National Park Service
Fire Ecology Annual Report 2006
Sequoia & Kings Canyon National Parks and Devils Postpile National Monument

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Executive Summary

During 2006 35 FMH plot visits were made within nine monitoring units in Sequoia and Kings Canyon N.P. (SEKI) and Devils Postpile N.M. (DEPO). These included four new plot installations and reads of three preburn and three postburn plots. Significant progress was made in error checking legacy FMH data errors for all data converted to FEAT 2.4 (Fire Ecology Assessment Tool) in 2005. 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 was CBI (composite burn index) field sampling for the National Landscape Assessment Project (burn severity mapping). Fire ecology staff also participated in seven prescribed burns, suppression or wildland fire use (WFU) fires as fire- fighter, fire effects monitor (FEMO), or resource advisor positions.

A review of the overall fire ecology program in SEKI was organized and implemented in February. This review, ***Where Fire Ecology and Management Meet***, was the fourth since the Christenson Report program review in 1987 and the first since 2000. The purpose of the reviews are to provide 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.

A ten- year postfire report on the long- term effects 1992 Rainbow Fire in Devils Postpile was completed based on fire effects plots established immediately postfire. Two papers were also presented at the Association for Fire Ecology International Fire Congress in San Diego. One incorporated data from the DEPO fire effects sampling combined with more recent tree regeneration and fire history sampling to evaluate impacts of the 1992 Rainbow Fire and make recommendation on possible future fire management options for the area. The second paper detailed findings from fire history sampling of lodgepole pine in the southern Sierra Nevada that provides an update and significant improvement in our understanding of the past fire regime in this vegetation type. 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 (data and meetings) were also provided to the national LANDFIRE modeling effort with fire/vegetation models developed for high elevation vegetation types of the Sierra Nevada.

Considerable efforts in public outreach were also made through venues such as publications, the *Fire Information Cache* website, 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 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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I - Program Results

An updated summary of results is presented through 2006 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 remains 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

Table 1-1. **Management objectives and monitoring results for 2006.** 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% *(n=<u>28</u> plots, 18 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 *(n=<u>22</u> plots, 12 fires)*	**YES**
		10-yr stand density = 174-224 trees/ha <80 cm DBH 35-46 trees/ha ≥ 80 cm DBH *(n=<u>22</u> 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% *(n=<u>30</u> plots, 18 fires)*	**YES**
White fir-mixed conifer forest	60-95% total fuel reduction	total fuel reduction = 62-85% *(n=11 plots, 7 fires)*	**YES*** *but minimum sample size not achieved
	5-yr postburn stand density: 50-250 trees/ha <80 cm DBH 10-75 trees/ha ≥ 80 cm DBH	stand density = 272-356 trees/ha <80 cm DBH 28-44 trees/ha ≥ 80 cm DBH *(n=<u>10</u> plots, 6 fires)*	**NO** for trees <80 cm DBH; **YES** for trees >80 cm DBH
Low elevation-mixed conifer forest	60-95% total fuel reduction	total fuel reduction = 75-93% *(n=<u>5</u> 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 *(n=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 = 56 tons/acre post (total fuel reduction 24%) *(n=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) *(n=8, 6 treatments)*	**YES*** * but sample size too small

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 better understand treatment effects. Mechanical treatment objectives will be reviewed in 2007 by fire management and natural resources staff based on treatment results, plot data, and new research results.

II - Workload and Staffing

2.1 - Workload - In 2006 35 FMH plot visits were made in six monitoring types (***Table 2-1***). Four of these visits were new installs, with continued emphasis on thinning plots and a new monitoring type for xeric conifer (Jeffrey pine/montane chaparral type). Full transition to the Fire Ecology Assessment Tool (FEAT) has been completed and many legacy data errors corrected. All fire effect's plot data have been converted to FEAT version 2.4. Additionally, CBI data for the National Landscape Assessment Project was collected on two fires from 2005 (Comb WFU in Cedar Grove and Highbridge Rx Burn in Mineral King). Legacy CBI data was entered into FEAT in 2006 so all data through 2006 are in FEAT 2.4. Data quality checks continue.

