa pine/Douglas-fir

Total area available: 360 acres (120 acres/replicate x 3 replicates); additional area available, if needed.

Topographic range: Slopes range from about 10-35%, but are generally similar within a given replicate. Aspects range from southeast to southwest, but are reasonably similar within a replicate.

Representative land base: Study sites represent an extensive area of similar pine/fir forests in west-central Montana in particular, and the Northern Rockies in general.

Fire history: These stands historically experienced underburning at 5- to 30-year intervals, typical of pine/fir forests throughout western Montana and the Northern Rockies (Arno, 1980: Arno et al. 1997)

Contemporary fire hazard: The fire hazard in existing stands is high. The typical condition is densified, second-growth pine/fir forests, with thickets or a layer of Douglas-fir in the understory. Recent fires in the vicinity include the 1991 Clearwater fire, and the 1988 Milltown fire that threatened homes in the Riverside area. Recent regional fires in Northern Rocky Mountain ponderosa pine forests include the 150,000-acre Hawk Creek fire in central Montana, and the Lowman Complex on the Boise National Forest in Idaho, covering hundreds of thousands of acres.

Prior work and anticipated time line: Field locations have been selected for each of the three replicates; anticipated startup summer 2000.

Level of long-term interest: The Univ. of Montana School of Forestry, Montana Dept. of Natural Resources, and Rocky Mt. Research Station have all expressed long term commitment in the project.

Partnerships: University of Montana School of Forestry, the USFS Rocky Mountain Research Station, the Montana Department of Natural Resources and Conservation - Forestry Division, Clearwater State Forest, USFS Region 1, Missoula Ranger District, BLM District Office, State of Montana Dept. Natural Resources, and Plum Creek Timber Company.

Site/Plot selection constraints: No constraints on random assignment of treatments.

Treatments: All four core treatments will be installed.

5th treatment: None planned.

Thinning and burning prescriptions: Thin to approximately 50 ft^2/acre of basal area (the exact level will be determined collaboratively among the partners; the appropriate burning prescription and season of burn will be determined collaboratively among the partners.

KLAMATH MOUNTAINS

Contacts: Gary Fiddler, Carl Skinner, and Phil Weatherspoon, Pacific Southwest Research Station, Redding, CA.

Cooperating host agencies: USDA Forest Service (Region 5), USDI Bureau of Land Management, and possibly private land owners.

Location: No specific site location has been selected. Possible sites could be located on four National Forests in California (Klamath, Shasta-Trinity, Six Rivers, and Mendocino), USDI lands west of Redding, CA (both BLM and NPS [Whiskeytown Nat. Rec. Area]), and/or on lands owned by Sierra Pacific Industries.

Forest types: Douglas-fir--tanoak--pacific madrone (SAF 234), Sierra Nevada mixed conifer (SAF 243), pacific ponderosa pine--Douglas-fir (SAF 244), and pacific ponderosa pine (SAF 245).

Total area available: Since no specific site selection has been made this can only be addressed in a general nature. The forest types above represent vast areas (hundreds of thousands of acres) in the Klamath Province. Site selection will not be restricted due to lack of area.

Topographic range: All aspects are included. Ground based harvesting systems can be utilized on some of the area; major portions of the area will require the use of cable harvesting systems.

Representative land base: The forest cover types listed cover between 1,500,000 and 4,000,000 acres in the Klamath Province.

Fire History: Frequent fires of low-moderate intensity were characteristic of presettlement fire regimes in the forest types listed above (Agee 1991, Wills & Stuart 1994, Taylor and Skinner 1998). Median fire return intervals for 1-2 ha sites range generally from 10-20 yrs. Due to fire suppression, many of these areas have not experienced fire for 50 - 80 years.

Contemporary fire hazard: The efficiency of fire suppression has contributed to increased fuel build-up in these mountains similar to the build-up in other parts of the western United States. Millions of acres once characterized by low-moderate intensity fires now often burn with high intensity due to fuel build-up over the course of the 20th Century (especially since 1950). As a result, the Klamath Mountains have experienced several major fire years in the last couple of decades. Each of these years has seen the burning of 10,000s of acres of forest lands (~300,000 in 1987 alone), many acres at high intensity.

Prior work and anticipated time line: Almost all potential sites have had some form of harvesting in the past. Known candidates for study sites on National forest lands have varying degrees of environmental documentation; in some cases, no more documentation will be required prior to treatment implementation. In others, more NEPA work will be required in order to allow treatment installation. All other factors being equal, a potential site having all the NEPA documentation completed will be favored for selection. This consideration will greatly dictate implementation. Pretreatment data collection on the first experimental block is planned for FY2001, with treatment implementation to begin the following year.

Level of long-term interest: Forest Service District, Forest, and Regional Office staff indicate interest and commitment to the project. This interest is manifesting itself in the form of candidate sites being offered by District staff even prior to the scheduling of user meetings. Long-term interest among PSW scientists is keen.

Partnerships: All candidate sites being offered by National Forest staff come with full support of that organization. The scientific support of PSW will be added to owner support regardless of the site selected. This scientific support often brings support from cooperators from the state universities. Some interest in a possible satellite site located on National Park Service lands has been expressed. If chosen, this would include NPS partnerships.

Site/Plot selection constraints: Slopes are moderate to very steep. Major river drainages divide the Province. Management options (and thus site selection options) are often restricted in these drainages due to environmental constraints. Several T&E species are found in the Province. Management options are severely restricted by the presence of these species. Full replications might not be placed side by side due to the broken nature of the terrain. Plot shapes may not be squares due to dissected topography.

Treatments: All core treatments will be installed.

5th treatment: The need or desire for a 5th treatment will be determined after site selection.

Thinning and burning prescriptions: Thinning will probably be a combination of hand falling and mechanical cutting, depending on size of cut trees and steepness of the site. Yarding will be by ground based equipment on the more gentle slopes, and some form of Aflying@ on the steeper slopes. Initial prescribed fires will be of moderate intensity. Additional information will be generated from the site meetings.

BLODGETT FOREST RESEARCH STATION

Contacts: Scott Stephens, Professor, California Polytechnic State University San Luis Obispo, Bob Heald, Forest Manager and Co-director for the University of California Center for Forestry, Georgetown, CA.

Cooperating Host Agency: College of Natural Resources, University of California, Berkeley.

Location: Blodgett Research Forest is located in the central Sierra Nevada in Eldorado County on the Georgetown Divide.

Forest type: Sierra Nevada Mixed Conifer including ponderosa pine (*Pinis ponderosa*), sugar pine (*Pinis lambertiana*), white fir (*Abies concolor*), incense cedar (*Calocedrus decurrens*), Douglas-fir (*Pseudotsuga menziesii*), and California black oak (*Quercus kelloggii*).

Total area at Blodgett Forest: 1760 ha. Areas available for experimentation: 520 ha. Blodgett has 17 managed stands averaging 17 ha each available to select as treatment plots. An additional 240 ha of currently undesignated forest are also available.

Restrictions on site selection: none.

Topographic range included in sites: Elevation 1200-1550 m (3800 -4800'). West, south, and east aspects, 10-30% slopes. Entire area can be tractor logged. Entire area is well roaded for research access. A paved county maintained road provides year round access to the station.

Representative land base: The mixed conifer forest at Blodgett Forest has been repeatedly harvested (beginning in 1890), significant components of large overstory trees remain, understory dominated by small shade tolerant trees. High surface fuel loads and high horizontal and vertical fuel continuity has produced a forest that is vulnerable to catastrophic fire (Stephens 1998). Fire and/or fire surrogate treatments have the potential to reduce hazardous fuel conditions (Stephens 1998). In the Sierra Nevada there are 1,338,000 ha (3,345,000 acres) of Mixed Conifer Forests (SNEP 1996).

Historic range of variation in fire frequency: Fires occurred at a frequency of one fire every 7-20 years prior to the Gold rush of 1849. Mean fire return intervals at Blodgett Forest are similar to those reported in other mixed conifer forests in the Sierra Nevada (Kilgore and Taylor 1979; Caprio and Swetnam 1995). Fire suppression policy has been implemented for the last 80-100 years in this area of the Sierra Nevada.

Contemporary fire hazard: Archived fire records at Blodgett Forest reveal a high rate of lightning and human caused fires. An average of one lightning ignited fire requiring suppression was recorded every 1.5 years between 1975 and 1999, and an average of 0.8 human caused ignitions occur each year that require suppression. This is in contrast to one lightning caused ignition requiring suppression every 9 years during a similar time period in the mixed conifer forests at Redwood Mountain in Sequoia National Park (Kilgore and Taylor 1979). All-consuming fires occurred in a portion of this area in 1903 and 1919. The potential of large, high severity wildfires in this area is high.

Prior work and anticipated timing for implementation: Blodgett Forest research has a sixty-six year history which includes studies of tree growth, forest succession, harvesting costs, forest insect and disease dynamics, forest ecology, silviculture, wildlife population dynamics, range animal dynamics, control of non-tree vegetation, thinning and spacing of commercial conifers, soil compaction from logging operations, effects and techniques of prescribed fire, conifer regeneration methods, harvesting methods, nutrient cycling, and much more. The major mission of Blodgett Forest is to evaluate response, cost, and impacts of different management activities. Fire-fire surrogate treatments would be installed in the summer and fall of 2001, pretreatment data would be collected in the summer and fall of 2000. Blodgett Research Forest will fund all direct treatment costs. Blodgett Forest will secure all environmental permits (Timber Harvest, Burn and Air Pollution) required by the State for treatments. Blodgett Forest has mechanical mastication (tracked excavator), fireline construction (tractor), and fire management (water tender, developed water sources, pick-up pump trucks) equipment. Blodgett Forest provides a permanent staff to insure year round gated research security. Blodgett Forest will make available on site housing, office and laboratory space for research staff and field technicians. The nearby California Department of Forestry and Fire Protection Growlersburg Conservation Camp will provide labor support for prescribed fires.

For both scientific and management, level of long-term interest: Blodgett Research Forest was donated to the University of California by the Michigan-California Lumber Company in 1933 and since this time has been a very active research forest. The forest is also linked to the University of California Center for Forestry, which has a tremendous outreach and education program. Blodgett Forest has on site a 100-person conference center to extend research results. Blodgett Research Forest has been collecting data on over 1000 permanent vegetation, fuel and terrestrial vertebrate plots for 25 years. This data can be used to support the fire-fire surrogate study. Blodgett also has maintained atmospheric monitoring stations for over 38 years and maintains a network of permanent instream structure plots and stream gauging stations.

Partnerships: The full support of the Blodgett Research Forest Staff has been given. The current research program at Blodgett forest has representatives from UC Berkeley, UC Davis, UC Santa Cruz, Northern Arizona University, California Department of Forestry and Fire Protection, University of Nevada – Reno, USFS Pacific Southwest Research Station, and others. There is the potential for this site to be connected to a “satellite” site located in Sequoia-Kings Canyon National Parks and adjacent Whitaker forest also managed by the UCB Center for Forestry. The park site would be installed in “old growth” mixed conifer forests. This type of forest structure is fundamentally different; no logging has occurred in the parks.

Treatments: control, prescribed fire alone, mechanical alone, combination of prescribed fire and mechanical treatments. All treatments will conform to protocols of the national fire-fire surrogate study.

5th treatment: none.

Harvest procedure and burning prescription: The small group selection silviculture system is currently under consideration for rangewide implementation in the Sierra Nevada mixed conifer forests. Blodgett forest has the oldest and most well documented trial of this prescription in existence on the West Coast. The group selection regeneration method has and will be used to produce openings each of which average 0.4 ha. in size at a rate of 10% of each stand area on approximately 10 year intervals. The matrix forest surrounding the groups averages 80 years of age, will be thinned by hand felling, and yarded with tractors. Current stand densities range from 150 to 200 square feet of basal area per acre (70 to 90% overstory canopy cover averaging over 100 feet tall). The existing 25-year baseline vegetation data will be utilized to compare potential changes in wood production among study treatment types. Initial prescribed fires will be of moderate intensity to reduce surface fuels, which currently exceed an average of 40 tons per acre. Subsequent fires will first kill and finally consume standing low and mid canopy non-merchantable trees. Initial mechanical treatments will masticate standing low and mid canopy trees as well as reduce surface fuel vertical height. Combined treatments will first masticate standing trees and subsequently reduce resulting surface fuel by prescribed fire. Overall, goal is to produce a forest structure where 80% of the dominant and co-dominant trees would survive a wildfire at 80th percentile weather conditions. Our goal is also to test treatments that are operational in nature.

--

SEQUOIA NATIONAL PARK

Contacts: Jon E. Keeley and Nathan L. Stephenson, USGS Biological Resources Division, Sequoia-Kings Canyon, CA; Anthony Caprio, USPS Natural Resources Division, Sequoia-Kings Canyon.

Cooperating host agencies: US Park Service, US Geological Survey

Location: East Fork and Marble Forks of the Kaweah Drainage, Sequoia National Park.

Forest cover: Mixed coniferous forest: *Pinus ponderosa, P. lambertiana, Abies concolor, Calocedrus decurrens*

Total area available: NA

Topograhic range: 15-25' inclination, aspects not yet determined.

