National Park Service
Sequoia and Kings Canyon National Parks
and Devils Postpile National Monument
Fire Ecology Annual Report
Calendar Year 2004

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Summary

During 2004 a total 32 fire effects plots (FMH) were re-measurement in seven monitoring units with one new plot installation. Additional fieldwork involved data collection for several projects that have or will provide supplemental information to the fire management program at both the local and national levels. The most involved was the national Landscape Assessment Project (burn severity mapping) with 78 CBI (composite burn index) plots sampled in several areas burned in 2003. A significant effort was also made to incorporate and test the Fire Ecology Assessment Tool (FEAT) in a work environment by the fire effects staff, which provided valuable feedback to the developers. All FMH and CBI plots were sampled using FEAT software and PDAs. Unfortunately this meant that all 2004 data was in FEAT format and all previous data remains in FMH format. The fire effects crew also participated in three prescribed burns within Sequoia and Kings Canyon National Parks (SEKI) and one interagency prescribed burn.

The Fire Ecologist also received funding in 2004 for a fire history reconstruction at Devils Postpile N.M. (DEPO) with a crew of two working on this project throughout the summer. Preliminary results have already reshaped our ideas about fire in the DEPO area and had important input into the recently completed draft DEPO Fire and Fuels Management Plan (FFMP) and Environmental Assessment (EA). Additionally, Fire Ecology collaborated with and was actively involved in a number of fire related research projects underway in the parks by USGS, USDA, or university researchers (several funded through JFSP) and participated in developing proposals for several new projects.

Several types of public outreach were also provided though publications, the *Fire Information Cache* website, and lectures to university classes. These reach a large audience and provide important support for fire management and natural resources activities in the parks. Significant time was also devoted in 2004 to the preparation of the draft FFMP and EA for DEPO that incorporated results from the fire ecology program.

Unfortunately, there continued to be funding support issues with some positions in the Fire Ecology Program, although temporary solutions were found during 2004 with the assistance of the Fire Management Office and the Division and Natural Resources.

I - Workload and Staffing

Workload - In 2004 Fire Effects resampled 29 postburn plot and four preburn plots (three of which were rereads of postburn plots prior to second entry burns). The one new installation was located in a mechanical thinning+pile-burning project near Wuksachi Lodge (***Table 1.1***). A significant effort to incorporate and test Fire Ecology Assessment Tool (FEAT) in a field environment was also made by the Fire Ecology Program (see comments in ***Section 3.1***). Additionally, CBI sampling for the national Landscape Assessment Project (see comments/description below) occupied a considerable amount of the crew's time during 2004, a result of the large fire use fires during 2003. Seventy-eight random plots were sampled, nearly all in backcountry locations. Since these were in wilderness locations the crew minimized wilderness impacts by traveling on foot or using stock to carry field gear.

Table 1.1. Fire ecology plot workload during 2004. Listed are FMH plots, CBI plots installed for the NPS Landscape Assessment Study. Other plot installs are listed or described by section in ***Section 3.2***.

Park	Monitoring Unit Name/ Total Number of Plots Installed to Date	Total Plots Installed to Date	Type of Plot (FMH, photo point, other – describe)	Pre-burn 2004	Immed. Post 2004	Post -burn 2003 (1-30 yrs)
SEKI	Chamise Chaparral	3	FMH brush plot			
	Mixed Chaparral	6	FMH brush plot			
	Montane Chaparral	6	FMH brush plot			6
	White-Fir Mixed Conifer Forest	17	FMH Forest plot			2
	Red Fir Forest	7	FMH Forest plot			1
	Buckeye Fire	3	FMH Forest plot			
	Low Elevation Mixed Conifer	8	FMH Forest plot			1
	Ponderosa Forest	25	FMH Forest plot			1
	Blue Oak Forest	2	FMH Forest plot			
	Giant Sequoia Mixed Conifer Forest	48	FMH Forest plot	3	3	9
	Mechanical Thinning + Pile Burning	7	FMH Forest plot	1*		6
DEPO	Rainbow Wildfire	8	FMH Forest plot			
SEKI	West Kern Fire Use Fire	35	CBI			35
	Williams Fire Use Fire	40	CBI			40
	Atwood Rx	1	CBI			1
	Palisades Fire Use Fire	37	CBI			
	Tar Gap Rx	24	CBI			
	Highway Rx	2	CBI			
	Sherman Rx	3	CBI			
Total		**132 FMH + 142 CBI**		**4**	**3**	**26 FMH + 78 CBI**

* Forest Plot Installations

Discussions over the past few years have occurred about fire effects in xeric conifer vegetation (primarily open-to-moderately-closed stands of Jeffrey pine with a manzanita understory). Since additional burns are planned in this type a monitoring unit will be developed in the coming year and plot installation initiated as burn plans are written and burns occur.

Staffing - Fire funded staffing during 2004 consisted of Fire Ecologist, Lead Fire Effects Monitor, and four Fire Effects Seasonals (***Table 1.2***). Two additional positions, one seasonal and one SCA Associate, where funded via NRPP funding for a fire history study in DEPO. Staffing continued to be a problem within the program. While crew staffing has been maintained the elimination of one Fire Ecologist (Keifer) position in 2003 and the loss of function of the Division of Natural Resources Fire Planner/Fire Resource Specialist (Manley) coupled with the continued under funding (at 15 payperiods vs 20) of the Lead Fire Effects Monitor and lack of an Assistant Lead Fire Effects Monitor position (although an extra seasonal position has been substituted in lieu of this position) continues to affect the Fire Effects Program at SEKI. Additionally, during 2004 the Fire Ecologist position was erroneously funded at a Step 1 level rather than a Step 4 that had some impact on training and travel during the year.

Table 1.2. Fire ecology staffing 2004. Includes fire funded and non-funded staff.

Monitor	Starting Date	Ending Date	# of Pay Periods	Training and Development
Jennifer Sawyer*	5/24/04	10/30/04	11.5	S-130, S-190, S212
Amber Harrison*	5/24/04	8/28/04	7	S-130, S-190, S212
Sarah Stehn*	6/14/04	10/30/04	10	S-130, S-190
Phil Graeve*	5/30/04	10/30/04	11	S-290, Initiated Fire Effects Monitor Taskbook, S212
Karen Webster	2/23/04	11/19/04	20	FEAT PORE 5/04, FEAT/Stats 5/04
Tony Caprio			full time	FEAT PORE 5/04, FEAT/Stats 5/04, Landfire Workshop 11/04
Other Positions – funded through NRPP Small Park Block Allocation for DEPO 2004 fire history project				
Colin Meston*	5/30/04	10/02/05	9	
David Ristow$^{\propto}$	6/27/04	12/17/04	24 wks	

- * = seasonal/temporary employees
- $^{\propto}$ = Student Conservation Association associate position

Figure 1.1. Prescribed burns in Grant West during Oct. 2004 (plot 74) and Tharps in June 2004 (plot 82).

