A Regional Experiment to Evaluate Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome

Submitted as the final revised deliverable of the 2003 JFSP grant entitled,
"Designing an experiment to evaluate effects of fire and fire surrogate treatments in the sagebrush biome"

Principal Investigator(s)*: **J.D. McIver**[1], H. Barrett, M. Brunson, S. Bunting, J. Chambers, C. D'Antonio, P. Doescher, S. Karl, **S. Knick**[2], R. Miller, M. Pellant, F. Pierson, D. Pyke, K. Rollins, B. Roundy, G. Schupp, R. Tausch, D. Turner, M. Wisdom

*See affiliations of all principle investigators on Page 5

Point of Contact: [1]James McIver
Forestry and Range Sciences Lab, PNW Research Station
1401 Gekeler Lane, La Grande, Oregon 97850
Telephone: (541) 962-6528; FAX: (541) 962-6504
Email: jmciver@fs.fed.us

Federal Cooperator: [2] Steve Knick
USGS Forest and Rangeland Ecosystem Science Center
Snake River Field Station
970 Lusk Street, Boise, Idaho 83706
Telephone: (208) 426-5208; FAX: (208) 426-5210
Email: steve_knick@usgs.gov

Duration of Project: 5 Years

Annual Funding Requested**:** **FY2005: $1,613,175**
FY2006: $3,292,165
FY2007: $2,614,471
FY2008: $2,734,666
FY2009: $2,697,650

Total Funding Requested from the Joint Fire Science Program: **$12,952,128**

Total Value of In-Kind and Financial Contributions: **$3,692,213**

Signature of Point of Contact: ______________________________ Date :____________________
James McIver, USDA-FS

Signature of Federal Cooperator: ______________________________ Date :____________________
David Pyke, USGS

Signature of Federal Fiscal Representative: ______________________ Date: ____________________
Bob Spain, USGS

**Authorized signatures have been obtained from the following research institutions that are cooperating on this study, approving this proposal and its budget (see Table 4):

Oregon State University Utah State University Brigham Young University
University of Idaho University of Nevada-Reno Agriculture Research Service-Boise
USGS Biological Research Division - Boise USGS Biological Research Division - Corvallis
USFS PNW Research Station - La Grande Lab USFS Rocky Mt. Research Station - Reno Lab

A Regional Experiment to Evaluate Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome

Executive Summary

This proposal seeks funding to implement a comprehensive 5-year study that would evaluate the effects of fire and fire surrogate treatments that are designed to reduce fuel and to restore sagebrush communities of the Great Basin. The study would: 1) provide managers with improved information to restore ecological communities that is relevant across the 100+ million acres of the sagebrush biome; 2) match the temporal and spatial scales at which managers operate; 3) reduce management risk and uncertainty of catastrophic wildfire to the greatest degree possible; and 4) provide managers with information that would allow them to better understand tradeoffs inherent in the choice of management alternatives. The need for such an experiment is evidenced by the profound changes in fire regime experienced in the Great Basin in the past 150 years, coupled with the lack of information available to managers on the consequences of methods they might use to reduce fire risk or to restore more desirable plant communities and fire regimes.

The objectives reflect a research program that seeks to determine the conditions under which sagebrush steppe communities will recover on their own following treatment, versus conditions that will require expensive active restoration. Specific objectives include:

(1) Identify the abiotic and biotic thresholds that determine sustainability of big sagebrush plant communities in sagebrush-steppe and sagebrush semi-desert environments, specifically related to threats posed by cheatgrass and pinyon-juniper invasion.
(2) Assess the ecological effects of fire and fire surrogates on big sagebrush communities at risk of crossing a threshold of conversion to cheatgrass or pinyon-juniper, beyond which restoration may be difficult or logistically infeasible.
(3) Document how fuel loads change across vegetation treatments and ecological conditions in relation to the objectives above.
(4) Portray the ecological, economic, and socio-political trade-offs and treatment effects of no action, applying only fire and fire surrogate treatments, and restoration treatments in these sagebrush communities.
(5) Identify and measure environmental benefits affected by conversion to cheatgrass and pinyon-juniper systems, and identify induced changes in welfare to human populations.
(6) Provide insight and guidance regarding use of our results for effective multi-species and multi-scale planning as part of ecosystem management of sagebrush communities in the Great Basin.

Objectives closely match those called for under **Task Statement 4 of the 2003-1 JFSP Announcement for Proposals**, which calls for projects that *"Evaluate alternative treatments for restoring ecosystems altered by changing fire regimes, or where alterations have affected fire regimes"***.**

The project is fully interdisciplinary, with ecological, economic, and socio-political components. The ecological component (Objectives 1, 2, 3, and part of 6) is designed as two experiments, each consisting of a regional network of sites in sagebrush steppe ecosystems. The first experiment is focused on cheatgrass invasion, and consists of a network of sites in three

ecological provinces -- Snake River, Humboldt, and Bonneville. The second experiment is focused on woodland invasion, and consists of a network of sites dominated by either Western Juniper, Pinyon Pine, or Utah Juniper, located in three ecological provinces -- High Desert, Bonneville, and High Calcareous. Sites within each network have identical experimental designs, and so we will be able to provide information on thresholds and transition probabilities over a broad range of conditions across the Great Basin. Each site will be a fully replicated, stand-alone experiment, and will thus provide rigorous information at the site level, for more specific use by local managers. This feature also has the advantage that individual sites will not be dependent on the successful implementation of all other sites, in order for their results to be applicable at the sub-regional level. For the sagebrush/cheatgrass experiment, we will study response to four treatments: unmanipulated control, prescribed fire, mechanical, and herbicide (designed to reduce sagebrush dominance). An additional herbicide treatment to control cheatgrass will be applied within portions of treated units. For the sagebrush/woodland experiment, we will study response to control, prescribed fire, and mechanical treatments. For both experiments, the response to treatment will be evaluated by measuring a comprehensive array of ecological variables, chosen because of their interest to managers and stakeholders, and because of their importance for reflecting meaningful ecological change. These include vegetation, fuels, soils, hydrology, and wildlife disciplines. The experiments are thus fully interdisciplinary, and information will be used to understand how the entire ecological system changes in response to fire and fire surrogate treatments. Although this proposal asks for funding to implement treatments and to measure ecological variables within a 5-year time frame, we expect to continue measurement (and potentially to re-apply treatments) for many years thereafter.

The economic component features an environmental valuation study focused on relevant human populations who may be affected by treatment decisions designed to alter ecosystem conversion rates on Great Basin lands. The valuation study identifies and measures changes in environmental benefits flowing from these systems as a result of changes in the risk of conversion induced by alternative treatment strategies. Benefits include 'use' values such as recreation, ranching, and reduced risk of property loss due to wildfire, and 'non-use' values such as preservation of endangered species, cultural heritage, and bequests for future generations. The spatial scale of the economic component is different from the ecological component, because it is defined by where and when the induced changes in environmental value impact society. Survey data will be gathered from human populations that live in the Great Basin, and from the US population as a whole, and will be analyzed with econometric valuation models that will allow internal consistency tests of valuation estimates and that can be compared to results developed elsewhere.

The socio-political component is focused on understanding the social acceptability of alternative management practices. This emphasis is necessary because each of the restoration and fuel-reduction treatments evaluated in this project is a potentially controversial practice that might meet resistance from citizens and/or managers when applied to the public lands that comprise most of the region. We will assess social and/or political tradeoffs associated with alternative restoration decisions, including “no action,” as perceived by the general public, interest group members, and managers themselves. Our intent is to identify factors in the treatments, or the conditions those treatments produce, that can constrain or facilitate implementation of practices that biophysical research shows to be promising. While the research questions focus on practical issues of choosing among potential restoration actions, the socio-political component also offers opportunities to explore more basic questions about decision-making under uncertainty, and the foundations of social acceptability.

The combined ecological, economic, and socio-political approach of this study provides a practical focus on maintaining sustainable systems under multiple use management guidelines for public lands, and makes this a fully integrated interdisciplinary research project. Results will provide the broad context that is necessary to fully assess decisions and potential policy changes with regard to managing public lands. This approach is especially important in circumstances where decisions regarding public lands today can reduce the probability of potentially irreversible losses that would affect human populations for generations.

The study personnel will be organized into an 'executive' and a 'technical' committee. The executive committee will be composed of the network coordinator and four additional members of the science team, and will be responsible for project oversight, approval of distribution of funds, and for reporting to the Joint Fire Science Program. The technical committee will be composed of site representatives and network-level discipline leaders, and will be responsible for all technical details of the study, including decisions on protocol and treatment variances, and development of the site-level study plans. The responsibilities of these two committees are crucial to the network functioning as a whole, and help ensure continuity of the network through time, as participants come and go.

A Communications Plan (Appendix 3) has been developed to guide the flow of information products to clients, principally land managers, policy makers, the general public, land owners, other land users, and other scientists. The Communications Plan defines the scope and scale of information to be delivered, and identifies the methods to be used for product delivery. Outreach methods include conferences, workshops, lectures, electronic media, tours, the internet, e-mail, word of mouth, and professional and scientific journals. A key deliverable described in the Communications Plan is a set of three 'User's Guides', that we will develop from literature syntheses within the first three years of the study, one each for sagebrush, pinyon, and juniper-dominated systems. The User's Guide will contain the latest information on how these systems are known to respond to available treatments, and will thus allow managers to make more informed decisions as they consider how to apply treatments under a wide variety of conditions. Information from the current experiment will then be used to craft second editions of the User's Guides toward the end of the study period.

The design of this experiment represents a joint effort between scientists and managers, and identified the kinds of treatments to be studied, the kinds of variables to be measured, and the sites that were most relevant to examine. The three management representatives on our Technical Committee have been critical for keeping this effort focused on management needs. In addition, a number of state and field-level workshops have been conducted to present the study plan to managers, and to obtain their input into the design of the project (see Appendix 4C for lists of managers that we worked with at the State and Field Levels). Finally, the success of this regional study depends on the continued collaboration of scientists and managers, particularly as regards treatment implementation (see Letters of Support in Appendix 4A), focused science delivery, and the development of decision-support tools based on the ecological, economic, and socio-political components.

A Regional Experiment to Evaluate Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome

Principle Investigators

Hugh Barrett
Bureau of Land Management
Portland, Oregon

Mark Brunson
Utah State University
Logan, Utah
Social Science

Steve Bunting
University of Idaho
Moscow, Idaho
Fuels, Landscapes

Jeanne Chambers
Rocky Mt. Research Station
USDA Forest Service
Reno, Nevada
Plant Ecology

Carla D'Antonio
Agricultural Research Service
Reno, Nevada
Soils

Paul Doescher
Oregon State University
Corvallis, Oregon
Range Ecology

Sherm Karl
Bureau of Land Management
Denver, Colorado

Steve Knick
USGS -- Biological Research Division
Boise, Idaho
Wildlife

James McIver
PNW Research Station
La Grande, Oregon
Insect Ecology

Rick Miller
Oregon State University
Burns, Oregon
Plant Ecology

Mike Pellant
Bureau of Land Management
Boise, Idaho

Fred Pierson
Agric. Research Service
Boise, Idaho
Hydrology

David Pyke
USGS -- Biological Research Division
Corvallis, Oregon
Plant Ecology

Kim Rollins
University of Nevada
Reno, Nevada
Economics

Bruce Roundy
Brigham Young Univ
Provo, Utah
Plant Ecology

Gene Schupp
Utah State University
Logan, Utah
Plant Ecology

Robin Tausch
Rocky Mt. Res. Station
USDA Forest Service
Reno, Nevada
Plant Ecology

David Turner
Rocky Mt. Res. Station
Logan, Utah
Statistician

Mike Wisdom
PNW Research Station
La Grande, Oregon
Wildlife

TABLE OF CONTENTS

A Regional Experiment to Evaluate Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome

This proposal describes a major regional experiment that if implemented, will provide critical information to managers faced with a sagebrush steppe ecosystem that is increasingly at risk from wildfire. This proposal describes the nature and scope of the problem and discusses the tools and information that managers currently have available to manage it. We then present a research approach that is designed to gather and deliver the kind of information that managers need to make more rapid progress in restoring sagebrush steppe ecosystems. The experiment would: 1) provide managers with improved information to restore ecological communities across the 100+ million acres of the sagebrush biome; 2) match the temporal and spatial scales at which managers operate; 3) reduce management risk and uncertainty of catastrophic wildfire to the greatest degree possible; and 4) provide managers with information that would allow them to better understand tradeoffs inherent in the choice of management alternatives. The need for this research is evidenced by the undesirable impacts caused by the profound changes in fire regime experienced in the Great Basin in the past 150 years, coupled with the lack of information available to managers on the consequences of methods they might use to reduce fire risk and to restore more desirable plant communities and fire regimes.

Background

The sagebrush (*Artemisia* spp.) biome occupies 100 million acres in the West and is the largest biome in North America (Knick et al. 2003). Home to more than 300 wildlife species, the biome is the primary forage base for the western livestock industry, is an important recreation area, and provides precious water in a semi-arid region that has one of the fastest growing human populations in North America. Public land managers face an increasingly complex task in dealing with an array of competing interests and multiple uses in the sagebrush biome. As the region's population continues to grow and diversify, managers must be able to anticipate the impacts of current decisions on future states of the lands, while demonstrating accountability to current and future generations. An integrated approach to public lands management requires that managers use the best ecological, social and economic information available to evaluate proposed management actions (Loomis 1993). With regard to the sagebrush biome, however, there is a lack of information that is critical to successful integrated land management. The lack of information contributes to inefficient use of public resources, and possibly to increasing the rate of irreversible loss in the biome.

Unfortunately, the sagebrush biome is considered to be one of the most endangered in the United States (Noss et al. 1995). Perhaps a third of the biome has been lost, and as much as half in the Great Basin region. Expansion of exotic weeds such as cheatgrass (*Bromus tectorum*) and the encroachment of native conifers like juniper (*Juniperus* sp.) are the two factors that have contributed most to the decline of sagebrush communities in the Intermountain Region (Pellant 1994, Miller and Tausch 2001). This encroachment has significantly altered fire regimes across the region (Whisenant 1990, Miller et al. 1999, Miller and Tausch 2001). Exotic annual grasses have become dominant and threaten much of the more arid portions of the sagebrush biome, with mean fire return intervals shifting from >50 years to <10 years (Figure 1). Conifer invasion of the more mesic portion of the biome has shifted fire regimes from relatively frequent low to mixed severity fires (10-50 years mean fire return interval) to more infrequent high severity fires (>50 years) (Figure 2). The observed shift from shrub steppe to juniper or pinyon woodland has resulted in nearly a 6-fold increase in fuel loads (7 to 40 tons/ha; Tausch et al. 2004). Under current climatic conditions both exotic weeds and pinyon and juniper have the potential to occupy far more area than they do currently (Betancourt, 1987, West and Van Pelt 1986, Miller et al. 2000, Wisdom et al. 2003b).

The increased fire threat and loss of nearly half of the sagebrush biome in the Great Basin has resulted in millions of taxpayer dollars spent annually for fire suppression and restoration, an increased threat to property and life, increased erosion and sedimentation, decreased water quality, a decline in the forage base for domestic livestock, and decreased habitat for big game and threatened species of wildlife. The continued expansions of exotic weeds, conifers, and the urban interface throughout the Intermountain West will greatly increase economic losses due to wildland fire and the cost of fire suppression.

A conspicuous indication of this problem is the continuing decline in habitats and populations of Greater sage-grouse (*Centrocercus urophasianus*) (Connelly and Braun 1997; Schroeder et al. 1999; Knick et al. 2003). Habitat loss due to detrimental land uses and the continued expansion of exotic plants and conifers poses threats to the species' persistence

(Schroeder et al. 1999; Connelly et al. 2000; Raphael et al. 2001; Hemstrom et al. 2002; Wisdom

Figure 1. Map of risk of cheatgrass invasion in the Great Basin (Wisdom et al. 2003b), with photos of wildfire in a stand of cheatgrass and encroachment into Wyoming Big Sage stand.

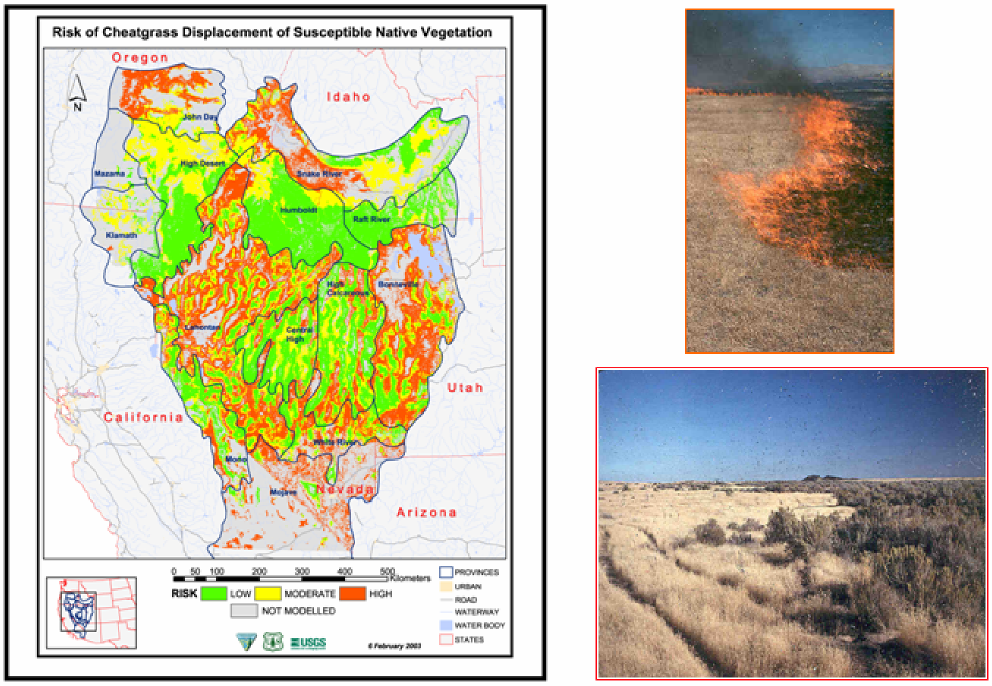
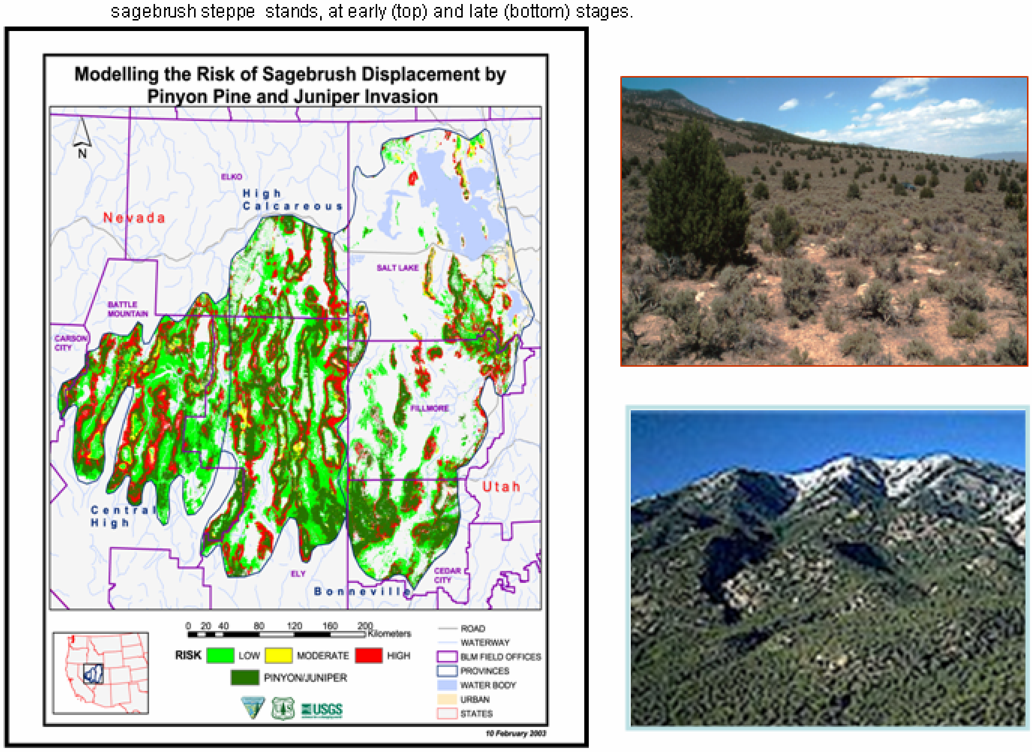


Figure 2. Map or risk of woodland invasion in the central Great Basin, with photo of tree invasion into sagebrush steppe stands, at early (top) and late (bottom) stages.



et al. 2002*a, b*, Knick et al. 2003). In addition to sage grouse, Wisdom et al. (2000) identified 30 other species of vertebrates in the Interior Columbia Basin that are closely associated with sagebrush habitats, and that are of concern because of declining or rare habitats or populations. As a consequence of these declines, a number of petitions have been submitted to place sage grouse on the endangered species list, and several other sagebrush obligate species will soon be considered for listing. Listing of endangered species will likely result in a dramatic reduction in management flexibility and use of the natural resources across the sagebrush biome.

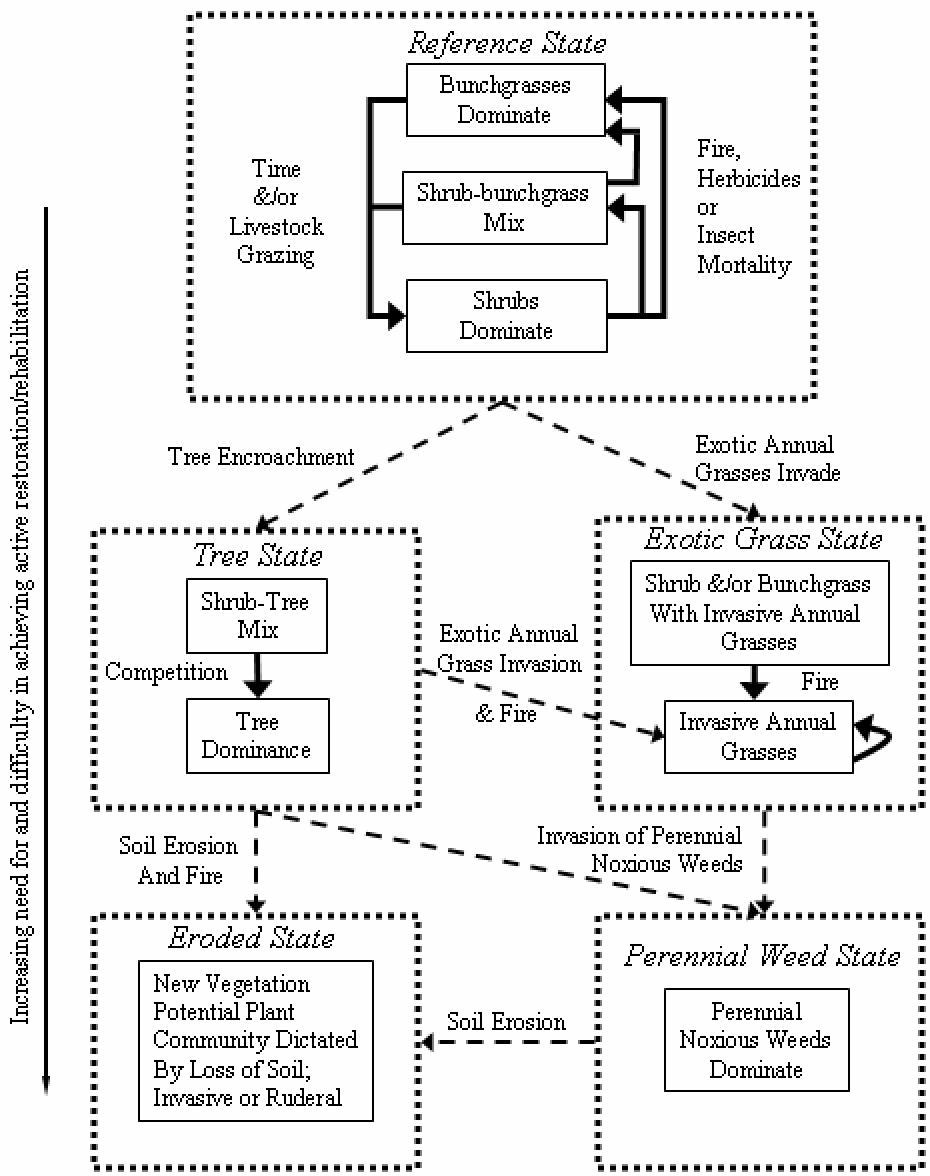
Unless these trends are altered, society will bear accumulating costs associated with increasing acreage of public lands that have converted to a degraded state. As the proportion of acreage affected increases, public funds for managing healthy lands will be increasingly diverted to dealing with problems on degraded lands - unless federal land management budgets are increased proportionally with these added costs. In an era with fixed budgets and scarce public funds, this situation could easily lead to an acceleration of the problem.

Our overall goal is to provide critical information on a combination of fire and fire surrogate treatments that are designed to create more fire resilient landscapes, leading to the maintenance and restoration of large portions of the sagebrush biome. Our approach will be multidisciplinary including aspects of plant ecology, wildlife ecology, soils, hydrology, economics, and sociology. A network of study sites will be established across the Great Basin to evaluate the ecological consequences of fire and fire surrogate treatments. Populations of residents who could be affected by the outcomes of the treatments will be surveyed to provide a socio-economic context within which to interpret ecological outcomes. The research team will be made up of land managers, and both state and federal scientists. The research will provide managers with the tools and guidelines for the development of landscapes that respond positively to fire and allow fire prescriptions to be more easily and safely applied.

Objectives

The goal of this research project is to provide information to managers that will allow them to better predict the extent to which their treatments will result in sagebrush steppe systems that are more resilient to wildfire, and to help them evaluate different treatment options using both ecological and socio-economic criteria. The research design is built around the concept of a 'state-and-transition' model that can be used to predict the types and probabilities of transitions

Figure 3. Conceptual model showing plant dynamics using states and thresholds (dotted boxes and dashed lines) in a typical sagebrush grassland site. Solid boxes and arrows within states are plant communities and pathways.



from one state to another (Figure 3). Historically, sagebrush steppe ecosystems within the Great Basin naturally shift from communities with sagebrush as dominant to those with perennial bunchgrasses as dominant (see *Reference State* Box). In drier areas, cheatgrass invasion into the sagebrush understory has set up the potential for much more frequent fires (*Exotic Grass State;*

photo in Figure 1), which can eventually eliminate the sagebrush entirely and lead to a community dominated by perennial weeds (*Perennial Weed State*). For the sagebrush/cheatgrass system, our objectives are focused on the *Exotic Grass State*, and address the question of how much representation of perennial bunchgrasses there needs to be in order for managers to recover the system without having to conduct expensive restoration (i.e. reseeding of native grasses). Similarly, in more mesic areas, tree encroachment due to years of fire suppression can result in a tree-dominated system in which sagebrush and the perennial bunchgrass understory is also eliminated (*Tree State*; photo in Figure 2). Continued dominance by trees can lead to a highly eroded state that features a variety of weedy species (*Eroded State*). For the sagebrush/woodland system, our objectives are focused on the *Tree State*, and address the question of how much representation of the native sagebrush/bunchgrass community there needs to be in order for managers to recover the system without having the conduct restoration. Thus for both systems, our research will provide much better information on the probabilities of transition from one state to another, when a variety of treatments are applied under a wide range of conditions.

This information is critical because managers need to understand where a given system lies in this model, and in particular the direction in which a given treatment will push the system. Without information on the probability of system change from one state to another, particularly with respect to critical thresholds, the manager is left with having to make decisions that could result in undesirable outcomes. If the primary goal of management is to increase the resilience of sagebrush steppe systems (especially to wildfire), much better information on transition probabilities within the model is needed. The objectives listed below reflect a research program that is aimed at defining critical ecological and socio-economic thresholds, through the application of alternative treatments over a wide array of conditions:

(1) Identify the abiotic and biotic thresholds that determine sustainability of big sagebrush plant communities in sagebrush-steppe and sagebrush semi-desert environments, specifically related to threats posed by cheatgrass and pinyon-juniper invasion.

(2) Assess the ecological effects of fire and fire surrogates on big sagebrush communities at risk of crossing a threshold of conversion to cheatgrass or pinyon-juniper, beyond which restoration may be difficult or logistically infeasible.

(3) Document how fuel loads change across vegetation treatments and ecological conditions in relation to the objectives above.

(4) Portray the ecological, economic, and socio-political trade-offs and treatment effects of no action, applying only fire and fire surrogate treatments, and restoration treatments in these sagebrush communities.

(5) Identify and measure environmental benefits affected by conversion to cheatgrass and pinyon-juniper systems, and identify induced changes in welfare to human populations.

(6) Provide insight and guidance regarding use of our results for effective multi-species and multi-scale planning as part of ecosystem management of sagebrush communities in the Great Basin.

This research is designed to complement related work on assessment and restoration within the Great Basin. Restoration efforts include the Great Basin Restoration Initiative (USDI BLM 1999; led by team member Mike Pellant), the IFAFS Project (led by team members Paul Doescher, Jeanne Chambers, David Pyke, and Eugene Schupp), and local and state-level conservation strategies for sage-grouse and associated habitats (e.g. Anonymous 1997, Canadian Sage Grouse Recovery Team 2001). Sagebrush habitat assessments include the SAGEMAP Project (http://sagemap.wr.usgs.gov; led by team member Steve Knick), ecoregion assessments (Freilich et al. 2001, Nachlinger et al. 2001; led by The Nature Conservancy), and ongoing local assessments by BLM and USDA Forest Service. Our research is designed to be used to support land use plan revisions underway by the BLM and the Forest Service in the Great Basin, and results will be available for use by these and other federal and state agencies engaged in the recovery and restoration of sagebrush communities across interior North America.

Research Approach

This section describes research designed to identify critical thresholds between ecological states that differ in their resilience to wildfire. The research consists of two experiments, each an integrated network of sites, at which we will apply a standard set of treatments, and measure a broad array of variables. The 'Cheatgrass' Network will focus on identifying thresholds of transition between cheatgrass-dominated and native grass dominated understories of Wyoming big sagebrush communities. The 'Woodland' Network will focus on identifying thresholds of tree density that determine probabilities of transition between shrub-dominated and tree-dominated sagebrush communities. Here we discuss the benefits of long-term, regional experiments relative to retrospective work, describe the benefits of multi-site interdisciplinary work, provide details of our experimental design, and describe how the experiments will be managed.

The research design proposed here has four important features that will add rigor and applicability to the results:

1) The overall project is composed of two regional networks of sites. Each network will consist of several sites, with each site having an identical experimental design. Thus, we will be able to provide information on thresholds and transition probabilities over a wide range of ecological conditions. As a consequence, the research will have broad applicability for sagebrush steppe systems over much of the Great Basin.
2) Each site will itself be a fully replicated, stand-alone experiment, and will thus provide rigorous information at the site level, for more specific use by local managers. This feature also has the advantage that individual sites will not be dependent on the successful implementation of all other sites, in order for their results to be applicable at the local level.
3) The response to treatment will be evaluated by measuring a comprehensive array of variables, chosen because of their interest to managers and stakeholders, and because of their importance for reflecting meaningful ecological change. The experiment is thus fully interdisciplinary, and information will be used to understand how the entire system changes. With this information, managers will be able to assess the tradeoffs inherent in their choices of treatment over a broad spectrum of conditions.
4) The variables measured will be used to calibrate a combined dynamic ecological-economic model that quantifies the values of environmental and economic trade-offs for the purpose of evaluating management decision options.

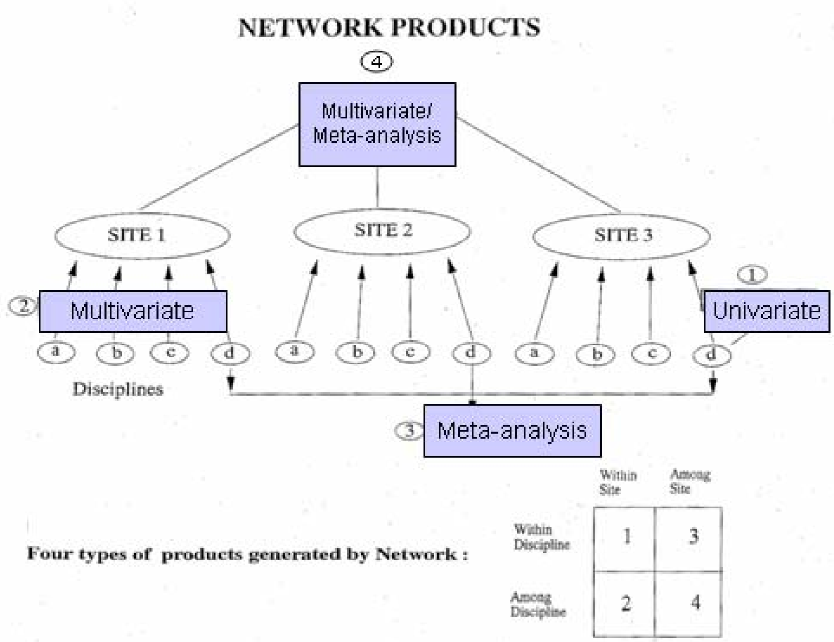
Benefits of Experimental Approach. A long-term experimental study, especially one with the scope and complexity of the proposed project, is expensive and time-consuming. A logical question is, “Why not learn what you need to know by examining previously-treated areas?” In other words, why not do a retrospective 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— experimental work has a significant advantage 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 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 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. This is particularly true for ecological studies, because typically 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 so much stronger inferences can be made about cause-and-effect relationships. An additional advantage of the proposed regional experiments is that a number of studies will be completed at several localities at the same time, enabling scientists to make inferences on which responses are common and which are different over a wide range of environmental conditions. This will allow managers to apply information within a 'conditional' framework. Considering the great importance and likely debate over the questions addressed in this study, there is a need for rigorous experimental work that offers the hope of drawing firm scientifically-based conclusions over as wide an area as possible.

Benefits of a Regional Network of Interdisciplinary Sites. The great strength of a regional network is being able to draw broad inferences that transcend the boundaries of individual sites. Another crucial value of the network approach is the synergy created by the interaction of scientists and managers 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 regional network is already apparent in the output of the ensemble of scientists and managers who designed this project, but the best evidence of the value of a truly integrated network is the kind of products that will be produced. 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 4).

Figure 4. Network products that can be generated by the Sagebrush Steppe Fire and Fire Surrogate Study.

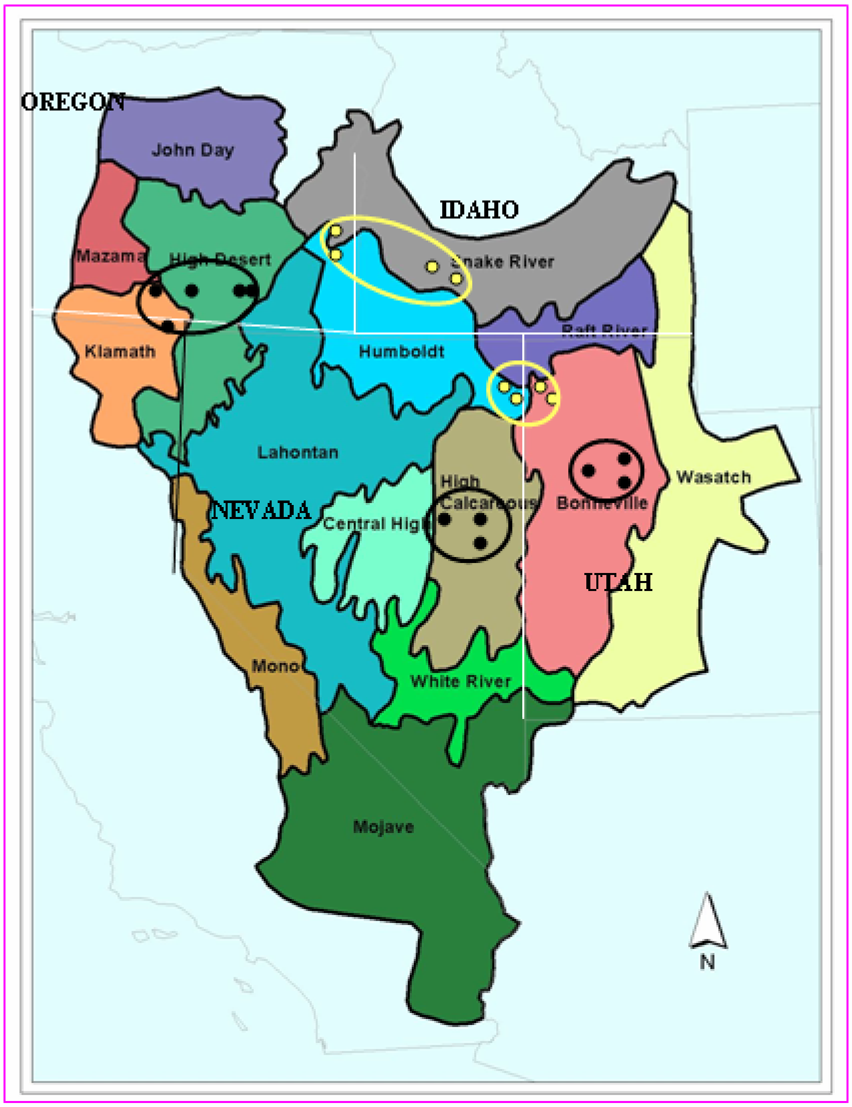


The simplest product is non-integrated, being publications or other outputs from disciplinary studies at individual sites. The remaining three products are integrated, but in different ways. First, results from disciplinary studies across sites can be compared more effectively and confidently because sites share common core variables and protocols. These comparisons are most important for disciplines in which a 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 plot and sub-plot level. This interdisciplinary product is essential for identifying interactions among key ecological variables, such as the functional linkages among fire, exotic plant species, and sagebrush obligate wildlife, or the relationship between the effectiveness of a treatment and the cost of its implementation. 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 regional scale than from cobbling together results from a group of independent studies. Because the network will emphasize monitoring as well, we have the potential for identifying those variables that are key to range sustainability, and for developing more useful protocols to measure them.

Sites. Fourteen ecological provinces have been described for the sagebrush biome within the Great Basin, each of which has a unique set of climate and vegetation characteristics (West et al. 1998, Miller et al. 1999, Wisdom et al. 2003; Figure 5). In general, climatic patterns follow temperature and precipitation gradients within the Basin, with northern provinces being cooler, and western provinces being more dominated by winter precipitation from the Pacific Ocean. These climatic patterns, and the vegetation patterns that follow them, set up a diverse array of conditions under which managers across the Basin operate. We located sites to maximize representation and inference space, so that managers in as many places as possible could reliably use the results. To the degree possible, we utilized projects that were in the planning stages to minimize impacts to the cooperating agency and to maximize dollar value. This constrained the distribution of sites in some cases, but all sites are reflective of the desired conditions. Research will focus on representative ecological provinces with high risk of cheatgrass invasion and subsequent conversion to annual domination (the Cheatgrass Network), and with high risk of pinyon and juniper encroachment (Woodland Network). The Cheatgrass Network will be composed of two locations, one in the Snake River Province of southern Idaho and eastern Oregon, and one spanning the Bonneville and Humboldt Provinces in NE Nevada and NW Utah

(Table 1; Figure 5). Each province will contain two or three research sites.

Figure 5. Study locations and sites in relation to ecological provinces in the Great Basin [map boundaries adapted from West et al. (1998) and Miller et al. (1999) by Wisdom et al. (2003*b*); State boundaries are outlined in white in the background]. Sagebrush/cheatgrass locations are yellow ellipses, with approximate sites depicted as solid yellow circles. Sagebrush/woodland locations are black ellipses, with approximate sites depicted as solid black circles.



The Woodland Network will be composed of three locations, one spanning the High Desert and Klamath Provinces of southern Oregon, one in the High Calcareous Province of eastern Nevada, and one in the Bonneville Province of eastern Utah (Table 1; Figure 5). Due to the size of the areas covered, there will be three or four research sites within each location for the Woodland Network.

