Final Report

Historical Wildland Fire Use:

Lessons To Be Learned From Twenty-five Years of Wilderness Fire Management

JFSP Project Number 01-1-1-06

Submitted 31 October 2007

Principal Investigators and their phone and emails:

Matt Rollins, 406-329-4960, mrollins@fs.fed.us

Penelope Morgan, 208-885-7507, pmorgan@uidaho.edu

Scott Stephens, 510 642 7304, stephens@nature.berkeley.edu

Zachary Holden, 208-885-1202, zholden@vandals.uidaho.edu

Project Location:

Field data were collected in four different locations. They were the 1) Gila/Aldo Leopold Wilderness Area on the Gila National Forest in New Mexico, 2) Rincon Mountain Wilderness in Saguaro National Park in Arizona, 3) Sugarloaf-Roaring River region of the Sequoia and Kings Canyon National Parks in California, and 4) the Illilouette Creek Basin in Yosemite National Park, California.

Data analysis and interpretation was done at three locations. They were 1) Fire Sciences Laboratory, Rocky Mountain Research Station, USDA Forest Service, Missoula, MT in Montana's First Congressional District 2) the University of Idaho in Moscow, Latah County, ID in Idaho's First Congressional District ID, and 3) the University of California, Berkeley, CA.

Overview and project objectives:

Our research project was designed to answer three major questions:

1. Are there thresholds in pre-fire stand structure in ponderosa pine/Douglas-fir forests that lead to undesired levels of canopy mortality in WFU operations?

2. How has the implementation of WFU Programs in these study areas affected the nature of fire spread over time?
3. How do landscape composition, structure, and function vary under different fire management strategies?

To address these questions, we combined landscape-scale experimentation and simulation based on existing fire history databases (e.g., fire atlases), comprehensive field inventories, extensive existing GIS databases, and 25 years of well-documented WFU in these wilderness areas.

This has been a 5-year project. Originally proposed for three years, we were twice granted 1-yr no-cost extensions. The first, in 2005, was due to extensive fires in the study areas that limited access for data collection. The second extension was granted in 2006 to allow additional time for the simulation modeling. At that time, work on the first two questions was largely complete and has since been completed.

Our research accomplishments are summarized below relative to each of these questions. We also include a summary table of deliverables proposed and completed. We completed all of the proposed deliverables and some others for the first two research questions. Although the landscape-scale simulation modeling is not completed, results of this modeling were presented in 2006 and we are in the process of drafting manuscripts based on that work even as we continue modeling efforts. Local managers at each of the field sites and other scientists that have given us feedback about this project have been very pleased with the project.

Thresholds, fire and restoration:

In this part of our research, we were interested in identifying thresholds in pre-fire stand structure that lead to undesired levels of tree mortality and canopy openings in WFU operations. In particular, we were interested in the trends in forest structure through time, and the degree to which repeated fires alone (without mechanical treatment) restore sustainable forest ecosystems. This project was designed to *evaluate the impacts of alternative management strategies on fire regimes … in unroaded or wilderness areas,* to aid in *reducing conflicts and building consensus* with the public to *build workable solutions* for fire management, including *cumulative effects* (from 2001 RFP).

Many have called for ecological restoration of ponderosa pine and other warm, dry conifer forests; usually with some combination of thinning, mechanical fuels reduction, and repeated fires. An important issue for fire managers is whether or not mechanical treatments are necessary to reduce the threat of historically unprecedented fire behavior and effects. We do not know the effects of using fires alone (without thinning). The stand and landscape conditions (e.g., tree density, fuels, or landscape pattern) that define thresholds where fire alone will restore ecological integrity and reduce subsequent hazard are unknown (Arno et al. 1995; Covington et al. 1997). Mechanical treatment of fuels to reduce the probability of tree mortality in ensuing wildland fires is not an option in most wilderness or unroaded areas, or many other locations. Our empirical research can provide the information needed to evaluate the options for, and consequences of different fire management strategies for ecological restoration of forest structure and natural fire regimes.