II - Program Results

A summary of results is presented through 2003 (***Table 2.1***). Results from 2004 are not included in this report since all 2004 data were entered in FEAT while pre-2004 data were still in FMH database format. Until the FMH database is converted and merged with FEAT there will not be an easy way to do an analysis.

Table 2.1. Management Objectives and Monitoring Results for 2003 - All results shown are 80% confidence intervals of the mean. Fuel reduction objectives/results are mean percent reduction from preburn to immediate postburn. Stand density objectives/results are for five-year postburn mean stand density. An underlined number of plots indicate that the minimum sample size has been attained for that variable.

Monitoring Unit	Management Objective (Restoration)	Monitoring Results (80% confidence interval)	Objective Achieved?
Giant sequoia-mixed conifer forest	60-95% total fuel reduction	total fuel reduction = 71-81% *(n=**28** plots, 18 fires)*	**YES**
	5-yr postburn stand density: 50-250 trees/ha <80 cm DBH 10-75 trees/ha ≥ 80 cm DBH	stand density = 190-256 trees/ha <80 cm DBH 34-46 trees/ha ≥ 80 cm DBH *(n=**29** plots, 18 fires)*	**YES**
	5-yr postburn stand composition: 40-80% fir, 10-40 sequoia, 5-20% pine	fir = 77.8% sequoia = 10% pine = 10% *(n=**30** plots, 18 fires)*	**YES**
White fir-mixed conifer forest	60-95% total fuel reduction	total fuel reduction = 62-85% *(n=11 plots, 7 fires)*	**YES*** *but minimum sample size not achieved
	5-yr postburn stand density: 50-250 trees/ha <80 cm DBH 10-75 trees/ha ≥ 80 cm DBH	stand density = 272-356 trees/ha <80 cm DBH 28-44 trees/ha ≥ 80 cm DBH *(n=**10** plots, 6 fires)*	**NO** for trees <80 cm DBH; **YES** for trees >80 cm DBH
Low elevation-mixed conifer forest	60-95% total fuel reduction	total fuel reduction = 75-93% *(n=**5** plots, 3 fires)*	**YES**
	5-yr postburn stand density: 50-250 trees/ha <80 cm DBH 10-75 trees/ha ≥ 80 cm DBH	stand density = 310-562 trees/ha <80 cm DBH 9-35 trees/ha ≥ 80 cm DBH *(n=5 plots, 3 fires)*	Uncertain – sample size too small
Chamise chaparral	No objectives developed to date	live shrub cover reduced by 85-92% (immediate postburn)	**N/A**
Mechanical Thinning + Pile Burning	Reduce fuels to < 12 tons/acre immediate post treatment	fuel load = 36 tons/acre (total fuel reduction 57%) *(n=2, 1 treatment)*	**NO*** * but sample size small
	Immediate post treatment stand structure: maximum of 25 trees/acre < 22.9 cm DBH	stand density = 10.1 trees/acre < 22.9 cm DBH *(n=2, 1 treatment)*	**YES*** * but sample size small

Table 2.1 continued.

Monitoring Unit	Management Objective (Maintenance)	Monitoring Results (80% confidence interval)	Objective Achieved?
Mixed-Conifer Forest	Use fire to maintain fuel load mosaic across the landscape as follows: 20-40% 5-30 tons/acre 20-50% 30-60 tons/acre 5-20% > 60 tons/acre *Note: % is percent of landscape for all Mixed-Conifer Forest Types.*	5-30 tons/acre = 15% 30-60 tons/acre = 38% > 60 tons/acre = 46% *(n=13 plots, 6 fires)*	**YES** for 30-60 tons/acre **NO** for 5-30 tons/acre and > 60 tons/acre
		total fuel reduction from "pre" second entry fire to 02POST = 53%* * "pre" second entry fire ranges from 01YR08 – 01YR16 *(n=13 plots, 6 fires)*	**N/A**
	Stand density immediately post second entry fire: 50-250 trees/ha <80 cm DBH 10-75 trees/ha ≥ 80 cm DBH	stand density = 281 trees/ha <80 cm DBH 50 trees/ha ≥ 80 cm DBH *(n=13 plots, 6 fires)*	**NO** for trees <80 cm DBH; **YES** for trees >80 cm DBH
	Stand composition for Giant Sequoia forest type: 40-80% fir, 10-40 sequoia, 5-20% pine	fir = 76.1% sequoia = 13.6% pine = 9.8% *(n=13 plots, 6 fires)*	**YES**

III - Other Fire Ecology Accomplishments or Projects

The fire effects crew gained substantial experience using FEAT in both the field and office during 2004 with feedback given to the developers (see ***Section 3.1***). This conversion to a new system of data collection had its ups and downs during the season. Fire ecology staff have also provided valuable outreach for the SEKI fire program (see ***Section 3.2***). This included several proceedings papers recently published or made available that have been in press for a number of years. Additionally, the *Fire Information Cache* web site also continued to be heavily utilized by the public. Staff also provided input into the DEPO Fire and Fuels Management Plan and EA (see ***Section 3.3***). Additionally, they were involved with a number of local or national NPS studies that supplemented plot monitoring duties (see ***Section 3.4***). This work complements SEKI's network of fire effects monitoring plots or provides additional fire ecology information important to the fire management program. Lastly, fire ecology staff were/are involved with a number of collaborative research studies with other agencies, universities, or parks (see ***Section 3.5***). A list of recently completed, currently underway, or proposed projects are given below with an abstract.

3.1 - FEAT Update

After attending the FEAT training at PORE and the FEAT Statistics training in Ft. Collins in May 2004 SEKI was very active in utilizing the recently released FEAT desktop and PDA software (version 1.1). They were used almost exclusively during the 2004 season although hard

copy datasheets were also used during field data collection in case of an unforeseen PDA failure (which did happen). This provided ample opportunity to acquire familiarity with software, hardware, and their utilization in the field. Feedback was given to Spatial Dynamics midseason as to what was working and what wasn't. All Fire Effects plot data, as well as CBI data, were collected in the field during 2004 with PDA's. As a result all data from 2004 resides only in the FEAT database while previous years data resides in FMH. This is anticipated to occur in spring 2005. This has limited analysis of 2004 plot data.