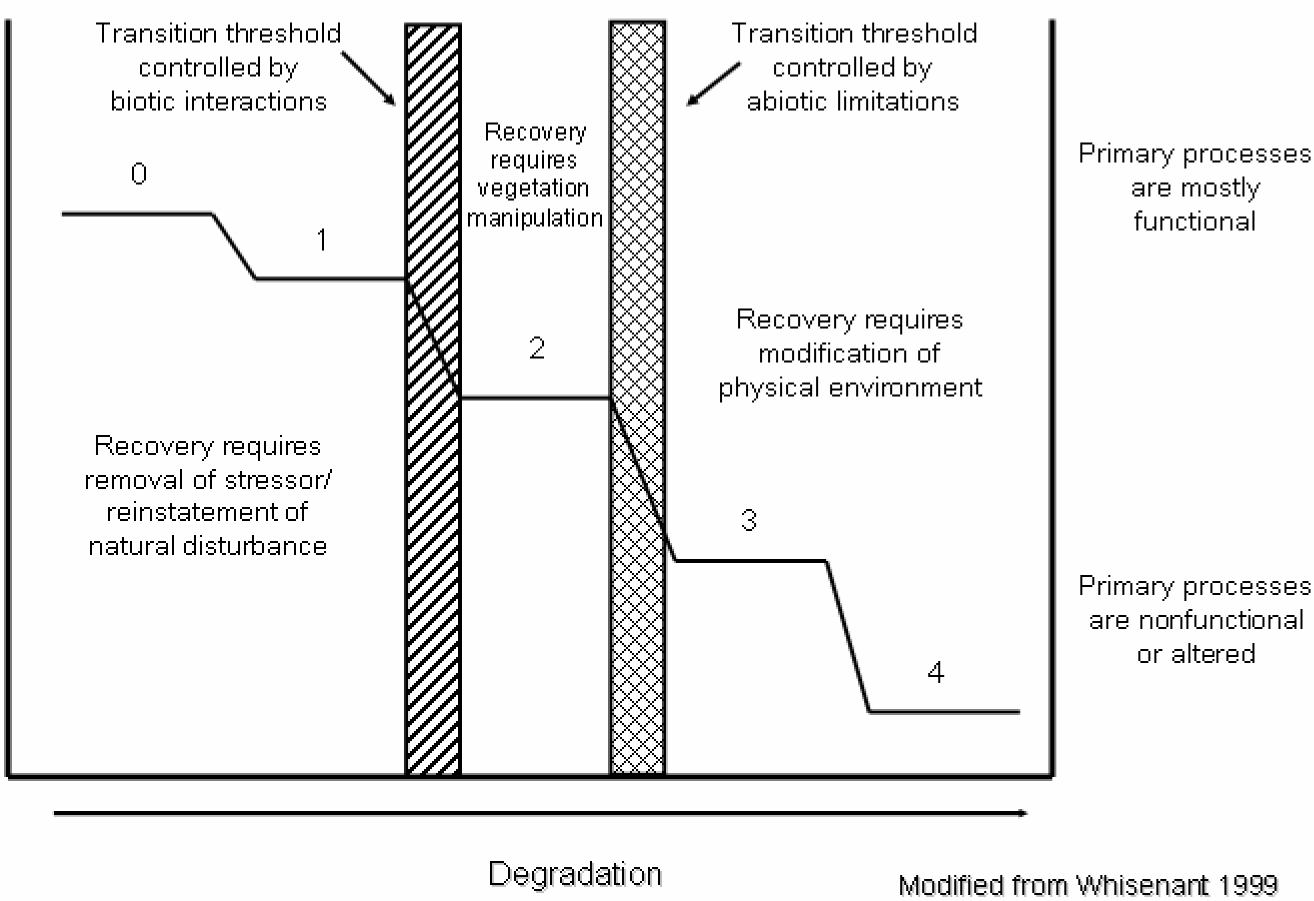
Table 1. Locations, sites, and management offices within the juniper/sage and cheatgrass/sage networks*
*Letters of support provided in Appendix 4A

LOCATION	SITE	MANAGEMENT OFFICE	SIGNATORY	TITLE
Juniper/Sage				
High Desert	Lakeview	BLM - Lakeview District	Steve Ellis	District Manager
	Steens Mt.	BLM - Burns District	Jeff Rose	Zone Fire Ecologist
	Owyhee	BLM - Lower Snake District	Glen Secrist	District Manager
High Calcareous	Robinson Summit	BLM - Ely Field Office	Gene Kolkman	Field Office Manager
	Spruce Mt.	BLM - Elko Field Office	Helen Hankins	Field Office Manager
	Seven-Mile	BLM - Battle Mt. Field Office	Gerald Smith	Field Office Manager
Bonneville	NW Utah	USFS - Wasatch-Cache N.F.	Faye Krueger	Deputy Forest Supervisor
	Central Utah	BLM - Salt Lake Field Office	Glenn Carpenter	Field Office Manager
	South Central Utah	BLM - Cedar City Field Office	Todd Christensen	Field Office Manager
		BLM - Fillmore Field Office	Sherry Hirst	Field Office Manager
Cheatgrass/Sage				
Snake River	Craters of the Moon	BLM - Shoshone Field Office	Bill Baker	Field Office Manager
Hunboldt/Bonneville	Vale District	BLM - Vale District	David Henderson	District Manager
	NW Utah	BLM - Salt Lake Field Office	Glenn Carpenter	Field Office Manager
	NE Nevada	BLM - Elko Field Office	Helen Hankins	Field Office Manager
		BLM - Battle Mt. Field Office	Gerald Smith	Field Office Manager

Each research site will include well-defined ecological types that represent major components of the region's sagebrush dominated ecosystems and that meet specific site selection criteria. An ecological type is defined as a distinctive kind of land with specific characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation (NRCS 1997). The Cheatgrass Network will focus on the Loamy 10-12" ecological type, and the Woodland Network will be conducted within the Loamy 12-14" ecological type. The Loamy 10-12" type is characterized by *Artemisia tridentata wyomingensis* and includes the grasses *Pseudoroegneria spicata*, *Poa secunda secunda* or *Stipa thurberiana* depending on the province. The Loamy 12-14" type is characterized by *Artemisia tridentata vaseyana* and the grasses, *Festuca idahoensis* and *Pseudoroegneria spicata*, in all ecological provinces. Additional selection criteria for research sites include areas that can be used for treatments with specific precipitation regimes (10-12" or 12-14"), slopes (2-10%), soil series within sites, soil textures (loamy), soil depths (20+"), and stoniness (minimal).

Experimental Approach. The primary objective of this research is to define the biotic and abiotic thresholds that result in degraded ecological states following fire and fire surrogate treatments. This requires knowledge of the ecological responses (soils, hydrology, vegetation, and wildlife) of representative sites that include the range of vegetation states (ecological conditions). Our experimental approach for obtaining this knowledge follows the general conceptual model developed by Whisenant (1999) (Figure 6).

Figure 6. General conceptual model relating the degree of ecosystem degradation to the type of recovery activity needed for restoration to improved conditions.



As ecosystems become progressively degraded by cheatgrass invasion or tree expansion, primary processes are increasingly altered. If the ecosystem is in the initial stages of cheatgrass invasion or tree expansion, recovery to the "reference state" (Figure 3) requires removal of a stressor, like overgrazing, or reinstatement of a natural disturbance, like fire. If a transition threshold controlled by biotic interactions has been crossed, return to the original state may require other vegetation manipulations such as shrub or tree removal in combination with herbicides. Finally, if an abiotic threshold has been crossed, a new ecological type often exists. Return to the original type requires both physical modification and revegetation and is seldom ecologically or economically feasible. To define the ecological thresholds that exist for the Loamy 10-12" and Loamy 12-14" ecological types and that are most meaningful to managers, we focus on states 1 through 3. At each site within all locations, we will select treatment plots that include all three states in approximately equal proportions, i.e., a mosaic of ecological conditions. The primary indicators of the ecological states within the Loamy 10-12" and Loamy 12-14" ecological types are species composition of the vegetation and soil characteristics. Thus, for the Loamy 10-12" type, the ecological states will be defined based on both the relative abundance of native herbaceous vegetation vs. cheatgrass in the sagebrush understory, and the density and size of the sagebrush within a location. For the Loamy 12-14" type, ecological states will be defined on the basis of both tree stand cover and understory characteristics. Tree cover will range from about 10 to 50% and understory cover of both shrubs and herbaceous species will range from about 50% to 5%, respectively, within a site. Herbaceous grass and forb cover will be no less than 2-3% for any given site. There will be minimal evidence of soil surface movement or soil chemical anomalies.

Each treatment plot will be sampled using a grid system and sample points (subplots) will be selected to insure that all ecological states are adequately sampled for rigorous statistical analysis. Core ecological variables will be sampled within each of the subplots across the range of ecological states at the appropriate scale (detailed below). This approach will allow us to examine the responses (i.e., response curves) of the different ecological variables to the different fire and fire surrogate treatments over the range of ecological states that are important for management of these ecosystems. This in turn will permit us to investigate the interactions among the different ecological variables and to define the biotic and abiotic thresholds that exist for these systems based on the responses of the core ecological variables and the interactions among them.

Treatments. A core set of treatments will be executed at all sites within each location. For the Cheatgrass Network, the primary treatments are designed to decrease sagebrush abundance and will include a control, prescribed burn, mechanical treatment, and an herbicide application. Each of these four treatments will be applied across 200 acres treatment plots. Because of the relatively small plot sizes for examining hydrologic and wildlife responses and the expense of collecting data for these variables, the emphasis will be on soils and vegetation, including fuels. The study variables will be measured using a sampling grid that covers the entire 200 acre plot and includes all ecological states. The prescribed burn will be conducted in the fall by agency personnel using standard protocols, will blacken 100% of the area, and will be of low severity. The mechanical treatment will involve dragging a pipe harrow over the entire treatment unit to open up the sagebrush canopy by decreasing sagebrush abundance by about 50%. The herbicide treatment will involve applying the herbicide Tebuthiuron at a rate sufficient to also decrease sagebrush abundance by 50%. The use of Tebuthiuron is not permitted on BLM land in Oregon at this time, and would not be used on any cheatgrass research locations selected in Oregon. A secondary treatment designed to decrease emergence of cheatgrass, the application of the pre-emergent herbicide Plateau, will be superimposed over each of the primary treatments using smaller plots (0.1 ha) and a stratified random approach. The BLM is conducting a risk assessment on herbicide use, and application of Plateau is currently limited to three, five acre plots per BLM field office. The EIS allowing the use of Plateau should be approved by study implementation – if it is not the Plateau treatment will be dropped.

For the Woodland Network, treatments will be installed at two different scales. Three core treatments will be executed at each site – a control, a prescribed burn, and a mechanical treatment. Each of the three treatments will be applied across 25-50 acre treatment plots. Again, due to relatively small plot sizes for examining hydrologic and wildlife responses, the emphasis will be on soils and vegetation, including fuels. The study variables will be measured using a sampling grid as for the Cheatgrass Network. The prescribed burn will be conducted in the fall by agency personnel using standard protocols. The mechanical treatment will involve clearcutting all trees down to ½ m in height on the treatment unit with a chain saw, and leaving them on the contour.

An operational scale prescribed fire in the pinyon/juniper experiment will include hydrologic and wildlife variables, and will allow us to examine the interactions among soils, vegetation, hydrologic and wildlife responses. At least one site per Province will include a 1000 acre burn plot and a paired control plot. Each of these plots will have several 25-50 acre intensive sampling grids as well as an extensive grid that spans the entire area.

Site Characterization. Since response to treatment will occur in the context of local weather conditions and inherent ecological characteristics, a portable weather station will be located at each network site, and the physical setting, soils, and general vegetation descriptions will be described for each core plot.

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 and a consistent within-site sampling approach. Details on variables, measurement protocols, and sampling design can be found in Appendix 2. The major ecological groups of variables to be measured in the study include vegetation, fuels, soils, hydrology, and wildlife. In addition, we will examine economics and the socio-political implications of fire and fire surrogate treatments in the Great Basin. A survey of populations affected by alternative conditions of the sagebrush biome in the Great Basin will be conducted to collect data necessary for socio-economic analysis. Here we describe briefly the major groups of variables to be measured in the study:

1) Vegetation and Fuels. Cover, frequency, and density will be measured for the three plant layers: trees, shrubs, herbs, and cover of bare ground. Fuels data will be collected using a modification of the methods described by Brown et al. (1982) that are required for BEHAVE, FARSITE and FlamMap.

2) Soils. The major goal of the soil-sampling program will be to provide enough descriptive information on local conditions to help explain some of the variation in vegetation responses to treatments within and across the sites. A secondary goal is to directly evaluate the response of soils to treatments, particularly soil chemistry parameters.

3) Hydrology. We will quantify the relationships between changes in overstory and understory vegetation and ground cover and hydrologic/erosion processes. Emphasis will be on

determining if critical thresholds exist in vegetation and ground cover that significantly influence hillslope hydrology and erosion and how management treatments may influence such thresholds.

4) Wildlife. Emphasis will be on determining the influence of treatment on nesting and foraging habitat of passerine birds (particularly sagebrush-obligate species). We will measure passerines directly in the woodland experiment, and focus on foraging (arthropod prey) and nesting habitat variables in both woodland and cheatgrass networks.

5) Sociology. Each of the restoration and fuels-reduction treatments evaluated in this project is a potentially controversial practice that might meet resistance from citizens and/or managers when applied to the public lands that comprise most of the region. This component of the project will assess the social and political feasibility of these alternative restoration approaches. Our intent is to identify factors in the treatments that can constrain or facilitate implementation of practices that biophysical research shows to be promising.

6) Economics. One objective is to estimate the benefits of reducing the probability of further irreversible losses in Great Basin ecosystems, as these benefits accrue to current and future generations. Since many of these values are extra-market in nature, there will be an emphasis on variables necessary to measure these. A second objective is to integrate the ecological and economic modeling regarding information about ecological thresholds with the economic estimates of the benefits and costs of reducing risk of loss. This data will largely come from the experimental results and non-market valuation survey.

Analysis--Ecological Component. Two analytical approaches will be used: 1) ANOVA and regression methods for analysis of univariate data at the site and network levels; and 2) ordination, classification and structural equation techniques for analysis of multivariate data at both site and network levels.

The study has been designed to allow for a standard analytic approach using an ANOVA type design. This insures a well-replicated and statistically valid design for the overall experiment in which differences among sites and treatments can be tested for the suite of ecological variables examined. Variables believed to be influencing ecosystem trajectories, like tree cover, cheatgrass biomass, or soil texture, can be treated as covariates to examine their overall influence on other response variables.

The experimental design for the Cheatgrass Network is a completely randomized design consisting of a random sample of at least six replicates in three provinces. The treatments (control, prescribed burn, mechanical, and herbicide) are a split-plot within each replicate. The pre-emergent herbicide treatment is a split-split plot with sub-sampling. Data will be collected over several years adding a repeated measures dimension to the design.

The design for the Woodland Network is a completely randomized design consisting of a random sample of at least nine replicates in three provinces. The treatments (control, prescribed burn, and mechanical) are a split-plot within each replicate. Data collected in different years will be treated as a repeated measure.

Data will be analyzed using SAS Institute's PROC MIXED. Several patterns for the variance-covariance structure of the residuals will be investigated, including both homogeneous and heterogeneous AR(1) autoregressive structures.

We also anticipate using multivariate techniques to capture whole system responses to fire and fire surrogate treatments. Information on whole system response has great value from a management perspective, because it will allow managers to assess tradeoffs in response to treatment for different key variables. From a scientific perspective, the multivariate design will allow us to better understand not only how multiple components of the system respond, but also how relationships among components change when treatments are applied. Use of multivariate techniques is necessary to extract this kind of information. For example, standard multivariate techniques such as ordination and classification can help us understand how treatments influence plant species *composition,* rather than just *diversity* as a single metric (McCune and Grace 2002). Compositional changes are likely to be more important than diversity changes *per se*, because species differ with respect to their function (e.g. nitrogen fixers), or with respect to their relative value for humans (e.g. native plants vs. invasive plants).

In order to evaluate how *relationships* among components within a system respond to treatment, we need multivariate techniques that go beyond simple ordination and classification. A potential tool is 'structural equation modeling" (SEM) (Pugesek et al. 2003). This analysis tool requires that the investigator build a hypothetical model *apriori*, that includes the key variables, and their causal relationships not only to the dependent variable, but to one another. In essence, one builds a model of how the system is predicted to work, and then tests the model with real data from the experiment. With SEM, we can answer questions about the response of key variables within the context of the whole system. For example, we can answer questions such as how soil type influences the degree to which fire and fire surrogates differ in their influence on plant species diversity. Factors such as slope, elevation, aspect, initial fuel loads, etc,. can also be evaluated in the context of a structural equation model. In summary, the design of this study will allow us to choose among a wide array of analysis tools, given the objective of providing information to managers in the most useful form possible.

Analysis -- Economics Component. Alternative treatments will likely result in different ecological states. Human populations will likely respond differentially to these ecological states. Furthermore, sub-populations of humans will likely exhibit differential response to the any given ecological state. A matrix of characteristics of the possible states of nature, of individual characteristics, and activities and values affected by treatment regimes will be used to help identify combinations that will be candidates for valuation. This will define the relevant populations to be surveyed, the sampling scheme, as well as the specific environmental 'goods' and 'services' that will be valued. Extra market environmental values will be estimated using standard econometric methods developed for non-market valuation. We will use a random utility framework and focus on individual assessment of risk associated with further loss and the value of changing the probability of preventing loss. Random utility models assume that individual preference patterns are observable up to a point, and use as a dependant variable an individual's 'yes' or' no' response to whether they would be willing to make a given sacrifice in order to obtain a state of nature that is preferable to one that they would otherwise be expected to achieve. Independent variables include a quantity of the 'sacrifice', the incremental change in the state of nature, and a number of demographic and other variables that describe individual characteristics and characteristics of the environmental change. A probit or logit maximum likelihood regression is used to estimate parameters for the probability of a 'yes.' The probability distribution is cumulative over the range of dollar-valued levels of 'sacrifice' people are willing to trade off to achieve the change, since a 'yes' to any amount would imply a 'yes to a smaller sacrifice to achieve the same change in state. Therefore the area beneath the estimated distribution, truncated appropriately, is its approximate expected value – or the mean willingness to pay to achieve the incremental change in the environmental resource. A number of additional statistical procedures and tests will be incorporated to extend the results over the population, and over different levels of risk of loss of the resource.

We plan to develop a ranch-level impact model that incorporates ecological relationships in the context of a ranch operation using public and private lands. We will use estimates of non-market environmental values (e.g., wildlife species, invasive species, erosion, water quality or others) that would be comparable to the market values that are explicitly considered by the rancher. The full set of values could then be used in a linear programming model (using GAMS) to incorporate environmental variables into a model that would optimize over both ranch and environmental values. We will then compare alternative runs of the model with and without the environmental values included to determine what the environmental costs would be if ranch level decisions were made without considering non-market values. In addition, we can determine the costs to the rancher of including environmental values into the public lands manager's decision. That is, the model will allow us to trace out the trade-offs between ranch-level costs and benefits and environmental impacts

The decision problem will be modeled as a stochastic dynamic programming problem that takes in to account relevant objectives, constraints, and the underlying physical and ecological processes that characterize the dynamics of the ecological system. Where possible, quantifiable incremental changes in physical characteristics that people care about (impacts on recreational use, productivity of rangeland for agriculture, amount of critical nesting habitat for sage grouse, forage for game species, hydrological impacts, the change in the probability of catastrophic fire, the change in the probability that a system will irreversibly transition to a degraded state) are assigned social values per unit change. The goal of the analysis is to build upon the ecological findings, to provide information that will aid in the decision-making process.

Analysis -- Sociopolitical Component. Most studies of social acceptability have used quantitative, survey-based methodologies that allow for generalization about judgments typical of important constituencies and/or evaluation of the influence of educational interventions intended to improve understanding about practices or conditions being evaluated (Shindler et al. 2002). We will use these measurement tools as well, but the project also will include qualitative, interview-based methods that are useful in identifying particular factors to include in subsequent surveys as well as in obtaining in-depth textural information about nuances of acceptability and its influences.

Research will take place in six phases that will each lead to a scientific product. Some phases will take place concurrently, but research will be underway in each of the first five years of the project, and can potentially continue as further funding becomes available. Interviews of "key informants" (persons in the region with particular knowledge about proposed treatments and their sociopolitical implications) and a review of existing literature in both lay periodicals and peer-reviewed journals will take place prior to initiation of any of the research phases, which are listed below roughly in chronological order:

Interest group intervention – Interviews will be conducted with members of interest groups (particularly environmental organizations and rural commodity advocacy groups) across the Great Basin to identify factors that are associated with decisions to engage in administrative appeals or lawsuits as a response to proposed restoration activities.

Initial social acceptability survey – Surveys of citizens in randomly selected households will be conducted of citizens in four locations within the Great Basin.

Institutional analysis: Review of existing laws and regulations, judicial decisions, and policy statements will be conducted along with qualitative interviews– using a semi-structured interview guide of open-ended questions – and focus groups with agency decision-makers.

Permittee survey: As noted previously, decisions that affect forage availability on public lands typically entail some cooperation with grazing permittees for the proposed treatment area.

Assessment of communications strategies: This phase will assess the effectiveness of different approaches to communicating about alternative approaches to restoration, including both on- and off-site (video or web-based) demonstrations and printed materials.

Post-treatment social acceptability survey: One advantage of conducting social research in conjunction with a long-term study such as this is that we can evaluate changes in acceptability over time.

Project Management. Given the substantial benefits of regional, integrated networks of sagebrush steppe research sites, it is essential that this project be maintained over time and that its integrity not give way to a collection of separate, uncoordinated studies. A project-wide oversight and management function is needed for this purpose. We propose a two-tiered project management organization, composed of two committees and a project manager. The first committee is the Technical Committee, which consists of site managers, disciplinary group leaders, management representatives, and the project manager (Table 2).

Table 2. The Technical Committee

Site Managers	
Snake (Cheatgrass)	David Pyke, USGS-Corvallis; Paul Doescher, OSU
Humboldt/Bonneville (Cheatgrass)	Gene Schupp, USU
High Desert/Klamath (Woodland)	Rick Miller, OSU
High Calcareous (Woodland)	Robin Tausch, Jeanne Chambers, USDA FS-Reno
Bonneville (Woodland)	Bruce Roundy, BYU
Discipline Group Leaders	
Vegetation/Fuels	Steve Bunting, UI
Soils	Carla D'Antonio, ARS-Reno
Hydrology	Fred Pierson, ARS-Boise
Wildlife	Mike Wisdom, Jim McIver, USDA FS-La Grande; Steve Knick, USGS-Boise
Socio-political	Mark Brunson, USU
Economics	Kim Rollins, UNR
Statistics	David Turner, USDA FS-Ogden
Management Representation	Hugh Barrett, Mike Pellant, Sherm Karl, BLM
Project Manager	Jim McIver, USDA FS-La Grande

The second is a five-member Executive Committee (EXEC), selected by the Technical Committee and consisting of the project manager, two disciplinary group leaders, and two site managers. 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 Technical Committee and the Governing Board. In addition, the Executive Committee will serve in an outreach or liaison role communicating the importance, uniqueness, and substantive outcomes of the Great Basin FFS project to members of government, industry, non-governmental organizations, and the general public.

At the outset of the project, the Technical 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 desired future condition for that site, and specifics on implementing the sampling protocols for the core variables. The Technical Committee will review the study plans and work with site managers as needed to bring the study plans into conformance with agreed-upon network guidelines. The Technical Committee will be responsible for recommending sites to the Executive Committee for initial and continued funding. In addition, over the course of the funding period the Technical Committee 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 project. The responsibilities outlined above are critical to guaranteeing that the project 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 project 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 regional data teams are used by a discipline. The Technical and Executive Committees 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 project.

To ensure project cohesiveness and foster interchange of data and ideas, an annual meeting will be held at one of the research sites. All site managers and disciplinary team leaders are expected to attend these meetings, with other project scientists, local 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.

Database Management. As with project management, database management is a requirement for the long-term integrity and viability of the research. 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 Project Manager 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 plot 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 Technical Committee will control access to the data within the database. Project access to the data will be handled by the site managers. The site managers will make summary statistics available to the project as they become available or are requested by the executive committee.

Communications Plan/Deliverables

The Great Basin Fire and Fire Surrogate project is an interdisciplinary study applied across the Great Basin and Snake River Plain in the big sagebrush biome. This comprehensive study will generate information of interest to a diverse audience. A communication plan that can adapt to the needs of all audiences is essential for effective technology transfer to practitioners and public outreach. In this section, we sketch the outline of our communications plan; more details on the plan can be found in Appendix 3.

The purpose of the Communication Plan is to guide the project through the outreach process by providing both conceptual and process frameworks, at the network and at the site levels. The communication plan identifies target audiences and the types of information and methods used to transfer information. The following three objectives will be addressed in the communications plan:

1. Identify the specific audiences we are planning to reach.
   We have identified 7 groups of potential audiences, listed in order of priority for outreach: 1) the professional land management community; 2) the scientific research community; 3) the general public; 4) the policy-making community; 5) the educational community; 6) land owners; and 7) land users.

2. Define the scope and scale of information we intend to transfer to specific audiences based on the needs of the audience and the information available to transfer.
   We will adapt information to be presented to suit the different interest group or groups as well as with the type of media to be used. The following steps identify the process used to transfer information to targeted groups: 1) define the target audience; 2) determine the range of interest, expertise, and information needs with the target audience; and 3) determine the range of information that is currently available.

3. Identify the methods to be used for public outreach and technology transfer.
   Outreach methods include conferences, workshops, lectures, electronic media, tours, the internet, e-mail, word of mouth, and professional and scientific journals. The actions below will be utilized to determine the appropriate outreach medium for a particular audience and information type: 1) determine the types of information that may be transferred using these audience-specific media; 2) determine the media that is compatible with the type of information to be transferred; and 3) develop a clear plan by which different outreach media can be most effectively used to reach different audiences. This action

involves the strategy used for presentations, publications, or information transferred through conferences, newsletters, workshops, tours, or other media.

A key deliverable is a set of three 'User's Guides', that we will develop from literature syntheses within the first three years of the study, one each for sagebrush, pinyon, and juniper-dominated systems. The User's Guide will contain the latest information on how these systems are known to respond to available treatments, and will thus allow managers to make more informed decisions as they consider how to apply treatments under a wide variety of conditions. Information from the current experiment will then be used to craft second editions of the User's Guides toward the end of the study period.

4. Establish guidelines for incorporating research into outreach efforts. Research activities that will be linked to outreach activities will take either of two forms: 1) Measurement of audience reactions during or immediately following field tours or electronic media presentations about the project and its ecological basis; and 2) Measurement of change in knowledge or acceptability following use of different outreach messages or methods.

Management Collaboration

Study Design and Oversight. Throughout this proposal, we have described this project as a 'management experiment', that would provide managers with information to restore ecological communities that is relevant across the 100+ million acres of the sagebrush biome, be matched to the temporal and spatial scales at which managers operate, and reduce management risk and uncertainty of catastrophic wildfire to the greatest degree possible. In order to design and carry out such an experiment, scientists cannot act alone, but must collaborate with managers closely to determine the kinds of treatments that should be studied, the kinds of variables that must be measured, and the sites that are most relevant to examine. The three management representatives on our Technical Committee have been critical for keeping this effort focused on management needs (Table 2). In addition, a number of state and field-level workshops have been conducted to present the study plan to managers, and to obtain their input into the design of the project (see Appendix 4D for lists of managers that we worked with at the State and Field Levels).

Treatment Implementation. One of the greatest challenges faced by a study of this kind is the difficulty in getting the treatments implemented on time, and as per specification. For this we require a substantial commitment in time and resources from the management units on which the research sites will be placed. Letters of intent that express commitments of time and resources are provided for each of the sites in Appendix 4A. From these letters of intent, we are in the process of developing MOUs that would provide us with guidelines for not only implementing but sustaining the study for the long-term. A sample MOU is also provided in Appendix 4B.

Schedule of Major Study Activities and Deliverables.

Table 3 lists major activities and deliverables of the project for the next several years, and provides a timeline for their completion. Because this is a 'real-time' ecological experiment, we obviously cannot speed up the time for delivery of the main ecological results. Yet we can provide useful, high quality information in the short term in two different ways: 1) By reaching out with our socio-political and economics results, that are not so strictly tied to the treatments (note several deliverables of this kind in Table 3); and 2) By focusing on the 'Fuels Guide' and the three 'User's Guides', that will provide critical information in the much shorter term.

The actual timeline for activities will have to be modified of course, if unplanned events occur during the treatment implementation process. The Table assumes that all sites will move forward together through the treatment implementation phase. Note also that we consider this project to be long-term. Thus while important findings will be delivered in the short-term (within the initial 5-year funding period), we anticipate that we will report results on a regular basis for many years thereafter. This approach is reflected in the Table below, through the separation of post-treatment data collection and analysis into two 'rounds'. Providing that treatment implementation generally proceeds as planned, we anticipate that we will be able to report 1st Round post-treatment ecological results in a major symposium in late 2010, about 5 ½ years after the beginning of the project. We anticipate however, that a second round of post-treatment collection will be needed to gain an acceptable level of confidence in short-term response to treatments, needed for the production of the 2nd Edition User's Guide. This pushes the anticipated time for production of the guide back to late 2011, 6 ½ years after the initiation of the project. In our view, the reality of these temporal constraints, common to any 'real-time' experiment, places even greater value on the production of the 1st Edition 'User's Guide', within just three years after project initiation, and on the production of the 'Fuels Guide' and various economics and socio-political products. Finally, note the commitment to both quarterly and annual products (listed at the bottom of the Table) as the project progresses.

Table 3. Schedule of major project activities (in black) and deliverables (in green), with associated completion dates.

ACTIVITY/DELIVERABLE	DATE
Plot Selection and Layout	2005
Memoranda of Understanding	2005
Pre-treatment Data Collection	2006
Papers/presentations on socio-economic trends, and ranch-level baseline budgets	2006
Treatment Implementation	2006/2007
Pre-treatment Data Entered	Late 2007
Field Guide to interest groups concerns	Late 2007
Papers/presentations on social acceptability	Late 2007
Papers/presentations on non-market values	Late 2007
Production of 'Fuels Guide'	Early 2008
Handbook on legal/institutional constraints on management	Mid 2008
1st Round Post-treatment Data Collection	2007/2008
Production of 1st Edition 'User's Guides'	Late 2008
Papers/presentations on economic optimization	2008
1st Round Post-treatment Data Entered	Late 2008
1st Round Site-level Data Analysis	Early 2009
2nd Round Post-treatment Data Collection	2009/2010
GTR: Site-Level Establishment Reports	Late 2009
Papers/presentations on economic comparison of treatments	2009/2010
1st Round Network-Level Analysis	Early 2010
Educational Assessment – what tech transfer tools work?	Mid 2010
1st Major Symposium – Presentation of 1st Round Results	Late 2010
2nd Round Post-treatment Data Entered	Late 2010
2nd Round Post-treatment Data Analysis	Mid 2011
Papers/presentations on economics of reducing risk of wildfire with prescribed fire treatments	2010/1012
Production of 2nd Edition 'User's Guide'	Late 2011
2nd Major Symposium – Presentation of 2nd Round Results	Early 2012
Publication of Papers in Special Journal Issue	Late 2012
Research Briefings, Site Field Tours, Annual Reports	Annual
Progress Report to JFSP Board	Quarterly

Literature Cited (Proposal Text)

Anonymous. 1997. Gunnison sage-grouse conservation plan. Gunnison Basin, Colorado. Bureau of Land Management, Gunnison, Colorado, USA.

Betancourt, J. L. 1987. Paleoecology of pinyon–juniper wood-lands: summary. Pages 129–139 *in* R.L. Everett, compiler. Proceedings: pinyon–juniper conference. USDA Forest Service General Technical Report INT-215.

Brown, J.K., R.D. Oberheu, and C.M. Johnston. 1982. Handbook for inventorying surface fuels and biomass in the interior west. National Wildlife Coordinating group NFES-2125. 48p.

Canadian Sage Grouse Recovery Team. 2001. Canadian sage grouse recovery strategy. Canadian Sage Grouse Recovery Team. Saskatchewan Environment and Resource Management, Regina, Saskatchewan and Alberta Sustainable Resource Development, Edmonton, Alberta, Canada.

Connelly, J. W., and C. E. Braun. 1997. Long-term changes in sage grouse Centrocercus urophasianus populations in western North America. Wildlife Biology 3:229-234.

Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin 28:967-985.

Freilich, J., B. Budd, T. Kohley, and B. Hayden. 2001. Wyoming Basins ecoregional plan. The Nature Conservancy, Boulder, Colorado, USA.

Hemstrom, M. A., M. J. Wisdom, M. M. Rowland, B. Wales, W. J. Hann, and R. A. Gravenmier. 2002. Sagebrush-steppe vegetation dynamics and potential for restoration in the Interior Columbia Basin, USA. Conservation Biology 16:1243-1255.

Knick, S. T., D. S. Dobkin, J. T. Rotenberry, M. A. Schroeder, W. M. Vander Haegen, and C. Van Riper III. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. Condor 105:611-634.

Loomis, J.B. 1993. Integrated Public Lands Management: Principles and Application sot National Forests, Parks, Wildlife Refuges and BLM Lands. Columbia University Press, New York.

McCune, B. and J. Grace. 2002. Analysis of ecological communities. MJM Software Design, Gleneden Beach, Oregon, 300 pages.

Miller, R.F., T.J. Svejcar, and J.A. Rose. 2000. Impacts of western juniper on plant community composition and structure. Journal of Range Management 53:574-585.

Miller, R. F., and R. J. Tausch. 2001. The role of fire in pinyon and juniper woodlands: a descriptive analysis. Pages 15-30 *in* K. E. M. Galley and T. P. Wilson, editors. Proceedings of the invasive species workshop: the role of fire in the control and spread of invasive species. Tall Timbers Research Station Miscellaneous Publication 11.

Miller, R., R. Tausch, and W. Waichler. 1999. Old-growth juniper and pinyon woodlands. Pages 375-384 *in* S. B. Monsen and R. Stevens, compilers. Proceedings: ecology and management of pinyon-juniper communities within the interior west. USDA Forest Service Rocky Mountain Research Station Proceedings RMRS-P-9.

Nachlinger, J., K. Sochi, P. Comer, G. Kittel, and D. Dorfman. 2001. Great Basin: an ecoregion-based conservation blueprint. The Nature Conservancy, Reno, Nevada, USA.

Noss, R. F., E. T. LaRoe III, and J. M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. National Biological Service Biological Report 28, National Biological Service, Washington, D.C., USA.

NRCS 1997. National Range and Pasture Handbook. USDA NRCS. Grazing Lands Technology Institute.

Pellant, M. 1994. History and applications of the Intermountain greenstripping program. INT-GTR-313 pg 63-68. USDA Forest Service, Intermountain Research Station.

Pugesek, B., A. Tomer, A. von Eye. 2003. Structural equation modeling. Applications in Ecological and Evolutionary Biology, 424 pages.

Raphael, M. G., M. J. Wisdom, M. M. Rowland, R. S. Holthausen, B. C. Wales, B. M. Marcot, and T. D. Rich. 2001. Status and trends of habitats of terrestrial vertebrates in relation to land management in the Interior Columbia River Basin. Forest Ecology and Management 153:63-88.

Schroeder, M. A., J. R. Young, and C. E. Braun. 1999. Sage-grouse (*Centrocercus urophasianus*). A. Poole and F. Gill, editors. Number 425, The birds of North America, The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C., USA.

Shindler, B., M. Brunson, & G. Stankey. 2002. Social acceptability of forest conditions and management practices: a problem analysis. General Technical Report PNW-537. Portland, OR: USDA Forest Service.

USDI Bureau of Land Management. 1999. The Great Basin Restoration Initiative: out of ashes, an opportunity. USDI Bureau of Land Management, National Office of Fire and Aviation, Boise, Idaho, USA.

West, N. E., and N. Van Pelt. 1986. Successional patterns in pinyon-juniper woodlands. Pages 43-52 in: Proceedings, Pinyon-Juniper Conference, USDA Forest Service Intermountain Research Station General Technical Report INT-58. 48 p.

West, N. E., R. J. Tausch, and P.T. Tueller. 1998. A management-oriented classification of pinyon-juniper woodlands of the Great Basin. USDA Forest Service General Technical Report RMRS-GTR-12.

Whisenant, S.G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. Pages 4-10 In: McArthur, ED, Romney EM, Smith, SD, and Tueller PT (Compilers) Proceedings – symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management, Las Vegas, NV, April 5-7, 1989. U.S. Forest Service, Intermountain Research Station, GTR INT-276, Ogden, UT.

Wisdom, M. J., R. S. Holthausen, B. C. Wales, C. D. Hargis, V. A. Saab, D. C. Lee, W. J. Hann, T. D. Rich, M. M. Rowland, W. J. Murphy, and M. R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale trends and management implications. USDA Forest Service General Technical Report PNW-GTR-485.

Wisdom, M. J., M. M. Rowland, B. C. Wales, M. A. Hemstrom, W. J. Hann, M. G. Raphael, R. S. Holthausen, R. A. Gravenmier, and T. D. Rich. 2002*a*. Modeled effects of sagebrush-steppe restoration on Greater Sage-Grouse in the interior Columbia Basin, USA. Conservation Biology 16:1223-1231.

Wisdom, M. J., B.C. Wales, M. M. Rowland, M. G. Raphael, R. S. Holthausen, T. D. Rich, and V. A. Saab. 2002*b*. Performance of Greater Sage-Grouse models for conservation assessment in the interior Columbia Basin, USA. Conservation Biology 16:1232-1242.

Wisdom, M. J., M. M. Rowland, Lowell H. Suring, and B. C. Wales. 2003. Sagebrush landscape project. USDA Forest Service, Pacific Northwest Research Station, La Grande, OR. http://www.fs.fed.us/pnw/lagrande/sagebrush/

Wisdom, M. J., L. H. Suring, M. M. Rowland, R. J. Tausch, R. F. Miller, L. Schueck, C. Wolff Meinke, S. T. Knick, and B. C. Wales. 2003*b*. A prototype regional assessment of habitats for species of conservation concern in the Great Basin Ecoregion and State of Nevada. Version 1.1, September 2003, unpublished report on file at USDA Forest Service, Pacific Northwest Research Station, 1401 Gekeler Lane, La Grande, OR 97850.

BUDGET
Request Funds (Table 4)
Contributed Costs (Table 5)

The budget proposed below (Table 4) covers a 5-year period – fiscal years 2005 through 2009. Given the scope of the project, and the several years required for site-specific planning, unit establishment and layout, pre-treatment data collection, treatment implementation, and early post-treatment collection, reasonable assurance of continued funding for 5 years is necessary to proceed with the project. However, while it would be desirable to obtain all funding in one or two fiscal years, we realize that it may be necessary to split the funding into several years. We anticipate that funding needs beyond 5 years will decrease significantly because data collection frequency for core variables will lessen, and the project should be able to attract more non-JFSP funds.

The proposed budget of requested funds is broken into three sections: 1) a Summary Budget, that lists the totals for the network itself, for the disciplines, and for the provinces; 2) the Network Budget, which provides line-item breakdowns for planned expenditures to administer the network and to procure items that are general to all provinces; 3) the Discipline Budgets, which break out planned expenditures into line items for the socio-political, economics, soils, hydrology, fuels, and wildlife disciplines; and 4) the Province Budgets, that breaks out line item expenditures for measuring vegetation at all 15 sites, by the five provinces: High Desert Juniper, High Calcareous Juniper, Bonneville Juniper, Snake River Sage/Cheat, and Humboldt/Bonneville Sage/Cheat.

Below the proposed budget of requested funds is the list of contributed costs (Table 5). We have separated these contributions into three sections, by: 1) research institution, consisting primarily of salary contributions of technical committee members for both federal labs and academic institutions (12-month appointments only), and indirect cost waivers for academic institutions; 2) project contributors, consisting of salary contributions of technical committee members not associated with disciplines or sites; and 3) management contributions, consisting of planning and treatment implementation costs expected to be incurred by our management collaborators.

Please note that the requested funds budget presented here is compiled from budgets that have been approved by each research institution, including federal labs (FS-Reno, FS-La Grande, ARS-Boise, USGS-Corvallis), and universities (BYU, Utah State, UN-Reno, OSU, and UI-Moscow). Instead of presenting the institution-level budgets at this time, we decided it would be better for us to present the requested budget by discipline and province, in order to make it easier for the JFSP to evaluate the proposed work with the proposed budget. If this proposal is funded by the JFSP, then we will present the institution-level budgets, which will serve as the fiscal documents on which the various agreements will be drawn up.

