



National Park Service Fire Ecology Annual Report 2007 Sequoia & Kings Canyon National Parks and Devils Postpile National Monument

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Executive Summary

During 2007 fire activity was minimal in Sequoia and Kings Canyon N.P. (SEKI) in contrast to fairly active years in 2005 and 2006. Although weather conditions were unusually dry, few lightning ignitions occurred and prescribed burning was limited. Thirty- three FMH plot visits were made within seven monitoring units. These included three new plot installations and preburn and postburn reads of two plots. Additionally, 14 Kilgore plots established in 1968 (last read in 1971) were located and resampled. Continued progress was made in error checking legacy FMH data errors for all data converted to FEAT 2.4 (Fire Ecology Assessment Tool). A significant problem encountered was the duplication of tree records in the many of plots. This issue was first noticed after FMH data was imported into FEAT. Data sets are now being readied for conversion to the new FFI fire ecology database and analysis software. Additional fieldwork continued on several projects that have or will provide supplemental information to the fire management program at both the local and national levels. The most involved of these, due to the large number of burns in 2006, was CBI (composite burn index) field sampling for the National Landscape Assessment Project (burn severity mapping). Other projects included cheatgrass monitoring in Rx units and an expanded data set evaluating fire and giant sequoia mortality (seedlings through monarchs). Fire ecology staff also participated on two prescribed burns and two crew members were part of a NPS crew on a WFU monitoring assignment in Montana.

Additionally, the Fire Ecologist collaborated with and was actively involved in a number of fire related research projects underway in the parks by USGS, USFS, NASA, or university researchers (several funded through JFSP). Inputs or feedback (data and meetings) were also provided to SIEN Inventory and Monitoring program and the national LANDFIRE modeling effort with fuel and fire/vegetation models developed for vegetation types of the Sierra Nevada. The SEKI Fire Effects Lead, Karen Webster, began graduate studies (NPS funded M.S. program) at the University of Washington that will focus on the analysis of understory plant species data collected by crews in the park's fire effects plots over the last 30 years.

Considerable efforts in public outreach were also made through venues such as publications, the *Fire Information Cache* website (undergoing revision to meet the NPS CMS standards), field trips, and lectures to university classes or other groups. These reach a large audience and provide important support for fire management and fire related natural resources activities.

Funding issues in FY 2007 continued to impact some positions in the SEKI Fire Ecology Program, although temporary solutions were found with the assistance of the Fire Management Office.

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Hot Spring WFU, Kern Canyon 2004



I - Program Results

An updated summary of results is presented through 2007 for the four primary monitoring units (**Table 1-1**). Monitoring over the last three decades has primarily emphasized giant sequoia, white fir, and low-elevation mixed-conifer vegetation. Recent sampling has been directed at mechanical treatments and xeric conifer (Jeffrey pine/greenleaf manzanita), although sample sizes remain limited. Additional plots will be added as implementation of treatments continues. Currently the mechanical treatment plots are providing the only quantitative documentation of effects and effectiveness (fuel reduction or changes in stand density) of the treatments. Data suggest density and fuel reduction objectives are not being met. Increases in fine fuel from the thinning operations might be responsible for the increase in fuel loading post treatment. The one plot added in 2006 is not shown since pile burning has not been completed. The analyses of mechanical treatment data also indicate plots may need to be looked at by vegetation type to

Table 1-1. Management objectives and monitoring results for 2007. Monitoring results are 80% confidence intervals around the mean. Fuel reduction objectives/results are mean percent reduction from preburn to immediate postburn. Stand density objectives/results are live stand density five years postburn. When the "n" value for number of plots is underlined 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% (<i>n</i> =30 plots, 20 fires)	YES
	5-yr postburn stand density: 50-250 trees/ha <80 cm DBH 10-75 trees/ha ≥ 80 cm DBH	5-yr stand density = 174-236 trees/ha <80 cm DBH 35-48 trees/ha ≥ 80 cm DBH (<i>n</i> =22 plots, 12 fires)	YES
		10-yr stand density = 174-224 trees/ha <80 cm DBH 35-46 trees/ha ≥ 80 cm DBH (<i>n</i> =22 plots, 12 fires)	N/A
	5-yr postburn stand composition: 40-80% fir, 10-40% sequoia, 5-20% pine	Fir = 77.8% Sequoia = 10% Pine = 10% (<i>n</i> =30 plots, 18 fires)	YES
White fir-mixed conifer forest	60-95% total fuel reduction	total fuel reduction = 62-85% (<i>n</i> =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 (<i>n</i> =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% (<i>n</i> =5 plots, 3 fires)	YES* but sample size too small
	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 (<i>n</i> =5 plots, 3 fires)	NO* * but sample size too small
Mechanical Thinning + Pile Burning	Reduce fuels to < 12 tons/acre immediate post treatment*	Fuel load = 52 tons/acre post (total fuel reduction 22%) (<i>n</i> =9, 7 treatments)	NO* * but sample size too small
	Immediate post treatment stand structure: maximum of 25 trees/acre < 22.9 cm DBH*	Stand density = 17 trees/acre < 20 cm DBH (range of 8-61 trees/acre <20 cm DBH) (<i>n</i> =9, 7 treatments)	YES* * but sample size too small

* Excluding DEPO plot.

better understand treatment effects. Mechanical treatment objectives are being reviewed by fire management and natural resources staff based on treatment results, plot data, and new research results.

II - Workload and Staffing

2.1 - Workload - During 2007, 33 FMH plot visits were made in seven monitoring types (**Table 2-1**). Three of these visits were new installs. Full transition to the Fire Ecology Assessment Tool (FEAT) has been completed and many legacy data errors corrected, although some data quality issues remain and are being corrected as plots are revisited (primary issue is occurrence of multiple—two to several—records for trees in plots found after FMH data were imported into FEAT). All fire effects plot data have been converted to FEAT version 2.4 and a copy of the database provided to Spatial Dynamics for beta testing conversion of FEAT data to the new FFI format. Final conversion is expected during late winter 2008 with full implementation of FFI use by the summer. Additionally, CBI data for the National Landscape Assessment Project was collected on seven 2006 fires (Redwood Mtn. R_x, Horse Trail R_x, Silver R_x, Cabin R_x, Valley View-A R_x, Burnt WFU, Roaring WFU). Multiple plots were collected within major vegetation types in each of five severity classes (unburned, low, low-moderate, moderate, moderate-high, and high) based on Δ NBR values. A total of 301 points were sampled in 14 vegetation types. All CBI data through 2007 has been entered into FEAT, although we continue to have issues editing some data imported via PDA (fields are locked).

Table 2-1. Fire ecology plot workload 2007.

Park	Type of Plot (FMH, photo point, other)	Monitoring Unit	Installs 2007	Postburn 2007	Postburn (1-40 yrs)	Not Treated [^]	Total Plots [#]
SEKI	FMH forest	Giant sequoia-mixed conifer	3	2	11	3	51/9
		White fir-mixed conifer			5		17/2
		Low elevation-mixed conifer			1		7/2
		Red Fir Forest					7/4
		Ponderosa Forest	0		3		24/7
		Xeric Jeffrey Pine	0	0	2		2/0
		Buckeye Wildfire					3/0
		Blue Oak Woodland					2/0
	FMH brush	Chamise Chaparral					3/0
		Montane Chaparral/Sagebrush					7/5
		Mixed Chaparral			2		9/0
	FMH Mechanical	Thinning + Pile Burning	0	0	4		10
	CBI ^{††}	Seven 06 Burns (WFU & R _x)	301				551
	Cheatgrass Monitoring ^{**†}	Horse Trail/Roads End R _x		139		53	377/53
	Forest Structure	Forest Structure					8
	Kilgore Plots (pre-FMH)	1968 Rattlesnake R _x			11	3	14/3
		1969 Redwood Mtn. R _x					14/6
DEPO	FMH Forest	Rainbow Wildfire (postfire)					9/3
	FMH Mechanical	Thinning + Pile Burning					1
	Fire Regime [*]	DEPO fire history					52
	Tree Regeneration [†]	Rainbow Fire Tree Regen.					42/9
Total FMH			3	2	28	3	152/29
Total Other			301	139	11	56	1058

^{*}Not permanent plots; [†]Sampled using specific rapid assessment protocols; [^]Not treated = unburned "controls"; [#]Total plots/number unburned

Over the past several years discussions have occurred about fire effects in xeric conifer vegetation (now classed as *Jeffrey pine/greenleaf manzanita woodland* in SEKI's new vegetation map). These are primarily open-to-moderately-closed stands of Jeffrey pine with a manzanita understory. These often burn with a high intensity headfire through the shrub understory with considerable impacts to overstory trees. Many of these trees are old-growth—many centuries old—indicating they survived repeated past fires (also documented by fire history data). The question raised is whether vegetation and/or fuels in this community have changed so dramatically since the 1860s that fire restoration under current prescriptions is having negative impacts. Since additional burns are planned in this type a monitoring unit is being developed and plots installed as burn plans are written and burns occur. Similar concerns are being raised for other xeric forest communities, i.e. western juniper and single-leaf piñon pine. These two communities have limited distributions in SEKI and are thus susceptible to long-term negative impacts. Both species have very limited resistance to fire other than survival in “safe sites” where ignition or fire spread is unlikely.

Several long-term “special study” projects were continued in 2007. These include data collection on giant sequoia mortality (seedlings and large mature trees), fire and sugar pine mortality, and named tree inventory (named giant sequoias). Each project is assigned to a seasonal crew member as an individual summer project. Work continued on the analysis of fire history samples and age structure data collected in SEKI and DEPO.

Fire ecology staff continued to assist on burn projects when duties allowed. They participate on prescribed burns, suppression or wildland fire use (WFU) fires as fire-fighter, FEMO, or resource advisor positions. In 2007, Fire Ecology staff participated on two prescribed burns and two crew members were part of a NPS crew on a WFU monitoring assignment in Montana.

As emphasized by park management, considerable effort in public outreach was made during the year though avenues such as publications, the *Fire Information Cache* website, field trips, and lectures to university classes or other groups. The “**Fire Bibliography**” concentrating on fire references on the southern Sierra Nevada continues to be widely utilized. The pages reach a large audience and provide important support for fire management and fire related natural resources activities. The website is now undergoing basic conversion to the new NPS CMS web page format.

2.2 - Staffing - Staffing during 2007 consisted of the Fire Ecologist, Lead Fire Effects Monitor, seasonal Assistant Lead Fire Effects Monitor, and three Fire Effects Seasonals (*Table 2-2 to 2-5*). The GS-6 Assistant Lead was again hired in order to recruit and retain quality fire effects monitors as



Figure 2-1. Preburn plot sampling of an open ponderosa pine/mountain misery vegetation before the plot was burned by the Comb WFU Fire. This plot has burned three times: 1980, 1998, 2005.

well as provide an assistant to the Fire Effects Lead. Overall, Fire Effects continues to be under-funded with supplemental funding required to maintain staffing. For example, the Lead Fire Effects Monitor is only base funded for 15 payperiods versus 20 in FY 2007 (however, full funding has been received for FY 2008) as workload analysis suggests and one seasonal position remains unfunded. This continues to hamper position development as opportunities for training and travel to valuable management/scientific meeting/conferences is limited.

Table 2-2. Fire Ecology Staffing 2007. Table gives staff names, start/end dates, number payperiods worked, account information, and training for the year. All positions were arduous duty red carded.

Staff	Start Date	End Date	# of Pay Periods	Training and Development
Heather McCarthy [*]	5/7/07	11/16/07	14 [#]	fire refresher, IT Info Security
Mike Stefancic [*]	5/14/07	11/16/07	12 [#]	S290, completed FEMO taskbook, fire refresher, S211, L180 IT Info Security,
Kathleen Walsh [*]	5/14/07	11/16/07	12 [#]	S290, initiated FEMO taskbook, fire refresher, L180, IT Info Security
Monica Delmartini [*]	5/14/07	11/16/07	12 [†]	S130, S190, L180, IT Info Security
Karen Webster	2/26/07	12/21/07	15 [#] +5 [†]	fire refresher, began MS graduate studies Univ. Washington, IT Info Security
Tony Caprio	Full Time [^]			fire refresher, NPS Alternate Consultation Agreement Certification, A101, A105, A106, A113, A116, A200_05, Records Mgmt, Privacy Act, IT Info Security, Workplace Discrim.

^{*} Seasonal/temporary employee, [#] Account no. 8557-0701-H14, [^] Account no. 8557-0021-H11, [†] funded by projects



Figure 2-2. Repeat photograph showing foliage recovery on Washington Tree between February 2005 and July 2007. In 2003 the crown of the tree burned and was damaged during a burnout operation on the Giant WFU Fire in Giant Forest with about half of the remaining crown collapsing during a wind-storm in an early winter storm 2004/2005. Rapid growth responses to both prescribed and natural fires have been well documented for sequoias (Mutch 1994, 1995; Caprio et al. 1994).

Table 2-3. Fire Ecologist accomplishments and focus areas.