Representative land base: These studies would have applicability to other U.S. National Park Service lands in the Western U.S.

Fire history: Bulk of the forest within 5 - 25 years return interval. Previous research on fire history for these forests is extensive.

Contemporary fire hazard: "Old growth" forest with substantial fuel loads above historical range of variation.

Previous work and anticipated time line: Initial treatments are planned for Fall 2001 and Spring 2002. A significant fraction of proposed sites are within the Prescribed Fire Operations Five Year Work Plan for Sequoia National Park. Hence, fire management personnel are confident they can work within the proposed time frame and restrictions imposed by random site selection criteria.

Level of long-term interest: Sequoia National Park representatives from the Division of Fire Management and the Division of Science and Natural Resources Management are enthusiastic about cooperating with this project. The park has a long history of involvement in fire research.

Partnerships: Sequoia National Park already cooperates with researchers from various universities from throughout the country. Future collaborations are expected to increase with the focus of the new University of California campus at Merced, with its proposed focus on problems of the Sierra Nevada.

Site/Plot selection constraints: No thinning treatments would be applied; burning treatments would be randomly assigned to experimental units.

Treatments: Only prescribed fire treatments would be applied. This site however, would serve as a satellite to the BLODGETT FOREST RESEARCH STATION site, and would add a missing dimension to the Joint Fire Science study plan by including old growth forest and manipulating fuels by altering season of burning. Treatments would be: Control, Autumn burning, Spring burning

Burning prescriptions: NA

--

SOUTHWEST PLATEAU

Contact: Carl Edminster, Rocky Mt. Research Station, Flagstaff, AZ

Cooperating host agency: USDA Forest Service, Region 3

Location: Experimental blocks will be located in the wildland-urban interface area west Flagstaff on the Peaks Ranger District, Coconino National Forest, and on the Williams Ranger District, Kaibab National Forest.   The two areas are separated by about 30 miles, but will be considered as one site for purposes of the Fire and Fire Surrogates study.

Forest type: Ponderosa pine, with bunch grass understory and occasional Gambel oak

Total area available: Specific areas are the A-1 Mountain west ecosystem management unit (about 5,000 acres) around Flagstaff and the Frenchy ecosystem management unit (18,000 acres) east of Williams.

Topographic range: NA

Representative land base: Approximately 5 million acres in the Southwest

Fire history: Low intensity ground fires occurred historically every 2 to 10 years before the 1880's (Swetnam 1990, Dieterich 1980). In a study near Flagstaff, fire intervals averaged from 1.25 to 4.9 years for the period from 1540 to 1865 (Dieterich 1980). The Coconino National Forest experiences over 300 lightning caused fires per year with a density of over 160 fires per million acres (Barrows 1978).

Contemporary fire hazard: Around the Flagstaff wildland-urban interface, the 1977 Radio fire burned over 7,000 acres on Mount Elden just northeast of the city. In 1996, the Hochderffer and Horseshoe fires combined to burn over 25,000 acres north of the city. All of these fires were high intensity crown fires outside the range of natural variability for the ponderosa pine type. Conditions have become worse in recent years with increases in stand density and more residential development in forested areas. Within wildland-urban interface areas in the Southwest, there are nearly 1 million acres with over 300,000 homes at high risk of catastrophic wildfire (Patton-Mallory 1997).

Prior work and anticipated time line: Environmental analysis of the A-1 Mountain area has been completed. Research plot installation could begin as soon as funding is available. Thinning is planned after FY00 and burning after FY01. The Frenchy environmental analysis process will be completed during summer 1999. Research plot installation could begin as soon as funding is available and treatments could be implemented during the 2000 operating season.

Level of long-term interest: Both management and research partners are committed to long-term success of the projects. The proposed Fire and Fire Surrogates study installations will expand ongoing work in alternative management strategies for fire risk reduction and forest health restoration. The National Forests have pledged support in implementing the treatments under the Fire and Fire Surrogates program as part of their management implementation in the two management units.

Partnerships: Principally Coconino and Kaibab National Forests, the Rocky Mts. Research Station, and the Grand Canyon Forests Partnership. The latter partnership is guiding the fire risk reduction and forest health restoration effort in the Flagstaff area. The Partnership is community based and has a formal cooperative agreement with the Forest Service, Rocky Mountain Research Station, and the Forest Products Laboratory. The Partnership includes environmental organizations, federal and state agencies, county and city governments, and Northern Arizona University.

Site/Plot selection constraints: There are no known restrictions on random assignment of treatments.

Treatments: All four core treatments will be installed. In both areas, 2 replicates of the Fire and Fire Surrogates treatment design are proposed, for a total of 4 replicates. The Rocky Mountain Research Station will provide funding for the fourth replicate if not available through the Fire and Fire Surrogates program.

5th treatment: A possible fifth treatment is the use of a tree shredder/mulcher to dispose of large numbers of cut non-merchantable trees and heavy slash accumulations.

Thinning and burning prescriptions: Silvicultural treatments for both areas are an uneven-aged or uneven-sized residual stand structure using group selection. The goal of the silvicultural treatment will be to enhance structural and spatial diversity in the residual stands with fuels reduction and restoration of forest health.

JEMEZ MOUNTAINS

Contact: Carl Edminster**,** Rocky Mt. Research Station, Flagstaff

Cooperating host agency: USDA Forest Service, Region 3

Location: Two study areas will represent the Jemez Mountains site, located about 30 km apart, west and northwest of Los Alamos; Espanola and Jemez Ranger Districts, Santa Fe National Forest

Forest type: Ponderosa pine and mixed conifer: ponderosa pine, southwestern white pine, Douglas-fir, white fir, Gambel oak, aspen

Total area available: Several thousand

Topographic range: NA

Representative land base: 5 million acres in the southwest

Fire History: Natural low intensity ground fires generally occurred historically every 2 to 10 years before the 1880's (Swetnam 1990). Local studies in the Jemez Mountains show a mean fire interval in the range of 5 to 25 years (Swetnam and Baisan 1996, Touchan et al. 1996) with the longer intervals in ponderosa pine/mixed conifer vegetation type.

Contemporary fire hazard: Stands are becoming much denser relative to historical conditions. There have also been higher levels of insect and disease infestations and higher risk of large scale outbreaks. Three major catastrophic wildfires have burned in the Jemez Mountains study area in recent years. The 1977 La Mesa Fire burned over 15,400 acres in Bandelier National Monument, on the Santa Fe National Forest and Los Alamos National Laboratory. The 1996 Dome Fire burned 16,000 acres in the Monument and on the National Forest. The 1998 Oso Fire burned 5,000 acres on the National Forest north of Los Alamos. All of these fires had large areas of high intensity crown fires outside the range of natural variability for the ponderosa pine type.

Prior work and anticipated time line: In the Jemez Mountains area, an Interagency Wildfire Management Team is a guiding force in the fire risk reduction effort. The team includes representatives from the Santa Fe National Forest, Bandelier National Monument, Los Alamos National Laboratory, the town and county of Los Alamos. The research program is a collaborative effort to examine the results of alternative management strategies developed by the partnerships in an adaptive management framework. Site installation is delayed one year with the exception of layout and survey. Thinning is planned after FY01 and burning after FY02.

Level of long-term interest: Both management and research partners are committed to long-term success of the projects. The Santa Fe National Forest has pledged support in implementing the treatments under the Fire and Fire Surrogates program as part of their management implementation in the two management areas.

Partnerships: Sante Fe National Forest, Rocky Mountain Research Station

Site/Plot selection constraints: Sites on both Districts have received prior partial harvests more than 40 years ago. Within the Valle area, plot locations will be restricted to areas large enough to meet study specifications. Subject to that restriction, there are no known restrictions on random assignment of treatments. On Virgin Mesa, current plans call for prescribed fire in a portion of the mesa and thinning followed by prescribed burning in other areas. The Jemez District will accommodate the establishment of the study plots without restriction on random assignment of treatments, subject to needs to protect portions of the mesa and adjacent lands from wildfire.

Treatments: All four core treatments will be installed, 3 replicates at the Jemez Mts. study area, 1 replicate at Valle, and 2 replicates at Virgin Mesa. One of the Virgin Mesa replicates will be established in an area with both 19th and 20th century cohort trees, and the other in an area with only 20th century cohort trees.

Thinning and burning prescriptions: Proposed silvicultural treatments for both areas are a multi-aged or multi-sized residual stand structure using group selection. The goal of the silvicultural treatment will be to enhance structural and spatial diversity in the residual stands with fuels reduction and improved forest health.

***Note:** A potential satellite site is in Bandelier National Monument, however, resources are not currently available for establishment of control and prescribed fire treatment plots to the Fire and Fire Surrogates study specifications.

OHIO HILL COUNTRY

Contacts: Daniel A. Yaussy, Todd Hutchinson [a], Elaine Kennedy Sutherland [b]
[a]Northeastern Research Station, Delaware, OH, and [b] Rocky Mountain Research Station, Missoula, MT;

Cooperating Agencies: US Forest Service--Wayne National Forest; Ohio Division of Forestry, Mead Paper Corporation, The Nature Conservancy

Location: The site is located in southern Ohio on lands managed by the Wayne National Forest, the Ohio Division of Forestry, Mead Paper Corporation, and The Nature Conservancy

Forest type: Oak-Hickory: white oak, chestnut oak, black oak, scarlet oak, hickories, maples, tulips, black gum

Total area available: Ohio contains 3 million ha of timberland of which, approximately, 20% is owned by industry and public agencies. More than 50% of the forested land is classified as sawtimber. Considering areas set aside for other uses and purposes, there is, conservatively, 200,000 ha of forested land available for experimentation.

Topographic range: Highly dissected topography, 10-40% slopes, elevation ranges 200 to 300m

Representative land base: Land base represents forests in the Ohio River Valley including Kentucky, s. Illinois, s. Indiana, Missouri, and s. Ohio

Fire history: Diaries and descriptions depict frequent under burning by Native Americans during the dormant seasons (Barker 1958, Loskiel 1794, Michaux 1904). Fire histories in similar oak-hickory forests in Missouri (Guyette and Cutter 1997) indicate presettlement fire intervals of 12.4-17.7 years. Postsettlement frequencies were high and less variable spatially, averaging 3.7 years. In Ohio, fire histories developed in second-growth forests 100-150 years old show fire frequencies of 3-5 years, occurring during the dormant season (dominantly in the spring) and very early (April) growing season (Sutherland 1997 and Sutherland, unpublished data).

Contemporary fire hazard: Typical fires occur during the dormant (leaf-off) season, usually in the spring but with a significant fire season during the autumn. Most fires are surface fires, carried primarily by hardwood litter which is highly flammable when dry. Ignition is almost entirely from humans, and lightning fires are extremely rare (Haines et al 1975, Yaussy and Sutherland 1993). Fire suppression effects are evident in the oak-hickory (Region 9 and Kentucky) wildfire records, indicating a reduction in number and size of fires through the early 1980's. Since then, however, fire size has been increasing while fire numbers have held steady. Variation in fire size is also increasing with dramatically higher fire sizes during drought periods (Yaussy and Sutherland, unpublished data). Forest structure has become more closed over the past 60-70 years, with a continuous canopy and litter layer covering the ground. Urban-wildland interfaces issues are a serious consideration in these areas of relatively dense human populations.

Previous work and anticipated time line: A study was initiated in 1994 to investigate the use of prescribed fire in the ecological restoration of oak-hickory forest ecosystems in southern Ohio. Treatments include annual burning for four years, burning at four year intervals, and an unburned control, each of which is replicated four times. Variables similar to the core variables have been monitored annually since 1994. For the proposed study, site selection would occur summer 1999, and plot layout spring 2000. Pre-treatment data collection would occur summer 2000, with thinning and herbicide treatments applied autumn 2000, and prescribed fire spring 2001. Post treatment data collection would occur 2001-2004.

Level of long-term interest: Both the science community and managers have already demonstrated commitment to a four year ongoing project, and have expressed interest in committing resources for the future as well.

Partnerships: The Ohio team, consisting of land managers and scientists, has a well-established working relationship. The site has an existing program for fuel treatments. Laboratory and computational facilities and personnel at the Delaware laboratory and The Ohio State University provide low-cost and established resource for chemical analyses and spatially-related database development.

Site/Plot selection constraints: No management constraints on site or plot selection.

Treatments: All core treatments would be installed

5th treatment: herbicide only, or herbicide X fire

Thinning and burning prescriptions: Thinning is designed to remove poor-quality oaks and low-value species retaining 50% of the canopy, 40% of the basal area (Brose and Van Lear 1998). Herbicide treatments will remove all stems between 5 to 20 cm which are not oak or hickory, reducing the basal area to approximately 70% of the basal area and 100% of the canopy.
Fires will be conducted in the early spring during the fire season, primarily March 15-April 15.

SOUTHEASTERN PIEDMONT

Contact: Thomas A. Waldrop, Research Forester, Southern Research Station, Clemson, SC 29631-1003 (864) 656-5054 or **twldrp@clemson.edu**

Cooperating host agency: Clemson University, Department of Forest Resources

Location: On Clemson University grounds, adjacent to the campus

Forest unit: Clemson Experimental Forest

Forest type: Piedmont pine and pine-hardwood type (*Pinus taeda, P. echinata, Quercus alba, Q. coccinea, Q. falcata, Q. stellata*)

Total area available: approximately 17,000 acres

Topographic range: 650 to 750 ft. above mean sea level, including all aspects. Slopes are moderate to steep. Dissected topography will limit the possibility of installing treatments in square blocks.