A variety of problems were encountered using FEAT and the PDAs. The most significant problem encountered using PDA's in the field was battery usage. SEKI used the HP IPAQ 2200 PDA ROM version 1.1 running Microsoft Pocket PC. FEAT installed without major problems on this PDA. One important lesson learned was to "always" backup plot data daily or after every completed plot onto a flash card (Sprite Backup was used). When collecting data away from the office for extended periods of time using multiple PDA's, managing your batteries becomes quite important to avoid data loss. The "backup" battery in each PDA lasts about 10 minutes, only enough time to "supposedly" change batteries. When the "main" battery reaches a low threshold of power, the PDA switches to the "backup" battery without warning the user it is doing so. This caused data loss in the field in a couple of instances. Battery power should be checked everyday and batteries should be changed before they reach a critical low level. Several extended run-time 2100mAh batteries were purchased to replace or supplement the 900mAh batteries that were provided with the PDAs resulting in greatly improved battery performance. SEKI also purchased two solar powered battery chargers (lightweight flexible solar panels that can be rolled; an IPC Powerflex 5 watt panel and a PowerFilm® rollable 5 watt panel) to use for general field equipment i.e. digital cameras, GPS's PDA's etc. These seemed to work well once we worked-out a "standard operating procedure". Additional external AA battery chargers for the PDAs were also utilized. These allowed the solar panels to charge AA batteries during the day that could then be used to charge the PDAs at night.

3.2 – Outreach: Publications, Presentations, and Other

(3.2.1) *Publications:*

Caprio, A.C. 2004. *Temporal and spatial dynamics of pre-EuroAmerican fire at a watershed scale, Sequoia and Kings Canyon National Parks.* Association for Fire Ecology Misc. Publ. No. 2:107-125. http://www.nps.gov/seki/fire/pdf/sierra_fire_history-caprio_cafe99.pdf

Several papers listed below were published in 2002 but not distributed until 2004.

Caprio, A.C., C. Conover, M. Keifer, and P. Lineback. 2002. *Fire management and GIS: a framework for identifying and prioritizing fire planning needs.* Association for Fire Ecology Misc. Publ. No. 1:102-113. http://www.nps.gov/seki/fire/pdf/sd97_frid.pdf

Caprio, A.C. and P. Lineback. 2002. *Pre-Twentieth Century Fire History of Sequoia and Kings Canyon National Parks: A Review and Evaluation of Our Knowledge.* In: Assoc. for Fire Ecology Misc. Pub. No. 1:180-199. http://www.nps.gov/seki/fire/pdf/sd_knwf.pdf

Keifer, M. and J. Manley. 2002. *Beyond Initial Fuel Reduction in the Giant Sequoia-Mixed Conifer Forest: Where Do We Go From Here?* In: Assoc. for Fire Ecology Misc. Pub. No. 1:213-222. http://www.ice.ucdavis.edu/cafe/agenda97/FireManagement/Planning/2FMKeifer.html

(3.2.2) *Graduate Student Committees served on by the Fire Ecologist during 2004:*

- *Andi Heard* (MS), *Colorado State University*, Fort Collins, CO (see project listing below for details)
- *Nathan Warmerdam* (MS), *University of Redlands*, Redlands, CA (see project listing below for details)

(3.2.3) *"Fire Information Cache" Fire and Natural Resources Web Site:*

- The *Fire Information Cache* web site, at: http://www.nps.gov/seki/fire/indxfire.htm, continues to be a popular destination providing a variety of information about fire management activities related to natural resources, information about fire research in the parks, a fire bibliography emphasizing fire in the Sierra Nevada with many downloadable papers in HTML or PDF format, and links to fire management activities and documents for SEKI. The pages have been receiving more than 30,000 visits annually and are one of the most visited pages on the SEKI web site. The bibliography is widely used or referenced on other web sites as a source for information about fire in SEKI and the southern Sierra Nevada Mountains. However, the pages are in need of a facelift to bring them up-to-date with current web standards.
- Assisted in web page development for the following fire related pages at SEKI
  "*Fire Portal*" (http://www.nps.gov/seki/fire/portal/portal.htm),
  "*Fire Information*" (http://www.nps.gov/seki/fire/fireinfo/current.htm),
  "*Fire and Fuels Management Plan*" (http://www.nps.gov/seki/fire/ffmp/ffmp.htm)

(3.2.4) *Presentations/Field Trips for Student or Other Groups*

- Field trip and lecture on fire management and natural resources to UC Fresno undergraduate Plant Ecology class
- SNHA Field Seminar (lecture and field trip) on Dendrochronology, Fire History, and Fire Management

3.3 - Feedback to Fire Management Program

A draft Fire and Fuels Management Plan (FFMP) and Environmental Assessment (EA) for Devils Postpile National Monument was nearing completion at the close of 2004 (now available for public review at: http://www.nps.gov/depo/pphtml/documents.html). The fire ecology program had significant input into the development of the preferred alternative in the Devils Postpile National Monument Fire Management Plan. Results from the fire effects plots and fire history sampling during 2004 provided important information for plan development. The preliminary results from fire history sampling (see ***Section 3.4.6***) indicated that much, but not all (the northwest appears to have had much longer intervals between fires), of the monument had a moderate frequency (~10 – 25 years) surface fire regime indicating that the 1992 Rainbow Fire, which resulted in large patches of complete overstory mortality, was an abnormal event. Prior to this study fire was generally thought to be rare in the area (SEKI 1982[1]) with stand replacing fire the rule. Plot data also indicated very limited tree regeneration in the high severity patches located away from seed sources with most regeneration present establishing within one or two years of the 1992 burn. As

[1] USDI. 1982. Natural Resources Management Statement for Devils Postpile National Monument. Sequoia and Kings Canyon National Parks and Devils Postpile National Monument. 20 pp.

a result it was felt care should be exercised in fire planning that would consider impacts since fire in these areas could potentially result in type conversion to shrub dominated vegetation. However, it was also felt that initiating a burn program in areas where the 1992 fire had been less severe (occurring primarily as an understory or of mixed severity burn) would be beneficial.

The first annual update has been made Fire and Fuels Management Plan for Sequoia and Kings Canyon has been completed and the first. The plan and EA can be found at: http://www.nps.gov/seki/fire/ffmp/ffmp.htm. The document contains a copy of the SEKI Monitoring Plan (Appendix C).