- Historical aerial photographs (taken in 1969, before WFU fires) and Quickbird

high resolution satellite imagery (taken in 2003) of the Gila Wilderness were purchased, georectified, and analyzed in order to evaluate changes in stand structure and to identify fire-caused canopy openings resulting from historical wildland fires.

- Field data on understory vegetation composition, surface fuel loading, and stand structure data were collected in all four study areas done during the summers of 2002, 2003 and 2004. With the assistance of local managers and Fire Sciences Lab personnel, project scientists sampled 149 FIREMON fire effects plots in 2 areas (Iron and Langstroth Mesas) of the Gila Wilderness and 30 FIREMON plots in the Rincon Mountain Wilderness.
- Our analysis has focused on the effects of repeated fires on ponderosa pine forest structure in the Gila and Rincon wilderness areas. The density of small diameter trees was significantly lower in those areas burned three or more times between 1979 and 1993, but the density of large diameter trees was not significantly different in areas burned repeatedly compared to those sites burned once or twice. Density of large diameter snags was significantly higher in areas burned once compared to areas that burned twice and thrice.
- Fires create and consume snags (standing dead trees), an important structural and ecological component of ponderosa pine forests. Line intercept sampling was used to estimate snag densities in areas of the Gila Wilderness that had burned one to three times under (WFU).Twenty randomly located transects were measured in areas burned since 1946; six in once-burned areas, six in twice-burned areas and eight in thrice-burned areas. The mean density of large (>47.5 cm dbh) snags for areas that burned once, twice and thrice was 7.0±2.7, 4.4± 1.1 and 4.1± 1.3 snags/ha, respectively. Differences in snag densities between once- and multiple-burned areas were significant (F-test; $p<0.05$).There was no significant difference in density of large snags between twice- and thrice-burned areas. Proportions of type 1 snags (recently created) were higher in once- and twice-burned areas than in areas that burned three times, likely reflecting high tree mortality and snag recruitment resulting from an initial entry fire. Type 3 snags (charred by previous fire) were more abundant in areas that burned multiple times. The lack of differences in snag densities between areas that burned two and three times suggests that repeated fires leave many snags standing. The increasing proportion of type 3 snags with repeated fires supports this conclusion.
- We also analyzed Landsat TM satellite imagery of the Gila Wilderness in order to validate our sampling. This work included the development and testing of two novel thermally enhanced Landsat Thematic Mapper (TM)-derived spectral indices for discriminating burned areas and for producing fire perimeter data (a s a potential surrogate to digital fire atlas data) within two wildland fires (1985 and 1993) in ponderosa pine (*Pinus ponderosa*) forests of the Gila Wilderness, New Mexico, USA. Image-derived perimeters (manually produced and classified from an index image) were compared to fire perimeters recorded within a digitized fire atlas. For each fire, the highest spectral separability was achieved using the newly proposed Normalized Burn Ratio-Thermal (NBRT1) index (M 51.18, 1.76, for the two fires respectively). Correspondence between fire atlas and manually digitized fire perimeters was high. Landsat imagery may be a useful supplement to existing

historical fire perimeters mapping methods, but the timing of the post-fire image will strongly influence the separability of burned and unburned areas.

