Project Title:	**Quantifying the Effects of Fuels Reduction Treatments on Fire Behavior and Post-fire Vegetation Dynamics**
Announcement for Proposals and task statement this proposal is responding to:	Joint Fire Sciences AFP 2006-2 Task 1,
Principal Investigator:	Scott Rupp
Affiliation:	University of Alaska Fairbanks
Address:	Box 757200, Fairbanks, AK 99775
Phone:	907-474-7535
Email:	scott.rupp@uaf.edu
Co-Principal Investigator:	Roger Ottmar
Affiliation:	USFS Pacific Wildland Fire Sciences Laboratory
Address:	400 North 34th Street, Suite 201, Seattle, Washington 98103
Phone:	206-732-7826
Email:	rottmar@fs.fed.us
Point of Contact:	Scott Rupp University of Alaska Fairbanks Box 757200, Fairbanks, AK 99775 Email: scott.rupp@uaf.edu Phone: 907-474-7535 Fax: 907-474-6184
Federal Cooperator:	Randi Jandt Bureau of Land Management, Alaska Fire Service P.O. Box 35005, Ft. Wainwright, AK 99703 Email: Randi_Jandt@ak.blm.gov Phone: 907-356-5864 Fax: 907-356-5697
Additional Federal Collaborator(s)*:*	Bret Butler – USFS, Fire Sciences Laboratory Colin Hardy – USFS, Fire Sciences Laboratory Kato Howard – BLM, Alaska Fire Service Skip Theisen – BLM, Northern District Office Peter Butteri – USFWS Tetlin National Wildlife Refuge Robert Schmoll – AK Dept. Natural Resources, Div. of Forestry Dale Haggstrom – AK Dept. Fish & Game, Div. of Wildlife Conserv.
Federal Fiscal Representative:	Joe Ribar Bureau of Land Management, Alaska Fire Service P.O. Box 35005, Ft. Wainwright, AK 99703 Email: Joe Ribar@ak.blm.gov Phone: 907-356-5699 Fax: 907-356-5697
Duration of Project:	3 calendar years (07/2006 through 06/2009); 3 fiscal years
Annual Funding Requested:	FY2006: $119,411 FY2007: $124,677 FY2008: $30,912
Total JFSP Funding Requested:	**$275,000**
Total Value of In-Kind Contributions:	**$427,627** *The value of in-kind services are not a pledge of cost share by the University of Alaska Fairbanks. The value represents contributions leveraged from our federal partners.

Abstract: Concerns about wildland fuel levels and a growing wildland-urban interface (WUI) have pushed wildland fire risk mitigation strategies to the forefront of fire management activities. Mechanical (e.g., shearblading) and manual (e.g., thinnings) fuel treatments have become the preferred strategy of many fire managers and agencies. However, few observations exist that document the actual effect of different fuel treatments on fire behavior. Alaska's Federal and State fire management agencies have identified this "data gap" as their most important fire science research need and priority. To address this need, we propose to quantify the effects of different mechanical and manual fuel treatments on fire behavior and transfer that information to the Federal and State fire management community through a series of technical reports and peer-reviewed journal articles.

Our proposed study site represents an ideal location because of its proximity to Fairbanks, existing road network, large area (550 acres) of homogenous fuels, and a current burn plan available for amendment. Our proposed sample design provides for three experimental burn units to allow for limited replication and offer easy access to plots. Within each burn unit four fuel treatment plots (150 x 150 m) will be established. We will conduct paired burn measurements to facilitate direct comparisons between the control vegetation matrix and the treatments. We will test 8 x 8 ft thinnings pruned to 4 ft under three different fuel removal strategies: (1) haul away, (2) burn piles on site, and (3) windrow and burn on site. In addition, we will test four shearblading treatments; with and without windrowing of debris and with and without pile burning. Quantification of fire behavior will be limited to the thinning treatments. Direct observations (but no instrumentation) of fire behavior will be made in the shearblading treatments. Alaska's fire managers and the Alaska Wildland Fire Coordination Group (AWFCG) provided prioritization of the treatments to be tested.

We will inventory the existing vegetation, including ground vegetation, understory and overstory trees and tree crowns, organic layer, and dead-down woody surface fuels throughout the control vegetation matrix. Following treatments we will inventory understory and overstory trees and tree crowns, organic layer, and dead-down woody surface fuels. All vegetation measurements will be re-measured post-burn. Fire behavior will be monitored extensively from the time of ignition until steady state behavior ceases using a combination of cameras, video, direct observations, and thermal dataloggers. Consumption plots will be located in both treatment units (thinnings and shearbladings) and the control vegetation. Post-fire vegetation recovery, following initial post-fire vegetation measurements, will be documented in all treatments and the control vegetation matrix for the duration of the project.

Our proposed research builds upon and links to several other JFSP sponsored projects and proposals, as well as other funded projects of our research team members. We anticipate that this proposed research will lead to the first quantified tests of the effects of fuel reduction treatments on fire behavior in Alaska. Our results will provide the data required by fire behavior models (FARSITE, BEHAVE, and NEXUS), fuels characterization system (FCCS), and fire effects models (CONSUME). In addition, we hope to develop guidelines directed at sampling design and methodology issues that can be used to assist in carrying out other experimental burns when the opportunity arises.

This proposal addresses the stated local research needs of Alaska's fire management community. This research has direct application potential to current and future fuels mitigation efforts in both Alaska and the Intermountain West.

Signature of PI:		
Signature of Co-PI:		
Signature of Federal Cooperator:		
Signature of Federal Fiscal Representative:		

Problem Statement

The 2004 and 2005 fire seasons in Alaska burned 11.2 million acres and represent the largest and third largest annual areas burned, respectively, since record keeping began in 1950. Both fire seasons occurred during prolonged drought conditions. Climate is changing in our region, and fire seasons like 2004 and 2005 may become more common. In the past two fire seasons more than 20 communities have been threatened. Fortunately, fire suppression actions limited losses to approximately 100 structures. Total suppression costs for the two fire seasons were over $180 million. State and federal officials have responded to these recent events with renewed interest in reducing fire risk to communities adjacent to forested wildlands. Fuel treatments are one option currently being explored **and implemented** across Alaska. In this regime of changing climate and with an increasing wildland-urban interface (WUI), we need to understand the short- and long-term effectiveness and consequences of these management actions.

The effectiveness of various fuel treatments has been modeled but no trials have been conducted in Alaska to quantify the effects of these treatments on fire behavior. Fire managers have recommended and funded fuel treatments, including shaded fuel breaks, without demonstrable evidence of their actual effect on fire behavior. A series of fuel treatments followed by experimental burning are required to verify fire behavior models and increase knowledge of fire behavior in Alaska. Understanding how fuel reduction treatments and subsequent burning influence vegetation succession, and therefore future fuel loading, is required to identify impacts on multiple components of the WUI, including future WUI fire risk and wildlife habitat. A series of fuel treatments combined with experimental burning can quantify these impacts.

The Alaska Wildland Fire Coordination Group (AWFCG), as representatives of the agencies (State, Federal, and Native Corporations) responsible for managing wildland fire and associated effects in Alaska has identified this problem as the **number one** Alaska fire science research need and priority. On behalf of the two land management agencies tasked with primary fire suppression responsibilities in the State, we strongly urge JFSP to fund research that will provide us with this much needed information.