Direct feedback was provided for a number of burn plans being developed in SEKI. This included development of five year burn plans and comments about portions of burn units that incorporated areas of vegetation that had limited fire occurrence in the past (for example, foxtail pine and piñon pine vegetation types) and where care needs to be used in planning so that these vegetation types are not negatively impacted. Close coordination is also occurring between fire management, fire ecologist, and SEKI USGS researchers on restarting the Cedar Grove burn program (burn scheduled for 2005) after it was shut down in 1998 due exotic cheatgrass invasion of the area. Results from the USGS cheatgrass study, funded by JFSP, will be utilized in making burn plan decisions.

3.4 - Fire Ecology Projects 2004

The Fire Ecology Program in SEKI/DEPO was directly involved in a variety fire-related projects during 2004. Some were the continuation of longer-term projects requiring annual monitoring (***Projects 3.4.1*** *through* ***3.4.3***) while others have specific data needs that will be completed in a season or two (***Projects 3.4.4*** *through* ***3.4.6***). These projects are providing valuable input into the SEKI fire management program.

(3.4.1) *Increased Giant Sequoia Sample Size*

Because of their great size, mature giant sequoia tree density is very low in the standard 20 m x 50 m forest plots. To increase the sample size of giant sequoia, we sample all, or a subset of, giant sequoia trees in prescribed burn units in the Giant Forest prior to and following prescribed burning. Pre- and post-burn methods that follow the FMH protocol for overstory tree sampling can be combined with the FMH database for the Giant sequoia-mixed conifer forest monitoring type. A total of 983 giant sequoias were sampled in seven separate units burned between 1993 and 1999. This information will provide sufficient sample depth to assess the long-term effects of prescribed fire on mature giant sequoia trees over a long period of time. While monitoring continues for trees currently in the study no additional giant sequoias will be added.

(3.4.2) *Giant Sequoia Seedlings in Reburns*

The fate of giant sequoia reproduction in second entry burns (following the initial restoration burn) has become timelier. Some areas of the parks where early-prescribed burning efforts were concentrated have surpassed the historic fire return interval without subsequent burning. In some of these areas, giant sequoia regeneration of varying density resulted from the initial burn.

Knowledge about fire effects on these young trees following subsequent prescribed burns is critical, especially given the importance of giant sequoias and their fire-dependent regeneration. As a result of the parks' interest in this issue, plots were installed in reburn areas beginning in 1988 (expanded in 1997) to specifically assess the reburn mortality/survival of groups of giant sequoia seedlings established after the initial burn. This information is expected to be helpful in making decisions related to reburn scheduling in other areas in the parks.

(3.4.3) *Sugar Pine Preburn Litter/Duff Removal*

Large tree mortality following prescribed fire is a concern for land managers attempting to reduce fuels and restore the process of fire in fire-dependent ecosystems. This information is especially critical in areas where fuels have accumulated following an unnaturally long fire free period due to past fire exclusion. Pines, including sugar pine seem to be especially susceptible to mortality following fire. Whether this mortality is directly related to returning fire after a long absence in short-return interval regimes, or a combination of fire and other previously existing stressors, is unknown at this time. Research scientists from the USDA Forest Service Riverside Fire Lab found that removing some of the deep organic layer around trees prior to burning reduces large tree mortality in some forest types in Arizona. This type of preburn fuel removal may be an option in areas where large tree mortality is an important sociological or ecological issue.

To examine whether a difference in mortality occurs between trees with fuels removed and trees without fuels removed and also to test the practicality of fuel removal methods, fuel was removed around large sugar pines in several prescribed burn units between 1996 and 2003. A total of 62 pairs of trees (trees were paired mitigated and unmitigated with 124 trees total) have been monitored (***Table 3.1***). Of these, 22 pairs were rejected postburn because of burns outside planned prescription (see ***Table 3.1*** for details). Overall mortality (mitigated and unmitigated) in 2004 was 10% of the remaining 80 trees (72 PILA and 8 PIPO) in four burn units. All trees dying were PILA (11.1% across the four burn units) and mortality occurred up to six-years postfire. However, interestingly, mortality of mitigated and unmitigated trees was similar (10% each) across all burn units. A Joints Fire Sciences Program proposal was submitted in 2004 by the USGS and SEKI to address questions about fire and sugar pine mortality that have been raised and become controversial. Protocols were slightly modified during 2004 so that annual censuses will be reduced.

Table 3.1. Burn treatments utilized in PILA fuels mitigation project.

Burn	Year Burned	# Paired Trees	Status
Sunset	1996	12	Rejected because burn was spotty and most trees not treated
Pinewood	1997	10	Rejected because severe crown scorch confounded mortality effects
Broken Arrow	1998	15	
Lower Deadwood	2000	2	
Bear Hill	2001	19	Subset of trees with temperature sensors installed during burn
Upper Deadwood	2003	2	

(3.4.4) *Named Trees Inventory*

In response to the accidental ignition of the Washington tree in 2003 and follow-up by the SEKI Fire Management Committee, a fire susceptibility inventory for all named sequoia trees in the park was begun. The purpose of the inventory is to identify named trees, document their location and condition, and describe site characteristics around each tree that might influence fire. A variety of conditions or site factors were identified and are being surveyed in the field. Digital photos of each tree are also being taken. This information can be used during burn plan development and implementation to assist in; 1) determining if a tree is susceptible to adverse fire impacts, and 2) developing potential mitigation actions appropriate to minimize these impacts. The information gathered will be made available as a database, spreadsheet, and as GIS layer(s).

As of November 2004 all known named trees in Giant Forest have been visited with the exception of the area from McKinley south to Circle Meadow and from Washington and Welton east to the House Group and President tree. All data has been entered into a database and can be joined to the GIS layers of named trees in the sequoia tree inventory map and viewed in ArcView/ArcGIS.

(3.4.5) *Composite Burn Index (CBI)*

The composite burn index sampling is part of a NPS/USGS study utilizing input from burns in parks located throughout the United States. Overall project development and analysis has been funded through the Joint Fire Sciences Program with field data collected by fire effects monitors funded through individual parks.

Background (from Landscape Assessment Sampling and Analysis Methods): Landscape Assessment primarily addresses the need to identify and quantify fire effects over large areas, emphasizing comparability of results, along with the capacity to aggregate information across geographic regions and time. Results provide information on spatial heterogeneity of burns and how fire interacts with vegetation and topography. The quantitative measure that is mapped is "burn severity", defined here as a scaled index gauging the magnitude of ecological change caused by fire. In the process, two methodologies are integrated. Burn Remote Sensing (BR) involves remote sensing with Landsat 30-meter data and a derived radiometric value called the Normalized Burn Ratio (NBR). The NBR is temporally differenced between pre- and post-fire datasets to determine the extent and degree of change detected from burning. The Burn Index (BI) adds a complementary field sampling approach, called the Composite Burn Index (CBI). In CBI field plots independent severity ratings for individual strata, and a synoptic rating for the whole plot area are collected. These provide a quantitative picture of the whole burn as if viewed from the air. Plot sampling may be used to calibrate and validate remote sensing results, to relate detected radiometric change to actual fire effects on the ground. Alternatively, plot sampling may be implemented in stand-alone field surveys for individual site assessment.