Representative land base: The Clemson Experimental Forest is representative of the 29 million acres of commercial forest land in the southeastern Piedmont. Of that land base, 72 percent is owned by nonindustrial private landowners who typically do not manage their land and few use any type of fuel-reduction treatment.

Fire history: Southeastern Piedmont ecosystems have historically been disturbance dominated. Native Americans were nomadic hunters and gatherers who used fire as a weapon, to control dense undergrowth, to clear land for cultivation and to ensure favorable habitat for game species. Whites introduced large scale cultivation, and fire suppression had become commonplace by the early 1900's.

Contemporary fire hazard: Fire suppression policies remained intact until the 1950's but prescribed burning was not widely accepted until the 1960's. Consequently, fuels have built since the reforestation period of 1910 through 1940 and have reached dangerous levels. Each year, the State of South Carolina alone suppresses almost 4,500 wildfires. During 1985, ten wildfires averaging over 2,000 acres each were suppressed by the state. Because of the high degree of urban/wildland interface in the region, fires of this size usually destroy homes, businesses, or other private property.

Prior work and anticipated time line: The Clemson Forest is managed by the University for timber production, protection, and multiple uses. Currently there are few constraints to establishing a full installation of FFS treatments. We anticipate being able to begin work in the summer of 2000.

Level of long-term interest: Clemson University has a long history of commitment to research on the Clemson Experimental Forest. Several University faculty members have agreed to participate by sponsoring students to conduct most of the research. Furthermore, the Southern Research Station has a long standing and fruitful relationship with Clemson University.

Partnerships: Clemson University (Departments of Forest Resources, Parks, Recreation and Tourism Management, and Biological Sciences; Strom Thurmond Institute); South Carolina Department of Natural Resources, Game Management Program, Heritage Trust Program, and South Carolina Forestry Commission; Southern Research Station

Site/Plot selection constraints: None

Treatments: All four core treatments will be installed

5th treatment: None planned

Thinning and burning prescriptions: Thinning is designed to remove vertical fuels by eliminating the understory and midstory and reducing stand basal area to a level that protect from crown fires but allow economically-feasible stand management. Burning will be frequent (2- to 3-year rotation) to eliminate sprouting and support a savannah-type community (Waldrop and others 1992).

FLORIDA COASTAL PLAIN

Contact: Robert Dye, Park Manager; Dale D.Wade, Research Forester, Southern Research Station, Athens, GA; Thomas A. Waldrop, Research Forester, Southern Research Station, Clemson, SC

Cooperating host agency: Department of Environmental Protection, Division of Recreation and Parks, Myakka River State Park, Sarasota, Florida

Location: Southwest Florida, 50 miles south of Tampa, Myakka River State Park

Forest type: Both longleaf pine (Pinus palustris) and south Florida slash pine (Pinus elliotti var.densa) are represented with the latter predominating. Advanced successional flatwoods are characterized by ascendent saw palmetto (Serenoa repens) with a canopy of live oak (Quercus virginiana) and sabal palm (Sabal palmetto) with scattered pines.

Total area available: 37,500 acres

Topographic range: All sites represented are at or below 45 feet above mean sea level. Topography is flat; slope and aspect do not affect site conditions.

Representative land base: Flatwoods occur throughout the southeastern coastal plain and cover approximately 50 percent of the land area of Florida (Abrahamson and Hartnett 1990). The systems under management by Myakka River State Park are representative of all stages of succession possible within flatwoods. Southern Rough or the Palmetto/Gallberry Fuel Model as flatwoods and Florida dry prairie are often called by prescribed burners, is notorious for its destructive, frequently unmanageable, fires when normal fire return intervals are exceeded.

Fire history: The park was once dominated by Florida dry prairie and open, savanna-like pine flatwoods. Flatwoods and prairie systems require frequent fire return intervals (annually to 7 years) to maintain the vegetative aspect and composition which characterizes them; low, herbaceous dominated ground cover with as many as 80 different species per square meter in frequently burned areas having no history of fire interruption.

Contemporary fire hazard: Aggressive fire exclusion and suppression starting in 1934 precipitated advanced succession with heavy fuel build-ups in the highly pyrogenic ground-cover, compositional skewing to woody species (especially saw palmetto), and the advent of far greater densities of pine in those areas of the park successfully “protected”. Highly destructive wildfires evolved as early as 1943 and despite the initiation of a prescribed fire program in the early 1970’s, which became very active in the 1980’s, woody dominance continues to support atypically intense, often severe fires which preclude pine reestablishment and a return to an herbaceous dominated ground-cover. The conditions on this site also exemplify conditions now found throughout Florida; conditions which invited and supported nearly 2300 wildfires in 1998 . These fires burned nearly 500,000 acres, destroyed 126 homes, accounted for 124 injuries and a total damage estimate of 500 million dollars.

Prior work and anticipated time line: A variety of mechanical treatments to reduce fuel loads and reverse successional responses have been used since 1985 at this site. Furthermore, to the maximum extent possible, a 2-3 year fire return has been initiated via prescribed burning. Appropriate management requires the mechanical treatment of more than 10,000 acres of atypical, high-risk fuels in the park however proposals to do so remain unfunded. Implementation of the surrogate study could begin as soon as funding can be gained.

Level of long-term interest: Park management has made a commitment to fuel reduction and restoration of all pyric communities within the park and has tried to be a paradigm for other land managers with similar needs. Research is recognized as critical to the success of ecosystems restoration and long-term relationships have been cultivated with researchers from universities, county, state, and federal agencies and other organizations. Studies on mechanical and burn treatments have existed for nearly 15 years and one on longleaf pine demographics for almost a decade. Interest in the Fire/Fire Surrogate Study is strong.

Partnerships: Southern Research Station, Clemson University, USDA Natural Resources and Conservation Service, Sarasota County Natural Resources Department, Florida Game and Fresh-water Fish Commission, Florida Division of Forestry, Southwest Florida Water Management District

Site/Plot selection constraints: None

Treatments: All core treatments will be installed.

5th treatments: Herbicide application

Thinning and Burning Prescriptions: Thinning is designed to remove vertical fuels by eliminating the understory and midstory and reducing stand basal area to a level that protect from crown fires but allow economically-feasible stand management. Burning will be frequent (1- to 2-year rotation) to eliminate sprouting and support a savannah-type community.

--

Literature Cited – Site Descriptions Section

Abrahamson, W.G., and D.C. Hartnett. 1990. Pine Flatwoods and Dry Prairies, pp 103-149. In Ecosystems of Florida, Eds., R.L. Myers and J.J. Ewel. University of Central Florida Press. Orlando

Agee, J.K. 1991. Fire history along an elevational gradient in the Siskiyou Mountains, Oregon. Northwest Science 65: 188-199

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Island Press. Washington, D.C.

Agee, J.K. 1994. Fire and other disturbances of terrestrial ecosystems in the eastern Cascades. USDA Forest Service General Technical Report PNW-GTR-344.

Agee, J.K. 1996. Fire in the Blue Mountains: a history, ecology and research agenda. Pages 119-146 In: Search for a Solution: Sustaining the Land, People, and Economy of the Blue Mountains. American Forests, Washington, D.C., 316 pp.

Arno, S.F. 1980. Forest fire history of the northern Rockies. J. Forestry 78: 460-465.

Arno, S.F., Smith, H.Y., and M.A. Krebs. 1997. Old growth ponderosa pine and western larch stand structures: Influences of pre-1900 fires and fire exclusion. USDA For. Serv. Intermtn. Res. Sta. Res. Pap. INT-RP-495. 20 p.

Barker, J. 1958. *Recollections of the first settlement in Ohio*. Marietta, OH: Marietta College.Notes: edited by G. J. Blazier.

Barrows, J.S. 1978. Lightning fires in southwestern forests. Final report prepared by Colorado State University, cooperative agreement 16-568-CA. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 154 p.

Brose, P. H., and D. H. Van Lear. 1998. Responses of hardwood advance regeneration to seasonal prescribed fires in oak-dominated shelterwood stands. *Canadian Journal of Forest Research* 28: 331-39.

Caprio, A.C., and T.W. Swetnam. 1993. Historic fire regimes along an elevational gradient on the west slope of the Sierra Nevada, California. USDA Forest Service GTR INT-320. pp. 173-179.

Dieterich, J.H. 1980. Chimney Spring forest fire history. Research Paper RM-220. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p.

Franklin, J.F., C.T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University Press, Corvallis, OR, 452 pp.

Guyette, R. P., and B. E. Cutter. 1997. Fire history, population, and calcium cycling in the Current River watershed. *11th Central Hardwood Forest conference* S. G. Pallardy, R. A.

Haines, D. A., and V. J. Johnson. 1975. *Wildfire atlas of the northeastern and north central States*. St. Paul, Minn.: USDA, Forest Service, North Central Experiment Station.

Hall, F.C. 1980. Fire History--Blue Mountains. Pages 75-81 In: Proceedings of the fire history workshop. USDA Forest Service PNW Station General Technical Report, GTR-RM-81.

Harrod, R.J., B.H. McRae, and W.E. Hartl. 1998. Historical stand reconstruction in ponderosa pine forests to guide silvicultural prescriptions. Forest Ecology and Management 96.

Kilgore, B.M., and D. Taylor. 1979. Fire history of a sequoia mixed conifer forest. Ecology 60(1): 129-142.

Loskiel, G. H. 1794. *History of the Mission of the United Brethren among Indians in North America*. London: Printed for the Brethren's Society for the Furtherance of the Gospel.Notes: Translated by C. I. LaTrobe

Michaux, A. 1904. Andre Michaux's travels into Kentucky. *Early western travels 1748-1846.* editor R. G. Thwaites. Cleveland: A. H. Clark Co.

Patton-Mallory, M. 1997. Southwest wildland/urban interface fire risk reduction workshop, Flagstaff, AZ, August 4-5, 1997. Unpublished summary report on file. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

Phillips, C. 1999. Fire return intervals in mixed-conifer forests of the Kings River Sustainable Forest Ecosystem Project area. J. Verner (editor). USDA Forest Service PSW GTR (in press).

Sierra Nevada Ecosystem Project. 1996. Vol. II, University of California, Davis, Centers for Water and Wildland Resources.

Stephens, S.L. 1998. Effects of fuels and silvicultural treatments on potential fire behavior in mixed conifer forests of the Sierra Nevada, CA. Forest Ecology and Management 105: 21-34.

Sutherland, E. K. 1997. The history of fire in a southern Ohio second-growth mixed-oak forest. *Proceedings, 11th Central Hardwood forest conference,* Editors S. G. Pallardy, R. A. Cecich, H.

Swetnam, T.W. 1990. Fire history and climate in the southwestern United States. p.6-17. In:

Krammes, J.S., tech. coord. Effects of fire management of southwestern natural resources. Proceedings of the symposium, Nov. 15-17, 1988, Tucson, AZ. General Technical Report RM-191. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 293 p.

Swetnam, T.W.; Baisan, C.H. 1996. Historical fire regime patterns in the southwestern United States since AD 1700. p. 11-32. In: Allen, C.D., tech. ed. Fire effects in southwestern forests: Proceedings of the second La Mesa Fire symposium, 1994 March 29-31; Los Alamos, New Mexico. General Technical Report RM-GTR-286. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 216 p.

Taylor, A.H.; Skinner, C.N. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management 111: 285-301.

Touchan, R.; Allen, C.D.; Swetnam, T.W. 1996. Fire history and climatic patterns in ponderosa pine and mixed-conifer forests of the Jemez Mountains, Northern New Mexico. p. 33-46. In: Allen, C.D., tech. ed. Fire effects in southwestern forests: Proceedings of the second La Mesa Fire symposium, 1994 March 29-31; Los Alamos, New Mexico. General Technical Report RM-GTR-286, 216 p.

Waldrop, Thomas A.; White, David L.; Jones, Steven M. 1992. Fire regimes for pine-grassland communities in the southeastern United States. Forest Ecology and Management. 47(1992):195-210.

Wills, R.D.; Stuart, J.D. 1994. Fire history and stand development of a Douglas-fir hardwood forest in northern California. Northwest Science 68: 205-212.

Wright, C.B. 1996. Fire history of the Teanaway Valley, Washington. M.S. thesis, University of Washington, Seattle.

Yaussy, D. A., and E. K. Sutherland. 1993. Fire history in the Ohio River Valley and its relation to climate. *12th Conference on Fire and Meteorology: Fire, Meteorology, and the Landscape*, 777-86. Bethesda, MD.: Society of American Foresters.