- The effects of 30 years (1974-2003) of Wildland Fire Use for Resource Benefit (WFU) fires on ponderosa pine forest stand structure were evaluated in the Gila Wilderness, New Mexico and the Rincon Mountain Wilderness (RMW), Arizona. Tree density (trees per ha), diameter-class distributions, basal area and stand density index were compared among areas that burned 0, 1 and 2 or more times, and areas that burned mid-century (1940-1950) and again during the WFU era (1974-2003). In both the Rincon Mountain Wilderness and the Gila Wilderness, significantly fewer small-diameter (0-22.5 cm) trees occurred in areas that burned multiple times compared to areas that were unburned ($p < 0.05$). The density of large-diameter (45-90+ cm diameter breast height) trees in the Gila Wilderness was highly variable and did not differ significantly among fire treatments ($p > 0.32$). In the Rincon Mountain Wilderness, significantly more large-diameter trees occurred in areas that burned mid-century and again during WFU than in all other fire treatments. Mean 10-year basal area growth rates (1840-2000) were similar for both areas prior to a 1946 fire, but growth rates of mid-century burned trees increased significantly in the early 1900's ($p<0.05$). Thus, tree density and diameter growth reflect the thinning effect of that mid-century fire. Ponderosa pine forests in the Gila Wilderness and RMW are structurally diverse and resilient to fires burning during the natural fire season, suggesting that repeated WFU fires have restored forest resilience to fire.
- Methods of remotely measuring burn severity are needed to evaluate the ecological and environmental impacts of large, remote wildland fires. The uncertain future of the Landsat program highlights the need to evaluate alternative sensors for characterizing post-fire effects. We compared pre- and post-burn imagery from four satellite sensors with varying spatial-resolutions, Quickbird Multi-spectral, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Landsat Thematic Mapper (TM), and the Moderate Resolution Imaging Spectroradiometer (MODIS), using a subset of the 2003 Dry Lakes Fire in the Gila Wilderness, NM. Where spectrally feasible, burn severity was evaluated using the differenced enhanced vegetation index (dEVI), differenced Normalized Difference Vegetation Index (dNDVI) and the differenced Normalized Burn Ratio (dNBR). We use 55 Composite Burn Index (CBI) plots to assess burn severity on the ground. Both the EVI derived from Quickbird and the ASTER-derived dNBR showed similar or slightly improved correlations over the dNBR derived from Landsat TM data ($r^2 = 0.82$, 0.84, and 0.78, respectively). The relatively coarse resolution MODIS-derived NDVI image was weakly correlated with ground data ($r^2 = 0.38$). Our results suggest that moderately high-resolution satellite sensors like Quickbird and ASTER have potential for providing accurate information about burn severity. Future research should further develop stronger links between higher resolution satellite data and burn severity across a range of environments.
-

Effects of WFU on landscape pattern and subsequent fires:

This was accomplished with GIS analysis and field data collection. This portion of the project was designed to *evaluate the impacts of alternative management strategies on fire regimes … in unroaded or wilderness areas.* It was also designed to *determine the cumulative effects of fuels manipulation/reduction methods and techniques on future landscape characteristics in terms of fire behavior and severity* and to *develop scientifically based support tools to improve fire management decision processes.*

- The landscape-scale effects of WFU were evaluated in two Sierra Nevada wilderness areas in two Sierra Nevada wilderness areas, the Sugarloaf-Roaring River region of the Sequoia and Kings Canyon National Parks in California, and the Illilouette Creek Basin in Yosemite National Park, California.
- Collins and Stevens (2007) reconstructed historical fire occurrence using tree ring proxies, along with chronologies of tree recruitment, to infer the effects of WFU programs on forest structure. Historically, fires burned every 6 to 9 years, which moderated tree recruitment. Fire suppression policies established in the early 1900s success-fully excluded fire and allowed for unprecedented tree recruitment. Despite the substantial changes in forest structure and composition, the frequency and extent of fires during the current WFU period (1972–present) approach historical levels. This information can provide some necessary insight in implementing WFU policy and developing management plans for similar forest types throughout the western US.
- We used gridded estimates of fire severity, derived from Landsat ETM+ imagery, to identify the biotic and abiotic factors contributing to the observed spatial patterns of fire severity in two large natural fires. Regression tree analysis indicates the importance of weather, topography, and vegetation variables in explaining fire severity patterns between the two fires. Relative humidity explained the highest proportion of total sum of squares throughout the Hoover fire (Yosemite National Park, 2001). The lowest fire severity corresponded with increased relative humidity.
- For the Williams fire (Sequoia/Kings Canyon National Parks, 2003) dominant vegetation type explains the highest proportion of sum of squares. Dominant vegetation was also important in determining fire severity throughout the Hoover fire. In both fires, forest stands that were dominated by lodgepole pine (*Pinus contorta*) burned at highest severity, while red fir (*Abies magnifica*) stands corresponded with the lowest fire severities.
- In both fires, lower wind speed corresponded with higher fire severity, although the highest fire severity in the Williams fire occurred during increased wind speed.
- In the vegetation types that were associated with lower severity, burn severity was lowest when the time since last fire was fewer than 11 and 17 years for the Williams and Hoover fires, respectively.
- Based on the factors and patterns identified, managers can anticipate the effects of management ignited and naturally ignited fires at the forest stand and the landscape levels.

