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April 29, 2005

Joint Fire Science Program
Erik Berg
Program Manager
3833 S. Development Ave.
Boise, ID 8370.9

Dear Erik,

Please forward to the JFSP Governing Board this revised JFSP proposal 05-2-1-08 "Evaluating the Effects of Pinyon Juniper Thinning Treatments at a Wildland/Urban Interface." The other authors and I have read the comments and specific concerns expressed by the Governing Board and other reviewers. We agreed with most of the concerns, and revised the proposal to address them. In a few cases reviewers asked for information that was already in the proposal. In these cases we reworded the material to make it more obvious and clear. The Governing Board noted two specific concerns which we addressed as follows:

1. The Board members and some reviewers had difficulty following the study design, and asked specifically if the treatments would be randomly assigned. We extensively revised the Materials and Methods section, including references to the random assignment of treatments, and added maps showing the spatial orientation of the randomly assigned treatment plots (Figs. 2 and 3). We also summarized the sampling timeline in a table within the Project Duration and Timeline section, and added details to the Statistical Analyses section, to improve the clarity of the information in these sections.
2. The Board also noted that they typically do not fund projects for >3 years duration, but that they would make an exception in this case as long as we understood that we could not ask for a time extension in the future. We accept these conditions, and do not anticipate the need for an extension, because BLM already has approval and funding to implement the treatments as scheduled during late summer FY05. In addition, we added a few sentences in the Introduction section explaining that, although this project would span 4 fiscal years (FY05 – FY08), it would not last a full 4 years (48 months). This is because funding would not be available until the last quarter of the first project year (FY05). Thus, the actual duration of this project would be roughly 3 years, 3 months.

Thanks for the opportunity to revise and resubmit this proposal. Please note that we attempted to keep the proposal within the page limit stated in the AFP, but had to slightly exceed this limit to provide the details requested by the Governing Board and other reviewers. We also want to note that environmental and cultural clearances have been completed by the BLM, and the project is approved and funded for implementation as described in this proposal. Please email confirmation that you have received this resubmitted proposal, and contact me if you need anything more.

Sincerely,

Matt Brooks

Evaluating the Effects of Pinyon Juniper Thinning Treatments at a Wildland/Urban Interface

A proposal for the Joint Fire Science Program, AFP 2005-2-Task 1

Principal Investigators:

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Federal Land Management Cooperators:

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Duration of Project: 4 years

Annual Funding Requested (4 years total):	FY05 (pre-treatment)	$87,981
	FY06 (post-treatment year 1)	$61,250
	FY07 (post-treatment year 2)	$16,382
	FY08 (post-treatment year 3)	$100,023
Total Funding Requested:		**$265,636**

Contributed Funding (base and cyclical from participating agencies): ($333,091)

Abstract: Land managers at the BLM Bishop Field Office and elsewhere in the western United States have identified the thinning of pinyon-juniper woodland fuels and the restoration of sagebrush-steppe fuels and fire regimes as a top management priority. The lack of credible scientific information on the most effective and cost efficient management prescriptions to achieve this task is a major impediment to the implementation of land management plans. This proposed project will experimentally compare the effects of two contrasting thinning prescriptions on fuel structure, potential and actual fire behavior, dominance by the invasive annual cheatgrass, and dominance and diversity of native sagebrush-steppe vegetation. The results will be communicated to other land managers and scientists through a website, field workshop, fact sheets, reports, seminars, peer-reviewed publications, and publication briefs. The study site will also be maintained by the Bishop Field Office as a demonstration site where the long-term effects of the thinning treatments can be observed and the information integrated back into the planning process. Although the JFSP Announcement for Proposals suggests that projects should last three years or less, we do not believe that the short-term effects of our experimental treatments can be effectively evaluated in less than four fiscal years (specifically 3 yrs., 3 mos.), allowing for both pre-treatment and post-treatment sampling.

Matthew Brooks ____________________ date: __________

Helen Smith ____________________ date: __________

Anne Halford ____________________ date: __________

Dale Johnson ____________________ date: __________

Federal Fiscal Representative:

Frank DiMora ____________________ date: __________

Agreements Management Specialist, USGS, Western Ecological Research Center, 3020 State University Dr. East, Modoc Hall, 3rd Floor Room 3006, Sacramento, CA 95819-2632. telephone: 916-278-9480; fax: 916-278-9475; email: fdimora@usgs.gov

Problem Statement

Fire and resource managers at the Bureau of Land Management, Bishop Field Office, California, have identified a critical research need to develop ecologically sound and cost-effective fuel treatment prescriptions for large areas where pinyon-juniper woodlands have expanded into during the 1900s. Such areas are now outside of their natural range of fuel and fire regime conditions, currently in fire regime condition classes 2 and 3. Many of these encroaching stands are also within designated Wildland/Urban Interface (WUI) areas, placing homesites and other structures at significant risk. The management of pinyon-juniper fuels in these WUI areas is one of the top priorities for the BLM and other agencies in the southwestern Great Basin and the eastern Sierra Nevada mountains. The recently completed Bishop Field Office Fire Management Plan directly identifies the need to treat pinyon-juniper stands within WUI areas and adjacent lands to protect both structures and natural resources.

Staff from the BLM Bishop Field Office, USGS, and USFS have identified two potentially desirable pinyon-juniper thinning options that represent contrasting application costs and potential ecological effects: (1) masticate-mulch; and (2) cut-remove-burn slash. Although these two treatments target the same size categories and numbers of pinyon and juniper trees, having similar immediate effects on live woody fuels, their longer term effects on fuel bed characteristics, and thus fire behavior and fire regimes, are potentially very different. One important difference is the relative ability of these treatments to suppress the post-treatment dominance of cheatgrass (*Bromus tectorum*). This invasive grass typically increases after landscape disturbances and has been identified as a significant fire hazard in the Bishop Field Office Fire Management Plan, and a significant threat to native plant communities and wildlife habitat in the Resource Management Plan. Another potential difference is the effect of these treatments on plant community composition and diversity. Various wildlife species could benefit from pinyon-juniper thinning treatments if they promote high diversity native sagebrush-steppe, achieving both fuels management and resource management goals and objectives. Treatment prescriptions that have multiple benefits are more desirable and ultimately less contentious. Because the responses to these treatments have not been adequately described, and their long-term effects are mostly unknown, we need to evaluate them experimentally to determine how they influence fuelbed structure, fire behavior, cheatgrass dominance, and native plant community composition and diversity before they are applied over broad landscapes.

This experimental study will also establish a demonstration site where the effects of these thinning treatments can be observed and compared to untreated stands first-hand by local and regional land managers, policy makers, and scientists involved in fuels management planning, funding, and research. This study will initially evaluate short-term thinning effects which will be highlighted at a demonstration site field workshop during the third post-treatment year. Maintenance of the demonstration site by the Bishop Field Office will provide continued opportunities for observations and feedback on long-term effects of the treatments. The site will also be established in a WUI where the mosaic of treated and untreated plots will provide additional benefits as a shaded fuel break between homesites at the base of the Bodie Hills, and heavy accumulations of pinyon-juniper fuels further upslope.

The evaluation of these thinning treatments will greatly assist the Bishop Field Office in providing information to help determine how best to address this critical fuel reduction need. There is particular urgency for this information because many thousands of acres are currently identified for treatment to reduce WUI fuel loads beginning within the next 4 years. Waiting for results from other research projects that may be implemented in the future would encumber the BLM from treating high risk sites before a catastrophic fire event takes place. As a final note, I should mention that the sampling effort required to evaluate these experimental treatments is well beyond the scope of typical effectiveness monitoring supported by BLM, and represents a bona fide need for JFSP research funding to support the USGS and USFS collaborators in this project.