Table 4. Budget -- Great Basin Fire and Fire Surrogate Study

Summary of Funding Request

	2005	2006	2007	2008	2009	TOTAL
Utah State University	179,787	280,424	310,192	330,780	303,562	**1,404,745**
University of Nevada - Reno	70,538	242,576	279,596	249,574	216,600	**1,058,885**
Brigham Young University	486,484	262,296	231,285	235,652	238,975	**1,454,692**
University of Idaho	53,598	60,971	81,557	84,788	63,568	**344,482**
Oregon State University	328,798	1,313,310	590,729	700,925	703,798	**3,637,560**
Forest Service - RMRS - Reno	92,877	210,354	219,235	228,731	239,081	**990,278**
Forest Service - PNW - La Grande	8,880	21,159	19,167	2,220	2,220	**53,646**
Agricultural Research Service - Boise	158,747	209,611	215,393	221,410	231,339	**1,036,500**
Sub-Total	**1,379,709**	**2,600,701**	**1,947,154**	**2,054,080**	**1,999,143**	**9,980,788**
USGS - Pass-though Indirect (6%)**	82,782	156,042	116,829	123,245	119,949	598,847
US Geological Survey - Boise	98,694	318,247	323,223	319,383	329,740	**1,389,287**
US Geological Survey - Corvallis	51,990	217,175	227,265	237,958	248,818	**983,206**
Total Request	**1,613,175**	**3,292,165**	**2,614,471**	**2,734,666**	**2,697,650**	**12,952,128**

** Indirect costs for Pass-through not charged to USGS budgets at Boise and Corvallis

Utah State University

	2005	2006	2007	2008	2009	TOTAL
Salary and Benefits						
Gene Schupp	5,829	6,004	6,184	6,370	6,561	30,948
OPE - Principal Investigator	2,367	2,462	2,535	2,612	2,690	12,666
Mark Brunson	6,325	6,515	6,710	6,911	7,119	33,580
OPE - Principal Investigator	2,568	2,671	2,751	2,834	2,919	13,743
Principal Investigator Subtotal	**17,089**	**17,652**	**18,180**	**18,727**	**19,289**	**90,937**
Site Manager (USU)	18,500	38,110	39,253	40,430	41,643	177,936
OPE - Site Manager	7,511	15,625	16,094	16,576	17,073	72,879
Communications Specialist (USU)	33,500	34,505	35,540	36,606	37,704	177,855
OPE - Communications Specialist	13,735	14,147	14,571	15,008	15,459	72,920
Research Associate Subtotal	**73,246**	**102,387**	**105,458**	**108,620**	**111,879**	**501,590**
Research Assistants (GRAs) - Ph.D. (2)	18,000	34,740	35,786	17,186	17,702	123,414
OPE - Ph.D. research assistants	1,494	2,883	2,971	1,426	1,469	10,243
Research Assistants (GRAs) - M.S. (2)	0	0	16,686	34,286	17,613	68,585
OPE - M.S. research assistants	0	0	1,385	2,845	1,462	5,692
Graduate Res. Assists Subtotal	**19,494**	**37,623**	**56,828**	**55,743**	**38,246**	**207,934**
Field crew leader (1)	6,300	6,489	6,684	6,885	7,092	33,450
OPE - field crew leader	523	539	555	572	589	2,778
Field crew (2 in yrs 1-2, 6 in yrs 3-5)	11,400	35,226	36,283	37,372	38,492	158,773
OPE - field crew members	946	2,924	3,011	3,102	3,195	13,178
Field crew subtotal	**19,169**	**45,178**	**46,533**	**47,931**	**49,368**	**208,179**
Total Salary and Benefits	**128,998**	**202,840**	**226,999**	**231,021**	**218,782**	**1,008,640**
Travel						
Principal Investigators	3,380	2,880	2,380	2,380	2,880	13,900
Research Associates						
Site Manager	2,425	2,425	2,425	2,425	2,425	12,125
Communications Specialist	2,000	3,500	3,500	4,000	4,500	17,500
Res. Assists (GRAs), Field Per Diem	0	3,925	5,350	7,350	4,425	21,050
Technical Assistants						

Field Per Diem	4,275	9,975	9,975	9,975	9,975	44,175
Vehicles	3,432	6,864	6,864	6,864	6,864	30,888
Total Travel	**15,512**	**29,569**	**30,494**	**32,994**	**31,069**	**139,638**
Supplies						
Lab (Sociopolitical)	0	2,250	1,000	10,500	0	13,750
Field	8,000	3,000	3,000	3,000	3,000	20,000
Communications	500	1,000	1,500	1,500	1,500	6,000
Total Supplies	**8,500**	**6,250**	**5,500**	**15,000**	**4,500**	**39,750**
Total Equipment	**0**	**0**	**0**	**0**	**0**	**0**
Total Contracts	**0**	**0**	**0**	**0**	**0**	**0**
Total Agreements	**0**	**0**	**0**	**0**	**0**	**0**
Publication/Technology Transfer	**0**	**0**	**1,000**	**2,500**	**4,000**	**7,500**
Total Direct Costs	**153,010**	**238,659**	**263,993**	**281,515**	**258,351**	**1,195,528**
Indirect Costs (17.5%)	**26,777**	**41,765**	**46,199**	**49,265**	**45,211**	**209,217**
Funding Requested	**179,787**	**280,424**	**310,192**	**330,780**	**303,562**	**1,404,745**

University of Nevada - Reno

	FY05	FY06	FY07	FY08	FY09	Total
Salary and Benefits						
Principal Investigators	7,874	7,874	7,874	7,874	7,874	39,370
Principal Investigator benefits (27%)	2,126	2,126	2,126	2,126	2,126	10,630
Dale Johnson Summer Salary		11,037	11,037	11,037	11,037	44,147
Johnson Fringe (27%)	0	2,980	2,980	2,980	2,980	11,920
Staff Res. Associate (SRA) II - soils	0	34,906	36,355	38,733	41,170	151,164
Benefits SRA II (40%)	0	13,962	14,542	15,493	16,468	60,466
Research Faculty (Econ) Salary	4,593	8,159	11,250	10,203	5,272	39,477
Research faculty benefits (27%)	1,240	2,203	3,038	2,755	1,423	10,659
Graduate Res. Assists (GRAs)	27,273	45,455	45,455	45,455	45,455	209,091
GRA benefits (10%)	2,727	4,545	4,545	4,545	4,545	20,909
Technicians (e.g. field or lab help)						
Field Crew Leaders (x persons)						
Field Crew and lab Assts	0	18,182	12,727	12,727	12,727	56,364
Benefits Field Crew (10%)	0	1,818	1,273	1,273	1,273	5,636
Hourly Res. Assists. (undergrads)	0	1,471	1,471	1,471	0	4,412
Benefits hourly assts (2%)	0	29	29	29	0	88
Total Salary and Benefits	**45,833**	**154,748**	**154,701**	**156,701**	**152,350**	**664,333**
Travel						
Principal Investigators	1,950	6,450	5,100	4,750	3,500	21,750
Staff Research Associate (SRA)	0	2,800	1,000	1,000	1,000	5,800
Research Faculty (Econ)	1,800	2,550	2,250	1,450	500	8,550
Graduate Res. Assists (GRAs)	350	750	500	0	0	1,600
Technical Assistants						
Field per Diem	0	4,100	2,000	2,000	2,000	10,100
Vehicles	0	3,000	500	500	500	4,500
Total Travel	**4,100**	**19,650**	**11,350**	**9,700**	**7,500**	**52,300**
Non-Expendable Equipment						
Computers	5,000	1,800	0	0	0	6,800
Software	1,850	1,400	0	0	0	3,250
Total Equipment	**6,850**	**3,200**	**0**	**0**	**0**	**10,050**
Supplies						
Lab	0	10,000	20,213	20,213	10,000	60,426

Field	0	3,000	1,500	1,500	1,500	7,500
Resin Capsules	0	0	9,240	9,240	9,240	27,720
Printing	2,800	2,800	3,800	2,000	0	11,400
Postage	250	250	850	400	0	1,750
Books, research materials	200	300	300	150	0	950
Implan data (Nevada)	0	1,500	0	0	0	1,500
Total Supplies	**3,250**	**17,850**	**35,903**	**33,503**	**20,740**	**111,246**
Contracts						
Soil Analysis equipment maintenance	0	0	5,000	5,000	0	10,000
phone bank survey center	0	10,000	30,000	5,000	0	45,000
expert reviews	0	1,000	1,000	0	0	2,000
Total Contracts	**0**	**11,000**	**36,000**	**10,000**	**0**	**57,000**
Total Agreements	**0**	**0**	**0**	**0**	**0**	**0**
Publication and Technology Transfer	**0**	**0**	**0**	**2,500**	**3,750**	**6,250**
Total Direct Costs	**60,033**	**206,448**	**237,954**	**212,404**	**184,340**	**901,178**
Indirect Costs (17.5%)	**10,506**	**36,128**	**41,642**	**37,171**	**32,260**	**157,706**
Funding Requested	**70,538**	**242,576**	**279,596**	**249,574**	**216,600**	**1,058,885**

Brigham Young University

	FY05	**FY06**	**FY07**	**FY08**	**FY09**	**TOTAL**
Salary and Benefits						
Principal Investigators	9,735	10,027	10,328	10,638	10,957	51,685
Research Associates						
Site Manager (0.5 yr 1, 1.0 other yrs)	27,640	56,938	58,647	60,406	62,218	265,848
Res. Assists (GRAs) 1 veg, 1 hydro	20,000	40,000	40,000	40,000	40,000	180,000
Technicians (e.g. field help)						
Field Crew (2 yr 1, 8 yrs 2-5)	12,936	53,296	54,895	56,542	58,239	235,908
Soil moisture installation crew (3 yr 2)	0	19,986	0	0	0	19,986
Total Salary and Benefits	**70,311**	**180,248**	**163,870**	**167,586**	**171,414**	**753,428**
Travel						
Principal Investigators	1,380	1,380	1,380	1,380	1,380	6,900
Research Associate - Site Manager	2,425	2,425	2,425	2,425	2,425	12,125
Res. Assists (GRAs), Field Per Diem	1,425	2,850	2,850	2,850	2,850	12,825
Technical Assistants						
Field Per Diem	2,850	15,675	11,400	11,400	11,400	52,725
Vehicles	3,638	16,653	10,914	10,914	10,914	53,033
Total Travel	**11,718**	**38,983**	**28,969**	**28,969**	**28,969**	**137,608**
Supplies						
Lab	2,000	1,000	1,000	1,000	1,000	6,000
Field	6,000	3,000	2,000	2,000	1,000	14,000
Soil moist. stations 108 ($3,000 ea)	324,000	0	0	0	0	324,000
Total Supplies	**332,000**	**4,000**	**3,000**	**3,000**	**2,000**	**344,000**
Total Equipment	**0**	**0**	**0**	**0**	**0**	**0**
Total Contracts	**0**	**0**	**0**	**0**	**0**	**0**
Total Agreements	**0**	**0**	**0**	**0**	**0**	**0**
Publication and Technology Transfer	**0**	**0**	**1,000**	**1,000**	**1,000**	**3,000**
Direct Costs Total	**414,029**	**223,231**	**196,839**	**200,555**	**203,383**	**1,238,036**
Indirect Costs (17.5%)	**72,455**	**39,065**	**34,447**	**35,097**	**35,592**	**216,656**
Funding Requested	**486,484**	**262,296**	**231,285**	**235,652**	**238,975**	**1,454,692**

University of Idaho

	FY05	FY06	FY07	FY08	FY09	TOTAL
Salary and Benefits						
I. Salaries						
Ia. Principal investigator	7,500	7,500	7,500	7,500	7,500	37,500
Ib. Graduate Research Assistantships	25,000	25,000	42,000	42,000	25,000	159,000
Ic. Irregular help (field crew)	0	0	0	0	0	0
II. Benefits						
Principal investigators (33% of Ia)	2,475	2,475	2,475	2,475	2,475	12,375
Graduate Res. Assists (1% of Ib)	250	250	420	420	250	1,590
Irregular help (9% of Ic)	0	0	0	0	0	0
Total Salary and Benefits	**35,225**	**35,225**	**52,395**	**52,395**	**35,225**	**210,465**
Travel						
Vehicle rental	1,200	3,375	3,375	3,375	3,375	14,700
Vehicle expenses	1,500	3,500	3,500	4,000	4,500	17,000
Field Per Diem	4,290	7,290	7,640	8,640	7,000	34,860
Total Travel	**6,990**	**14,165**	**14,515**	**16,015**	**14,875**	**66,560**
Equipment and Supplies						
Msc. research expenses	1,000	2,500	2,500	2,500	3,000	11,500
Computer software	1,400	0	0	0	0	1,400
IMPLAN data: Idaho & Oregon	1,000	0	0	0	0	1,000
Total Equipment and Supplies	**3,400**	**2,500**	**2,500**	**2,500**	**3,000**	**13,900**
Total Contracts	**0**	**0**	**0**	**0**	**0**	**0**
Total Agreements	**0**	**0**	**0**	**0**	**0**	**0**
Publication and Technology Transfer	**0**	**0**	**0**	**1,250**	**1,000**	**2,250**
Direct Costs Total	**45,615**	**51,890**	**69,410**	**72,160**	**54,100**	**293,175**
Indirect Costs (17.5%)	**7,983**	**9,081**	**12,147**	**12,628**	**9,468**	**51,306**
Funding Requested	**53,598**	**60,971**	**81,557**	**84,788**	**63,568**	**344,482**

Oregon State University

	FY05	FY06	FY07	FY08	FY09	Total
Salary and Benefits						
Principal Investigators	82,382	121,158	123,580	126,052	128,573	581,745
OPE - Principle Investigators	31,269	46,450	47,843	49,278	50,757	225,597
Research Associates		0	0			0
Site Manager	31,000	67,620	68,972	70,351	71,758	309,701
OPE - Site Manager	16,899	36,139	37,223	38,340	39,490	168,091
Database Manager (.50 FTE)	0	11,250	28,080	29,203	30,371	98,904
OPE (64% Salary)	0	7,200	17,971	18,690	19,437	63,299
Research Assistants (GRAs)	37,004	58,135	40,796	21,215	21,639	178,789
OPE - Research Assistants	2,834	4,423	3,052	1,594	1,642	13,545
Temporary Summer	0	26,000	0	27,000	27,446	80,446
OPE - Temporary Summer	0	2,261	0	2,399	2,471	7,131
Technicians (e.g. field help)	0	48,240	48,360	48,482	48,607	193,689
Technician's OPE (Summer Student)	0	4,858	5,003	5,153	5,307	20,321
Field Crew Leaders (x persons)	0	0	0	0	0	0
Integrated Field Crew (x persons)	0	0	0	0	0	0
Total Salary and Benefits	**201,388**	**433,734**	**420,880**	**437,757**	**447,498**	**1,941,258**
Travel						
PI's, Research Asst & Associates	12,790	14,590	11,290	14,790	14,500	67,960

Research Associates	1,350	4,850	6,000	4,000	5,000	21,200
Site Manager	0	5,000	5,000	5,000	5,000	20,000
Technical Assistants	0	1,000	2,000	2,000	2,000	7,000
Field Per Diem (techs only)	0	13,140	10,572	14,026	14,502	52,240
Vehicles	7,340	12,287	12,246	12,819	13,105	57,797
Mileage	1,000	4,500	4,300	5,130	5,493	20,423
Sage Group Annual Meetings	10,000	10,000	10,000	10,000	10,000	50,000
Total Travel	**32,480**	**65,367**	**61,408**	**67,765**	**69,600**	**296,620**
Supplies						
Survey Sampling	1,500	0	0	0	0	1,500
Survey Mailing	5,000	4,000	0	0	0	9,000
Survey Printing	4,000	2,750	0	0	0	6,750
Lab & Field	6,400	15,900	3,000	13,400	13,400	52,100
Fencing	0	378,000	0	0	0	378,000
IMPLAN data: ID and OR @1,000	1,000	0	0	0	0	1,000
Total Supplies	**17,900**	**400,650**	**3,000**	**13,400**	**13,400**	**448,350**
Expendable (Minor) Equipment						
Lab	8,500	3,000	1,000	500	500	13,500
Lab	5,900	0	0	0	0	5,900
Field	2,000	1,000	1,000	500	500	5,000
Total Expendable Equipment	**16,400**	**4,000**	**2,000**	**1,000**	**1,000**	**24,400**
Equipment						
	0	125,000	0	0	0	125,000
Total Equipment	**0**	**125,000**	**0**	**0**	**0**	**125,000**
Services						
Aerial Photos	0	60,000	0	0	0	60,000
Ant Specialist	6,660	12,960	13,460	13,860	14,479	61,419
Butterfly Surveys	0	1,000	1,000	1,000	1,000	4,000
Environmental Assessment	0	15,000	0	0	0	15,000
Network Analysis	0	0	0	50,000	0	50,000
Statistics	5,000	0	0	0	36,000	41,000
Satellite Imagery	0	0	0	0	0	0
Total Services	**11,660**	**88,960**	**14,460**	**64,860**	**51,479**	**231,419**
Publication/Tech Transfer	**0**	**0**	**1,000**	**11,750**	**16,000**	**28,750**
Total Direct Costs	**279,828**	**1,117,711**	**502,748**	**596,532**	**598,977**	**3,095,797**
Indirect Costs (17.5%)	**48,970**	**195,599**	**87,981**	**104,393**	**104,821**	**541,764**
Funding Requested	**328,798**	**1,313,310**	**590,729**	**700,925**	**703,798**	**3,637,560**

Forest Service - RMRS – Reno

	FY05	**FY06**	**FY07**	**FY08**	**FY09**	**TOTAL**
Salary and Benefits						
Research Associates						
Site Manager (GS-9; 6 mo in yr 1)	27,248	59,404	63,741	68,394	73,386	292,172
Research Assistants (GRAs)		20,000	20,000	20,000	20,000	80,000
Technicians						
Field Crew Leader (1, GS-7; 10ppd)	14,184	14,799	15,460	16,169	16,929	77,541
Field Crew (8, GS-5, 6 ppd; 2, GS-5, 6 ppd in year 1)	13,740	57,352	59,912	62,632	65,688	259,324
Total Salary and Benefits	**55,172**	**151,555**	**159,113**	**167,195**	**176,003**	**709,037**
Travel						
Principle Investigators ($2000 x 3	6,000	6,000	6,000	6,000	6,000	30,000

people)						
Research Associates						
Site Manager	2,000	2,000	2,000	2,000	2,000	10,000
Technical Assistants						
Field Per Diem (30 dys x $21 x 9 people; 2 people in yr 1)	672	5,670	5,670	5,670	5,670	23,352
Vehicles ($1,200 x 3 vehicles x 3mo; 2 vehicles in yr 1)	7,200	10,800	10,800	10,800	10,800	50,400
Total Travel	**15,872**	**24,470**	**24,470**	**24,470**	**24,470**	**113,752**
Supplies						
Lab	2,000	1,000	1,000	1,000	1,000	6,000
Field	6,000	2,000	2,000	2,000	2,000	14,000
Total Supplies	**8,000**	**3,000**	**3,000**	**3,000**	**3,000**	**20,000**
Total Equipment	**0**	**0**	**0**	**0**	**0**	**0**
Total Contracts	**0**	**0**	**0**	**0**	**0**	**0**
Total Agreements	**0**	**0**	**0**	**0**	**0**	**0**
Publication and Technology Transfer	**0**	**0**	**0**	**0**	**0**	**0**
Total Direct Costs	**79,044**	**179,025**	**186,583**	**194,665**	**203,473**	**842,789**
Indirect Costs (17.5%)	**13,833**	**31,329**	**32,652**	**34,066**	**35,608**	**147,488**
Funding Requested	**92,877**	**210,354**	**219,235**	**228,731**	**239,081**	**990,278**

Forest Service - PNW - La Grande

	FY05	FY06	FY07	FY08	FY09	TOTAL
Salary and Benefits						
Network Database Manager						
Salary	0	5,750	8,050	0	0	13,800
Benefits	0	2,013	2,818	0	0	4,830
Lab Fees	0	3,300	4,400	0	0	7,700
Total Salary and Benefits	**0**	**11,063**	**15,268**	**0**	**0**	**26,330**
Travel						
Travel for Wildlife Co-PI	2,000	2,000	2,000	2,000	2,000	10,000
Total Travel	**2,000**	**2,000**	**2,000**	**2,000**	**2,000**	**10,000**
Total Supplies	**0**	**0**	**0**	**0**	**0**	**0**
Total Equipment	**0**	**0**	**0**	**0**	**0**	**0**
Total Contracts	**0**	**0**	**0**	**0**	**0**	**0**
Total Agreements	**0**	**0**	**0**	**0**	**0**	**0**
Publications and Tech Transfer	**6,000**	**6,000**	**0**	**0**	**0**	**12,000**
Total Direct Costs	**8,000**	**19,063**	**17,268**	**2,000**	**2,000**	**48,330**
Indirect Costs (11%)	**880**	**2,097**	**1,899**	**220**	**220**	**5,316**
Funding Requested	**8,880**	**21,159**	**19,167**	**2,220**	**2,220**	**53,646**

Agricultural Research Service – Boise

	FY05	FY06	FY07	FY08	FY09	TOTAL
Salary and Benefits						
Research Assistants	0	20,000	20,000	20,000	20,000	80,000
Technicians (e.g. field help)						0
Field Crew Leaders (GS7)	44,115	46,952	49,920	53,024	54,614	248,625
Integrated Field Crew (GS4)	0	76,503	78,792	81,158	83,594	320,047

Total Salary and Benefits	**44,115**	**143,455**	**148,712**	**154,182**	**158,208**	**648,672**
Travel						
Principle Investigator	4,000	4,000	4,000	4,000	4,000	20,000
Technical Assistants – camping	4,500	12,500	12,500	12,500	12,500	54,500
Vehicles						
3/4 ton Pick-up	6,500	6,500	6,500	6,500	6,500	32,500
3/4 ton Suburban		6,500	6,500	6,500	6,500	26,000
3000+ gal. Water Truck		13,600	13,600	13,600	13,600	54,400
Total Travel	**15,000**	**43,100**	**43,100**	**43,100**	**43,100**	**187,400**
Non-expendable Equipment						
2-Rainfall/rill simulators	76,000	0	0	0	0	76,000
Field computers for data entry	4,000	0	0	0	0	4,000
Camping equipment	2,000	0	0	0	0	2,000
Total Equipment	**82,000**	**0**	**0**	**0**	**0**	**82,000**
Supplies						
Lab	1,200	2,000	2,000	2,000	2,000	9,200
Field	2,000	2,000	2,000	2,000	2,000	10,000
Total Supplies	**3,200**	**4,000**	**4,000**	**4,000**	**4,000**	**19,200**
Total Contracts	**0**	**0**	**0**	**0**	**0**	**0**
Total Agreements	**0**	**0**	**0**	**0**	**0**	**0**
Publication and Technology Transfer	**0**	**0**	**0**	**0**	**5,000**	**5,000**
Total Direct Costs	**144,315**	**190,555**	**195,812**	**201,282**	**210,308**	**942,272**
Indirect Costs (10%)	**14,432**	**19,056**	**19,581**	**20,128**	**21,031**	**94,227**
Funding Requested	**158,747**	**209,611**	**215,393**	**221,410**	**231,339**	**1,036,500**

US Geological Survey – Boise

	FY05	FY06	FY07	FY08	FY09	TOTAL
Salary and Benefits						
Wildlife Ecologist (GS-12 Post-Doc)						
Salary	30,288	62,999	65,519	68,140	70,865	297,811
Benefits (35%)	10,601	22,050	22,932	23,849	24,803	104,234
3 Field Crew Leaders (GS-7)	0	35,515	36,936	38,413	39,949	150,813
3 - 3 Person Field Crews (GS-5)	0	62,030	64,512	67,092	69,776	263,410
Temp Benefits (17%)	0	16,583	17,246	17,936	18,653	70,418
Total Salary and Benefits	**40,889**	**199,177**	**207,144**	**215,430**	**224,047**	**886,686**
Travel						
Wildlife Ecologist	2,000	2,500	2,500	2,500	2,500	12,000
Knick	2,000	2,000	2,000	2,000	2,000	10,000
Field Crews						
Field Per Diem	1,000	21,060	21,060	21,060	21,060	85,240
Vehicles	1,382	4,800	4,992	5,192	5,399	21,765
Mileage	1,050	4,200	4,368	4,543	4,724	18,885
Total Travel	**7,432**	**34,560**	**34,920**	**35,294**	**35,684**	**147,890**
Supplies						
Mist nets, bird bands, isotope analysis	25,000	35,000	35,000	25,000	25,000	145,000
Total supplies	**25,000**	**35,000**	**35,000**	**25,000**	**25,000**	**145,000**
Non-expendable Equipment						
Field Camping Equipment	2,500	3,000	1,000	1,000	1,000	8,500
Computers, GPS, Misc. Equipment	10,000	5,000	3,000	1,000	1,000	20,000
Total Equipment	**12,500**	**8,000**	**4,000**	**2,000**	**2,000**	**28,500**
Total Direct Costs	**85,821**	**276,737**	**281,064**	**277,724**	**286,730**	**1,208,076**

Indirect Costs (15%)	**12,873**	**41,511**	**42,160**	**41,659**	**43,010**	**181,211**
Funding Requested	**98,694**	**318,247**	**323,223**	**319,383**	**329,740**	**1,389,287**

US Geological Survey – Corvallis

	FY05	FY06	FY07	FY08	FY09	Total
Salary and Benefits						
Snake Riv. Site Mgr (GS-9)	20,441	42,246	44,358	46,576	48,905	202,526
Benefits	6,950	14,364	15,082	15,836	16,628	68,859
Technicians (GS-5)	6,563	92,006	96,606	101,437	106,509	403,120
Benefits	853	11,961	12,559	13,187	13,846	52,406
Total Salary and Benefits	**34,807**	**160,576**	**168,605**	**177,035**	**185,887**	**726,911**
Travel						
Vehicles						
GSA lease	1,692	7,106	7,462	7,835	8,227	32,321
Mileage	2,360	8,515	8,705	9,200	9,400	38,180
Principle Investigator	1,500	1,500	1,500	1,500	1,500	7,500
Site Manager	1,525	2,050	2,050	2,050	2,050	9,725
Technicians	525	6,300	6,300	6,300	6,300	25,725
Total Travel	**7,602**	**25,471**	**26,017**	**26,885**	**27,477**	**113,451**
Supplies	1,000	1,000	1,000	1,000	1,000	5,000
Cell Phone/FedEx	600	600	600	600	600	3,000
Computer Costs	1,200	1,200	1,400	1,400	1,400	6,600
Total supplies	**2,800**	**2,800**	**3,000**	**3,000**	**3,000**	**14,600**
Total Direct Costs	**45,209**	**188,848**	**197,622**	**206,920**	**216,364**	**854,962**
Indirect Costs (15% of Direct Costs)	**6,781**	**28,327**	**29,643**	**31,038**	**32,455**	**128,244**
Funding Request	**51,990**	**217,175**	**227,265**	**237,958**	**248,818**	**983,206**

Table 5. List of Contributed Costs.

Research Institution Support		2005	2006	2007	2008	2009	Total
Utah State University	Indirect Cost Waiver	$34,427	$53,698	$59,398	$63,341	$58,129	$268,993
University of Nevada - Reno	Indirect Cost Waiver	$16,509	$56,773	$65,437	$58,411	$50,694	$247,824
Brigham Young University	Salary Contribution	$13,796	$13,796	$15,296	$15,296	$15,296	$73,480
	Indirect Cost Waiver	$134,559	$72,550	$63,973	$65,180	$66,099	$402,361
University of Idaho	Indirect Cost Waiver	$15,436	$17,560	$23,488	$24,419	$18,307	$99,210
Oregon State University	Salary Contribution	$46,132	$47,188	$48,270	$49,378	$50,511	$241,479
	Indirect Cost Waiver	$76,146	$154,874	$94,099	$89,381	$91,803	$506,303
Forest Service - RMRS - Reno	Salary Contribution	$44,783	$46,575	$48,438	$50,375	$52,390	$242,561
Forest Service - PNW - La Grande	Salary Contribution	$15,000	$16,000	$17,000	$18,000	$19,000	$85,000
Agricultural Research Service - Boise	Salary Contribution	$20,000	$22,000	$24,000	$26,000	$28,000	$120,000
US Geological Survey - Boise	Salary Contribution	$43,000	$44,720	$46,509	$48,369	$50,304	$232,902
US Geological Survey - Corvallis	Salary Contribution	$5,000	$5,000	$5,000	$5,000	$5,000	$25,000
Total Research Institutions		**$464,788**	**$550,734**	**$510,908**	**$513,150**	**$505,533**	**$2,545,113**

Project Contributors		2005	2006	2007	2008	2009	Total
Dave Turner - Statistician	Salary Contribution	$5,000	$5,000	$5,000	$10,000	$20,000	$45,000
Mike Pellent - Agency Rep	Salary Contribution	$5,000	$5,000	$5,000	$5,000	$5,000	$25,000
Sherm Karl - Agency Rep	Salary Contribution	$5,000	$5,000	$5,000	$5,000	$5,000	$25,000
Total Project Contributors		**$15,000**	**$15,000**	**$15,000**	**$20,000**	**$30,000**	**$95,000**

Management Support		2005	2006	2007	2008	2009	Total
EA Preparation	Planning Staff	$112,500	$0	$0	$0	$0	$112,500
Clearances	Botany, Archeology	$600,000	$0	$0	$0	$0	$600,000
Cutting (juniper)	10 sites*$55/acre *40acres	$0	$11,000	$11,000	$0	$0	$22,000
Burning (juniper/cheat)	4280 acre*$45/acre	$0	$0	$67,500	$125,100	$0	$192,600
Mechanical (cheat)	1000 acres* $125/acre	$0	$0	$62,500	$62,500	$0	$125,000
Total Management Support		$712,500	$11,000	$141,000	$187,600	$0	$1,052,100
TOTAL CONTRIBUTED COSTS		**$1,192,288**	**$576,734**	**$666,908**	**$720,750**	**$535,533**	**$3,692,213**

Budget Justifications

Below are provided justifications for aspects of the budget questioned by the JFSP Governing Board in their September 2004 letter. Also included is a description of the anticipated duties of the 'Technology Transfer Specialist', to be hired through Utah State University.

• **Justification of hydrology costs**. The total *direct* cost of the hydrology effort is $942,272. The costs are broken into several categories, including salary ($648,672), travel ($187,400), equipment ($83,200), supplies ($18,000), and publications/technology transfer ($5,000). I will treat each of these line items in turn.

Salaries and Benefits: $648,672. The majority of the project cost is to fund one full time (GS-7) Crew Leader for the life of the project and a seven member field crew (GS-4) for 18 weeks each year throughout the period 2006-2009.

The first year of the project will be spent picking field sites, laying out field plots, equipment purchasing, rainfall/concentrated flow simulator fabrication, etc. The Crew Leader will complete these tasks.

A. Objective 1 (see Proposal, Appendix 2: Variables and Protocols, Hydrology section) will be accomplished in 2006 and will require data collection from 216 small rainfall simulation plots and 216 concentrated flow (rill) simulation plots over an 18-week period.

Training = 1 week for entire crew = **320** hrs

Travel time = 0.5 days each week for 18 weeks = **504** hrs

Rainfall plot installation/pre simulation data collection = 2hr-2people/plot = **864** hrs
Rainfall simulation/post simulation data collection = 2hr-3people = **1296** hrs

Rill plot installation/pre simulation data collection = 2hr-2people/plot = **864** hrs
Rill simulation/post simulation data collection = 1.5hr-3people = **972** hrs

Laboratory processing of runoff/sediment samples = 1 person full time = **720** hrs

Total work hours = 5540 hrs / 720 hrs (18 weeks) = **7.69 people**

B. Objective 2 will be accomplished in 2007 and will require data collection from 216 small rainfall simulation plots and 216 concentrated flow (rill) simulation plots over an 18-week period. The workload to accomplish this objective is identical to that for Objective 1 requiring 7.69 people for 18 weeks. The data collected under objective 1 will serve as the control for this portion of the study.

C. Objective 3 will be accomplished in 2008 and will require data collection from 108 concentrated flow simulations over four weeks.

Training = 2 day for entire crew = **128** hrs

Travel time = 0.5 days each week for 4 weeks = **128** hrs

Rill plot installation/pre simulation data collection = 2hr-2people/plot = **432** hrs
Rill simulation/post simulation data collection = 1.5hr-3people = **486** hrs

Laboratory processing of runoff/sediment samples = **60** hrs

Total work hours = 1234 hrs / 160 hrs (4 weeks) = **7.7 people**

D. Objective 4 will be accomplished in 2008 (14 weeks) and 2009 (18 weeks) over a total of 32 weeks. Data will be collected from a total of 72 large rainfall simulation plots.

   Training = 1 week for entire crew = **320** hrs

   Travel time = 0.5 days each week for 32 weeks = **1024** hrs

   Rainfall plot installation/pre simulation data collection = 40hr-2people/plot = **5760** hrs
   Rainfall simulation/post simulation data collection = 4hr-8people/plot = **2304** hrs

   Laboratory processing of runoff/sediment samples = **192** hrs

   Total work hours = 9600 hrs / 1280 hrs (32 weeks) = **7.5 people**

E. Objective 5 will be accomplished over the life of the project as data comes available. The Principle Investigator will complete the work with support from the Crew Leader.

The Crew Leader will spend their additional time (2006-2009) conducting laboratory analyses, data entry, data reduction, equipment maintenance, supply purchasing, etc.

<u>Travel:</u> $187,400. A large travel budget is necessary for transportation of equipment and water and for per diem since the majority of the field crew time will be in travel status.

1. Principle Investigator - travel and per diem = $20,000. This is to offset the costs associated with oversight of the fieldwork and attendance of scientific meetings, technology transfer workshops etc.
2. Field per diem – field crew = $54,400. The field crew (8 people) will be in the field for 68 weeks over the life of the project.

   68 weeks X 5 days X 8 people = 2720 days

   2720 days X $20/day = $54,400
3. A minimum of a pick-up and a suburban are needed to haul the field crew and equipment throughout the life of the project (GSA cost = $58,500). The cost is based on what we currently pay GSA to lease such vehicles. Since our location is such a small user of GSA vehicles, GSA does not allow us seasonal leases. If we turn in a vehicle we may or may not get another vehicle when we request it.
4. A large water truck is necessary to meet the water use requirements of the project (GSA cost = $54,500). Our location has one large water truck we will use, but an additional truck is also required. At times, this project will require over 10,000 gallons of high quality water per day. To meet this requirement we commonly have to haul water long distances.

<u>Non-expendable Equipment</u>: $83,200. Our location currently has one large plot rainfall simulator, one small plot simulator and one concentrated flow simulator to allocate to this project. To accomplish the objectives of this project in the time allotted two additional small plot simulators and two concentrated flow simulators will be required. The costs shown are for parts only. Our location will provide the electronics support for assembly and data logger programming. Our location will provide one utility trailer to aid the transport of equipment. An additional trailer is needed to transport additional simulators etc.

<u>Supplies</u>: $18,000. Minimal supplies are needed to support data collection in the field and sample processing in the laboratory. A number a pieces of equipment such as pumps and generators must be serviced at least once a year.

Publication and Technology Transfer: $5,000. To offset the pages charges for publications, printing charges for poster presentations etc.

• **Justification of Wildlife Costs.** The total *direct* cost of the wildlife effort is $1,834,017, of which 81% (Sum of three line items in wildlife budget: Salary and Benefits + Agreements + Lab Fees Line Item = $1,481,349) is a consequence of salary and wages. Other costs include travel ($174,524), Supplies ($66,400), and Equipment ($111,743). A total of 93% of these costs is related to the field research effort; just 7% has been budgeted for analysis (a portion of the time of Insect Ecologist {McIver), and GS-12 Wildlife Ecologist) with most of the analysis and outreach effort being picked up through contributed costs (Steve Knick and Mike Wisdom).

The measurement of bird responses (population survival and productivity, species richness, density, and the insect food resources) to the fire and fire surrogate treatments in the sagebrush biome are costly for four related reasons:

1. Estimates of survival and productivity of bird species require intensive sampling of each species over many years. Achieving sufficient sample sizes to detect potential changes in survival and productivity in response to land use treatments is particularly challenging, in that the majority of individuals of a species must be captured, marked, and recaptured repeatedly, across years, on each treatment and control unit. Given the large size of treatment and control units (each 1,000 acres) on the sagebrush-woodland sites, the effort to conduct these mark-recapture activities requires large field crews (three 6-person crews for each summer from 2006 through 2009) who must work long hours to capture and recapture enough individuals of each of the targeted bird species (total salary of bird field crews = $517,385, supported by $167,524 in travel expenses). This level of intensive sampling is needed to achieve sufficient statistical power to detect population changes that may occur in response to the burning and mechanical treatments over time, and to ensure that such changes are not simply a reflection of background changes in climate (thus the need for these same estimates over time on the control units).

    The challenges posed by estimation of avian survival and productivity were documented recently by Bock and Jones (2004:403-410, Frontiers in Ecology and the Environment). These authors found that almost no avian habitat studies had estimated population survival, owing to the high costs, intensive effort required, and associated logistical challenges. Similarly, few studies of avian habitat had estimated productivity, again because of the high costs and intensive sampling effort required. And yet, measurements of change in survival and reproduction of birds and other vertebrates in response to environmental changes are essential in understanding the effect of land uses on these populations (Garton et al. 2001:15-42, Radio Tracking and Animal Populations, Academic Press). Moreover, estimates of species abundance or density by themselves can be highly misleading (Van Horne 1983:893-901, Journal of Wildlife Management).
2. Estimates of species richness and density during the breeding season also require large field crews to obtain sufficient sample sizes to estimate changes over time. These estimates become particularly challenging in that sampling must be done over compressed time periods of each day (early morning hours), and repeated through the breeding season. As with the estimates of survival and productivity, intensive sampling is required to achieve sufficient statistical power to detect differences over time and in response to the treatments.
3. The large geographic area over which the responses will be measured, which is necessary to provide appropriate inferences of results over the sagebrush biome, requires separate field

crews for each geographic area (Oregon-Idaho, Nevada, Utah), supervised by one individual (GS-12 Wildlife Ecologist). While sampling across such a large area may seem inefficient and unnecessary, the targeted inference space is vast. Consequently, sampling bird responses across the entire geographic area is needed to make credible inferences to the sagebrush biome. Much of the proposed travel budget is associated with support of the field crews covering this large geographic area.

4. Assessment of the how avian food resources (particularly insects) change with respect to treatment is important for identifying the mechanisms behind avian response. Field crews are necessary throughout each summer to conduct the insect sampling effort (two season Research Assistants for 2006, 2008, and 2009; total cost = $87,937). Once samples are collected, personnel are needed to sort, count, and identify individuals (.25 FTE of Insect Ecologist {McIver}and .50 FTE of one Research Assistant for 2006 through 2009; total cost = $247,765). Once again, this is labor-intensive work, and most of the budget is designed to allow processing of samples collected during the field effort.

We recognized that the necessary resources to conduct a study needed to be large in order to draw strong conclusions regarding relationships between patterns and underlying processes in bird communities and habitat change. Consequently, we elected to focus only on those sites within the sagebrush/pinyon-juniper experiment rather than invest in a reduced effort (and risk loss of statistical power) across all treatments and sites. We are also cutting costs substantially by hiring three field crews, each of which will cover one location, thus reducing persistent long-distance travel costs among locations. Field crews, both avian and entomological, will also be camping out during most of each field season, thus keeping lodging and per diem costs to a minimum.

• **Justification of fuel sampling costs.** The *direct* cost currently budgeted in the fuels assessment portion of the disciplines budget (p. 45: $250,225) will be utilized for initial coordination of fuels data collection by the field sampling crews and the analyses of those data. The costs of the fuel data collection (salary and fringe benefits of field personnel, sampling equipment, vehicles, and travel expenses) are included in the budgets for the five provinces (pp. 46-49), approximately 20% (>$400,000) of the allocated costs are for fuels data collection. We anticipate that having the field sampling crews collect all vegetation and fuel data simultaneously will be more efficient than budgeting and collecting vegetation and fuels data separately. Many of the same data will be used in the fuel, vegetation, wildlife habitat and hydrologic assessments and standardization of sampling protocols will be simplified by collecting these data with fewer field crews.

• **Primary list of duties for dedicated 'Technology Transfer Specialist'**

- Lead the production of three comprehensive 'User's Guides' for managers (one each for Western Juniper, Pinyon-Juniper, and Cheatgrass), to be produced within the first three years of the study, that would summarize in a useable form all available information currently available on predicted ecological consequences of applying alternate treatments designed to improve conditions in the sagebrush steppe biome. These "User's Guides' would be the first editions of one of the primary products the project would produce. The first edition, using currently available information, would ultimately be replaced by a second edition, using experimental data from the proposed study**. (To be accomplished by the end of 2008)**
- Assist in the production of an annotated 'Fuels Guide' for managers, that will link measured fuel loads (by size class) with measured vegetation, particularly canopy cover and annual:perennial grass production ratios. Fuels and vegetation data will be linked to site photographs into a format readily

accessible via Internet. This product will assist fire managers in making better estimates of fuel loads on sites where prescribed fire or wildland fire use is being considered. This product will be available following completion of the pre-treatment data collection in late 2006. **(To be accomplished by early 2008)**

- Managing an external website as a public information/outreach tool for managers, scientists, educators, and the general public. **(To be accomplished in Year 1).**
- Producing a newsletter, to be published three times per year, that would provide updates on the progress of the experiment and information about field tours or other outreach activities. This would be designed to serve primarily our federal agency cooperators, although other interested persons would be added to the mailing list as requested, and interested policy makers. **(To be initiated in Year 1, but may not require three editions until later in the project.)**
- Producing various short publications (brochures, fact sheets, etc.) for field tours and/or particular target audiences. **(Likely initiation in Year 3. Initial topics might include lessons learned from applying treatments, or descriptions of the range of conditions measured in pre-treatment data gathering.)**
- Coordinating with site managers to tailor field tours to audiences and assist with publicity. Because these tours will take place on public land, the communications specialist also will work closely with agency information/outreach personnel. **(Potentially could occur immediately after treatments are applied, but most work will be accomplished in years 4 and 5.)**
- Coordinating production of informational videos by serving as liaison between the investigators and video production specialists. **(Initial filming will occur immediately prior to and during treatment, with the remainder in years 4-5).**
- Assisting, where appropriate, with any editing of technical FFSSB papers that are intended for a non-scientific audience. **(Variable – mainly late in project.)**
- Maintaining a library of FFSSB technical papers, including providing web-based access to reports. **(Begins with "user's guide" and any other initial publications.)**
- Maintaining and updating, as appropriate, the FFSSB PowerPoint presentation. **(To be initiated in Year 1, with intermittent action until project termination.)**
- Assisting in the organization and coordination of a national conference to showcase results of the study. **(Years 4-5)**
- Working closely with the socio-political research team on design of outreach materials and presentation methods, as well as on evaluation of outreach approaches. **(Begins in Year 2, continuing through project termination.)**

APPENDIX 1
SITE DESCRIPTIONS

SNAKE RIVER LOCATION
(sagebrush/cheatgrass)

Craters of the Moon Site

Contact: David A. Pyke, USGS, Forest & Rangeland Ecosystem Science Center, Corvallis OR

Cooperating host agency: USDI, Bureau of Land Management, Shoshone Field Office, Craters & National Park Service, Craters of the Moon National Monument

Location: South-central Idaho, about 40 miles northeast of Shoshone ID, Craters of the Moon National Monument and Preserve

Vegetation type: Sagebrush – grassland complex: Wyoming big sagebrush, bluebunch wheatgrass, needlegrasses, Sandberg bluegrass

Total area available: 1000 - 2000 acres (possibly two sites)

Topographic range: 4700' to 6500' (1430 to 1980m)

Representative land base: Several hundred thousand acres of the eastern Snake River Plain.

Fire History: The Wyoming big sagebrush type is the driest of the sagebrush steppe communities and historically had a fire return interval of approximately 50-100 years (Whisenant 1990).

Contemporary fire hazard: The introduction of cheatgrass into the sagebrush grassland communities has increased fine fuels and reduced the fire return interval to less than 10 years

Prior work and anticipated time line: Management projects to reduce the amount of cheatgrass in these communities are being planned by the BLM and NPS for the region and are published in their recent Management Plan and Environmental Impact Statement (NPS/BLM 2004). In addition, the Nature Conservancy of Idaho and a local sheep rancher are interested in the potential for studies to investigate the use of sheep to reduce cheatgrass in restoration projects.

Level of long-term interest: During the 20 April 2004 meeting, the BLM Shoshone Field Office and the Nature Conservancy of Idaho expressed interest in participating in this study. They are currently preparing letters of support for the project.

Partnerships: This site would involve work by BLM, NPS, USGS, The Nature Conservancy and several at least 3 universities in the region (Oregon State University, University of Idaho and

Utah State University). In addition, we may involve the cooperation of a local sheep rancher in the area.

Site/Plot selection constraints: We must clear all sites through normal botanical and archeological clearances and must receive agreements to fence and remove livestock from the areas.

Treatments: All four core treatments will be installed.

5th treatment: We are considering a sheep grazing treatment.

Vale District Site

Contact: David A. Pyke, USGS, Forest & Rangeland Ecosystem Science Center, Corvallis OR

Cooperating host agency: USDI, Bureau of Land Management, Vale District Office

Location: Eastern Oregon in Malheur and Baker Counties

Vegetation type: Sagebrush – grassland complex: Wyoming big sagebrush, bluebunch wheatgrass, needlegrasses, Sandberg bluegrass

Total area available: 1000 - 2000 acres (possibly two sites)

Topographic range: 4700' to 6500' (1430 to 1980m)

Representative land base: Several hundred thousand acres of the eastern Snake River Plain.