See Appendix E for Original Signature

Robert Schneider, Manager, BLM Fairbanks District Office	Phone/email	Date

See Appendix E for Original Signature

Chris Maisch, State Forester, Alaska DNR Division of Forestry	Phone/email	Date

I. Introduction

Growing wildland fuel levels caused by a century of fire suppression (Arno and Brown 1991, Covington and Moore 1994) combined with growing wildland-urban interface (WUI) communities are putting more people and property at risk of wildfire damage (Winter et al. 2002, Cleaves 2001). As a result, wildland fire managers are attempting to reduce fire risk with fuel treatments such as harvesting or prescribed burning that reduce fuel levels and maintain desirable qualities of forest structure and composition (Winter et al. 2002). With limited resources, managers set priorities by choosing the type and location of treatments to minimize expected wildfire damage to people, houses, or natural resources.

Although our current understanding of mechanical and manual treatment effects on fire behavior relies almost completely on model simulations, these treatment applications are increasingly being applied to the WUI with the assumption that fire risk will be reduced. Quantification of treatment effects on fire behavior through experimental trials is needed to verify changes in fuel structure, micrometerology, and associated fire behavior. A better understanding of the effects of different treatments will allow wildland fire managers to more effectively mitigate WUI fire risk.

1. Project Justification

Alaska's fire managers have recommended **and funded** fuel treatments, including shaded fuel breaks and shearblading, **without** demonstrable evidence that they work. Interest and application of mechanical and manual fuel treatments has increased dramatically following the record wildland fires in 2004, which burned 6.6 million acres in Alaska, threatened 17 different communities, destroyed more than 100 structures, and cost over $120 million. The record 2004 fire season was followed this year by the third largest fire season on record, which burned an additional 4.6 million acres, threatened several remote communities, and cost more than $60 million. In response, many of Alaska's interior communities are reassessing wildland fire risk and aggressively pursuing mechanical and manual fuel treatments in an attempt to reduce identified or presumed fire risk. For example, the Fairbanks North Star Borough (FNSB) and city of Fairbanks have received approximately $3.5 million in federal funding to assess fire risk and apply fuel treatments in response to the 700,000+ acre Boundary and Wolf Creek fires that threatened the Fairbanks WUI in 2004. An additional $6.5 million in federal funding has been secured by the Municipality of Anchorage and the Kenai Peninsula to assess and mitigate fire risk in southcentral Alaska.

This project will provide the first empirical observations of fuel treatment effects on fire behavior in Alaska. The problem statement that this proposal addresses (see page 3) identifies these empirical observations as the **number one** Alaska fire science research need and priority (as determined by the AWFCG). This project will also provide important empirical observations on duff consumption and post-fire vegetation dynamics. In addition, this project will provide guidelines focused on study design, sampling methodology, and burn operations to assist and streamline future experimental burn opportunities in Alaska. Finally, this proposed experimental burn offers excellent opportunities for other JFSP funded projects to gain additional data (see Appendix E for letters of support).

2. Project Objectives

The primary goal of this project is to quantify the effects of two different shearblading techniques and 8 x 8 ft thinning treatments, under three different fuel removal strategies, on fire behavior and transfer that information to the Federal and State fire management community through various media forms including reports, databases, and video (see details of our technology transfer objectives in the science delivery and application section). The proposed experimental burns offer numerous other research opportunities beyond the scope of this proposed project for which we will actively seek potential collaborators. We will focus our research on the following specific objectives:

a. Document changes in fuel loading and vegetation structure in treated areas.
b. Document site specific weather observations and associated fire danger indices.
c. Quantify differences in fire behavior between treated and control plots.
d. Quantify fuel consumption in both treated and control plots.
e. Document the initial response of vegetation to burning in treated versus control plots.
f. Develop guidelines regarding study design and methods for use by managers to streamline future opportunities for experimental burns.

3. *Background*

Fire research in both the US and Canada has focused on the prediction of wildland fire behavior. The emphasis in Canada has focused primarily on empirical wildfire observations, while US efforts have focused on theory and laboratory-based experiments (Stocks et al. 2004b). Both research programs have resulted in fire danger rating and fire behavior prediction systems (see Andrews et al. 2003 for US; see Forestry Canada Fire Danger Group 1992 for Canada). Both systems have documented relationships between natural (and a limited number of harvested) stand conditions and fire behavior (Stocks et al. 2004b, Peterson et. al. 2005).

The emergence and extension of the WUI phenomenon has greatly complicated the management of wildland fires (Winter et al. 2002). Prescribed fire has been shown to be effective in reducing general fire behavior, but broad-scale use as a mitigation strategy has met strong resistance from the public due to concerns about escapement, smoke, and aesthetics (Fernandes and Botelho 2003). Fuels reduction treatments are increasingly being used across the United States as a primary mitigation strategy to reduce fire risk in the WUI (Agee 2000, Johnson and Peterson 2005). Research continues to document relationships between various fuel treatments and fire behavior (Johnson et al. *in press*). However, the effectiveness of various thinning treatments has largely been analyzed using fire behavior models (van Wagtendock 1996, Graham et al. 1999), with few empirical observations (although these observations are slowly growing).

Findings from the recently completed JFSP project **00-2-34** "Fuels treatment demonstration sites in the boreal forests of interior Alaska" by Ott and Jandt caught the attention of the Alaska fire management agencies due to adverse changes documented in surface fuelbeds and model predictions of higher rates of spread in treated areas. Shaded fuelbreak treatments in Interior boreal forest have substantial ecological effects on the forest floor, permafrost and surface fuels (Jandt, et al. 2005), including increase of fine downed woody and grass fuels, increased midflame wind speed, and dryer forest floor moss layers. The fire behavior modeling tool used to compare treated and untreated fuels (NEXUS 2.0, http://www.fire.org) have not been field-validated in Alaska. We know of only two efforts to model fire behavior in treated stands in Alaska (Theisen 2003, Horschel *unpublished*) and **no** empirical observations to quantify important fire behavior characteristics such as rate of spread. All of this contributed to the AWFCG decision in 2005 to make empirical testing of fire behavior in fuel breaks (both thinnings and shearblading) the top priority for fire management research in Alaska.

II. Materials and Methods

1. *Study Site*

The Nenana Ridge Ruffed Grouse Project Area is 6,000 acres of typical interior Alaska boreal forest located 30 miles southwest of Fairbanks, Alaska. The area includes a mix of deciduous and spruce forest distributed across both uplands and lowlands. Various ruffed grouse habitat projects have been conducted in the past including prescribed burning. This site is an ideal location for our proposed experimental burn because (1) it is in close proximity to Fairbanks and offers good access via an existing road network, (2) the site is owned by the State of Alaska and has a burn plan in place that can be modified to include the proposed experimental burns, and (3) the area offers a large homogenous fuel type to allow for limited replication.

The proposed experimental burn site is approximately 930 acres with approximately 550 acres of relatively homogenous closed black spruce with a typical understory of moss, lichen and ericaceous shrubs (Fig. 1). The site is located on a 0-10% slope with a southerly aspect and approximately 200 ft. elevation gradient. Prevailing summer winds are from the southwest.