Figure 3.1. Composite Burn Index (CBI) plots in the 2003 West-Kern Burn. Low severity burn in an old dry PIJE stand with an open canopy (left) and an area of severe fire effects with nearly 100% crown mortality in a moderately young mixed PIJE/ABCO forest with a more closed canopy (right).

CBI field sampling methods are used to derive severity index values that summarize general fire effects within an area or the average burn condition on a plot. The question CBI attempts to answer is how ecologically important are consequences of a given fire or how much has fire altered the biophysical conditions of a site? CBI ratings incorporate such factors as condition and color of the soil, amount of vegetation or fuel consumed, resprouting from burned plants, establishment of new colonizing species, and blackening or scorching of trees. The primary goal of field sampling is to capture the range of variation found within burns, covering as many fire effects and biophysical settings as possible. Average conditions of many factors are considered across multiple strata to derive the severity value and parallels the way Landsat satellite sensors average all features within a pixel to record the multi-spectral brightness values used to model burn severity. The landscape sampling design is hierarchical and multi-layered (***Table 3.2***). Each strata of a vegetative community is evaluated independently using several criteria and given a rating. The CBI provides an index representing the magnitude of fire effects combined across all strata and provides a numeric scale, from 0.0 to 3.0, for gauging changes. Field data are quick to collect, relying mostly on ocular estimation and judgment allowing a representative number of plots to be sampled effectively over large areas.

All field sampling n SEKI was undertaken as *extended assessment* (about one year postburn) , which is the primary reference point for change from prefire conditions, as it has a chance to reveal survivorship potential and delayed mortality. Burns occurring in 2003 sampled in 2004

Table 3.2. Three composite levels (A-C) encompass the five strata level (1-5). CBI scoring is done for each strata and averaged to the desired composite level.

A. Total Plot	B. Understory	1. Substrates
		2. Herbs, Low shrubs and Small Trees
		3. Tall Shrubs and Sapling Trees
	C. Overstory	4. Intermediate Trees (pole-sized trees, subcanopy)
		5. Big Trees (mature, dominant/co-dominant, upper canopy)

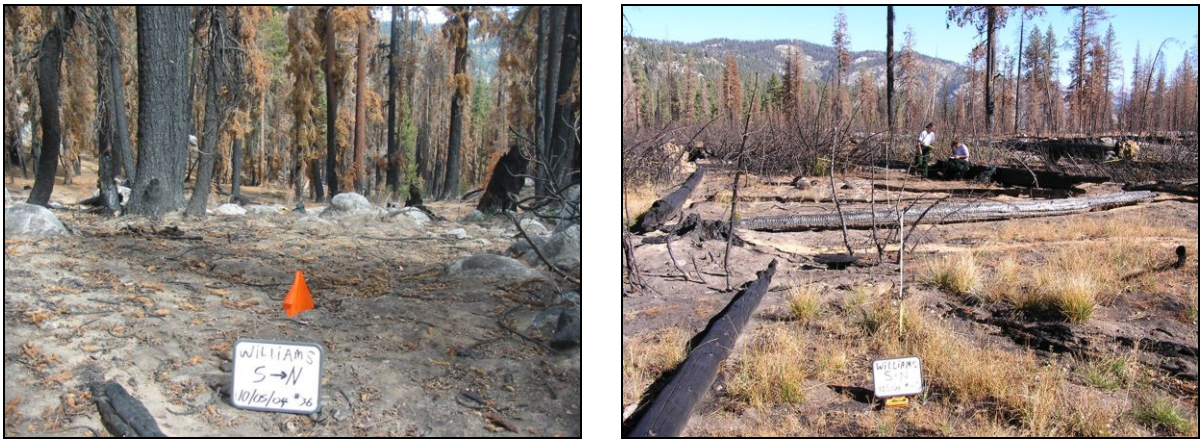

Figure 2.2. CBI plots in the 2003 Williams Burn. Moderate-to-severe fire effects in red-fir forest (left) and severe fire effects in a lodgepole pine stand (right) in an area where overstory mortality was originally caused by the 1985 Sugarloaf Burn with the post-1985 regeneration killed by the Williams Fire.

included the West-Kern (3,226 ha, 1,421 ha in park, ***Figure 3.1***), Williams (1,405 ha, ***Figure 3.2***)), and Atwood prescribed burn (1,099 ha)

(3.4.6) ***Reconstructing Pre-EuroAmerican Fire History of Devils Postpile National Monument***, PMIS #: 92344, Anthony Caprio, SEKI and Deanna Dulen, DEPO

This study is reconstructing attributes of fire prior to EuroAmerican settlement using fire scarred trees and stand structure data to provide baseline information for developing and implementing natural resource and fire management plans and activities. Little is known about fire's past role in this ecosystem although elsewhere in the Sierra Nevada significant alterations occurred with settlement resulting in dramatic vegetation changes and unnaturally high fuel loadings. Using dendrochronological analysis properties of pre-1900 fire regimes can be determined that characterize temporal and spatial attributes and the variability of past fires, providing insight about how fire helped shape the landscape. Results will be valuable in fire management planning in DEPO (preliminary results have already reshaped our view of fire regimes in the monument).

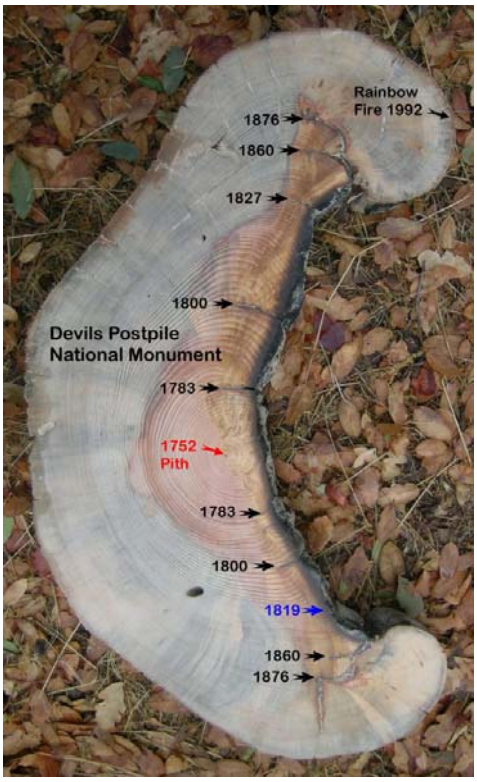

Figure 3.3. Fire history sample (cross-section from a PIJE log) collected near the southeast corner of Devils Postpile NM showing fire scars and dates of seven fires: 1783, 1800, 1819 (no scar visible on this section but found on other sections from the same tree), 1827, 1860, 1876, and 1992 (Rainbow Burn).