APPENDIX B-2
Site Budgets

MISSION CREEK

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Scientists					
Agee (U Washington - Lead, fire & fuels)	5,000	5,000	5,000	5,000	5,000
Zabowski (U Wash. - soils)	5,000	5,000	0	5,000	5,000
Edmonds (U Wash. - soils, pathology)	5,000	5,000	0	5,000	5,000
Research associates					
Wildlife PhD avian ecologist	5,000	5,250	0	5,775	6,064
Soils GS9 (Term) soil scientist	20,000	5,000	5,000	10,000	10,000
Research assistants					
Soils 2 RA at U Wash.	38,000	38,000	10,000	19,000	0
Fire 1 RA at U Wash.	19,000	19,000	5,000	15,000	5,000
Pathology/Microbiology	19,000	19,000	0	15,000	10,000
Technicians (all positions are terms or temps)					
Vegetation GS7 biotech (subplots)	15,600	5,000	0	16,500	6,000
Vegetation 5 GS5 biotechs (subplots)	45,000	0	0	27,000	0
Vegetation 2 GS5 biotechs (tree census)	18,000	0	0	19,100	0
Vegetation GS7 forestry tech (horse packer)	1,950	0	0	2,100	0
Wildlife small mammal GS-7 wildlife bio.	9,100	0	0	10,010	5,000
Wildlife small mammal 2 GS-5 biotechs	10,800	0	0	11,880	0
Wildlife small mammal 6 GS-4 biotechs	13,950	0	0	15,345	0
Wildlife bird GS-9 wildlife bio.	10,500	11,025	0	12,128	12,734
Wildlife bird 2 GS5 biotechs	12,600	13,230	0	14,553	15,281
Fire UW crew (as per national protocol)	5,000	3,000	10,000	0	0
Entomology crew (as per national protocol)	35,000	0	0	35,000	35,000
Pathology (as per national protocol)	30,000	0	0	30,000	30,000
Econ (per FFS national protocol)	0	10,000	2,000	0	0
Total salaries and benefits	**323,500**	**143,505**	**37,000**	**273,391**	**150,078**
Travel					
National meetings	1,000	5,000	3,000	2,000	1,000
U Wash. Per Diem	5,000	5,000	1,500	5,000	1,000
Vegetation vehicles	8,800	6,500	0	8,000	0
Fire vehicle	2,500	0	2,500	2,000	1,500
Soils vehicles	4,000	4,000	0	4,000	0
Wildlife vehicles	5,400	1,890	0	6,039	2,183
Wildlife travel and training	1,800	945	0	2,030	1,091
Entomology vehicle	2,500	0	0	2,500	2,500
Pathology vehicle	2,500	0	0	2,500	2,500
Total travel	**33,500**	**23,335**	**7,000**	**34,069**	**11,774**
Nonexpendable Equipment					
USFS compatible IBM pc	3,000	0	0	0	0
Analytical software	2,000	0	0	0	0
Total Nonexpendable Equipment	**5,000**	**0**	**0**	**0**	**0**

MISSION CREEK (continued)

	FY00	FY01	FY02	FY03	FY04
Contracts					
Data entry & archiving	6,000	6,200	2,000	6,600	3,500
Aerial Photography	5,000	0	0	5,500	0
Photo Interpretation	3,500	0	0	4,000	0
Soils lab costs	15,000	5,000	0	15,000	5,000
Total Contracts	**29,500**	**11,200**	**2,000**	**31,100**	**8,500**
Supplies					
Vegetation	4,000	0	0	1,500	0
Wildlife pitfall traps (FS Tomahawk traps)	864	0	0	950	0
Wildlife small mammal	1,500	0	0	1,650	0
Wildlife bird	1,500	1,500	0	1,500	1,500
Fire supplies	2,500	2,500	0	0	0
Soils supplies	10,000	5,000	0	5,000	0
Entomology	1,000	0	0	1,000	1,000
Pathology	1,000	0	0	1,000	0
Total Supplies	**22,364**	**9,000**	**0**	**12,600**	**2,500**
Publication costs	**0**	**0**	**1,000**	**2,000**	**2,000**
Total Direct Costs	**413,864**	**187,040**	**47,000**	**353,159**	**174,853**
Indirect Costs					
Direct Costs for PNW Lab	278,364	69,040	11,500	257,159	136,853
Indirect Costs (15%)	**41,755**	**10,356**	**1,725**	**38,574**	**20,528**
Direct Costs for U Wash	135,500	118,000	35,500	96,000	38,000
Indirect Costs on pass through to U Wash (10%)	**13,550**	**11,800**	**3,550**	**9,600**	**3,800**
Annual Funding Requested	**469,169**	**209,196**	**52,275**	**401,333**	**199,181**
Total Funding Requested	**1,331,154**				

Timeline:
FY00 - pre-treatment sampling, control sampling, mechanical treatments initiated
FY01 - mechanical treatments completed, burn treatments initiated
FY02 - burn treatments completed
FY03 - control sampling, post-treatment sampling
FY04 - control sampling, post-treatment sampling, final data analysis

MISSION CREEK—Contributed Costs

	FY00	FY01	FY02	FY03	FY04
Federal Salaries					
Lehmkuhl	9,750	6,750	7,500	11,500	16,000
Gaines	5,000	5,000	3,000	5,000	8,000
Harrod	20,000	12,000	5,000	12,000	20,00
Hessburg	5,000	5,000	3,000	5,000	5,000
GS-7 biological technician	11,000	11,000	0	11,000	0
GS-9 Geographer	11,250	11,250	0	11,250	0
GS-7 Botanist	10,000	10,000	0	10,000	0
State Salaries					
Agee	10,000	10,000	10,000	10,000	10,000
Edmonds	5,000	5,000	2,000	5,000	0
Zabowski	5,000	5,000	2,000	5,000	0
Total Salaries Contributed	**92,000**	**81,000**	**32,500**	**85,750**	**59,000**
Contributed Overhead by UW					
Direct costs to UW under Coop Agreement	130,000	110,500	32,500	90,000	36,500
Contributed UW Overhead 20%*	**26,000**	**22,100**	**6,500**	**18,000**	**7,300**
*overhead 51% but UW claims only 20%					
Annual Contributed Costs	**118,000**	**103,100**	**39,000**	**103,750**	**66,300**
Also new GIS equipment worth $108K					
Total Contributed Costs	**430,150**				

Note: no salary is requested for permanent Federal employees
UW faculty funded are 9-month employees requesting summer salary only

HUNGRY BOB

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Research Associates					
Site Manager (USFS Term-1 position)	33,000	33,990	35,010	36,060	37,142
Site Integration Analysis (USFS Term)	0	0	0	36,060	37,142
Technical Assistants (USFS Seasonal)					
Vegetation[1]	6,000	10,800	0	0	10,800
Entomology[1]	7,000	7,000	0	0	7,000
Pathology[1]	2,000	2,000	0	0	2,000
Soils[1]	5,000	5,000	0	0	6,000
Fuels (1 position)	3,840	12,800	0	0	0
Wildlife (costs as per national protocol)	21,350	21,350	8,000	8,000	8,000
Total Salaries and Benefits	**78,190**	**92,940**	**43,010**	**80,120**	**108,084**
Travel					
Vegetation	0	8,700	0	0	8,700
Entomology	0	0	0	0	0
Pathology	0	0	0	0	0
Fuels	3,520	5,080	0	0	200
Soils	200	200	0	0	200
Wildlife	19,500	19,500	6,500	6,500	6,500
Total Travel	**23,220**	**33,480**	**6,500**	**6,500**	**15,600**
Equipment and Supplies					
Vegetation	0	0	0	0	5,000
Entomology	0	0	0	0	0
Pathology	0	0	0	0	0
Fuels	200	0	0	0	0
Soils	4,000	0	0	0	0
Wildlife	15,000	15,000	5,000	5,000	5,000
Total Equipment and Supplies	**19,200**	**15,000**	**5,000**	**5,000**	**10,000**
Contracts					
Fuel Analysis	0	1,200	0	0	0
Soil characterization	9,600	0	0	0	0
Soil analysis	12,560	22,320	0	0	35,120
Total Contracts	**22,160**	**23,520**	**0**	**0**	**35,120**
Publications & technology transfer	**0**	**0**	**10,000**	**5,000**	**2,000**
Direct Costs Total	**142,770**	**164,940**	**64,510**	**96,620**	**170,804**
Indirect costs PNW Station (15%)	**21,416**	**24,741**	**9,676**	**14,493**	**25,621**
Annual Funding Requested	**164,186**	**189,681**	**74,186**	**111,113**	**196,424**
Total Funding Requested	**735,590**				

[1]Vegetation, entomology, pathology, and soils data will be collected by a team of 4 technicians.
Timeline: Thinning treatments have been applied; prescribed fire will occur this summer 2000 Bird data will be

collected each year starting FY00; small mammal data will be collected for two years (FY2000, FY2001); other variables will be measured as described in the proposal appendix--mostly pre, post year 1, and one additional post year (FY98/99=pre; FY2001=post year 1; FY2003 or FY2004= post year 3 or 4).

HUNGRY BOB—Contributed Costs

	FY98/99	FY00	FY01	FY02	FY03	FY04
Salaries and benefits						
USDA F.S. Scientists						
Youngblood (vegetation)	6,860	7,000	7,140	7,283	7,428	7,577
McIver (soils, entomology)	9,800	10,000	10,200	10,404	10,612	10,824
Parks (pathology)	1,960	2,000	2,040	2,081	2,122	2,165
Ottmar (fuels)	2,450	2,500	2,550	2,601	2,653	2,706
Scott (entomology)	2,450	2,500	2,550	2,601	2,653	2,706
Hayes (entomology)	2,450	2,500	2,550	2,601	2,653	2,706
USFS Total	**25,970**	**26,500**	**27,030**	**27,571**	**28,122**	**28,684**
Oregon State University Faculty						
Kellog (Economics)	5,390	5,500	5,610	5,722	5,837	5,953
Oregon State Total	**5,390**	**5,500**	**5,610**	**5,722**	**5,837**	**5,953**
Treatment Implementation (National Forest)						
District Planning	45,000	0	0	0	0	0
Prescribed Fire	0	11,000	0	0	0	0
Total	**45,000**	**11,000**	**0**	**0**	**0**	**0**
USDA NRI Grant (received 1996)[1]	**125,000**	**50,000**	**50,000**	**0**	**0**	**0**
Overhead (26% differential on NRI grant)[1]	**32,500**	**13,000**	**13,000**	**0**	**0**	**0**
Annual Contributed Costs	**233,860**	**106,000**	**95,640**	**33,293**	**33,959**	**34,638**
Total Contributed Costs	**537,390**					

[1] USDA National Research Initiative Competitive Grant (225,000 to Oregon State University) funded site establishment, pre-treatment response variable measurement, operational economics, and a portion of post-treatment year 1 response variable measurement.

[2] In 1996, when the NRI grant was funded, Oregon State University charged 41% indirect costs on competitive grants; because USDA NRI allowed only 15% indirect cost assessment in 1996, OSU contributes 26% indirect cost as in-kind.

LUBRECHT FOREST

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Scientists					
Fiedler (UM-veg/fire)	6,000	6,180	6,365	6,556	6,753
Harrington (USFS-veg/fire)	-	-	-	-	-
Deluca (UM-soils)	3,000	3,090	3,183	3,278	3,377
Mills (UM-wildlife)	3,000	3,090	3,183	3,278	3,377
Six (UM-ent/path)	3,000	3,090	3,183	3,278	3,377
Fringe (22%)	3,300	3,399	3,501	3,606	3,714
Keegan (UM-Utilization)	0	1,386	0	0	0
Fringe (32%)	0	444	0	0	0
Research Specialists					
salary - UM 1 position (veg/fire)	24,000	24,720	25,462	26,225	27,012
Fringe	6,960	7,169	7,384	7,605	7,834
health - UM 1 position ($295/mon.)	3,540	3,646	3,756	3,868	3,984
Research Assistants					
Veg/Fire (MS)	0	14,976	15,425	0	0
Soils (Ph.D.)	0	15,595	16,063	16,545	0
Wildlife (Ph.D.)	0	15,595	16,063	16,545	0
Ent/Path (Ph.D.)	0	15,595	16,063	16,545	0
Fringe	0	6,176	6,361	4,964	0
Technical Assistants (UM)					
Field Asst. (veg/fire 2 positions)	7,200	7,416	7,638	0	8,104
Field Asst. (wildlife 4 positions)	12,000	12,360	12,732	13,112	13,508
Field Asst. (ent/path 3 positions)	9,000	9,270	9,549	9,834	10,131
Field Asst. (path 1 position)	3,000	3,090	3,183	3,278	3,377
Res Asst. (12 wks-fire)	0	0	4,278	0	0
Res Asst. (12 wks-soils)	0	4,153	4,278	0	4,538
Res Asst. (10 wks-wildlife-2 positions)	6,800	7,004	7,214	7,430	7,654
Res Asst. (12 wks-ent/path)	4,032	0	4,278	0	4,538
Res Asst. (Utilization)	0	6,500	2,000	0	0
Fringe	4,203	4,979	5,515	3,365	5,185
Total Salary/Benefits	**99,035**	**178,924**	**186,657**	**149,316**	**116,457**
Contracted Services					
Harvest cost/product value analysis (Univ. of Montana)	0	0	10,609	10,927	11,255
Firefighters (10 @ $120/day for 18 days)	0	0	21,600	0	0
Lg tanker 12 days @ $1250/day	0	0	15,000	0	0
Sm tanker 12 days @ $500/day	0	0	6,000	0	0
Aerial photography	5,000	0	0	0	5,000
Photo interpretation	3,500	0	0	0	4,500
Total Contracted Services	**8,500**	**0**	**53,209**	**10,927**	**20,755**
Travel					
Scientists (study sites; mtgs.)	3,000	8,000	6,000	7,000	8,000
Research Spec/Asst to site	7,360	7,370	5,430	5,395	5,400
Students to study site	8,000	8,000	8,000	8,000	5,000
Total Travel	**18,360**	**23,370**	**19,430**	**20,395**	**18,400**