2. *Sampling Design*

We plan to take advantage of the knowledge gained from the International Crown Fire Modeling Experiment (ICFME) carried out between 1995 and 2001 in the Northwest Territories (Stocks et al. 2004a). The ICFME was designed to improve the physical modeling of crown fire propagation and spread and provides a fully tested design for quantifying fire behavior (Stocks et al. 2004b). That basic design calls for experimental plots of 150 x 150 m (approximately 5 acres), which represents an area large enough to provide unbiased observations of fire behavior (Stocks et al. 2004b). The square design accommodates fluctuations in wind direction. In contrast to the ICFME our plots will not be surrounded by a cleared fireline, but instead will be surrounded by an uncleared black spruce fuel matrix. This deviation from the ICFME design will allow us to specifically address our research question regarding the effect of fuel treatments on fire behavior. It should be noted that we are **not** attempting to simulate a landscape-level fuelbreak, rather we are quantifying changes in fire behavior between treated and control vegetation.

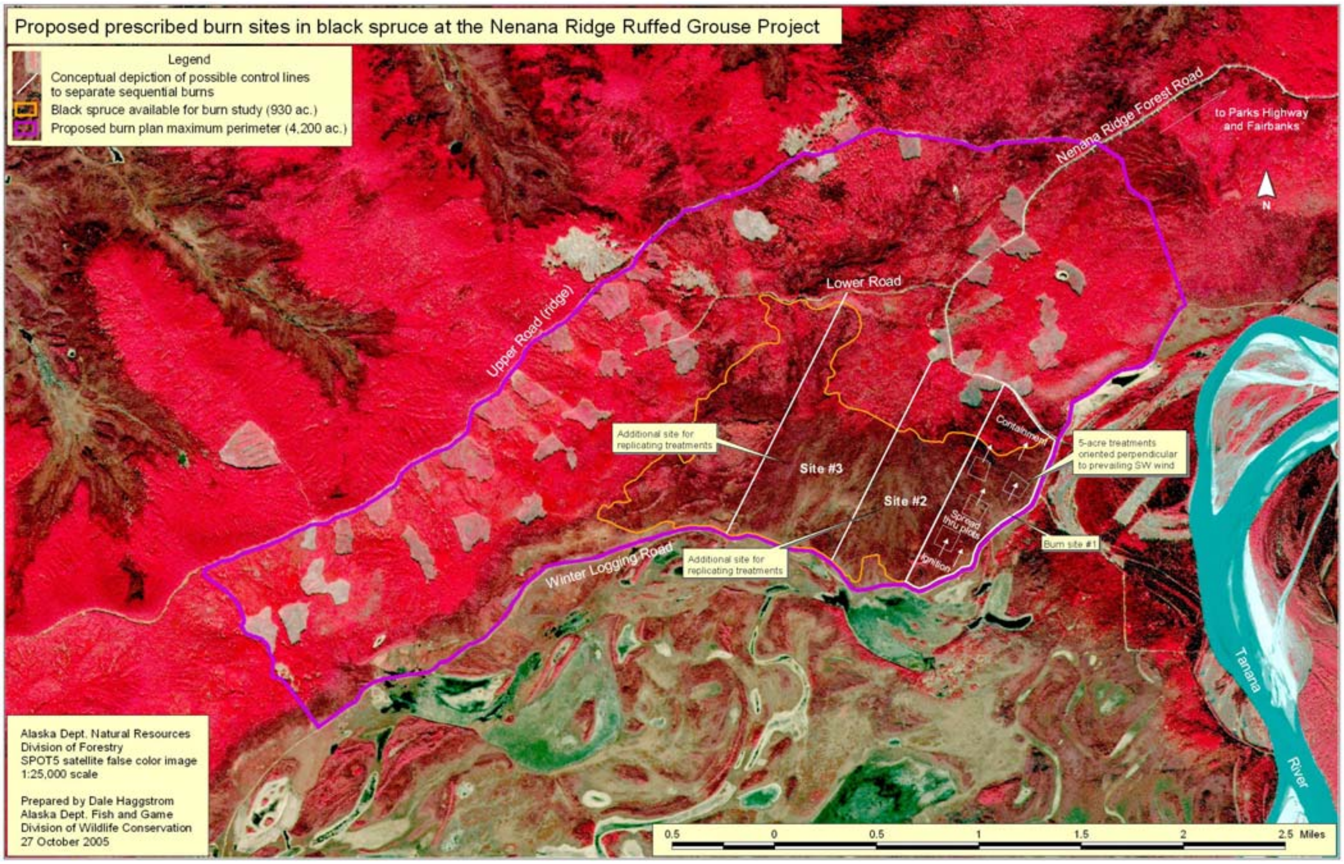

Figure 1. Location of experimental burn showing burn plan maximum perimeter (purple), black spruce vegetation (orange), and burn units separated by cleared fire lines (white).

Our sample design provides for 3 experimental burn units, each approximately 185 acres (Fig. 1). Each burn unit will be separated by a fireline cleared to mineral soil. Within each burn unit 4 fuel treatment plots (150 x 150 m) will be established (Fig. 2). Individual treatments will be spaced in a manner such that each treatment is surrounded (minimum of 150 m on all sides) by sufficient control vegetation, and will not affect fire behavior in neighboring plots.

We propose testing two primary treatment strategies that reflect the actual treatment types currently being implemented by Federal and State agencies in Alaska. Each burn unit will have two shearblading treatments and two thinning treatments. Burn unit A consists of two 8 x 8 ft thinning treatments. In both thinnings the fuels have been removed from sight and remaining trees have been pruned to 4 feet. In addition, burn unit A has one shearbladed treatment where the fuels have been windrowed and one treatment where the fuels remain on the ground. Burn unit B consists of two 8 x 8 thinning treatments pruned to 4 feet. Instead of fuels being removed from the site they will be burned in piles. In addition, burn unit B has one shearbladed treatment where the fuels have been windrowed and burned and one treatment where the fuels remain on the ground one year after shearblading. Burn unit C consists of two 8 x 8 thinning treatments pruned to 4 feet. Instead of fuels being removed from the site they will be burned in windrows. This third unit will also provide for two additional thinning treatments in the event that additional observations are required following the initial burn in unit A (see below for details on burning operations). In all instances we will conduct **paired burn** measurements to facilitate direct comparisons between a control and the treatments. The paired measurements will eliminate any confounding effects of varied burn years. Quantification of fire behavior will be limited to the thinning treatments. Consumption measurements will be collected in all the treatments as well as the control vegetation. Direct observations (but no instrumentation) of fire behavior will be made in the shearblading treatments. Our primary interest in the shearblading treatments will be to evaluate basic fire behavior as well as the effect on post-fire plant succession. Temporary conversion of spruce-dominated sites to hardwood species is important from a fuels management perspective.

3. *Methods*

We will inventory the existing vegetation, including ground vegetation, understory and overstory trees and tree crowns, organic layer, and dead-down woody surface fuels, throughout the control vegetation matrix. These measurements will serve as baseline data for post-treatment and post-burn comparisons. We will not make direct measurements within the treatment plots prior to treatment to minimize trampling and its potential effects on fire behavior. Following treatments we will inventory understory and overstory trees and tree crowns, organic layer, and dead-down woody surface fuels within the treated plots. All vegetation measurements will be re-measured post-burn. Exisiting ground vegetation will be characterized by establishing 32 randomly located 1 x 1 m sampling quadrats throughout the control vegetation (Alexander et al. 2004).