Landscape-scale effects of different fire management strategies:

We used simulation modeling to explore how landscape composition, structure, and function vary under different fire management strategies. In particular, we were interested in implications for ecosystem processes and landscape patterns. This part of our research was designed to *evaluate the impacts of alternative management strategies on fire regimes … in unroaded or wilderness areas ... on ecological factors (JFSP RFP 2001)*. In addition, our research is useful to *address fuels treatment impacts on wildlife populations, habitat structure, hydrology, soils, ecosystem health … at a landscape or regional level* and *the effects of multiple vegetation manipulation treatments … on potential fire behavior, severity, and resistance of fire to control.* Lastly, we sought to *develop methods or systems for incorporating existing weather and climate predictions (ranging from short- to long-term) into tactical and strategic fire preparedness and planning, prescribed fire planning* and to *develop scientifically based support tools to improve fire management decision processes* specifically *quantitative means to assess the risk of escape of prescribed fire.*

This part of the project is still in progress. Simulation modeling has been challenging because further development was needed in Fire-BGC before modeling could be initiated, and because Matt Rollins was reassigned to the LANDFIRE project, which has consumed all of his time. This modeling research task was larger and took longer than we anticipated. We will submit a manuscript in early 2008.

- We used the FireBGCv2 simulation model to assess the effects of five different fire management scenarios for each of two areas, one from the Gila/Aldo Leopold Wilderness Complex (GALWC), NM and one from the Rincon Mountain Wilderness (RMW) in Saguaro National Park, AZ. The goal was to understand the effects of WFU at the landscape scale (a mesoscale), which are less understood than effects at local and regional scales. The simulation landscapes were chosen to encompass multiple potential vegetation types and fire frequency (i.e. areas that have burned 0, 1, 2, and 3 times since the 1975 implementation of WFU). In the GALWC, five 6th code HUC's were combined into a single simulation landscape of 44,793 ha.In the RMW, the simulation landscape was 2830 ha in size.
- We simulated five fire management scenarios in each study area, chosen to represent the range of possible fire management approaches for these landscapes. Fire occurrence is a stochastic process in FireBGCv2. Fire return intervals are specified for all site types and this is incorporated into the fire occurrence algorithm. The number of ignitions allowed to burn varies among scenarios. For all fire management scenarios, the size and severity of any fire that is allowed to burn is dependent on vegetation and fuels. The fire management scenarios include:
    - **Natural Fire** (NF) allows all fires to burn during the simulation. The frequency and severity of the fires is dependent only on vegetation, fuels, and climate.
    - **Fire suppression (FS)** means that only 0% of ignitions are allowed to burn.

- **Wildland fire use (high/aggressive)** (HFU) means that 60% of ignitions are allowed to burn as prescribed natural fires.
- **Wildland fire use (low/passive)** (LFU) means that 30% of ignitions are allowed to burn as prescribed natural fires.
- **Wildland fire use and Rx burning** (FRX) means that we will start a pre-defined number of fires as prescribed fires (25%) and let 25% of naturally occurring ignitions burn as prescribed natural fire.