Fire History: The Wyoming big sagebrush type is the driest of the sagebrush steppe communities and historically had a fire return interval of approximately 50-100 years (Whisenant 1990).

Contemporary fire hazard: The introduction of cheatgrass into the sagebrush grassland communities has increased fine fuels and reduced the fire return interval to less than 10 years

Prior work and anticipated time line: Management projects to reduce the amount of cheatgrass in these communities are being planned by the BLM for the region. The BLM in this area is participating with USGS and a number of other institutions on a series of studies to examine reseeding techniques for native plants on areas now dominated by cheatgrass. The BLM has several planned fuel reduction treatments planned in the next few years and is willing to modify those plans to fit this study's needs.

Level of long-term interest: During the 27 April 2004 meeting, the BLM Vale District Office expressed interest in participating in this study. They are currently preparing letters of support for the project.

Partnerships: This site would involve work by BLM, NPS, USGS, The Nature Conservancy and several at least 2 universities in the region (Oregon State University and University of Idaho).

Site/Plot selection constraints: We must clear all sites through normal botanical and archeological clearances and must receive agreements to fence and remove livestock from the areas.

Treatments: All four core treatments will be installed.

HUMBOLDT/BONNEVILLE LOCATION
(sagebrush/cheatgrass)

NW Utah and NE Nevada Sites

Contacts: Eugene Schupp, Utah State University, Logan, Utah; Bruce Roundy, Brigham Young University, Provo, Utah.

Cooperating host agencies: USDI Bureau of Land Management- Salt Lake Field Office (UT) and Elko District (NV)

Location: North-western Utah and north-eastern Nevada

Vegetation type: *Artemisia tridentate* ssp. *wyomingensis* sagebrush with bunchgrass-forb understory invaded to varying extent by cheatgrass (*Bromus tectorum*) and other exotic annual weeds.

Total area available:

Topographic range: From 4500' to 5300'

Representative land base: Over 3.5 million acres of sagebrush are at moderate to high risk of displacement by cheatgrass invasion (Wisdom and others 2003).

Fire History: As with many other sagebrush communities throughout the Great Basin, fire frequency decreased with settlement and overgrazing, but with cheatgrass invasion it has greatly increased.

Contemporary fire hazard:
Fine fuel loads from cheatgrass are increasing, greatly increasing the frequency and size of fires.

Prior work and anticipated time line: Some fuel reduction and restoration projects are currently underway and others planned. We expect to capitalize on environmental assessments associated with planned treatments.

Level of long-term interest: Because of the risk of cheatgrass invasion and wildfire, and the concern over the potential listing of sage grouse and pygmy rabbit, there is a continuing strong and ongoing concern for these lands.

Partnerships: Salt Lake Field Office and Elko District of the Bureau of Land Management, Utah State University, Brigham Young University.

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

Treatments: All core treatments will be installed.

Additional treatments: In addition to the core treatments, comparisons with other mechanical tree control methods as recommended by the particular management agency will be considered.

Thinning and burning prescriptions: 200 acre prescribed low intensity fire, 200 acre harrow treatment (50% sagebrush kill), 200 acre tebuthiuron (50% sagebrush kill).

HIGH DESERT LOCATION
(sagebrush/western juniper)

Steens Mountain Site

Contact: Rick Miller, Oregon State University, Corvallis, OR

Cooperating host agency: USDI Bureau of Land Management, Burns District

Location: Harney County, OR

Vegetation type: Mountain big sagebrush with encroaching western juniper woodland

Total area available: 2000+ acres

Topographic Range: 4500' to 6000'

Representative land base: Over several million acres in eastern Oregon, northeastern California, southwestern Idaho, and northwestern Nevada.

Fire History: The majority of the mountain big sagebrush alliance burned with frequent to moderately frequent (10-70 years) low intensity to mixed severity fires (Miller and Tausch 2001). Prior to the 1900s, fires maintained plant composition and structure within the historic natural range of variability, which varied from grasslands to shrub steppe grasslands. Woodland invasion into these communities suggests the majority of these communities have not burned since the late 1800s.

Contemporary fire hazard: As woodlands gain dominance the fire regime shifts to infrequent high intensity fires. Fuel loads, which are estimated to be around 6,000 to 10,000lb/ac in shrub steppe communities, increases over 4 fold in closed invasive woodlands (Johnson and Miller 2004).

Prior work and anticipated time line: Several projects are completed or near completion in western juniper on the Steens Mountain that have evaluated the (1) rates, timing, and extent of woodland encroachment, (2) the effects of increasing woodland dominance on understory vegetation, (3) changes in fuel loads resulting from woodland encroachment into shrub steppe, and (4) impacts of woodland encroachment on avian populations (Miller and Rose 1995, 1999, Miller et al. 2000). Environmental analyses are currently being conducted. We expect to select project locations during the summer of 2005 and initiate measurements during the spring of 2006 and initiate treatments in the late summer and fall of 2006.

Level of long-term interest: The Burns BLM district has been actively treating western juniper during the past 10 years. Their long term management plan includes a continued active program of juniper control to maintain or restore sagebrush grassland communities, decrease potential soil erosion, and to maintain and restore habitat for sagebrush obligate species. However, their management activities have been questioned in several areas including; (1) are the best management practices being used and (2) are management goals being met. These questions are difficult to answer due to a current lack of monitoring.

Partnerships: Oregon State University and Burns BLM, with possible involvement with the Oregon Department of Fish and Wildlife, and US Fish and Wildlife.

Site/Plot selection constraints: No

Treatments: All three core treatments

Lakeview Site

Contact: Rick Miller, Oregon State University, Corvallis, OR

Cooperating host agency: USDI Bureau of Land Management, Lakeview district

Location: Lake County, OR

Vegetation type: Mountain big sagebrush with encroaching western juniper woodland

Total area available: 2000+ acres

Topographic Range: 4500' to 6000'

Representative land base: **O**ver several million acres in eastern Oregon, northeastern California, southwestern Idaho, and northwestern Nevada.

Fire History: The majority of the mountain big sagebrush alliance burned with frequent to moderately frequent (10-70 years) low intensity to mixed severity fires (Miller and Tausch 2001). Prior to the 1900s, fires maintained plant composition and structure within the historic natural range of variability, which varied from grasslands to shrub steppe grasslands. Woodland invasion into these communities suggests the majority of these communities have not burned since the late 1800s.

Contemporary fire hazard: As woodlands gain dominance the fire regime shifts to infrequent high intensity fires. Fuel loads, which are estimated to be around 6,000 to 10,000lb/ac in shrub steppe communities, increases over 4 fold in closed invasive woodlands (Johnson and Miller 2004).

Prior work and anticipated time line: Several projects are near completion at this location that evaluated; (1) the rates, timing, and extent of woodland encroachment, (2) the effects of increasing woodland dominance on understory vegetation, and (3) changes in fuel loads resulting from woodland encroachment into shrub steppe. Environmental analyses are currently being conducted. We expect to select project locations during the summer of 2005 and initiate measurements during the spring of 2006 and initiate treatments in the late summer and fall of 2006.

Level of long-term interest: The Lakeview BLM District has been actively treating western juniper during the past 10 years. Their long term management plan includes a continued active program of juniper control to maintain or restore sagebrush grassland communities, decrease potential soil erosion, and to maintain and restore habitat for sagebrush obligate species. However, their management activities have been questioned in several areas including; (1) are the best management practices being used and (2) are management goals being met. These questions are difficult to answer due to a current lack of monitoring.

Partnerships: Oregon State University and Lakeview BLM, with possible involvement with the Oregon Department of Fish and Wildlife and US Fish and Wildlife.

Site/Plot selection constraints: No

Treatments: All three core treatments

Owyhee Site

Contact: Rick Miller, Oregon State University, Corvallis, OR

Cooperating host agency: USDI Bureau of Land Management, Boise District

Location: Juniper and South Mountain, Owyhee County, Idaho

Vegetation type: Mountain big sagebrush with encroaching western juniper woodland

Total area available: 2000+ acres

Topographic Range: 4500' to 6000'

Representative land base: **O**ver several million acres in eastern Oregon, northeastern California, southwestern Idaho, and northwestern Nevada.

Fire History: The majority of the mountain big sagebrush alliance burned with frequent to moderately frequent (10-70 years) low intensity to mixed severity fires (Miller and Tausch 2001). Prior to the 1900s, fires maintained plant composition and structure within the historic natural range of variability, which varied from grasslands to shrub steppe grasslands. Woodland invasion into these communities suggests the majority of these communities have not burned since the late 1800s.

Contemporary fire hazard: As woodlands gain dominance the fire regime shifts to infrequent high intensity fires. Fuel loads, which are estimated to be around 6,000 to 10,000lb/ac in shrub steppe communities, increases over 4 fold in closed invasive woodlands (Johnson and Miller 2004).

Prior work and anticipated time line: Several projects are near completion at this location that evaluated; (1) the rates, timing, and extent of woodland encroachment, (2) the effects of increasing woodland dominance on understory vegetation, and (3) changes in fuel loads resulting from woodland encroachment into shrub steppe. Environmental analyses are currently being conducted. We expect to select project locations during the summer of 2005 and initiate measurements during the spring of 2006 and initiate treatments in the late summer and fall of 2006.

Level of long-term interest: The Boise BLM district has conducted limited western juniper treatment in this region. There has been considerable resistance from concerned citizens in the Boise area. The district is currently developing a long term western juniper management plan in attempt to restore shrub steppe communities and maintain old growth juniper. They have a strong commitment to work closely with the research group. The Boise district would greatly benefit from the intensive monitoring, data gathering, treatment evaluation, and workshops with both federal and state biologists and private citizens that would result from the Joint Fire Science Project.

Partnerships: Oregon State University and Boise BLM, with possible involvement with the Idaho Department of Fish and Wildlife.

Site/Plot selection constraints: No

Treatments: All three core treatments

BONNEVILLE LOCATION
(sagebrush/Utah juniper-single needle pinyon)

NW Utah, Central Utah, South Central Utah Sites

Contacts: Bruce Roundy, Brigham Young University, Provo, Utah; Eugene Schupp, Utah State University, Logan, Utah.

Cooperating host agencies: USDA Forest Service, Wasatch-Cache National Forest; USDI Bureau of Land Management- Salt Lake, Fillmore, and Cedar City Field Offices

Location: North-western, Central, and South-central Utah

Vegetation Type: Utah juniper, Utah juniper- one and two needle pinyon, with sagebrush/bunchgrass understory

Total area available: 6,000 to 7,000 acres

Topographic range: From 4800' to 6000'

Representative land base: Over 1.2 million acres of sagebrush at moderate or high risk to displacement by tree invasion (Wisdom and others 2003).

Fire History: As with other pinyon-juniper communities throughout the Great Basin, fire frequency decreased with settlement, allowing invasion on sagebrush sites.

Contemporary fire hazard: Fuel loads from tree growth on invasion sites are increasing (Tausch and others 2004). Regrowth from old chainings is also increasing risk of wildfire. Over 240,000 acres have burned since 1994 (Wisdom and others 2003).

Prior work and anticipated time line: Many fuel reduction projects are currently underway and many others planned. We expect to capitalize on environmental assessments and planned fuel-treatment projects.

Level of long-term interest: Because of the risk of cheatgrass invasion after tree invasion and wildfire, there is a continuing strong and ongoing concern for these lands.

Partnerships: Wasatch-Cache National Forest; Salt Lake, Fillmore, and Cedar City Field Offices of the Bureau of Land Management, Utah State University, Brigham Young University, Forest Service Shrub Sciences Laboratory, USDA/ARS Northwest Watershed Research Unit.

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

Treatments: All core treatments will be installed.

Additional treatments: In addition to the core treatments, comparisons with tree-chipping (Bulhog) and other mechanical tree control methods as recommended by the particular management agency will be considered.

Thinning and burning prescriptions: 1000 acre prescribed fire, 25-50 acre hand clearcut areas to ½ m in height, cut and left on contour.

HIGH CALCAREOUS LOCATION
(sagebrush/single needle pinyon - Utah juniper)

Robinson's Summit Site

Contact: Robin J. Tausch, USDA Forest Service, Rocky Mountain Research Station, Reno, NV

Cooperating host agency: USDI, Bureau of Land Management, Ely Field Office, 702 North Industrial Way, HC33 Box 33500, Ely, NV 89301-9408. 775-289-1800

Location: East-central Nevada about 20 miles west of Ely, Nevada north of Highway 50 just west of Robinson's Summit and along the east side of 30 Mile Road.

Vegetation type: Single needle pinyon/Utah juniper woodland and associated Vasey big sagbrush community: Vasey big sagebrush, bluebunch wheatgrass, needlegrasses, Sandberg bluegrass

Total area available: 1000 - 2000 acres

Topographic range: 7200' to 7600' (2195m to 2317m)

Representative land base: This site is representative of vast acreages in both the High Central and the High Calcareous Provinces.

Fire History: Sagebrush ecosystems and associated pinyon-juniper woodlands in this region historically had a fire return interval of approximately 30-40 years (Miller and Tausch 2002).

Contemporary fire hazard: Expansion of the woodlands and progressive canopy closure are resulting in increased fuel loads and significantly increasing the risk of catastrophic fire in these ecosystems. Both woody and herbaceous species in the associated sagebrush communities are being eliminated by woodland expansion, exacerbated by conversion to invasive annual species, primarily cheatgrass, following fire.

Prior work and anticipated time line: Management projects to reduce the amount of pinyon and juniper in sagebrush communities in this area of the Great Basin are being planned by the BLM, forest Service, and the Eastern Nevada Landscape Coalition.

Level of long-term interest: The BLM, the Forest Service, the Eastern Nevada Landscape Coalition, and the Nature Conservancy have expressed interest in participating in this study. The BLM Ely Field Office has prepared a letter of support for the project.

Partnerships: This site would involve work by BLM, RMRS, The Nature Conservancy and at least 2 universities in the region (University of Nevada, Reno and Utah State University). In addition, the Eastern Nevada Landscape Coalition is very interested in these types of projects and would be an active partner

Site/Plot selection constraints: The botanical and archeological clearances have been performed for this site. Discussions are underway for agreements to fence and remove livestock from the treated 9areas.

Treatments: All three core treatments will be installed. The site would be used for a 1,000 acre burn treatment.

5th treatment: None are being considered currently.

Seven Mile Site

Contact: Robin J. Tausch, USDA Forest Service, Rocky Mountain Research Station, Reno, NV

Cooperating host agency: USDI, Bureau of Land Management, Battle Mountain Field Office, 50 Bastian road, Battle Mountain, NV 89820-1420, 775-635-4000

Location: West of Eureka, NV at the south end of Antelope Valley, 30 miles south of Highway 50 in the area between the Antelope Range and the Monitor Range.

Vegetation type: Single needle pinyon/Utah juniper woodland and associated Vasey big sagbrush community: Vasey big sagebrush, bluebunch wheatgrass, needlegrasses, Sandberg bluegrass

Total area available: 1000 - 3000 acres

Topographic range: 7200' to 7600' (2195m to 2317m)

Representative land base: This site is representative of vast acreages in the High Central Province.

Fire History: Pinyon-juniper woodlands in this region historically had a fire return interval of approximately 30-50 years (Miller and Tausch 2002).

Contemporary fire hazard: Expansion of the woodlands and progressive canopy closure are resulting in increased fuel loads and significantly increasing the risk of catastrophic fire in these ecosystems. Both woody and herbaceous species in the associated sagebrush communities are being eliminated by woodland expansion, exacerbated by conversion to invasive annual species, primarily cheatgrass, following fire.

Prior work and anticipated time line: Management projects to reduce the amount of pinyon and juniper in sagebrush communities in this area of the Great Basin are being planned by the BLM and the Forest Service.

Level of long-term interest: The BLM, the Forest Service, and the Nature Conservancy have expressed interest in participating in this study. The BLM Battle Mountain Field Office is currently preparing a letter of support for the project work at this site.

Partnerships: This site would involve work by BLM, RMRS, and at least 2 universities in the region (University of Nevada, Reno and Utah State University). In addition, the Nature Conservancy is very interested in these types of projects and could potentially be an active partner.

Site/Plot selection constraints: Planning is underway for the botanical and archeological clearances for this site, and agreements to fence and remove livestock from the areas are being pursued.

Treatments: All three core treatments will be installed. The site would be used for a 1,000 acre burn treatment.

5th treatment: None are being considered currently.

Spruce Mountain Site

Contact: Robin J. Tausch, USDA Forest Service, Rocky Mountain Research Station, Reno, NV

Cooperating host agency: USDI Bureau of Land Management, ELKO Field Office, 3900 E. Idaho Street, Elko, NV 89801-4611. 775-753-0200

Location: East of Highway 93 about 40 miles south of Wells, Nevada in the area between Spruce Mountain and the Pequop Range.

Vegetation type: Single needle pinyon/Utah juniper woodland and associated Vasey big sagbrush community: Vasey big sagebrush, bluebunch wheatgrass, needlegrasses, Sandberg bluegrass

Total area available: 1000 - 3000 acres

Topographic range: 7200' to 7600' (2195m to 2317m)

Representative land base: This site is representative of vast acreages in the High Calcareous Provinces.

Fire History: Pinyon-juniper woodlands in this region historically had a fire return interval of approximately 30-50 years (Miller and Tausch 2002).

Contemporary fire hazard: Expansion of the woodlands and progressive canopy closure are resulting in increased fuel loads and significantly increasing the risk of catastrophic fire in these ecosystems. Both woody and herbaceous species in the associated sagebrush communities are being eliminated by woodland expansion, exacerbated by conversion to invasive annual species, primarily cheatgrass, following fire.

Prior work and anticipated time line: Management projects to reduce the amount of pinyon and juniper in sagebrush communities in this area of the Great Basin are being planned by the BLM, the Forest Service, the Eastern Nevada Landscape Coalition, and the Nature Conservancy.

Level of long-term interest: The BLM, the Forest Service, the Eastern Nevada Landscape Coalition, the Nature Conservancy have expressed interest in participating in this study. The BLM Elko Field Office has prepared a letter of support for the project.

Partnerships: This site would involve work by BLM, RMRS, The Nature Conservancy and at least 2 universities in the region (University of Nevada, Reno and Utah State University). In addition, the Eastern Nevada Landscape Coalition is very interested in these types of projects and would be an active partner.

Site/Plot selection constraints: Planning is underway for the botanical and archeological clearances for this site, and agreements to fence and remove livestock from the areas are being pursued.

Treatments: All three core treatments will be installed. The site would be used for a 1,000 acre burn treatment.

5th treatment: None are being considered currently.

APPENDIX 2

Core Variables and Protocols

The goal of this project is to establish a network of research sites in the sagebrush steppe in which the ecological, sociological, and economic consequences of different fire and fire surrogate treatments will be determined. For such a network to function in a manner that facilitates cross-ecosystem, inter-disciplinary research, a common set of core variables must be measured at each site using common sampling protocols. In this appendix, we review the project's basic experimental design, list and justify the core variables to be measured in each of the six disciplinary areas, and provide general protocols for their measurement. More detailed protocols (sufficient for the development of study plans) will be written in the first year of the study.

Study Design and Site Characterization

For the Woodland Network, each research site will have three core treatment plots (25 to 50 ac). Sites with large-scale treatments (1,000 ac) will have multiple extensive plots that will be located within each treatment using a stratified random approach. Twenty, 0.1 ha subplots (30 m x 33 m) will be centered on systematically placed grid-points within each core and extensive plot.

For the Cheatgrass Network, each research site will have four, 200 ac core treatment plots. Forty, 0.1 ha square subplots (30 m x 33 m) will be centered on systematically placed grid points within each of the four, core treatment plots. Using a stratified random approach, twenty of the subplots will be selected to receive the preemergent herbicide treatment and twenty will be chosen to serve as controls.

Sampling protocols will be similar for the Woodland and Cheatgrass Networks. For each of the core and extensive plots, the corners will be permanently marked, UTMs recorded, and the 1:24000 quad map listed. Information collected for each subplot will include: elevation, aspect, slope, topographic position, microtopography (concave, convex, flat), plant association (if known), current vegetation (dominant species in each vegetation layer, and soils (mapping unit).

Within each of the core and extensive plots, all of the 0.1 ha subplots will be marked in the center of the subplot (i.e. at the grid point) with a steel fencepost, and the position of the fencepost will be GPSed. Three parallel transects (30 m) will be permanently located within each of the subplots. Sampling will be conducted along the permanent transects prior to treatment and for at least three years after treatment. The variables and sampling protocols are described below:

Vegetation/Fuels

Vegetation measurements will be recorded in both the core treatment plots and operational-scale burn plots across the range of ecological states defined by soil characteristics and plant species composition. The primary goals are to identify the influence of vegetation structure and composition on threshold crossings, and the interacting effects of changes in vegetation and soils on hydrology and wildlife. Several vegetation response variables can be used to indicate threshold crossings that require changes in management strategies. For example: (1) a change in fuel characteristics can result in altered fire regimes and necessitate different fire management approaches; (2) a decrease in understory perennial herbaceous vegetation can alter the recovery potential of a site necessitating revegetation; and (3) high population densities of invasive plants before fire or fire surrogate treatments can result in conversion of the site to the invasive necessitating both herbicide treatments and revegetation. Knowledge of the response of these and other important vegetation variables can be used to define the most appropriate sample variable or combination of variables for determining the effects of management treatments. Information on the combined responses of the vegetation, soils, hydrologic and wildlife variables will insure that decisions are based on the full suite of ecosystems variables likely to respond to fire and fire surrogate treatments.

Trees. All trees > 1.0 (or >.05) m in height that are rooted within each 30 x 33 m subplot will be measured. Measurements include height, crown base height, basal diameter, longest and perpendicular crown diameters, and crown diameters falling within the plot. Tree density, canopy cover, and fuel loads will be calculated from these measurements. The litter layer depth will be sampled beneath the trees to determine fuel loads. A litter sample will be collected in an 0.25 m^2 quadrat at the inner, mid, and outer canopy zones. Samples will be dried and weighed. Total juniper litter biomass/tree will be estimated by calculating the area of each zone and the biomass per unit area measured from the juniper litter sample.

Shrubs. Shrub canopy cover will be measured and shrub density will be recorded in each extensive 30 x 33 m subplot for the Woodland Network using the line intercept technique along the 3, 30 m transects. Density of trees < ½ m in height also will be counted in the 2 x 30 m subplots. In the 20 subplots located within the core plots for the Woodland and Cheatgrass Networks, shrubs will be measured along one belt transect (2 x 30 m). Elliptical crown diameter and maximum height measurements will be obtained for each shrub by species to estimate crown area, crown height percent cover, and shrub biomass (for fuel loads). Litter beneath 10 representative shrubs will be collected to estimate fuel loads.

Herbaceous Species. The herbaceous species will be evaluated in each extensive and core plot. Nested frequency by species will be evaluated in 0.025, 0.25, and 0.5 m^2 nested quadrats located at 2-m increments along each of the three, 30-m transects. Ground cover and vegetation cover by species or functional group will be estimated in 0.25-m^2 quadrats located at 2-m increments along each 30-m transect. Functional groups include: deep rooted perennial grasses, shallow rooted perennial grasses (*Poa* sp.), annual grasses (exotics), perennial forbs, and annual forbs. Ground cover includes vegetation, cryptogamic crusts, litter, bare ground, and rock. Density of deep rooted perennial grasses will be recorded in 0.5 m^2 quadrats located at 2-m increments along each 30-m transect.

Fuels. Live and dead herbaceous fuel loads will be estimated along one 30-m transect parallel to the above transects to be used for destructive sampling. Quadrats ($0.25m^2$) will be located at 2-m increments along the transect. Average height of the herbaceous layer will be estimated. Herbaceous biomass will be clipped to 1-cm height, separated into live and previous years' dead components, and weighed. Biomass samples (>100 g) from 2 quadrats will be saved to be oven dried on order to convert the field wet weight values to dry weight.

Down dead wood fuels will be estimated utilizing the planar intercept method (Brown 1974, Brown et al. 1982). A randomly selected 10-m segment (0-10, 10-20 or 20-30 m) of each 30-m transect used to sample the herbaceous component will be utilized. Intersecting down wood fuel material will be separated into 4 size classes (1-hr, 10-hr, 100-hr and 1000-hr) and tallied along each 10-m segment.

Crown bulk density data for pinyon and juniper are being derived in studies that are currently being conducted by project investigators (R. Tausch and R. Miller). Crown bulk density estimates from this research will be utilized in this research.

Soils

The major goal of the soil-sampling program will be to provide enough descriptive information on site conditions to help explain some of the variation in vegetation responses to treatments within and across the sites. A secondary goal is to directly evaluate the response of soils to treatments.

Soil Pits for site descriptions. Descriptions of the soils at each site and within each proposed plot will be completed prior to the implementation of treatments. These descriptions are designed to provide average soil variables to help explain variation in treatment effects across the sites. We propose to dig between 4 soil pits per plot for each PJ treatment plot and 3 soil pits per plot for each Sagebrush treatment plot. The pits will be located so as to represent typical site conditions. Assuming 12 PJ and 12 Sagebrush sites, this will mean a total of 144 soil pits per vegetation type (12 sites x 3 treatments/site x 4 pits per treatment plot for PJ, 12 sites x 4 treatments x 3 pits per site for SB). Soil pits will be about 1 m^2 and extend to lithic contact or 1 m whichever is deeper. At each soil pit, features such as geomorphic setting, slope, and aspect will be recorded. Soils will be field described and sampled by horizon using established protocols (Schoeneberger et al., 2002). Critical soil properties described for each horizon will include: color, structure, consistency, root abundance and architecture, coarse-fragment abundance, texture, presence, bulk density, and any special features. Samples of all horizons will be bulked and returned to the laboratory, dried, and sieved to < 2-mm for further chemical and physical characterization including: 1) particle size distribution (clays will be saved for possible x-ray diffraction analysis), total N and C, pH, acetate-extractable cations, bicarbonate-extractable P, saturation-extractable cations and anions, calcium carbonate content (when appropriate), and DTPA-extractable metals. Standard protocols will be used for all analyses.

*Soil responses to treatments***.** The goals of this sampling are to describe how soil characteristics might respond to the vegetation manipulations in the proposed research. These samples will be taken at a much finer spatial scale than the soil pits and will represent a time sequence. We will sample one surface (0-20 cm) core from 10 of the subplots that are being monitored for vegetation response in each of the treatment plots at each site. Samples will be taken the year before, immediately after and 2 years after treatment implementation. For the PJ study, this will entail a total of 15 x 3 (plots/site) x 12 (sites) samples at each of the three sampling dates (=540 cores per time point). For the sagebrush study, we will sample 10 of the twenty subplots from the main 4 treatments (control, burn, roller-harrow, tebuthiron) and 10 from the twenty subplots within each main plot that are receiving the 'nested' Plateau treatment (20 cores/plot x 4 trt plots/site x 12 sites = 960 samples per time point). The soil cores will be returned to the laboratory, homogenized, and analyzed for KCl-extractable nitrate and ammonium, organic carbon, phosphatase and amidase enzymes activities, and potential mineralizeable nitrogen. All data will be recalculated to an oven-dry basis. At the same time that cores are taken, we will install ion exchange resin capsules that will remain in the field for two months. These will be used as a time-averaged relative index of N availability among treatments. Phosphatase and amidase activities proxy for rate controlling steps in the mineralization of P and N, respectively and will be measured as outlined by Tabatabai (1994). Potential mineralizeable nitrogen will be measured with a standard aerobic laboratory incubation on moistened soils over a 28 day period (Robertson et al. 1999). Organic carbon will be measured by dichromate digestion (Nelson and Sommers, 1982). We use 40 mL of 1N HCl with 1 hour of shaking to extract sorbed ions from resin capsules. Ammonium, nitrate and phosphate will be measured on a Lachat autoanalyzer using an appropriate module. We will also quantify sorbed Fe, Mn, Zn, Cu, Na, and K on resin capsules using atomic adsorption/emission spectroscopy.

Soil Water Availability. This is an critical variable to measure, because variation in soil water availability will very likely contribute to variation in vegetation response. The following questions will be addressed with information on soil water availability:

1) What are the effects of increasing tree dominance and loss of understory in Pinyon-Juniper, or of decreasing understory perennial species in sagebrush, on soil water availability?
2) Are there soil water availability thresholds that correlate with vegetation thresholds?
3) What are the effects of vegetation disturbance for different suspected understory theresholds on soil water availability?
4) What are the available water/soil temperature conditions that affect recovery of desirable species versus weed invasion?

We will install gypsum blocks at a number of stations throughout our network to measure soil water availability. Gypsum blocks will measure whether soils are wet or dry to about -1.5 MPa. Although plants take up water below that water potential, at -1.5 MPa hydraulic conductivity is extremely low and the loss of a litter more water results in a great decrease in matric potential, so gypsum blocks can indicate resource availability in relation to plant and soil nutrient data. One can also use microloggers to monitor blocks continuously at many different sites. We will measure 15-16 gypsum blocks and 15-16 soil temperature thermocouples at each station in the network. We will measure either 4 depths x 4 subsamples, or 5 depths x 3 subsamples. Each station would thus cost $3,000, including software and other equipment needed for each location, to communicate with the data-loggers and download and handle data (not including the cost of a laptop). We will install Blocks at two PJ and two Sage locations, which will be sufficient to provide an unprecedented level of information.

Hydrology/Erosion

Variations in infiltration, runoff and erosion on a site are closely correlated with variations in vegetation and surface soil conditions (Pierson et al. 2002). Therefore, the hydrology/erosion portion of this experiment will quantify the relationships between changes in overstory and understory vegetation and ground cover and hydrologic/erosion processes. Emphasis will be on determining if critical thresholds exist in vegetation and ground cover that significantly influence hillslope hydrology and erosion and how management treatments may influence such thresholds. We will focus on the pinyon-juniper zone due to limited understanding of hydrologic processes and the hydrologic effects of tree control treatments in this zone (Roundy and Vernon 1999, Wilcox 2002). Hydrology/erosion work will be conducted on the 1000-acre control and fire units and on specific hillslopes where all junipers have been cross-felled on the slope.

Hydrology/erosion objectives are as follows:

1. Identify thresholds for increased runoff and erosion along the gradient of increasing juniper overstory dominance and the associated decline in understory vegetation.
2. Quantify the impact of prescribed fire on infiltration capacity, overland flow and soil erodibility along the gradient of increasing juniper dominance and the associated decline in understory vegetation.
3. Determine the impact of cross-felled juniper trees on hillslope surface runoff and rill erosion dynamics.
4. Improve our basic understanding of the hydrologic connectivity between areas of a hillslope under juniper canopy and areas between tree canopies.
5. Develop parameter data sets to expand the applicability of the Erosion Risk Management Tool (ERMiT – currently funded by the Joint Fire Sciences Program) to cover juniper management scenarios studied as part of this grant proposal.

Specific core variables and protocols.

Small-plot rainfall simulation procedures will be used to examine variations in infiltration capacity and interrill erosion before and after prescribed fire along a gradient of juniper overstory dominance and associated decrease in understory vegetation and ground cover. Methods will be similar to those successfully used in previous work funded by the Joint Fire Sciences Program (Pierson et al. 2001). Sampling along the gradient will be stratified based on percent ground cover to insure that the entire spectrum of variation in hydrologic conditions is captured. For example if the range in ground cover along the gradient is 20-80%, sampling would be stratified into areas with 20-35, 35-50, 50-65 and 65-80 percent ground cover. This will facilitate the identification of significant hydrologic thresholds that might exist as ground cover decreases. In the case of the fire-treated sites, percent ground cover will be assessed prior to the fire treatment. Portable oscillating-arm rainfall simulators with specifications described by Meyer and Harmon (1979) will be used to apply rainfall at a rate sufficient to generate runoff from all runoff plots 0.5 m^2 in size with uniform antecedent soil moisture conditions. Thirty-two runoff plots will be sampled per fire-treated and control plot at each site - four replicated runoff plots for each of eight stratifications of ground cover. Runoff samples will be collected at two-minute time intervals throughout the simulation until steady-state runoff occurs and analyzed for runoff volume and sediment concentration by oven drying. Infiltration capacity for each time interval will be calculated as the difference between applied rainfall and measured runoff.

Variations in overland flow and rill erosion will be examined using overland flow simulation and measurement techniques to create flow paths similar to rills found under natural conditions (Pierson et al. 2003). Sampling will again be stratified along the gradient of increasing juniper dominance and the associated decline in understory vegetation to insure that the entire spectrum a variation in rill erosion along the gradient is captured. Computer controlled and monitored flow regulators will be used to apply rill flow rates of 7, 15, 30, and 48 l/min to six randomly selected points within each of five stratifications along the juniper dominance gradient at each fire-treated, cut juniper and control site. For the juniper-cutting treatments, each simulated rill will begin above and conclude below a cross-felled tree. Flow grab-samples will be collected 4-m down slope of the release point at 2-min intervals for 12 min at each rill flow rate. Flow samples will be weighed, oven-dried at 105^{o}C then re-weighed to determine rill discharge rate and sediment yield. Flow velocity in each rill will be measured by releasing a concentrated salt solution into the rill and using electrical conductivity probes to estimate the mean travel time of the salt over a known rill length. The width and depth of flowing water will be measured along perpendicular cross-sections through the rill at 0.5-m intervals down the slope. The tortuosity of the flow path will be quantified by measuring the actual flow length necessary to travel 4-m down slope. The hydrologic connectivity between areas under juniper canopy and areas between tree canopies will be further studied by simultaneously using a combination of overland flow simulation and large-plot rainfall simulation procedures described above. Four large (35 m^2) rainfall simulation plots will be sampled at each end of the gradient of increasing juniper dominance and the associated decline in understory vegetation at one fire-treated and one control site per juniper location. Runoff and erosion will be monitored from each large plot for 45 min. Then while maintaining a constant rainfall rate of approximately 60 mm/hr, concentrated flow will be released at the top of each plot at a flow rate of 48 l/min for an additional 15 min. This will provide a better understanding of how runoff and erosion processes are affected by juniper invasion at varying spatial scales.

Before simulated rainfall or overland flow is applied, soil samples will be collected adjacent to each plot and analyzed by oven drying for gravimetric soil moisture content. Following the simulations, soil samples will be collected and analyzed for bulk density using the core method (Blake and Hartge 1986), organic carbon content (Nelson and Sommers 1982) and soil texture using the hydrometer method (Bouyoucos 1962). Vegetation canopy cover for each plant functional group (including standing dead material) and ground cover will be estimated for each runoff and rill plot using a double-sampling technique based on a combination of ocular and point-frame estimation procedures (citation).

The impact of fire-induced and naturally occurring water-repellent soil conditions on infiltration during simulated rainfall will be quantified using the water repellency index (WRI) defined by Pierson et al. (2001). The index quantifies the percent reduction in infiltration capacity during the initial stages of the infiltration process attributed to water repellency. The WRI is a relative index that can range from zero in a soil with no water repellency to 100% when all runoff is attributed to water-repellent soil conditions. Soil water repellency will also be measured using the water-drop penetration time procedure (Pierson et al. 2001). Depth and uniformity of the wetting front immediately following rainfall on each runoff plot will be examined by digging a 50-cm long by 20-cm deep trench across the center of each plot and quantifying the size and position of all remaining dry portions of the soil profile.

Data will be tested for normality, skewness and kurtosis prior to analysis and appropriate transformations of the data performed if necessary. Differences between treatments for all variables will be tested by analysis of variance using appropriate mean separation tests with a 95% (or otherwise specified) confidence level. Linear regression and multivariate gradient analyses will be used to define relationships and thresholds between vegetation/soil variables and hydrologic/erosion variables.

The infiltration and erosion data collected in this study will expand the use of the Erosion Risk Management Tool (ERMiT, Robichaud et al. 2003) currently being developed under the Joint Fire Sciences Program to the management of juniper woodlands. ERMiT provides the probability that significant erosion will occur on range or forested lands each year for four years after a wild- or prescribed-fire. It also allows the effectiveness of various erosion mitigation techniques to be compared. Our data will provide parameter data sets covering prescribed fire in pinyon-juniper systems and the effectiveness of cross-felling juniper trees for reducing erosion which are not currently available in ERMiT.

Wildlife and Invertebrate Biodiversity

We will evaluate three aspects of faunal biodiversity: (1) demography and habitats of passerine birds; (2) food sources of Greater sage-grouse; and (3) species richness and abundance of butterflies. Passerine birds are of keen interest because sage-obligate passerines are considered to be especially at risk to habitat loss and subsequent population declines, given the rapid habitat changes now occurring in sagebrush steppe biome (Knick and Rotenberry 1995). Moreover, federal land managers are required to address issues of population viability for species considered at higher risk of extirpation Similarly, focus on Greater sage-grouse is needed because all populations of this species are now being considered for federal designation as threatened or endangered. Finally, butterflies have been considered as indicators of conditions for many other invertebrates, as have passerine birds (Fleishman et al. 2000), thus allowing us to provide further insights about the likely responses of a larger set of fauna of conservation concern (Fleishman et al. in press).

Birds. The rapid and often radical changes in sagebrush habitats across the Intermountain West have had significant effects on populations of birds living in these systems. Greater sage-grouse (*Centrocercus urophasianus*) currently are being considered for protection under the Endangered Species Act because of declining populations related to loss and degradation of habitat (Western Association of Fish and Wildlife Agencies 2004). Populations of other species dependent on sagebrush habitats, such as Brewer's sparrows (*Spizella brewerii*), are declining and are considered species of conservation concern by management agencies across their range (Knick and Rotenberry 2002). Because of concern for loss of sagebrush habitats, many management actions are implemented to restore these systems or reverse the trajectory of habitat degradation. In particular, we will evaluate breeding season communities of selected birds because the sagebrush and juniper habitats in this study provide nesting and summer habitats for all passerine species of interest. By contrast, some of the passerines of interest migrate off-site to other wintering areas, which we cannot study. Focus on nesting and summer habitats allows a larger number of passerines to be evaluated, and prior work on passerines suggests that productivity (nest success and fledging success) are important contributors to population growth of passerines (Noon and Sauer 1992).

The relationship between habitat changes that result from management actions using fire and fire surrogates and the response of the bird community forms the overarching question that we will address in this study. Birds respond to habitat features at multiple scales (Rotenberry and Knick 1999, Vander Haegen et al. 2000). In addition, response by bird species to habitat changes often lags the habitat change (Wiens and Rotenberry 1985, Wiens 1989). Therefore, we need to better understand the hierarchical relationships between the spatial and temporal structure of habitats and bird communities. The primary questions that we will consider are:

1. What are the dominant habitat characteristics that determine response in the bird community? What spatial and temporal scales are the primary drivers of change in birds populations?

2. What are the primary mechanisms by which the bird community responds to changes in quantity, composition, and configuration of their habitat? Does

individual or area/specific productivity of birds change relative to habitat treatments?

Avian responses will be measured as part of the sagebrush/pinyon-juniper experiment within the paired, 1000-acre (approximately 4 km^2) burn and 1000-acre control units. Avian responses will not be measured as part of the sagebrush/cheatgrass experiment because the size of experimental units at the sagebrush/cheatgrass sites will be too small to measure population responses of avian species. Moreover, increasing the size of experimental units to accommodate avian response variables at the sagebrush/cheatgrass sites appears to be logisticially and economically infeasible.

Landscape variables at spatial scales >1 km^2 had a significant influence on distribution and abundance of passerine birds (Knick and Rotenberry 1995). Therefore, treatments and control units that influence habitats at these spatial scales in the sagebrush/juniper experiment are sufficiently large enough to influence populations of passerine birds in these study areas. At a minimum, three replicates of the paired, 1000-acre burn and 1000-acre control units will be available for avian research: one in Oregon, one in Nevada, and one in Utah. Avian responses on these treatments will be compared to larger scale information derived from other sources, such as the Breeding Bird Surveys (Peterjohn and Sauer 1999), to develop regional trends for comparison to site-specific changes.

Three types of response variables will be measured: (1) species richness and density; (2) survival; and (3) productivity. Response variables will be measured as changes over time within each burn plot and each control plot across the three replicates. Species richness and density will be measured for the avian community at each plot. Survival and productivity will be measured for selected passerine species of conservation interest that are strongly associated with sagebrush, pinyon-juniper, or both habitat types. Example species may include Sage thrasher (*Oreoscoptes montanus*), Sage sparrow (*Amphispiza belli),* Brewer's sparrow (*Spizella breweri*), Gray flycatcher (*Empidonax wrightii*)*, and* Green-tailed towhee (*Pipilo chlorurus*).

As part of this experiment, a wide variety of habitat variables related to vegetation composition, structure, cover, and abundance will be estimated by vegetation ecologists (see earlier sections of proposal). We will use these variables as part of a larger set of treatment or predictor variables for evaluating avian responses. The vegetation-based habitat variables will be used in combination with a large number of landscape variables that we will collect regarding sagebrush and juniper habitat amount and configuration, as well physiographic variables (e.g. slope, aspect, elevation, and hydrologic patterns). These landscape and physiographic variables will be estimated with the use of GIS layers developed as part of the study. This large suite of environmental variables will provide the basis for evaluate avian responses to the experimental treatments, as described in the following sections.

1. Species Richness and Density—Changes in species richness and density of birds will be estimated over time within each 1000-acre burn and control plot. Estimates of species richness and density will be based on distance sampling (Buckland et al. 2001, Rosenstock et al. 2002) conducted along transects that are located using a stratified random process. Bird species will be counted and their distances estimated within 100 meters at predetermined stopping points along each transect. The stopping points will be located along transects to ensure sampling independence (sufficient distance) among the points. Counts and distance estimates will take place for 10 minutes at each predetermined point. Surveys will be conducted twice during the breeding season, early and late, within each burn and control plot.