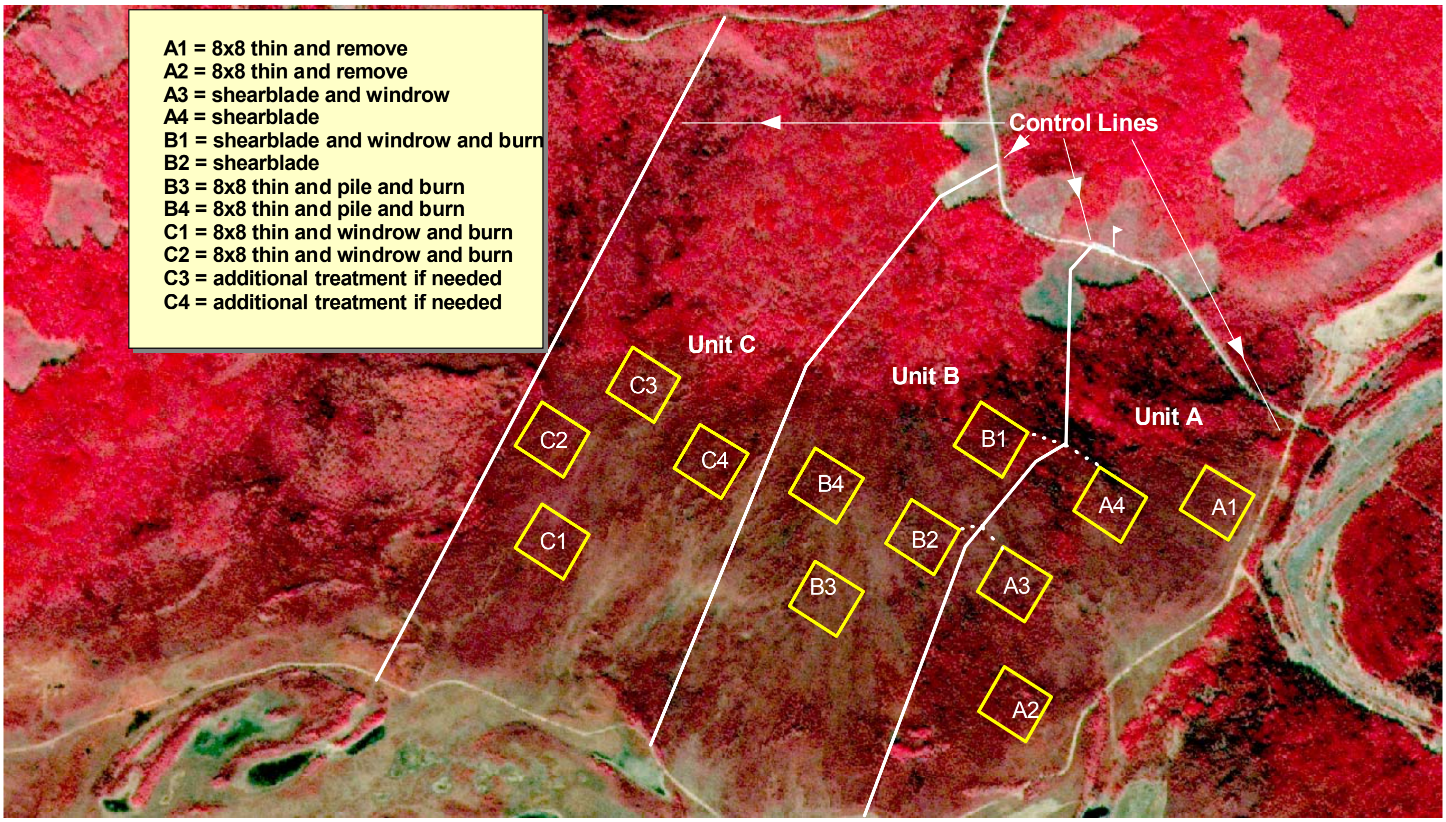

Figure 2. Proposed layout of treatment plots (white) dispersed within control vegetation matrix.

This ground vegetation sampling will serve to characterize species density, composition, and cover. A grid of permanently marked plot centers (30 x 30 m spacing; n=16) will be established within each treatment unit to sample the understory and overstory trees and tree crowns, and to locate the consumption plots and dead-down woody surface fuel transects; permanent plot centers (n=16) will also be established in the surrounding control vegetation (Fig. 3). A point-centered quarter method (Cottam and Curtis 1956, Alexander et al. 2004) will be used to sample overstory trees (DBH ≥ 3.0 cm) at each grid point. These measures will be used to calculate density and basal area and to characterize tree crown geometry. In addition, we will use a point intersect method and densitometer to quantify canopy cover. Understory trees (DBH< 3.0 cm) will be sampled using 2-m radius fixed area plots at every other grid point (n=8).

Consumption plots will be located using the grid points in both treatment units and the control vegetation. We will determine fuel loading using the line intersect inventory method (Brown 1974, Alexander et al. 2004). We will randomly select line direction and lay out three 10 meter lines from each grid point (n=16; Fig. 3). We will tally 0-0.25", 0.26-1.0", and 1.01-3.0" sound woody fuels along these transect lines before and after the fire. We will measure diameter of all 1000+ fuels along the lines before and after the fire. If there are significant numbers of woody fuels larger than 4.0", we will wrap wires around 30-40 logs to determine diameter reductions. Woody fuel samples will be collected 3 hours before the burn and oven dried to determine fuel moisture content for the 0-0.25", 0.26-1.0", and 1.01-3.0", and +3.0" woody material classes. We will position 16 duff pins at alternating grid points (n=8) to measure the forest floor consumption.

We will also take four depth plugs to determine the depth of the live and dead moss, upper and lower duff. Eight forest floor plugs will be collected three hours before the burn and separated into the live moss, dead moss, upper duff and lower duff fuelbed categories. The samples will be oven dried to determine moisture content. Depth of burn (DOB) pins (McRae et al. 1979) will be systematically located (n=8) around each consumption plot following the methodology of Ottmar et al. (JFSP **03-1-3-08**). In the shearblading plots we will permanently mark each windrow and pile created by the shearing operation. We will classify each pile for shape and take the appropriate width, length and height measurements. Consume3.0 will be used to calculate total biomass in each pile. We will return after the burn, determine a shape, and re-measure each pile or windrow and calculate a loading using Consume 3.0. Subtracting the pre-burn and post-burn loadings will determine the fuel consumption. If the down-woody fuels are uniform rather than in piles, we will determine fuel loading using the line intersect inventory method as described for the thinning and control treatments.