Category	Time (%)	Accomplishments/Focus Areas
General Planning	20%	- Detailed SEKI five year burn plan review - Implemented annual updates to SEKI FFMP - SEKI annual fire management work plan development/implementation - SEKI Fire Management Committee Member - Review R_x burn plans - Planning - 40th Anniversary of Operational R_x Fire in SEKI - Updates to SEKI Res. Adv./MIST guidelines for SEKI
Presentations and Field Trips (see Public Outreach below)	7%	- SEKI Fire Ecology Review – Work Groups 1) Progress in meeting goals: data & graphics 2) FMH: R_x and mechanical + other 3) Ash Mountain - Introduction, discussion, and field trip on fire management and fire effects monitoring for Inventory & Monitoring “Forest/Landscape Protocol” contract developers (OSU & NASA) - Presentation and field trip for Fresno State “ecology” class - Presentations to SEKI Backcountry Rangers and Scripps Institute on campfires and foxtail pine related to development of fire elevation limits
Intrapark Support / Task Groups	7%	- SIEN I&M landscape/forest protocol development - SEKI digital photography data management workgroup - SEKI sequoia trees of special interest workgroup - SEKI campfire elevational limits and foxtail pine analysis - Escaped pile burn fact finding review team SEKI
Interpark / Interagency Support	5%	- USDA FS Region 5 Sierra Nevada LANDFIRE fuels modeling/verification workshop – Sacramento - SEKI fire info to USDA FS PSW Research Station researchers - SEKI fire info and images to Missoula USDA FS Fire Sciences Lab. - Site visit to YOSE with local staff to look at the potential for investigating lodgepole pine fire regimes in YOSE - Joint Sequoia N.F./SEKI <i>Workshop on Scientific Values for the Southern Sierra</i> - Provided data to Southern Sierra Fisher Assessment Proj., Cons. Biology Inst.
Fire Assignments and Fuels Projects	0%	
Research	5%	- Resampled 1968 Kilgore Rattlesnake plots (installed for 1st R_x fire in West) and reconstructed original data - Develop and analyze age-tree structure data for Sheep Cr. plots - SEKI fire ecology liaison to NASA/NPS/CSU project on fire and exotics, summarized and provided data on fire effects and CBI - Continued input into JFSP Wilderness Inst. “Retrospective Fire Analysis Study” for SEKI - Oriole Lake coring – Coop. research between Univ. Rhode Island Graduate School of Oceanography and SEKI on fire regimes in lake sediments - Data or other research assistance to: Pennsylvania State Univ., CSU Colo. - Summarized and provided fire effects and CBI data to Dylan Schwilk (USGS Sequoia-Kings Canyon Research Station) for ESA symposium presentation on “<i>Leaf size, litter flammability, and restoration fire: Changes in stand composition influence pattern of burning</i>”
Management or Research Document Reviews	8%	- Fire plan reviews (Ash Mtn, Wall Spring, Halstead, Cedar Buffs) - Data reviews and responses to issues related to 1) fire caused mortality and postfire harvesting of white fir, 2) fire and foxtail pines. - Internal ‘fact finding’ review team on escaped pile burn and structure loss in Cedar Grove Mar. 2007
Fx Field Work	5%	- Assisted fire effects crew with FMH plots and CBI sampling - Cedar Grove cheatgrass – baseline sampling Roads End R_x Burn/Horse Trail R_x - Resample 1968 Kilgore plots + fire history of area.

Category	Time (%)	Accomplishments/Focus Areas
Data Entry	<1%	- Expanded sampling Giant sequoia postfire mortality - Site visit to YOSE to look at potential lodgepole pine fire history sampling sites - Fire effects monitors completed all 2007 FMH data entry - Roads End/Horse Trail cheatgrass - Error checking of 2007 CBI data
Data Management and Conversion	5%	- Data checks and backup - Prepare data for conversion from FEAT to FFI - GIS support for Fire Ecology (CBI & FMH plots, other sampling & analysis)
Data Analysis	5%	- FMH data - DEPO fire history/age structure analysis - Fire climate analysis of East Fork Kaweah R. watershed fire regimes - Forest structure Sheep Cr.
Reports/Publications /Proposals	20%	- SEKI 2006 Div. Nat. Res. Fire Ecology Annual Report 2006 PWR Fire Ecology Annual Report - Internal SEKI 'fact finding' report on escaped pile burns and structure loss in Cedar Grove Mar. 2007 - Five research/resource mgmt. funding proposals submitted in 2007 (one funded)
Supervision/Admin	<5%	- Supervised lead monitor, completed evaluations - Travel, credit card, and time paperwork
Training & Professional Development	5%	- Firefighter refresher + Aviation training/refresher - Contributed to USGS/NPS FFS paper "Tree mortality from fire and bark beetles following early and late season prescribed fires in a Sierra Nevada mixed-conifer forest" - Attended FEAT Sametime/conference call training sessions - Physical Training (PT)
Miscellaneous	5%	miscellaneous other things, SEKI Resources & USGS input/coordination
Public Outreach	<5%	- Fire Information Cache, SEKI Fire Portal - Fresno State - ecology class - Univ. Washington – field trip for Jerry Franklin "Forest Ecol./Mgmt." class - Interviewed by several newspapers (Fresno Bee) - Info to USGS for a U.S. Climate Change Science Program chapter on current state of fire and resource management in national parks - Field trip for Berkeley Montessori School - Presentation and discussion on fire ecology with Sierra Club Activist Outing



Figure 2-4. Sampling composite burn index (CBI) sampling in: 1) montane chaparral and xeric conifer (with scattered Jeffrey pine) that had a fairly continuous shrub understory preburn (Hot Springs WFU 2004 with Kern Canyon, Chagoopa Plateau, and Great Western Divide are visible in near, middle, and far distance), 2) higher elevation dry foxtail/lodgepole pine stand with isolated patches of fuel under trees where fire spread (Hot Spring WFU) occurred as embers were carried by the wind between patches, 3) open ponderosa/Jeffrey pine with mountain misery understory at lower elevations in the 2005 Comb WFU burn.

Table 2-4. Fire Effects Crew Accomplishments. The following time estimates are based out of the total number of weeks the fire effects crew worked (roughly 12 pay periods).

Category	Time (%)	Notes
FMH plots	45%	Completed 35 reads. Installed three plots (SEGI unburned).
Mechanical Treatment plots	<5%	Read four previously installed plots.
CBI plots	20%	Installed 301 plots for Silver Rx, Cabin Rx, Valley View Rx, Upper Redwood Rx, Horse Trail Rx, Roaring/Ridge WFU, Burnt WFU.
Other plot work	10%	- Increasing giant sequoia sample size - Sugar pine mortality study - Giant sequoia seedlings in re-burns - Giant sequoia trees of special interest - Cheatgrass monitoring
Fire Assignments and Fuels Projects	5%	Crew assisted on one prescribed burn. Two crewmembers completed a two week fire assignment on a NPS Fire Use Module.
Data Entry	5%	- Completed data entry for 2007 data (FMH and CBI) - Entered missing herb data from FMH into FEAT
Database Maintenance	5%	Error checking converted FMH to FEAT data and other database cleanup tasks.
Data Analysis	<2%	Independent crew projects
Training and Professional Development	10%	1 crewmember attended S130 and S190 1 crewmember attended S211 2 crewmembers completed S290 and initiated/completed FEMO taskbooks. - Three crewmembers attended fire refresher training - All crewmembers participated in PT - All crewmembers attended mandatory park trainings (defensive driver, hazmat etc).
Miscellaneous		

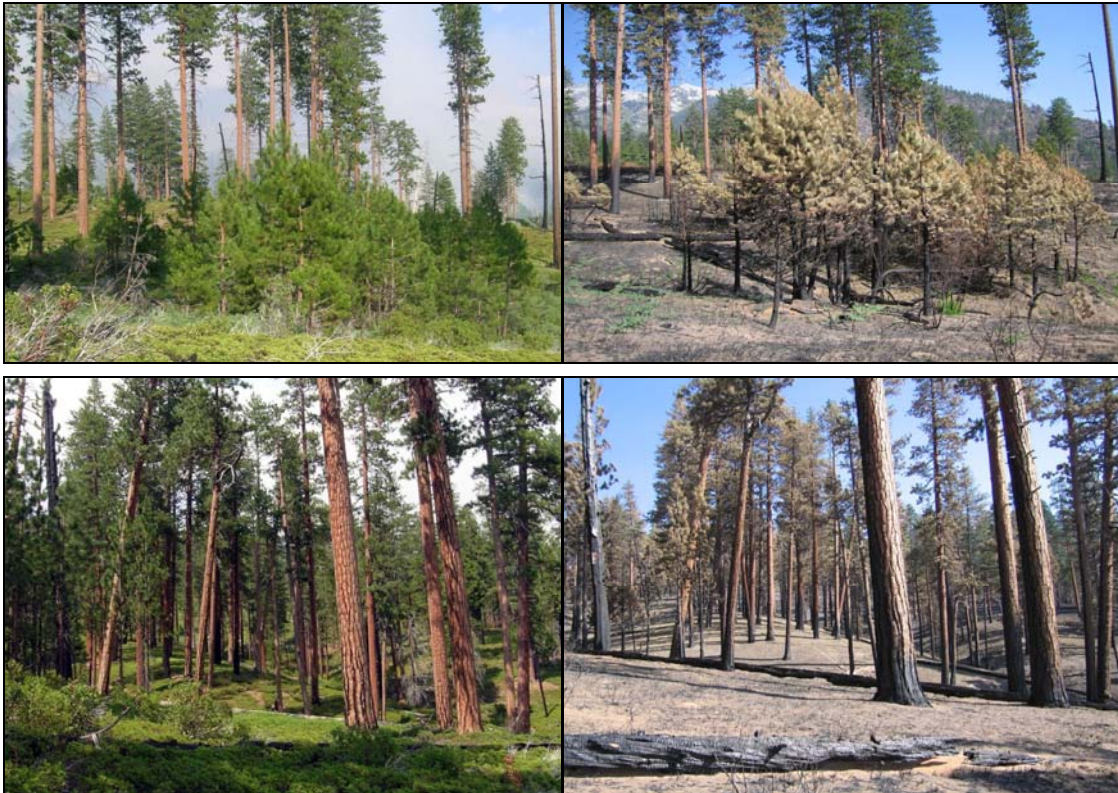


Figure 2-5. (left) Patch of giant sequoia regeneration in area of severe crown scorch that occurred during the 1987 Pierce Wildfire at Redwood Mountain, Kings Canyon N.P. This human caused fire, started outside the park, burned hot until reaching areas that had been prescribed burned in the parks. (below) Oatmeal like sequoia seeds scattered on ashes in an area of moderate crown scorch that occurred during the 2007 Wall Spring Rx. Sequoia cones are semi-serotinous and convective heat pulses often result in considerable seed release. This often results in patches of dense regeneration in fire caused gaps.



Table 2-5. Lead Fire Effects Monitor Accomplishments. The following time estimates are based out of the total number of weeks the lead fire effects monitor worked (20 pay periods).

Category	Time (%)	Notes
FMH plots	25%	Completed 31 reads, installed three plots.
Mechanical Treatment plots	5%	Completed four plot reads.
CBI plots	<1%	Installed one plot, participated in crew CBI training
Other plot work	<3%	Cheatgrass monitoring
Fire Assignments and Fuels Projects	0%	
Data Entry	<1%	
Data Management and Conversion	20%	• Error checked converted data • Error checked data entered from 2007 • Corrected data conversion errors • Miscellaneous database upkeep
Data Analysis	<5%	• Provided analyses to Fire Ecologist • Provided other data as requested
Supervision/Admin	20%	• Hired and supervised four fire effects monitors; evaluations, time, travel and other administrative paperwork
Training & Professional Development	25%	• Attended graduate level courses at University of Washington • Participated in FEAT training conference calls • Completed fire refresher training • Participated in PT
Miscellaneous		

**Figure 2-6.** Prefire and immediate postfire images of two paired photo points (right to left) in the Comb WFU Fire showing fire effects on overstory (ponderosa pine) and understory (primarily mountain misery). The plots are shown being burned by a headfire in Fig. 4.4-1 that resulted in patches of crown scorch.

III - Outlook for FY2008

The outlook for Fire Ecology in 2008 includes regularly scheduled rereads of 34 FMH fire effects plots, and three potential preburn rereads of established plots located in areas with burns planned. Additionally, several new plots (4+) may be installed in mechanical or in other fire monitoring vegetation types (xeric conifer - Jeffrey pine/montane chaparral) depending on burn or thinning project implementation. FFI database software will be installed and utilized during 2008 for all FMH and other plot data. Final conversion of data in FEAT format to FFI format is expected during late winter 2008, with full implementation of FFI use by the summer. Staff will attend training sessions on use of FFI during the winter and spring of 2008. Special projects will be continued (see **Section 4.1** for project list). A 40-year reread of the Kilgore plots at Redwood Mountain is planned (~14 plots last read 10 years ago). Rapid assessment of cheatgrass occurrence and fire severity in Cedar Grove R_x burn units (pre and postfire) will also be conducted. This will involve third-year postfire sampling of the Roads End R_x unit. CBI sampling will be minimal during 2008 because of few fires in 2007. There will also be continued involvement in a number of collaborative field or research projects underway in the parks with the USGS, NASA, and USDA. In association with the NASA project, a field crew of two seasonals will be hired (jointly with SEKI's invasive plant crew) in 2008 to collect data on distribution of bull thistle (*Cirsium vulgare*) and cheatgrass (*Bromus tectorum*). Additionally, a cooperative research project between USGS, YOSE, and SEKI will be initiated to look at similarities and differences between WFU and R_x fires. A substantial revision of the monitoring and research chapters in the SEKI Fire and Fuels Management Plan will be made in 2008 to bring the sections up-to-date.