2. Survival—Selected passerine species, such as those listed above, will be captured with mist nets and marked (banded) during the breeding season within each burn and control plot. Mist-netting will occur throughout the breeding season in each burn and control plot so that a sufficient sample of individuals of each targeted species is captured and marked. A small number (10-20 at each plot) of birds will also be equipped with radio transmitters. Mark-recapture methods will be used estimate changes in population size, population turnover, and survival over time (Powell et al. 2000, Bowden et al. 2003, Bradshaw et al. 2003) in relation to burn and control units. For migratory birds, we will assume that off-site survival during migratory and wintering periods is not different among individuals of a species occupying burn versus control units. We will evaluate this assumption by testing for differences in survival among burn versus control plot birds during the non-breeding season, with the use of our mark-recapture data.

Survival of passerines off-site from our study areas, or during the fall or winter on-site, can be estimated with the use of mark-recapture data provided from mist-netting of birds over multiple years. Survival of passerines during the spring and summer periods can be estimated with use of mark-recapture data provided from mist-netting and radio-telemetry data collected throughout the spring and summer periods each year. Thus, we anticipate being able to partition out survival of selected passerine species during spring and summer versus fall and winter. Estimates of on-site survival, whether spring-summer or fall-winter, can be attributed directly to environmental changes brought about by the experimental treatments. By contrast, off-site estimates of passerine survival during fall and winter for migratory birds can provide insights about the effects of off-site conditions versus on-site conditions.

Mist-netting will be used as the primary basis for estimating survival of targeted species because of its lower cost in contrast to radio-telemetry monitoring of birds. However, radio-tagging and monitoring of targeted passerine species will allow us to obtain estimates of survival independent of those estimated from mist-netting, thus providing two separate estimates. Moreover, radio-tagging and relocation of birds provides opportunities to collect other types of information, such as finding nests and monitoring nest success and fledging success, which also serve as response variables in our study, as described below.

3. Productivity—We will focus on two aspects of productivity: nest success (percentage of nests hatching at least one egg) and fledging success (percentage of nests with young that fledge). Intensive nest searches will be conducted for selected passerine species, such as for some of the species listed above. Monitoring of radio-tagged birds will also be used to find and monitor nests. Nests will be monitored to estimate nest success and fledging success. Individual nestlings will be banded prior to fledging.

Vertebrate responses will be measured within and among the burn and control units with the use of a repeated measures, factorial design, with blocking on replicate sites. Response variables will be measured annually, during each breeding season, starting at least one year before treatment application, and continuing for at least 5 years after units are burned. For many bird species, a true response to the treatments may not be realized until 10 years or longer after treatment application. A necessary assumption, therefore, is that additional research will be required to monitor vertebrate responses beyond the 5-year limit provided under this initial research.

We also will use ordinations of bird communities and habitat variables to determine the primary characteristics along which bird species and habitat communities are organized (Gauch 1982). Ordinations are statistical techniques that reduce multiple variables to individual components (or axes) that describe the dominant environmental gradients describing the relationships among species and their habitats (ter Braak 1995). We will determine the environmental trajectory over which bird communities and habitats have changed by plotting bird and habitat variables in the same ordination from data collected at the same site over successive intervals. We also will partition sources of variance (ter Braak et al. 1988) in the ordinations to determine the relative contribution of spatial and temporal scales to changes in bird communities (Knick and Rotenberry 2000). Therefore, the ordinations will serve to (1) determine species and habitat relationships, (2) determine the dominant trajectory for community response to habitat changes, and (3) provide a predictive model for understanding future habitat alterations.

Long-term changes in the avian community within and across each burn and control plot, and trends in species' densities, will provide new knowledge about the response of bird communities to management of sagebrush and pinyon-juniper in relation to prescribed burning. Current knowledge about the response of avian communities to changes in sagebrush and pinyon-juniper habitat manipulations from large-scale use of fire is sparse (Knick et al.. *in press*). Yet, large-sale use of prescribed burning to reduce encroachment of pinyon or juniper into sagebrush habitats is being proposed across extensive areas of the Great Basin.

Similarly, the estimation of survival and productivity of selected passerine species will provide the first knowledge regarding these species' demographic responses to large-scale use of prescribed burning to manage encroachment of pinyon-juniper into sagebrush habitats. Measurement of demographic responses, particularly the estimates of productivity, is essential in understanding whether the selected bird species will continue to persist with habitat changes brought about by burning, and by habitat changes brought about by doing nothing (control units).

Cursorial (Ground-living) Arthropods. The primary food for sage grouse and other sagebrush obligate species are ground-living arthropods (Knowlton and Thornley 1942), particularly in the breeding season (Johnson and Boyce 1990). Thus we will estimate population sizes and probabilities of capture for the main groups of potential bird prey, especially ants, beetles, and spiders. We will pay special attention to ants, because they play so many roles in the sagebrush steppe ecosystem (ants are seed harvesters, seed predators, scavengers, predators, food for vertebrates, and their nests serve as biodiversity 'hotspots' for a host of invertebrate species)(Holldobler and Wilson 1990).

For the sagebrush/cheatgrass experiment, cursorial (ground-living) arthropods will be sampled from the same intensive grid as laid out for vegetation. For the sagebrush/PJ experiment, we will work in the 1000-acre control and fire units only, and will sample cursorial insects and butterflies over the same extensive grids as laid out for vegetation.

Cursorial arthropods will be sampled with the use of pitfall traps, and by counting the nests of the two primary types of large-colony ant species (seed harvesters and predator/scavengers). In the woodland experiment, pitfall trapping will take place only where passerine bird point counts are taken (1000-acre prescribed fire and control units), and will be designed to understand the extent to which changes in passerine numbers are due to changes in their arthropod prey base. In the sagebrush experiment, passerine birds will not be studied directly, and so the emphasis of the cursorial arthropod work will be primarily to understand effects of each of the four experimental treatments. Data on arthropod response can then be used to predict how treatments may influence potential foraging habitat for birds and other vertebrates. For both the woodland and cheatgrass experiments, pitfall traps will be employed twice per year for three years: pre-treatment (2006), and twice post-treatment (2008, 2009). While assessment of the numbers of cursorial arthropods will provide short-term information on response to treatment, counting ant nests is intended as to provide a measure of intermediate and long-term changes.

For the cheatgrass experiment, pitfall trapping will take place in experimental units having all four treatment types. One set of treatment units (control, herbicide, mechanical, prescribed fire) will be studied within each of the three sagebrush provinces (Snake, Humbodlt, Lahontan), for a total of three replicates in the Basin. Within each 200-acre sagebrush/cheatgrass plot, pitfall traps will be arrayed uniformly in five clusters throughout, each containing 33 traps. Within each cluster, traps will be placed in 11 uniformly spaced groups of three, consisting of a 'central' trap and two traps placed at .5 m and 3 m distance. Each trap will consist of a standard test tube placed within a 3/4" PVC pipe that will act as a permanent 'sleave' that can be closed with a number neoprene stopper (Majer 1978). This spatial array of 165 traps will allow estimation of the relative abundance of most cursorial arthropods, as well as allow us to construct isopleths of 'probability of capture' for the entire 200-acre experimental plot.

For the PJ woodland experiment, pitfall trapping will take place in the 1000-acre prescribed fire and control units only, to correspond with the sampling of passerine birds. One pair of 1000-acre burn/control units will be sampled within each of the three PJ alliances, for a total of three replicates per treatment. Within each of these six 1000-acre units, pitfall traps will be arrayed uniformly in eight clusters throughout, with each cluster containing 66 traps. Within each cluster, traps will be placed in 22 uniformly spaced groups of three, consisting of a 'central' trap and two traps placed at .5 m and 3 m distance from it. This spatial array of 528 traps will allow estimation of the relative abundance of most cursorial arthropods, as well as allow us to construct isopleths of 'probability of capture' for each 1000-acre experimental plot. The arrangement of the eight clusters within the burn units is intended to sample arthropods across the range of fire intensities that will likely occur. With the use of regression techniques, we will able to link arthropod catches to fire intensity, and combined with nearest-neighbor analysis, estimate the effect of the treatment on cursorial arthropods over the entire 1000-acre experimental plot. These data can then be compared to passerine point-count information to determine the extent to which changes in the arthropod food base are tracked by passerine birds.

Ant Nest Monitoring. The large conspicuous nests of harvester ant (e.g. *Pogonomyrmex* spp.) and thatching ant species (*Formica rufa*-group species) will be counted for all units within the intensive grids in both the cheatgrass and woodland experiments. Monitoring these large dominant ant colonies provides a simple way to assess intermediate and long-term effects of fuel reduction and restoration treatments. Both of these species rely solely on the soil for nesting (Weber 1935; Wheeler and Rissing 1975). Thus, while many foraging workers (usually older individuals) will be killed outright by treatments like fire, the majority of colony members (mostly younger individuals) will be expected to survive through escape into the underground nest. As a result, while pitfall traps will be effective for assessing the short-term consequences of treatments, through capture of foraging ant workers, monitoring nests will provide an easy tool assess longer term consequences. Generally, we expect that fire will favor the seed harvester species, because thatching ants rely so much on an extant sagebrush canopy for foraging (McIver and Yandell 1998).

Butterflies. We will evaluate the response of butterflies to treatment, because they are so easily counted and identified (Swengel 1996), are well studied in prairie and range systems (Swengel 1998), represent a biodiversity component that is important to a wide public sector (Moffat and McPhillips 1993), and will respond to the changes in the relative abundance of their larval host plants (mainly native forbs and grasses in the sagebrush understory)(Scott 1986).

Butterflies will be sampled yearly (2006-2009) only in the 1000-acre control and fire units within the sagebrush/PJ experiment. The method for counting butterflies will be adapted from the protocol of Hammond (pers. comm..), which has been used successfully in juniper woodlands of southeastern Oregon (Rick Miller pers.comm). Three 500-meter transects will be walked within the extensive grid area of each experimental plot, at least 3 times per field season. To avoid edge effects, each transect will established so as to follow the grid point layout of the central portion of the extensive grid. On a warm, sunny, relatively calm day (>70^{o}F, >70% clear sky, and <10kph wind), an observer will slowly walk the transect so as to cover each 300 m distance in about 15 minutes (5 min / 100 m). Two individuals will be trained in butterfly identification, and will each survey one 1000-acre experimental plot per day. Given travel between locations in early morning or early evening, these two individuals will be able to survey the 6 sagebrush/PJ plots within a site in three days time. This survey routine will be followed each year in May, July, and September. Figuring a travel day to begin each survey run and one day to return home, plus one travel day between alliances, it will require a total of 13 days to complete each of the three seasonal surveys within each year.

Data will be recorded on field forms and entered in the computer at the end of each week in the field. Over the full field season, the survey will generate a species list, phenology for each species, relative abundance for each species within each experimental plot, and will allow comparison of community structure. Statistics (a standard ANOVA design needs to be described somewhere, appropriate for each of the experiments). ANOVA for analysis of treatment effects on common species and diversity metrics; NMS (non-metric multi-dimensional scaling) for description of how patterns of community structure relate to sites and treatments.

Sociopolitical

Core Variables

Each of the restoration and fuels-reduction treatments evaluated in this project is a potentially controversial practice that might meet resistance from citizens and/or managers when applied to the public lands that comprise most of the region. This component of the project will assess the social and political feasibility of these alternative restoration approaches.

We will assess social and/or political tradeoffs associated with alternative restoration decisions, including "no action," as perceived by the general public, interest group members, and managers themselves. Our intent is to identify factors in the treatments, or the conditions those treatments produce, that can constrain or facilitate implementation of practices that biophysical research shows to be promising. While the research questions focus on practical issues of choosing among potential restoration actions, the study also offers opportunities to explore more basic questions about decision-making under uncertainty, and foundations of social acceptability.

Measurements will be made at the individual level, with data subsequently aggregated to form generalizations about categories of stakeholder or decision maker. The fundamental dependent variable for the analysis is *acceptability*, defined as *a psychological disposition resulting from individual comparative judgments about alternative practices or conditions, which creates an intention to behave in ways that can maintain or produce a preferred practice or condition.* Thus acceptability is an attitude held by individuals that may tend to lead to social or political action.

While the judgments themselves are made at the individual level, they evolve in response to a host of external (typically but not always social) influences. Accordingly, Brunson (1996) reserved the term *social acceptability* to refer to aggregate forms of public consent whereby judgments are shared and articulated by identifiable, politically relevant segments of society.

Acceptability judgments will be measured across relevant groups (e.g., managers, livestock permittees, environmental activists, general public) within treatments.

In addition, research has shown that a number of factors influence acceptability judgments, including factors specific to the practice or condition being judged as well as characteristics of the evaluator and the social, political, or economic context within which the judgment is made (Shindler et al. 2002). We will measure many of these factors as well, specifically including:

Factors specific to the practice or condition being evaluated: These include perceived impacts on public health and safety, scenic quality, fire hazard, wildlife habitat, personal and/or community well being, geographic location of implementation, and timing of implementation.

Factors specific to the individual evaluator: Knowledge about fuels management, knowledge about sagebrush-steppe ecology, source(s) of household income, environmental orientation, beliefs about legal implications of treatments (e.g., liability), and sociodemographic attributes.

Contextual factors: Beliefs about judgments by peers (family, friends, creditors, members of affiliated interest groups), community-level economic and social attributes, agency culture, and specific events or tendencies in local public- and private-land management history.

Protocols and Methodologies

Most studies of acceptability have used quantitative, survey-based methodologies that allow for generalization about judgments typical of important constituencies and/or evaluation of the influence of educational interventions intended to improve understanding about practices or conditions being evaluated (Shindler et al. 2002). We will use these measurement tools as well, but the project also will include qualitative, interview-based methods that are useful in identifying particular factors to include in subsequent surveys as well as in obtaining in-depth textural information about nuances of acceptability and its influences.

Research will take place in six phases that will each lead to a scientific product. Some phases will take place concurrently, but research will be under way in each of the first five years of the project, and can potentially continue as further funding becomes available. Interviews of "key informants" (persons in the region with particular knowledge about proposed treatments and their sociopolitical implications) and a review of existing literature in both lay periodicals and peer-reviewed journals will take place prior to initiation of any of the research phases, which are listed below roughly in chronological order.

Interest group intervention – Interviews will be conducted with members of interest groups (particularly environmental organizations and rural commodity advocacy groups) across the Great Basin to identify factors that are associated with decisions to engage in administrative appeals or lawsuits as a response to proposed restoration activities. Sampling will be purposive rather than random, based on information provided by key informants about individuals and groups that are particularly influential or active in issues related to restoration and wildland fuels management. The research question for this phase is: How do key stakeholder groups assess tradeoffs associated with alternate approaches to restoration? The products of this qualitative study include findings that can guide development of a public survey, and an analysis that will be used to make recommendations to agency decision makers about planning models that are designed to address anticipated objections from stakeholders.

Initial social acceptability survey – Surveys of citizens in randomly selected households will be conducted of citizens in four locations within the Great Basin. Each location will consist of an urbanized center (Bend, Boise, Reno, Wasatch Front) paired with a nearby rural county where an experimental treatment site is located. The overall research question is: How do citizens generally judge the acceptability of alternate approaches to restoration?

Institutional analysis: Review of existing laws and regulations, judicial decisions, and policy statements will be conducted along with qualitative interviews– using a semi-structured interview guide of open-ended questions – and focus groups with agency decision-makers. The research question is: What institutional factors are likely to influence managers' decisions whether to propose alternate treatments? Decision-maker interviews will follow a format similar to that employed in the interest group intervention phase, in that one goal of the study is to identify which factors managers themselves believe are most influential on decisions. Sampling will be purposive, with interviews involving managers at multiple levels in agency hierarchies. Respondents at local levels will include managers whose lands are part of the experiment as well as those who do not host an experimental site, and all four states will be represented in the sampling design.

Permittee survey: As noted previously, decisions that affect forage availability on public lands typically entail some cooperation with grazing permittees for the proposed treatment area. This is important because agencies have regulations governing activities likely to significantly reduce short-term availability of forage, and also because implementation of such activities often entails cooperative activities with agency managers and permittees. Therefore we plan to survey a random sample of Forest Service and Bureau of Land Management grazing permittees. The research question is: How do grazing permittees assess tradeoffs associated with alternate approaches to restoration on public lands? This quantitative survey will include questions from the initial social acceptability study as well as categorical versions of open-ended questions used in the agency decision-maker interviews conducted as part of the institutional analysis.

Assessment of communications strategies: This phase will assess the effectiveness of different approaches to communicating about alternative approaches to restoration, including both on- and off-site (video or web-based) demonstrations and printed materials. We will take advantage of ongoing outreach efforts by the entire research team (as outlined in the Communications Plan), rather than developing tools specifically so they can be studied. The research question is: What differences exist in the understandability, credibility, and helpfulness of various outreach methods for communicating about alternate approaches to restoration? Methods will include short surveys of pre- and post-intervention knowledge and attitude regarding treatments, as well as qualitative assessment designed to understand how beneficiaries of communication judge the understandability, trustworthiness, and usefulness of different media and messages.

Post-treatment social acceptability survey: One advantage of conducting social research in conjunction with a long-term study such as this is that we can evaluate changes in acceptability over time. Relatively few longitudinal studies of social acceptability exist, and none focus on rangeland management. Thus the research question is: How do citizens judge the acceptability of alternate approaches to restoration after having had an opportunity to assess the progress of those approaches? This will be a random household survey that includes many of the same items as in the initial evaluation of social acceptability, as well as questions specifically addressing factors that might influence a change of attitude (e.g., unsuccessful manipulations, new information about benefits or costs of different treatments).

One of the most valuable aspects of this project will be the ability for individual analyses to inform each other. For example, by combining results of the ranch- and field office-level economic analyses with institutional analysis, it should be possible to determine the policy implications of different alternatives and make recommendations about adjustments in policy that can enhance the implementability of alternative treatments. Equally important, we can incorporate social-psychological factors into economic models in order to test theoretical constructs about social acceptability and decision-making under conditions of risk and uncertainty. (For example, it is possible to incorporate variables into non-market valuation models that measure the influence upon decisions of factors that theory suggests are important influences on judgments of social acceptability: level of trust in implementing agencies, geographic proximity of treatment, perceived fairness of the decision process, or length of time needed to achieve a "restored" condition. Similarly, economic analysis of risk heuristics that affect choices to accept economically sub-optimal management strategies will be informed by studies of social-psychological factors that affect choices among alternatives.

Economics

Purpose. The economic analysis considers the problem of the manager of public lands, who must decide in any given season whether to treat public lands in his/her district, which lands to treat, and what types of treatment to use. We assume that the land manager's primary objective is to take actions that would prevent lands that are at risk of becoming highly degraded with accelerated fire cycles from irreversibly transitioning to that state. The public lands manager also must consider resource use and the environmental value of the land to all citizens, including those who may positively or negatively value changes in the land but do not directly use it for extractive or on-site services. The research is designed to develop optimal management strategies based on results from the biophysical study and from additional results about resource and environmental values. The joint analyses provide an interdisciplinary framework for objective and defensible land management strategies. These strategies take into account competing resource values while minimizing the risk of transition to a degraded state.

The objective is to characterize options and decision-making criteria for evaluating outcomes from alternative fire risk management regimes for each of the ecological regions in the study, including the case of choosing to do nothing. The effect of timing of actions will be explicitly considered, as these are dynamic systems and delaying optimal actions involves trade-offs that can be characterized in the same units as other costs and benefits. Risk and uncertainty will be incorporated into the models we use in two ways: we will incorporate estimated probability distributions from the ecological data into the dynamic predictions of outcomes as they affect costs and benefits of decision-makers. We will also collect primary data from a random sample of the population affected by choice of fire risk management strategies to determine their attitudes toward risk, and relevant mitigating actions that these individuals could or would take to reduce risk to themselves. These individuals would be people who derive some level of use or non-use value directly or indirectly from changes in Great Basin lands where those changes are directly induced by choice of fire risk management strategies considered in the study.

Background: Integrating biological and economic models into a decision framework. An economic approach casts the decision-maker's problem in a constrained optimization framework. In this case, the decision maker chooses the levels for a set of variables under her/his control to optimize an objective (or set of objectives), subject to constraints. Representation of the problem, and thus its solution, will be different depending upon the perspective, objectives and constraints of the decision-maker. We shall focus on the decision problem faced by the public land manager, but we will also include a component that considers the problem faced by a private rancher using public lands that would be affected by the choice of treatments.

Objectives and constraints are represented in mathematical form, and the solution to the optimization problem indicates the efficient use of resources to achieve stated objectives. For example, a public lands manager's objective may be to minimize the probability of transitioning to the degraded state subject to a fixed annual budget and additional resource use constraints and agreements; or to achieve a given reduction in the probability of transition within a given annual budget and at least social cost; or to achieve maximum present valued net resource and environmental benefits to society given a fixed annual agency budget.

The solution to the optimization problem explicitly predicts the future costs or benefits of a current management action as a function of the future changes in the resource. Since we plan to incorporate environmental costs and benefits into the model, we will be able to the value of current management actions in terms of future environmental benefits and costs and current. We will also be able to estimate the trade-offs between market valued land uses and environmental benefits and costs that are implied by alternative sets of objectives and constraints.

A constrained optimization approach provides quantifiable information according to given objectives, what is known about the ecological system, what is known about resource values, and given constraints. The requirements for building the optimization model fall into the following five categories:

(1) Objectives that are chosen by the decision-maker, the land manager in this case;
(2) constraints that are imposed by social institutions (agency protocol, legal agreements, federal and agency budgets, the endangered species act);
(3) resource values which are a function of societal interactions and individual values;
(4) constraints that are imposed by nature (the dynamics of the ecological system); and
(5) a functional description of predicted incremental impacts of managers' actions on the ensuing trajectory of the ecological system and on resource values.

For this research, the decision-maker's choice variables include type of treatment, amount of land to treat in a given year, and which lands to treat. Choice variables in a dynamic optimization framework are also called control variables to indicate that through these actions the decision maker indirectly has some control over the long run trajectory of the dynamic ecological system (the progression of the characteristics of the system as they change over time, represented as a series of discrete variables, or a series of discontinuous functions that describe the system), while directly affecting short run gains and losses through management actions. Variables that describe the state of the ecological system at any given time are called state variables. The objective is to determine the optimal choice of control variables over time that will achieve the desired objectives within the given constraints.

For example, a BLM manager may choose an action that impacts short run agricultural use values while also inducing longer run changes in the ecological system that might speed up or slow down the rate at which it achieves a threshold level of cheatgrass cover. For the sake of example, a decision to apply treatment that requires limitations on grazing in the short run has a short run cost of lost ranch revenues, with a longer run change in the probability that the parcel will eventually cross the threshold to a permanently degraded state. The purpose of the bioeconomic model is to be able to determine what these trade-offs are and to predict optimal combinations of control variable levels over time, and for given constraints.

The constraints include difference equations (or differential equations in a continuous time format) that describe how the resource is expected to change over time. If the activities taken by managers and/or other resource users affect the dynamics of the ecological system, then these effects are included in the difference equations. Because these dynamic constraints are derived from biological or ecological models and parameters, the solution to the optimization problem takes into account both ecological and economic considerations simultaneously, hence the term 'bioeconomic' model (Clark, 1991). Inherent in bioeconomic models is the notion that renewable resources grow and replenish at growth rates that may vary dependent on the state of the resource at a given time. If a stock is large and healthy, the rate of growth may be faster than if the stock is small and degraded. Investments in restoration of the resource have short run costs, with long run gains derived from an increased growth rate and a reduction in the probability that the renewable resource will be exhausted. The difference equations that describe resource change and the impacts of control variables on those changes are therefore key components to the model. We will derive these relationships from the ecological results.

This particular research problem will be modeled as a stochastic dynamic optimization problem. In this case, the change in the state variables resulting from a specific set of choice variable levels has a deterministic component and a random component. That is, the future trajectories of state variables (and hence of the dynamic system) as a function of particular levels of control variables are not known with certainty, but only up to a probabilistic level of certainty.

Finally, while many bioeconomic models are concerned with dynamic ecological systems that are characterized by one steady state system (such as bioeconomic fisheries models), the same approach can be taken with problems that are characterized by more than one steady state system with transitions between that once crossed, are much more costly to reverse. If the costs of reversing a transition from one steady state to another are so high as to be infeasible, then we can consider the transition to be irreversible. The characteristics of irreversibility and uncertainty are also key to the ecologists' state-and-transition model. We plan to investigate the effects of these characteristics on optimal decision-making by land managers using a real options approach.

The solution to constrained optimization problems result in the set of control variables that solve the problem as it is defined for a given set of constraints. And once solved, an optimization problem can be resolved many times while changing levels of constraints, resource values, and parameters that enter the objective function and constraints, in order to determine how sensitive the solution is to these parameters. Where there is uncertainty about the precise values of certain parameters, sensitivity analysis can provide a starting point to determine the value of gathering more scientific or economic data about these values. As objectives, constraints and parameters are varied, the model can be used to predict impacts of trade-offs between different objectives and values. For example, a model that includes environmental benefits that are not traded in markets or are owned by individuals would be expected to result in different solution set for choice variables (treatment type, treatment timing, spatial organization of treated areas, and the resulting changes in the probability that a parcel will eventually transition to the undesirable state) than a model that does not include these values. Running both versions of the problem would provide an estimate of the costs to society of ignoring environmental benefits and provide quantifiable measures of trade-offs between market values and non-market environmental values. It is often the case that when environmental values are incorporated into economic optimization models, the optimal levels of consumptive resource use decline.

Methods and Protocols. The analysis relies on areas of specialization, data collection, and analytical methods that tend to be best handled as sub-components and by economists who specialize in these areas. Thus the proposed work is to be conducted as 4 concurrent subprojects:

1. Primary valuation study for valuation of non-market and environmental goods and services (includes recreational use, environmental benefits, non-use values)
2. Ranch-level Costs and Benefits
3. Regional input/output model for local economic impacts of land changes

4. Use the resource valuation estimates from the first three parts, along with science results regarding ecological dynamics and treatment effects to develop the constrained bioeconomic optimization decision-making model. Conduct sensitivity analyses and run model with different assumptions about constraints.

Summary Descriptions of each subcomponent. The subcomponents are related in terms of the conceptual models, methods of data collection and quantitative analysis. The non-market valuation component supplies data for the analytical parts of the remaining subcomponents. It will require a general population survey to identify and quantify non-market and environmental benefits and costs. Focus groups and pretesting of the survey instruments will use groups that represent interests of affected parties, including people at the regional levels. It is anticipated that these preliminary focus groups will also provide necessary data for the farm level and regional economic impact models.

The non-market valuation component is intensive due to the data collection and due to the need to draw on econometric expertise from Dr.s Scott Shonkwiler, Klaus Moeltner and Jeffrey Englin. Dr.s Kimberly Rollins, Douglass Shaw and Englin have a combined breadth and depth of experience designing and implementing nonmarket environmental valuation studies that will ensure the success of this part of the study. Dr. Allison Davis, a research faculty member, specializes in non-market valuation and spatial modeling, will be a valuable member of the research team. Dr. Michael Havercamp specializes in focus group facilitation and environmental policy analysis, and will be responsible for the focus groups required to refine the definition of relevant environmental values. Graduate students will be required for supporting focus groups, pretesting and piloting the survey, data entry and cleaning, running summary descriptive statistics, and assisting in running the econometric models for calculating non-market values. We anticipate using a commercial survey research firm for the initial establishment of a random sample of the relevant population.

The second and third components are economic impact models (a ranch level and a regional model) that will be overseen by Dr.s Tom Harris, John Tanaka, and Neil Rimbey. Dr. Davis will also support Dr. Harris.

The fourth component is the dynamic ecological-economic decision model. This model is driven by the dynamics of the ecological state and transition model. The non-market valuation model and economic impact models provide economic data. It will use stochastic dynamic programming methods and will be formulated as a constrained optimization model. This model will be developed as an extension of Niell et al (2004), and be overseen by Dr.s Rollins and Darek Nalle.

I. Primary Valuation Study

Some resource values are mirrored by the prices that emerge from market interactions. The markets that determine these public lands values are not likely to be direct markets for the resource values, since these lands are not privately owned. Instead, they are secondary markets for products that are produced using public lands inputs. For example, beef markets play a crucial role in determining the factor input value of the productivity of rangelands to ranchers. In these cases, agricultural production functions and market information can be used to derive implicit factor prices for these rangelands values.

However, a great many resource values from public lands studies in this project are not mirrored by market prices. Great Basin ecosystems provide numerous environmental goods and

services that are of value to people now and in the future. Examples of these are habitat for game species, for endangered species, hydrological functions that affect when, where and how much water flows, recreational opportunities for ATV users, hikers, nature viewers. One important feature of environmental goods and services is that since they are not under the ownership of any specific decision-making entity, they tend to be treated as "free gifts of nature." The reality is that environmental services are not free. Land management decisions we make today will affect (1) whether future generations bear costs or benefits relative to what people today receive from these ecosystems, (2) the relative magnitudes of benefits and costs that competing user groups will receive, (3) the distribution of benefits and costs among user groups, (4) the magnitudes of benefits that flow to 'non-users' who also benefits from these lands, even though they may never personally visit these areas.
In this case, non-market valuation methods must be used, which involve gathering data through surveys. These data in turn are used in econometric models to estimate resource and environmental values. We plan to collect data from a random sample of people who value goods and services that flow from the resource, including people who value the resource without any direct on-site contact. These would include environmental values that change as a result of changing levels of wildlife habitat, hydrological services, and the existence value associated with preserving threatened ecosystems (Rollins and Lyke, 1998). This will allow us to estimate incremental changes in resource values that would be expected to occur as a result of changes in the state of the resource, as well as changes in the probability that the resource may change in state. These resource values can then be incorporated as benefits and costs in the optimization problem.

2. Ranch-level Costs and Benefits

We plan to develop a ranch-level impact model that incorporates ecological relationships in the context of a ranch operation using public and private lands. We will use dollar-valued estimates of non-market environmental values from the nonmarket valuation component (e.g., wildlife species, invasive species, erosion, water quality or others) that would be comparable to the market values that are explicitly considered by the rancher. The full set of values could then be used in a linear programming model (using GAMS) to incorporate environmental variables into a model that would optimize over both ranch and environmental values. We can then compare alternative runs of the model with and without the environmental values included to determine what the environmental costs would be if ranch level decisions were made without considering non-market values. In addition, we could determine the costs to the rancher of including environmental values into the public lands manager's decision. That is, the model would allow us to trace out the trade-offs between ranch-level costs and benefits and environmental impacts.

The goal with this subcomponent is to model how choices among treatments made at one time period will affect the trajectory of future options and impacts felt by the ranch community, and to also indicate how the ranch-level decisions made at one point will affect the trajectory of future options for other relevant groups. The ranch unit is used in this model as the primary economic decision-making unit. Incorporating the ecological information and nonmarket values will integrate the known ecological information with the economic information for a typical ranching operation. This would be a new feature to the considerable literature that considers ranch-level budgeting problems in the west. This would allow land managers to determine how their decisions regarding fire and fire surrogates will affect private rancher grazing decisions and revenues, which in turn will impact other groups through the environmental impacts. This model can also include expected future demographic trends and their impacts.

On-going research being conducted under Western Regional Research Project W192 (Rural Communities and Public Lands in the West: Impacts and Alternatives) has resulted in the development of multi-period, dynamic, linear programming models. These models have been used effectively to assess ranch-level economic analysis in a number of policy analysis situations (Torell et al. 2002; Rimbey et al. 2003) for assessing the ranch-level economic impacts of alternative land management strategies. Similar models have been used to evaluate riparian area management (Stillings et al. 2003) and juniper control (Aldrich 2002). These models will be enhanced to fit the ranch situation within the study areas. This refinement process will be undertaken in cooperation with the ecologists, sociologists and others involved in this project, along with area ranchers or those familiar with ranching systems (eg. County extension faculty, agency personnel and others) in the study area.

Finally, using this information in a Computable Generalized Equilibrium (CGE) Model to evaluate regional economic and fiscal impacts of changing expenditure patterns by ranchers and other public lands users on a regional basis would provide more information to the managers on how their decisions will affect the community. This is the focus of the third subcomponent.

3. Input/output model for regional economic impacts of land changes

Unexpected consequences can occur and may differ with alternative scenarios for fire risk management on public lands. Rural economic sectors such as agricultural supply firms, fuel supply firms, banking, etc. could be impacted by induced changes in the nature of economic linkages to the local agricultural sectors. Also, local governments would be impacted by changes in property tax receipts from agricultural operations. To estimate the regional impacts of proposed fire suppression scenarios, a dynamic regional Computable General Equilibrium (CGE) model would be developed for selected study areas that are representative of regional economies in the Great Basin.

This approach uses an input-output model to derive the economic impacts of alternative wildfire suppression management scenarios. The input-output model describes the economic linkages of a local economy between and amongst local economic sectors. IMPLAN (Minnesota IMPLAN Group 1997) derives county input-output models for estimation of county-wide impacts from changes in the local economy. In order to derive the economic sector linkages, the IMPLAN data set must be purchased for the states of Nevada, Idaho, and Oregon. With these data sets, county or region wide input-output models can be developed for this analysis.

Input-output models are good for showing linkages within a local economy. However a disadvantage of a regional input-output model is that there are no constraints. That is, it is assumed that with projected growth of agricultural production there will be no limits on land or labor. This means the price of land and labor do not change when in actuality, these inputs would change in price as consumption increases. One procedure that allows for input supply constraints and import supply is the Computable General Equilibrium (CGE) model. A CGE employs the input-output matrices from IMPLAN but to handle resource constraints, the GAMS non-linear programming package must be used.

Regional dynamic CGE analysis will be run under current production practices and proposed fire suppression programs. Included with these fire suppression scenarios, alternative ranch operations, alternative fire suppression expenditures, and alternative non-market valuations will be estimated to be introduced to the dynamic CGE model. Working with Dr. John Tanaka and Neil Rimbey alternative ranch level operations will be modeled; as well as working with Dr. Derek Nalle and Kim Rollins, alternative fire suppression activities and non-market valuations will be estimated. Procedures to introduce ranch level activities, fire suppression scenarios, and non-market valuations will follow procedures outlined by Seung, et al. (2000). For this analysis, it will be assumed that policy makers are interested in maximizing per capita income of all residents in the study area, including original residents who remain in the study area as well as immigrants.

The welfare change will be updated to measure welfare changes in each period of the dynamic analysis. Welfare can be derived when aggregate representative consumer is assumed to have a CES utility function. Equivalent variation will be used to measure welfare changes where in each period welfare is measured as the change in per capita real expenditures of study area residents. This value is updated through time in the dynamic analysis.

Policy impacts from current operations and alternatives implied by the different treatment options will be estimated using procedures outlined by Ballard, et al. (1985). These procedures derive the policy impact for a given variable as the percentage deviation from the continuous benchmark or current operations to counter factual operations which will incorporate alternative fire suppression scenarios.

The regional economic models will use the IMPLAN software and datasets as the basis for the analysis. There will be some ground-truthing of the models for the study areas and development of the sectors related to the project treatments and market and nonmarket outputs. Results from individual models will be incorporated into the final regional model analysis to estimate what the total economic impact will be on the affected counties and states.

4. Bioeconomic Decision Model

We will develop the bioeconomic decision model from the perspective of the public lands manager. As an agent of the public, the manager would be expected to take into account a larger set of societal values than those that are represented in market commodity prices. These include extra-market environmental values. The research will optimize over alterative and multiple objectives. Constraints are of two main types, those imposed by nature and those imposed by society. For the latter type, we will use current agency guidelines for land management (i.e. a given number of acres per year treated and budget per district) as well as alternatives (i.e. relax the set number of acres per year and budget constraints, impose constraints that reflect potential changes in public lands policies).

The decision problem will be modeled as a stochastic dynamic programming problem that takes in to account relevant objectives, constraints, and the underlying physical and ecological processes that characterize the dynamics of the ecological system. Where possible, quantifiable incremental changes in physical characteristics that people care about (impacts on recreational use, productivity of rangeland for agriculture, amount of critical nesting habitat for sage grouse, forage for game species, hydrological impacts, the change in the probability of catastrophic fire, the change in the probability that a system will irreversibly transition to a degraded state) are assigned social values per unit change. The goal of the analysis is to build upon the ecological findings to provide information that will aid in the decision-making process regarding use of treatments on public lands that are intended to reduce or eliminate the probability that these lands will cross thresholds into less desirable states that are, for most practical purposes, not reversible.

We are most specifically concerned with determining the optimal economic thresholds for the various treatments in terms of reducing risk associated with a management decision with an irreversible outcome. A manager's decision each period (season) consists of whether to treat, type of treatment, and which lands to treat. The combination of these each period leads to a number of options - the number of which is partly dependant on how we deal with the spatial scope. The decision to do nothing on a parcel in a given year is one option. As time goes by, these systems are evolving - cheatgrass cover is increasing, accumulation of fuel is increasing, events that have cumulative effects in turn increase the probability that the system could move past its threshold. A decision to use one treatment over another, or to delay treatment on a given parcel in a given year will have a different impact on reducing the probability that the system will eventually cross the threshold than the same decision made at another time.

A variety of random outcomes (accumulated precipitation, likelihood of a fire, other environmental events) affect the ability to precisely predict the outcome of a decision to treat or not to treat at a given time and place on the eventual probability that the system may pass its threshold. So how would a land manager decide what to do in a given season? If a goal is to reduce the risk of a system passing the threshold from one state to another, in a world where the manager has an unlimited budget, every parcel could be treated as early as possible and as many times as necessary to avoid an irreversible loss.

But with trade-offs between land uses (and for example costs of temporary retirement of treated lands to ranchers) and with limited budgets, the manager must at any given time choose which lands to treat and the treatment type. In addition, since the precise outcome is stochastic there will always be a positive probability that a given parcel may cross its threshold. So we can cast the manager's problem as a risk management problem and the risk being managed is the probability that a given parcel will eventually cross its threshold - when a different decision could have caused otherwise. Hence, a decision potentially has irreversible consequences in that an irreversible transition from one state to another might have been avoided.

We will model this first starting from a Markovian process - with one stochastic variable. As we build the model, we hope to add multiple stochastic variables. We will explore the use of other frameworks based on stochastic dynamic programming with numerical solution methods will be used to describe the decision circumstances. One such example is a real options approach, which applies to situations where one is attempting to determine when to make a decision that cannot be reversed. Markov models have been used to depict ecosystem dynamics. For example, Niell (2003) developed a 17-state transition model for the Wyoming big sagebrush-steppe ecosystem that modeled fire cycles, revegetation practices, cheatgrass invasion. Suppose that t = time; s = state of the system; and x_t = state variable that characterizes the system as being in state s at time t. Then if system dynamics possess the Markov property; i.e., if

$$P(X_t = j \mid X_{t-1} = i; X_{t-2} = k; \ldots; X_1 = m) = P(X_t = j \mid X_{t-1} = i)$$

for all states s, times t, and transition probabilities, then a state-and-transition model reduces to a Markov chain model. Further, if the Markov chain is ergodic, then steady state probabilities exist that predict the long-run proportion of time the system will be in any given state.

While Markov models are relatively simple to build, their assumptions can be rather unrealistic. Namely, such models assume that (i) transition probabilities depend only on the current state of the system at a given point in time, and (ii) transition probabilities are unchanging over the entire horizon of the study. For example, the relative risk of invasion of cheatgrass and pinyon-juniper at a particular site might be expected to depend on occupation densities in neighboring areas, site-specific fire histories, and other factors such as multi-year drought. For these reasons, results from Markov models can be overly optimistic.

To more realistically estimate tradeoffs between ecological, economic, and socio-political objectives, a model that is less constraining in its assumptions is needed. Stochastic dynamic programming offers a promising alternative. In deterministic dynamic programming, payoffs, payouts and next state are assumed known with certainty. If we instead know payoffs, payouts, and the next state only as probability functions, then the problem takes the form of a stochastic dynamic program. Such models are used to determine an optimal set of management actions given uncertain outcomes. Outcomes can be represented as both point estimaties and variances in order to capture variability. Output from the stochastic dynamic program consists of an optimal path to manuevre the system from its current state to so some other state that is more desirable.

Since the ecological experimentation will determine ecological thresholds and transition probabilities, this information will be directly incorporated to parameterize the stochastic dynamic program. Used in conjunction with valuation studies occuring in parrallel, it will be possible to derive optimal paths that simulatenously accounts for tradeoffs between objectives. That is, in addition to data on vegetation, fuels, soils, hydrology, and wildlife, economic and socio-political thresholds will also be identified.

Each study site will correspond to a possibly unique stochastic dynamic program with it possibly unique set of constraints. Since objectives are global, each site-level model will be linked and modeled as contributing to landscape level objectives. This way, site level solutions will aggregate to specify the globally optimal solution.

Literature Cited (Variables and Measurement Protocols)

Aldrich, Gwendolyn A. 2002. "Optimal Management of Western Juniper on Ranches Located in the John Day Ecological Province of North-Central Oregon." Unpub. M.S. Thesis. Oregon State University, Corvallis.

Ballard, C., D. Fullerton, J. Shoven and J. Whalley. "A General Equilibrium Model for Tax Policy Evaluation." Chicago, Illinois: University of Chicago Press, 1985.

Blake, R.G., and K.H. Hartge. Bulk density. P. 363-376. IN: A. Klute (ed.). Methods of soil analysis. Part I. Physical and mineralogical methods. Agron. Ser. 9, ASA, SSSA, Madison, WI. 1986.

Bouyoucos, G.J. Hydrometer method improved for making particle size analysis of soil. Agronomy Journal 54:464-465. 1962.

Bowden, D.C., G.C. White, A. B. Franklin, and J.L. Ganey. 2003. Estimating population size with correlated sampling unit estimates. Journal of Wildlife Management. 67(1):1-10.

Bradshaw, C., J.A., R.J. Barker, R.G. Harcourt, and L.S. Davis. 2003. Estimating survival and capture probability of fur seal pups using multistate mark-recapture models. Journal of Mammalogy. 84(1):65-80.

Brown, J.K. 1974. Handbook for inventorying downed woody material. U.S. Department of Agriculture, Forest Service, Intermountain Research Station Ogden, UT. General Technical Report INT-16. 48p.

Brown, J.K., R.D. Oberheu, and C.M. Johnston. 1982. Handbook for inventorying surface fuels and biomass in the interior west. National Wildlife Coordinating group NFES-2125. 48p.