Bill Dunkelberger ______________________________ date: __________
Field Office Manager
Bureau of Land Management, Bishop Field Office, 760-872-5001

INTRODUCTION

Background and Project Justification

Woodlands dominated by pinyon pine (*Pinus* spp.) and juniper (*Juniperus* spp.) occupy over 30 million ha of the western United States (West 1999). Prior to anglo-American settlement of this region during the late 1800s, the range of pinyon-juniper woodland was estimated to be only 3 million ha (Miller et al. 1999). This 10-fold expansion of the pinyon-juniper range may have only just begun, since it currently occupies less area then climate conditions seem to allow (Miller et al. 2000). The range expansion of pinyon and juniper has been associated with increased fire return intervals due partly to fire suppression and the reduction of surface fuels caused by the introduction of livestock grazing (Miller and Rose 1999). This woodland expansion has replaced shrub steppe vegetation, leading to increased amounts of hazardous woody fuels in WUI and other areas, loss of wildlife habitat otherwise provided by sagebrush-steppe vegetation, decreased species diversity, loss of soil seedbanks, decreased aquifer recharge, and increased soil erosion rates (Koniak and Everett 1982, Wilcox and Breshears 1994, Davenport et al. 1998, West, 1999, Miller et al. 2000).

As sagebrush-steppe has converted to pinyon-juniper woodlands, fire regimes have shifted from moderate intensity, moderate return interval (~50 years), surface fires, to high intensity, long return interval (>100 years), crown fires. Changes in vegetation composition, fuel structure, and fire regime are generally characterized as shifts in fire regime condition class (FRCC), from historical, pre-settlement or otherwise "natural" conditions (FRCC1), to moderate (FRCC2) and high (FRCC3) departures from historical conditions (Hann and Bunnell 2001).

In FRCC2 stands where invading woodlands are relatively young, having established since the middle of the 1900s, tree cover is low and comprised of younger age class 1 and 2 trees (Bradshaw and Reveal, 1943), and cover and seedbank densities of shrubs, grasses, and forbs are likely to be similar to the adjacent shrub steppe vegetation. These stands tend to be on the deeper soils of the lower slopes of hillsides and mountains. These open woodlands possess surface fuels that may still carry low to moderate intensity surface to passive crown fires. These early successional invading woodlands are generally classified as FRCC2 landscapes, deviating slightly from historic natural fuel and fire regimes characteristics. The potential is relatively high for FRCC2 areas to recover back to their pre-invasion state following pinyon-juniper thinning without active revegetation of sagebrush-steppe species.

In FRCC3 strands where invading woodlands are relatively old and are comprised of young and old age class 1 through 4 trees (Bradshaw and Reveal, 1943), having established before or soon after the beginning of the 1900s, tree cover is high, whereas cover and seedbank densities of shrubs, grasses, and herbs are low, differing significantly from adjacent shrub-steppe vegetation. These stands tend to be on the shallower soils of the middle slopes of hillsides and mountains. In these closed-canopy woodlands fire does not propagate easily except under extreme fire weather conditions, which typically results in intense crown fires that endanger rural communities and have undesirable effects on soils and plants (Miller et al. 2000). The potential may be relatively low for FRCC3 landscapes to recover to their pre-invasion conditions following woodland thinning without active revegetation of sagebrush-steppe species.

Various thinning treatments have been used to reduce density and cover of pinyon and juniper, and ultimately shift FRCC2 and FRCC3 woodlands to historical FRCC1 shrub-steppe landscapes, but their effects have been poorly documented and are difficult to predict. This lack of predictability makes many land managers wary of embarking on expensive thinning projects that could potentially have undesirable side effects. The existing information void also complicates the environmental review and approval process and can stall fuels reduction projects in the planning phase. Prudent land management requires that expensive, broad-scale, landscape manipulations should be studied and evaluated first to identify the best prescription to correct the problem, before obligating significant resources to treatments that may do more environmental harm than good. Thus, there is a significant management need across the United States for fuel management prescriptions that can effectively restore FRCC1 fuel and fire regime characteristics, while producing minimal negative ecological side-effects.

One of the primary concerns about thinning treatments is that they cause significant amounts of disturbance, which may promote the dominance of non-native plants such as cheatgrass (*Bromus tectorum*) (Brooks and Pyke 2001). In some cases, invasive plants create new fuel conditions and alter fire regimes (D'Antonio and Vitousek 1992, Brooks et al. 2004). Cheatgrass is prevalent in the pinyon-juniper/sagebrush steppe ecotone, especially in disturbed areas. There is a very real concern that efforts to restore FRCC2 and FRCC3 woodlands to FRCC1 shrub-steppe may increase cheatgrass dominance, promote recurrent fire, and push landscapes into FRCC2 and FRCC3 non-native invasive annual grasslands. Reducing the availability of soil nitrogen by adding carbon to the soil can reduce cheatgrass dominance (Young et al. 1995, M. Brooks unpublished data). One efficient way to add carbon is to chip the biomass that is removed as thinned trees, and apply it as a mulch across the soil surface.

Before BLM Bishop Field Office managers implement large-scale pinyon and juniper thinning treatments, they need information to reliably determine the best methods to achieve the goal of hazardous fuel reduction and historical fuel and fire regime restoration. Specifically, recommendations are needed on management approaches that will most effectively restore FRCC2 and FRCC3 pinyon-juniper landscapes (high intensity, long return interval, crown fire) to FRCC1 sagebrush-steppe (moderate intensity and return interval, surface fire), without promoting the dominance of cheatgrass which would replace one fuel hazard with another, and potentially shift the landscape into another FRCC2 or FRCC3 situation (mixed intensity, short return interval, fast-moving surface fire).

This proposed project is therefore submitted in response to the JFSP AFP 2005-2-Task 1, because it will establish a fire management experiment and a demonstration site that will address a significant local knowledge gap hindering the management of pinyon-juniper woodland fuels within lands managed by the BLM Bishop Field Office, the southwestern Great Basin and eastern Sierra Nevada mountains, and more generally the western United States. We realize that the JFSP Announcement for Proposals states "the Governing Board anticipates that these projects can be accomplished within three years or less." However, we do not believe the short-term effects of thinning treatments, particularly fuel responses that lead to differential fire behavior responses, can be evaluated in less than four fiscal years, accounting for pre-treatment sampling and three years of post-treatment sampling. This is largely due to the fact that funding for this project would not become available until the last quarter of the first project year (FY05). Thus, we propose this as a project that spans 4 fiscal years, beginning towards the end of FY05, and ending at the close of FY08.

Project Objectives

1. Compare the immediate effects of pinyon-juniper thinning treatments on their target fuel types, standing live coarse woody fuels, during the first post-treatment year.
   H_A: Standing live coarse woody fuel loads (100, and 1,000 hr fuels) will be highest on control plots and lowest on masticate-mulch and cut-remove-burn slash plots.
   * This objective is basic effectiveness monitoring that will be used to determine if the treatment prescription significantly reduced the target fuels. All other objectives focus on the net effect of the treatments on overall fuel structure, fire behavior, and plant community composition.
2. Compare the short-term effects of pinyon-juniper thinning treatments on fine fuel characteristics during the first and third post-treatment years.
   H_A: Finer fuel loads (1 and 10 hr) will be highest on cut-remove-burn slash plots, moderate on masticate-mulch plots, and lowest on control plots.
3. Compare the short-term effects of pinyon-juniper thinning treatments on potential fire behavior (using existing fuel models) and actual fire behavior (in an experimental fire) during the third post-treatment year.
   H_A: Fire behavior will be most extreme (high temperatures, flame lengths, rates of spread, etc.) in the control plots, moderately extreme in the cut-remove-burn slash plots, and least extreme in the masticate-mulch plots.
4. Compare the short-term effects of pinyon-juniper thinning treatments on cheatgrass during the first and

second post-treatment years.

H_A: Cheatgrass density and cover will be highest in the cut-remove-burn slash plots, moderate in the masticate-mulch plots, and lowest in the control plots.

5. Compare the effects of pinyon-juniper thinning treatments on native plant communities during the first and second post-treatment years.