IV - Other Fire Ecology Accomplishments or Projects

Several “special topic white papers”, which came out of the 2006 review of the SEKI fire ecology program, were completed or in progress in 2007 (see **Section 4.1**). Fire Effects was involved with a number of local or national NPS studies that supplemented plot monitoring duties (see **Section 4.3**). This work complements SEKI's network of fire effects monitoring plots or provides additional fire ecology information important to the fire management program and is providing feedback on specific management issues. Staff also provided feedback to the SEKI fire management program on burn plans and general postfire R_x burn evaluations (see **Section 4.2**). Fire ecology staff was involved with a number of collaborative research studies with other agencies, universities, or parks (see **Section 4.3**). A summary of recently completed, currently underway, or proposed projects is provided below with an abstract. A number of presentations, reports, and papers were prepared during 2007 that used various portions of fire ecology data (see **Section 4.2**). Lastly the ‘*Fire Information Cache*’ provides a valuable and much used source of information on fire and natural resources including an extensive bibliography on fire in the southern Sierra Nevada (see **Section 4.4**).

4.1 - Fire Ecology Review 2006

A review of the overall fire ecology program in SEKI/DEPO, **Where Fire Ecology and Management Meet**, was the fourth review since the Christenson Report reviewed the fire program in 1987. One of the report's recommendations was to hold periodic reviews with the purpose of providing an opportunity to examine and evaluate the current status and future direction of the Parks' fire ecology program and “desired future conditions” with special emphasis on the use of and need for natural resource and scientific data.

Review Objectives

- Review program history and objectives through 2005.
- Provide an update on recent and current fire monitoring and research program results.
- Discuss issues relating to fire ecology in Sequoia & Kings Canyon NP (SEKI) and Devils Postpile (DEPO) and develop an overview of priority needs and future direction.
- Develop “workgroups” that will address issues of special concern in more detail and develop “white papers” with management implications summarized.

New issues emphasized during the review included global climate change and issues with exotic species and their management implications for fire in the parks. For example, what impacts will global change have on the fire program and fire/ecosystem dynamics in the parks, how is the fire program going to respond, and what are our resource and research needs? Breakout sessions/groups tasked to further research and develop special topics of concern included: 1) ***Season of Prescribed Burning***, 2) ***Ash Mountain - Prescribed Fire in Foothills Vegetation***, 3) ***Restoration versus Maintenance Burning***, 4) ***Mechanical Fuel Treatments***, 5) ***Exotics and Fire***, 6) ***Long-Term Issues***. Work continued on several of the breakout group topics into 2007.

4.2 – Presentations, Reports, and Publications

Presentations were given to SIEN Inventory and Monitoring Landscape Protocol development group, SEKI backcountry rangers, Scripps Institute of Oceanography, Fresno State University. An in-house report and presentation was made to the SEKI Superintendents Office detailing findings. Several presentation were also given that utilized FMH or CBI data provided by SEKI (*see Appendix*)

4.3 - Fire Ecology Projects

The Fire Ecology Program in SEKI/DEPO was directly involved in a variety of fire-related projects during 2007. Some were the continuation of longer-term projects requiring annual or periodic monitoring (***Projects 4.1.1 through 4.1.5***) while others have specific data needs that will be completed in a season or two (***Projects 4.1.6 through 4.1.7***). These projects are providing input into the SEKI and DEPO fire management programs.

(4.3.1) 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 FMH forest plots. To increase the sample size of giant sequoia for detecting possible fire effects, we sampled all, or a subset of, giant sequoia trees (>2.5 cm DBH) in prescribed burn units in the Giant Forest (*Fig. 4.3.1-2*). Pre- and postburn methods followed the FMH protocol for overstory tree sampling combined with the FMH database for the giant sequoia-mixed conifer forest monitoring type. A total of 983 giant sequoias were sampled preburn in seven separate units burned between 1993 and 1999 with postfire monitoring continuing through 2007. Mortality has been low (<3%) in large size classes (DBH >50 cm) (*Fig. 4.3.1-1*). This information will provide greater sample depth to assess the long-term effects of prescribed fire on mature giant sequoia trees over a long period of time.

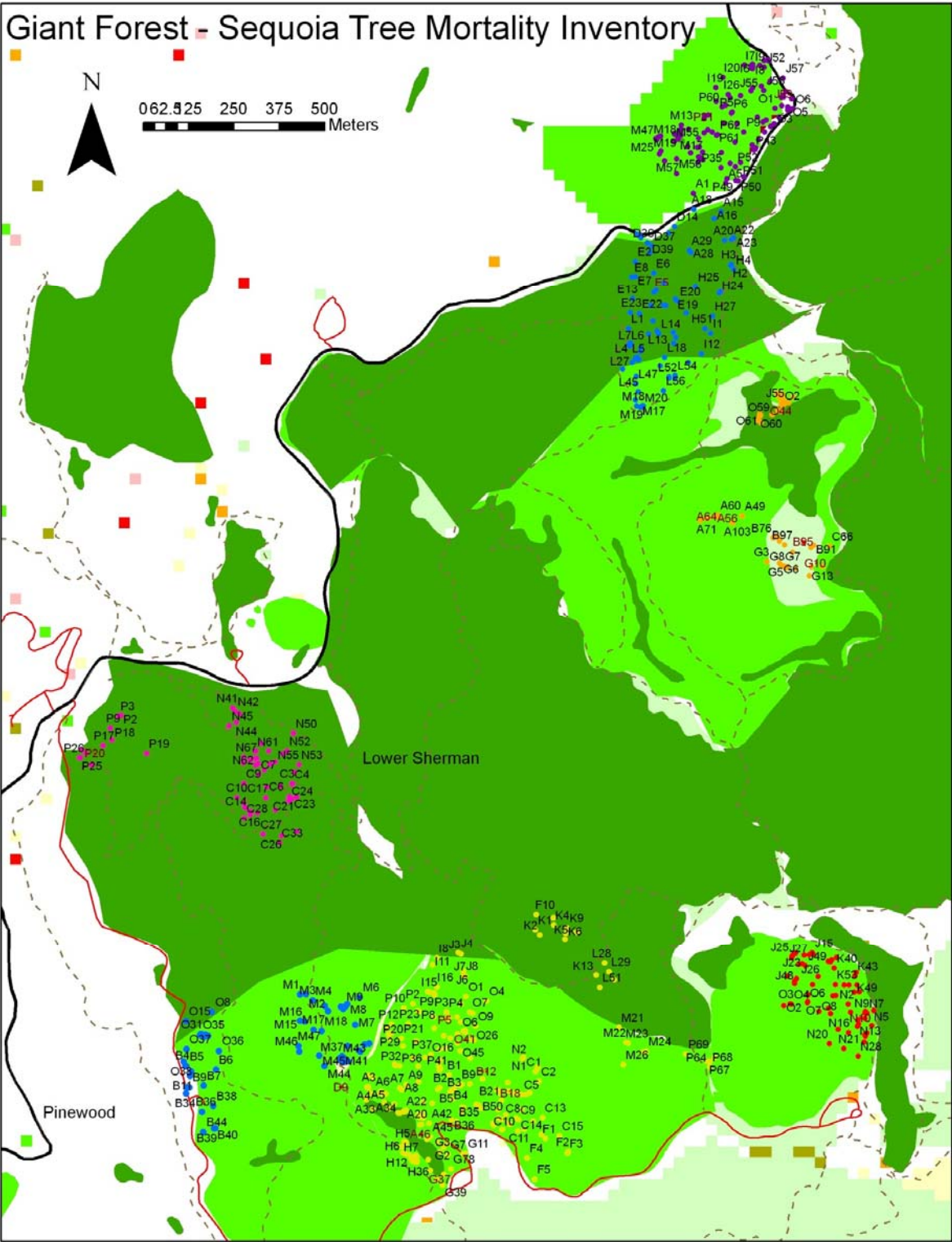


Figure 4.3.1-2. Giant sequoia mortality inventory sites and tree locations in Giant Forest used as an expanded data set for evaluating fire effects. Green shaded areas show locations of burns within the grove and labels correspond to sequoia tree inventory locations.

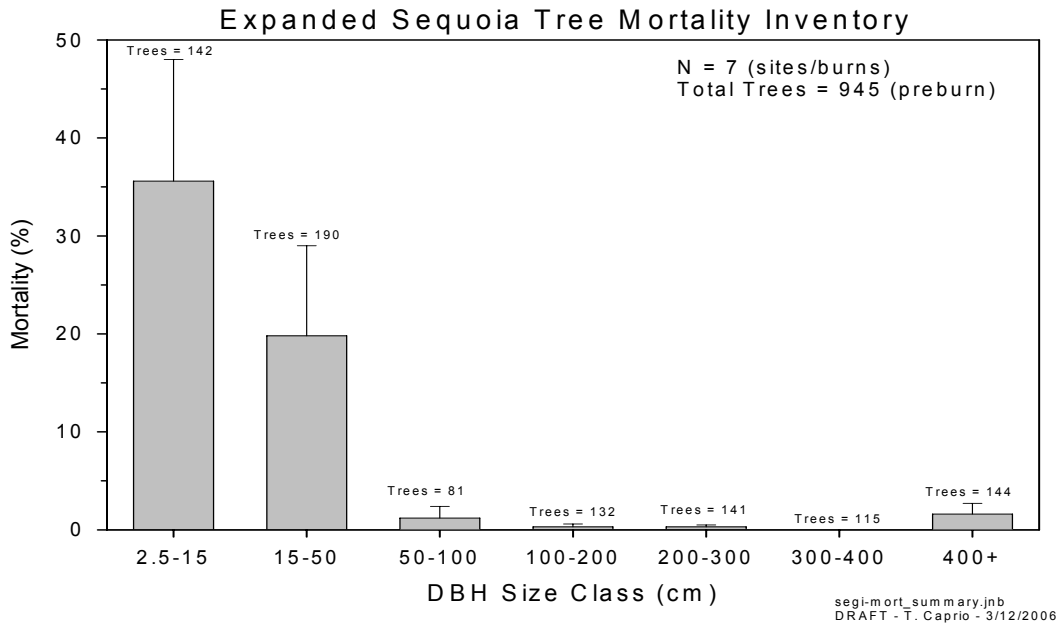


Figure 4.3.1-1. Percent mortality by diameter size class of giant sequoias following prescribed burns in Giant Forest (error bars ± 1 SE).

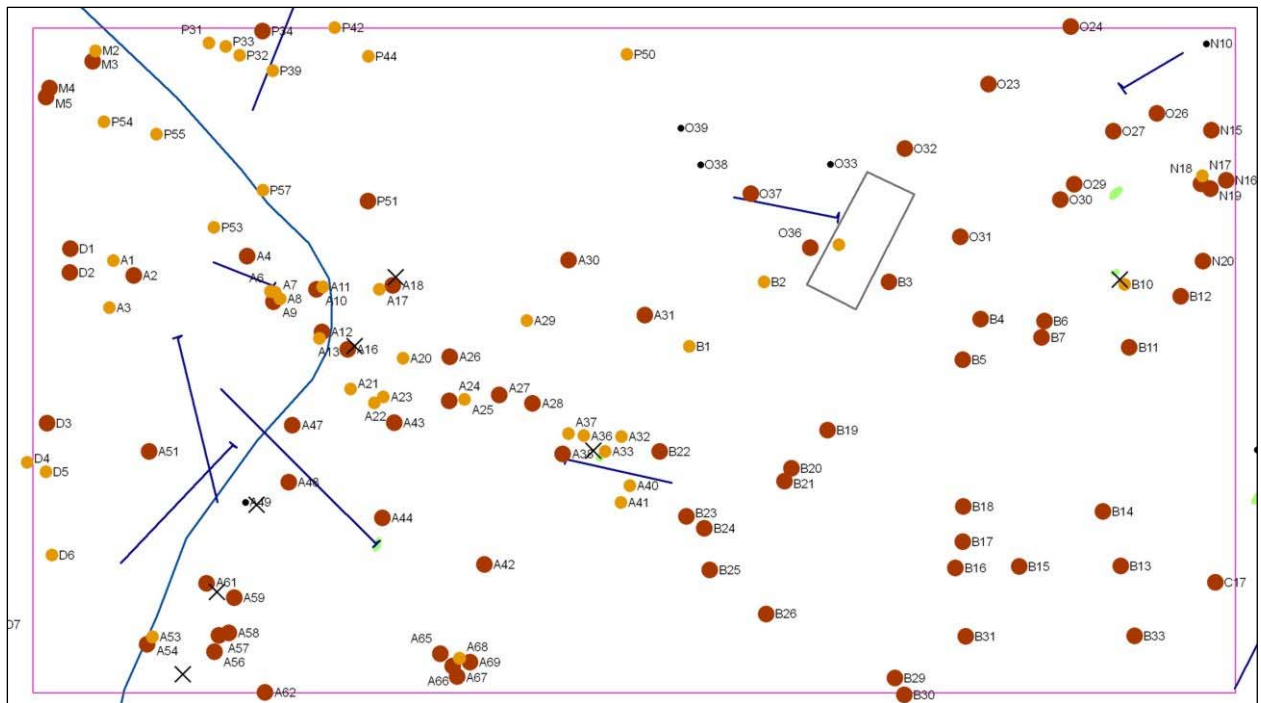


Figure 4.3.1-3. Unburned giant sequoia mortality inventory site (Sherman Cr.) sampled to provide estimate of giant sequoia mortality in unburned area. Sequoias greater than 100 cm DBH are shown as large red dots, greater than DBH height but less than 100 cm DBH are shown as medium yellow dots, sequoias less than DBH height are shown as small black dots, and green polygons show patches of sequoia reproduction. Snags and logs are shown respectively as X and linear T features. Alphanumeric codes refer to each tree's inventory code. Black rectangle within the sampled area is a 20x50 m fire effects plot.