Brunson, M.W. 1996. A definition of "social acceptability" in ecosystem management. Pp. 7-16 in M. Brunson, L. Kruger, C. Tyler, and S. Schroeder (Eds.), Defining social acceptability in ecosystem management: a workshop proceedings. General Technical Report PNW-369. Portland, OR: USDA Forest Service.

Buckland, S.T., D. Anderson, K. Burnham, J. Laake, D.L, Borchers, and L. Thomas, Editors. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, England.

Clark, C.W. 1991. Mathematical Bioeconomics: TheOptimal Management of Renewable Resources, Second Edition, John Wiley and Sons, Inc, New York.

Fleishman, Erica, Dennis D. Murphy, and Peter F. Brussard. 2000. A new method for selection of umbrella species for conservation planning. Ecological Applications. 10(2):569-579.

Fleishman, Erica, James R. Thomson, Ralph Mac Nally, Dennis D. Murphy, and John P. Fay. in press. Predicting species richness of multiple taxonomic groups using indicator species. Conservation Biology.

Gauch, H. G., Jr. 1982. Multivariate analysis in community ecology. Cambridge University Press, Cambridge, UK.

Holldobler, B., and E.O. Wilson. 1990. The Ants. Harvard University Press, Cambridge, MA, 732 pp.

Johnson, G.D. and M.S. Boyce. 1990. Feeding trials of juvenile sage grouse. J. Wildlife Management 54:89-91.

Knick, S. T., and J. T. Rotenberry. 1995. Landscape characteristics of fragmented shrubsteppe habitats and breeding passerine birds. Conservation Biology 9:1059-1071.

Knick, S. T., and J. T. Rotenberry. 2000. Ghosts of habitats past: contribution of landscape change to current habitats used by shrubland birds. Ecology 81:220-227.

Knick, S. T., and J. T. Rotenberry. 2002. Effects of habitat fragmentation on passerine birds breeding in intermountain shrubsteppe. Studies in Avian Biology 25:130-140.

Knick, S. T., A. L. Holmes, and R. F. Miller. The role of fire in structuring sagebrush habitats and bird communities. Studies in Avian Biology. *In press.*

Knowlton, G.F. and H.F. Thornley. 1942. Insect food of sage grouse. J. Econ. Entom. 35:107-108.

Majer, J.D. 1978. An improved pitfall trap for sampling ants and other epigaeic invertebrates. Journal of the Australian Entomological Society 17:261-262.

McIver, J.D. and K. Yandell. 1998. Honeydew harvest in the western thatching ant (Hymenoptera: Formicidae). Amer. Entom. 44:30-35.

Meyer, L.D., and W.C. Harmon. Multiple-intensity rainfall simulator for erosion research on row sideslopes. Trans. ASAE 22:100-103. 1979.

Minnesota IMPLAN Group, Inc. 1997. *IMPLAN Pro*. Minnesota IMPLAN Group, Inc.: Stillwater, Minnesota.

Moffat, M., and N. McPhillips. 1993. Management for butterflies in the Northern Great Plains: a literature review and guide for managers. U.S. Fish and Wildlife Service, South Dakota Field Office, Pierre, S.D.

Niell, R., J. Englin and D. Nalle. 2004. Modeling Economic and Ecological Benefits of Post-Fire Revegetation in the Great Basin: An Application of Markov Processes. Selected paper for presentation at the American Agicultural Economics Association Annual Meetings, Denver, CO, August 1-4, 2004.

Nelson, D.W, and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. *In* Methods of Soil Analysis Part 2 Chemical and Microbiological Properties. A.L. Page (Ed) Amer. Soc. Agron. Inc., Madison, WI. pp. 539-579.

Noon, Barry, R., and John R. Sauer. 1992. Population models for passerine birds: structure, parameterization, and analysis. Pages 441-465 in Wildlife 2001: Populations, Dale R. McCullough and Reginal H. Barrett, editors. Elsevier Science Publishers, Essex, England.

Peterjohn, B. G., and J. A. Sauer. 1999. Population status of North American grassland birds from the North American Breeding Bird Survey, 1966-1996. Studies in Avian Biology 19:27-44.

Pierson, F.B., P.R. Robichaud, and K.E. Spaeth. Spatial and temporal effects of wildfire on the hydrology of a steep rangeland watershed. Hydro. Proc. 15:2905-2916. 2001.

Pierson, F.B., K.E. Spaeth, M.E. Weltz and D.H. Carlson. Hydrologic response of diverse western rangelands. J. Range Manage. 55:558-570. 2002.

Pierson, F.B., P.R. Robichaud, K.E. Spaeth, and C.A. Moffet. Impacts of fire on hydrology and erosion in steep mountain big sagebrush communities. IN: Renard, K.E., S.A McElroy, S.A. Gburek, W.J. Canfield, H. Evan, and R.L. Scott (eds). Proceedings of the First Interagency Conference on research in the Watersheds. Benson, Arizona. p. 625 – 630. USDA – Agricultural Research Service. 2003.

Powell, L.A., M.J. Conroy, J.E. Hines, J.D. Nichols, and D.G. Krementz. 2000. Simultaneous use of mark-recapture and radiotelemetry to estimate survival, movement, and capture rates. Journal of Wildlife Management. 64(1):302-313.

Rimbey, Neil R., Tim D. Darden, L. Allen Torell, John A. Tanaka, Larry W. Van Tassell, and J.D. Wulfhorst. 2003. "Ranch Level Economic Impacts of Public Land Grazing - Policy Alternatives in the Bruneau Resource Area of Owyhee County, Idaho." Dept. of Ag. Econ. and Rural Soc. Univ. of Idaho. AEES No. 03-05. available at: http://www.ag.uidaho.edu/aers/publications/AEES_2003/aees2003.htm

Robertson, G.P., D. Wedin, P.M. Groffman, J.M. Blair, E.A. Holland, K.J. Nadelhoffer and D. Harris. 1999. Soil carbon and nitrogen availability: nitrogen mineralization, nitrification, and soil respiration methods. Pp. 258-271. In, Standard soil methods for long-term ecological research. G.P. Robertson, D.C. Coleman, C.S. Bledsoe and P. Sollins (eds). New York: Oxford University Press.

Robichaud, P.R., W.J. Elliot, F.B. pierson and D.E. Hall. Erosion Risk Management Tool (ERMiT). A WEPP-based probabilistic erosion prediction tool for evaluating postfire conditions and rehabilitation treatment effectiveness. Available online at http://forest.moscowfsl.wsu.edu/fswepp. 2003.

Rollins, K. and A. Lyke. 1998. The Case for Diminishing Marginal Existence Values. Journal of Environmental Economics and Management 36: 324-344.

Rosenstock, S. S., D. R. Anderson, K. M. Giesen, T. Leukering, and M. F. Carter. 2002. Landbird counting techniques: current practices and analternative. Auk. 119(1):46-53.

Rotenberry, J. T., and S. T. Knick. 1999. Multiscale habitat associations of the sage sparrow: implications for conservation biology. Studies in Avian Biology 19:95-103.

Roundy, B A., and J. L. Vernon. Watershed values and conditions associated with pinyon-juniper communities. P. 172-187 IN: Monsen, S. B. and R. Stevens (compilers). Proceedings: Ecology and management of Pinyon-Juniper communities in the Interior West. USDA Forest Service Rocky Mountain Research Station, RMRS-P-9, Ogden, Utah. 1999.

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and W.D. Brodrson (eds). 2002. Field book for describing and sampling soils, Version 2.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Scott, J.A. 1986. The Butterflies of North America. Stanford University Press, Palo Alto, CA, 583 pp.

Seung, C.K., T.R. Harris, J.E. Englin, N.R. Netusil. "Impacts of Water Reallocation: A Combined Computable General Equilibrium and Recreational Demand Model Approach." *The Annals of Regional Science* 34(2000): 473-487.

Shindler, B., M. Brunson, & G. Stankey. 2002. Social acceptability of forest conditions and management practices: a problem analysis. General Technical Report PNW-537. Portland, OR: USDA Forest Service.

Stillings, Amy M., John A. Tanaka, Neil R. Rimbey, Timothy DelCurto, Patrick A. Momont, and Marni L. Porath. 2003. "Economic Implications of Off-Stream Water Developments to Improve Riparian Grazing." J. Range Manage. 56:418-424.

Swengel, A.B. 1996. Effects of fire and hay management on abundance of prairie butterflies. Biol. Cons. 76:73-85.

Swengel, A.B. 1998. Effects of management on butterfly abundance in tallgrass prairie and pine barrens. Biol. Cons. 83:77-89.

Tabatabai, M.A. 1994. Soil enzymes. Pp. 775-834, In Methods of Soil Analysis, Part 2 Microbiological and Biochemical properties. SSSA Book Series: 5, Soil Sci. Soc. Amer. Inc.

ter Braak, C. J. F. 1995. Ordination. Pages 91-173 *in* R. H. G. Jongman, C. J. F. ter Braak, and O. F. R. van Tongeren, editors. Data analysis in community and landscape ecology. Cambridge University Press, Cambridge, UK.

ter Braak, C. J. F., and C. W. N. Looman. 1988. Parital canonical correspondence analysis. Pages 551-558 *in* H. H. Bock, editor. Classification and related methods of data analysis. North Holland, Amsterdam, Netherlands.

Torell, L.A., J.A. Tanaka, N.R. Rimbey, T.D. Darden, L.W. VanTassell and A.J. Harp. 2002. The economic impact of changing grazing policies on BLM land to protect the Greater Sage Grouse: Evidence from Idaho, Nevada and Oregon. Policy Analysis Center for Western Public Lands Policy Paper SG-01-02.

Vander Haegen, W. M., F. C. Dobler, and D. J. Pierce. 2000. Shrubsteppe bird response to habitat and landscape variables. Conservation Biology 14:1145-1160.

Weber, N.A. 1935. The biology of the thatching ant, *Formica rufa obscuripes* Forel, in North Dakota. Ecol. Monog. 5:165-206.

Western Association of Fish and Wildlife Agencies. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats: an assessment of the species' habitat and populations. Draft manuscript.

Wheeler, J. and S.W. Rissing. 1975. Natural history of Veromessor pergandei, I: The nest (Hymenoptera: Formicidae). *Pan Pac. Entomol*. 51:303-314.

Wiens, J. A. 1989. The ecology of bird communities. Vol. II. Processes and variations. Cambridge University Press, Cambridge, UK.

Wiens, J. A., and J. T. Rotenberry. 1985. Response of breeding passerine birds to rangeland alteration in a North American shrubsteppe locality. Journal of Applied Ecology 22:655-668.

Wilcox, B.P. Shrub control and streamflow on rangelands: A process based viewpoint. J. Range Manage. 55:318-326. 2002.

APPENDIX 3

Communications Plan

Sagebrush Biome Fire and Fire Surrogate Study

Introduction

Because the need to restore sagebrush ecosystems is an important environmental issue in the Great Basin, and because restoration will require disturbances that are obvious to the public and may be viewed negatively in the short run, we expect that our research will generate considerable public interest. A communications plan that can adapt to the needs of all audiences is essential for effective public outreach as well as for technology transfer to practitioners. In addition, because we propose to study citizens' responses to alternative restoration and fuels-reduction treatments, as well as the effectiveness of various outreach approaches, a communications plan is needed that can accommodate needs for research as well as outreach and technology transfer.

Purpose

The purpose of the Communications Plan is to guide the project through research and outreach processes by providing both conceptual and process frameworks at the network and site levels. The communication plan identifies target audiences and the types of information and methods used to transfer information.

Objectives and Process

The following four objectives will be addressed in this plan:

1. Identify the specific audiences we are planning to reach.
2. Define the scope and scale of information we intend to transfer to specific audiences based on the needs of the audience and the information available to transfer.
3. Identify the methods to be used for public outreach and technology transfer.
4. Establish guidelines for incorporating research into outreach efforts.

Objective 1: Identify the specific audiences we are trying to reach. The comprehensive nature of this study will be of interest to a wide range of audiences varying from scientific, professional, economic, and political groups. We have identified 7 groups of potential audiences, listed in order of priority for outreach:

1. Professional land managers – This includes all persons working in professional fields involved in the assessment, planning, and management of forested ecosystems and/or processes related to sagebrush ecosystems. General examples include range conservationists, wildlife biologists, hydrologists, foresters, and land use planners.
2. Scientists – This includes all persons directly involved scientific research on rangeland ecosystems and/or processes related to the sagebrush biome and associated human communities (i.e., persons whose work directly involves collection and analysis of information about sagebrush ecosystems or their associations with human communities). General examples include university researchers and graduate students, federal and state agency researchers, and scientists with non-governmental and/or trade organizations whose missions focus on protection and sustained use of rangeland ecosystems.

3. General public – Includes any persons who may or many not directly use rangeland ecosystems, but who have a collective interest in management of the sagebrush biome.
4. Policy makers – This includes all persons involved in making policy that directly or indirectly affects both public and private rangeland ecosystems and/or processes related to rangeland ecosystems. Examples include state boards of agriculture and departments of state lands, county commissions and planning boards, state and federal agencies whose missions focus on environmental quality, and public land management agencies.
5. Educators – This includes all persons and institutions with the primary mission of education in formal classroom or informal outreach settings. Examples include public schools, universities and colleges, Extension offices, and non-profit environmental education organizations.
6. Range landowners – This category includes all individuals and organizations that have ownerships or stewardship of rangeland holdings in the Great Basin, whether large or small. General examples include ranchers, conservation groups, public land management agencies, utilities, rangeland smallholders, and private consultants whose work focuses on service to the above-listed groups.
7. Rangeland users – Includes all members of the public who use public or private rangelands in the Great Basin for commercial or non-commercial purposes including recreationists, mining interests, livestock producers, piñon-nut gatherers, and others.

Objective 2: Define the scope and scale of information we intend to transfer to specific audiences based on the needs of the audience and the information available to transfer. We will adapt information to be presented to suit the different interest group or groups as well as with the type of media to be used. The following steps identify the process used to transfer information to targeted groups:

1. Define the target audience.
2. Determine the range of interest, expertise, and information needs with the target audience.
3. Determine the range of information that is currently available.

Objective 3: Identify the methods to be used for public outreach and technology transfer. Outreach methods include professional and scientific journals, conferences, workshops, lectures, electronic media, tours, the internet, e-mail, and word of mouth. The actions below will be utilized to determine the appropriate outreach medium for a particular audience and information type.

1. Determine the types of information that may be transferred using these Audience-specific media.
2. Determine the media that is compatible with the type of information to be transferred.
3. Develop a clear plan by which different outreach media can be most effectively used to reach different audiences. This action involves the strategy used for presentations, publications, or information transferred through conferences, newsletters, workshops, tours, or other media.

Objective 4: Establish guidelines for incorporating research into outreach efforts.

Research activities that will be linked to outreach activities will take either of two forms:

1. Measurement of audience reactions during or immediately following field tours or electronic media presentations about the project and its ecological basis; and
2. Measurement of change in knowledge or acceptability following use of different outreach messages or methods.

In order to maintain the scientific integrity of research conducted as part of the outreach effort:

1. The socio-political research team will maintain frequent communication with scientist or agency employees providing outreach activities.
2. Permanent educational efforts (e.g., interpretive signs) will be designed and implemented in cooperation with the socio-political research team to ensure that they can meet the outreach missions of the agencies on whose land the research sites are located, while not compromising the ability of the research team to measure and analyze constituents' judgments about study treatments and their effects.
3. The socio-political research team will work with agency public education staff, where appropriate, to test outreach methods that are used by (or of interest to) hosting agencies.
4. Some outreach activities will be designed and conducted by the socio-political research team as part of the research effort.

Current Communication Plans

The following is a summary of the communication plans designed so far for the FFSSB network, and for the Nevada, Utah, and Northern (Oregon and Idaho) Provinces. These plans should be viewed as under development, as we expect there to be changes as projects proceed. In general, they have been designed to address the three objectives listed above, and to follow the actions listed under the objectives. For the network and for each state, products are listed, messages briefly described, and principal audiences given.

FFSSB Regional Network

Website. The network FFSSB website will be built and maintained by the network database manager. This product will contain a variety of messages, focusing on a basic description of the FFSSB project, and its principal investigators. The website will be linked to the Joint Fire Science Program website, to websites describing other similar projects (e.g. the dry forest FFS project, Teakettle Project), and to any FFSSB sites that have websites themselves. The website is aimed at all audiences that are computer-literate, and so the information is geared toward the informed general public.

User's Guides. A key deliverable is a set of three 'User's Guides', that we will develop from literature syntheses within the first three years of the study, one each for sagebrush, pinyon, and juniper-dominated systems. The User's Guide will contain the latest information on how these systems are known to respond to available treatments, and will thus allow managers to make more informed decisions as they consider how to apply treatments under a wide variety of conditions. Information from the current experiment will then be used to craft second editions of the User's Guides toward the end of the study period. Production of the User's Guides will be led by a 'Technology Transfer Specialist', hired out of Utah State University. A complete list of anticipated duties for this key personnel is provided in the Budget Justification.

Publication Series. We envision that we will produce a large number of scientific papers as describe various aspects of the results. All FFSSB papers that are published will become part of an FFSSB 'publication series', and will contain either of the following acknowledgment statements: 1) For FFSSB work directly supported by JFSP funds: *"This is contribution number XX of the Sagebrush Biome Fire Surrogate Research Project, supported by funds from the U.S. Joint Fire Science Program.*"; or 2) For work that uses FFSSB sites or treatments but does not get direct funding: *"This is contribution number XX of the Sagebrush Biome Fire and Fire Surrogate Research Project. Although the authors received no direct funding from the U.S. Joint Fire Science Program (JFSP), this work could not have been accomplished without JFSP support of existing FFSSB sites."* The intended audiences of most technical papers will be scientists and management professionals. Papers will be published periodically, as they are written. It should be noted that all sites will be active participants in publishing a number of technical papers, aimed at producing four distinct kinds of products: 1) within-disciplinary papers at the site level; 2) inter-disciplinary papers at the site level; 3) among-site papers within each major discipline; and 4) among-site, inter-disciplinary papers. Since publication is a universal aspect of all research, it is assumed that all sites will participate in this activity, and thus scientific papers will not be listed as separate products within each of the site communication plan summaries.

Brochure. A "four-color" brochure will be produced, aimed at general audiences. The brochure will describe the design of the FFSSB project, and will provide a map of the sites. A one-page insert describing details of each site will also being printed, which can be included within the brochure by any of the sites.

Powerpoint presentation. A 20-minute Powerpoint presentation has been developed, (including video clips to illustrate key dynamic elements), which can be used by any of the FFSSB principal investigators or collaborators to present to a variety of audiences. Notes to allow an informed person to present it accompany the presentation.

Poster. A large-format poster will be prepared, containing information similar to the brochure and the Powerpoint presentations.

Fact Sheet. This will be a two-page description of the FFSSB project for use primarily by the principal investigators, when dealing with the press.

Study Plan. Aimed at the FFSSB principal investigators themselves, the study plan will be a general description of the study, including its basic design, and descriptions of variables and protocols for their measurement. An appendix will be provided that gives more detailed descriptions of study plans for each of the sites that are currently underway.

Corporate Database. All data needed for meta-analysis and other network analyses will be archived and structured in a corporate database available to all principal investigators

National Conference. Toward the end of the initial funding cycle, the FFSSB team will hold a national conference, in conjunction with an annual meeting of the Society of Range Management, or similar society, in order to showcase the results of the study.

Northern Provinces

The northern sagebrush provinces will consist of several sites within four provinces of south central and southeastern Oregon, northeastern California, and southern Idaho. The provinces will encompass three to four BLM district offices and possibly one Forest Service ranger district. This plan will encompass methods of transferring information and results from our project to the general public (both rural and urban), land resource managers, and scientists.

Website – A website will be developed that explains the project, and describes the specific treatments and their locations. This web page will be maintained by the USGS Forest and Rangeland Ecosystem Science Center (FRESC) as part of the SAGEMAP Project (http://sagemap.wr.usgs.gov/). The web page will include information on the collaborating scientists conducting work at these sites and will be linked to other appropriate sites, including other project web pages, JFSP-related projects. The audience will be general.

Research Brief – A research brief about the project will be developed by the USGS FRESC to describe the study for a general audience. These briefs will be distributed to local BLM offices for display and public distribution. Progress reports describing work accomplished and preliminary results will be produced and distributed to keep managers and funding sources up to date on status of the research.

Newspaper & Radio – We will offer press briefings on project and results. Target audience is general.

Meetings: Regular meetings will be held with resource management professionals, and they will occur during project establishment, and periodically thereafter to provide information on research results as they become available.

Workshops: Workshops will be periodically conducted to transfer current information and results of the studies to resource management professionals and to other interested university and private groups.

Field Days & Site Tours – We will offer an annual meeting and site visit to at least one of the field sites. The annual meeting will highlight the project treatments and results. Target audience is land managers.

Presentations at Scientific/Professional Meetings – Collaborators will present findings at scientific and professional meetings. Collaborators also will host regional workshops and field tours to share findings and help facilitate their use in management. Target audiences are land resource managers, scientists, and educators.

Nevada

The Nevada section will include both sites with only sagebrush, and sites with sagebrush and pinyon-juniper. These sites will represent major vegetation types that are of interest and importance to resource management professionals working in the region. For the establishment of the sites, and for disseminating the initial research accomplishments we plan the following outreach activities:

Website: The Nevada group will contribute project specific information on the Nevada sites selected, and on the studies to be conducted to the overall project website.

Meetings: Regular meetings will be held with resource management professionals, and they will occur during project establishment, and periodically thereafter to provide information on research results as they become available.

Field Tours/ Site Visits/ Field Trips: Site visits and field tours will be conducted at one of the Nevada field sites at least annually. This will be the same Demonstration Area site used for the Interpretive Exhibits described below. This site will be, by necessity, located some distance from the population centers of Reno, NV, Las Vegas, NV and Salt Lake City, UT, and will require travel days both before and after the field tour. The tour may require two days after the research efforts are underway. These tours and site visits will be on an open invitation basis to any groups or individuals that are interested. Additional field trips will be conducted for interested groups and individuals on an as needed basis.

Brochure: Information on the specific sites and studies for the Nevada groups' research efforts will be summarized for inclusion in a brochure for the overall project.

Newspapers: Periodic press releases will be provided to local newspapers on project sites, research goals and accomplishments, and upcoming field tours.

Interpretive Exhibits: One major research site in Nevada, also used as a Demonstration Area for the field tours described above, will also have on-site interpretive exhibits installed explaining the goals and accomplishments of the research occurring on the site.

Workshops: Workshops will be periodically conducted to transfer current information and results of the studies to resource management professionals and to other interested university and private groups.

Utah

Besides using the resources of the larger project, such as brochures and videos, we will aim the following activities at these two general audiences:

Professional and Management Agencies - Society-oriented tours for Society for Range Management, Wildlife Society, Western Coordinating Committees (e.g., WCC-21) and other interested groups

Agency-oriented tours for BLM, Forest Service, and Utah Division Wildlife Resources groups, e.g. BLM Resource Advisory Committee

Restoration Ecology class field trips for Utah State University, Brigham Young University, and other student groups

Professional oral and poster presentations at scientific meetings held by the Society for Range Management, Society for Ecological Restoration, American Water Resources, Association, Ecological Society of America, and others.

Workshops for management agencies

Short, informative articles for newsletters of conservation and professional groups

University seminars for students and faculty

General Public and Media - Tours for environmental and conservation groups such as The Nature Conservancy, Utah Native Plant Society, Audubon Society, and Southern Utah Wilderness Alliance.
Informational web site linked off the project web site and linked to other related sites
Tours and interviews for radio, television, and newspaper reporters
Local citizen and group tours

APPENDIX 4: MANAGEMENT COLLABORATION

4A: LETTERS OF INTENT

Provided here are all of the 'Letters of Intent' from management offices that will implement treatments on individual sites within each of the two networks. We have been fortunate enough to obtain commitments for specific on-the-ground activities that are required to conduct this comprehensive project, for all sites listed in the proposal. We have provided these letters in the order that the sites are listed in Table 5 below. Note that three management units will handle two sites each: Elko District will handle the Spruce Mt. juniper site and the NE Nevada cheat site; Battle Mt. Field Office will handle the Seven-Mile juniper site and the NE Nevada cheat site; and Salt Lake Field Office will administer Central Utah juniper site and the NW Utah cheat site.

If this project is funded, we will work on obtaining formal 'Memoranda of Understanding' between the institutions conducting the research (universities and federal labs) and management units. These MOUs will serve as the working documents that describe the relationship between the science and management teams, during the treatment implementation phase, and for all subsequent planned activities. An example MOU is provided in Appendix 4B.

Table 5. Provinces, sites, and management offices within the juniper/sage and cheatgrass/sage networks*
*Letters of support provided in Appendix 4A

PROVINCE	SITE	MANAGEMENT OFFICE	SIGNATORY	TITLE
Juniper/Sage Network				
High Desert	Lakeview	BLM - Lakeview District	Steve Ellis	District Manager
	Steens Mt.	BLM - Burns District	Jeff Rose	Zone Fire Ecologist
	Owyhee	BLM - Lower Snake District	Glen Secrist	District Manager
High Calcareous	Robinson Summit	BLM - Ely Field Office	Gene Kolkman	Field Office Manager
	Spruce Mt.	BLM - Elko Field Office	Helen Hankins	Field Office Manager
	Seven-Mile	BLM - Battle Mt. Field Office	Gerald Smith	Field Office Manager
Bonneville	NW Utah	USFS - Wasatch-Cache N.F.	Faye Krueger	Deputy Forest Supervisor
	Central Utah	BLM - Salt Lake Field Office	Glenn Carpenter	Field Office Manager
	South Central Utah	BLM - Cedar City Field Office	Todd Christensen	Field Office Manager
		BLM - Fillmore Field Office	Sherry Hirst	Field Office Manager
Cheatgrass/Sage Network				
Snake River	Craters of the Moon	BLM - Shoshone Field Office	Bill Baker	Field Office Manager
	Vale District	BLM - Vale District	David Henderson	District Manager
Hunboldt/Bonneville	NW Utah	BLM - Salt Lake Field Office	Glenn Carpenter	Field Office Manager
	NE Nevada	BLM - Elko Field Office	Helen Hankins	Field Office Manager
		BLM - Battle Mt. Field Office	Gerald Smith	Field Office Manager

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
Lakeview District Office
1301 South G Street
Lakeview, Oregon 97630
www.or.blm.gov/lakeview

TAKE PRIDE IN AMERICA

In Reply Refer To:
9210/1746 (010) P

July 20, 2004

Dr. James McIver
Research Ecologist
PNW Research Station
USDA Forest Service
1401 Gekeler Lane
La Grande, OR 97850

Dear Dr. McIver:

This letter offers the Lakeview BLM District's support of the consortium proposal entitled "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome," being submitted to the Joint Fire Sciences Research Program.

The proposal addresses several of the Bureau of Land Management's National and Western Science/Research Priorities including: 1) the control of invasive species and the restoration of native plant diversity on BLM lands, and 2) species at risk. In addition, due to accelerated acreages being consumed annually by wildfire, fuel reduction strategies that promote ecosystem health but reduce the risk of catastrophic wildfire are of great need on many public lands of the western United States.

Currently, millions of acres of sagebrush-dominated rangeland are at high risk to vegetation conversion. These include low elevation sites which are at high risk to cheatgrass domination following wildfire, and higher elevation sites which are being lost to invasion by pinyon pines and junipers in the absence of fire. Loss of wildlife habitat, declines in livestock production and accelerated erosion, are just some of the potential negative impacts encountered when sagebrush ecosystems are lost to other species. Invasive weeds and pinyon/juniper encroachment are the greatest threats to the biological diversity of the Great Basin Region. The loss of this biological diversity as well as conversion of sagebrush grasslands has led to a significant reduction in suitable habitat for sage grouse. The BLM has a critical need for this type of research in determining appropriate management strategies to restore native habitats within the sagebrush ecosystems.

The nature of this research project will, by necessity, involve a **cooperative and positive** working relationship between managers and scientists. By this letter, the Lakeview BLM District agrees to the following support for this research project:

1. Lakeview BLM will apply the core treatments to a minimum of 25 to 50 acres for the juniper and pinyon plots and/or 200 acres for the sagebrush/cheatgrass plots to locations mutually agreed upon by all parties. The three core treatments include fire, mechanical

(consisting of cutting and dropping the trees with a chain saw), and control. The treatments on the pinyon/juniper sites may be nested within a larger prescribed burn.

2. Lakeview BLM will work with the investigators of this study to apply core treatments in the fall of 2006.

3. Lakeview will allow the three core treatment areas to be fenced at the expense of the study.

4. Personnel of this district will provide the necessary environmental clearances and analysis under the National Environmental Protection Act.

5. Personnel of this district will coordinate and consult with livestock grazing permitees to accommodate the research effort and grazing practices.

6. No additional treatments or data gathering from researchers outside of the core scientific team will be allowed on the core treatments areas for at least 10 years following the beginning of the studies, unless written agreements are developed and signed by all parties. This is to insure that the integrity of the experimental design will not be compromised.

Overall we strongly support this research because it addresses significant managerial needs within sagebrush ecosystems of the Great Basin Region. We look forward to the co-development of this important project.

Sincerely,

M. Joe Tague

for Steve A. Ellis, Manager
Lakeview District

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
Burns District Office
28910 Hwy 20 West, Hines, OR 97738
or020mb@or.blm.gov
www.or.blm.gov/Burns/

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
9210 (OR-024)

Dr. James McIver
Research Ecologist
PNW Research Station
USDA Forest Service
1401 Gekeler Lane
La Grande, Oregon 97850

Dear Dr. McIver:

This is a letter pledging the Burns District Office's support of the consortium proposal entitled "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome," being submitted to the Joint Fire Sciences Research Program.

The proposal addresses several of the Bureau of Land Management's (BLM) National and Western Science/Research Priorities including: 1) the control of invasive species and the restoration of native plant diversity on BLM land, and 2) species at risk. In addition, due to accelerated acreages being consumed annually by wildfire, fuel reduction strategies that promote ecosystem health but reduce the risk of catastrophic wildfire are of great need on many public lands of the western United States. In addition to addressing these national priorities, the proposal addresses several important local issues faced by the Burns District. The research will provide the local BLM offices with regionally and site-specific research that helps the land and fire management staff adapt current and future actions.

Currently, tens of millions of acres of sagebrush-dominated rangeland are at high risk to vegetation conversion. These include low elevation sites which are at high risk to cheatgrass domination following wildfire, and higher elevation sites which are being lost to invasion by pinyon pines and junipers in the absence of fire. Loss of wildlife habitat, declines in livestock production, accelerated erosion, property loss, and reduced aesthetics are just some of the potential negative impacts encountered when sagebrush ecosystems are lost to other species. Invasive weeds and pinyon juniper encroachment are the greatest threats to the biological diversity of the Intermountain Region. As an example of how important this research would be to BLM management, discussions are currently underway to list the greater sage-grouse as a threatened species under the Endangered Species Act. Conversion of sagebrush grasslands has led to a reduction in suitable habitat for these native birds. If sage-grouse were to be listed as threatened, BLM's application of multiple-use management principles on many public land uses would almost certainly be impacted. The BLM needs research to assist us in determining appropriate methods that can be used to restore native habitats within the sagebrush ecosystem.

The nature of this research project will by necessity involve a cooperative and positive working relationship between managers and scientists. By this letter, the Burns District Office commits the following support to this research project:

1. We will apply the core treatments to a minimum of 25 to 50 acres for the juniper plots and/or 200 acres for the sagebrush/cheatgrass plots to locations mutually agreed upon by all parties. The three core treatments include fire, mechanical (consisting of cutting and dropping the trees with a chain saw), and control. The treatments on the pinyon juniper sites may be nested within a larger prescribed burn.

2. We will work with the investigators of this study to apply core treatments in the fall of 2006.

3. We will allow the three core treatment areas to be fenced at the expense of the study.

4. Personnel of the Burns District Office will provide the necessary environmental clearances under the National Environmental Protection Act.

5. Personnel of the Burns District Office will coordinate livestock grazing with permittees to accommodate the research effort.

6. No additional treatments or data gathering from researchers outside of the core scientific team will be allowed on the core treatments areas for at least 10 years following the beginning of the studies unless written agreements are developed and signed by all parties. This is to ensure the integrity of the experimental design will not be compromised.

Overall we strongly support this research because it addresses significant managerial needs within sagebrush ecosystems of the Intermountain West. We look forward to the co-development of this important project.

Sincerely,

Jeff Rose
Fire Ecologist
Burns Interagency Fire Zone

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

Lower Snake River District
3948 Development Avenue
Boise, Idaho 83705
http://www.id.blm.gov/offices/lsrd

TAKE PRIDE IN AMERICA

In Reply Refer To:
9217 (096)

JUN 14 2004

Dr. James McIver
Research Ecologist
PNW Research Station
USDA Forest Service
1401 Gekeler Lane
La Grande, Oregon 97850

Dear Dr. McIver:

This is a letter pledging the Lower Snake River District's support of the consortium proposal entitled "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome," being submitted to the Joint Fire Sciences Research Program.

The proposal addresses several of the Bureau of Land Management's science and research priorities including: 1) the control of invasive species and the restoration of native plant diversity on BLM lands, and 2) species at risk. In addition, due to accelerated acreages being consumed annually by wildfire, fuel reduction strategies that promote ecosystem health and reduce the risk of catastrophic wildfire are of great need on public lands of the western United States.

Currently, tens of millions of acres of sagebrush-dominated rangeland are at high risk to vegetation conversion. These includes low elevation sites which are at high risk to cheatgrass domination following wildfire, and higher elevation sites which are being lost to invasion by pinyon pines and junipers in the absence of fire. Loss of wildlife habitat, declines in livestock forage production, accelerated erosion, property loss and reduced aesthetics are just some of the potential negative impacts encountered when sagebrush ecosystems are lost to other species. Invasive weeds and pinyon-juniper encroachment are the greatest threats to the biological diversity of the Intermountain Region.

As an example of how important this research would be to BLM management, the U.S. Fish and Wildlife Service has determined that information in a recent petition provides substantial biological information to warrant a full status review of the greater sage grouse. This review will determine whether the greater sage grouse should be listed as a threatened or endangered species. Conversion of sagebrush grasslands has led to a reduction in suitable habitat for these native birds. If sage grouse were to be listed, BLM'S application of multiple-use management principles on many public land uses would almost certainly be impacted. The BLM needs research to assist us in determining appropriate methods that can be used to restore native habitats within the sagebrush ecosystem.

The nature of the research project will by necessity involve a cooperative and positive working relationship between managers and scientists. By this letter, the Lower Snake River District commits to support this research project. Generally, the District could commit the following:

1. We will apply the core treatments to a minimum of 25 to 50 acres for the juniper plots and/or 200 acres for the sagebrush/cheatgrass plots to locations mutually agreed upon by all parties. The three core treatments include fire, mechanical, and chemical control. The treatments on the juniper sites may be nested within a larger prescribed burn.

2. We will work with the investigators of this study to apply core treatments in the fall of 2006.

3. We will allow the three core treatment areas to be fenced at the expense of the study.

4. Personnel of the District will provide the necessary environmental clearances under the National Environmental Policy Act.

5. Personnel of this District will coordinate livestock grazing with permitees to accommodate the research effort.

6. No additional treatments or data gathering from researchers outside of the core scientific team will be allowed on the core treatments areas for at least 10 years following the beginning of the studies unless written agreements are developed and signed by all parties. This is to ensure the integrity of the experimental design will not be compromised.

If the research project is funded, the Lower Snake River District would propose developing a Memorandum of Agreement (or similar document) to detail specific commitments, as well as roles and responsibilities. Overall we strongly support this research because it addresses significant managerial needs within sagebrush ecosystems of the Intermountain West. We look forward to the co-development of this important project.

Sincerely,

Glen M. Secrist
District Manager

cc:
Rick Miller, Squaw Butte Research Station
Mike Pellant (ID-931)

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Ely Field Office
HC 33 Box 33500 (702 No. Industrial Way)
Ely, Nevada 89301-9408
http://www.nv.blm.gov/ely

TAKE PRIDE IN AMERICA

In Reply Refer To:
1150 (NV-040)

MAY 28 2004

Dr. James McIver
Research Ecologist
PNW Research Station
USDA Forest Service
1401 Gekeler Lane
La Grande, Oregon 97850

Dear Dr. McIver:

This is a letter pledging our Ely District's support of the consortium proposal entitled "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome," being submitted to the Joint Fire Sciences Research Program.

The proposal addresses several of the Bureau of Land Management's National and Western Science/Research Priorities including: 1) the control of invasive species and the restoration of native plant diversity on public lands, and 2) Bureau of Land Management Sensitive Species. In addition, due to accelerated acreages being consumed annually by wildfire, fuel reduction strategies that promote ecosystem health but reduce the risk of catastrophic wildfire are of great need on many public lands of the western United States.

Currently, tens of millions of acres of sagebrush-dominated rangeland are at high risk to vegetation conversion. These include low elevation sites which are at high risk of cheat grass domination following wildfire, and higher elevation sites which are being lost to invasion by pinyon pines and junipers in the absence of fire. Loss of wildlife habitat, declines in forage production, accelerated erosion, property loss and reduced aesthetics are just some of the potential negative impacts encountered when sagebrush ecosystems are lost to other species. Invasive weeds and pinyon juniper encroachment are the greatest threats to the biological diversity of the Intermountain Region. As an example of how important this research would be, discussions are currently underway to list the greater sage grouse as a threatened species under the Endangered Species Act. Conversion of sagebrush grasslands has led to a reduction in suitable habitat for these native birds. If sage grouse are listed as threatened, application of multiple-use management principles on many public land uses would almost certainly be impacted. The research would assist us in determining appropriate methods that can be used to restore native habitats within the sagebrush ecosystem.

The nature of this research project will by necessity involve a **cooperative and positive** working relationship between managers and scientists. Pending funding and the results of the environmental analysis and the prescribed burn plan, the Ely District commits the following support to this research project:

1. We will apply the core treatments to a minimum of 25 to 50 acres for the juniper and pinyon plots and/or 200 acres for the sagebrush/cheatgrass plots to locations mutually agreed upon by all parties. The three core treatments include fire, mechanical (consisting of cutting and dropping the trees with a chain saw), and control. The treatments on the pinyon juniper sites may be nested within a larger prescribed burn.

2. We will work with the investigators of this study to apply core treatments in the fall of 2006.

3. We will allow the three core treatment areas to be fenced at the expense of the study.

4. Personnel of this field office will conduct compliance and clearances under the National Environmental Policy Act.

5. Personnel of this district/field office will coordinate livestock grazing with permitees to accommodate the research effort.

6. No additional treatments or data gathering from researchers outside of the core scientific team will be allowed on the core treatments areas for at least 10 years following the beginning of the studies unless written agreements are developed and signed by all parties. This is to insure the integrity of the experimental design will not be compromised.

Overall we strongly support this research because it addresses significant managerial needs within sagebrush ecosystems of the Intermountain West. We look forward to the co-development of this important project.

Sincerely,

Stephanie Connolly

for Gene Kolkman
Ely Field Manager

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Elko Field Office
3900 East Idaho Street
Elko, Nevada 89801-4611
http://www.nv.blm.gov

TAKE PRIDE IN AMERICA

In Reply Refer To:
1120(NV-014)
JUL 1 2004

Dr. James D. McIver
USDA Forest Service, PNW Research Station
1401 Gekler Lane
La Grande, Oregon 97850

Dear Dr. McIver:

This is a letter pledging Elko Field Office's support of the consortium proposal entitled "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome," being submitted to the Joint Fire Sciences Research Program.

The proposal addresses several of the Bureau of Land Management's National and Western Science/Research Priorities including: 1) the control of invasive species and the restoration of native plant diversity on BLM lands, and 2) species at risk. In addition, due to accelerated acreages being consumed annually by wildfire, fuel reduction strategies that promote ecosystem health but reduce the risk of catastrophic wildfire are of great need on many public lands of the western United States.

Currently, tens of millions of acres of sagebrush-dominated rangeland are at high risk to vegetation conversion. These include low elevation sites which are at high risk ofcheatgrass domination following wildfire, and higher elevation sites which are being lost to invasion by pinyon pines and junipers in the absence of fire. Loss of wildlife habitat, declines in livestock production, accelerated erosion, property loss and reduced aesthetics are just some of the potential negative impacts encountered when sagebrush ecosystems are lost to other species. Invasive weeds and pinyon juniper encroachment are the greatest threats to the biological diversity of the Intermountain Region. As an example of how important this research would be to BLM management, discussions are currently underway to list the greater sage grouse as a threatened species under the Endangered Species Act. Conversion of sagebrush grasslands has led to a reduction in suitable habitat for these native birds. If sage grouse were to be listed as threatened, BLM'S application of multiple-use management principles on many public land uses would almost certainly be impacted. The BLM needs research to assist us in determining appropriate methods that can be used to restorenative habitats within the sagebrush ecosystem.

The nature of this research project will by necessity involve a **cooperative and positive** working relationship between managers and scientists. By this letter, the Elko BLM Field Office commits the following support to this research project:

1. We will apply the core treatments to a minimum of 25 to 50 acres for the juniper and pinyon plots to locations mutually agreed upon by all parties. The three core treatments include fire, mechanical (consisting of cutting and dropping the trees with a chain saw), and control. The treatments in the pinyon juniper sites may be nested within a larger prescribed burn.

2. We will work with the investigators of this study to apply core treatments in the fall of 2006. (or earlier if necessary)

3. We will allow the three core treatment areas to be fenced at the expense of the study. The fenced area will be between 25 to 50 acres in size and will be maintained by the study.

4. Personnel of the Elko field office will provide the necessary environmental clearances under the National Environmental Protection Act.

5. Personnel of the Elko field office will coordinate livestock grazing with permitees to accommodate the research effort.

6.No additional treatments or data gathering from researchers outside of the core scientific team will be allowed on the core treatments areas for at least 10 years following the beginning of the studies unless written agreements are developed and signed by all parties. This is to insure the integrity of the experimental design will not be compromised. Elko field office personnel would be allowed to join the core scientific team during visits and or monitoring of the core treatment areas.

Overall we strongly support this research because it addresses significant managerial needs within sagebrush ecosystems of the Intermountain West. We look forward to the co-development of this important project.