LUBRECHT FOREST (continued)

	FY00	FY01	FY02	FY03	FY04
Supplies/Nonexpendable equipment					
Portable computer (2) for wildlife	4,000	0	0	0	0
Computer for veg/fire	2,500	0	0	0	0
Traps/scales	8,000	0	0	0	0
Total Supplies/Nonexpendable Equipment	**14,500**	**0**	**0**	**0**	**0**
Supplies					
Plot Installation	1,200	0	0	0	0
Vegetation	3,500	1,500	0	1,000	1,500
Fire	1,000	1,000	2,000	1,000	500
Soils	1,550	7,550	7,050	500	7,550
Wildlife	2,000	2,000	2,000	2,000	2,000
Entomology	2,000	2,000	2,000	2,000	2,000
Pathology	1,000	500	500	500	0
Total Supplies	**12,250**	**14,550**	**13,550**	**7,000**	**13,550**
Publications	**0**	**0**	**2,500**	**3,000**	**3,000**
Total Direct Costs	**152,645**	**216,844**	**275,346**	**190,638**	**172,162**
Indirect Costs Univ. Montana (15%)	**22,897**	**32,527**	**41,302**	**28,596**	**25,824**
Annual Funding Requested	**175,542**	**249,371**	**316,648**	**219,234**	**197,986**
Total Funding Requested	**1,158,781**				

Project Timeline
FY00 - Select field study sites and install grid points; install small mammal and herp traps; collect pretreatment data for all disciplines, obtain aerial photography.
FY01 - Conduct harvest treatments in winter-spring 2001 (or late-summer/fall of 2001 if heavy snow year); collect data for treatment cost/utilization study; reestablish grid points as needed, continue to collect small mammal, herp, and avifauna data, collect post-treatment vegetation and fuels data, collect post-treatment data for all other disciplines as appropriate.
FY02 - Inventory fuels immediately before burning; conduct burning treatments in cut/burn and burn-only treatments in spring of 2002 (or fall of 2002, if weather doesn't cooperate), continue to collect wildlife data, collect post-treatment data for all other disciplines as appropriate, analyze and publish initial results for soils and entomology/pathology studies.
FY03 - Continue to collect data for all disciplines as appropriate, particularly wildlife, ent/path, and fire effects.
FY04 - Final data collection for all disciplines, analysis, and publication of results for all studies.

LUBRECHT FOREST—Contributed Costs

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Fiedler Site Leader - UM	6,000	6,180	6,365	6,556	6,753
DeLuca Soils - UM	3,000	3,090	3,183	3,278	3,376
Mills Wildlife - UM	3,000	3,090	3,183	3,278	3,376
Six Entomology/Pathology - UM	3,000	3,090	3,183	3,278	3,376
Keegan Industry Research - UM	0	1,376	0	0	0
Forester Lubrecht Exp Forest - UM	3,000	5,000	5,000	1,000	1,000
Res. Asst. Lubrecht Exp. Forest - UM	1,000	1,000	2,000	500	500
Res. Asst. School of Forestry - UM	2,000	2,000	2,000	1,000	500
Fringe (15%)	3,150	3,275	3,737	2,834	2,832
Total Salaries and Benefits	**24,150**	**28,561**	**28,651**	**21,724**	**21,713**
Travel	**1,000**	**1,000**	**1,000**	**1,000**	**500**
Total Direct Costs	**25,150**	**29,561**	**29,651**	**22,724**	**22,213**
Indirect Costs (40.5% MTDC)	**10,186**	**11,972**	**12,009**	**9,203**	**8,996**
Unrecovered Indirect Costs (40.5% MTDC) less IDC as assessed	**39,924**	**55,295**	**109,167**	**77,753**	**72,240**
Annual Contributed Costs	**74,260**	**96,828**	**109,167**	**77,753**	**72,240**
Total Contributed Costs	**430,248**				

KLAMATH MOUNTAINS

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Support Crews					
Fire/Fuels : Floor (1@GS-6, 4@GS-5 Seasonal)	0	8,088	8,330	18,761	12,140
Fire/Fuels : Woody (1@GS-6, 4@GS-5 Seasonal)	0	7,230	7,450	15,347	8,140
Wildlife : Birds (3 student positions)	0	13,100	27,000	0	14,000
Wildlife : Mammals – Herps (3 student positions)	0	13,100	27,000	0	14,000
Soils (2@GS-6, 4@GS-5 Seasonal)	0	10,785	22,220	0	11,100
Entomology (1@GS-6, 3@GS-5 Seasonal)	0	0	5,800	17,900	18,460
Pathology (1@GS-6, 3@GS-5 Seasonal)	0	7,770	16,000	0	8,500
Vegetation (1@GS-6, 3@GS-5 Seasonal)	0	6,090	12,545	0	6,655
Site Administration Personnel (all are PSW term employees)					
Site Coordinator GS-11	20,600	26,455	27,250	28,100	28,945
Sale Administration	0	0	7,205	14,845	0
Site Layout/Grid	0	1,700	3,500	1,800	3,700
Total Salaries and Benefits	**20,600**	**94,318**	**164,300**	**96,753**	**125,640**
Travel					
Science Personnel					
Fire/Fuels	0	1,250	2,580	1,325	2,650
Wildlife	0	3,980	5,240	0	4,470
Soils	0	2,000	4,125	0	2,250
Entomology	0	2,560	5,270	2,120	6,550
Pathology	0	2,560	5,270	0	2,880
Vegetation	0	3,730	7,680	1,325	5,450
Crews					
Fire/Fuels : Floor	0	5,600	5,775	12,330	7,890
Fire/Fuels : Woody	0	5,600	5,775	11,900	6,315
Wildlife : Birds	0	18,360	37,820	0	20,000
Wildlife : Mammals - Herps	0	18,360	37,820	0	20,000
Soils	0	7,455	15,355	0	8,390
Entomology	0	0	3,850	11,500	11,840
Pathology	0	2,050	4,220	0	2,240
Vegetation	0	3,730	7,680	0	4,075
Site Administration	7,658	14,550	14,500	15,440	15,900
Total Travel	**7,658**	**91,785**	**162,960**	**55,940**	**120,900**
Supplies and Equipment					
Fire/Fuels : Floor	0	0	0	0	0
Fire/Fuels : Woody	0	1,100	2,266	2,295	3,500
Wildlife : Birds	0	1,080	2,230	0	1,180
Wildlife : Mammals - Herps Sup.	0	1,000	2,060	0	1,100
Wildlife : Mammals - Herps Equip	0	12,000	0	0	0
Soils	0	3,600	7,425	0	3,950
Entomology	0	0	2,100	4,500	4,775
Pathology	0	500	1,100	0	565
Vegetation	0	500	0	0	0
Camera Documentation	0	1,000	0	0	0
Grid Establishment/Maint.	0	2,000	4,200	1,250	2,500
Site Administration	3,000	1,250	1,350	1,400	1,500
Total Supplies and Equipment	**3,000**	**24,030**	**22,731**	**9,445**	**19,070**

KLAMATH MOUNTAINS (continued)

	FY00	FY01	FY02	FY03	FY04
Total Direct Costs	**31,258**	**210,133**	**349,991**	**162,138**	**265,610**
Indirect Costs PSW Station (15%)	**4,689**	**31,520**	**52,499**	**24,321**	**39,842**
Annual Funding Requested	**35,947**	**241,653**	**402,490**	**186,459**	**305,452**
Total Funding Requested	**1,172,001**				

Timeline:
FY00- Coordinate for NEPA on the cooperating national forests.
FY01- Pretreatment data collection on Block 1 - continue NEPA coordination for Blocks 2 & 3
FY02- Mechanical treatments of Block 1 - Pretreatment data collection of Blocks 2 & 3
FY03- Fire treatments of Block 1 - Mechanical treatments of Blocks 2 & 3
FY04- Post treatment data collection Block 1 - Fire treatments of Blocks 2 & 3
FY05- Post treatment data collection of Blocks 2 & 3
FY06- 3rd Yr Post treatment data collection for soils of Block 1
FY07- 3rd Yr Post treatment data collection for soils of Blocks 2 & 3

KLAMATH MOUNTAINS—Contributed Costs

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
National Forest NEPA	35,385	72,888	0	0	0
Fire/Fuels : Floor - Scientist	0	6,035	6,220	6,400	6,600
Fire/Fuels : Floor - Technician	0	7,076	7,076	3,600	3,600
Fire/Fuels : Woody - Scientist	0	6,035	6,220	0	0
Fire/Fuels : Woody - Technician	0	7,076	7,076	0	0
Wildlife : Birds - Scientist	5,857	6,035	6,220	6,400	6,600
Wildlife : Birds - Technician	0	0	0	0	0
Wildlife : Mammals - Herps - Scientist	0	6,035	6,220	6,400	6,600
Wildlife : Mammals - Herps - Technician	0	0	0	0	0
Soils - Scientist	0	6,035	6,220	3,200	6,600
Soils - Technician	0	7,076	7,076	3,600	3,600
Entomology - Scientist	0	0	6,220	12,800	19,800
Entomology - Technician	0	0	7,076	7,076	7,076
Pathology - Scientist	0	6,035	6,220	0	6,600
Pathology - Technician	0	7,076	7,076	0	7,076
Vegetation - Scientist	5,857	6,035	6,220	6,220	6,600
Vegetation – Technician	0	7,076	7,076	7,076	7,076
Annual Contributed Costs	**47,099**	**150,513**	**92,216**	**62,772**	**87,828**
Total Contributed Costs	**440,428**				

BLODGETT FOREST RESEARCH STATION

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
UC Berkeley (All 9 month appointments)					
Fire Ecology (10% time) Stephens	0	7,210	7,426	7,649	7,879
Silviculture (7% time) O'Hara	0	5,150	5,305	5,464	5,628
Pathology and Entomology (7% time) Storer	0	5,150	5,305	5,464	5,628
Research Associate - UC Berkeley					
Site Coordinator[1]	8,500	36,050	37,132	38,245	39,393
Benefits (annual - 30%)	2,550	10,815	11,139	11,474	11,818
Research Assistants -UC Berkeley					
Vegetation, fuels, fire behavior (MS student)	0	17,800	17,800	17,800	0
Entomology (PhD student)	0	17,800	17,800	17,800	17,800
Soils (MS students)	0	17,800	17,800	17,800	17,800
Pathogens (PhD student)	0	17,800	17,800	17,800	17,800
Small mammals and herps (MS student)	0	17,800	17,800	17,800	0
Avifauna (MS student)	0	17,800	17,800	17,800	0
Benefits - 14%[2]	0	14,952	14,952	14,952	7,476
Technicians -UC Berkeley					
Number of summer techs paid by JFS funds	2	6	2	4	6
Cost of summer JFS technicians (includes housing and benefits)	15,000	36,000	15,000	24,000	36,000
Total Salaries & Benefits	**26,050**	**222,127**	**203,059**	**214,048**	**167,222**
Travel					
Rental vehicles, gas (summer only)	3,500	7,000	3,815	7,649	7,878
Rental vehicles, gas (annual, res. assoc. & assist.)	1,000	6,180	3,365	6,556	6,753
Temporary housing (annual, res. assoc. & assist.)	1,000	4,000	2,244	4,371	4,502
Total travel	**5,500**	**17,180**	**9,424**	**18,576**	**19,133**
Non-expendable Equipment					
Small mammals and herps (traps, scales)	0	8,000	0	0	0
Two desktop computers	7,000	0	0	0	0
Digital camera	0	900	0	0	0
Economics/utilization (Servis Recorder)	0	2,000	0	0	0
Total non-expendable equipment	**7,000**	**10,900**	**0**	**0**	**0**
Contracts					
Harvest cost/product yield analysis (Univ. Cal Davis)	10,000	24,199	26,523	27,318	0
Wood product potential analysis (Cal For Prod Lab)	0	16,199	26,523	27,318	0
Air photos (50% paid by Blodgett)	0	2,500	0	0	2,500
Total contracts	**10,000**	**42,898**	**53,046**	**54,636**	**2,500**

[1]Site coordinator is a critical position and will be filled by a temporary employee. Duties include participation and supervision of all field data collection and development and maintenance of site database. Coordinator will also work with Blodgett Forest Managers to coordinate housing and transportation for all technicians and scientists. Will also perform meta analysis of data in years 4 and 5.
[2] UC students receive health and workers compensation insurance.