Additionally, three unburned sites varying in size from 11.6 to 15.8 ha were surveyed in 2007. This sampling was carried out to provide an estimate of giant sequoia mortality in the absence of fire. Nearly all giant sequoias were inventoried and mapped in the late 1960s allowing us to evaluate population changes over the last four decades. Preliminary data summary indicates mortality of trees greater than 100 cm DBH, at the time of original 1960s sampling (347 trees), ranged from 3.31% to 4.90% (mean 3.97%, SD 0.83) over this time period.

(4.3.2) Giant Sequoia Seedlings in Reburns

Giant sequoias can reproduce prolifically following fire, particularly in areas where overstory gaps occur. There is interest in the fate of this reproduction following second entry burns (following the initial restoration burn). Knowledge about fire effects on these young trees following subsequent prescribed burns is important, especially given the importance of giant sequoias and their fire-dependent regeneration.

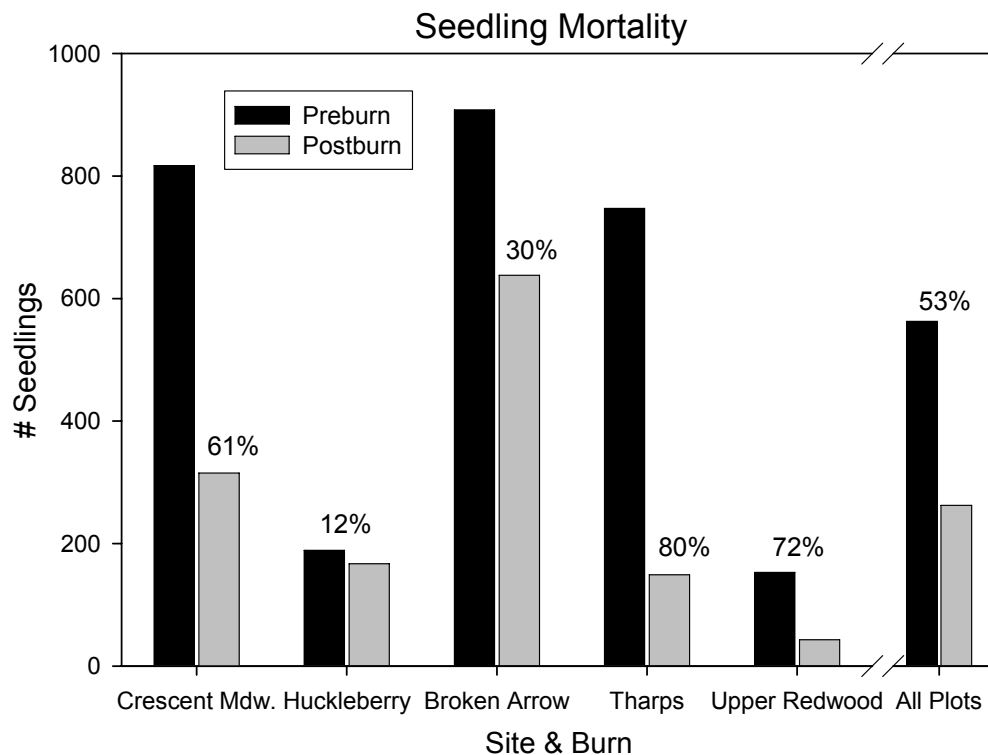


Figure 4.3.2-1. Seedling mortality following five second entry prescribed burns at five sites in Giant Forest. Average mortality for all plots pre- and postburn is shown at right

Due to the interest in this issue, plots were installed in reburn areas beginning in 1988 and expanded in 1997 to specifically assess the reburn mortality/survival of groups of 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. In addition to continued monitoring of established sites new sampling sites (additional replicates) were established in the Redwood Mountain area during 2005 since re-entry burns were to be conducted over the next several years. Overall mortality has been about 53% to date (**Fig. 4.3.2-1**).

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

Questions about sugar pine mortality, fire, and blister rust have been raised and become controversial. 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. Information is especially critical in areas where fuels have accumulated following an unnaturally long fire free period due to past fire exclusion. Some Sierran pines species, 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 what were once 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 social-political 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, litter and duff fuels were removed around large sugar pines in several prescribed burn units between 1996 and 2003. A total of 62 pairs of trees were monitored (trees were paired, mitigated and unmitigated, with 124 trees total) (**Table 4.3.3-1**). Of these, 22 pairs were rejected postburn because of burns outside planned prescriptions. Overall mortality (mitigated and unmitigated) through 2006 was 14% of the remaining 80 trees (72 PILA and 8 PIPO) in four burn units. All trees dying were PILA (13.5% across the four burn units) and mortality occurred up to seven-years postfire. However, interestingly, mortality of mitigated and unmitigated trees was similar (14% and 13% respectively, mitigated and unmitigated, each with N=40) across all burn units. This suggests little correlation between either mitigation practice or mortality. Protocols were slightly modified during 2004 so that annual censuses will be reduced. A Joint Fire Sciences Program proposal submitted in 2004 by USGS and SEKI to address the issue in more detail was not funded but funding for a larger scale study was received by the USGS SEKI Field Station from USGS funds earmarked to support NPS research needs. In 2007 several USGS study sites, involving several hundred study trees, were burned in the Wall Spring, Upper Redwood, and Valley View R_x burns.

Table 4.3.3-1. 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 prior to burn
Upper Deadwood	2003	2	

(4.3.4) *Composite Burn Index (CBI)*

The composite burn index sampling is part of the National Landscape Assessment Project (burn severity mapping). The 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. Although the scale of the results is coarse they provide information on spatial heterogeneity of burns and how fire interacts with vegetation and topography. At this time, this is also our only monitoring of WFU fires and data on whether they are meeting expected objectives. The quantitative measure that is mapped is "burn severity", defined as a scaled index gauging the magnitude

of ecological change caused by fire. 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. They also validate pre- and postburn Landsat imagery from which a burn severity index is determined (ΔNBR or change in Normalized Burn ratio). Questions ΔNBR /CBI attempts to answer include; 1) how ecological importance are the consequences of a given fire and 2) how much a 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.

All field sampling in SEKI has been 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. Seven burns were sampled in 2007—in Kings Canyon; Burnt WFU (254 ha), Roaring/Ridge WFU (721 ha), Upper Redwood R_x (251 ha), Valley View, and Horse Trail R_x units while in Sequoia; Silver (145 ha) and Cabin (176 ha) R_x units were sampled. A total of 301 CBI plots in 14 vegetation types were sampled in 2007.

Both the ΔNBR fire severity satellite data and imagery and validation data have been utilized by a number of management and research projects other than the Landscape Assessment. These include the joint NASA/NPS exotics study currently under way, LANDFIRE analysis, SEKI fuels analysis/annual fuel change updates, USGS, and lodgepole fire regime reconstructions.



Figure 4.3.4-1. Fire effects crew crossing Boreal Plateau in route to the Hot Springs WFU Burn in 2005 where CBI sampling was carried out in dry high elevation vegetation types (photo by Amanda Young).

(4.3.5) Kings Canyon Cheatgrass Monitoring

Over the last decade cheatgrass (*Bromus tectorum*) has invaded many mid-elevation sites on the west slope of the Sierra Nevada including areas of Sequoia and Kings Canyon National Parks. One area where the increase in this winter/spring annual has been very pronounced is the valley floor of Kings Canyon. Invasion of plant communities in the Great Basin by this species has often resulted in dramatic and undesirable changes in fire regimes (increased frequency) and plant community composition (decreased diversity). Concern about the rapid increase in the dominance of this species in Kings Canyon led to the suspension of the burn program in the valley in the fall of 1998. Surveys to detect spatial patterns of its occurrence also suggested interaction with the combined affects of stock use and severe fire occurrence. A JFSP funded USGS research study examined a variety of factors that were thought to influence cheatgrass dynamics. Results suggested little could be done to control the infestation once established. In 2005 the Roads End R_x Burn was the first prescribed burn back on the valley floor since 1998. This was followed in 2006 by the Horse Trail R_x. Monitoring of cheatgrass within the burn units was initiated to help ascertain how cheatgrass responds to the fires. A rapid assessment protocol for monitoring was adapted from protocols developed by SEKI invasive plant survey teams. It uses a georeferenced 50x50 m grid overlaying the burn unit. Within each grid cell cheatgrass cover and burn severity observations are recorded (most of these units have been burned more than once with prescribed fires). Burns will be resampled at one and three years postfire (year one to observe immediate postfire response and to record fire severity patterns that may be important in explaining postfire cheatgrass response while sampling at three years will permit longer term cheatgrass population responses to be recorded). A crew of six (without experience) was able to collect data on ~120 cells in one work day. A set of unburned cells are also being sampled in each burn unit.

Sampling results showed distinct preburn patterns of cheatgrass occurrence (**Fig. 4.3.5-1** and **4.3.5-2**) with presence generally corresponding to locations that had experienced past fire and were adjacent to trails used by stock. Postfire sampling, in 2006 of the Roads End R_x and in 2007 the Horse Trail R_x, indicated little change in cheatgrass cover (**Fig. 4.3.5-3**). Several small areas showed increases in cover (>20%) but overall cheatgrass cover declined or remained unchanged in more cells than it increased relative to prefire cover (32 versus 42 respectively). This may-or-may-not be a temporary phenomenon. Overall, the burned areas showed more cell-to-cell variation (%), with increases and decreases, than unburned areas. Roads End will be resampled in 2008, three years postfire, to detect whether there is a longer-term response.

Severity data indicated burns were predominantly of moderate severity (**Fig. 4.3.5-4**) with lower crowns scorched and subcanopy tree mortality. Severity was also not evenly distributed across the burn units with high severity generally occurring in localized patches (**Fig. 4.3.5-5**). Field sampling also showed mapped severity patches corresponded well with severity patterns detected using Landsat ΔNBR (**Fig. 4.3.5-5** and **4.3.5-6**)

Additionally, the postfire severity data proved useful when the park received a letter critical of the burn severity of the Roads End and Horse Trail Burns. The severity results showed the actual severity was moderate to low (**Fig. 4.3.5-4**) with mortality largely confined to younger subcanopy trees. Reducing fuels and tree densities are both important ecological objectives of the burning and important aspects of our attempts to begin returning these ponderosa pine forests back toward a more natural and resilient condition.

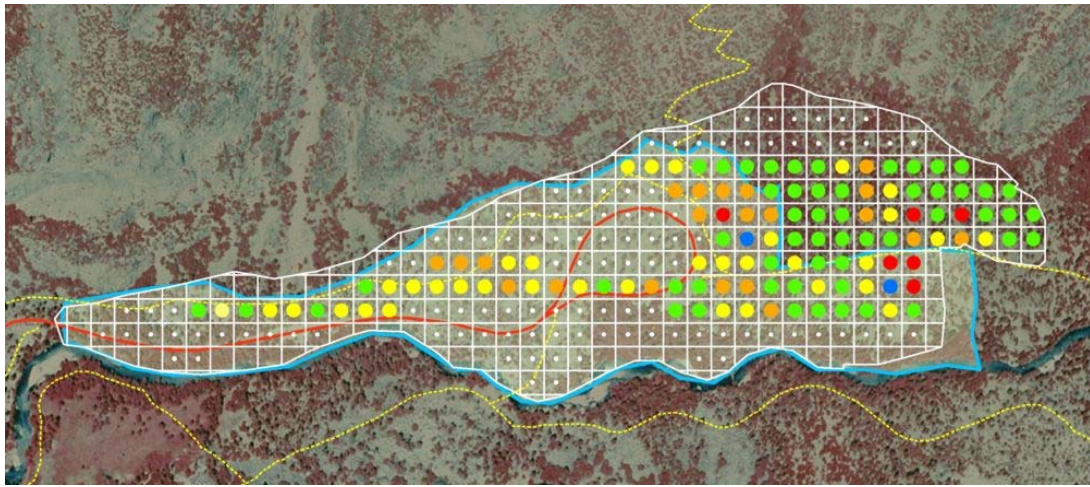


Figure 4.3.5-1. Results of preburn cheatgrass monitoring of the Roads End R_x Burn, Kings Canyon. Colored dots represent cheatgrass cover (%) detected within 50x50 m cells (green=not detected, yellow=present <1% cover, orange= 1 to <10%, red= 10 to <20%, blue= 20 to <40%). Original burn unit is outlined in white over ortho quad (north is to top). Area actually burned in 2005 is shown as lightly shaded polygon enclosed by blue line. Portions of the unit had been burned previously. Dotted yellow lines are trails and solid red line the Kings Canyon Road.