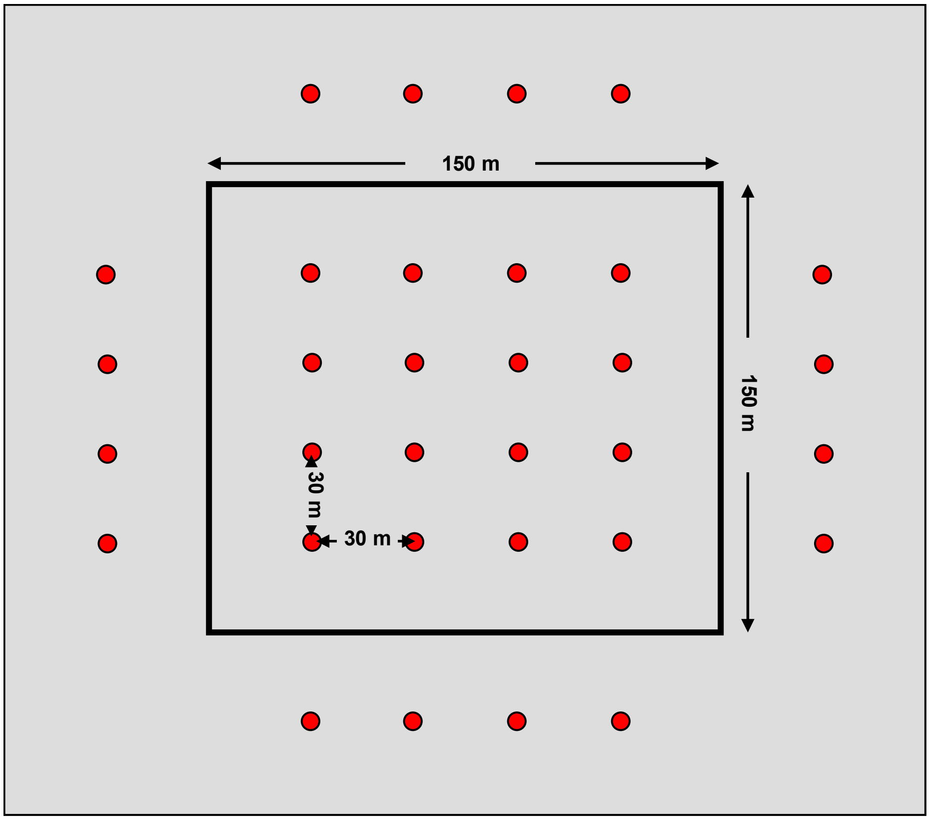

Figure 3. Proposed sampling grid following the methodology of Alexander et al. (2004). Treatment units measure 150 x 150 m. Grid points (red dots) are spaced 30 x 30 m inside treatment unit and around control vegetation borders.

Fire behavior will be monitored, in both the treatment plots and the surrounding control matrix, extensively from the time of ignition until steady state behavior ceases. Cameras, video (both ground and helicopter platforms), and direct observations will be used to document fire development and flame front characteristics to determine rate of spread (Stocks et al. 2004b, Taylor et al. 2004). Buried thermal dataloggers will provide additional information regarding incremental growth and spread of the fire (Taylor et al. 2004). Instrument packages designed to measure and record air temperature, horizontal and vertical velocities, total and radiant heat flux released from the flames will be deployed in the treatment and control plots (Butler et al. 2004). Video images of the flames will also be recorded to quantify flame geometry. We propose to deploy four cameras (two in the control and two in the treatment) for each control-treatment paired plot (8 cameras per burn unit).

A fully instrumented hourly remote automated weather station (RAWS) will be located at the burn site to quantify fire weather. Hourly weather observations will be recorded from snowmelt through September each year. Hourly weather data will be utilized to calculate fuel moisture codes and fire behavior indices of the Canadian Forest Fire Weather Index System. In addition, two Hobo weather stations will be deployed to capture all relevant weather fields throughout the burning operations at 2 minute intervals. Prior to burning operations, but following treatments one Hobo weather station will be deployed in the control matrix and one in the treatment for a one week period to document plot-level differences in wind speed, temperature, and relative humidity.

The experimental burning will seek to reflect "extreme conditions" that would likely exist when WUI is threatened. Due to the cost and tenuous nature of fire behavior instrumentation and observations (pers. comm. B. Butler) we propose to burn only burn unit A in year 1. This strategy will insure we are able to maximize data quality and adjust our methodology to any unforeseen problems. In the event of circumstances that preclude burning in year 1 we will burn all three units (one at a time) in year 2. Although our preferred strategy has burns occurring in two different years this will not influence our data analysis as all treatments will have paired control measurements. All burn units will be hand ignited along the bottom edge of the units utilizing the existing winter logging road for burn operations. Ignition of an entire unit edge will be accomplished as quickly as possible. The fire will then be allowed to spread upslope through the control vegetation and treatment plot matrix.

Post-fire vegetation recovery, following initial post-fire vegetation measurements, will be documented in all treatments and the control vegetation matrix for the duration of the project. We will revisit randomly chosen grid points (Fig. 3) in each treatment (n=8) and its surrounding control vegetation (n=4). Once determined, the same grid points will be monitored each year. We will use 3.5 m^2 fixed area plots to monitor changes in species composition, density, and cover of all life forms including tree seedlings and sprouts. This project provides a unique opportunity to monitor long-term effects on vegetation structure. We will seek ways to support continued vegetation recovery observations on a periodic basis, including direct funding from state and/or federal agencies, leveraging other research at the University of Alaska Fairbanks, and encouraging other collaborations (see letter of support from J. Johnstone).

4. Data Analysis

The objective of this study is to document differences in fire behavior and fuel consumption between treated and untreated vegetation. Due to budget constraints we have limited replication (n=2), but in all cases we have **paired plot** measurements for comparison. This design is not ideal, but it is the reality of today's budget climate and the tenuous nature of fire behavior measurements. We will follow the methodology of Alexander et al. (2004) for analysis of vegetation characteristics. Species composition, cover, frequency, and prominence of the understory vegetation will be characterized for the control vegetation matrix and will be assumed to apply to the treatment plots prior to the actual treatments (see methods section above). Similarly, the understory and overstory tree and tree crown characteristics will be summarized including post-treatment. Surface fuel loads will be calculated following standard procedures (Brown 1974, McRae et al. 1979, Alexander et al. 2004). Pre-burn organic layer depth, load, and total and organic bulk density will be calculated from the post burn measurement and a unit average with standard errors calculated. Woody fuel loading and consumption will be determined using the line intersect inventory methodology and calculation procedures outlined by Brown (1974).

Fire progression observations will be used to characterize changes in fire behavior between the control vegetation matrix and the fuel treatment plots (Stocks et al. 2004b). Estimated average spread rate values will be based on the maximum spread distance in a given plot and the elapsed time between the initial entrance of the flame front into the plot and the emergence of the flame front from the plot. Rate of spread in the control fuel matrix will be similarly calculated based on the elapsed time between established points of known distance. Variations in within-plot surface spread rates will be characterized following the methods of Talyor et al. (2004) based on fire-arrival times and temperatures recorded at thermocouple grid points within each plot. Fire behavior will be characterized through flame geometry calculations and energy release rates. Video images collected from digital video cameras deployed in fire proof enclosures will be analyzed to determine flame height, depth and angle. These data will also provide a redundant measurement of fire rate of spread. Direct measurements of energy release will be collected by calibrated total and radiant energy sensors collected at a 1hz sampling rate.