BLODGETT FOREST RESEARCH STATION (continued)

	FY00	FY01	FY02	FY03	FY04
Materials and Supplies					
Fuels-fire behavior	0	2,000	2,112	2,175	2,241
Entomology	0	4,000	0	4,244	4,244
Soils	0	12,000	0	12,370	12,740
Small mammals and herps	0	1,000	0	1,061	1,093
Avifauna	0	3,000	0	1,061	1,093
Pathogens	0	5,000	0	5,150	5,305
Vegetation	1,000	3,500	2,000	0	2,185
Total Supplies	**1,000**	**30,500**	**4,112**	**26,061**	**28,901**
Total Direct Costs	**49,550**	**323,605**	**269,641**	**313,321**	**217,756**
Indirect Costs UC Berkeley (10%)	**4,955**	**32,361**	**26,964**	**31,332**	**21,776**
Annual Funding Requested	**54,505**	**355,966**	**296,605**	**344,653**	**239,532**
Total Funding Requested	**1,291,261**				

Timeline:
FY2000 - All 12 experimental plots have been selected (complete randomized design). Plot boundaries entered into GIS system. Work to be done includes surveying and establishing all grid points within each plot, monument all grid locations, install small mammal and herpetofauna traps, collect pretreatment data for vegetation, soils, fuels, pathogens, small mammals, herpetofauna, avifauna, and entomology. Update GIS system with all grid locations.
FY2001 - Install all treatments (prescribed fire alone, mechanical alone, fire + mechanical treatment), reestablish all grid points, monuments, and traps, collect treatment cost data for economics study, collect post-treatment data for vegetation and fuels. Enter data into site database.
FY2002 - Collect first year post-treatment data on all plots including vegetation, soils, fuels, pathogens, small mammals, herpetofauna, avifauna, and entomology. Enter all data in site database. Conduct public workshop at the Blodgett Research Forest Conference Center to present early results.
FY2003 - Continue data collection on all variables, collect soil samples. Trained undergraduate students will continue data collection for small mammals, herps, avifauna, and soils because MS students will graduate. Enter all data into site database. Conduct public workshops at the Blodgett Conference Center to present results.
FY2004 - Obtain air photos the of experimental area for final vegetation analysis. Collect data for all disciplines and enter into site database. Perform meta analysis on all data, coordinate meta data analysis with other sites. Publish results in peer reviewed journals. Present results to national meetings. Conduct public workshops at the Blodgett Conference Center to present complete five year results.

BLODGETT FOREST RESEARCH STATION—Contributed Costs

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
USDA Forest Service					
Scientists					
Barbour (USFS - Utilization)	3,500	3,605	3,713	3,824	3,939
Fringe (33%)	1,155	1,190	1,225	1,262	1,300
FS Total	**4,655**	**4,795**	**4,938**	**5,087**	**5,239**
Faculty and Staff Salaries (UC Berkeley)					
McBride (Forest ecology)	6,000	6,180	6,365	6,556	6,753
Beall (Utilization)	6,000	6,180	6,365	6,556	6,753
Barrett (Wildlife)	6,000	6,180	6,365	6,556	6,753
Heald (Forest scheduling, contracts)	6,000	6,180	6,365	6,556	6,753
Schurr (Forest operations)	5,000	5,150	5,305	5,464	5,628
Faculty/Staff Total	**29,000**	**29,871**	**30,765**	**31,689**	**32,640**
Technicians					
Summer technicians (2 positions)	15,000	15,000	15,000	15,000	15,000
Technicians Total	**15,000**	**15,000**	**15,000**	**15,000**	**15,000**
Housing					
Temporary housing (res. assoc. & assist)	8,000	4,000	8,000	8,000	8,000
Housing Total	**8,000**	**4,000**	**8,000**	**8,000**	**8,000**
Contracts					
Air photos (50-50 split with Blodgett)	2,500	0	0	0	2,500
Air photo analysis	5,000	0	0	0	5,000
Total Contracts	**7,500**	**0**	**0**	**0**	**7,500**
Operations					
Prescribed Burning					
Fireline Preparation (6 sites*60hrs/site*$25/hr)	0	9,000	0	0	0
Personnel for burning (6 sites*15hrs/site*$100/hr)	0	9,000	0	0	0
Mastication Equipment + Operation (6 sites*70hrs/site*$100/hr)	0	42,000	0	0	0
Total Operations	**0**	**60,000**	**0**	**0**	**0**
Annual Contributed Costs	**64,155**	**95,665**	**58,703**	**59,775**	**68,379**
Total Contributed Costs	**346,677**				

SEQUOIA NATIONAL PARK

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Site Manager (GS-11 Term 100%)	0	53,095	54,685	56,325	58,015
Technicians					
Veg/fuels (GS-6 Temp 50%)	0	13,515	13,915	0	14,765
Veg/fuels (GS-5 Temp 30%)	7,850	8,085	8,325	0	8,835
Veg/fuels (GS-5 Temp 30% 2 positions)	0	16,170	16,650	0	17,670
Fire Monitoring (GS-6 Temp 7%)	0	1,890	1,925	0	0
Wildlife (GS-6 Temp 30%)	0	8,109	8,300	8,575	8,73
Wildlife (GS-5 Temp 20% 4 positions)	0	14,000	14,400	14,800	15,200
Soil crew (as per national protocol)	0	18,000	18,000	0	18,500
Pathology crew (as per national protocol)	0	20,000	20,000	0	20,000
Entomology crew (as per national protocol)	0	29,000	0	29,000	0
Total Salaries and Benefits	**7,850**	**181,894**	**156,200**	**108,700**	**161,720**
Travel					
National Travel	0	0	0	1,200	2,400
Field	2,000	14,600	14,850	8,000	15,400
Total Travel	**2,000**	**14,600**	**14,850**	**9,200**	**17,800**
Nonexpendable Equipment					
Traps/scales	0	7,000	0	0	0
Servis recorder	0	2,000	0	0	0
Laptop computer	0	3,000	0	0	0
PC computers	0	5,500	0	0	0
Digital camera/storage	0	975	0	0	0
Printer	0	1,900	0	0	0
Convection oven	0	4,500	0	0	0
Refrigerator	0	1,300	0	0	0
Balance	0	1,500	0	0	0
pH meter	0	950	0	0	0
Total Nonexpendable Equipment	**0**	**28,625**	**0**	**0**	**0**
Supplies					
Vegetation/plot setup	500	4,000	1,000	0	1,000
Wildlife	0	5,100	1,500	1,000	500
Soils	0	8,000	2,900	0	3,000
Pathology	0	1,000	1,100	0	1,400
Entomology	0	1,000	0	1,000	0
Total Supplies	**500**	**19,100**	**6,500**	**2,000**	**5,900**
Contracts					
Office space/housing	0	12,000	10,000	10,000	10,000
Aerial Photography	0	5,000	0	0	5,500
Aerial Interpretation	0	3,500	0	0	3,750
Soils Lab	0	17,000	17,000	0	17,500
Pathology analysis	0	10,000	10,000	0	10,000
Total Contracts	**0**	**47,500**	**37,000**	**10,000**	**46,750**
Total Direct Costs	**10,350**	**291,719**	**214,550**	**129,900**	**232,170**

SEQUOIA NATIONAL PARK (continued)

	FY00	FY01	FY02	FY03	FY04
Indirect Costs USGS (15%)	**1,553**	**43,758**	**32,183**	**19,485**	**34,826**
Annual Funding Requested	**11,903**	**335,477**	**246,732**	**149,385**	**266,996**
Total Funding Requested	**1,010,493**				

Timeline
2001: Preburn sampling for all variables, conduct fall prescribed burn
2002: Conduct spring prescribed burn, sample all first-year post-burn variables except entomology
2003: Second-year post-burn sampling for wildlife and entomology.
2004: Third-year sampling for all variables except entomology

SEQUOIA NATIONAL PARK—Contributed Costs

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Jon Keeley (USGS)	10,460	16,165	16,535	16,920	17,285
Nate Stepehenson (USGS)	1,525	3,920	4,010	4,130	4,255
Anne Pfaff (USGS)	1,020	1,050	1,075	1,100	1,200
Anthony Caprio (NPS)	1,020	1,050	1,075	1,100	1,200
Bill Kaage (NPS)	1,300	3,250	3,325	1,420	1,455
Jeff Manley (NPS)	1,175	2,940	3,010	1,280	1,310
Total Salaries and Benefits	**16,500**	**28,375**	**25,445**	**24,850**	**26,705**
Operations					
GIS work (NPS)	1,500	0	1,000	0	0
Prescribed Burning ($11/ha* x 14 ha x 3 sites)	0	4,725	4,725	0	0
Total Operations	**1,500**	**4,725**	**5,725**	**0**	**0**
Travel (meetings)	**1,100**	**1,200**	**1,200**	**1,200**	**1,500**
Annual Contributed Costs	**19,100**	**34,300**	**32,370**	**26,050**	**28,205**
Total Contributed Costs	**140,025**				

SOUTHWEST PLATEAU

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits (temporary technicians)					
Fuels, Fire Behavior - PSW 4403 3 seasonal technicians	0	50,000	50,000	0	50,000
Soils, Forest Floor - RMRS 4302 2 2 seasonal technicians	30,000	0	30,000	0	30,000
Wildlife - RMS 4251 - 2 seasonal technicians	20,000	0	20,000	20,000	20,000
Total Salaries	**50,000**	**50,000**	**100,000**	**20,000**	**100,000**
Travel					
Fuels, Fire Behavior - PSW 4403	0	10,000	10,000	0	10,000
Soils, Forest Floor - RMRS 4302	3,000	0	3,000	0	3,000
Wildlife - RMS 4251	3,000	0	3,000	3,000	3,000
Total Travel	**6,000**	**10,000**	**16,000**	**3,000**	**16,000**
Supplies					
Fuels, Fire Behavior - PSW 4403	0	5,000	5,000	0	5,000
Soils, Forest Floor - RMRS 4302	8,000	0	8,000	0	8,000
Wildlife - RMS 4251	10,000	0	2,000	2,000	2,000
Total Supplies	**18,000**	**5,000**	**15,000**	**2,000**	**15,000**
Grants and Agreements					
Vegetation (Northern Arizona University - includes plot layout and surveys)	60,000	0	60,000	0	50,000
Wildlife (Northern Arizona University)	40,000	0	40,000	0	40,000
Pathology (Northern Arizona University)	14,000	0	14,000	0	14,000
Entomology (Northern Arizona University)	40,000	0	40,000	0	40,000
Utilization (Northern Arizona University)	10,000	25,000	0	0	0
Total Grants and Agreements	**164,000**	**25,000**	**154,000**	**0**	**144,000**
Total Direct Costs	**238,000**	**90,000**	**285,000**	**25,000**	**275,000**
Indirect Costs RM Station(10%)	**23,800**	**9,000**	**28,500**	**2,500**	**27,500**
Annual Funding Requested	**261,800**	**99,000**	**313,500**	**27,500**	**302,500**
Total Funding Requested	**1,004,300**				

Timeline:
Most sampling has been reduced to alternate years. Thinning is planned after FY00 and burning after FY01.
Small mammal inventories are needed annually after treatments are imposed. Utilization, costs, and economics work is critically needed in the Southwest where the forest products processing and harvesting infrastructure has been lost. Indirect cost rate is 10% for program management assessed by RMRS for Forest Service Research and Development funding.
Notes:
There is no FS reimbursement to NAU (state cooperative institution) for indirect costs.
RJVAs with NAU include a portion of summer salary only for faculty/staff on 9-month appointments. Other salaries are for graduate research assistants.
No salary is requested for permanent federal employees.