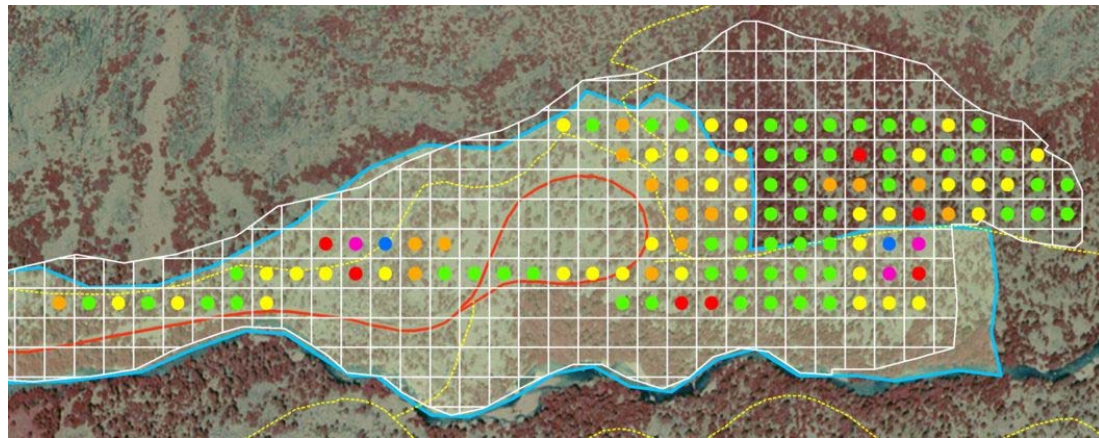


Figure 4.3.5-2. Results of postburn cheatgrass monitoring for the Roads End R_x Burn, Kings Canyon. Colored dots represent cheatgrass cover (%) detected within 50x50 m cells (green=not detected, yellow=present <1% cover, orange= 1 to <10%, red= 10 to <20%, blue= 20 to <40%, purple= >=40%). Original burn unit is outlined in white over ortho quad (north is to top). Area actually burned in 2005 is shown as lightly shaded polygon enclosed by blue line. Portions of the unit had been burned previously. Dotted yellow lines are trails and solid red line the Kings Canyon Road.

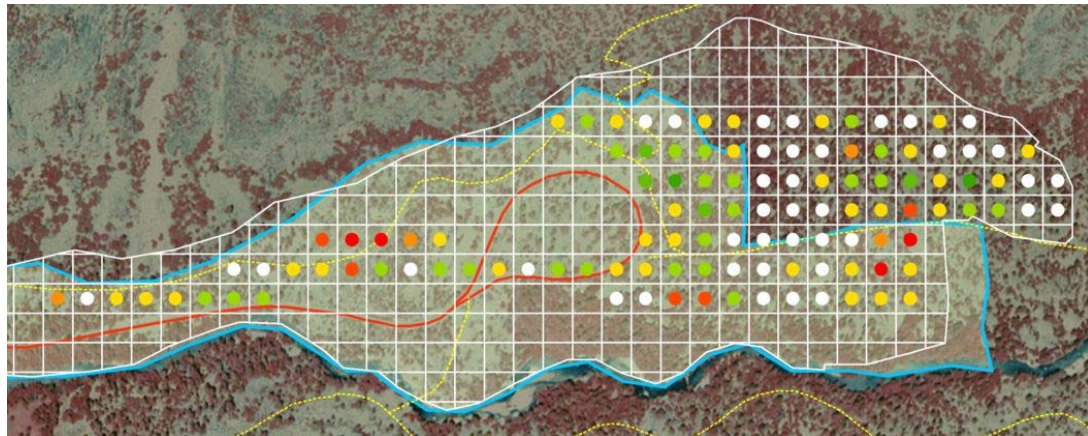


Figure 4.3.5-3. Change in cheatgrass cover from 2005 to 2006 in areas unburned and burned in 2005. Colored dots represent cheatgrass cover (%) detected within 50x50 m cells (white=no change, -0.1 to 0.1%, from 2005 to 2006, yellow= 0.1 to 5% cover increase, orange= 5 to 20%, and red= >20% increase, while light green= 0.1 to 5% and green= >5% decrease). Original burn unit is outlined in white over ortho quad (north is to top). Area actually burned in 2005 is shown as lightly shaded polygon enclosed by blue line. Portions of the unit had been burned previously. Dotted yellow lines are trails and solid red line the Kings Canyon Road.

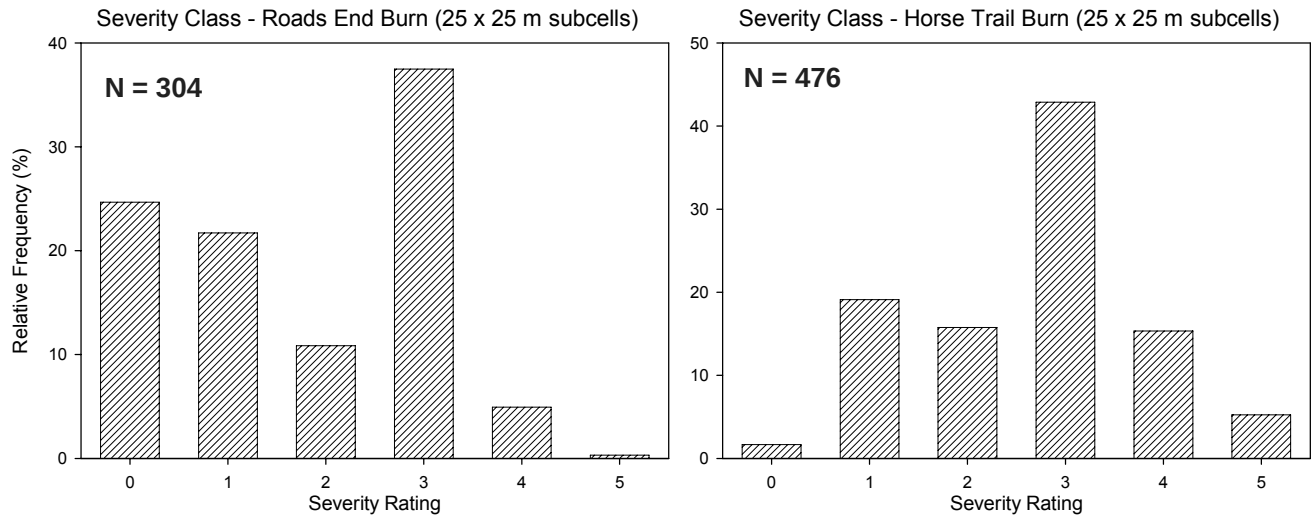


Figure 4.3.5-4. Relative proportion of sampled burned areas in Roads End R_x and Horse Trail R_x within each of six severity classes (from 0 or no fire evidence to 5 where complete overstory mortality occurred). Little of the units showed evidence of high severity fire with class 3 “scorch of lower tree crowns” the most frequent.

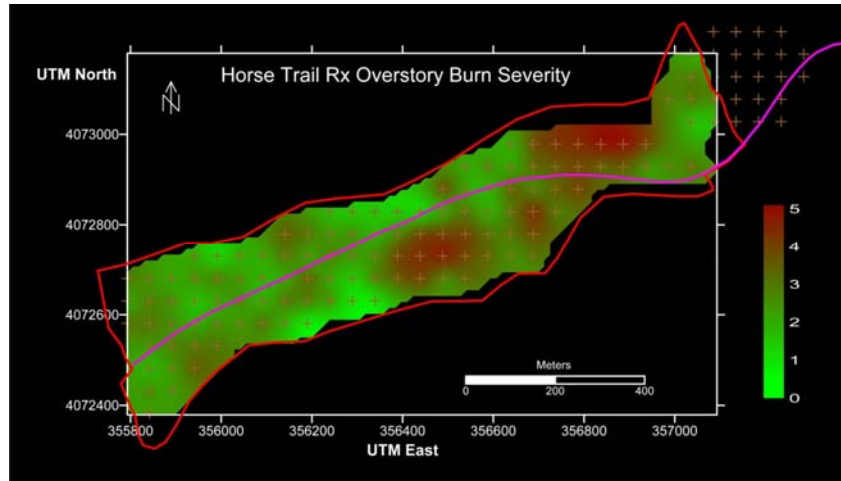


Figure 4.3.5-5. Spatial pattern of overstory burn severity in the Horse Trail R_x unit based on five classes recorded by sample cell in the field. Green indicated little impact to overstory and red severe. Sample points are indicated by “+” and burn perimeter by red polygon (purple line is the Roads End Road). Patterns of severity are similar to that seen in Δ NBR mapping (see Fig. 4.3.5.5)

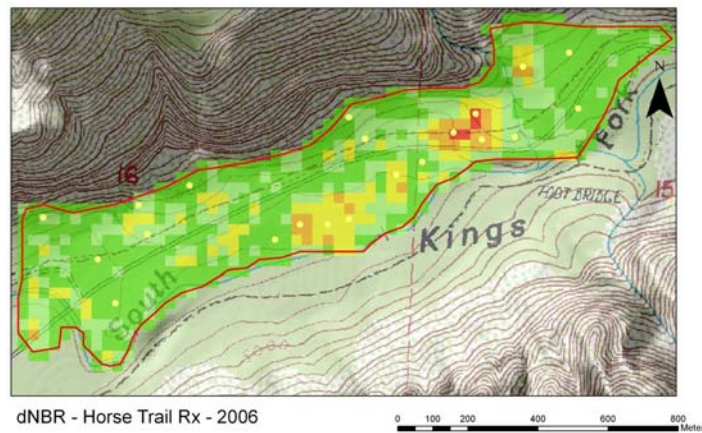


Figure 4.3.5-6. Δ NBR burn severity patterns (30x30 m pixel) in the Horse Trail R_x unit based on LandSat imagery from USGS. Dark green indicates low severity, light green, yellow, and orange intermediate severity levels, and red patches show areas of high severity that registered a high degree of change between pre and postfire images. Burn perimeter (red) used by USGS is slightly different that actual burn boundary.

(4.3.6) 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 (***Trees of Special Interest***) in the park was begun. The purpose of the inventory is to identify named trees, document their location and condition (**Table 4.3.6-1**), and describe site characteristics around each tree that might influence fire. A number 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).

In early 2005 a workgroup in SEKI established criteria that trees need to meet to be considered a “named tree”. The current list contains 98 trees located in seven park groves. As of November 2006 83 of these trees have been surveyed (no additional data was collected in 2007). All known named trees in Giant Forest have been visited with the exception of the area from the House and Senate Groups south to Circle

Table 4.3.6-1. Listing of tree characteristics and conditions surveyed.

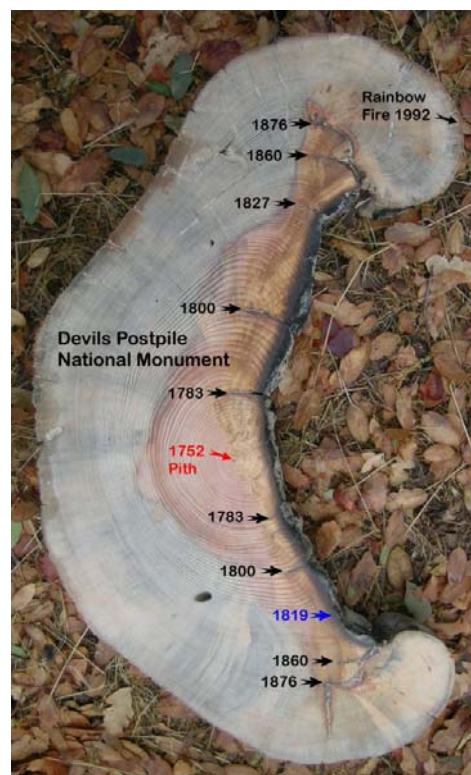
live/dead	fuel jackpots (#)	Slope (%)
FMH CPC code	mean litter and duff depth (inches)	presence of nearby snags (#)
hollow (y/n)	tree lean (degrees)	crown condition (%)
catface present (y/n, #, width)	presence of facing trees (y/n)	photos: tree, crown, fuel
fuel continuity (y/n)		

Meadow and from Washington and Welton east to the House Group and the 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. This should provide a valuable easy to access source of information during burn plan development or during wildland fires.