If you have any questions please contact me or Joe Freeland of my staff at (775) 753-0200.

Sincerely,

Helen Hankins

Helen Hankins
Field Manager

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Battle Mountain Field Office
50 Bastian Road
Battle Mountain, Nevada 89820
http://www.nv.blm.gov

In Reply Refer To:
9210
(NV-064)

MAR - 2 2004

Ms. Jeanne C. Chambers, Research Ecologist
USDA Forest Service
Rocky Mountain Research Station
920 Valley Road
Reno, Nevada 89512

Dear Ms. Chambers:

I would like to thank you and the rest of those present for what I felt was a very productive meeting in Winnemucca on February 10th.

My staff and I look forward to working with you and the Rocky Mountain Research Station staff to complete research located on Public Lands within the Battle Mountain Field Office's jurisdiction.

I wish to state that the Battle Mountain Field Office whole heartedly supports the concept of the research proposal and a partnership in moving this proposal forward to the Joint Fire Sciences Program (JSFP) for funding.

The Battle Mountain Field Office has several potential prescribed fire projects and other vegetation manipulation projects that may meet your needs in gaining the JFSP's funding and support. As my staff identified, the project furthest along in the permitting/planning stages is the 7 Mile Hazard Fuels Reduction Project; but other projects are possible. We look forward to our March 16th meeting to further discuss these potential research projects.

To the extent that this office may, my staff and I will endeavor to work with you and your staff to complete the planning and clearances necessary to implement a JSFP project.

Please contact either Dave Davis, Fire Management Officer, Chad Lewis, Fuels Program Manager, or Donovan Walker, Fire Ecologist at (775) 635-4000 should you need further information about this correspondence.

Sincerely,

Mark Stenger

for Gerald M. Smith
Field Manager

cc: Paul Flannigan, Acting
District Ranger
Austin Ranger District
P.O. Box 130
Austin, Nevada 89310

United States Department of Agriculture **Forest Service** **Wasatch-Cache National Forest** **125 South State Street**
Federal Building, Room 8236
Salt Lake City, Utah 84138

File Code: 4200, 4300
Date: April 12, 2004

Dr. James McIver
Research Ecologist
Pacific Northwest Research Station
USDA Forest Service
1401 Gekeler Lane
La Grande, OR 97850

Dear Dr. McIver

This is a letter of support from our Forest for the consortium proposal entitled "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome," being submitted to the Joint Fire Sciences Research Program.

The proposal addresses several of the Forest Service Chief's priorities including: 1) the control of invasive species (non-native and destructive weeds, insects and other pests); and 2) what can be done to reduce the size and power of wildfire on National Forest lands.

The Great Basin and Range has lost many acres of low elevation sagebrush to cheatgrass and higher elevation sagebrush to juniper and pinyon pine invasion. And more acres are currently at risk for vegetation conversion. We have investigated the potential for wildlife habitat restoration projects in the Stansbury Mountains, where juniper have successfully replaced thousands of acres of sagebrush. The Forest welcomes this important research, which will ultimately help us and other Forests and State and Federal agencies to use the best methods to restore native habitats within this sagebrush zone.

Overall we strongly support this research because it addresses significant managerial needs within sagebrush ecosystems of the Intermountain West. We look forward to the co-development of this important project and working agreement.

Sincerely,

FAYE L. KRUEGER
Deputy Forest Supervisor

cc: Loren M Kroenke

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Salt Lake Field Office
2370 South 2300 West
Salt Lake City, UT 84119

www.ut.blm.gov/saltlake_fo

TAKE PRIDE IN AMERICA

JUL 29 2004

Dr. James McIver
Research Ecologist
PNW Research Station
USDA Forest Service
1401 Gekeler Lane
La Grande, Oregon 97850

Dear Dr. McIver

This is a letter pledging our Field Office's support of the consortium proposal entitled "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome," being submitted to the Joint Fire Sciences Research Program.

The proposal addresses several of the Bureau of Land Management's National and Western Science/Research Priorities including: 1) the control of invasive species and the restoration of native plant diversity on BLM lands, and 2) species at risk. In addition, due to accelerated acreages being consumed annually by wildfire, fuel reduction strategies that promote ecosystem health but reduce the risk of catastrophic wildfire are of great need on many public lands of the western United States.

Currently, tens of millions of acres of sagebrush-dominated rangeland are at high risk to vegetation conversion. These includes low elevation sites which are at high risk to cheatgrass domination following wildfire, and higher elevation sites which are being lost to invasion by pinyon pines and junipers in the absence of fire. Loss of wildlife habitat, declines in livestock production, accelerated erosion, property loss and reduced aesthetics are just some of the potential negative impacts encountered when sagebrush ecosystems are lost to other species. Invasive weeds and pinyon juniper encroachment are the greatest threats to the biological diversity of the Intermountain Region. As an example of how important this research would be to BLM management, discussions are currently underway to list the greater sage grouse as a threatened species under the Endangered Species Act. Conversion of sagebrush grasslands has led to a reduction in suitable habitat for these native birds. If sage grouse were to be listed as threatened, BL'M'S application of multiple-use management principles on many public land uses would almost certainly be impacted. The BLM needs research to assist us in determining appropriate methods that can be used to restore native habitats within the sagebrush ecosystem.

The nature of this research project will by necessity involve a **cooperative and positive** working relationship between managers and scientists. By this letter, the Salt Lake Field Office commits the following support to this research project:

Specifications for PJ

1. Treatments
   A. Basic treatments with optimum areas
      a. Control – 25-50 acre core monitoring plot nested within larger experimental area.
      b. Fall prescribed fire – 1000 acre mosaic; 25-50 acre core monitoring plot that is 100% black.
      c. Mechanical -25-50 acre core monitoring plot nested within larger experimental area; clearcut areas down to 1/2 m in height; cut and leave on the contour
   B. Basic treatments with minimum areas
      a. Control -100 acres total; 25-50 acre core monitoring plot
      b. Fall prescribed fire -100 acres total; 25-50 acre core monitoring plot that is 100% black
      c. Mechanical -100 acres total; 25-50 acre core monitoring plot; clearcut down to ½ m in height; cut and leave on contour
2. No prescribe fire in mechanical, no mechanical in prescribed fire, no mechanical or prescribed fire in the control for at least 10 years.
      a. Any further treatment needs to be agreed on by all parties
3. Focus on Loamy 12-14" ecological sites
4. Fencing required around all three core monitoring plots, but will be paid for by study.
5. Specifications of Hydrology
      a. Need to be flexible with clearcut location with advice from hydrologist
6. Final site selection and setup in spring through summer 2005
7. Pretreatment sampling in summer 2006; implementation in fall 2006

Specification for Sage

1. Treatments
      a. Control -200 acres
      b. Prescribed fire -200 acres; low severity fire in the fall throughout the unit, 100% black
      c. Herbicide (Tebuthiuron) -200 acres; fall application; 50% sage kill
      d. Mechanical (roller-harrow) -200 acres; 50% sage kill
      e. Herbicide (plateau) treatments nested within each of the four treatment units; fall application; 20, 0.1 ha plots within each treatment unit; equivalent to about 20 acres combined for all four treatment units; dependent upon EIS approval
2. 200 acre fenced enclosures for each of the four treatment units, managers to commit to 10 years (changes negotiated)
3. Focus on Loamy 10-12" ecological sites
4. Fencing required around all four treatment units, but will be paid by study 5. Final site selection and setup in spring through summer 2005
5. Final site selection and setup in spring through summer 2005.
6. Pretreatment sampling in summer 2006, implementation in fall 2006.

Over all we strongly support this research because it addresses significant managerial needs within sagebrush ecosystems of the Intermountain West. We look forward to the co-development of this important project.

Sincerely,

Glenn A. Carpenter
Field Office Manager

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Cedar City Field Office
176 East DL Sargent Drive
Cedar City, UT 84720
Telephone (435) 586-2401
www.ut.blm.gov/cedar_city/

TAKE PRIDE® IN AMERICA

In Reply Refer To:
UT-042
9200

July 22, 2004

Dr. James McIver, Research Ecologist
PNW Research Station
USDA Forest Service
1401 Gekeler Lane
La Grande, OR 97850

RECEIVED
JUL 26 2004
La Grande, Oregon

Dear Dr. McIver:

I am writing to express my desire to partner in this valuable research effort and show this office's support of the consortium proposal entitled, "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome" being submitted to the Joint Fire Sciences Research Program.

The proposal addresses several of the Bureau of Land Management's National and Western Science/Research Priorities including: 1) the control of invasive species and the restoration of native plant diversity on BLM lands; and 2) species at risk. In addition, due to accelerated acreages being consumed annually by wildfire, fuel reduction strategies that promote ecosystem health but reduce the risk of catastrophic wildfire are of great need on many public lands of the western United States.

The nature of this research project will, by necessity, involve a **cooperative and positive** working relationship between managers and scientists. By this letter, the Cedar City Field Office indicates willingness to support to the extent possible, this research project.

The Cedar City Field Office is currently in various phases of planning, implementation, and monitoring of several large scale projects that may provide a selection of the sites suitable for conducting this research. I would like to encourage you and your research associates to participate in site visits with members of my staff to determine if any of these sites would be feasible for your study. Also, any of our existing treatment areas and monitoring data that may provide information valuable to your research could and should be reviewed.

As you know, we have many partners, cooperators, permittees, and users of the public lands that also have expectations of us and these project areas. Specific time frames for treatments, fencing, and data collection could affect site selection and/or follow up management on selected areas. Also, the timing of activities such as prescribed fire and even mechanical treatments can be dictated to a degree by weather, availability of contractors, and funding as well as seasonal restrictions for wildlife and other factors.

As for the requirements for no fire within portions of the study areas and specifically the control areas, I can make no guarantee that these areas will not be affected by wildfire for the entire ten year study period. Also, 200-acre complete black areas can be difficult to achieve under low severity fall burning conditions. Again, I would encourage you to review with my staff, the areas identified for these types of treatment within the Field Office and determine the suitability of these areas that may have NEPA and associated clearances in place.

Overall, we strongly support this research because it addresses significant managerial needs within sagebrush ecosystems of the Intermountain West. We look forward to the co-development of this important project.

Sincerely,

Todd S. Christensen
Field Office Manager

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
FILLMORE FIELD OFFICE
35 East 500 North
Fillmore, Utah 84631

TAKE PRIDE IN AMERICA

In Reply Refer to:
9200
(U-010)

June 23, 2004

DR. JAMES MCIVER
RESEARCH ECOLOGIST
PNW RESEARCH STATION
USDA FOREST SERVICE
1401 GEKELER LANE
LA GRANDE OREGON 97850

Dear Dr. McIver:

The Fillmore Field Office of the Bureau of Land Management (BLM) appreciates the opportunity to be a cooperator with the Joint Sciences Research Program (JSRP) in "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome". Your trip to the field office area gave the specialist a better understanding of the research you plan to conduct and the possible sites that would meet your requirements. As you and my staff discussed on the field trip, your research would be coordinated with the fuels treatments being implemented in the years 2004, 2005 and 2006 by the fuels team.

After looking at three possible sites for your proposal, the Scipio, Utah (see attached map) site appears to be the most suitable. As the work is implemented, JSRP could take advantage of these efforts and set up the study plots as needed at little or no cost. This site was selected for two reasons.

- As agreed in our field trip, that particular juniper/big sagebrush ecosystem appeared to meet the criteria you need for studying the impacts of fire and mechanical treatments.
- The BLM, under the Wild land Urban Interface Program, is in the process of planning a series of controlled burns and mechanical treatments in the area; therefore, the Joint Sciences Research Program (JSRP) would be on the ground floor of this planning effort.

The planning is now in progress and some mechanical treatments will be done in 2004, you will need to contact this office as soon as possible to be a partner in the planning effort. I encourage you to be on site to identify the plot locations before implementation begins late summer and fall of 2004.

I look forward to this cooperative effort, between the BLM Fillmore Field Office and the Joint Fire Sciences Research Program. By this letter, I am willing to commit the following support for this project:

- The BLM plans to conduct vegetative treatments on approximately 3600 acres of public lands east of Scipio, Utah. The planned treatments include controlled burning, tree cutting, and vegetation chopping. The BLM would authorize the Joint Sciences Research Program (JSRP) to conduct research on 300 acres of the treated lands. There would be approximately 100 acres of each type of treatment identified for JSRP to establish study plots. All of the lands would remain open for BLM to manage under multiple use management policies. The BLM fire crew would conduct the burning, chopping and tree thinning processes.

- The BLM would authorize the fencing of three, 25 acre study enclosures, each 100 acre treatment areas. Fences would be installed in accordance with BLM fencing standards and stipulations.

- The BLM would prepare needed environmental documents, including clearances, cooperative agreements etc.

- The BLM would contact users of the public lands involved to ensure cooperation with the research project. This could include taking livestock off the treated acres for at least two vegetative growing seasons.

- The BLM and JSRP would work together to determine the fire severity, percent kill of plant species for each treatment, number of plots, fencing standards and times for treatment applications.

The Fillmore Field Office supports this research project due to its importance in the future management of the sagebrush ecosystems throughout the Intermountain West. My staff and I look forward to the development of this project.

Sincerely,

Sherry K. Hirst
Field Office Manager

Enclosure
Map

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Shoshone Field Office
400 West F Street
Shoshone, Idaho 83352-5284
(208) 732-7200

In Reply Refer To:
6711

May 2, 2004

Dr. James McIver
Research Ecologist
Pacific Northwest Research Station
USDA Forest Service
1401 Gekeler Lane
La Grande, Oregon 97850

Dear Dr. McIver:

This is a letter pledging the Upper Snake River Districts/Shoshone Field Office support of the consortium proposal entitled "Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome," being submitted to the Joint Fire Sciences Research Program.

The proposal addresses several of the Bureau of Land Management's National and Western Science/Research Priorities including: 1) the control of invasive species and the restoration of native plant diversity on BLM lands, and 2) species at risk. In addition, due to accelerated acreages being consumed annually by wildfire, fuel reduction strategies that promote ecosystem health but reduce the risk of catastrophic wildfire are of great need on many public lands of the western United States.

Currently, tens of millions of acres of sagebrush-dominated rangeland are at high risk to vegetation conversion. These includes low elevation sites which are at high risk to cheatgrass domination following wildfire, and higher elevation sites which are being lost to invasion by piñon pines and junipers in the absence of fire. Loss of wildlife habitat, declines in livestock production, accelerated erosion, property loss and reduced aesthetics are just some of the potential negative impacts encountered when sagebrush ecosystems are lost to other species. Invasive weeds and piñon juniper encroachment are the greatest threats to the biological diversity of the Intermountain Region.

As an example of how important this research would be to BLM management, the US Fish and Wildlife Service is currently conducting a full status review of the greater sage grouse. This status review will determine whether the greater sage grouse warrants listing as a threatened or endangered species under the Endangered Species Act. Conversion of sagebrush grasslands has led to a reduction in suitable habitat for these native birds. Whether the greater sage grouse becomes a listed species or not, BLM's application of multiple-use management principles on many public land uses will almost certainly be impacted. The BLM needs research to assist us in determining appropriate methods that can be used to restore native habitats within the sagebrush ecosystem.

The nature of this research project will by necessity involve a **cooperative and positive** working relationship between managers and scientists. By this letter, the Upper Snake River District/Shoshone Field Office commits the following support to this research project:

1. We will apply the core treatments to a minimum of 200 acres for the sagebrush/cheatgrass plots to locations mutually agreed upon by all parties. The three core treatments include fire, mechanical, and control.

2. We will work with the investigators of this study to apply core treatments in the fall of 2006.

3. We will allow the three core treatment areas to be fenced at the expense of the study.

4. Personnel of the Shoshone Field Office will provide the necessary environmental clearances under the National Environmental Protection Act.

5. Personnel of the Shoshone Field Office will coordinate livestock grazing with permittees to accommodate the research effort.

6. No additional treatments or data gathering from researchers outside of the core scientific team will be allowed on the core treatments areas for at least 10 years following the beginning of the studies unless written agreements are developed and signed by all parties. This is to insure the integrity of the experimental design will not be compromised.

Overall we strongly support this research because it addresses significant managerial needs within sagebrush ecosystems of the Intermountain West. We look forward to the co-development of this important project. Please contact Joe Russell at (208) 732-7290 for any questions or additional support.

Sincerely,

Bill Baker
Field Office Manager

cc:
K Lynn Bennett (ISO 910)
Andy Payne (ISO 910)
Joe Kraayenbrink (ID 070)
Susan Giannettino (ISO 930)
Mike Pellant (ISO 930)
John Foster (ISO 931)
Krista Gollnick-Waid (ISO 932)
Mark Jones (ISO 932)
Rick VanderVoet (ID 079)
Jim Morris (NPS CRMO)

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
VALE DISTRICT
100 Oregon Street
Vale, Oregon 97918
http://www.or.blm.gov/Vale/

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
9212

JUN - 4 2004

Dr. James McIver
Research Ecologist
PNW Research Station
USDA Forest Service
1401 Gekeler Lane
La Grande, Oregon 97850

Dear Dr. McIver:

The Vale District, Oregon, Bureau of Land Management (BLM), supports the Joint Fire Sciences Research Program's (JFSP) proposal entitled "*Evaluating the Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome*".

The proposal addresses several BLM National and Western Science/Research Priorities, which are also local concerns, including: 1) the control of invasive species and the restoration of native plant diversity on public lands, and 2) species at risk. In addition, due to accelerated acreages being consumed annually by wildfire, fuel reduction strategies that promote ecosystem health but reduce the risk of catastrophic wildfire are of great need on our public lands in the Vale District.

Loss of ecosystem function and wildlife habitat, accelerated erosion, property loss and reduced aesthetics are just some of the negative impacts encountered when our at-risk sagebrush communities are lost to other species. Invasive weeds and juniper encroachment are a great threat to the biological diversity and productivity of the sagebrush communities we manage. BLM needs the kind of research identified in the JFSP proposal to assist us in determining appropriate methods to use in restoring native habitats within the sagebrush ecosystem.

The nature of this research project will by necessity involve a cooperative and positive working relationship between managers and scientists. We would like to commit the following support to this research project:

1. Vale BLM District in Oregon will, in the course of normal operations, provide JFSP scientists with core treatments ranging in size from 25 to 50 acres each for western juniper research plots, and core treatments of 200 acres each in lower elevation sagebrush communities. The core treatments include fire, mechanical, and an untreated control. The treatment locations will mutually agreed upon by all parties.

2. BLM will work with JFSP investigators of this study planning and applying core treatments in the fall of 2006.

3. BLM will allow the core treatment areas to be fenced at JFSP expense.

4. BLM will complete the necessary environmental clearances under the National Environmental Protection Act for the projects.

5. BLM will coordinate livestock grazing with permitees to accommodate the research effort.

6. To insure the integrity of the experimental design, no additional treatments or data gathering from researchers other than those working with JFSP will be allowed on the core treatments areas for at least 10 years following the beginning of the studies unless agreed upon, in writing, by all parties.

We strongly support this research because it addresses significant managerial needs within sagebrush ecosystems in the Vale District. We look forward to working with JFSP in facilitating this important research and anticipate periodic updates on scientific findings and the final research results.

Sincerely,

Larry Frazier

-for- David R. Henderson
Vale District Manager

APPENDIX 4B: EXAMPLE MOU

(MOUs would succeed the Letters of Intent provided in Appendix 4A)

MEMORANDUM OF UNDERSTANDING
BETWEEN
UNITED STATES DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT,??? Field Office
AND
USFS Pacific Northwest Research Station or ???
CONCERNING
A REGIONAL EXPERIMENT TO EVALUATE THE EFFECTS OF FIRE AND FIRE SURROGATE TREATMENTS IN THE SAGEBRUSH BIOME

I. PURPOSE: Conduct research on the effectiveness of fire and fire surrogate treatments on reducing the dominance of several invasive species thereby restoring land health in the Great Basin sagebrush biome.

II. OBJECTIVES:

(1) Identify the abiotic and biotic thresholds that determine sustainability of big sagebrush plant communities in sagebrush-steppe and sagebrush semi-desert environments, specifically related to threats posed by cheatgrass and pinyon-juniper invasion;

(2) Assess the ecological effects of fire and fire surrogates on big sagebrush communities at risk of crossing a threshold of conversion to cheatgrass or pinyon-juniper, beyond which restoration may be difficult or logistically infeasible;

(3) Evaluate the effectiveness of supplemental restoration treatments (revegetation) needed to prevent big sagebrush communities from crossing the threshold, and to ultimately restore these communities to sustainable states;

(4) Portray the ecological, social, and economic trade-offs and treatment effects of no action, applying only fire and fire surrogate treatments, and restoration treatments in these sagebrush communities;

(5) Document how fuel loads change across vegetation treatments and ecological sites in relation to the objectives above; and

(6) Provide insight and guidance regarding use of our results for effective multi-species and multi-scale planning as part of ecosystem management of sagebrush communities in the Great Basin.

III. AUTHORITY:

Federal Land Policy and Management Act of 1976 (Public Law 94-579), Section 307 (b)), which authorizes cooperative agreements for the management and development of public lands.

IV. PROCEDURES:

The Management Unit agrees to:

1. Apply the core treatments to a minimum of 25 to 50 acres for the juniper and pinyon plots and/or 200 acres for the sagebrush/cheatgrass plots to locations mutually agreed upon by all parties. The three core treatments include fire, mechanical (consisting of cutting and dropping the trees with a chain saw), and control. The treatments on the pinyon juniper sites may be nested within a larger prescribed burn.

2. Work with the investigators of this study to apply core treatments in the fall of 2006.

3. Allow the three core treatment areas to be fenced at the expense of the study.

4. Provide the necessary environmental clearances under the National Environmental Protection Act.

5. Coordinate livestock grazing with permitees to accommodate the research effort.

6. Conduct no activities within the core treatment areas for at least 10 years following the beginning of the studies unless written agreements are developed and signed by all parties. This is to insure the integrity of the experimental design will not be compromised.

The Researcher Unit agrees to:

1. Collect cover and composition data from studies established in the prescribed burn and mechanically manipulated area.
2. Analyze and provide summaries of all data collected (including GPS coordinates and photos) from the Big Sage Basin treatments.

V. ADMINISTRATION:

A. Nothing in this MOU will be construed as affecting the authorities of either party, or as binding beyond their respective authorities or to require any of the employees of either party to obligate or expend funds in excess of available appropriations. Such endeavors will be outlined in separate agreements that shall be made in writing by representatives of the parties and shall be independently authorized by appropriate statutory authority. This instrument does not provide such authority. Specifically, this instrument does not establish authority for noncompetitive award to the cooperator of any contract or other agreement. Any contract or agreement for other services must fully comply with all applicable requirements for competition.

B. Conflicts between the parties concerning procedures under the MOU which cannot be resolved at the operational level will be referred to the next higher lever, as necessary, for resolution.

C. The terms of this MOU may be renegotiated at any time at the initiative of either party, following at least 30 days written notice to the other party.

D. Either party may propose changes to this MOU during its term. Such changes will be in the form of a written modification and will become effective upon signatures of both parties.

E. Either party, upon mutual agreement, in writing, may terminate the instrument in whole, or in part, at any time before the date of expiration.

F. This instrument in no way restricts the parties from participating in similar activities with other public or private agencies, organizations, and individuals.

G. Pursuant to Section 22, Title 41, United States Code, no member of, or Delegate to, Congress shall be admitted to any share or part of this instrument, or nay benefits that may arise therefrom.

H. The need for this MOU is expected to continue for 5 years, at the end of which period it will expire, unless canceled, extended, or renewed.

I. The MOU will become effective upon signatures by all of its participants.

VI. PRINCIPAL CONTACTS:

Name	Name
BLM Field Office Resource Contact	Local Project Scientist or Project Leader

VII. APPROVED:

Name	Name
BLM Field Office Manager or District Manager	JFS Project Leader

APPENDIX 4C

LIST OF ATTENDEES AT MANAGER WORKSOPS

BLM State Office -- Salt Lake City, Utah; 12 January 2004

Name	Job Title	Contact Information
Verlin Smith	Branch Chief Renewable Resources	Verlin_Smith@ut.blm.gov
Steve Madsen	Wildlife Biologist	Steve_C_Madsen@blm.gov
Lisa Bryant	Soils/Weeds	lisa.Bryant@blm.gov
Larry Lichthardt	Rangeland Mgt Specialist	larry_lichthardt@ut.blm.gov
Sheldon Wimmer	Branch Chief Fire and Aviation	swimmer@ut.blm.gov
Jolie Pollet	Fire Ecologist	jpollet@ut.blm.gov

Sage Group Reps: McIver, Roundy, Schupp

BLM State Office -- Boise, Idaho, 15 January 2004

Name	Job Title	Contact Information
Tom Wordell	JFSP Tech Trans Specialist	Tom_Wordell@nifc.blm.gov
Jeff Lord	Idaho Cattlemen's Association	jeff@andersonbolen.com
Glen Secrist	District Mgr, Boise District	glen.secrist@blm.gov
K. Lynn Bennett	BLM State Director	208-373-4001
Mark Hilliard	BLM -- Fish, Wildlife, Botany	208-373-4040
Rich Howard	USFW Service	208-378-5297
Roger Roentreter	ISO -- BLM	208-3733824
Jenna Whitlock	Field Mgr, Owyhee Field Office	jenna_whitlock@blm.gov
Susan Giannettino	Deputy Director Resources, Idaho BLM	susan_giannettino@blm.gov
Jon Foster	Branch Chief, Resources, Sciences, BLM	jon_foster.blm.gov
Lou Lunte	Director Conservation Programs -- TNC	llunte@tnc.org
Art Talsma	TNC	atalsma@tnc.org; 343-8826, ext15

Sage Group Reps: McIver, Pellant, Pierson

BLM State Office, FS Region 6 Office -- Portland, Oregon, 15 January 2004

Name	Job Title	Contact Information

Cliff Fanntwell	OSO, BLM	cfanntwl@or.blm.gov
Terry Johnson	OSO, BLM	Terry_1_Johnson@blm.gov
Steven Buttrick	The Nature Conservancy	sbuttrick@tnc.org
Louisa Evers	OSO, BLM	Louisa_Evers@or.blm.gov
Mark Barrington	Oregon Dept. Agriculture (503-986-4715)	mbarring@oda.state.or.us
Tom DeMeo	Forest Service Region 6 (503-808-2963)	tdemeo@fs.fed.us
Jim Alegria	BLM, Forest Service (503-808-6090)	jalegria@fs.fed.us
Miles Brown	BLM (503-808-6357)	m1brown@blm.gov
Ray Jaindl	Oregon Dept. Agriculture (503-986-4713)	rjaindl@oda.state.or.us
Nancy Phelps	Forest Service Region 6 (503-808-2940)	nphelps@fs.fed.us

Sage Group Reps: Doescher, Barrett

Wasatch-Cache National Forest

Name	Job Title	Contact Information
Diane Probasco	Wildlife Biologist, SLC District	801-733-2667
Mike Duncan	Botanist	801-524-3915
Wayne Padgett	Ecologist	801-524-3943
Faye Krueger	Deputy Forest Supervisor	801-524-3905
Richard Williams	Wildlife Biologist	801-524-3941
Paul Flood	Soil Scientist	801-524-3940
Charlie Condrat	Hydrologist	801-524-3939
Lauren Kroenke	Salt Lake District Ranger	801-733-2675

BLM Field Office -- Salt Lake City, Utah

Name	Job Title	Contact Information
Pam Schuller	Rangeland Mgt Specialist	801-977-4356; pschuller@ut.blm.gov
Lesley Tullis	Fuels Technician	801-977-4337 Lesley_Tullis@blm.gov
Brook Chadwick	Fuel Mgt Specialist	801-977-4311 Brook_Chadwick@blm.gov
Gary Kidd	Emergency Stabilization/Weeds	801-977-4375 Gary_Kidd@blm.gov
Glenn Carpenter	Field Office Manager	801-977-4375 gcarpenter@ut.blm.gov

---

Shoshone BLM Field Office -- Shoshone, Idaho

Name	Job Title	Contact Information
Rick Vander Vort	Craters of the Moon National Monument and BLM	Richard_Vandervort@ blm.gov
Gary Wright	BLM	Gary_Wright@blm.gov
Cody Martin	BLM	Cody_Martin@blm.gov
Dan Patten	BLM	Dan_Patten@blm.gov
Joe Russell	BLM	Joeseph_Russell@blm.gov
Alan Sands	TNC	asands@tnc.org

Vale BLM District Office, Vale, Oregon, April 27, 2004

Name	Job Title	Contact Information
Steve Christistsen	BLM	stevechristensen@or.blm.gov
Tom Hilken	BLM-Vale	thilken@or.blm.gov
Jean Findley	BLM-Vale	jean_findley@or.blm.gov
Randy Eyre	BLM-Vale	randy_eyre@or.blm.gov
Tom Dabbs	BLM-Vale	tom_dabbs@or.blm.gov
Mitch Thomas	BLM-Vale	mitcheltthomas@or.blm.gov
Chip Fannish	OSO-BLM	cfannish@or.blm.gov
Jon Sadowski	BLM-Vale	jon_sadowski@or.blm.gov
Ron Rembowski	BLM-Vale	ron_rembowski@or.blm.gov
Jack Wenderoth	BLM-Vale	jack_wenderoth@or.blm.gov

Sage Group Reps: Doescher, Barrett

Ely Field Office - BLM; Ely District - Humboldt-Toiyabe National Forest, May 2004

Name	Job Title	E-Mail
Meg Jensen	Deputy State Director, Nevada BLM	mjensen@nv.blm.gov
Chris Mayer	Dist. Range Management Specialist	cmayer@nv.blm.gov
William E. Dunn	Fire Management Officer	wdunn@nv.blm.gov
Patricia Irwin	Ely District Ranger	pirwin@fs.fed.us
Paul T. Flanagan	Austin District Acting Ranger	pflanagan@fs.fed.us
Barbara Walker	Resource Forester, Ely District	bcwalker@fs.fed.us
Lucas Phillips	Rangeland Management Specialist Ely District	ljphillips@fs.fed.us
William Morrill	Chair, ENLC Science Committee	wimorrilnv@aol.com
Tara Forbis	Plant Ecologist, Nature Conservancy	tforbis@tnc.org
Dave Tart	Regional Ecologist	dtart@fs.fed.us
Curt Johnson	Rangeland Specialist	cjohnson@fs.fed.us

Clint Williams	Plant Ecologist	cwilliams@fs.fed.us
Clint McCarthy	Wildlife Ecologist	cmccarthy01@fs.fed.us
Teresa Prendusi	Regional Botanist (rare plants)	tprendusi@fs.fed.us
Steven Winward	GIS Specialist	swinward@fs.fed.us
Dr. Roger Rosentreder	BLM Botanist, Boise State Office	

APPENDIX 5

Technical Review Comments and Reconciliation

Technical Reviewers

Steve Archer, Range Ecologist
BESE 325
School of Natural Resources
University of Arizona
Tucson, AZ 85721-0043
sarcher@ag.arizona.edu

Thomas Holmes, Economist
Forestry Sciences Laboratory
3041 Cornwallis Rd.
Research Triangle Park, NC 27709
tholmes@fs.fed.us

Patricia Kennedy, Wildlife Ecologist
Eastern Oregon Agricultural Research Station
Oregon State University
Union, OR 97883
pat.kennedy@oregonstate.edu

Bob Nowak, Ecophysiologist
Mail Stop 370
1664 N. Virginia Street
University of Nevada
Reno, Nevada 89557
Nowak@cabnr.unr.edu

Brad Wilcox, Hydrologist
Rangeland Ecology and Management
2126 TAMU
Texas A&M University
College Station, Texas 77843
bwilcox@tamu.edu

Comments and Reconciliation

The following is a summary reconciliation of the major comments and concerns expressed by the five reviewers. Minor editorial comments were considered individually and for the most part, were adopted in the revision.

Steve Archer

1) The Executive Summary read very well and was a clear road map of the proposed program. I really like the overall approach of asking a common set of questions and proposing a series of coordinated interdisciplinary studies for a regional network of sites and using a common methodology. Bravo! I was part of an international program that used this sort of approach for studying savannas worldwide. The problem was that we had no common or reliable funding threads; so each scientist was left to his/her own devices and initiative. Thus, while a lot of good ideas emerged from this program, there was little follow-up field testing. The approach outlined in the Exec Sum has a lot of real potential given that there is the prospect of funding to make this effort work.

2) From my read of the proposal, it is not clear that Objective 1 will really be addressed (see Comment 14); however, a reader of the Exec Sum won't know that.
Meeting Objective 1 is clearly critical for the successful completion of this project. So Dr. Archer's comment here required us to completely rethink and rewrite the section on 'Experimental Approach', including the addition of Figure 6. Basically, we believe that our scheme of establishing sub-plots that range across a variety of soil and vegetation conditions, will allow us to effectively identify thresholds. The variables we chose to measure will be the metrics that we use to gauge whether or not a treatment has caused the vegetation or soils within a given sub-plot to move in the desired direction.

3) Objective 4 seems a bit vague; the word 'portray' is too soft. Use a word or phrase that is more aggressive and more action oriented. How does objective 4 relate to the 'combined dynamic ecological-economic model' mentioned on p. 14, line 28? Item 4 on p. 14 reads like a major objective.
The dynamic model mentioned as one of the key 'features' of the project, is a product that will arise from the completion of objectives 4 and 5.

9) One of the attractive aspects of the proposal is its stated emphasis on using an interdisciplinary approach in a premeditated fashion (e.g., p. 2, p. 10, Fig. 4). This sounds great, but unfortunately, the text of the Research Approach section and Appendix 2, read more like a series of independent investigations that will go on simultaneously and share some common study sites rather than a truly interdisciplinary project *per se*. There is some good "hand-waving" re: interdisciplinary research, but there was not a clear roadmap of how interdisciplinarity will be achieved. Part of the problem might be that the disciplines are largely relegated to their own subsections in the Research Approach and Appendix 2. I don't think a major re-structuring warranted; but the proposal would be strengthened and the interdisciplinary emphasis would have more credibility if there was, on pages 23-26, (a) cross-referencing among the sub-sections to explicitly illustrate how the various disciplines will interact and (b) explicit indications of feedbacks and how information or data generated

by one group might be used by (and is critical to) another group(s), etc. See also Comment 36.
The most important feature of this study that will allow us to analyze and interpret our data in an interdisciplinary fashion is that all variables will be collected from the same sub-plot grid, at the same time and in the same place. Use of multivariate techniques such as structural equation modeling will then allow us to build models that not only show response of key variables to treatments, but will show how key co-variables are effected as well, including how they interact with the key response variables.

10) The types of data to be gathered (p. 22) and the specifics of their collection (Appendix 2) were fairly general laundry lists. It was difficult to evaluate the specific merits of the research approach, given that there were not well-defined questions or hypotheses accompanying the six objectives. Based on the material presented, it is not clear how the data collected in the 7 areas listed on p. 22 would be used or if the data in one of the 7 areas would be collected at a spatial or temporal scale appropriate to enable it to be meaningfully used in one or more of the other 6 areas. Indeed, on p. 3, line 5, we are told there is a spatial scale disconnect between the economic and ecological components; but later (p. 14, line 28) we are told that a 'combined dynamic ecological-economic model' will be calibrated (no details given). The proposal would be strengthened if you could develop a series of cross-cutting questions and hypotheses for each objective (in other words, make at least some of them interdisciplinary) and for each of the 'Analysis' subsections (Ecological, Economics, Sociopolitical); and then tailor the general approach around addressing these. Doing this would also help address the problem outlined in Comment 9. As written, the proposal has a large 'trust us' component.
Our road map for eventual implementation of this study will include several meetings during which we will develop specific questions and hypotheses. This is a big chore, and needs to be accomplished as we simultaneously consider analytic techniques. We believe that the time will be ripe for this step within the next year or so, prior to the collection of any pre-treatment data.

11) The proposal does an excellent job of extolling the benefits of the experimental approach applied at a regional scale (p. 15). However, experimentation also has its limitations in studies of complex systems. So, to be fair, it should not be over-stated. A more illuminating approach would be to keep the experimental focus, but with the expressed intent of looking for creative ways to tie that in with retrospective studies (this is alluded to on p. 15, line 4-5, but is not explicitly incorporated into the Research Approach). Using an experimental approach in conjunction with (as opposed to 'instead of') retrospective approach holds the promise of taking advantage of the strengths of the two perspectives (each has its own strengths and weaknesses; each provides certain insights the other does not). Also, a 'multiple working hypothesis' approach would help guide the research.
We are aware of the major retrospective studies currently underway in the Basin, and will certainly link up with any that come into being as we proceed. There may also be opportunities to engage in some retrospective work within the context of this study.

12) Figure 5. Several of the sites appear situated near province boundaries. If the objective is to have sites located to 'maximize representation' (p. 17, line 23) of various provinces, it seems

like they should be selected from well-within a province. Sites near province boundaries may be transitional in nature and hence more dynamic and 'noisy' that sites from the heart of the province.
We are confident that our choice of sites will be very representative of a wide range of conditions in the Great Basin. We do not believe that locations near eco-region boundaries will diminish our inference space for this study.

13) An 'operational scale prescribed fire will be conducted as part of the PJ study; why not for the sage/brome study as well?
We were not confident that we could convince managers to conduct prescribed burns in Wyoming Big Sage on the order of 1000 acres – we believe that 200 acres is pushing it.

14) If Tebuthiuron is not permitted on the Oregon sites (p. 21, lines 5-6), what will be used for the herbicide treatment? Won't using a different herbicide on the Oregon sites potentially confound regional comparisons?
This is a very good point. Yes, the use of a different herbicide will introduce variation; but the important result will be reduction of overstory density, which should overwhelm any subtle differences due to herbicide type.

15) The ranch-level impact model with be run with and without environmental values. This strikes me as too simplistic. It seems like it would be more illuminating to propose a series of runs whereby the treatment of the environmental values has some variation. In other words, if environmental values are included and treated as 'x' you get these results; if environmental values are included and treated as 'y' you get these results; if environmental values are included and treated as 'z' you get these results. Thus rather than looking at a simple binary response, you would generate a response surface.
Yes in reality the model will probably be run over a range of values.

16) Project Management (p. 27 and Table 2). (a) all the disciplines represented have one leader, except wildlife which has 3. Any reason for that? (b) A database management leader should be identified. For a project of this magnitude, database management will be a major factor and should not be minimized. As presented, a database manager is alluded to as under the supervision of the Project Manager (p. 29, line 22). I suggest the database manager have a more prominent role. In addition to organizing all of the data from the network into a common and readily accessible format, this person could regularly interact with other database management professional working with large multidisciplinary research groups (for example, at some of the LTER sites); (c) An outreach leader should be identified to coordinate and organize the Communications Plan (p. 30)
We will certainly consider elevating the database manager to 'team' status. The communications work will be shared by the PIs, and their technical people. We didn't think we could afford a unique position for a 'Communications Director'.

17) P. 30, line 18 prioritizes potential audiences. I found myself wondering what the basis for these priorities was. Perhaps that is covered in Appendix 3 (which I have not read). Even if covered in Appendix 3, a brief mention of the rationale (and a reference to Appendix 3) would be nice.

The primary audience is the land manager. Other audiences have been identified based on perceived interest in the type of information we will have available.

18) Objective 3 in the Communications Plan (p. 31) refers to identifying methods to be used for public outreach and technology transfer. This objective implies that there will be someone on the project with methodological expertise. I don't recall seeing anyone with this expertise on the PI list or on the Technical Committee (Table 2).
As for communications, McIver does have substantial expertise in this area, having served for 4 years as 'Learning Center' director for the Blue Mts. Natural Resources Institute. In this position, McIver was charged with technology transfer and communication of natural resources information to a wide variety of audiences.

19) The proposal would be more credible if you could articulate how you will chart your progress in this large, interdisciplinary undertaking. One way to do that would be to develop a series of specific 'milestones'. These milestones could be developed for each discipline; but there should be interdisciplinary milestones as well.
This is a very suggestion, and one that we will probably implement if the project is funded.

20) This study will generate lots of data and information; but will it increase our <u>understanding</u>? A lot of changes will be documented; but will your design and approach generate mechanistic insights that enable you to explain <u>why</u> the system behaved or changed as it did? Strive to convey to reader a sense that our understanding and explanatory powers will be improved by the research.
We believe that our study design, and the use of multivariate analytical tools such as structural equation modeling, will lead to the identification of mechanistic insights.

36. The 1000 ac prescribed fire will not burn uniformly. There will be parcels within the 1000 ac area that do not burn and areas that will burn at high, medium or low intensities. How will this heterogeneity in fire intensity and coverage be dealt with in the various sampling schemes?
We will have enough sub-plots sprinkled through these large 1000-acre plots, to insure that we will be able to cover the expected heterogeneity.

Tom Holmes

This is an ambitious project, but one that holds great promise if the goals are actualized. I have read the Economics section of the proposal several times and think that there may be some ways to improve both the presentation and the substance of the research agenda. In my comments, I will try to follow the organizational structure used in the proposal.

Overall, Dr. Holmes has made thoughtful and constructive suggestions and comments that will help us to clarify the description of proposed economics work for other readers and for the research team. Many of the comments will result in changes in future presentation of the work. Other comments anticipate our next steps in modeling, and will need to be dealt with as a matter of course. The reviewer's comments do not indicate major modifications of proposed methods or identify any issues of a substantive nature. We have broken the reviewer's comments down into parts and responded to each in turn.

Comment: As the argument is currently stated, you view land managers as making decisions that will minimize the risk of sagebrush ecosystems flipping from "healthy" conditions to "degraded" conditions. While this may be a laudable goal, I'm not sure why you make this assumption and, further, it's not clear how you can represent economic variables in the land manager's objective function. I would suggest considering a broader objective function along the lines of maximizing social welfare. In this setup, the economic arguments in the objective function are benefits and costs. For example, control variables affect ecosystem states, which, in turn, may provide benefits to society (e.g., via enhanced non-market values or range productivity) as well as costs (e.g., control action costs, short-term loss in range productivity leading to long term productivity gains).