5. Materials

This research will utilize various materials and equipment during three distinct project phases: (1) treatment preparation and implementation, (2) burning operations, and (3) post-fire measurements and analysis. **All** materials and equipment related to phase 1 and 2, as well as a majority of the materials and equipment required for phase 3, will be provided as in-kind support by the federal and state project collaborators. Major material and equipment requirements are listed below (see budget narrative for further details on phase 3 materials and equipment related to this funding request):

- Two fully instrumented Hobo weather stations and one RAWS

- Fuel treatment and burning operations materials and equipment
- Cameras, video, and associated fire behavior materials and equipment
- Thermocouples and dataloggers for fire behavior measurements
- Fuel consumption measurement supplies and materials
- Vegetation structure and fuel loading measurement supplies and materials

III. Project Duration and Timeline

Our project collaborators are committed to this project because of its importance to wildfire management in Alaska (see letters of support in Appendix E). Therefore, in-kind funding sources (see budget and research linkages sections) have already been utilized this winter (shearblading) and spring (thinning) to move the project along and allow us to take advantage of the 2006 fire season should this proposal be funded. The study area has been divided into 3 separate burn units to allow for limited replication. As discussed in the methods section we plan to burn unit A this summer, followed by unit B and C next summer. If we are unable to burn this summer we will burn all three units next summer.

Project Task	Proposed Completion Date	Status
Unit and treatment layout – Alaska DOF and ADF&G	November 2005	Completed
Shearblading treatments – Alaska ADF&G	April 2006	Completed
Control line construction – Alaska ADF&G	April 2006	Completed
Control plot establishment – UAF	May 2006	Completed
Burn plan amendment – Alaska DOF and AFS	May 2006	Completed
Existing vegetation sampling – UAF	May 2006	On-going
Thinning treatments – AFS Hotshots	May 2006	On-going
Treatment plot establishment – UAF	June 2006	On-going
Post-treatment/pre-burn vegetation sampling – UAF	June 2006	To-do
Post-treatment/pre-burn consumption sampling – FERA	June 2006	To-do
Deploy fire-behavior instrumentation – Missoula Fire Lab	July 2006	To-do
Unit A burn operations/fire behavior measurements – DOF/AFS/Fire Lab	July 2006	To-do
Post-fire consumption sampling – FERA	July 2006	To-do
Post-fire vegetation sampling – UAF	July 2006	To-do
Analyze results from burn unit A – UAF/FERA/Fire Lab	Winter 2006-2007	To-do
Two additional treatments in unit C if necessary – AFS Hotshots	May 2007	To-do
Post-treatment/pre-burn vegetation sampling – UAF	June 2007	To-do
Post-treatment/pre-burn consumption sampling – FERA	June 2007	To-do
Deploy fire-behavior instrumentation – Missoula Fire Lab	July 2007	To-do
Unit B&C burn operations/fire behavior measurements – DOF/AFS/Fire Lab	July 2007	To-do
Post-fire consumption sampling – FERA	July 2007	To-do
Post-fire vegetation sampling – UAF	July 2007	To-do
Re-vegetation monitoring – UAF	July 2007, 2008, 2009, +	To-do
Analyze results from burn unit B & C – UAF/FERA/Fire Lab	Winter 2007-2008	To-do
Initiate work on experimental burn guidelines technical report	Winter 2007-2008	To-do
Prepare reports, manuscripts, and other deliverables	Winter 2008-2009	To-do
Finalize prescribed burn guidelines technical report	Winter 2008-2009	To-do
Submit final report and deliverables, and complete technology transfer	Summer 2009	To-do

IV. Project Compliance - NEPA and other clearances.

The Nenana Ridge Ruffed Grouse Project Area is wholly within the Tanana Valley State Forest, owned by the State of Alaska and managed by DOF. The fuel treatment and burning operations will be carried out by DOF and AFS. For the federal involvement in the project, planning staff at AFS may be required to update the existing Environmental Assessment document for assisting the State with prescribed burning in the Nenana Ruffed Grouse habitat area (AK AFS

EA 98-002), which was signed in 1998. However, the planning staff at this time feels the project will meet guidelines for more recently implemented Categorical Exclusions for prescribed burning for hazardous fuel reduction. Either the exemption or the revised EA will be prepared by BLM/AFS staff and signed by the AFS Manager prior to ignition of the unit. The project area has been the site of ongoing prescribed burning operations to meet wildlife habitat objectives. The existing burn plan will be amended by the State DOF to include the proposed experimental burns. A smoke permit will be obtained from the Alaska Department of Environmental Conservation.

V. Budget

All costs associated with treatment application and burn operations will be covered by in-kind contributions from our agency collaborators (Alaska DNR – Division of Forestry, Alaska Department of Fish and Game - Division of Wildlife Conservation, and BLM – Alaska Fire Service; see Appendix B for details related to treatment and burn implementation).

We request funding from JFSP for pre- and post operations **measurements only**. This project involves close cooperation between Federal and State agencies and the University of Alaska Fairbanks (UAF). The following justification provides a description of the proposed budget (see Appendix A – Table 5 for further details).

Salaries

Senior Personnel

Principal investigator Rupp will direct the overall project in cooperation with federal cooperator Jandt. Dr. Rupp's lab will also lead the vegetation sampling and monitoring effort. Rupp has a 9-month teaching position at UAF. He is responsible for the other 3 months, which are contingent on grants and contracts obtained from outside the university system. We request 1 month salary and staff benefits for Rupp each year of the project (see Appendix D for salary justification).

Other Personnel

We request 2 months of support for Rupp's research technician position each year. In addition, we request a summer undergraduate research assistant position in year 1 and 2. These two positions will be responsible for a majority of the vegetation sampling and monitoring work. The Alaska DNR-DOF and ADF&G-DWC, and AFS are contributing in-kind personnel support for all activities related to treatment and burn implementation. AFS is also contributing 0.5 months per year for Jandt to act as federal cooperator, as well as 1 month total technician time to assist with vegetation sampling and monitoring. ADF&G-DWC is contributing 1.5 additional months per year for wildlife sampling.

Subawards

The Missoula Fire Lab requests salary for technician time to assist in plot instrumentation. Butler and Hardy are contributing 1 month salary each per year and will lead the fire behavior measurements component.

The Pacific Wildland Fire Sciences Lab requests 24 weeks technician time in year 1 and 2 to assist in fuel loading and consumption measurements. In addition, 10 weeks of professional time and 4 weeks of Co-PI Ottmar's time will be contributed in-kind. Ottmar will lead the consumption measurements component.

Travel

PI Meeting

No travel funds are requested for the annual JFSP principal investigator meeting. PI Rupp will find other funding sources for these meetings.

Subawards

The Missoula Fire Lab requests total domestic travel expenses (including field and site visits) of $27,429 over the 3 year project. See Table 5 for itemized details.

The Pacific Wildland Fire Sciences Lab requests total domestic travel expenses (including field and site visits) of $30,000 over the 3 year project. In addition, they are contributing a total of $4800 in-kind travel expenses. See Table 5 for itemized details.

Equipment

AFS will contribute two Hobo weather stations valued at $1700.

Subawards

The Missoula Fire Lab requests a total of $30,000 in equipment expenses related to thermal dataloggers, cameras, and calibration expenses. In addition, they are contributing a total of $95,000 in-kind equipment costs.

The Pacific Wildland Fire Sciences Lab will contribute $6000 total in-kind equipment costs.

Materials and Supplies
PI Rupp will find other means of meeting his supply needs – no funds are requested. AFS will contribute a total of $2000 in-kind value of sampling materials and supplies.