(4.3.7) 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

Figure 4.3.7-1. 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 Fire).



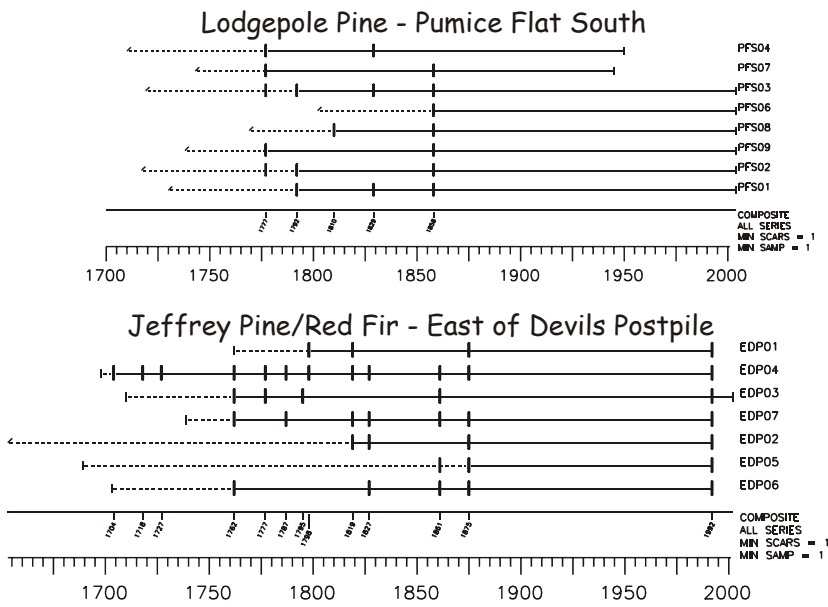


Figure 4.3.7-2. Fire history chronologies from two sites in DEPO. Greater frequency is being observed in Jeffrey pine/red fir and in lodgepole pine communities. Each horizontal line represents a single tree and the span of its record. Each vertical dash along each of these lines indicates a fire event record. A composite at the bottom of each graph lists all fire dates for the site. The 1992 scar or death date at EDP was a result of the Rainbow Fire.

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). Data from this study were utilized in two presentations given at the 2006 AFE International Fire Congress (Caprio 2006; Caprio et al. 2006).

A total of 74 samples (partial cross-sections from old trees or logs – see **Figure 4.3.7-1**) were collected at 12 sites in or adjacent to the monument in the most common forest types. Detailed data describing each site's vegetation, topography, and fuels were also collected. Samples are being processed (stabilized and sanded) and crossdated to obtain fire event dates. Preliminary results suggest moderate fire frequency over much but not all the monument (**Figure 4.3.7-2**). 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 forest regeneration (nine similar plots were also established in unburned areas for comparison). These circular plots are permanently marked and could be resampled at some point in the future to determine how forest vegetation is responding long term. Information from the regeneration plots was presented at the 2006 AFE International Fire Congress in a talk on the long-term effects of the 1992 Rainbow Fire (Caprio et al. 2006).

(4.3.8) Kilgore 1968 Rattlesnake Plots

In 1968 the NPS initiated operational prescribed burning in the western United States by conducting a full scale 324 ha “experimental” burn in the Rattlesnake drainage in the Middle Fork of the Kings River, Kings Canyon National Park. This was the first operational prescribed burn in the NPS in the western United States (Everglades N.P. had been conducting burns since the 1950s). Part of the project involved investigating fire effects. Fourteen permanent plots were established preburn in 1968 by SEKI scientist Bruce Kilgore that were resampled annually through 1970 (copies of the original data were recently provided by Dr. Kilgore and are archived in SEKI). Plots were primarily dominated by red fir and

lodgepole pine and included seven burned and seven unburned plots. In 1997, the SEKI Fire Ecologist revisited the area briefly with Bruce Kilgore, who pointed out the location of about half the plots. Some photo points were rephotographed at this time. An opportunity arose in 2007 to revisit the plots because they were located adjacent to the 2006 Burnt WFU Burn in which CBI sampling was scheduled.

In 2001 eleven of the plots burned during the Burnt WFU fire. All seven plots originally burned in 1968 reburned, with the addition of four of the unburned 1968 plots. Fortuitously, three of the original unburned plots remained unburned. As a result, there are plots that have burned twice (1968 + 2001), only once (2001), or remained unburned. The fire effects crew was able to locate all plots (nearly all rebar or t-posts were present after forty years) and resample trees and fuels on all plots (understory vegetation was not resampled).

Preliminary analysis of 2007 fuels data (collected six years after 2001 fire **Fig. 4.3.8-1**) suggest overall fuel loads decreased following a single burn but increased following a second burn when the unburned, once burned, and twice burned plots are compared (33 years between burns). Within the latter two categories, specific fuel types indicate reduction in duff was still apparent six years postfire (2001) while litter and woody fuels were similar to unburned plots. Litter and fine woody fuels probably increased rapidly postfire due to crown scorch. The overall heavy fuel loads in the plots burned twice is primarily the result of the accumulation large 1000 hr fuels (>3 inch diameter). Observations on site suggest many

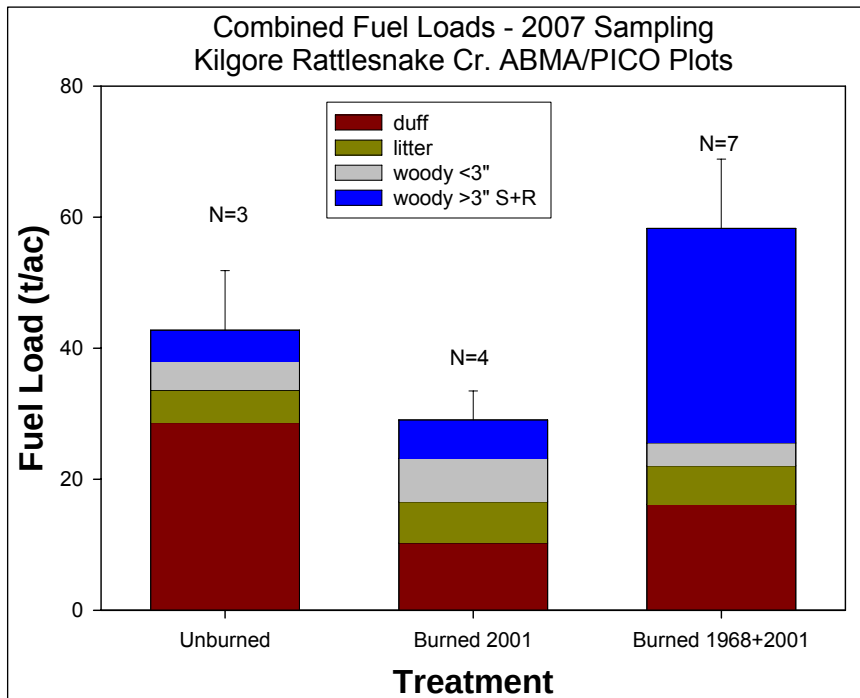


Figure 4.3.8-1. Averaged fuel loads (tons/acres) by type (duff, litter, woody <3 in. dia., and sound+rotten woody >3 in. dia.) for the Rattlesnake plots that have been burned twice (1968 + 2001), burned once (2001), and are unburned. Duff fuel has been reduced by fire (even though sampling occurred 6 years postfire) while larger sized fuels (>3 in. dia.) increased following the second burn. Long-term reduction of litter and small woody fuels is not apparent.

Plot 13 - Point B



Plot 2 - Point A-1



Plot 1 - Point D-1



Figure 4.3.8-2. Repeat photo series from three points in the Rattlesnake Creek plots taken in 1968, 1969, 1997, and 2007 (left to right). All three plots burned in 1968 and 2001. A high incidence of lodgepole pine mortality of lodgepole is obvious in plots 1 and 2. The dynamic nature of seedlings and smaller sapling occurrence through time is also apparent.

trees killed by the first burn remained standing and either burned out and fell during or soon after the second burn. Additionally, the preponderance of the tree mortality was lodgepole pine rather than red fir which in general is more fire resistant (**Fig.4.3.8-2**). This indicates a shift in overstory forest composition is occurring on these sites with the plots becoming increasingly open with greater herbaceous cover.

4.4 - Feedback to Fire Management Program

The Fire and Fuels Management Plan (FFMP) and Environmental Assessment (EA) for Devils Postpile N. M. were completed in 2005 (<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 provided important information for plan development (they are provided in more detail in the 10 year DEPO report and 2006 Association for Fire Ecology International Conference extended abstract). The preliminary results from fire history sampling (see **Section 4.3.7**) 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. This indicates 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 1982¹) with stand replacing fires the rule. Plot data also indicated very limited tree regeneration in the high severity patches located away from seed

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.

sources. Nearly all the regeneration (primarily *P. Jeffreyi*) that was present established within one or two years of the 1992 burn and appeared to have originated from buried seed that survived the fire (much of the regeneration occurred as clusters of seedlings indicating seed caches). As 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 long-term type conversion of what has been conifer forest 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 fourth annual update has been made to the Fire and Fuels Management Plan for Sequoia and Kings Canyon. Full copies of the plan and EA for SEKI can be found at:

<http://www.nps.gov/seki/fire/ffmp/ffmp.htm>. Both the SEKI and DEPO plan contain copies of the Fire Monitoring Plan (Appendix C of FFMP). With five years since the original plan was written a more detailed review of the SEKI FFMP will take place during the winter of 2008.

Direct feedback was also provided for a number of burn plans being developed in SEKI. This included development of five year burn plans. There was also close coordination between fire management, fire ecologist, and SEKI USGS researchers on restarting the Cedar Grove burn program (prescribed burns were conducted in 2005 and 2006) after it was shut down in 1998 due to the exotic cheatgrass invasion of the area. Results from the USGS cheatgrass study, funded by JFSP, have been utilized in making burn plan decisions. The extent and severity of cheatgrass occurrence was documented in the area of the Roads End and Horse trail Burns prior to the fires (see **Fig. 4.3.5-1**) using rapid assessment sampling methods. Postfire changes were documented in the Roads End unit in 2006 and Horse Trail in 2007. This effort will continue in 2008 as burn plans are developed and implemented in Cedar Grove.

One question that has surfaced repeatedly during planning for a number of our burn units is the



appropriateness of burning all the vegetation types within the unit. This practice occasionally presents problems because units often incorporate areas of vegetation that had limited fire occurrence in the past (for example, foxtail pine [*P. balfouriana*], western juniper [*Juniperus occidentalis*], some old-growth live-oak stands, and single-leaf piñon pine [*P. monophylla*] vegetation types), and negative impacts could occur if care is not used in planning and carrying out ignitions. These areas are often small portions of large burn units where holding lines are placed on high rocky ridges or on similar barriers, or the units abut the black from previous burns. For example, single-leaf piñon pine occurrence, often mixed with large old canyon live oaks – *Q. Chrysolepis*, is rare on the west slope of the Sierra Nevada but moderately extensive stands occur on steep rocky slopes in Kings Canyon. This species is very sensitive to fire with little resistance to even light surface burns. Because of the sensitivity of the

Figure 4.4-1. Wood wasp (or horntail – Family: *Siricidae*) on a burned red fir in SEKI one year postfire. Larvae of the species mine entirely within the wood and pack their circular galleries, up to one-quarter inch in diameter, with fine dust from their boring.