   H_A: Native plant density, cover, and species richness will be highest in the masticate-mulch plots, moderate in the cut-remove-burn slash plots, and lowest in the control plots.
6. Compare the short-term effects of thinning treatments in FRCC2 (where woodlands are just beginning to invade sagebrush-bitterbrush steppe) and FRCC 3 (where woodlands are approaching canopy closure) stands.

   H_A: Fine fuels, cheatgrass, and native plants will respond sooner to thinning treatments in FRCC2 than in FRCC3 stands.
7. Compare the implementation cost of the cut-remove-burn slash and masticate-mulch treatments.

   H_A: Cut-remove-burn slash treatments will cost more to implement than masticate-mulch treatments.
8. Establish a demonstration site and interpretive materials to illustrate the relative effects of cut-remove-burn slash and masticate-mulch thinning treatments, in comparison to unthinned pinyon-juniper stands.

<u>Comparisons and Links to Other Related Research</u>

Although there is some literature on the ecology and management of pinyon-juniper woodlands (e.g. annotated bibliographies at http://wsare.usu.edu/pinyon/biblio.htm and http://www.fs.fed.us/database/feis/plants/tree/pinmon/index.html), very little is known about the effects of woodland thinning treatments. The effects of thinning are likely to be highly variable across the extensive pinyon-juniper range which extends from the Columbia plateau and Great Basin desert to the Colorado plateau in western North America. Possible differences across this geographic range include the presence of different species of pinyon, juniper, understory plant species, and wildlife species, differences in the ratio of pinyon:juniper cover, and differences in the ratio of summer:winter rainfall (West 1999).

Our proposed study will be a replicated, randomized experimental study with quantitative fuelbed, vegetation, and fire behavior response variables allowing for rigorous statistical evaluation of the effects of thinning treatments in FRCC2 and adjacent FRCC3 stands at the ecotone between the southwestern Great Basin and the eastern Sierra Nevada Mountains in California. This region is dominated by singleleaf pinyon pine (*Pinus monophylla*), with very little juniper. This project will provide important local knowledge for a region where woodland fuels management in WUI areas is a particularly high priority for land managers. Detailed descriptions of treatments, site conditions, and vegetation responses will facilitate the application of treatment results to other regions in western North America as well.

Current Joint Fire Science Projects

Brooks et al. *Effects of Fuel Management Treatments in Pinyon Juniper Vegetation at a Site on the Colorado Plateau.* (project website at http://www.werc.usgs.gov). Their project focuses on the effects of cut-leave, cut-buck-scatter, and herbicide thinning treatments on fuels, plant cover, and seedbanks in a *Pinus monophylla*/*Pinus edulis*/*Juniperus osteosperma* woodland with an *Artemisia tridentata tridentata*/*Purshia mexicana* understory at a site on the Colorado Plateau in northern Arizona.

Jeanne Chambers et al. *A Demonstration Area on Ecosystem Response to Watershed-Scale Burns in Great Basin Pinyon-Juniper Woodlands*. and *Effects of Fire and Rehabilitation Seeding on Sage Grouse Habitat in the Pinyon-Juniper Zone.* The first demonstration project is focused on describing fuel loads, fire effects, and soil erosion in early, mid, and late seral pinyon-juniper woodlands at a Great Basin site in Nevada. The second project evaluates fire effects, with and without postfire seeding, on soil erosion, and vegetation characteristic important to the sage grouse and other sagebrush obligate birds in the same region.

Other Current Research

Bandelier National Monument is currently evaluating the effects of a mechanical thinning-mulch treatment, and has plans to evaluate future follow-up burn treatments, on *Pinus edulis/Juniperus monosperma* woodlands in the southern Colorado Plateau (Brian Jacobs, Bandelier NM, pers. comm.). We are also aware of a JFSP proposal being developed to evaluate fire and fire surrogate treatments in the sagebrush biome, including treatments involving pinyon and juniper at the upper sagebrush ecotones (McIver et al). It is possible that we could integrate our study site into their larger study plan should both efforts be funded. However, we do not believe that this larger study will produce the local information we need as soon as the study we propose. The BLM Bishop Field Office needs immediate guidance on which management approaches are best to reduce hazardous fuels to alter fire behavior and create defensible space around homesites and other structures, while having minimal positive effects on cheatgrass.

MATERIALS AND METHODS

StudyArea

The proposed study area is in the Mono Basin and Bodie Hills (Mono County, CA) at elevations ranging from 2,100 to 2,600 m (6,890 to 8,530 ft) (Fig. 1). The study area is comprised of two study sites, one to evaluate the response of vegetation to the thinning treatments (Fig. 2) and another to evaluate the response of fire behavior to the thinning treatments (Fig. 3)

Annual precipitation in the study area averages 40 cm (16 in). Summer temperatures range between 15 and 32 ºC (59 and 90 ºF), and winter temperatures range between -9 and 2 ºC (16 and 36 ºF). Soil parent material in the study area is comprised primarily of Tertiary volcanics with granitic and calcareous inclusions. Soil textures range from rocky to loamy.

The study area is dominated by singleleaf pinyon pine (*Pinus monophylla*), as indicated by a baseline vegetation inventory for the region completed in 1984 using the BLM Site Inventory Method (SVIM). Early seral FRCC2 woodland communities are dominated by an overstory (15-20% cover) of singleleaf pinyon pine with a sagebrush/bitterbrush steppe understory, whereas in later seral FRCC3 pinyon stands (~50% cover) understory cover is largely absent. FRCC2 stands tend to be downslope of the FRCC3 stands (see Figs. 2 and 3), since the historical encroachment of pinyon has proceeded from the upper slopes towards the lower slopes in this region. The FRCC2 and FRCC3 experimental stands in the study area were identified and mapped by BLM by comparing woodland cover on historic (early 1900s) with recent (1991) aerial photos.

Understory sagebrush/bitterbrush steppe in this region is dominated by sagebrush (*Artemisia arbuscula, A. tridentata* ssp. *vaseyana*, *A. tridentata* ssp. *tridentata*, *A. tridentata* ssp. *wyomingensis* and *A. tridentata* ssp. *parishii*) and bitterbrush (*Purshia tridentata* var. *tridentata)*. Understory grasses include Indian rice grass (*Achnatherum hymenoides*), needle and thread (*Hespirostipa comota*), western needlegrass (*Achnatherum occidentalis*), Thurber's needlegrass (*Achnatherum thurberianum*), squirreltail grass (*Elymus elymoides),* and Great Basin wild rye (*Leymus cinereus*). Forbs are dominated by species from the following genera: *Astragalus, Arabis, Cryptantha, Eriogonum, Gilia, Lupinus, Onagaraceae, Phacelia, Phlox*, and Asteraceae genera.

Thinning Treatments

The thinning target will be 80% of post-settlement pinyon trees in each treatment plot. Old growth pinyon trees will be left untreated. Post-settlement trees range from one-year seedlings to 100-175 year old trees (Class 1-3 trees, Bradshaw and Reveal, 1943). The goal will be to return FRCC2 and FRCC3 landscapes to FRCC1 condition.

Masticate-Mulch

- Every 4 post-settlement pinyon trees encountered in the treatment plot will be treated, leaving every 5th post-settlement tree.
- Treatment will be accomplished by a tractor-mounted masticating head, grinding Class 1, 2, and 3 trees to ground level.
- The shredded tree and shrub material will be left on-site as a form of mulch material.

Cut-Remove-Burn Slash

- Every 4 post-settlement pinyon trees encountered in the treatment plot will be thinned, leaving every 5th post-settlement tree.

- Treatment will be accomplished by cutting selected Class 1 (youngest) trees at ground level using loping shears or chainsaws, and cutting selected Class 2 and 3 trees at ground level using a chainsaw.
- Boles of Class 2 and 3 cut trees will be limbed to manageable lengths and removed from the plots and made available as firewood.
- Class 1 trees and the limbs and tops of Class 2 and 3 trees will be hand piled within the treatment plots, but outside of the sampling plots. Hand piles will be burned as soon as conditions permit.