- For each of five different scenarios, simulation results are reported in terms of fire frequency and location, dominant species and species diversity of trees and shrubs, leaf area index (LAI), and amount of coarse woody fuel, fine woody fuel, and duff and litter.
- Fire frequency varied as expected. Under NF, fires occurred at some points as many as 27 times. With fire suppression, no fires occurred.
- Loading of coarse woody debris carbon (CWDC) across the landscape is higher in the Fire Suppression scenario than with all other fire scenarios. In the high fire use scenario, fuel loading was about the same as under the natural fire scenario. More of the landscape is able to support crown fires under the Fire Suppression FS scenario than with the other scenarios. Across all fuel types, we found an increase in fuels with decreasing fire on the landscape. This increase is most pronounced in the CWDC fuel category. The FS scenario has much more CWDC than all other scenarios. Looking again and the FS and NF scenarios, we can see that we have more of a range in landscape area occupied by different Fire Behavior Fuel Models (FBFM) with FS than with NF. More of the total area of the landscape is occupied by FBFMs that can support crown fire (10-12) in the FS scenario than the NF scenario.
- The dominant species composition across the landscape was defined as the species in each stand with the highest stand basal area. In the Natural Fire (NF) scenario, ponderosa pine dominates. In the Fire Suppression (FS) scenario, much of the landscape is dominated by ponderosa pine, but there is a significant area dominated by Douglas-fir. A more important distinction is the maintenance of high tree species diversity on the landscape with the NF scenario. Under the FS scenario we lose almost all other trees but ponderosa pine and Douglas-fir. If we define the dominant species as that with the greatest canopy cover, there is much more landscape dominated by PSME in the FS scenario than in the NF scenario.
- We can get a different look at vegetation looking at the landscape average pLAI. The pLAI is a weighted landscape average. The overall range in pLAI values is low, but by the end of the simulation, the two most different fire scenarios, FS and NF, have the highest LAI. LFU is next in magnitude with HFU and FRX about the same.

Technology transfer activities:

We worked closely with local managers to share our results and address their relevance to management. Most of this was informal, through one-on-one discussions with local managers. The presentations we made at workshops with managers are listed in Table 1. Managers in each of the field sites have asked us about implications of our research for their future management decisions. In the Gila Wilderness, we now have two

ongoing research projects that followed this one, both focused on questions that arose from questions asked of us by local managers.

We have a web site for the research focused on the two research sites in California. The address is http://www.cnr.berkeley.edu/stephens-lab/research.htm (Select the Landscape Scale Effects of Prescribed Natural Fire Programs in Three Wilderness Areas project). The second web site was to include a synthesis of findings from all of the questions. It has not yet been established and completed because the simulation modeling is not complete.

Deliverables:

We produced many deliverables as originally proposed. This includes eight publications in refereed journal articles, of which four are completed, with two more in review and another two are in preparation (8 were originally proposed) (Table 1). We also have one web site (two originally proposed) and six presentations to managers and scientists (Table 1). In addition, four undergraduate students worked on this project; two helped to collect field data, one completed an undergraduate research thesis using samples from this project, and the others assisted with data entry and other office tasks. In each research site, we established strong collaborative partnerships with local land managers in each of the study locations that enabled us to compile wilderness fire databases. Further, we have developed generalized procedures for classifying remotely sensed imagery for stand structure and input to Fire-BGC and for classifying stand structure. We did provide a project database (tabular and spatial) for addressing fire management issues in the GALWC.

We also accomplished much that was not originally proposed. For instance, several students completed degree programs based, in part, on research conducted as part of this project (Table 1). Two students completed dissertations, one completed an MS, one completed an undergraduate senior thesis, and four students gained valuable work experience.

We have not completed some deliverables that were originally proposed. These include a general technical report detailing applied use of Fire-BGC and a general technical report containing a set of empirically derived guidelines for planning for wildfire use. These await completion of the simulation modeling portion of this study.

Table 1. Products of this research relative to what we originally proposed.