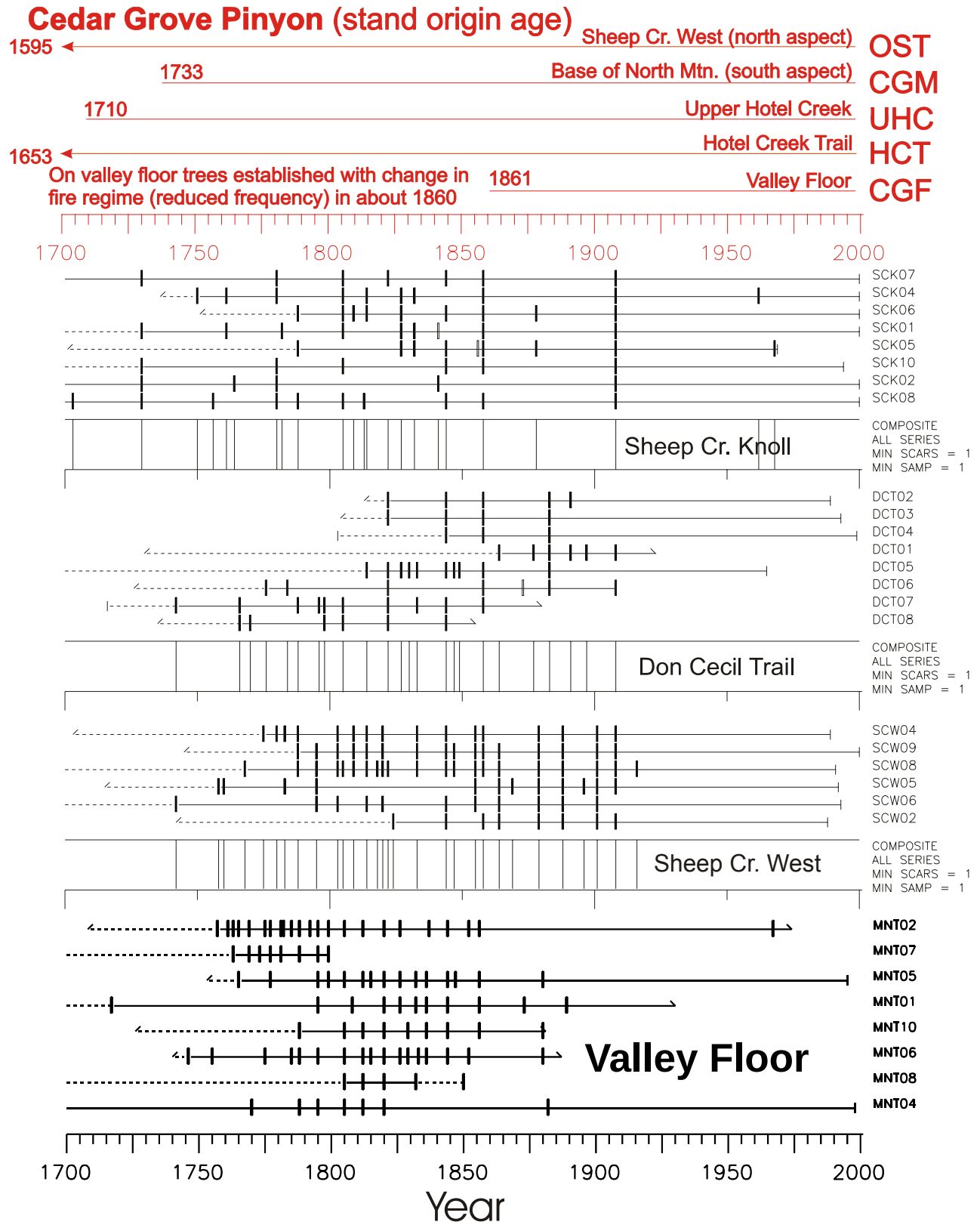


Figure 4.4-2. Piñon stand age (in red - top) and fire scar chronologies from adjacent pine sites in Kings Canyon. Note that valley floor piñons (CGF site) established following fire exclusion on the valley floor (MNT site - bottom).

species to fire, stand ages can be used to infer a minimum time since the fire occurred in the stand. Sampling in a number of these stands indicates most trees are 300 – 400 years old. Because of strong topographic changes piñon stands are often found adjacent to ponderosa pine stands that had very frequent fire (every 3 to 7 years) in the past and are in great need for fire to be restored (**Fig. 4.4-2**). It has been recommended that fire managers exclude this vegetation type from active ignition within units but not actively limit fire spread from surrounding areas that have been ignited.

4.5 – SEKI/DEPO Fire Research Projects and Collaboration

This section on research projects and collaboration is broken into three subsections; completed, current, and proposed projects. No projects were completed in 2007, several were ongoing or initiated in 2007, and five proposals submitted with one of these receiving funding (a second received partial funding from a non-NPS proposal and sampling was initiated in 2007). Fire effects and CBI (see **Section 4.3.4**) data was also analyzed and provided to Dylan Schwilk (USGS Sequoia & Kings Canyon Field Station) for a symposium presentation at the 2007 Ecological Society of America Annual Meeting (see **Appendix A**) and the NASA/Colorado State University exotic project (see **4.5.2.4 and Appendix B**).

(4.5.1) Projects Completed 2007

None

(4.5.2) - Current Projects

{4.5.2.1} Reconstructing Pre-EuroAmerican Fire History of Devils Postpile National Monument. NPS funded; SEKI PI, Anthony Caprio and DEPO, Deana Dulan.

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.

{4.5.2.2} 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

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.

{4.5.2.3} Records of the presence and intensity of past fires in sediments and soils: Detecting black carbon and organic molecular tracers. Rainer Lohmann (University of Rhode Island Graduate School of Oceanography).

The research rationale of this proposal is to investigate the presence and sorption characteristics of natural chars in soils and sediments as a function of their aging in the field. Natural chars are the by-product of incomplete combustion during wildfire and man-made fires. We will use native polycyclic aromatic hydrocarbons (PAHs) as probe molecules to elucidate the sorptive properties of natural chars in soils and sediments in situ, and compare to them to organic and soot-like black carbon. Simultaneously, this research will also aim to re-construct the historical record of natural fires by detecting the occurrence of fire-produced chars and the molecular fingerprint of past fires in sediments/soils by measuring PAHs.

We hypothesize that (i) the occurrence of natural fires can be detected by isolating charcoals in sediments/soils; and (ii) selected PAHs are robust molecular tracers of natural fires. We propose to test these hypotheses with samples taken in Oriole Lake (Sequoia and Kings Canyon National Park), where an independent record of historic fire occurrence and fire extent is preserved in the scars of conifer trees.

The scientific objectives of the research I propose are to (i) quantify the char fraction, the organic and soot-like black carbon content of soil and sediment samples affected by frequent natural fires by combining microscopic isolation of chars with a chemical oxidation method for their detection; (ii) study the sorptive properties of isolated chars and char-enriched samples by studying the desorption of native PAHs using passive polyethylene samplers in tumblers, and by performing sorption isotherms. I hypothesize that these soils and sediments retain these fire products much better than predicted by organic matter absorption; and (iii) compare three different sediment ‘ages’ with respect to sorption of PAHs, sorption linearity and linking it to isolated chars bulk (geo-)chemical characteristics.

The significance to the field of research lies in being able to understand and predict how natural chars affect the retention of hydrophobic organic compounds (HOCs), notably PAHs, in the field. Forest fires affect millions of acres in the US alone, and thus impact the geochemistry of soils and sediments. In July 2007 cores were successfully extracted from the lake (*see Fig. 4.5.2.8-1*) and transported to Rhode Island. Several short cores covered the biologically active first meter, and three cores covered 1-4 meter of depth. Currently, we are in the process of sectioning the cores and will initiate analysis of their age profiles.



Figure 4.5.2.8-1. Sediment core being extracted from Oriole Lake by crew from University of Rhode Island.

{4.5.2.4} Using NASA’s Invasive Species Forecasting System to Support National Park Service Decisions on Fire Management Activities and Invasive Plant Species Control. NPS PI: Nate Benson, NASA PI: Jeff Morisette, CSU PI: Brad Welch (SEKI fire ecology liaison: Anthony Caprio)(*see also Appendix B*).

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 a 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.

{4.5.2.5} The Sugar Pine Dilemma: Prescription Burning and the Management of a Declining Species. USGS PI: Phillip van Mantgem. Park-Orientated Biological Studies BRD Cyclical Funds.

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.



Figure 4.5-1. 2007 Willow WFU fire in high elevation foxtail (*Pinus balfouriana*) and lodgepole pine (*P. contorta*) in Big Arroyo (Sequoia N.P.). Such fires are relatively uncommon and usually involve single trees. Without continuous surface fuels this fire primarily spread by spotting among scattered patches of fuel. Highly resinous foxtail pine logs burn readily once ignited (Photos by SEKI Fire Monitors).

{4.5.2.6} Effects of Prescribed Fire on Understory Vegetation in Mixed-Conifer Forests of the Southern Sierra Nevada, California. NPS Karen Webster.

Background - National Park Service (NPS) policy requires fire managers to define and evaluate restoration objectives and results (NPS RM-18). Evaluation is assessed via a national standardized fire effects monitoring program (NPS FMH 2003). For more than 20 years Sequoia and Kings Canyon National Parks (SEKI) and most other land managers have primarily used overstory tree and fuels data to determine success of reintroducing fire to mixed-conifer forests. It is assumed that by restoring overstory tree structure and fuel loading, other aspects of the community will automatically follow. Although extensive, long-term data on understory vegetation have been collected as part of the national NPS fire effects program, they have not been examined quantitatively, limiting our ability to assess the effectiveness of prescribed fire for

restoring other important components of these forests (e.g., understory structure and biological diversity). The majority of biodiversity in the mixed-conifer forests occurs in the understory. In particular, the southern Sierra Nevada mixed-conifer is home to the greatest vascular plant species richness as well as endemic and rare plants (Shevock 1996).

NPS policy requires fire managers to define and evaluate restoration objectives and results. Objective 3 in the SEKI Fire and Fuels Management Plan (FFMP) specifies that we will “Understand the consequences of fire management actions”. This research will address the following major tasks under Objective 3: (1) The project will provide information on plant community responses to fire. This information is lacking and identified as an important research need in SEKI’s FFMP, Appendix D, Fire and Fuels Research Plan. (2) The results will help managers to refine both the planning and execution of management activities. For example, understanding the differences in understory vegetation between untreated and fire treated forests will assist managers in making decisions regarding fire treatment and suppression actions. Also, knowledge of how fire frequency affects understory vegetation can help managers to schedule future treatments, which is a critical part of the fire program’s success. (3) Measurable understory vegetation objectives and structural goals are currently non-existent. The results will begin the process of adding an understory vegetation component to restoration and maintenance target conditions, which are used to gauge overall program success. The research will support development of desired future conditions and quantifiable understory vegetation objectives.

This research project will also contribute to our continuing understanding of non-native plant responses to fire and thus assist the parks in adjusting management actions as necessary. Finally, this research will provide the opportunity to analyze existing long term fire effects monitoring data sets, which is encouraged at the regional and national NPS Fire Ecology program levels. Understanding the broader range of ecosystem responses and incorporating that knowledge into the fire management program is particularly important as managers face ever increasing constraints (air quality regulations, fiscal limitations, non-native species) and are directed to use more creative methods in applying fire (e.g., changes in the season or frequency of burning).

The project will provide information on plant community responses to fire that is lacking. Most studies on understory vegetation in the Sierra mixed-conifer forest involve thinning and burning and are of short duration (Wayman and North 2007; Knapp et al. 2007) or are only interested in silviculture practices and ignore fire altogether (Battles et al. 2001). By improving our understanding of post-fire understory vegetation dynamics, land managers can more effectively apply management activities. The research will aid in refinement of desired future conditions for these parks and support development of quantifiable understory vegetation objectives and target conditions. Overall, the research will provide a strong foundation for understanding understory vegetation responses to prescribed fire, and for refining strategies that seek to maintain native plant diversity and structure, vital components of ecosystem health and resiliency.

Research Questions - My project will investigate the responses of understory vegetation to prescribed fire in mixed-conifer forests of the Sierra Nevada using existing long-term, fire effects monitoring data from Sequoia & Kings Canyon National Parks (SEKI). Four questions will be addressed:

- (1) How do areas which have burned differ from areas that have not?
- (2) How does understory vegetation respond to fire over time (e.g. one year post fire vs. ten years post fire)?
- (3) How does fire severity and heterogeneity of the burn affect understory vegetation?
- (4) How does fire frequency affect understory vegetation? Does timing of the second burn (i.e. years since the first fire) make a difference in understory vegetation?

I will evaluate these questions by specifically focusing on the following for each question:

- a) Are there differences in species composition and diversity?
- b) Are there differences in functional groups (e.g. herb, shrub, tree, and fern)?
- c) Are there differences in relative abundance of species and functional groups?

Methods - I will be using existing data from the fire effects monitoring program at SEKI. I am proposing to use the following statistical analyses: 1) repeated measures PERMANOVA and 2) NMDS ordination to plot successional trajectories of communities.

Current Status - I am currently taking coursework to support the research project. I am conducting exploratory analysis to further refine the research questions.

Future Plans - Data collected during the 2008 season will be incorporated into the final analyses. I will complete more coursework in support of the research project during the 2008/2009 academic school year. The final statistical analyses will be complete by January 2009. The research project will be completed by June 2009.

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(4.5.3) - Proposed Projects

{4.5.3.1} Effects of Prescribed Fire versus Wildland Fire Use in Sequoia and Kings Canyon and Yosemite National Parks Jon E. Keeley, Anthony C. Caprio, and Jen Hooke. *(Funded)*

Since the late 1960s and early 1970s Sequoia, Kings Canyon and Yosemite national parks have had a formal program for managing natural lightning-ignited wildland fire use fires (WFU) and applying prescribed fire (R_x). The long history and widespread application of both practices to a range of forest types provides a natural laboratory to compare resulting effects and burn patterns. There will be close collaboration with fire managers in order to fully understand the prescriptions and protocols associated with each of these fire types. Results will be valuable to managers because large areas within the parks are being managed with R_x burning due to various constraints.

Burn patterns will be determined from fires occurring within the last 5 years and severity patterns from fires within the past 10 years. For both we will determine percentage area burned by fire severity class based on measures of tree crown scorch height. We will also map patterns of tree demography in both burned and unburned patches and evaluate understory recovery among severities. We will focus on paired comparisons between recent R_x and similar aged WFU fires in areas of similar forest types, elevation, slope, and aspect. Data collection will center on field sampling, since Landsat fire severity maps are available for all fires over 300 acres in the last 10 years and EROS data center can provide digital maps of smaller prescribed burns. We will use these data to evaluate the ability of remote sensing data for capturing differences in fire type.