A total of 74 samples (partial cross-sections from old trees or logs – see ***Figure 3.3***) were collected at 12 sites in or adjacent to the monument in the most common forest types (***Table 3.3***). Detailed data describing each site's vegetation, topography, and fuels were also collected. Samples are being processed (stabilized and sanded) and are being crossdating to obtain fire event dates. Preliminary results suggest moderate fire frequency over much but not all the

monument. Age structure data was also collected at two one hectare unburned sites. Additionally, 33 random "regeneration" plots were established in burned areas to collect data on preburn forest structure, composition, and postfire regeneration (nine similar plots were also established in unburned areas for comparison).

Table 3.3. Fire history plot installs in DEPO during 2004. Regeneration plots were permanently marked for future rereads.

DEPO Fire History 2004[∝]	Fire History	12
	Stand Structure	2
	Regeneration	42

[∝] NRPP funded project in 2004 with its own crew

3.5 – SEKI/DEPO Fire Research Projects and Collaboration

This section on research projects and collaboration has been broken into three subsections; completed, current, and proposed projects.

3.5.1 - *Projects Completed 2004*

(3.5.1.1) ***Developing a Landscape-Scale Framework for Interagency Wildland Fuels Management Planning***. JFSP funded 1999; NPS/USDA/CDF, Lead PI Pat Lineback with MaryBeth Keifer and Anthony Caprio NPS fire ecology Co-PIs.

Project Abstract: Fire suppression has led to fuel accumulations, uncontrollable wildland fires, increased risk to human life and property, and the deterioration of fire dependent ecosystems. Although one of the strategies available for reducing fuel levels is the use of naturally ignited wildland fire, this option is seldom used because of risks to values in the wildland urban interface. Managers are unable to take advantage of all their alternatives because they lack tools for planning at the landscape scale and they lack information on fire benefits. Researchers will develop a GIS-based model that quantifies both the risks and benefits of fire across the landscape and allows managers to weigh the risks from fire against its longer benefits and the risks of continued fire suppression. This information will help managers develop strategic fire and fuels management plans.

Final report can be obtained at the following URL: http://www.nps.gov/seki/fire/pdf/ssgic_finaldocument.pdf

(3.5.1.2) ***The Use of GIS to Determine the Relationship Between Fire Frequency and Topography*.** Univ. Redlands M.S. graduate project, Nathan Warmerdam; advisor, Karen Kemp (with support from SEKI, Pat Lineback and Anthony Caprio)

Abstract: Wildland fire has and always will be a part of Sierra Nevada forests' natural life cycle. Fire exclusion policies implemented over the past century have led to the development of unnatural forest structure and composition. Such forests are prone to very large and destructive fires that often threaten both property and human life. Those responsible for our nation's forests are increasingly restoring fire as a natural part of many forests' ecology. Land managers need tools that help them assess fire risk and find optimal fuel treatment locations for both mechanical and prescribed fire. This work found statistically significant correlations between fire frequency data and the topographic data sets of incident solar radiation, topographic position, aspect, and Topographic Relative Moisture Index (TRMI). Linear regression techniques were used to explore these relationships and generate predictive models. The most significant model demonstrates a relationship between fire frequency, vegetation type, elevation and aspect. A custom ArcGIS user interface was created to generate Time Since Last Fire (TSLF), Fire Return Interval (FRI), Fire Return Interval Departure (FRID) grids.

3.5.2 - *Current Projects*

(3.5.2.1) *Reconstructing Pre-EuroAmerican Fire History of Devils Postpile National Monument.* NPS funded; SEKI PI, Anthony Caprio and DEPO PI, Deana Dulan.

Abstract: Understanding historic fire regimes and how they have changed is critical in developing and implementing appropriate natural resource and fire management planning (the fire management plan for Devils Postpile will be started in 2004). Important attributes of these regimes can be reconstructed by dendroecological analyses of fire history samples (fire scars found on old trees or logs). These provide a powerful tool to characterize temporal and spatial attributes of past fires, to examine their variability, and to understand how they have shaped landscapes over time. Understanding past variation across a landscape may also be key in understanding potential future variation in fire under a changing climate regime. This fire history study in Devils Postpile National Monument will provide important baseline information on these attributes and help in the selection of appropriate fire related management actions and restoration goals. Such information has become a key component of fire planning at Sequoia and Kings Canyon N.P. using "ecological needs" models and fire return interval departure (FRID) analysis in GIS. Study objectives are to reconstruct fire history in major vegetation types of the monument over the last 300-400 years and to ascertain patterns of fire frequency, spatial extent and patchiness of past fires (limited to immediate area of DEPO, actual area of fires might be larger), temporal and spatial fire occurrence variability, and approximate seasonal occurrence.

(3.5.2.2) *Learning from the Past: Retrospective Analyses of Fire Behavior in Yosemite and Sequoia-Kings Canyon National Parks*. JFSP funded 2004; PI Wilderness Institute, Carol Miller and Anne Black; YOSE, Mike Beasley; SEKI, Anthony Caprio

Abstract: Yosemite and Sequoia-Kings Canyon National Parks have identified a critical need to be able to understand and track the consequences of their fire suppression decisions. To address this local research need, we will use retrospective fire behavior modeling and risk-benefit assessments for suppressed lightning ignitions that have occurred since 1991 in the two Parks. For the first time, the Parks will be able to quantify the consequences of their suppression decisions. We will determine where lightning ignitions would have spread had they not been suppressed and we will assess the effects that would have resulted from these fires. The proposed project combines fire behavior modeling technology with the information contained in the Parks' fire records and the local experience of the current fire management staff to better understand and quantify the consequences of suppression decisions. Results from our analyses will be compiled and presented in a GIS data library that will allow easy reference for managers during the fire season when making the decision whether or not to suppress, when preparing Stage III Wildland Fire Implementation Plan (WFIP) analyses, and when developing appropriate management response on suppression incidents. Furthermore, the project will develop methodology and step-by-step procedures for conducting these retrospective analyses so that Park fire management staff can update and add to this information resource annually. The information and understanding generated by this research will improve the prioritization and planning of fuels management activities by supplementing the Fire Return Interval Departure analysis that is routinely done by both Parks. The results of our analyses will allow park managers to frame future decisions and cost-benefit analyses in the context of past experiences, to track the cumulative effects of suppression, and to communicate tradeoffs to the public and other governmental entities. As all land managers need to understand and track the consequences of their fire management decisions, the methods we develop will have broad national applicability and will provide a template for conducting similar analyses.