Proposed	Delivered	Status
Publication in refereed journal	Collins, B.M., M. Kelly, J.M. von Wagtendonk, and S. L. Stephens. 2007. Spatial patterns of large natural fires in Sierra Nevada wilderness areas. Landscape Ecology 22:545-557. DOI 10.1007/s10980-006-9047-5.	Completed & Published Collins et al 2006 Landscape Ecol
Publication in refereed journal	Collins, B.M. and S. L. Stephens. 2007. Managing natural fires in Sierra Nevada wilderness areas. Frontiers in Ecology and the Environment. DOI 10.1890/070007.	Completed & Published Collins Stephens Yos Frontiers in press 07
Publication in refereed journal	Collins, B.M, Stephens, S.L. Fire scarring patterns in Sierra Nevada wilderness areas burned by multiple wildland fire use fires. In review at Fire Ecology.	Completed & In Review
Publication in refereed journal	Collins, B.M., Miller, J.D., Thode, A.E., Kelly, M. van Wagtendonk, J., Stephens, S.L. Natural wildfires become self-limiting in Sierra Nevada mixed conifer forests. In review at Ecological Applications.	Completed & In Review
Publication in refereed journal	Holden, Z.A., P. Morgan, M.G. Rollins, and K. Kavanagh. In Press. Effects of multiple wildfires on ponderosa pine stand structure in two southwestern wilderness areas, USA. Journal of Fire Ecology.	Completed & In Press Holden_etal-WFU072407revised
Publication in refereed journal	Holden, Z.A., A.M.S. Smith, P. Morgan, M.G. Rollins, and P.E. Gessler. 2005. Evaluation of novel thermally enhanced spectral indices for mapping fire perimeters and comparisons with fire atlas data. *International Journal of Remote Sensing*. 26(21): 4801-4808.	Completed & Published 2006_Holden et al
Publication in refereed journal	Holden, Z.A., P. Morgan, A.M.S. Smith and L. Vierling. In Review. Beyond Landsat: Multi-scale Assessment of Four Satellite Sensors for Detecting Burn Severity in Ponderosa Pine Forests of the Gila Wilderness, NM, USA.	Completed & In Review
Publication in refereed journal	Holden, Z. A., P. Morgan, M.G. Rollins, and R. G. Wright. 2005. Ponderosa pine snag densities following multiple fires in the Gila Wilderness, New Mexico. *Forest Ecology and Management* 221(2006): 140-146.	Completed &Published Holden_2006-Gilasnags
Publication in refereed journal	Keyser, A., M.G. Rollins, P. Morgan. In preparation. Changes in vegetation structure in southwestern ponderosa pine forests after 25 years of wildland fire use. International	In Preparation, to be submitted in early 2008