We will test hypotheses related to patterns of burn heterogeneity such as: 1) do WFU fires exhibit a significantly different proportion of area within the fire perimeter in unburned patches than R_x fires, 2) do WFU fires exhibit a significantly different proportion of high severity burning, 3) do WFU fires exhibit significantly greater or lesser variance in the size of high severity patches than R_x fires, and 4) is fuel consumption more or less heterogeneous in WFU fires than in R_x ?

A second component of this study is to better understand patterns of forest regeneration and biodiversity. We will examine several response variables within each patch type and test hypotheses such as: 1) within high severity patches is regeneration (trees < 1.37 m tall) significantly different from either unburned patches or the low severity matrix in which both patch types are embedded, 2) within unburned patches is regeneration (trees < 1.37 m tall) survivorship significantly different than in either high severity patches or the low severity matrix in which both patch types are embedded, 3) in burned areas not classified as high severity, is the variance in fire severity (measured by crown scorch height and bole char height) significantly different than in WFU fires than in R_x fires, 4) in both high severity patches as well as the surrounding matrix of low severity surface fire, is proportional mortality significantly different in smaller DBH classes, 5) in both high severity patches as well as the surrounding matrix of low severity surface fire, is proportional mortality significantly different in white fir (*Abies concolor*) than associated species, and 6) as the heterogeneity in burning patterns increases does plant biodiversity increase?

{4.5.3.2} Setting Forest Structural Goals for Fire Management: Spatial Aspects. Nathan L. Stephenson (USGS), Phillip J. van Mantgem (USGS), and Anthony C. Caprio (NPS). *(Not Funded)*

At an interagency workshop in 1998, resource managers, fire managers, and scientists began developing quantitative forest structural goals for fire management in the Sierra Nevada. We refined these goals locally for eight forest types found in Sequoia and Kings Canyon National Parks (SEKI); however, we encountered critical information gaps that forced our preliminary structural targets to be very broad, and therefore not very useful. Specifically, for each tree species in each forest type, we needed to be able to distinguish among trees that are likely to have become established before and after Euro-American disruption of fire regimes (median date of last fire: 1875).

We propose to continue refining a general approach for setting quantitative and defensible forest structural goals for fire management using several existing data sets, with our efforts focused on analyzing the available data. The first phase of this work involved **determining the size ranges of trees likely to have established pre-1875, post-1875, and mixed pre- and post-1875 for various species and forest types**. Before funds ran out on this initial phase of work, we compiled available age-size data (from tree cores) from studies within and near SEKI, and completed preliminary analyses determining diameter

thresholds for trees likely to have established pre-1875, post-1875, and mixed pre- and post-1875. In the current phase of work proposed here, we will finalize these preliminary analyses, then devote the bulk of our energy to our second objective:

to determine, across a range of spatial scales and by species for each forest type, 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. Structural goals for forest restoration will vary according to spatial scale, tree species, and forest type.

However, to our knowledge, no one has systematically considered the role of spatial scale in setting restoration goals. At the tenth-hectare scale, almost any outcome of a fire is acceptable, whether it kills all trees or leaves all trees untouched; at such a fine spatial scale, any of those outcomes has precedent in pre-EuroAmerican times (e.g. Stephenson 1996). At broader spatial scales the range of acceptable outcomes progressively narrows. By aggregating data from many tenth-hectare plots, we propose to address the issue of defining acceptable structural goals at different spatial scales. We will use inventories of all trees >1.4 m tall, by diameter and species, available for more than 800 tenth-hectare plots scattered throughout all SEKI forest types (e.g. Stephenson 1988; Graber et al. 1993; Keifer et al. 2000; Keifer, unpublished data; Haultain, unpublished data). The data will be randomly aggregated to form larger “virtual” plots in order to determine the relationship between area sampled and variation in tree density. Coupled with the age-size data developed under Objective 1, these data will allow us to estimate -- by species, forest type, and at several spatial scales -- the mean and range of pre-burn density of pre-1875 trees, post-1875 trees, and mixed pre- and post-1875 trees on the contemporary landscape.

{4.5.3.3} Leaf traits, litter flammability, and restoration fire: Effects of stand composition on fire behavior. PI: Dylan W. Schwilk (Texas Tech Univ.), Co PI Anthony C. Caprio (NPS, SEKI). *(Not Funded)*

Over the last century, fire exclusion in the forests of the Sierra Nevada has allowed surface fuels to accumulate and has led to increased tree density. Community composition has also been altered as shade tolerant tree species crowd out shade intolerant species. To restore forest structure and reduce surface fuels, managers have increasingly used prescription burning. 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, prescribed burns may not mimic natural lightning-ignited patterns in that they are often designed to produce homogeneous burning patterns. Evidence from replicated burns in Sequoia National Park suggests that burn heterogeneity is a primary influence on patterns of tree mortality and understory species response (Schwilk et al., 2006; Knapp et al., 2007). Furthermore, current forests differ from historical conditions not only in total fuel loads, but also dramatically in the composition of species that contribute to the surface fuelbed. The role that changes in stand composition may play in influencing burning patterns has been relatively neglected but would be valuable for burn planning and management response to fires.

Previous investigation of species-specific differences in flammability have shown that leaf and wood litter differ very little in chemical properties affecting combustion (van Wagtenonk et al., 1998b), but morphological leaf and twig traits differ among species to an extent which may significantly affect fuelbed characteristics (van Wagtenonk et al., 1998a). Recent work in Australia has shown leaf size to be an important trait influencing leaf litter flammability (Scarff and Westoby, 2006) and leaf size varies predictably over water and light environments. If composition changes in Sierran forests have changed the distribution of leaf sizes in litter, then fire behavior may also be affected. Shorter-leaved shade tolerant species, which have increased since fire exclusion, may play a negative feedback role by reducing fire severity.

Post-fire vegetation plots in Sequoia National Park provide an excellent opportunity to investigate possible species-specific effects on fire behavior. Composite Burn Index (CBI) plots which sample both prescription burns and wild fires provide measures of fire severity and species composition and may provide evidence for a species-trait signal in patterns of burning. Preliminary investigation of both CBI plot data and data from Fire Effects plots in Sequoia National Park suggest that leaf size may have a significant effect on local patterns of fuel consumption and fire severity. Evidence suggests that leaf size, by changing litter bulk density, significantly influences patterns of burn heterogeneity and severity. A more complete investigation will require structural equation modeling in order to allow for site environmental effects (soil moisture, elevation, etc) which can jointly influence stand composition and fire severity. Understanding stand composition effects on fire behavior will improve decisions regarding appropriate management response to wildfire. Linking species traits to fire behavior and severity will allow managers to better predict the effects of prescribed fire and wild fire and will improve long-term forest modeling by helping to parameterize species feedback effects on disturbance.

{4.5.3.4} Effects of Prescribed Fire on Understory Vegetation in Mixed-Conifer Forests of the Southern Sierra Nevada, California. Karen Webster, Anthony Caprio, and Jen Hooke (YOSE). *(Not Funded but partial funding found elsewhere)*

Project Description: This project will investigate the responses of understory vegetation to prescribed fire in mixed-conifer forests of the Sierra Nevada using long-term, fire effects monitoring data from Sequoia, Kings Canyon and Yosemite National Parks (SEKI and YOSE). Four primary questions will be addressed: (1) How do understory composition

and diversity differ in areas that have been burned and those that have not? (2) Are there short- and long- term effects of prescribed fire on understory composition and diversity? (3) How do responses vary with time since fire, fire severity, “patchiness” of burn, fire frequency, or season of burn? (4) Is prescribed fire resulting in understory composition and structure that more closely resemble those that existed prior to fire suppression?

Purpose and Need: NPS policy requires fire managers to define and evaluate restoration objectives and results. Objective 3 in the SEKI Fire and Fuels Management Plan (FFMP) specifies that we will “Understand the consequences of fire management actions”. For more than 20 years SEKI and most other land managers have primarily used overstory tree and fuels data to determine success of reintroducing fire to mixed-conifer forests. Although extensive, long-term data on understory vegetation have been collected as part of the NPS fire effects program, they have not been examined quantitatively, limiting our ability to assess the effectiveness of prescribed fire for restoring other important components of these forests (e.g., understory structure and biological diversity). Understanding the broader range of ecosystem responses and incorporating that knowledge into the fire management program is particularly important as managers face ever increasing constraints (air quality regulations, fiscal limitations, non-native species) and are directed to use more creative methods in applying fire (e.g., changes in the season or frequency of burning).

The project will provide information on plant community responses to fire that is lacking and identified as an important research need in SEKI’s FFMP. The results will help managers to refine both the planning and execution of management activities. For example, knowledge of how fire frequency affects understory vegetation can help managers to schedule future treatments. The results will also begin the process of adding an understory vegetation component to restoration and maintenance target conditions, which are used to gauge overall program success. The research will support development of desired future conditions and quantifiable understory vegetation objectives. Finally, how non-native understory species respond to fire is an important management consideration. This project will contribute to our understanding of the responses of these species to fire and thus assist the parks in adjusting management actions as necessary. Overall, the research will provide a strong foundation for understanding understory vegetation responses to prescribed fire, and for refining strategies that seek to maintain native plant diversity and structure, vital components of ecosystem health and resiliency.

{4.5.3.5} Records of the presence and intensity of past fires in sediments and soils in SEKI: Detecting chars, soots and organic molecular tracers. Rainer Lohmann (University of Rhode Island Graduate School of Oceanography) and Anthony C. Caprio (SEKI). (*Not Funded but partially funded from other sources*)

Objectives: We propose to establish a historical record of pre-EuroAmerican fires by detecting the occurrence of pyrogenic chars and soot and the molecular fingerprint of past fires in sediments/soils by measuring polycyclic aromatic hydrocarbons (PAHs) and lower chlorinated dibenzofurans (PCDFs). Chars and soot-like black carbon (SBC) are the products of incomplete combustion of biomass burning and fossil fuels. We hypothesize that (i) the occurrence of natural fires can be detected by isolating chars and SBC in sediments/soils; and (ii) selected PAHs and PCDFs are robust molecular tracers of natural fires. We propose to test these hypotheses with samples taken in Oriole Lake (Sequoia and Kings Canyon National Park, SEKI), where an independent record of historic fire occurrence and fire extent is preserved in the scars of conifer trees.

4.6 – “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. The



Figure 4.4-1. Headfire that burned through the Comb Fire pine/bear clover fire effects plots. (photo by Todd Erdody)

pages are currently undergoing conversion to CMS format and should be posted by early 2008.

V - References

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VI Appendices

A) ESA Symposium 8-9: *Leaf size, litter flammability, and restoration fire: Changes in stand composition influence pattern of burning.* Dylan Schwilk, USGS Sequoia-Kings Canyon Research Station.

Over the last century, fire exclusion in the forests of the Sierra Nevada has allowed surface fuels to accumulate and has led to increased tree density. Community composition has also been altered as shade tolerant tree species crowd out shade intolerant species. To restore forest structure and reduce surface fuels, managers have increasingly used prescription burning. 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, prescribed burns may not mimic natural lightning-ignited patterns in that they are often designed to produce homogeneous burning patterns. Evidence from replicated burns in Sequoia National Park suggests that burn heterogeneity is a primary influence on patterns of tree mortality and understory species composition. Furthermore, current forests differ from historical conditions not only in total fuel loads, but also in the composition of species that contribute to the surface fuel bed. The role that changes in stand composition may play in influencing burning patterns has been relatively neglected. Evidence from both prescribed fire and wild fire at Sequoia National Park suggests that leaf size, by changing litter bulk density, significantly influences patterns of burn heterogeneity and severity. Shorter-leaved shade tolerant species, which have increased since fire exclusion, may play a negative feedback role by reducing fire severity.

B) *The Significance of Fire and Burn Severity in Predicting Invasive Species Habitat.* Joel Silverman, Monique Rocca¹, Nate Benson², Kara Paintner², Jeffery T. Morissette³, Pete Ma³, Jeff Pedelty³, John Schnase³, Neal Most³, Asad Ullah³, Weijie Cai⁴. ¹Colorado State University, ²National Park Service, ³NASA Goddard Space Flight Center, ⁴George Mason University.

Fire and invasive plant species are two major sources of ecological disturbance which often interact. Such synergistic disturbances can dramatically impact native biota, requiring research and insightful management planning. Our project investigates the relationships between burn severity, environmental factors, and life history traits of particular invasive species with the objective of improving species habitat models. The "Invasive Species Forecasting System" (ISFS), a project co-developed by USGS and NASA, was used to analyze differenced Normalized Burn Ratio (dNBR) burn severity maps in conjunction with field data and environmental GIS layers to identify predictors of exotic invasions. Invasive species habitat models with and without burn-related inputs were compared to determine the significance of burn severity in predicting potential habitat. The initial phase of our study focused on several species including spotted knapweed (*Centaurea biebersteinii*) in the Yellowstone/Tetons ecosystem, bull thistle (*Cirsium vulgare*) in Sequoia/Kings Canyon National Parks, and white sweet clover (*Melilotus alba*