(3.5.2.3) *Setting Forest Structural Goals for Fire Management.* NPS funded; PI USGS Nate Stevenson and Scott Martens; and SEKI, Anthony Caprio

Abstract: We aim to create a general approach to aid in setting quantitative and defensible forest structural goals for fire management, and apply the approach across all forest types in Sequoia and Kings Canyon National Parks (SEKI). To reach this end, this project is organized to accomplish four tasks. First, for a variety of species and forest types, we will use available age-size data (from tree cores that have already been collected) from at least ten separate studies within SEKI to determine diameter thresholds for trees likely to have established pre-1875, post-1875, and mixed pre- and post-1875 (1875 is the median date of last fire at more than 60 sites in a variety of forest types in SEKI). Second, across a range of spatial scales and by species for each of SEKI's eight forest types, we will determine the contemporary (unburned, at the time the plots were established) mean and range of densities of trees

in the three key size classes determined in Objective 1. Third, we will use the combined age and density data to aid in setting forest structural restoration goals for fire management.

(3.5.2.4) ***Fire and Fire Surrogates: Sequoia and Kings Canyon Study Area*****.** JFSP funded 2000. SEKI PI, Jon Keeley; Project Manager, Eric Knapp

Abstract: Compared to historic conditions, many forests in the U.S. are now denser and have more surface fuels. For years, managers have recognized this problem and have acted to reduce stem density and fuels by thinning, burning, and/or fuel treatments. The Fire and Fire Surrogate study is a network of 13 long-term sites established nationwide to evaluate the ecosystem impacts of different fire hazard reduction treatment in forests that historically experienced short-interval, low- to moderate-severity fire regimes. Results at each site and meaningful comparisons across sites will be enabled by a common or a core research design, one key aspect of which is a large set of core response variables and measurement protocols. Core variables encompass several broad disciplinary areas, including fire and fuels, vegetation, wildlife, entomology, pathology, soils/hydrology, utilization/economics, and social science. The fuel reduction treatments being investigated by USGS researchers at Sequoia National Park are early season and late season prescribed fire. USGS is cooperating with the National Park Service in this effort. Late season burns were carried out in the fall of 2001 and early season burns in the spring of 2002.

(3.5.2.5) ***Fire and Invasive Annual Grasses in Western Ecosystems*****.** JFSP funded 2001; PI USGS, Matt Brooks, Jayne Belnap, Jon E. Keeley, and Robert Sanford.

Abstract: Annual grasses have invaded shrub and forest ecosystems in western North America and are linked to changes in both ecosystem structure and function and in some cases have altered fire regimes. This has occurred over vast expanses of public lands in the Great Basin and the Mojave Desert, and is a threat to lower elevation yellow pine forests. We hypothesize that fire has the potential for contributing the most to annual grass invasion in low nutrient soils, where postfire increases in their availability are more effectively exploited by invasive grasses than by the native flora. Soil nutrient changes can vary widely depending on soil properties and the amount and duration of soil heating. In forested ecosystems such impacts of fire on soil nutrients and light solar radiation are potentially more profound now than under historic conditions because of unnaturally high fuel loads.
We propose to investigate the interactions between fire and soil nutrients over three ecosystems currently dominated or threatened by invasive annual grasses in western North America -- Great Basin shrubland, Mojave Desert scrub and Sierra Nevada yellow pine forest. Common factors driving the fire/annual grass cycle in these ecosystems will lead to generalizations widely applicable beyond the ecosystems under study. In addition, each of these systems has unique features that contribute to the dominance of invasive annual grasses, and elucidation of these will contribute to a broader understanding of the problem.

We will use intensive field manipulations at representative sites in these three regions that will couple burning, nutrients, fuels and light treatments. In addition, extensive surveys will be conducted across these regions to assess the soil nutrient status associated with invaded and non-invaded sites. These field studies will be coupled with laboratory studies to examine in detail the relationship between soil heating and nutrient availability for invasive grasses. With this information, managers could determine in advance if habitats are naturally vulnerable or resistant to invasions, enabling limited resources to be more effectively deployed both during and after fires. Fire prescriptions could be designed to avoid creating conditions susceptible to invasion, plus, restoration techniques could be better targeted, saving both time and money.

(3.5.2.6) ***Historical Wildland Fire Use: Lessons to be Learned from Twenty-five Years of Wilderness Fire Management*****.** JFSP funded 2002; RMRS PI, Matthew Rollins with work in SEKI by Co-PI, Scott Stephens.

Abstract: We propose three research tasks that take advantage of a 25-year legacy of wildland fire use in the Sugarloaf-Roaring River (SRR) region of the Sequoia and Kings Canyon National Parks, California; the Illilouette Creek Basin (ICB) in Yosemite National Park, California; the Rincon Mountain Wilderness (RMW) in Saguaro National Park, Arizona; and the Gila/Aldo Leopold Wilderness Complex (GALWC) in the Gila National Forest, New Mexico using landscape-scale experimentation and simulation modeling. Individually, these tasks will address the following main research 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 wildland fire use operations? 2) How has the introduction of wildland fire use programs in Sequoia and Kings Canyon, Yosemite, and the Gila National Forest affected the nature of fire spread in these areas over time? And, 3) How do landscape composition, structure, and

function vary under different fire management strategies? Together, the three proposed research tasks will quantify the effects of specific types of fires on landscape structure, composition, and function based on extensive field inventories, broad-scale ecological simulation modeling, and 25 years of well-documented wildland fire use in these four wilderness areas.

(3.5.2.7) ***The Effects of Prescribed Burning on Stream Water Chemistry at Different Spatial and Temporal Scales.*** Colorado State University M.S. graduate project for Andi Heard; Advisor John Stednick; SEKI collaboration, Anthony Caprio.