Subawards
The Missoula Fire Lab requests a materials and supply budget of $2,000 in year 1 and 2. In addition, they will contribute a total of $4,000 in-kind value of sampling materials and supplies.

The Pacific Wildland Fire Sciences Lab will contribute $300 total in-kind materials and supplies.

Science Delivery and Application
We will find other sources of funding to assist with publication costs.

Subawards
The Pacific Wildland Fire Sciences Lab will contribute $500 in year 3 for publication costs.

Other
Subawards
The Pacific Wildland Fire Sciences Lab requests $4,290 in indirect costs for year 1 and 2 of the project, associated with their portion of the project (represents 11% of applicable direct costs). They will also contribute $12,200 in administrative and facilities support in each year of the project.

***The value of in-kind services are not a pledge of cost share by the University of Alaska Fairbanks. The value represents contributions leveraged from our federal partners.**

Table 1. Proposal Budget Summary for FYs 2006, 2007, and 2008

Budget Item	2006		2007		2008	
	Requested	Contributed	Requested	Contributed	Requested	Contributed
LABOR	$57,417	$140,470	$61,486	$54,700	$25,236	$54,700
TRAVEL	$26,121	$1,600	$31,308	$3,200	$0	$0
VEHICLES	$0	$250	$0	$250	$0	$250
Capitalized Equipment:	$15,000	$63,700	$15,000	$32,000	$0	$7,000
Materials and Supplies:	$2,000	$28,507	$2,000	$1,950	$0	$1,950
Science Delivery and Application:	$0	$0	$0	$0	$0	$500
Other	$4,290	$12,200	$4,290	$12,200	$0	$12,200
Total Direct Costs	$104,828	$246,727	$114,084	$104,300	$25,236	$76,600
Indirect Costs: 17.5% CESU + 4.25% project admin. costs to BLM-AFS	$14,566	$0	$10,593	$0	$5,676	$0
Total Requested JFSP Funding	**$119,411**		**$124,677**		**$30,912**	

VI. Research Linkage:

Our proposed research builds upon and links to several other JFSP sponsored projects and proposals, as well as other funded projects of our research team members. Fire intensity and flame characterization measurements will use techniques and equipment designed and deployed in the Firefighter Safety Zone study by Butler (JFSP **03-2-1-03**) and Hardy's rapid response study (JFSP **03-S-01**). The fuel consumption and FCCS fuelbed development and fire potential prediction will use techniques designed and deployed in the 1) forest floor and emissions project (JFSP **03-1-3-08**), 2) Okanogan and Wenatchee fuelbed and hazard assessment study (internal funding from PNW), 3) FCCS fuelbed pre-proposal (JFSP 2006 AFP 4, task 1), and 4) FCCS fire potential validation and improvement pre-proposal (JFSP 2006 AFP 4, task 1). Our project results will also be linked to larger, landscape-level modeling efforts by PI Rupp (JFSP **01-1-1-02** and **05-2-1-07** funded projects). An USDA funded pilot project (Rupp) will utilize the study results to assist in modeling the optimal treatment type(s) and location(s) to reduce fire risk in the WUI. These projects also link to a large

NSF funded project (Rupp) that is integrating human interactions including suppression effects into a regional-level perspective of the Alaskan fire regime. In addition, this research project offers additional collaborative potential for other related JFSP projects and proposals including Johnstone and Hollingsworth (**05-1-2-06**) and Camp and Omi (**04-2-1-96**).

Our Alaska Department of Fish and Game collaborator, Dale Haggstrom, has requested an additional $15,000 per year from the Ruffed Grouse Society to assist in funding burning operations and long-term vegetation monitoring related to wildlife habitat issues. These additional pending funds are **not** identified in the in-kind contributions in Table 5.

Table 2. Current and Pending Research Grants

Grant Program	**Project or Proposal Description/Identification**	**Funding Amount**	**Project Completion Date**
JFSP	Post-Fire Studies Supporting Computer-Assisted Management of Fire and Fuels During a Regime of Changing Climate in the Alaskan Boreal Forest	$398,000	2008
USDA	Managing Small Diameter Forest Stands in Interior Alaska: a Model-Based Analysis of Fuels Mitigation, Wildlife Habitat Enhancement, and Fiber Supply	$85,000	2007
NSF	Fire-Mediated Changes in the Arctic System: Interactions of Changing Climate and Human Activities.	$1,400,000 ($395,000 to Rupp)	2006
USFS	Classification and Modeling for FRCC Implementation in Alaska.	$32,000	2006
M.J. Murdock Foundation	Understanding fire severity patterns in Alaska's boreal forest.	$48,000	2006
JFSP	Characterization of Firefighter safety zone effectiveness	$75,825	2007
JFSP	Forest floor consumption and emissions in Alaska	$589,000	2007
PNW	Fire hazard assessment on the Okanogan & Wenatchee NF	$150,000	2006
JFSP 2006 AFP (pending)	Improving the Fuel Characteristic Classification System's national fuelbed library	$231,601	2008
JFSP 2006 AFP (pending)	Validating and expanding fire potential ratings for wildland fuelbeds using the FCCS	$271,023	2008
Ruffed Grouse Society (pending)	Nenna Ridge Ruffed Grouse Project – Habitat enhancement and monitoring	$45,000	2008

VII. Science Delivery and Application

The primary objective of this research is to quantify the effects of fuel treatments on fire behavior, and deliver that information to the fire management community. Technology transfer will be accomplished primarily through technical reports and peer-reviewed manuscripts. In addition, all datasets, video, and other observations will be made available to the fire management community via the web and/or DVDs. Finally, we will host an annual half-day workshop/symposium where the researchers and fire management community can interact and receive the latest information regarding the project.

VIII. Deliverables

The primary deliverables from this project will be technical reports that provide fire managers with detailed description and quantification of fuel treatment effects on fire behavior. Reports by burn unit will be produced and distributed to the fire management community. A technical report providing guidelines for assisting future experimental burns will also be produced. This project will also provide video and photo footage of the burns that will be delivered to the agencies for education and training opportunities. We also anticipate 2-3 peer-reviewed manuscripts being generated from this project.

Table 3. Deliverable, Description and Delivery Dates

Deliverable	Description	Delivery Dates
Unit 1 Report	Technical report characterizing results of burn unit 1.	Spring 2007
Unit 2 Report	Technical report characterizing results of burn unit 2.	Spring 2008
Unit 3 Report	Technical report characterizing results of burn unit 3.	Spring 2008
Technical Report	Guidelines for future experimental burns.	Spring 2009
Manuscripts	Peer-reviewed manuscripts	2007-2009
Videos and Photos	Footage from experimental burns.	2007-2009
Datasets	Datasets from experimental burns.	2007-2009
Final Report	JFSP final project report.	Summer 2009

IX. Expected Benefits of the Proposal

We anticipate that this proposed research will lead to the first quantified tests of the effects of fuel reduction treatments on fire behavior in Alaska. Our results will provide the data required by fire behavior models (FARSITE, BEHAVE, and NEXUS), fuels characterization system (FCCS), and fire effects models (CONSUME). We anticipate documenting changes in vegetation structure following treatments and the successional implications following burning. In addition, we hope to develop guidelines directed at sampling design and methodology issues that can be used to assist in carrying out other experimental burns when the opportunity arises. Knowledge gained of both fire behavior and vegetation response will be incorporated into the Boreal ALFRESCO model (JFSP **01-1-1-02** and **05-2-1-07** funded projects), which applies state-change probability to predict future vegetation from disturbances applied to current vegetation, and applied at the landscape-level to measure the effectiveness of larger projects under various environmental conditions. This project provides additional collaborative opportunities for two other currently funded projects (JFSP **05-1-2-06** and **04-2-1-96**) dealing with post-fire successional dynamics and fire behavior, respectively.