Untreated Control

- We will not remove any pinyon trees.

Study Design

This study will evaluate the effects of two experimental factors, FRCC type and thinning treatment type. Because the FRCCs are the result of 100+ years of land management practices and climatic conditions, the assignment of FRCCs to treatment plots cannot be done randomly. We attempted to intersperse the two FRCC treatments as much as possible by choosing a study area with a mosaic of FRCC2 and FRCC3 patches, although the former tended to be slightly downslope from the latter (Figs. 2 and 3). We do not view this as a flaw in the study design, because FRCCs covary with soil depth and position on topographic slopes (as discussed above), and this pattern is typical of pinyon-juniper woodlands in the southwestern Great Basin. This post-hoc approach to matching FRCC treatments with treatment plots is sometimes referred to as a "natural experiment (Diamond 1986). In contrast, thinning treatments will be randomly assigned to treatment plots, by first establishing unassigned plots within the FRCC2 an FRCC3 patches, then randomly assigning treatments to them (Figs. 2 and 3).

The responses of vegetation and fire behavior to the experimental factors will be evaluate separately in two different experiments, located in two different sites within the study area (Fig. 2 and 3). We separated these two experiments to ensure that the vegetation response plots would not be compromised by activities related to experimental burning. Also, the logistics of conducting the experimental burns were simplified by grouping them within close proximity of each other. This will both facilitate pre-burn site preparation and increase firefighter safety during the burns.

Vegetation Response Experiment

Each factorial combination of 3 thinning treatments and 2 FRCCs will be replicated 8 times (n=48 vegetation response plots). A map of the vegetation response plots and their assigned treatments is provided in Fig. 2. These plots will be used to compare the effects of thinning treatments in FRCC2 and FRCC3 stands on plant community composition and structure. Each treatment unit will be 2.5 acres (1 ha), 39.6 total acres (16 ha) per treatment type (Table 1).

Table 1. Approximate area distribution by thinning treatment type and FRCC for the fuel and vegetation response experiment.

	Thinning Treatment Type			
Condition Class	C-R-BS	M-M	Control	Totals
FRCC2	19.8 ac (8 ha)	19.8 ac (8 ha)	19.8 ac (8 ha)	59.4 ac (24 ha)
FRCC3	19.8 ac (8 ha)	19.8 ac (8 ha)	19.8 ac (8 ha)	59.4 ac (24 ha)
	39.6 ac (16 ha)	39.6 ac (16 ha)	39.6 ac (16 ha)	118.8 ac (48 ha)

C-R-BS = Cut-Remove-Burn Slash
M-M = Masticate-Mulch
Control = no removal of any trees/shrubs
FRCC2 = class 1-2 trees, Bradshaw and Reveal (1943)
FRCC3 = class 1-4 trees, Bradshaw and Reveal (1943)

Fire Behavior Response Experiment

We will also establish 3 replicate blocks of the 3 thinning treatment plots in each of the 2 FRCCs (n=18 fire behavior response plots) to evaluate the effects of the thinning treatments on fire behavior (Table 2) which will allow us to infer the effects on fire regimes (Fig. 4). A map of the fire behavior response plots and their assigned treatments is provided in Fig. 3. These plots will be used to compare the effects of thinning treatments in FRCC2 and FRCC3 stands on fuels, potential fire behavior, and actual fire behavior. As with the vegetation response experiment, each treatment plot will be 2.5 acres (1 ha), 14.8 acres (6ha) per treatment type (Table 2).

Table 2. Approximate area distribution by thinning treatment type and FRCC for the fire behavior response experiment. All treatment blocks will be treated with prescribed fire.

	Thinning Treatment Type			
Condition Class	C-R-BS	M-M	Control	Totals
FRCC2	7.4 ac (3 ha)	7.4 ac (3 ha)	7.4 ac (3 ha)	22.2 ac (9 ha)
FRCC3	7.4 ac (3 ha)	7.4 ac (3 ha)	7.4 ac (3 ha)	22.2 ac (9 ha)
	14.8 ac (6 ha)	14.8 ac (6 ha)	14.8 ac (6 ha)	44.4 ac (18 ha)

C-R-BS = Cut-Remove-Burn Slash
M-M = Masticate-Mulch
Control = no removal of any trees/shrubs
FRCC2 = class 1-2 trees, Bradshaw and Reveal (1943)
FRCC3 = class 1-4 trees, Bradshaw and Reveal (1943)

<u>Sampling Methods</u>

The sampling unit will consist of a 5 x 30m FMH brush belt transect (USDI National Park Service 2001), overlaid with a 20 x 50m modified Whittaker plot (mod-whit plot) (Stohlgren et al. 1995)(Fig. 5). Each of the treatment plots will have three sampling units systematically located within them, such that the edge of each sampling unit will be 10m from each other and ≥10m from the plot edge (Fig. 6). By orienting the plots in two perpendicular planes, we will maximize the measurement of within-treatment-plot variance that may be caused by local environmental gradients or by biased orientation of downed trees that can occur in logging operations (e.g. trees are often felled downslope and/or away from where the crews will move to next).

Pre-treatment sampling, and sampling during the first three post-treatment years, will be used to evalute the short-term effects of the thinning treatments. Longer-term effects can be studied in the future since the site will be maintained as a demonstration site. The timeline for sampling is provided in the Project Duration and Timeline section of this proposal.

Photomonitoring plots will be installed in each treatment plot following the NPS-FMH methods (USDI National Park Service 2001). These plots will provide important visual documentation that we will use in the development of interpretive information for the demonstration site, and will provide a baseline for future photomonitoring that will be continued by the BLM Bishop Field Office to evalute the long-term effects of thinning treatments past the end of the proposed project.

Plant Density and Cover (FMH Brush Belt Transect)

Density of woody perennial plants will be measured in the 5x30m belt transect centered within each mod-whit plot (Fig. 5). Each individual having >50% of its rooted base within the belt transect will be counted. Data will be recorded by species and age class. Age class of each individual will be identified as either dead, immature-seedling, resprout, or mature-adult (USDI National Park Service 2001).

Density of herbaceous plants will be collected within five 1m^2 subplots along the two 30m sides of the brush belt transect as subsamples (Fig. 5). Herbaceous plants will be counted by species for each frame, separating live and dead individuals (USDI National Park Service 2001).

Cover of woody perennial and herbaceous plants, non-vascular plants, litter, and soil will be measured by the point-intercept method, using the two 30m sides of of the brush belt transect as subsamples (Fig. 5). Starting at the end of each transect and repeated every 30 cm, a 0.25inch diameter sampling rod (a rigid plumb bob), graduated in decimeters, will be lowered gently so that the sampling rod is plumb to the ground. Since the transect length is 30 m, there will be 100 points from 30 to 3,000 cm. The height at which each species touches the sampling rod will be recorded, tallest to shortest. If the rod fails to intercept any vegetation, the substrate will be recorded (bare soil, rock, forest litter, etc.) (USDI National Park Service 2001).

Plant Diversity (Mod-Whit Plot)

Plant diversity will be calculated at multiples scales within the 20 x 50m mod-whit plot (Fig 5). The effects of disturbance on plant diversity can vary among spatial scales. For example, the effects on plant community diversity due to fire (Brooks and Matchett 2003) and grazing (Stohlgren et al. 1999) can vary between 1 and 1,000m^2 scales. It is possible that similar variation will occur among management treatment in pinon-juniper woodland, warranting the use of the spatially nested modified-Whittaker plots in this study. Plant species richness will be measured for all species recorded at 1, 10, 100, and 1,000m^2 scales.

Fuelbed Characteristics

Tons per acre of fuels will be calculated by size class using the line transect method (Brown et al. 1982). The total length of the fuels transect for 1000-hr fuels will be 50m, oriented along one of the sides of each mod-whit plot (Fig. 5). There will be 3 sampling units per treatment block giving 24 per treatment type/condition class for the fuel and vegetation response experiment and 9 per treatment type/condition class for the fire behavior response experiment.