Abstract: Federal agencies are using prescribed burning as a tool to reduce fuel loads and to restore ecological integrity in forests. A better understanding of the effects of prescribed fire and fire exclusion on forested watersheds is needed in order to better establish objectives for prescribed fire programs and methods to monitor if these objectives are met. The Mineral King Risk Reduction Project in Sequoia National Park is a landscape scale prescribed fire project, in which a 20,000 ha watershed is being treated with prescribed fire over several years. Prescribed burning has the potential to alter chemical and physical water quality parameters. The extent to which water quality is affected by prescribed fire at different scales requires further investigation. An earlier study in Sequoia National Park demonstrated that the reintroduction of fire had a significant effect on the hydrology and water quality in a 13 ha catchment. Our research will expand on this study and investigate the changes on specific water quality parameters associated with the large scale prescribed fire project in Sequoia National Park. The water quality parameters that have the potential to be affected by fire are pH, specific conductivity, alkalinity, stream temperature and concentrations of sulfate, nitrate, orthophosphate, chloride, calcium, magnesium, potassium, and sodium.

Our study will test the hypothesis that changes in stream water chemistry as a result of prescribed burning will be the same at different spatial and temporal scales. The project will investigate the effects of prescribed burning on stream water chemistry at different spatial and temporal scales in the East Fork of the Kaweah River in Sequoia National Park, California. Pre- and post fire, water quality parameters will be monitored. To investigate the potential effects of prescribed fire at different scales these parameters will be measured in small (i.e. 100 ha) and large (i.e. 20,000 ha) catchments treated with prescribed fire over the past several years.

This study will provide a further understanding of how prescribed burning is affecting stream water chemistry in Sequoia National Park. The results of this study will aid land managers in determining the effect of prescribed fire on water quality and what water quality parameters should be included in a monitoring program and the most effective scale at which these parameters should be monitored.

3.6.3 - *Proposals Submitted in 2004 for Fire Related Projects*

(3.6.3.1) ***Using NASA's Invasive Species Forecasting System to support National Park Service decisions on fire management activities and invasive plant species control.*** Submitted to NASA; NPS PI: Nate Benson, NASA PI: Jeff Morisette, CSU PI: Brad Welch.

Abstract: Two major sources of ecological disturbance are fire and invasive species. They are not independent. Both are major issues affecting land management decisions throughout the National Park System. The proposed work will allow the National Park Service to enhance management decisions related to invasive species and fire management. The approach is to utilize existing Earth Science resources to better understand the interaction between fire, burnt area, and invasive species, and then to utilize this understanding to better manage National Park lands in such as way as to respect the natural ecological significance of fire while guarding against alien plant invasion. The Earth Science tools to be used are satellite-based active fire and burn scar mapping available through NASA Earth Observing System (EOS) resources and invasive species habitat modeling available through the existing, joint NASA/USGS "Invasive Species Forecasting System" (ISFS). Study areas include Sequoia and Kings Canyon National Parks, Alaska Region, and Yellowstone & Grand Teton National Parks with local support from invasive species managers, fire ecologists, and GIS specialists.

(3.6.3.2) ***The Sugar Pine Dilemma: Prescription Burning and the Management of a Declining Species***. Submitted to Joint Fire Sciences Program; PI USGS, Phil van Mantgem and Nate Stephenson and SEKI, Anthony Caprio.

Abstract: Prescribed fire is a primary tool for forest restoration, but changing forest conditions may create circumstances where the simple reintroduction of fire may not be sufficient to achieve some restoration goals. This may be true for sugar pine (*Pinus lambertiana*) in the Sierra Nevada of California, where high post-fire mortality coupled with the ongoing effects of an introduced pathogen (white pine blister rust, *Cronartium ribicola*) could contribute to local extinctions. The objective of this study is to determine if fuels removal, a simple and cost effective strategy, may help to reduce sugar pine mortality following prescribed fire. We propose removing fuels in a 0.5 m radius around the base of individual trees and compare post-fire survivorship between treated and untreated trees. We will test the effectiveness of the fuels removal treatment at multiple fires to help managers decide under which conditions the added expense of this treatment might be most worthwhile. This study addresses significant local knowledge gaps in at least three areas of importance to parks management: (1) setting of desired future conditions for the composition and structure of mixed conifer forests through fire management, (2) direct management of sugar pine populations, and (3) interpretation of the fire management program to the general public, in particular the relations among fire, pathogens, and climate. The results of this study will provide fire managers a much-improved knowledge base when burning stands containing sugar pine.

(3.6.3.3) ***Fire Effects of Prescribed Fires vs. Wildland Fires in Sequoia and Kings Canyon National Parks*****.** Submitted to Joint Fire Sciences Program; PI USGS. Jon Keeley and SEKI, Anthony Caprio.

Abstract: Prescription burning has been widely accepted by fire managers as an important management option for correcting the perturbations caused by fire suppression policy. Prescribed burns are constrained by factors that may not simulate natural burning patterns, and could affect the extent to which this management practice can return forested ecosystems to naturally functioning systems. For example, prescription burning occurs under weather conditions that comprise a more narrow range than wildland fires burn under. Also prescribed burns may not mimic natural lightning-ignited patterns in that they are often designed to produce homogenous burning patterns and may not reflect the natural range of ignition patterns, heterogeneity of unburned and high severity patches. Heterogeneity of natural wildland fires may be critical to the sustainability of ecosystem diversity and forest recruitment as well as maintenance of wildlife habitat. This project addresses AFP 2005-2, Task 1 and proposes to address this issue by comparing fire effects of prescribed fires and wildland use fires in Sequoia & Kings Canyon National Parks. We will test hypotheses concerned with the extent of unburned patches, high fire severity patches and low severity burning in these two types of managed fires. In order to understand the functional significance, in terms of forest regeneration and biodiversity patterns, of these three patterns of burning we will test hypotheses about the important response variables.

IV Outlook for FY05

The outlook for Fire Ecology in 2005 includes regularly scheduled rereads of about 30 fire effects plots, plus five rereads of plots that are off schedule, and four potential preburn rereads of established plots located in areas with burns planned. Additionally, several new plots may be installed in mechanical or in a new fire monitoring vegetation type (xeric conifer - Jeffrey pine) depending on burn or thinning project implementation. CBI sampling will be completed in Atwood and Paradise II burns and possibly the 2004 Hot Springs Burn (if the burn meets minimum size requirements). FEAT will continued to be implemented with data converted from FMH format. The 10-Year Devils Postpile Fire Effects Report will be completed and the data from the DEPO fire history study will be analyzed and written-up. Planned training and professional meeting will include the FEAT Access/Stats training in Fort Collins, Annual PWR Regional Fire Ecology Meeting (to be held in SEKI), a Fire History-Climate Workshop in Flagstaff, and potentially the annual Association of Fire Ecologist meeting in the fall. There will also be continued involvement in a number of collaborative projects.