The economic objective function for the main decision model is (and should be) in terms of social welfare (hence the non-market valuation portion of the research is required to provide the necessary values for this). The underlying values are what drive the economic problem; done properly, the model will incorporate the net marginal environmental costs to society of an ecosystem flip (at a given place and time). The goal of reducing risk that a system will 'flip' to a degraded state is not consistent with maximizing social welfare, because the social costs of preventing the flip may be greater than the benefits, or the budget constraint may be binding and there might instead be another area that is at the margin more valuable as an investment for treatments to reduce risk of loss.

Because of the interdisciplinary audience for the proposal we attempted to simplify the decision problem in this introductory section to mirror the written objectives of the ecological regional experiment. We used the language used in the abstract and main body of the proposal, where the goals of the ecological study are stated in terms of land managers' information needs, in order to reduce risk of loss. These goals include providing managers with information about ecological thresholds and about pre-fire treatment methods in order "to reduce the risk and uncertainty of catastrophic wildfire to the greatest degree possible", and "to provide managers with information that would allow them to better understand tradeoffs inherent in their choices of treatment/management alternatives."

Even in an 'non-economic' literal sense, the objective of a BLM land manager is obviously not to minimize the risk of a healthy ecosystem crossing a threshold to flip to a degraded system, although it might be considered to be one of several potentially competing 'goals'. There are also variables associated with institutional mandates and individual incentives within the institution. In addition, BLM managers do not have the full discretion, or mandate, to make decisions that would result in maximizing social welfare, or that take into account all of the information about trade-offs, or even about what treatments they may or may not use in a given year. Intra-agency budget constraints, institutional mandates, and other restrictions define the scope of their objectives more narrowly than the social planner's problem.

While we used language that refers to the 'land manager's problem' the actual decision problem we describe implies a broader set of objectives, more akin to the standard economic social planners' objectives. Our intent is to model the problem from the perspective of maximizing social net benefits, which would include the non-market benefits and costs of management actions, environmental changes and associated fire regimes. We envision a series of constraints that model existing conditions land managers work within, such as budget constraints, annual quotas on acres treated, spatial restrictions of land unit designations, and others that are indicated as a result of interactions between the economists, land mangers and ecologists during the study. In this way, values of relieving specific constraints can be calculated.

To summarize, the correct objective of the economic model is to maximize expected social welfare. A stated overall goal for the ecological study is to reduce management risk of catastrophic wildfire (which leads to 'flipping' from one state to another) to the greatest degree possible. We will rewrite these statements of goals and objectives to be reconciled and the role of reducing risks of flipping to the degraded state will be placed in the broader economic context.

Comment: Entering benefits and costs in the public land manager's objective function would also presumably facilitate spatial analysis and efficient allocation of control expenditures. That is, I can imagine, for a fixed public budget constraint, that the cost of treating some land management units might exceed the benefit. Such a result might not be feasible if the objective function is simply to minimize the risk of ecosystem flips. Maybe it's OK to let some areas flip if limited resources can protect more valuable ecosystems from flipping.

The proposed research will necessarily involve spatial analysis. This is an area that Dr. Nalle specializes in, and is also an area of ecological/economic dynamics research that is still relatively new. In discussions with ecologists who are part of the project team, we have identified the likelihood that optimal outcomes might indeed involve allowing some areas to degrade.

Comment**:** Given that this proposal is related to JFSP funding, I think that it is important to give greater emphasis to the role of wildfire and fire management in this section. As I understand this proposal, invasion by exotic cheat-grass is changing both the wildfire regimes in sagebrush ecosystems as well as decreasing the productivity of rangeland for grazing. However, I am unclear about how specific control actions would influence the role of wildfire in these ecosystems. Presumably, wildfire helps maintain the native grasses that are valuable for grazing by suppressing shrub growth.

As it was originally written, the economics section was meant to be an appendix to the first section, which describes the proposed ecological study, the treatments, thresholds between the states, and the role of wildfire in the Great Basin. These relationships should probably be summarized in this appendix as well. Briefly, the process is as follows. The great basin lands under investigation are in one of two states. State (1) is a healthy sagebrush system where fire is a normal phenomenon, which occurs about once every 50 years as fuel loads of native species increase; and when fire occurs the system responds to regenerate itself as a healthy sagebrush ecosystem with a reduced fuel load. In this state, wildfire is not catastrophic, because it does not cause the system to 'flip' into the degraded state. State (2) is a cheatgrass monoculture where fire is also a normal phenomenon, but which occurs about every 7 years. This fire regime is different from that of the healthy state because fires are more frequent, and they burn hotter (more intense). Because of this, there is also more of a likelihood that these fires will spread to adjacent areas and cause these to 'flip' to also become degraded. Also, because of the increased fire frequency and intensity, these degraded areas are unable to revert back to the healthy state without massive and expensive rehabilitation efforts. So both states have a fire cycle, but the cycles are very different.

What causes a system to flip from being a healthy to degraded state? Healthy systems become invaded by cheatgrass (an exotic annual that germinates and goes to seed before any native plants, and then remains as a highly flammable fuel amid the native sagebrush and perennial grasses. At lower levels of invasion, non-catastrophic wildfires and prescribed burns can reduce the cheatgrass understory, and the system remains in a steady state (1) with a fire cycle as described above. However, as the amount of cheatgrass in the understory increases, all else equal, the accumulated fuel load increases so that an ignition has a higher probability of becoming a catastrophic wildfire. A catastrophic fire is one in which the native sagebrush and perennial grasses do not regenerate and instead a cheatgrass monoculture emerges. This is a flip to the degraded state. So there are two types of roles for wildfire: one that is part of each system, even though the intensity and timing of the fire cycles in each are very different; and one that is catastrophic in that it causes an irreversible (without expensive restoration efforts) flip from one state to the other.

The manager's decision variables in a given period include, for each area under management, include either doing nothing or to take an action that will decrease the probability that if a fire were to be ignited, it would be catastrophic. Thus the probability of flipping to the degraded state is in part endogenous and the control variables change the probability of a 'flip'. Since treatments are expensive, and given a budget constraint, it is better to treat later than earlier and it is better to reserve treatments for lands for which at the margin the expected cost is equal to the expected gain.

Comment: Are prescribed burning and wildland-use fire being contemplated as control variables? If so, this should be highlighted.

The control variables include the treatment regimes that are being investigated in the ecological experiment – which is basically driving the economic study. These include prescribed burning as well as mechanical and chemical removal of accumulated fuels. These are described in detail in the experimental design. The control variables at any given period include the treatment used (including the option of no treatment). The experimental design includes lands under differing levels of cheatgrass cover (accumulated fuel). A goal for the ecological study is to determine how the systems respond under the differing treatments and accumulations of cheatgrass. The objective is to determine the 'threshold' levels of cheatgrass invasion for which treatment is effective in preventing a flip. So the state variables include the level of cheatgrass invasion (or fuel accumulation) at a given time for a given location. The control variables include choice of treatment.

Comment: Also, is over-grazing a problem regarding the productivity of these systems? Would a reduction in grazing pressure be considered as another control variable?

There are a number of land uses that contribute to the level of cheatgrass invasion, rate of cheatgrass expansion, and productivity of these systems, including over-grazing. The experimental design of the ecological study, however, focuses on responses to treatments as a function of accumulated fuels. How the fuels accumulate and level of accumulation is taken as exogenous. Other studies have focused on these questions, including on how grazing influences cheatgrass invasion and on the differences in productivity between cheatgrass monocultures and other native and non-native grasses and sagebrush. Therefore the decision was made to not allow grazing to vary and to concentrate on the effectiveness of treatments for given levels of invasions.

The treatments investigated here do not include reduction of grazing pressure – and all grazing pressure is eliminated from the experimental lands in order to focus on the responses to the treatments. Therefore any use of grazing pressure reductions as a control variable for the economic modeling would have to be based upon secondary data sources. The farm-level economic impact model will be based in part on some of these secondary studies on scenarios, where grazing AUMs are varied as a result of fire treatment and rehabilitation policies.

Comment: Finally, what can be done to limit or eliminate the influence of cheat-grass in these ecosystems? A better understanding of the control variables (especially related to fires) would enhance understanding in this section.

The basic point of the ecological experiment is to determine whether and how the proposed treatments can limit or eliminate cheatgrass influence in these systems. The influence of cheatgrass can be affected in the following ways: For land already characterized by a cheatgrass monoculture, or following a catastrophic fire, expensive restoration efforts to reseed with native or non-native plants that prevent cheatgrass invasion are used. This is the current management strategy – which is reactive. In addition to being expensive, reseeding fails about 50% of the time (depending on location, conditions and whether natives or non-natives are used). This project focuses on land that has not yet flipped to the degraded state, where the proactive treatments under investigation are intended to reduce or eliminate cheatgrass and reduce the probability that an ignition will result in a catastrophic fire. An important contribution of the economics portion of this study is to evaluate the desirability of the alternative treatments under investigation in reducing the risk that a system will flip to a cheatgrass monoculture. Hence the control variables include the timing and choice of treatments.

Comment: On a somewhat broader note, it seems to me that the purpose of the economics research is to develop a better understanding of how changes in ecosystems influence the well-being of people. This is a particularly difficult problem when ecosystems don't always change slowly, but can suddenly jump from one "basin of attraction" to another. Thus, I think that some of the outstanding features of this research that should be emphasized in this section are: (1) the possibility of estimating the economic consequences (costs) of sagebrush ecosystem flips, (2) the benefits of avoiding those flips, and (3) identifying the economic-ecological dynamics of movements along potential trajectories.

The combination of the non-market values and the modeling of the ecosystem dynamics in the economic model makes this research particularly interesting for us. Present efforts to restore degraded systems fail about half of the time; therefore ecosystem flips are potentially irreversible. The proposed treatments aim to influence the probability of irreversible loss by preventing the cheatgrass understory from achieving a threshold level for which a wildfire would result in a flip. The timing and type of treatment, relative to the accumulation of cheatgrass understory affect the ecological as well as economic trajectories of the system, and thus the impact on risk of irreversible loss. The economic-ecological dynamics is a key role of this research and if it is not well-enough emphasized in the proposal at this point, then we need to do so in the next iteration. We plan to build on previous work in this area, as described in Dasgupta and Maler (2003), Perrings and Walker (1997), Nalle and Arthur (2004), Calkin et al (2003) and elsewhere.

The economic research will involve valuing the change in the probability of irreversible loss at the margin. Since 20% of the Great Basin lands have already been lost to cheatgrass monoculture, and due to spatial effects that may lead to acceleration in conversion rates, the marginal costs of additional losses may be measurably increasing. Given that a number of threatened and endangered species use these lands, the economic consequences of flipping into the cheatgrass monoculture short cycle fire regime also involve marginal losses in existence values. Thus benefits of avoiding flips will require valuing marginal changes in the risk of losing existence values, similar to Rollins and Lyke (1998).

Comment: Then, given this "big picture" you can go into your discussion about constrained optimization in the Public Land Manager Model. I would suggest including some literature review in this section similar to what you are proposing. A very good reference is the following: *Dasgupta, P. and K-G Maler, 2004. The economics of non-convex ecosystems, Kluwer Academic Publishers*. This book contains a collection of papers that are very similar to what you are proposing. (Note: these papers were also published in a special issue of *Environmental & Resource Economics*). The point is that you are not the first economists to think about these issues, but instead will be extending what others have already accomplished.

The next version of the research description will include these references, as this work by these authors and others has influenced our thinking and approach. There are also other references that should be added as well, and a partial list of additional references will be attached to this set of responses.

Comment: You mention the "real options" approach in this section, but never describe what it is. If you intend to use this approach, please provide enough information so that readers will understand what you are thinking about.

A "real options" approach is a method used in the finance literature to solve a dynamic problem under uncertainty when decision/actions are irreversible. The approach has been used recently in the forestry literature where the uncertain variable is price (Plantinga 1998, Insley 2002,). Trigorgis (1996), Dixit and Pindyck (1994), Saphores, Insley (2001), Insley and Rollins (2004) and others have adapted this approach to a variety of resource-related problems. It is one approach to setting up and solving a dynamic stochastic problem that is characterized by irreversibilities in outcomes. It is not the only approach one might use, and our research will not be limited to this approach. But we do wish to consider it as one approach we will pursue.

Briefly, a real options approach would consider a treatment (to reduce cheatgrass fuel accumulation) as an investment with an uncertain payout. The treatment changes the probability of an irreversible loss. The change in risk of loss is a function of the timing the 'investment'. The payout is the value of the reduced risk of irreversible loss. The decision maker is faced with the decision in any given time to treat or not treat, and if to treat, the type of treatment. The 'threshold' level of cheatgrass accumulation is treated as stochastic, with a deterministic component from the ecological study results and a stochastic component that incorporates environmental factors that contribute to whether a fire is catastrophic or not (accumulated rainfall, windspeed and direction, etc). We would like to consider the solution methods for our research here because it is appealing in that the mathematical results have a direct economic interpretation that may provide insight to our problem. Envisioning a land management action as an investment to maximize social net benefits in a stochastic dynamic setting – through its impact in changing the probability that an irreversible loss will occur is consistent with the Real Options approach, and is an interesting way of viewing BLM land management.

Comment: *Summary descriptions of each sub-component:* This section is in pretty good shape, particularly if you use some sort of schematic as described above that shows how the various models fit together.

Comment: 1. *Primary valuation study*: As you are attempting to value multiple environmental goods and services, you should think about the issue of complements and substitutes, and include the relevant references that have appeared in the literature in the past several years (especially in the *Journal of Environmental Economics and Management*).

We will need to take into account the effects of complements and substitutes. This is true for a number of the goods/services: in the context of recreational users of these areas – who may choose to visit other healthy sites in lieu of continuing to visit degraded sites; in the context of existence values that may be complementary to use values such as recreation; etc. Some of the work by Kling and others that focus on complementarities among existence and use values is of special interest to us.

Comment: 2. *Ranch-level costs and benefits*: I am confused here. Are you proposing to enter non-market values into the objective function of farmers? It seems to me that you should be adding ecological variables and functions as constraints on the ranchers' optimization model and, through the optimization process you will be able to estimate shadow prices of the constraints. In turn, it seems that the shadow prices of the constraints are what would enter the objective function (as costs) in the Public Land Manager Model. Is this a dynamic optimization model? If so, you should state that. Also, is this model deterministic or static?

The rancher's optimization problem is set up as a standard ranch-level linear programming farm budget model with constraints that incorporate land use (and therefore AUM) limitations on grazing following fire, pre-fire treatments to reduce fire risk, post fire restoration, on rangelands. The shadow prices associated with the alternative restrictions can be incorporated into the land manager's objective problem – which is dynamic. The ranch model is not dynamic – rather, it is a standard multiyear static farm budgeting model. The ranch model is deterministic, but can be run over different scenarios for whether a fire occurs or not, and over different scenarios of whether a treatment is effective in restoring rangeland productivity to given levels in given time periods. The resulting alternative costs to the rancher under different combinations of scenarios can then be used in the stochastic land manager's model.

Comment: *3. Input/ output model*: It seems that you can break this model into 2 stages. First, implement and IMPLAN analysis and, second, implement the full CGE model. In reading this section, I am unclear on the role of fire in the local economy model. I expect that there will be lots of transfers between sectors in the economy, but I'm not sanguine that obtaining the data to estimate the transfers will be easy to obtain. In particular, see the following: *Brian Kent et al. 2003. Social and economic issues of the Hayman fire. USDA Forest Service General Technical Report, RMRS-GTR-114.*

A dynamic CGE model will be developed which can be used to derive an economic path without a fire. However with fire there are expenditures for fire suppression, and opportunity costs associated with moratoria on grazing. The costs and locations of these fire suppression efforts and expenditures can be derived through direct interviews of federal, state, and local government officials. Interviews with local producers can be used to derive amount and location of private fire suppression expenditures. Federal agencies can provide information about the length of moratoria in public land grazing due to rangeland fires, subsequent rangeland restoration efforts, and with pre-fire treatment regimes associated with the study. Gathering the fire suppression expenditures and location of these expenditures will be a time consuming part of the study. Harris et al. (2002) provide information as to procedures for collecting fire suppression costs and location of these expenditures for input-output and CGE analysis.

Comment: 4. *Bioeconomic decision model*: I would suggest breaking the modeling down into 3 phases. First, I think that much might be gained by developing a deterministic optimal control model in continuous time. This will force you to think carefully about the state variables and control variables, and the nature of the objective function and the constraints. Analytical solution of this model may provide some very useful qualitative information about optimal ecologic-economic trajectories, and help you design the empirical models. In the second phase, I would suggest developing a deterministic dynamic optimization model in discrete time with "reasonable" parameter values. For an example of this approach, see: *Perrings, C., and B. Walker. 1997. Biodiversity, resilience and the control of ecological-economic systems: the case of fire-driven rangelands, Ecological Economics 22: 73-83*. Finally, in stage 3, you can go ahead with the stochastic dynamic optimization problem and, hopefully, have the requisite ecological data at that point.

We agree that this is a big problem that should be addressed in stages as you suggest, starting with a deterministic model. This is exactly what we had in mind – although it is not stated explicitly in the description of the research. We most definitely plan to add specific details about the stages of this model within the first few months of the research program, as it is critical that the ecologists and economists together develop parts of these models together.

Pat Kennedy

1. The experimental design is very good. However, it was not clear to me why you chose to study birds as indicators of wildlife. Also, why only measure them at the juniper sites and not at the sage sites?

We have clarified in the introduction to the section on wildlife/ biodiversity about why passerine birds, Greater sage-grouse, and butterflies were chosen as areas of faunal biodiversity in which to measure responses to the sagebrush/juniper experiment. We also now explain why sagebrush/juniper sites are the focus of the work, rather than sagebrush/cheatgrass or other types of sagebrush sites.

2. A general set of predictions would help the reader understand your choice of response variables. At this point it is not clear why you chose to measure breeding season communities. Is the effect of fire clearly most important to breeding season birds and not wintering or migrating birds?

We chose to evaluate breeding season communities because the habitats we propose to study provide nesting and summer habitats for all passerine species of interest. By contrast, some of the passerines of interest migrate off-site to other wintering areas, which we cannot study. Focus on nesting and summer habitats allows a larger number of passerines to be evaluated, and prior work on passerines suggests that productivity (nest success and fledging success) are important contributors to population growth of passerines. These points have been clarified in the section on wildlife/biodiversity.

3. Survival – I am unclear why you are estimating survival from both mark and resighting of banded birds and following the fate of radio-tagged birds. I would eliminate mist-netting and put those efforts towards monitoring fate of a larger sample of tagged birds (20-50). You could also

use the radio-tagged birds to identify foraging locations and if possible evaluate habitat characteristics of foraging locations.
Mark-recapture of banded birds with the use of mist nets, and mark-relocation of birds with the use of radio-telemetry, represent two different but complementary methods that can be used to estimate survival of passerine birds. Mist-netting was chose because it is less expensive than radio-tagging and relocation methods. By contrast, radio-tagging and relocation of birds provides opportunities to collect other types of information, such as finding nests and monitoring nest success and fledging success. We have clarified these points.

It is also not clear how you are estimating non-breeding survival. You mention it but you are only collecting mark-recapture data during the breeding season.
Survival of passerines off-site from our study areas, or during the fall or winter on-site, can be estimated with the use of mark-recapture data provided from mist-netting of birds over multiple years. Survival of passerines during the spring and summer periods can be estimated with use of mark-recapture data provided from mist-netting and radio-telemetry data collected throughout the spring and summer periods each year. Thus, we anticipate being able to partition out survival of selected passerine species during spring and summer versus fall and winter. Estimates of on-site survival, whether spring-summer or fall-winter, can be attributed directly to environmental changes brought about by the experimental treatments. By contrast, off-site estimates of passerine survival during fall and winter for migratory birds can provide insights about the effects of off-site conditions versus on-site conditions. We have clarified these points.

4. You have a heading titled productivity but then you indicate in the paragraph that you are estimating nest success and fledging success. This is not productivity. How are you measuring productivity for species that double or triple brood?
Two major aspects of passerine productivity are nest success and fledging success. We have clarified that we are focusing on these aspects of productivity. We have also clarified that we will use the radio-tagged birds as a means of monitoring the degree to which the selected passerine species double or triple brood, in addition to estimating nest success and fledging success.

5. Avian habitat – you are trying to estimate spatial and temporal effects of treatments on avian habitat – yet you don't define what you mean by avian habitat and what exactly you will measure for defining avian habitat. What will you be using to define avian nesting habitat from a functional point of view?

We have intentionally not defined avian habitat a priori. Instead we will evaluate a diverse set of variables regarding vegetation composition and structure, as well as physiographic variables, in relation to the bird response variables. This wide variety of habitat measures will be estimated either by the vegetation ecologists involved in the study, or through use of GIS layers available regarding slope, aspect, elevation, and other measures of physiography. We have clarified these points in the text.

6. Foraging Behavior – I did not find a description of how you were going to measure foraging behavior in Appendix 2.

Foraging behavior of passerine birds is not currently part of the response variables included in the proposal, and we have deleted any reference to this topic as it relates to passerine response variables.

Bob Nowak

Overall comments

The proposal lays out a comprehensive series of studies that address issues of paramount importance to land owners and managers in the Great Basin. The research team has strong credentials in their areas of expertise and represents some of the best of the researchers in the Great Basin. The research team has successfully and seamlessly integrated a number of research areas that do not typically work together into a solid, interdisciplinary approach, and the team has a high probability of accomplishing many of their tasks. The research team has also worked closely with land managers in the study design, and it is clear that both the researchers and managers are committed to continued cooperation during the studies, which helps ensure that the results and knowledge will be applied.

Comments on main body of proposal

Strengths of the proposal include:

- Well-presented, strong justification and rationale for the studies (pp. 7-10).
- The greater relative benefit of experimental studies versus retrospective studies (p. 15) is persuasive. A side question: does the project team plan to use the available retrospective information to help generate testable hypotheses, to extrapolate to other sites (besides loamy 10-12 and loamy 12-14), and to validate models?
  The project team is aware of existing retrospective studies relevant to the proposal work, and will use this information to help in generating hypotheses and expanding inference space beyond the loamy 10-12 and loamy 12-14.
- The inter-relationship among sites and disciplines (pp. 16-17) and their ability to generate products of different levels of integration is well thought-out.
- Integration of the sociopolitical and economics studies from the beginning of the studies is excellent.
- Project management (pp. 27-30) is well-conceived, responsive, and responsible. Data management is critical to the success of the project, and the PI's have clearly given the issue much thought. The concept to spatially register all data is excellent.
- The communication plan demonstrates that the authors have identified potential target audiences and have given thought to how they will disperse their knowledge to these groups.

Areas needing clarification:

- The state and transition model framework for the studies is reasonable, and the goal to "provide much better information on the probabilities of transition" (p. 11, l 17) is excellent. However, it is not clear that the research design can accomplish this goal. First, will the range of abiotic and biotic conditions studied be sufficient to define the probabilities, especially given the wide range of conditions across the Great Basin? For example, a "range of successional stages and ecological condition/state" (p. 20, l 12-13 & 19) will be used, but what is that range, and why are the PI's confident that the range will exceed threshold levels?

  We are confident that the range of vegetation conditions within our relatively large plots (25-50 acres for the PJ, and 200 acres for the sage/cheatgrass) will be large enough to capture the significant variation in both tree density (for PJ) and cheatgrass cover (for sage/cheat) that is necessary to accurately define thresholds. In fact, we expect to encounter conditions both below and above potential thresholds for each plot that we install. We have re-written the section on experimental approach in an attempt to clarify the regression method we will use to identify thresholds.

Second, will the planned methods measure the important drivers for the transition? For example, the proposed vegetation measurements will document a change in the vegetation, but will provide no reliable information on what vegetative process may have contributed to passing the threshold.

We are not measuring drivers or mechanisms. That is not the purpose of this study, and documenting drivers is not necessary to successfully address our goals. Instead, we want to be able to document the thresholds so that we can predict recovery following treatment – based on vegetation condition, not on drivers.

Third, how do the planned treatments affect biotic/abiotic conditions and the drivers that are important to pass thresholds (and hence provide a rational basis for use of these particular treatments)? In essence, the proposal needs to clearly articulate what conditions and drivers are thought to induce transitions; once these are articulated, then the answers to these 3 questions are obvious. I am not confident that I can articulate these conditions and drivers, but I can envision the planned experiments as a critical (and greatly needed) step towards defining them.

We are not proposing treatments that will drive the community over a threshold from a degraded condition to a new stable state that is not degraded. Instead, we are interested in quantifying where in ecological condition the threshold is between conditions that will recover to a desirable condition after treatment.

- A series of related issues pertains to how the specific sites and plots were selected for the 2 networks. What criteria were used in the selection of sites in order to "maximize representation and inference space" (p. 17, l 23-24)? For example, the PI's identify the general climatic gradients across the Great Basin (p. 17, l 18-21), but it is not clear how the proposed sites represent the climatic ranges.
  The PJ sites span the Great Basin east to west, and include the juniper regions of the north. These clearly cover a great deal of climatic variation and consequent woodland community structure available in the Great Basin. The cheatgrass sites are somewhat more constrained geographically, largely due to the need to keep them in areas where cheatgrass invasion is pertinent. Nonetheless, our sites across northwestern Utah and northeastern Nevada, though including important variation east to west, clearly contrast with the Snake River sites to the north.
- Why exclude areas that are "at low risk or have already crossed a threshhold" (p. 20, l 14-15); don't these types of plots provide a check on the probabilities (i.e. reference points)?
  We want to exclude areas that are a low risk overall. To accomplish our goals, we need to focus on areas that are at risk of invasion and loss. If they are clearly not at risk then there is no need to be concerned about tree or cheat invasion (triage concept).

- For the Woodland Network, why tree cover between 10-50%, shrub + herb 50-5%, etc., as opposed to other ranges (say tree cover of 0-100%)?
  This is from preliminary data from Robin and Jeanne that suggests very strongly that this range of cover values encompasses the region of very rapid transition from healthy to degraded communities.
  Furthermore, the implication of combining shrub plus herb is that they are equivalent; is this true?
  They are not equivalent per se, but both respond similarly to increasing tree cover and both contribute to site occupancy and recovery following tree loss. We will of course have data collected separately on each to address the importance of herbs versus shrubs in recovery.
  Why are the Cheatgrass Network plots 4-8 times larger than the Woodland Network plots (200 acres vs. 25-50 acres, respectively)?
  Good preliminary data suggest that we can find the range of vegetation conditions/cover that we need in a 25-50 acre PJ plot, but that we will need a 200 acre sagebrush/cheat plot for the same purpose.
- For the Woodland Network, the 1000-acre burn plot raises 2 concerns. First, it appears that the single 1000-acre burn plot will not necessarily be the same tree/shrub+herb cover combination for all the sites; won't this compromise comparability of data across sites? Second, the rationale given is that the 1000-acre burns "allow a more realistic assessment of the effects of fire on wildlife and hydrologic processes" (p. 21, l 23-24). What does this statement mean? Does it mean that the effects on wildlife and hydrologic processes that are measured on the 25-50 acre plots are not realistic, and hence not reliable pieces of data? Given the large requested budgets for these 2 disciplines, this concern becomes more disconcerting.
  We plan to install an 'extensive' sampling grid over the 1000 acre area, to cover the potential vegetation, cover, and fire effects variability.
- The "structural equation modeling" (p. 24, l 4-8) is a superb concept, and this exercise (or something very similar) needs to be initiated very early in the research plan. In fact, I'd argue that this needs to be done as the very first task, before any treatments are implemented or any study plans written. This exercise will help the PI's articulate the abiotic/biotic conditions and drivers to pass thresholds, which in turn help to focus the treatments and justify which variables need to be measured.
  We plan to consult with Jim Grace (USGS-BRD), who is an expert with structural equation modeling, early in the study, to insure that the data we collect will be suitable for this important multivariate technique.

<u>Comments on budget</u>

Most of the budget is reasonable and necessary. My biggest concern relates to the field crew requests in the Hydrology and Wildlife Discipline budgets. First, are the requested sizes of the field crews necessary? Second, how do these field crews differ from the field crews requested as part of the individual site budgets (the notations in the budget imply a large degree of overlap)?
Both hydrology and wildlife are extremely labor intensive endeavors, and definitely require the requested personnel to get the work done. The field crews in the site budget are primarily for vegetation, fuels, and soils, and are separate from the field crews listed in the wildlife and hydrology budgets.

Comments on core variables and protocols (Appendix 2)

1) Vegetation and fuels – The methods outlined are standard, reliable tools to characterize vegetation composition and structure. Although it is never explicitly stated, I assume that all measurements will be at the individual species level; otherwise, multivariate analyses (p. 23) will be severely constrained. The measurements are required for documenting vegetation changes. However, these vegetation measurements will not elucidate why a shift in vegetation occurred; do the PI's intend to separately fund other types of studies, such as population ecology and seedbank studies, to elucidate these mechanisms?
   The plan is to use this overall experimental design as a core on which to build other studies, some of which may be designed to identify mechanisms that drive the responses we see.
2) Soils – As with the vegetation, the proposed methods are standard, reliable tools to characterize soils, and the combination of soil pits and finer scale, 0-20 cm sampling should adequately document soil characteristics. The use of resin capsules will be especially critical towards determining the soil response to treatments in the context of what is important for the vegetation responses. However, the proposal does not indicate when during the growing season that the finer-scale sampling will occur and that the resin capsules will be installed; the timing of these measurements is critical towards providing information that is relevant for vegetation responses. It is surprising that systematic soil water availability measurements are not planned, given that soil water availability is the primary driver of vegetation responses in semiarid ecosystems.
   The installation of the resin capsules will be timed to the active growing season when water is available. Soil water availability might be a driver, but it is difficult to measure, and in any case, we are not focused on identification of mechanisms in this experiment..
3) Wildlife / biodiversity – The proposed measurements of insect and bird populations will provide interesting information and potentially has importance in the context of sage grouse management. It is less clear how this information relates to the state and transition framework of the proposal; can this information be incorporated into determining thresholds? In addition, the reliability of the information from <1000 acre plots seems to be suspect, as discussed previously.
   Information on wildlife (vertebrate and invertebrate) will be tied closely with measured information on vegetation, fuels, and soils, and so will be interpreted in that vein, since changes in these categories will essentially drive changes in wildlife.
4) Economics – I appreciate the clear, logical writing of this section. Although I lack the expertise on this area to know if better methods exist, the PI's lay out compelling arguments for their approach. Note that this section often does not correctly punctuate "Drs.".

• Additional response to Nowak's concerns, as requested by the JFSP Governing Board (September 2004). Both Dr. Nowak's and Dr. Archer's comments on the experimental design were taken seriously in the initial submission. The section on *Experimental Approach* (pages 20 & 21) was written in response to their comments, and the section on *Experimental Treatments* (22-24) was revised. In response to the JFSP Board's concerns about Dr. Nowak's comments, we have spoken with him directly and tried to address any additional concerns.

1. *Will the range of abiotic and biotic conditions studied be sufficient to define probabilities across the Great Basin?*

Every attempt was made to locate sites that include the range of abiotic and biotic conditions across the Great Basin. At the beginning of the project, meetings were held with managers from across the Basin in an attempt to locate sites in all of the major ecological provinces. Constraints placed on site location included: 1) an inability to tie in with existing or planned projects; 2) a lack of interest by certain managers who were already maximally committed to other research and fuels management treatments; and 3) the inability to find the necessary site condition or to obtain the necessary clearances. As the project developed other administrative and logistic constraints were encountered. These included: 1) the inability of individual researchers and their associated universities or research labs to administer more than one or two research sites (with three locations); and 2) the costs required to install the individual sites and collect the necessary data. The range in abiotic and biotic characteristics of the sites that were selected is detailed below. We will continue to look for opportunities to include sites or at least locations in areas that are underrepresented like the Lahontan Province in western Nevada.

The Woodland Network spans much of the Great Basin, encompassing both the north-south gradient in temperature and, to a lesser degree, the east-west gradient in precipitation. Sites have been included in the northern part of the Great Basin (Rick Miller's western juniper sites in Oregon and Idaho), and in the more southern part of the Great Basin (Robin Tausch's and Jeanne Chambers' single-needle pinyon sites in central Nevada) to examine sites with different temperature regimes. Sites also have been included that are representative of the bimodal precipitation patterns observed on the eastern side of the Basin (Bruce Roundy and Gene Schupps' Utah juniper sites in central Utah), and that are more representative of the primarily winter precipitation observed in the central part of the Great Basin (Robin Tausch and Jeanne Chambers' single-needle pinyon sites in central Nevada). Efforts to locate sites on the western side of the Basin were not as fruitful as hoped due toan abundance of archeological sites, and to the difficulty of obtaining the necessary clearances and locating sites large enough to accommodate the experimental design. The difficulty in finding sites, coupled with the required increase in funding and research staff, ultimately precluded initially including a site on the west side of the Basin. Nonetheless, our sites span a large portion of the Great Basin and a wide range of climatic conditions.

The Cheatgrass Network focuses on areas of eastern Oregon, southern Idaho, northern Nevada, and northern Utah where sagebrush ecosystems are at highest risk of conversion to cheatgrass. While they do not encompass all of the conditions across the Great Basin, they do include a broad range of abiotic and biotic conditions within representative Wyoming sagebrush ecosystems at high risk of invasion. Efforts to locate sites within north-central Nevada, another area at high risk, were challenging due to; 1) field managers that were maximally committed and that did not want to take on additional projects, and 2) the difficulty of finding suitable sites. Some locations within this area are still under investigation, and it may yet be possible to include a site in north-central or north-western Nevada.

2. *Will the planned methods measure the important drivers of the transition? For example, the proposed vegetation measurements will document a change in the vegetation, but will provide no reliable information on what vegetative processes may have contributed to passing the threshold.*

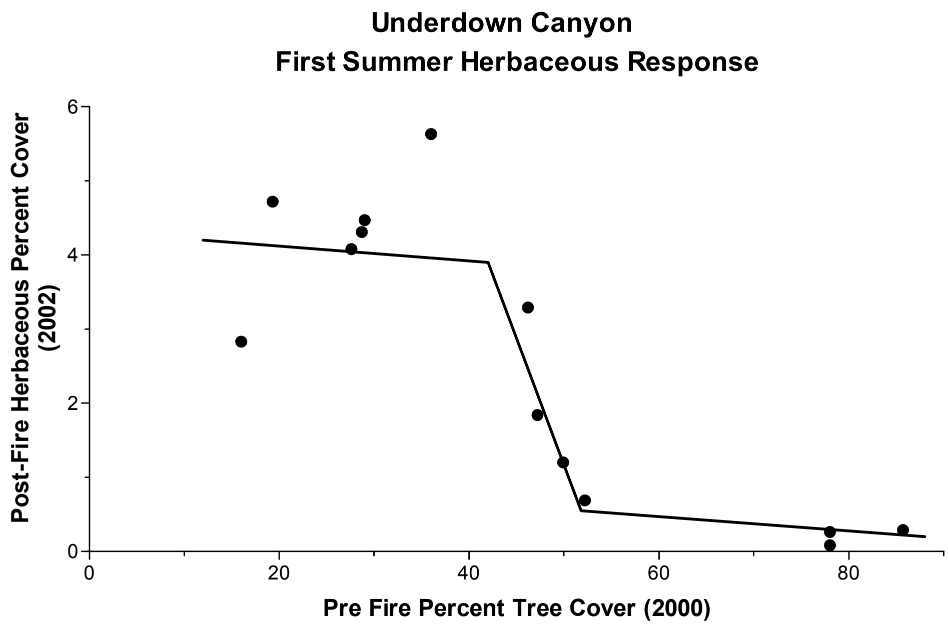
Dr. Nowak's comment referred primarily to mechanistic studies designed to examine specific aspects of the soil/vegetation responses to the study treatments. He was particularly interested in biogeochemical and ecophysiological response variables such as plant/soil water relations, plant nutrient contents and N_{15} ratios. The ecological response variables that we are planning to measure and that are in the proposal include resource availability (soil water potentials as proposed in our response to the Board's comments) and the change in plant community composition and relative abundance of individual functional groups. We believe that this will allow us to measure the changes that occur in the primary variables (soil water and nutrient availability) that control vegetation response both to 1) increases in pinyon-juniper or cheatgrass dominance and 2) the fire and fire surrogate treatments that we are proposing. This in turn will permit us to quantify the transitions that occur in these systems in terms of both controlling variables and vegetation response and to examine the relationships among the driving variables and vegetation response.

In addition, it is our intention to actively recruit other researchers in the area, like Dr. Nowak who studies plant water and nutrient relations, for future proposals that will focus on specific aspects of the project and that are geared to their specific expertise. These proposals will be submitted to a variety of funding agencies such as NSF, USDA NRES and JFSP as appropriate. Such leveraging of additional studies will add greatly to our understanding of the drivers of the system, but are not necessary for the success of our project.

3. *How do the planned treatments affect biotic/abiotic conditions and the drivers that are important to pass thresholds (and hence provide a rationale basis for use of these particular treatments)?*

We attempted to more clearly articulate the ecological conditions and drivers thought to induce transitions in the study systems in our rewrite of the proposal (pages 20 & 21; Figure 6). In the context of this proposal, the conditions that induce transitions are increases in tree dominance or cheatgrass abundance that alter the ecological potential of a site to recover following disturbance. The drivers that induce the transitions are disturbance and management actions (fire, tree cutting, shrub reduction, and herbicides). The treatments used were included because they are commonly used by managers and because they can induce transitions.

The utility of this approach and the potential products are perhaps best visualized through the results of another JFSP sponsored project, "A Demonstration Area on Ecosystem Response to Watershed-scale Burns in Great Basin Pinyon-Juniper Woodlands." The following figure shows the herbaceous species response to a spring burn for a range of single-needle pinyon tree covers. It shows that tree herbaceous species response begins to decline precipitously at tree covers of about 40%, and that at tree covers between 50 and 60% the herbaceous understory is largely depleted and unassisted recovery following fire is unlikely. Thus, the initial results indicate that the recovery threshold for this ecosystem is between 40 and 50% tree cover. Above this tree cover, active rehabilitation will be required. A similar approach can be used for all of the response variables that will be measured in the current study. Relationships among individual variables can be determined using multivariate analyses.



- **Retrospective studies.** In his initial review, Dr. Nowak asked the question: does the project team plan to use the available retrospective information to help generate testable hypotheses, to extrapolate to other sites (besides loamy 10-12 and loamy 12-14), and to validate models? My response to this question was: **The project team is aware of existing retrospective studies relevant to the proposal work, and will use this information to help in generating hypotheses and expanding inference space beyond the loamy 10-12 and loamy 12-14.** After discussing this issue again with the Sage FFS Team, I am certain that among us we have a thorough awareness of all retrospective studies that have been done or are currently being done in the Great Basin. Accordingly, we will most certainly be using information from these studies as we continue to plan and develop our project, and when we begin the process of analyzing and reporting our experimental information. In fact, retrospective studies will make up an important part of the information base we will use to develop our interim "User's Guide", described late in this letter, within our response on technology transfer concerns. Finally, membership in the current research team includes many of the scientists who have been working in the Great Basin for years, and as such, collectively we have a comprehensive grasp of the literature and of ongoing studies. For example, several members of our team (Bunting, Chambers, Miller, Roundy, Tausch) are currently engaged in writing GTRs that will report the results of a recent JFSP-funded project, "Changing fire regimes, increased fuel loads, and invasive species effects on sagebrush steppe and pinyon-juniper ecosystems", information from which will help inform the proposed study.

Brad Wilcox
An evaluation of "A Regional Experiment to Evaluate Effects of Fire and Fire Surrogate Treatments in the Sagebrush Biome"

Reviewed by Bradford P. Wilcox, Texas A&M University, College Station, Texas 77843

1. The project adequately lays out the problem and how it is going to address it.
2. Approach: I have evaluated mainly the hydrologic approach.
3. Additional data—I have some ideas here as well.

The project described in this proposal is an exciting and relevant one. A talented and multidisciplinary team as been assembled to address this issue. The proposal is well written. My commentary centers on the hydrologic aspect of this study.

The hydrologic experimental plan is a reasonable one and one that is commonly used, at least the application of the small plot studies. This work in combination with the overland flow studies will yield useful information. If funding permits I would recommend adding some additional components. In my work, I have found that monitoring naturally occurring runoff and erosion from small catchments, hillslopes or large plots provides very meaningful information. This is especially useful if a multiple scale approach can be incorporated. See Wilcox et al. 2003 as an example of this approach.
To add monitoring of natural rainfall/runoff plots with sufficient replication to make comparisons along the ecological gradient at each study site is well outside the budget submitted for this project. The Northwest Watershed Research Center (NWRC) has vast experience with monitoring natural rainfall/runoff processes and has found such monitoring to be very expensive. Natural rainfall/runoff plots can yield very useful data, but are very risky for a project like this one. Chances are that some study sites/plots would yield data while others would not due to high spatial/temporal variations in precipitation patterns across the large areas being studied. This would not allow for direct comparisons of treatments or trends along the ecological gradient of increasing juniper density.

My second recommendation would be to expand on the small plot and rill studies by using large-scale rainfall simulation. Small scale infiltration studies are useful but they can be much more useful if combined with larger scale studies. The problem with small plot rainfall simulation is that it is so hard to make a meaningful interpretation of what these data are really telling you. We are finding that hillslope scale rainfall simulation is yielding very useful and enlightening information.
We added the following text to the hydrology section of Appendix 2: after …The tortuosity of the flow path will be quantified by measuring the actual flow length necessary to travel 4-m down slope.: *The hydrologic connectivity between areas under juniper canopy and areas between tree canopies will be further studied by simultaneously using a combination of overland flow simulation and large-plot rainfall simulation procedures described above. Four large (35 m^2) rainfall simulation plots will be sampled at each end of the gradient of increasing juniper dominance and the associated decline in understory vegetation at one fire-treated and one control site per juniper location. Runoff and erosion will be monitored from each large plot for 45 min. Then while maintaining a constant rainfall rate of approximately 60 mm/hr, concentrated flow will be released at the top of each plot at a flow rate of 48 l/min for an additional 15 min. This will provide a better understanding of how runoff and erosion processes are affected by juniper invasion at varying spatial scales.*

Wilcox, B. P., D. D. Breshears, and C. D. Allen. 2003. Ecohydrology of a resource-conserving semiarid woodland: temporal and spatial scaling and disturbance. Ecological Monographs 73:223-239.