There will be additional fuels data collected in the masticated treatment units. Several small cover plots will be established along the outside of the mod-whit plots where the cover of masticated fuel will be estimated and depth of fuels will be taken at several places within the cover plot. Along the 20m sides of the mod-whit plots there will be two additional masticated fuel cover plots established, but those fuels will be collected, oven dried, and weighed in hopes of establishing regression equations for determining load of masticated fuels.

We will use Tausch's allometric model to estimate pinyon fuel classes and biomass (Tausch In Prep.) by measuring tree height, crown diameter, height to live fuel, and ground-line diameter by tree species in the FMH brush-belt transects. We will use our own allometric models to estimate fuel classes and biomass for mountain big sagebrush (*Artemisia tridentata vaseyana*) and bitterbrush (*Purshia tridentata*.) (M. Brooks et al. unpublished data), after validating, and possibly modifying, them with site specific data for these two shrub species.

Fire Behavior

Potential fire behavior will be estimated from the fuelbed data using the shrub fuel models of Albini (1976). We will use the specific model that best fits our fuelbed characteristics (either model 4, 5, 6, or 7) using Anderson (1982) as a guide. These models will estimate potential rates of spread and flame lengths, for statistical comparison among the 3 thinning treatments and 2 FRCCs.

Actual fire behavior will be measured during prescribed fires conducted during the 3rd post-treatment year. Vegetation responses to similar pinyon-juniper thinning projects in other regions have indicated that surface fuels can respond significantly after just a few years (M. Brooks unpublished data), and these fuels responses appear to be sufficient to cause differing fire behavior. These data will allow us to evaluate the reliability of fire behavior predictions generated from the shrub fuel models of Albini (1976).

We will calculate rates of spread, residency times, and heating patterns by directly measuring temperatures using thermocouples systematically arranged in arrays within the treatment plots (Fig. 7). These measures will be verified by direct observations and by recorded observations from a single digital video camera in a fire-proof box pre-positioned within each of the treatment plots. These videos will be used to supplement other outreach interpretive materials associated with this demonstration study site.

<u>Statistical Analyses</u>

Data will be analyzed separately for the vegetation response and fire behavior response experiments as fixed factorial, randomized, analysis of variance statistical models. Response variables for the vegetation response experiment will include: (1) stem density and cover of pinyon and juniper, perennial grasses, shrubs, cheatgrass, other alien annuals, and native annuals; and (2) alien and native plant richness at 1, 10, 100, and

1,000m^2. Response variables for the fuel and fire behavior response experiment will include: (1) fuelbed characteristics; and (2) potential and actual fire behavior. Multiple response variables within each of these four response variable categories will be analyzed together using multivariate analysis of variance. If separate analyses are needed, we will use analysis of variance with Bonferroni corrected *p*-values. Multiple post-treatment years will be treated as a repeated-measures variable, using a model known as a doubly-multivariate repeated measures model ('doubly' with respect to multiple response variables measured over multiple time periods; SAS Proc GLM). We will evaluate how each multivariate response variable contributes to overall treatment effects by evaluating their standardized canonical coefficients followed by univariate tests for these variables. Larger coefficients indicated a response variable had more contribution to the overall treatment effect. When making univariate *a posteriori* pair-wise comparisons, we used the step-down Sidak method to control experimental-wise Type I error rates (Sokal and Rohlf 1995). Finally, stand or species composition data may be compared among the treatment combinations by ordination techniques, such as canonical correlations or percent similarity measures, if determined to be appropriate.

Data Management

Completed project data sets will be housed in duplicate at the USGS Las Vegas Field Station, at the BLM Bishop Field Office, and archived in the USGS-NBII.

PROJECT COMPLIANCE

Environmental and cultural clearances as well as Native American consultations have been completed by the BLM. The project is approved for implementation.

PROJECT DURATION AND TIMELINE

This project will begin during the last quarter of FY05 and be completed by the end of FY06. The specific duration will be 3 years, 3 months. The timeline for the completion of products is provided in the Deliverables section of this proposal. The timeline for the sampling of response variables is as follows:

Response Variables	Pre-treatment	Post-treatment		
	FY05	FY06	FY07	FY08
	Vegetation response experiment			
Photo-monitoring	Summer	Summer	Summer	Summer
Plant density and cover	Summer	Summer	Summer	
Plant diversity	Summer	Summer	Summer	
	Fire behavior response experiment			
Photo-monitoring	Summer	Summer	Summer	Summer (pre and post-fire)
Fuelbed characteristics	Summer	Summer		Summer (pre and post-fire)
Fire behavior				Summer

BUDGET (contributed base and cyclical funds from participating agencies are in parentheses)

Fiscal Year		FY05	FY06	FY07	FY08
		Pre-treat & Treatment	Post-treat 1	Post-treat 2	Post-treat 3 & Burn
USGS	Matt Brooks	(9,720)	(10,498)	(11,337)	(12,244)
	Ecologist (GS-9)	22,860	17,800	9,500	25,400
	Biol Techs (GS-5)	24,700	19,000		23,000
	Travel	15,000	10,000	1,000	12,000
	Supplies	2,000	1,000		1,000
	field workshop				5,000
	thermocouples and dataloggers				(55,000)
	Subtotal	64,560	47,800	10,500	66,400
	20% indirect rate	17,484	9,560	2,100	13,280
	21% indirect rate contributed (USGS-WERC rate 41%)	(13,558)	(10,038)	(2,205)	(13,944)
	USGS requested	**82,044**	**57,360**	**12,600**	**79,680**
	USGS contributed	**(23,278)**	**(20,536)**	**(13,542)**	**(81,188)**
USFS	Helen Smith	(9,880)	(10,275)	(10,686)	(11,113)
	Forester (GS-9)				7,500
	Travel	3,500	2,500	2,500	7,500
	supplies and lab maintenance	1,095	511	427	745
	Subtotal	4,595	3,011	2,927	15,745
	19.2% indirect rate + 10% USGS pass-through*	1,342	879	855	4,598
	USFS requested	**5,937**	**3,890**	**3,782**	**20,343**
	USFS contributed	**(9,880)**	**(10,275)**	**(10,686)**	**(11,113)**
BLM	Anne Halford	(10,000)	(5,400)	(5,832)	(6,299)
	Dale Johnson	(15,000)	(5,400)	(5,832)	(6,299)
	Steve Nelson (GIS support)	(5,000)	(5,400)	(5,832)	(6,299)
	Arch. Tech	(5,000)			
	thinning implementation	(45,000)			
	experimental fire implementation				(20,000)
	BLM requested	**0**	**0**	**0**	**0**
	BLM contributed	**(80,000)**	**(16,200)**	**(17,496)**	**(38,897)**
	Total Funds Requested	**87,981**	**61,250**	**16,382**	**100,023**
	Total Funds Contributed	**($113,158)**	**($47,011)**	**($41,724)**	**($131,198)**
	GRAND TOTAL				**$265,636** **($333,091)**

* We will utilize an existing cooperative agreement between USGS-WERC and the USFS-Rocky Mountain Research Station-Fire Sciences Lab to transfer funds from the USGS to the USFS. There is a 10% assessment associated with this pass-through.

SCIENCE DELIVERY AND APPLICATION

We will develop a website to provide information on the study plan, progress reports, and other deliverables for this project, similar to another pinyon-juniper thinning project website developed by USGS and funded by the JFSP (http://www.werc.usgs.gov/fire/lv/pj/lakemead). We will host a field workshop for land managers, policy makers, and research scientists describing the short-term effects of the thinning treatments on fuel structure, fire behavior, invasive plants dominance, and native plant community characteristics. The study area will be maintained by the BLM Bishop Field Office as a demonstration site, including annual photo-monitoring and future workshops and site visits, so that longer-term effects of the treatments can be observed, evaluated, and feedback into management planning within an adaptive management framework. The USGS will work with the BLM to develop interpretive materials and will maintain the project website to improve the educational value of this demonstration site. The USGS will also coordinate the development of peer-reviewed journal articles and publication briefs for each journal article focused on the management applications of the research (see examples at http://www.werc.usgs.gov/pubbriefs). Finally, the transfer of information to a broad range of land managers will be facilitated through the USGS PI's regular participation as an instructor in agency training workshops such as the NPS "integrated fire and resource management planning" courses, and the NAFRI "fire in ecosystem management" (FIEM) course.