X. Qualifications of Investigators

The CVs of T. Scott Rupp, Roger Ottmar and Bret Butler are included in Appendix C. A summary of the project personnel, (including collaborators) and their responsibilities are described in the table below.

Table 4. Personnel Involved in Project, and their Responsibility

Personnel	Title	Responsibility
T. Scott Rupp	Assistant Professor, Univ. of Alaska	Project Management/Vegetation and Fuels
Roger Ottmar	PWFSL Research Forester	Fuel Consumption
Bret Butler	USFS Research Mechanical Engineer	Fire Behavior
Colin Hardy	USFS Fire Behavior Project Leader	Fire Behavior
Kato Howard	AFS Fuels Program Leader	Fuel Treatments and Burn Operations
Robert Schmoll	Fire Management Officer, DOF	Fuel Treatments and Burn Operations
Skip Theisen	Fire Management Officer, BLM	Fuel Treatments and Burn Operations
Randi Jandt	Fire Ecologist, AFS	Federal Cooperator/ Vegetation & Fuels Monitoring
Dale Haggstrom	Fire and Habitat Mgmt. Coordinator	Obtain Private Funding Support/Wildlife Habitat
Tom Paragi	Wildlife Biologist	Treatment Design/Wildlife Habitat
Peter Butteri	Manager, Tetlin NWR	Experimental Burn Guidelines and Technical Report
Sharon Stephens	Research Technician	Vegetation and Fuels
Mark Olson	Research Technician	Statistical Analysis
Jason Dollard	Fuels Specialist, AFS	Fuel Treatments and Burn Operations
Robert Vihnanek	Forester, PNW	Fuel Consumption

XI. Literature Cited

Agee, J.K, B. Bahro, M.A. Finney, P.N. Omi, D.B. Sapsis, C.N. Skinner, et al. 2000. The use of shaded fuelbreaks in landscape fire management. For. Ecol. Manage. 127:55-66.

Alexander, M.E., C.N. Stefner, J.A. Mason, B.J. Stocks, G.R. Hartley, M.E. Maffey, et al. 2004. Characterizing the jack pine-black spruce fuel complex of the International Crown Fire Modelling Experiment (ICFME). Can. For. Serv. Inf. Rep. NOR-X-393.

Andrews, P.I., C.D. Bevins, and R.C. Seli. 2003. BehavePlus fire modeling system, version 2.0: user's guide. USDA For. Serv. Gen. Tech. Rep. RMRS-GTR-106WWW.
Arno, S.F. and J.K. Brown. 1991. Overcoming the paradox in managing wildland fire. West. Wildl. 17:40-46.
Brown, J.K. 1974. Handbook for inventorying downed woody material. US Dep. Agric., For. Serv., Intermt. For. Range Exp. Stn., Ogden, UT. Gen. Tech. Rep. INT-16.
Butler, B.W., J. Cohen, D.A. Latham, R.S. Schuette, P. Sopko, K.A. Shannon, et al. 2004. Measurements of radiant emissive power and temperatures in crown fires. Can. J. For. Res. 34:1577-1587.
Cleaves, D. 2001. Fires in the wildland-urban interface: dilemmas of duality and the role of national science leadership. Presented at the Natural Disasters Roundtable. January 26, 2001. Washington, DC. 15 p.
Cottam, G. and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology. 37:451-460.
Covington, W.W. and M.M. Moore. 1994. Southwestern ponderosa forest structure – changes since Euro-American settlement. J. For. 92:39-47.
Fernandes, P.M. and H.S. Botelho. 2003. A review of prescribed burning effectiveness in fire hazard reduction. International Journal of Wildland Fire 12:117-128.
Forestry Canada Fire Danger Group. 1992. Development and structure of the Canadian Forest Fire Behavior Prediction System. For. Can. Inf. Rep. ST-X-3.
Graham, R.T., A.E. Harvey., T.B. Jain. and J.R. Tonn. 1999. The effects of thinning and similar stands treatments on fire behavior in western forests. USDA Forest Service Pacific Northwest Research Station General Technical Report PNW-GTR-463. Portland, Oregon.
Jandt, R.R., J.A. Allen, and E.A. Horschel. 2005. Forest floor moisture content and fire danger indices in Alaska. BLM Technical Report 54, Bur. Land Manage., Fairbanks, Alaska. 30 pp.
Johnson, M.C., D.L. Peterson, and C.L. Raymond. 2005. Guide to fuel treatments in dry forests of the western United States: assessing forest structure and fire hazard. US Forest Service PNW Research Station Gen. Tech. Rep. In press.
Johnson, M.C. and D.L. Peterson. 2005. Forest fuel treatments in western North America: merging silviculture and forest management. The Forestry Chronicle. 81:365-368.
McRae, D.J., M.E. Alexander, and B.J. Stocks. 1979. Measurement and description of fuels and fire behavior on prescribed burns: a handbook. Can. For. Serv. Inf. Rep. O-X-287.
Peterson, D.L., M.C. Johnson, J.K.Agee, T.B. Jain,D.McKenzie, and E.D. Reinhardt. 2005. Forest structure and fire hazard in dry forests of the western United States. US Forest Service PNW Research Station Gen. Tech. Rep. PNW-GTR-628. Portland, Oregon.
Stocks, B.J., M.E. Alexander, and R.A. Lanoville. 2004a. Overview of the international Crown Fire Modeling Experiment (ICFME). Canadian J. of Forest Research 34: 1543-1547.
Stocks, B.J., M.E. Alexander, B.M. Wotton, C.N. Stefner, M.D. Flannigan, S.W. Taylor, et al. 2004b. Crown fire behavior in a northern jack pine – black spruce forest. Canadian J. of Forest Research 34: 1548-1560.
Taylor, S.W., B.M. Wotton, M.E. Alexander, and G.N. Dalrymple. 2004. Variation in wind and crown fire behavior in a northern jack pine-black spruce forest. Can. J. For. Res. 34:1561-1576.
Theisen, Steve. 2003. An analysis of shaded fuel breaks on fire behavior. Tech. Fire Management Paper (TFM 17). Bur. of Land Manage. Alaska Fire Service, Ft. Wainwright, Alaska. 39 pp.
van Wagtendonk, J.W. 1996. Use of a deterministic fire growth model to test fuel treatments. P. 1155-1165 *in* Sierra Nevada Ecosystem Project: Final Report to Congress, vol. II, Assessments and Scientific Basis for Management Options. Univ. of California, Davis, Centers for Water and Wildland Resources. 624 p.
Winter, G.J., C. Vogt, and J.S. Fried. 2002. Fuel treatments at the wildland-urban interface: common concerns in diverse regions. J. For. 100:15-21.