	Journal of Wildland Fire.	
MS Thesis	Holden, Z. 2005. Thirty years of wildland fire use: effects of multiple fires on stand structure in two southwestern wilderness areas. MS Thesis. University of Idaho, Moscow, ID 83843.	Completed & Available at University of Idaho Holden_Thesis-TOC & Holden05MSthesis
Dissertation	Collins, B.M. 2007. Natural Wildfires in Sierra Nevada Wilderness Areas. Ph.D. dissertation, Univ. California, Berkeley.	Completed & Available from Univ. California, Berkeley
Dissertation (Accomplished but not originally proposed)	Holden, Z. In Preparation. Twenty year temporal and spatial patterns of fire extent and severity in a large southwestern wilderness area, USA.	In Preparation. To be completed in fall 2007
Presentation	Rollins, M., P. Morgan, S. Stephens, Z. Holden, T. Moody, A. Keyser. 2004. Historical Wildland Fire Use: Lessons to be Learned from Twenty-five Years of Wilderness Fire Management. Presentation at the American Meteorological Society, November 14, 2004.	Completed
Presentation	Morgan, P., Z. Holden, and M. Rollins. 2003. Evaluating 25 Years of Wildland Fire Use in Ponderosa Pine Forests: Tree Mortality and Stand Structure. Presentation at the American Meteorological Society, November 14, 2003.	Completed
Presentation	Keyser, A., R. Keane, M. Rollins, P. Morgan and S. Stephens. 2006. Changes in vegetation structure and landscape composition in Southwest ponderosa pine forests after 25 years of wildland fire use. 3rd International Fire Ecology and Management Conference, 14 November 2006.	Completed
Presentation	Holden, Z.A., Penny Morgan, Matthew G. Rollins And Alisa R. Keyser. 30 Years of Wildland Fire Use: Effects of Repeated Fires on Ponderosa Pine Forest Stand Structure in the Gila. Natural History of the Gila Symposium. Silver City, NM. October 6-7, 2006.	Completed
Presentation	Holden, Z.A., P. Morgan, M. Rollins, Twenty-year patterns of burn severity in the Gila National Forest, New Mexico, International Fire Ecology and Management Conference. November 13-17, 2006. San Diego, CA.	Completed
Presentation	Keyser, A., M. Rollins, P. Morgan. Changes in landscape composition in Southwest ponderosa pine forests after 25yr of wildland fire use. International Fire Ecology and Management Conference, November 13-17, 2006. San Diego,	Completed

	CA.	
Presentation	Collins, B., S. Stephens. Effects of natural fire programs on fire occurrence and stand age structure in Sierra Nevada wilderness areas. International Fire Ecology and Management Conference, November 13-17, 2006. San Diego, CA.	Completed
Website (Accomplished but not originally proposed)	http://www.cnr.berkeley.edu/stephens-lab/research.htm (Select the Landscape Scale Effects of Prescribed Natural Fire Programs in Three Wilderness Areas project).	Completed
Final Report	Van Wagtendonk, J., S. Stephens, and B. Collins. 2007. Landscape scale effects of wildland fire use programs in Sierra Nevada wilderness areas. Submitted to M. Rollins, Fire Sciences Laboratory, Missoula, MT.	Completed Stephens_FinalReoprt_HWFU
Multiple annual and final reports (Accomplished but not originally proposed in list of deliverables)	Multiple annual and final reports submitted to JFSP and to Rocky Mountain Research Station	Completed JFSP01ProposalResubmission Accomplishment Report 2004 HWFUProgress_March2005 JFSPAccomplishment Report 2005 JFSPAccReport_2005_01-1-1-06 FinalReport_HWFU-061306
Student education	Zack Holden defended his MS thesis and completed his MS degree program in spring 2005.	Completed: 1 MS Thesis Holden_Thesis-TOC & Holden05MSthesis
Student education (Accomplished but not originally proposed)	Zack Holden will complete his PhD dissertation in fall of 2007. Heather Heward completed her senior thesis based, in part, on this project. She graduated in May 2006 with a BS in Ecology and Conservation Biology. Amie June Brumble and Tyler Morrison worked during the summer doing field work on this project while there were pursuing B.S. degrees at UI. Similarly, two other undergraduate students worked part-time on this project.	Completed: 1 PhD Dissertation (to be done fall 2007) 1 Senior Thesis completed in 2006 4 other students employed part-time in 2005 and 2006
Student education (Accomplished but not originally proposed)	Examples from this research have been incorporated into FOR 426 Fire Management and Ecology, into FOR 526 Fire Ecology, and into FOR 434 Assessing Burn Severity, all courses taught at the University of Idaho. Two of these	Completed Two classes in 2005, two classes in 2006, and three classes in 2007

	courses are offered online to fire professionals (http://401series.net) as part of degree programs and certificates in fire ecology and management (http://www.cnr.uidaho.edu/wildlandfire).	
Database	We provided a project database (tabular and spatial) for addressing fire management issues in the Gila Aldo Leopold Wilderness Complex. This was a CD given to Joe Encinas, GIS Analyst, Gila National Forest, Silver City, NM.	Completed