DELIVERABLES

Deliverables	Delivery Dates
FY06 progress report presented at the Joint Fire Science PI workshop	Spring 2006
Project website	Fall 2006
Integrate preliminary results into NAFRI FIEM course	Winter 2007
FY07 progress report presented at the Joint Fire Science PI workshop	Spring 2007
Integrate preliminary results into NAFRI FIEM course	Winter 2008
FY08 progress report presented at the Joint Fire Science PI workshop	Spring 2008
Integrate preliminary results into NAFRI FIEM course	Winter 2009
Fact sheets and other interpretive information	Spring 2009
Field workshop at the demonstration site	Spring 2009
Final report presented at the Joint Fire Science PI workshop	Spring 2009
Peer-reviewed journal articles and publication briefs	Spring 2009 through 2010

Aside from the website, all deliverables will be produced for distribution in both paper and electronic formats. In addition, annual progress summaries will be submitted to the JFSP office by 15 February 2006, 2007, and 2008.

QUALIFICATIONS AND RESPONSIBILITIES OF THE INVESTIGATORS

The combined knowledge and experience of these scientists and land managers will ensure that the recommendations that developed from this project will be scientifically valid and defensible, and directly applicable to land management. All team members will be involved in each step of the project from inception to completion, and in particular during the production of final products. Brief CVs are listed in Appendix A.

Matt Brooks, USGS: fuels management, postfire restoration, fire ecology and management of arid and semi-arid ecosystems, invasive plant ecology, study design, biostatistics, website design.

Helen Smith, USFS: fuels and fire behavior modeling

Anne Halford, NPS: plant ecology and management

Dale Johnson, BLM: wildland fuels management, wildland and urban interface fire suppression operations

<u>Other Cooperators</u>

Sue Weis, Botanist, Inyo National Forest: eastern Sierra Nevada flora and vegetation management

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Figure 1. General map of the study area.
See attached file.

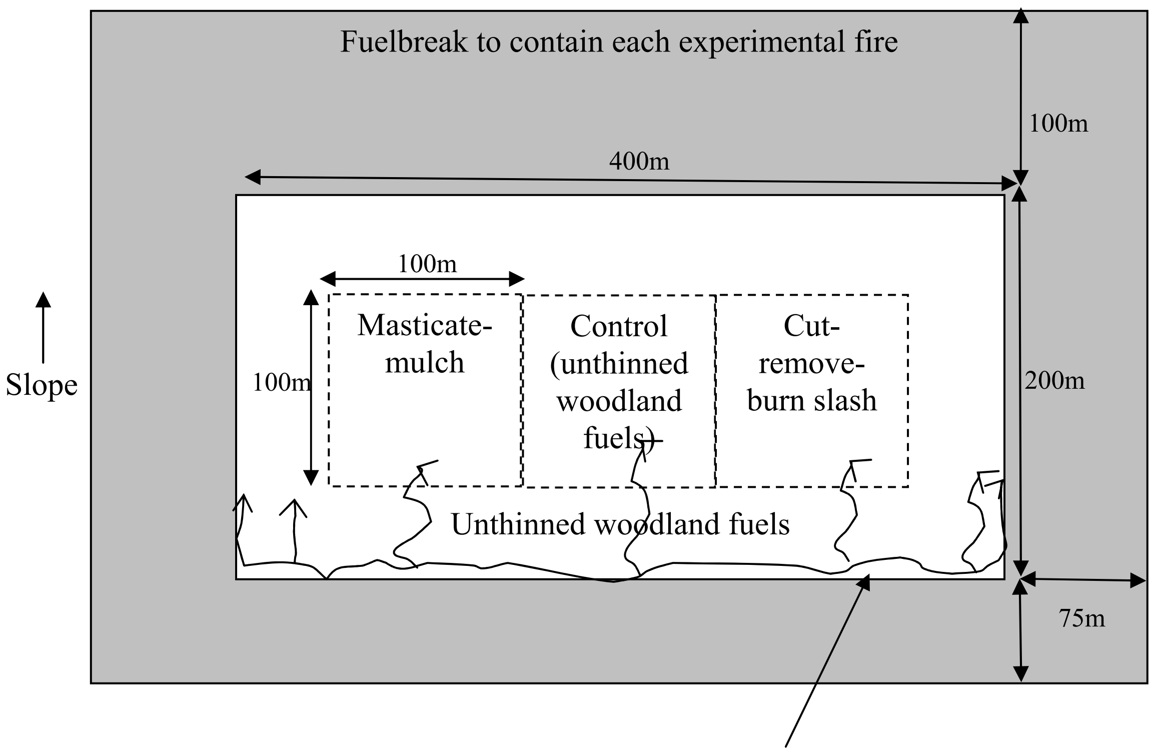
Figure 2. Specific locations of the vegetation response plots.
See attached file.

Figure 3. Specific locations of the fire behavior response plots.
See attached file.

Figure 4. Burn plot design for the fire behavior response experiment.

Within each of the three 2.47acre (1ha) treatment plots we will:

- Quantify fuels
- Measure rate-of-spread and fire intensities (temps and durations) using 3 replicate thermocouple arrays (36 thermos in a 6x6 grid).
- Video the fire using fire-proof camera boxes prepositioned in the plots



- Strip-fire downslope side to create a heading fire moving through the experimental plots.
- Each experimental fire will be 19.77 acres (8ha, 400 x 200m).
- The entire experimental area, including the fuelbreak, will be 50.97 acres (20.63 ha, 375 x 550m).

Figure 5. Diagram of the vegetation sampling unit, which consists of a (A.) 20 x 50m modified Whittaker (mod-whit) plot positioned around a (B.) 5 x 30m FMH brush belt transect