SOUTHWEST PLATEAU—Contributed Costs

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
RMRS 4156 - Edminster; site coordinator	32,000	15,000	32,000	10,000	50,000
PSW 4403 - Haase; Burke	0	45,000	45,000	0	55,000
RMRS 4302 - Neary; Overby; Telles	50,000	10,000	50,000	10,000	70,000
RMRS 4251 - Block; Moir; Zimmerman	22,000	0	22,000	22,000	35,000
Equipment					
RMRS Soils and biochemistry lab equipment	120,000	0	0	0	0
RMRS Survey and GPS, GIS equipment	45,000	0	0	0	0
Grants and Agreements					
NAU indirect (48.3% of salaries)	57,500	9,600	52,000	0	48,700
NAU P.I./staff salaries	31,000	14,000	29,000	0	36,000
Annual Contributed Costs	**357,500**	**93,600**	**230,000**	**42,000**	**294,700**
Total Contributed Costs	**$1,017,800**				

JEMEZ MOUNTAINS

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits (temporary technicians)					
Fuels, Fire Behavior - PSW 4403 3 seasonal technicians	0	0	50,000	50,000	0
Soils, Forest Floor - RMRS 4302 1 seasonal technician	0	10,000	0	10,000	0
Wildlife - RMS 4251 2 seasonal technicians	0	20,000	0	20,000	20,000
Total Salaries	**0**	**30,000**	**50,000**	**80,000**	**20,000**
Travel					
Fuels, Fire Behavior - PSW 4403	0	0	15,000	15,000	0
Soils, Forest Floor - RMRS 4302	0	3,000	0	3,000	0
Wildlife - RMS 4251	0	8,000	0	8,000	8,000
Total Travel	**0**	**11,000**	**15,000**	**26,000**	**8,000**
Supplies					
Fuels, Fire Behavior - PSW 4403	0	0	5,000	5,000	0
Soils, Forest Floor - RMRS 4302	0	3,000	0	3,000	0
Wildlife - RMS 4251	0	10,000	0	2,000	2,000
Total Supplies	**0**	**13,000**	**5,000**	**10,000**	**2,000**
Grants and Agreements					
Vegetation (Stephen F. Austin State Univ. - includes plot layout and surveys)	20,000	60,000	0	60,000	0
Wildlife (Northern Arizona University)	0	40,000	0	40,000	0
Soils (Univ New Mexico & Los Alamos Natl Lab.)	0	40,000	0	40,000	0
Pathology (Univ. New Mexico)	0	20,000	0	20,000	0
Entomology (Northern Arizona University)	0	40,000	0	40,000	0
Utilization (Northern Arizona University)	0	10,000	25,000	0	0
Total Grants and Agreements	**20,000**	**210,000**	**25,000**	**200,000**	**0**
Total Direct Costs	**20,000**	**264,000**	**95,000**	**316,000**	**30,000**
Indirect Costs RM Station (10%)	**2,000**	**26,400**	**9,500**	**31,600**	**3,000**
Annual Funding Requested	**22,000**	**290,400**	**104,500**	**347,600**	**33,000**
Total Funding Requested	**797,500**				

Timeline and Notes:
Site installation is delayed one year with the exception of layout and survey. Most sampling has been reduced to alternate years. Thinning is planned after FY01 and burning after FY02. Small mammal inventories are needed annually after treatments are imposed. Utilization, costs, and economics work is critically needed in the Southwest where the forest products processing and harvesting infrastructure has been lost. Indirect cost rate is 10% for program management assessed by RMRS for Forest Service Research and Development funding. There is no FS reimbursement to SFASU and NAU (state cooperative institutions) for indirect costs. There is no FS reimbursement to LANL for indirect costs. FS reimbursement to UNM (non-state cooperative institution) for indirect costs is limited to 10%. RJVAs with SFASU, NAU, and UNM include a portion of summer salary only for faculty/staff on 9-month appointments. Other salaries are for graduate research assistants. No salary is requested for permanent federal employees. Support for FY05 (year 6) is anticipated from JFSP to complete the first full 5 years.

JEMEZ MOUNTAINS—Contributed Costs

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
RMRS 4156 - Edminster; site coordinator	20,000	32,000	15,000	32,000	10,000
PSW 4403 - Haase; Burke	0	0	45,000	45,000	0
RMRS 4302 - Neary; Overby; Telles	0	30,000	10,000	30,000	10,000
RMRS 4251 - Block; Moir; Zimmerman	0	22,000	0	22,000	22,000
Equipment, Contracts for Equipment					
RMRS Soils and biochemistry lab equipment	0	42,000	0	0	0
RMRS Survey and GPS, GIS equipment	10,000	0	0	0	0
Grants and Agreements					
University indirect	7,500	59,600	9,000	57,800	0
University P.I./staff salaries	4,500	28,000	6,000	29,000	0
LANL indirect	12,000	0	12,000	0	0
LANL salaries	4,000	0	4,000	0	0
Annual Contributed Costs	**42,000**	**229,600**	**85,000**	**231,800**	**42,000**
Total Contributed Costs	**$630,400**				

OHIO HILL COUNTRY

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Administrative Assistant					
Clerk/typist GS-3	18,470	19,024	15,676	16,146	16,631
Research Associates					
Pathogens GS-11 (Term) 33%	13,384	13,786	0	0	15,064
Wildlife (Ohio U MS)	14,238	14,665	15,105	15,558	16,025
Fire (Ohio U PhD)	17,445	17,968	0	0	19,636
Vegetation (Ohio U PhD)	17,445	17,968	0	0	19,636
Utilization (Ohio U MS)	8,000	2,000	0	0	0
Research Assistant					
Soils (Ohio State Laboratory Assistant)	26,400	27,192	11,330	0	30,900
Student Labor (OU Soils)	4,500	4,635	2,500	2,400	5,000
Wildlife Field Crew Leader (OU)	3,600	3,600	0	0	0
Wildlife field crew (OU 2-1 students)	14,286	14,286	7,519	7,519	7,519
Fire Crew (OU 2 students)	5,500	5,500	0	0	0
USFS GS-4 (Term - Veg. Maint.)	20,733	21,355	21,996	22,656	23,335
Fringe (All positions)	30,723	30,812	16,806	15,862	30,006
Total Salaries and Benefits	**194,724**	**192,792**	**90,932**	**80,141**	**183,751**
Travel					
National Meetings	4,500	6,000	6,000	4,500	4,500
Field Work	13,000	13,000	7,500	4,000	8,800
Total Travel	**17,500**	**19,000**	**13,500**	**8,500**	**13,300**
Nonexpendable Equipment					
Plot Setup and Maintenance	1,625	250	250	250	250
Traps and Scales	5,000	0	0	0	0
Computers (3), Digital Camera, Storage	10,000	1,500	500	500	500
Pathology tools and equipment	7,000	3,500	0	0	3,500
Microplate Reader	7,185	0	0	0	0
Pipetters (2)	1,260	0	0	0	0
All Terrain Vehicle	7,000	0	0	0	0
Total Nonexpendable Equipment	**39,070**	**5,250**	**750**	**750**	**4,250**
Contracts					
Aerial Photography	5,000	0	0	0	5,000
Total Contracts	**5,000**	**0**	**0**	**0**	**5,000**
Supplies					
Plot setup and maintenance	1,000	250	250	250	250
Soils	5,000	5,000	1,000	1,000	6,000
Wildlife	2,000	2,000	2,000	2,000	2,000
Fire Behavior	1,000	1,000	0	0	0
Total Supplies	**9,000**	**8,250**	**3,250**	**3,250**	**8,250**

OHIO HILL COUNTRY (continued)

	FY00	FY01	FY02	FY03	FY04
Total Direct Costs	**265,294**	**225,292**	**108,432**	**92,641**	**214,551**
Indirect Costs					
USFS in-house portion of total direct costs	87,962	68,415	45,172	43,802	70,930
Pass-through money to cooperators	177,332	156,877	63,260	48,839	143,622
NE Station overhead for in house portion (15%)	13,194	10,262	6,776	6,570	10,639
NE Station overhead for pass-through (10%)	17,733	15,688	6,326	4,884	14,362
Cooperators overhead (15%)	26,600	23,532	9,489	7,326	21,543
Total Indirect Costs	**57,527**	**49,481**	**22,591**	**18,780**	**46,545**
Annual Funding Requested	**322,822**	**274,773**	**131,022**	**111,421**	**261,096**
Total Funding Requested	**1,101,134**				

Timeline:
FY00 - Select study sites; install grid points and monuments; install small mammal and herpetofauna traps; obtain aerial photography; collect pretreatment data for vegetation, soils, pathogens, small mammals, herpetofauna, avifauna, and fuels.
FY01- Install treatments (Winter 2000-2001), reestablish grid points, monuments, and traps; collect treatment cost data for economics study; collect first-year post-treatment data for vegetation, soils, pathogens, small mammals, herpetofauna, avifauna, and fuels; analyze and publish data for vegetation, soils, small mammals, herpetofauna, and fuels.
FY02-Data collection, analysis and publication for studies of pathogens and avifauna; continued data collection for vegetation..
FY03-Data collection for vegetation, collect soil samples, establish follow-up studies for avifauna, and conduct second prescribed burn.
FY04-Final data collection, analysis and publication for all studies.

OHIO HILL COUNTRY—Contributed Costs

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Scientists					
Yaussy (USFS - Vegetation)	13,488	13,893	14,309	14,739	15,181
Hutchinson (USFS - Vegetation)	10,194	10,500	10,815	11,139	11,473
Iverson (USFS - Landscape Ecology)	3,750	3,863	3,978	4,098	4,221
Miles (Ohio Univ. - Wildlife/Birds)	10,700	11,021	11,352	11,692	12,043
McCarthy (Ohio Univ. - Fire &Veg.)	10,000	10,300	5,305	5,464	11,255
Williams (Ohio State - Util.)	5,000	0	0	0	0
Long (USFS - Pathology)	7,500	7,725	7,957	8,195	8,441
Rebbeck (USFS - Pathology)	13,400	13,802	14,216	14,643	15,082
Boerner (Ohio State - Soils)	13,270	13,668	14,078	14,500	14,936
Administrative Assistant					
Site Coordinator GS-7 75%	28,733	29,595	24,386	25,118	25,871
Research Associates					
GIS Specialist (Ohio State)	2,250	2,318	2,387	2,459	2,532
Research Assistants					
USFS GS-9 (Veg., Maint.)	39,834	41,029	42,260	43,528	44,834
Fringe (all positions)	52,179	52,045	49,844	51,339	54,737
Total Salaries and Benefits	**210,298**	**209,758**	**200,887**	**206,914**	**220,606**
Travel					
National Meetings	1,000	1,500	1,500	1,000	2,000
Total Travel	**1,000**	**1,500**	**1,500**	**1,000**	**2,000**
Nonexpendable Equipment					
Computers and Peripherals	1,500	1,500	1,500	1,500	1,500
Total Nonexpendable Equipment	**1,500**	**1,500**	**1,500**	**1,500**	**1,500**
Total Direct Costs	**212,798**	**212,758**	**203,887**	**209,414**	**224,106**
Indirect Costs (15%)	**31.920**	**31,914**	**30,583**	**31,412**	**33,616**
Annual Contributed Costs	**244,718**	**244,671**	**234,470**	**240,826**	**257,722**
Total Contributed Costs	**1,222,407**				

SOUTHEASTERN PIEDMONT

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Research Associates (USFS)					
Site Coordinator GS-7 (Term)	28,265	30,374	32,608	34,972	36,371
Fringe (33%)	9,327	10,024	10,761	11,541	12,002
Research Assistants (Clemson Univ.)					
Soils (1 MS Student)	11,000	11,500	0	0	0
Pathology (1 MS followed by 1 PhD)[1]	11,000	11,500	16,000	16,500	17,000
Small Mammals (1 MS Student)	11,000	11,500	0	0	0
Herpetofauna (1 MS Student)	11,000	11,500	0	0	0
Avifauna (1 PhD followed by 1 MS)[1]	15,000	15,500	16,000	12,500	13,000
Entomology (2 MS Students)[1]	11,000	11,500	0	12,500	13,000
Student Labor (Clemson Univ.)					
Soils (1 position)	0	0	0	4,000	0
Pathology (1 position)	3,000	3,000	3,000	3,000	3,000
Small Mammals (1 position)	3,500	3,500	0	0	0
Herpetofauna (1 position)	3,500	3,500	0	0	0
Avifauna (2 positions)	6,000	6,000	6,000	6,000	6,000
Technical Assistants (USFS)					
GS-6 Term (veg,fuels,&util)[2]	25,435	27,334	29,345	31,471	32,730
GS-5 Term 50% (veg,fuels,&util)[2]	11,410	12,261	13,163	14,117	14,682
Fringe (33%)	12,159	13,067	14,027	15,044	15,646
Total Salaries & Benefits	**172,596**	**182,060**	**140,904**	**161,645**	**163,431**
Travel					
Conferences/Symposia (faculty and students)	0	2,000	2,000	2,000	2,000
Local travel for students and techs	3,600	3,600	2,000	3,600	3,600
Total travel	**3,600**	**5,600**	**4,000**	**5,600**	**5,600**
Nonexpendable Equipment					
Traps/scales	5,000	1,000	0	0	0
Servis recorder	2,000	0	0	0	0
Portable computer	3,000	0	0	0	0
Digital camera + data storage	1,000	0	0	0	0
Desktop computer	2,000	0	0	0	0
Core samplers and pathology equipment	1,000	500	0	0	0
Total Nonexpendable Equipment	**14,000**	**1,500**	**0**	**0**	**0**
Contracts					
Aerial Photography	5,000	0	0	0	5,000
Photo Interpretation	3,500	0	0	0	4,500
Soil sample processing	12,100	12,100	0	12,100	0
Total Contracts	**20,600**	**12,100**	**0**	**12,100**	**9,500**

[1] In each case, one student will conduct a preliminary study and another will complete a follow-up study.
[2] The field crew will be responsible for grid point and study plot installation for the core design; data collection for vegetation, fuels, and economics; plot maintenance; and assisting graduate students of all disciplines. They will collect soil samples during FY03 when no graduate student is funded.