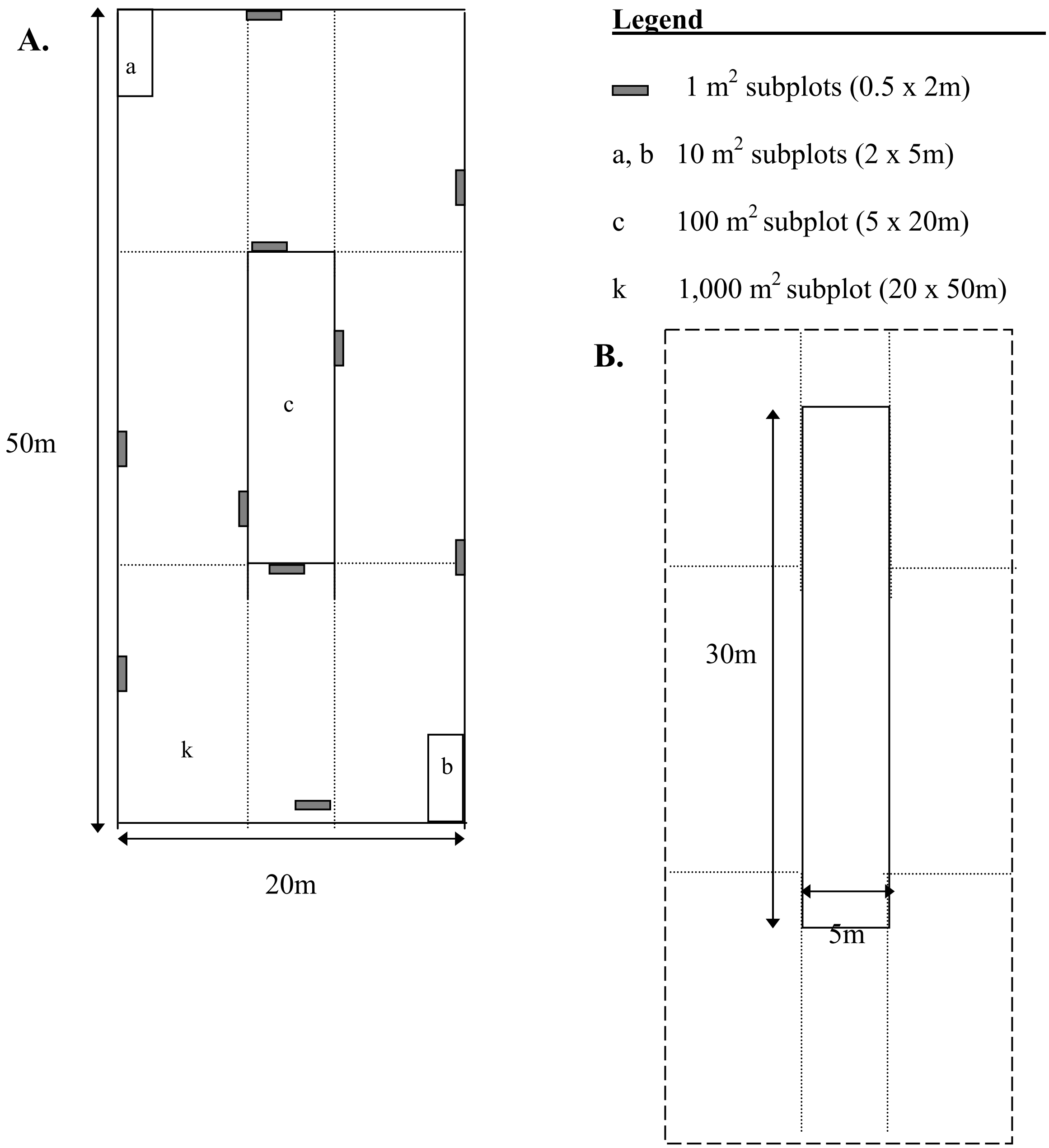


Figure 6. Relative locations of the 3 vegetation sampling plots (shaded) within each of the treatment plots.

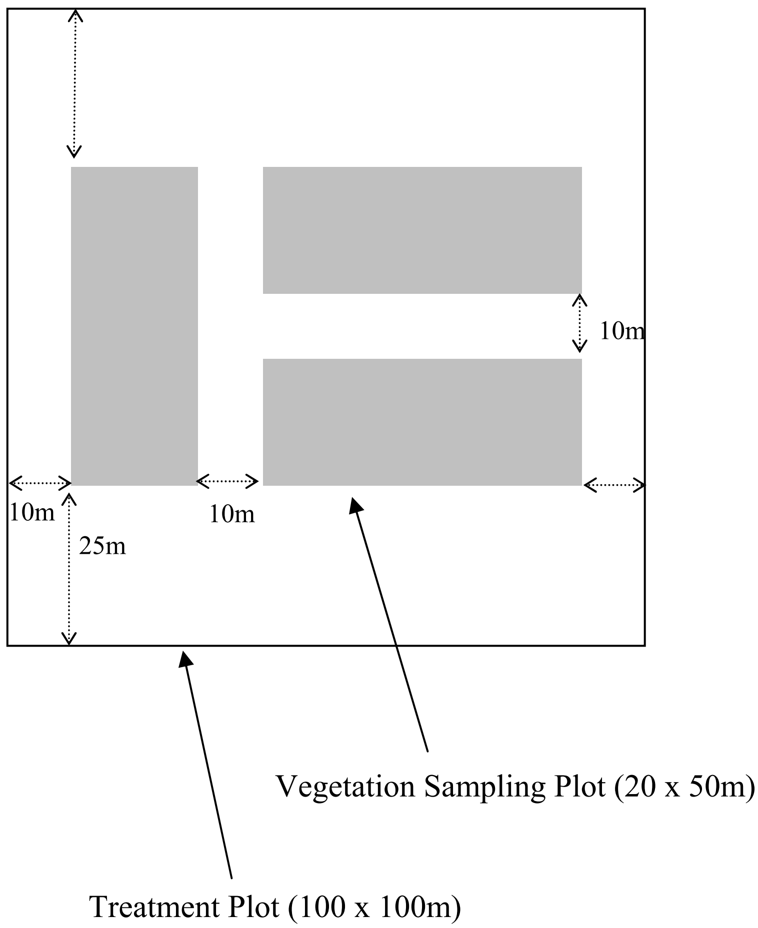
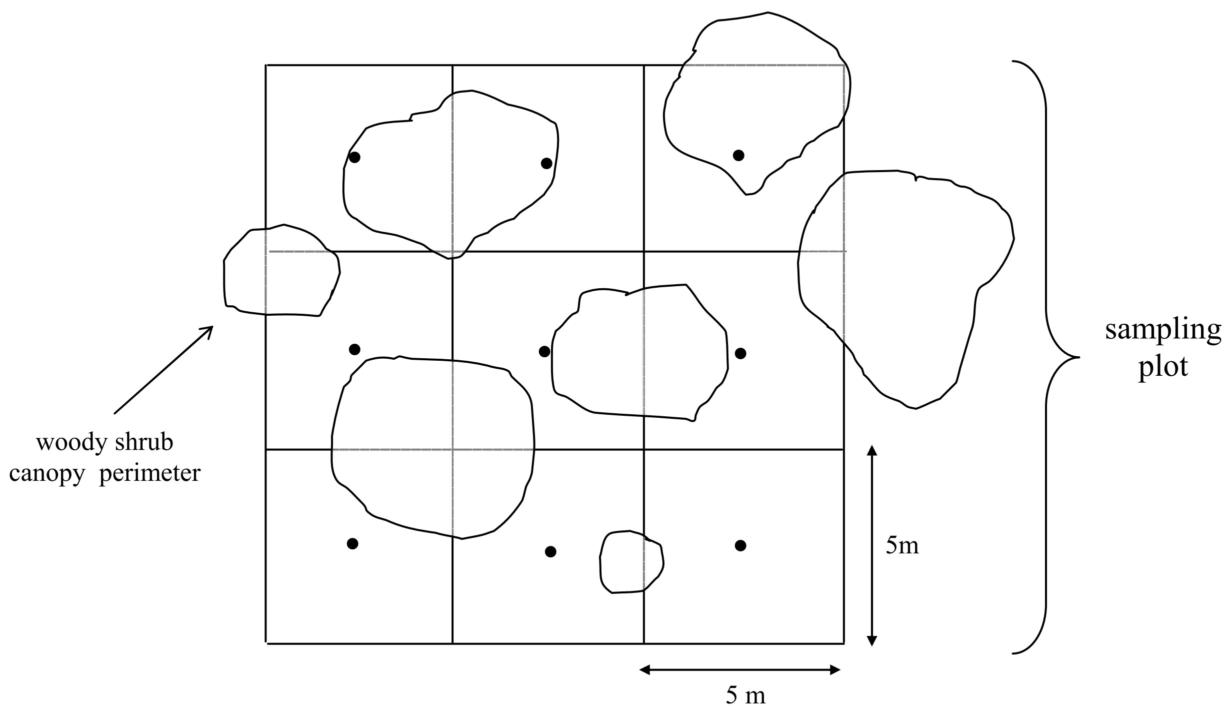


Figure 7. Locations of the thermocouple temperature sampling arrays (•) within the 9 sub-plots within each of the 3 replicate sampling units in each fire behavior treatment plot. A single data logger will be attached to the thermocouple arrays in each sampling unit. Sampling units are described in Figs. 5 and 6.



APPENDIX A
Research team qualifications

Matthew L. Brooks

Research Botanist, United States Department of the Interior, United States Geological Survey, Western Ecological Research Center, Las Vegas Field Station, 160 N. Stephanie, Henderson, NV 89074. phone: 702-564-4615; email: matt_brooks@usgs.gov

Education

Ph.D.	Biology	University of California, Riverside	1998
M.A.	Biology	California State University Fresno	1992
Secondary Teaching Credential		California State University Fresno	1990
B.S.	Biology	University of California, Irvine	1987

Experience

Research Botanist, USGS, Western Ecological Research Center, 1998-present
Adjunct Professor of Biology, University of Nevada, Las Vegas, 2002-present
Board of Directors, Association for Fire Ecology, 2002-present
Editorial board of Fire Ecology, the journal of the Association for Fire Ecology, 2002-present
Board of Directors, California Exotic Pest Plant Council, 2000-present
Graduate Student Researcher/Prin. Investigator, University of California Riverside, 1995-1998
Adjunct Professor, Department of Biology, California State University, Northridge. 1997
Scientific Aid, California Department of Fish and Game, 1989-1990
Science Teacher at the high school, community college, and university levels, 1988-1998

Current Research

My research is focused on the ecology and management of fire and invasive plants in western North America. Current fire projects are designed to evaluate the effects of pre-fire fuels treatments and post-fire seeding treatments on fuel structure, potential fire behavior, plant community composition and diversity, and dominance by alien invasive plants in sagebrush-steppe, blackbrush scrub, pinyon-juniper woodland, and ponderosa pine forest ecosystems.

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Education

M.S., Resource Conservation, The University of Montana, 1999
B.S., Wildlife Biology with High Honors, The University of Montana, 1995
A.A.S., Science with High Honors, Flathead Valley Community College, 1993

Employment

1999-Present: Ecologist, Prescribed Fire and Fire Effects Project, Intermountain Fire Sciences Laboratory, Missoula, Montana.
1996-1999: Graduate Research Assistant, The University of Montana, Missoula.
1995-1999: Forestry Technician, Prescribed Fire and Fire Effects Project, Intermountain Fire Sciences Laboratory, Missoula, Montana.
1994: Forestry Technician, Glacier View Ranger District, Flathead National Forest, Columbia Falls, Montana.
1993: Forestry Technician, Hungry Horse Ranger District, Flathead National Forest, Hungry Horse, Montana.

Publications

Smith, Helen Y., ed. 2000. The Bitterroot Ecosystem Management Research Project: What we have learned: symposium proceedings; 1999 May 18-20; Missoula, MT. Proc. RMRS-P-17 Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 154 p.
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Smith, Helen Y. 2000. Factors affecting ponderosa pine snag longevity. In: Proceedings of the Society of American Foresters 1999 National Convention; 1999 September 11-15; Portland, OR. SAF publication 00-1: 223-229.
Smith, Helen Y. 1999. Assessing longevity of ponderosa pine (*Pinus ponderosa*) snags in relation to age, diameter, wood density, and pitch content. Missoula, MT: The University of Montana. 46 p. Thesis.

Smith, Helen Y.; Arno, Stephen F., eds. 1999. Eighty-eight years of change in a managed ponderosa pine forest. Gen. Tech. Rep. RMRS-GTR-23. Ogden, UT: U.S. Department of Agriculture, Rocky Mountain Research Station. 55 p. + 14 foldout photopoint pages, one poster.
Arno, Stephen F.; Smith, Helen Y.; Krebs, Michael A. 1997. Old growth ponderosa pine and western larch stand structures: influences of pre-1900 fires and fire exclusion. Res. Pap. INT-RP-495. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 20 p.

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Education

M.S. Plant Ecology	University of Nevada-Reno	1991
B.S Environmental Science	University of Colorado-Boulder	1983

Work Experience

1991- Present **Botanist**, BLM, Bishop Field Office, Bishop, California
Current projects and responsibilities include:
- Coordination and implementation of Field Office's Special Status Plant, Revegetation/Restoration and Invasive Weed Programs which involves the cooperation between 14 different agencies, federal, state, and county as well as private and non-profit organizations.
- Development and administration of grants, contracts and cooperative agreements for Special Status Plant, revegetation/restoration and invasive weed projects and studies.
- Coordination, development and review of vegetation and Special Status Plant portions of Environmental Assessments and EIS's/EIR's.
- Emergency Fire Rehabilitation Team lead
- Supervision and training of biological seasonal field personnel.
- Integration of Geographical Information Systems (GIS) with resource projects that require locational, ecological trend and cumulative impact analyses.
- Enhancement of environmental education opportunities for local schools and University of California students.

1989-1991 **Biological Technician,** Tahoe National Forest, California - Foresthill and Sierraville Districts
- Coordinated District's Sensitive Plant Program which entailed habitat mapping and extensive field data collection of population locations, trend and environmental site characteristic information.
- Coordinated and trained seasonal personnel on survey and monitoring protocols for both rare plant and spotted owl surveys.

1988 **Biological Technician,** Gates of the Arctic National Park, Brooks Range, Alaska
- Collected and analyzed baseline biological data to monitor vegetation response to human impacts.
- Compiled species lists and collected specimens for Park Service Herbarium.
- Participated in large mammal and raptor surveys.
- Consolidated biological data into data base programs for future use by the Park Service in formulating management directives.

1987 **Biological Technician,** Sunriver Nature Center, Bend, Oregon

- Formulated a vegetation study to examine the fire fuel potential of bitterbrush (*Purshia tridentata)* via manipulation of litter types and densities.
- Collected and analyzed data for an on-going pine beetle infestation study.

1983-1987 **Interpretive Ranger,** North Cascades National Park, Marblemount, Washington

- Created a variety of environmental lectures, multi-media slide presentations and interpretive hikes.
- Participated in monitoring of human impacts to high-altitude vegetation.

1984-1986 **Editor**, National Audubon Society, Rocky Mountain Regional Office, Boulder, CO

- Developed monthly environmental issues newsletter.
- Developed and implemented marketing proposals for Audubon's Field Camps.

Publications and Technical Reports

1991-2003 - BLM Bishop Field Office Special Status Plant Monitoring Reports.

1992- BLM Bishop Field Office - Special Status Plant Guide.

1993 – BLM Bishop Field Office - Report to the California Department of Fish and Game and Nature Conservancy on the germination and site characteristic study of *Sidalcea covillei* (Owens Valley checkerbloom).

Halford, A.S., Nowak, R.S. 1996. Distribution and Ecological Characteristics of *Lewisia longipetala (*Piper) Clay, A High-Altitude Endemic Plant. Great Basin Naturalist 56(3) pp. 225-236.

1998 - BLM Bishop Field Office - Report to the California Department of Fish and Game on the results of three revegetation projects in alkali meadow and desert scrub community types.

Sada, D.W., Williams, J.E., Silvey, J.C., Halford, A.S., Rmakka, J., Summers, P., Lewis, L. 2001. A Guide to Managing, Restoring, and Conserving Springs in the Western United States. Technical Reference 1737-17, Bureau of Land Management. National Science and Technology Center, Denver, CO

Halford, F.K., Halford, A.S. 2002. Trench Canyon Prescribed Burn - The Effects of Fire in a Sagebrush Steppe Environment. Paper presented in Symposium 2 *The effects of Fire/Heat on Obsidian.* 33rd Annual Meeting of the Society for California Archaeology. Sacramento, CA

2003 – BLM Bishop Field Office – Fire Rehabilitation Monitoring Reports for the Cannon and Slinkard Fire Complexes.

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Education

B.S. - Forest Resources University of Minnesota 1983

Experience

Feb 2004 – present Fuels Specialist/Planner, BLM, Bishop Field Office, Bishop, California
Jun 2003 – Feb 2004 Fuels Specialist/Planner, Inyo Nat'l Forest, Lee Vining, California
Sep 2001 – Jun 2004 Silviculturist, Inyo Nat'l Forest, Lee Vining, California
Apr 1992 – Sep 2001 Forestry Technician, Inyo Nat'l Forest, Lee Vining, California