SOUTHEASTERN PIEDMONT (continued)

	FY00	FY01	FY02	FY03	FY04
Supplies					
Soils	3,000	3,000	0	3,000	0
Small Mammals	1,000	1,000	0	0	0
Herpetofauna	1,000	1,000	0	0	0
Avifauna	3,000	3,000	2,000	1,000	1,000
Entomology	2,000	1,500	0	2,000	1,500
Fuels	2,500	1,500	1,500	1,500	1,500
Pathology	1,000	1,000	1,000	1,000	1,000
Vegetation	2,500	1,500	1,500	1,500	1,500
Total supplies	**16,000**	**13,500**	**6,000**	**10,000**	**6,500**
Total Direct Costs	**226,796**	**214,760**	**150,904**	**191,345**	**185,031**
Indirect Costs					
Pass-through portion of total direct costs	109,200	106,200	37,700	62,900	48,800
Southern Research Station portion	117,596	108,560	113,204	126,445	136,231
Pass-through portion * 10%	10,920	10,620	3,770	6,290	4,880
Southern Research Station portion * 15% (13.6 % Station + 1.4% RWU)	17,640	16,284	16,981	18,967	20,435
Total Indirect Costs	**28,560**	**26,904**	**20,751**	**25,257**	**25,315**
Annual Funding Requested	**255,356**	**241,664**	**171,655**	**214,602**	**210,346**
Total Funding Requested	**1,093,623**				

Timeline:
FY00 - Select study sites; install grid points and monuments; install small mammal and herpetofauna traps; obtain aerial photography; collect pretreatment data for vegetation, soils, pathogens, small mammals, herpetofauna, avifauna, entomology, and fuels.
FY01- Install treatments (Winter 2000-2001), reestablish grid points, monuments, and traps; collect treatment cost data for economics study; collect first-year post-treatment data for vegetation, soils, pathogens, small mammals, herpetofauna, avifauna, entomology, fuels; analyze and publish data for vegetation, soils, small mammals, herpetofauna, entomology, and fuels.
FY02-Data collection, analysis and publication for studies of pathogens and avifauna; continued data collection for vegetation; establish second entomology study; conduct second prescribed burn (if necessary).
FY03-Data collection for vegetation, collect soil samples, establish follow-up studies for avifauna and entomology, and conduct second prescribed burn (if necessary).
FY04-Final data collection, analysis and publication for all studies.

SOUTHEASTERN PIEDMONT—Contributed Costs

	FY00	FY01	FY02	FY03	FY04	
USDA Forest Service						
Salaries and Benefits						
Scientists						
Waldrop (USFS - Fire Ecology)	15,400	15,400	15,400	15,400	15,400	
Barbour (USFS - Utilization)	3,500	3,500	3,500	3,500	3,500	
Fringe (33%)	6,237	6,237	6,237	6,237	6,237	
FS Total	**25,137**	**25,137**	**25,137**	**25,137**	**25,137**	
Clemson University						
Faculty Salaries						
Guynn (Wildlife)	6,500	6,500	0	0	0	Tainter
(Pathology)	6,500	6,500	6,500	6,500	6,500	
Shelburne (Soils)	5,500	5,500	5,500	5,500	5,500	
Lanham (Avifauna)	4,500	4,500	4,500	4,500	4,500	
Hedden (Entomology)	6,500	6,500	6,500	6,500	6,500	
Fringe (19%)	5,605	5,605	4,370	4,370	4,370	
Overhead (48% Modified Total Direct Costs)						
Soils	10,896	11,136	0	7,248	0	
Pathology	7,968	7,968	8,448	8,688	8,928	
Small Mammals	8,928	8,208	0	0	0	
Herpetifauna	8,928	8,208	0	0	0	
Avifauna	9,168	8,928	8,448	7,728	7,968	
Entomology	6,528	6,528	0	6,528	6,628	
Prescribed Burning						
Fireline Preparation (6 sites*4hrs/site*$65/hr)	0	1,560	0	1,560	0	
Personnel for burning (6 sites*4hrs/site*$100/hr)	0	2,400	0	2,400	0	
Equipment Standby (6 sites*4hrs/site*$20/hr)	0	480	0	480	0	
Clemson University Total	**87,521**	**90,521**	**44,266**	**62,002**	**50,894**	
Annual Contributed Costs	**112,658**	**115,658**	**69,403**	**87,139**	**76,031**	
Total Contributed Costs	**460,889**					

FLORIDA COASTAL PLAIN

	FY00	FY01	FY02	FY03	FY04
Salaries and Benefits					
Research Associates (Univ. FL)					
Post-Doctoral - Wildlife[1] .	30,000	30,900	31,827	32,782	33,765
Fringe (33%)	9,900	10,197	10,503	10,818	11,142
Research Assistants (Univ. FL)					
Soils (1 MS Student)	15,000	15,500	0	0	0
Entomology (1 MS Student)	0	0	16,000	16,500	0
Student Labor (Univ. FL)					
Soils	2,000	2,000	0	4,000	0
Wildlife	12,800	13,184	13,580	13,987	14,407
Entomology	10,000	10,300	0	0	0
Technical Assistants (USFS)					
GS-6 Term (veg,fuels,&util)[2]	25,435	27,334	29,345	31,471	32,730
GS-5 Term (veg,fuels,&util)[2]	22,819	24,522	26,325	28,234	29,363
GS-7 Term (pathology - 2 positions)	20,000	20,000	20,000	0	0
Fringe (33%)	22,524	23,713	24,970	19,703	20,492
Total Salaries & Benefits	**170,478**	**177,650**	**172,550**	**157,495**	**141,899**
Travel					
USFS Scientists and Technicians[3]					
Fire Ecology, Vegetation, Fuels	15,000	10,000	10,000	10,000	10,000
Pathology	5,000	5,000	5,000	0	0
Cooperators (Soils, Wildlife, & Entomology)	10,000	9,000	8,000	8,000	6,000
Conferences/Symposia	0	0	0	0	2,000
Total travel	**30,000**	**24,000**	**23,000**	**18,000**	**18,000**
Nonexpendable Equipment					
Traps/scales	5,000	1,000	0	0	0
Servis recorder	2,000	0	0	0	0
Portable computer	3,000	0	0	0	0
Desktop computer	2,000	0	0	0	0
Digital Camera and data storage	1,000	0	0	0	0
Field office - purchase or lease[4]	5,000	0	0	0	0
Core samplers	1,000	500	0	0	0
Total Nonexpendable Equipment	**19,000**	**1,500**	**0**	**0**	**0**
Contracts					
Aerial Photography	5,000	0	0	0	5,000
Photo Interpretation	3,500	0	0	0	4,500
Soil Sample Processing	12,100	12,100	0	12,100	0
Total Contracts	**20,600**	**20,100**	**0**	**12,100**	**9,500**

[1] The Post-doctoral research associate will be responsible for all vertebrates listed in the proposal.
[2] The field crew will be responsible for grid point and study plot installation for the core design; data collection for vegetation, fuels, and economics; plot maintenance; and assisting graduate students of all disciplines. They will collect soil samples during FY03 when no graduate student is funded.
[3] USDA Forest Service Scientists are located approximately 600 miles from the study sites.
[4] Myakka River State Park does not have office facilities available. A portable building will be purchased to house technicians and will become property of the state park at the end of the study.

FLORIDA COASTAL PLAIN (continued)

	FY00	FY01	FY02	FY03	FY04
Supplies					
Soils	3,000	3,000	0	3,000	0
Wildlife	5,000	3,000	1,000	1,000	1,000
Entomology	3,000	2,000	2,000	2,000	0
Fuels	2,500	1,500	1,500	1,500	1,500
Vegetation	2,500	1,500	1,500	1,500	1,500
Pathology	5,000	5,000	5,000	0	0
Electricity/water	1,500	1,650	1,815	1,997	2,196
Total supplies	**22,500**	**17,650**	**12,815**	**10,997**	**6,196**
Total Direct Costs	**262,578**	**232,900**	**208,365**	**198,592**	**175,595**
Indirect Costs					
Pass-through portion of total direct costs	100,900	95,484	69,407	88,369	51,172
Southern Research Station portion	161,678	137,416	138,958	110,233	124,423
Pass-through portion * 10%	10,090	9,548	6,941	8,837	5,117
Southern Research Station portion * 15% (13.6 % Station + 1.4% RWU)	24,252	20,612	20,844	16,535	18,663
Total Indirect Costs	**34,342**	**30,160**	**27,785**	**25,372**	**23,780**
Annual Funding Requested	**296,920**	**263,060**	**236,150**	**223,964**	**199,375**
Total Funding Requested	**1,219,469**				

Timeline:
FY00 - Select study sites; install grid points and monuments; install small mammal and herpetofauna traps; obtain aerial photography; collect pretreatment data for vegetation, soils, pathogens, small mammals, herpetofauna, avifauna, entomology, and fuels.
FY01- Install treatments, reestablish grid points, monuments, and traps; collect treatment cost data for economics study, collect first-year post-treatment data for vegetation, soils, pathogens, small mammals, herpetofauna, avifauna, entomology, fuels, and social dimensions; analyze and publish data for vegetation, soils, small mammals, herpetofauna, entomology, and fuels.
FY02-Data collection, analysis and publication for studies of pathogens and avifauna; continued data collection for vegetation; conduct second prescribed burn (if necessary).
FY03-Data collection for vegetation, collect soil samples; establish follow-up studies for avifauna and entomology; conduct second/third prescribed burn (if necessary).
FY04-Final data collection, analysis and publication for all studies.

FLORIDA COASTAL PLAIN—Contributed Costs

	FY00	FY01	FY02	FY03	FY04
USDA Forest Service					
Salaries and Benefits					
Scientists					
Waldrop (USFS - Fire Ecology)	7,700	7,700	7,700	7,700	7,700
Outcalt (USFS - Fire Ecology)	14,300	14,300	14,300	14,300	14,300
Brockway (USFS - Fire Ecology)	14,000	14,000	14,000	14,000	14,000
Otrosina USFS - Pathology)	7,700	7,700	7,700	7,700	7,700
Barbour (USFS - Utilization)	3,500	3,500	3,500	3,500	3,500
Fringe (33%)	15,576	15,576	15,576	15,576	15,576
FS Total	**62,776**	**62,776**	**62,776**	**62,776**	**62,776**
University of Florida					
Faculty Salaries					
Comerford (Soils)	7,500	7,500	7,500	7,500	7,500
Tanner (Wildlife)	7,500	7,500	7,500	7,500	7,500
Folz (Entomology)	6,500	6,500	6,500	6,500	6,500
Fringe (22%)	4,730	4,730	4,730	4,730	4,730
Overhead on Cooperative Agreements (44.2% Modified Total Direct Costs)					
Soils	13,746	13,746	0	8,001	0
Wildlife	24,222	22,137	21,838	21,998	22,618
Entomology	6,630	6,321	8,840	9,061	0
University of Florida Total	**70,828**	**68,434**	**56,908**	**65,290**	**48,848**
Myakka River State Park					
Salaries					
Park Manager	5,000	5,000	5,000	5,000	5,000
Botanist	3,000	3,000	3,000	3,000	3,000
Prescribed Burning					
Fireline Preparation (6 sites*4hrs/site*$65/hr)	0	1,560	0	1,560	0
Personnel for burning (6 sites*8hrs/site*$56/hr)	0	2,400	0	2,400	0
Equipment Standby (6 sites*4hrs/site*$20/hr)	0	480	0	480	0
Chopping ($40/acre * 440 acres)	0	17,600	0	17,600	0
Mowing ($40/acre * 440 acres)	0	17,600	0	17,600	0
Myakka River State Park Total	**8,000**	**47,640**	**8,000**	**47,640**	**8,000**
Annual Contributed Costs	**141,604**	**178,850**	**127,684**	**175,706**	**119,624**
Total Contributed Costs	**743,468**				

Summary of Assumptions to Calculate Indirect Costs

Mission Creek - Funding will be administered by the PNW Station. PNW will receive 15% indirect costs on in-house money and 10% on money awarded to the University of Washington. The University of Washington has an agreement with PNW to contribute all indirect costs.

Hungry Bob - All money will stay within the PNW Station. PNW will receive 15% indirect costs.

Lubrecht Forest - All money will go directly to the University of Montana and will be charged 15%. The Rocky Mountain Station will not be involved and will not collect indirect costs.

Klamath Mountains - All money will stay within the PSW Station. PSW will receive 15% indirect costs.

Blodgett Forest Research Station - All money will go directly to the University of California, Berkeley. UCB will receive 10% indirect costs. The PSW Station is not involved and will not collect indirect costs.

Sequoia National Park - All money will go directly to USGS. USGS will receive 15% indirect costs. The PSW Station is not involved and will not collect indirect costs.

Southwest Plateau - All money will be administered by the Rocky Mountain Station. RM charges 10% indirect costs on grants coming from Forest Service sources. Financing of this site with Forest Service funds is therefore requested. Cooperating universities have agreements with RM to contribute all indirect costs.

Jemez Mountains - All money will be administered by the Rocky Mountain Station. RM charges 10% indirect costs on grants coming from Forest Service sources. Financing of this site with Forest Service funds is therefore requested. Cooperating universities have agreements with RM to contribute all indirect costs.

Ohio Hill Country - Funding will be administered by the Northeast Station. NE will receive 15% indirect costs on in-house money and 10% on money awarded to the University of Ohio and Ohio State University. The University of Ohio and Ohio State University will receive 15% indirect costs on their portions.

Southeastern Piedmont - Funding will be administered by the Southern Research Station. SRS will receive 15% indirect costs on in-house money and 10% on money awarded to Clemson University. Clemson University has an agreement with SRS to contribute all indirect costs.

Florida Coastal Plain - Funding will be administered by the Southern Research Station. SRS will receive 15% indirect costs on in-house money and 10% on money awarded to the University of Florida. The University of Florida has an agreement with SRS to contribute all indirect costs.