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

Table 2-1. Fire ecology plot workload 2006**.**

Park	Type of Plot (FMH, photo point, other)	Monitoring Unit	Installs 2006	Postburn 2006	Postburn (1-30 yrs)	Total Plots
SEKI	FMH forest	Giant sequoia-mixed conifer		1	17	**48**
		White fir-mixed conifer			3	**17**
		Low elevation-mixed conifer			1	**8**
		Red Fir Forest				**7**
		Ponderosa Forest	2		3	**27**
		Xeric Jeffrey Pine	1	1	1	**2**
		Buckeye Wildfire				**3**
		Blue Oak Woodland				**2**
	FMH brush	Chamise Chaparral				**3**
		Montane Chaparral/sagebrush				**7**
		Mixed Chaparral				**6**
	FMH Mechanical	Thinning + Pile Burning	1	1	2	**9**
	CBI*†	Highbridge+Comb WFU	79			**253**
	Cheatgrass Monitoring*†	Horse Trail/Roads End Rx	139	119		**377**
	Forest Structure	Forest Structure	2			**8**
DEPO	FMH Forest	Rainbow Wildfire (postfire)				**9**
	FMH Mechanical	Thinning + Pile Burning			1	**1**
	Fire Regime*	DEPO fire history				**52**
	Tree Regeneration†	Rainbow Fire Tree Regen.				**42**
Total FMH			**4**	**3**	**28**	**149**
Total Other			**79**			**732**

*Not permanent plots; †Sampled using specific rapid assessment protocols 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”.

Several long-term “special study” projects were continued in 2006. 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 participated in seven prescribed burns, suppression or wildland fire use (WFU) fires as fire-fighter, FEMO, or resource advisor positions. One seasonal crew member took a two week crew assignment. The Fire Ecologist was SEKI’s resource advisor contact for the Roaring/Ridge and Burnt WFU fires during August and September.

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. Programs were done in coordination with the SEKI Fire Information Officer (Jody Lyle) or other park staff. These reached a large audience and provided important support for fire management and fire related natural resources activities. Unfortunately there is neither time nor funding available for the site to be converted to the new NPS CMS web page format mandated to be completed in 2006.

2.2 - Staffing - Staffing during 2006 consisted of Fire Ecologist, Lead Fire Effects Monitor, and four Fire Effects Seasonals (***Table 2-2 to 2-5***). A change this year was the hiring of one seasonal at a GS-6 level in order to recruit and retain quality fire effects monitors as 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 as workload analysis suggests and one seasonal position remains

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.

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 2006. 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*	5/15/06	11/3/06	12.5#	HECM refresher, fire refresher
Mike Stefancic*	5/22/06	11/3/06	12#	S290, S131, initiated FEMO taskbook, fire refresher
John Garner*	5/22/06	11/3/06	12#	S131, S290, initiated FEMO taskbook, fire refresher
Shaun Collins*	5/22/06	11/3/06	12†	S212, S131, S290, initiated FEMO and FALA taskbooks, fire refresher
Karen Webster	2/21/06	12/1/06	15#+5†	fire refresher, AFE 2006 International Fire Ecology Congress
Tony Caprio	Full Time^			fire refresher, AFE 2006 International Fire Ecology Congress, Carhart Wilderness Training

* seasonal/temporary employee, # Account no. 8557-0601-H14, ^ Account no. 8557-0021-H11, † funded by projects

Figure 2-2. The Roaring-Ridge WFU fires, Sheep Creek Kings Canyon National Park, were visible from portions of Lewis Cr. burned by the Comb Fire where CBI plots were being installed.

Figure 2-3. Cabin Meadow prescribed burn 2006 in Jeffrey pine/greenleaf manzanita (NPS Photo – SEKI Fire Monitors).

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

Category	Time (%)	Accomplishments/Focus Areas
General Planning	12%	• SEKI five year burn plan development • Implemented annual updates to SEKI FFMP • SEKI annual fire management work plan development/implementation • SEKI Fire Management Committee – Trees of Special Interest (sequoias) • Rx burn plans • Updates to SEKI Res. Adv./MIST guidelines for SEKI
Presentations and Field Trips (see Public Outreach below)	10%	• SEKI Fire Ecology Review presentations 1) Progress in meeting goals: data & graphics 2) FMH: Rx and mechanical + other 3) SEKI Fire severity mapping (remote sensing) CBI/ΔNBR 4) Fire regimes – patterns and processes, SEKI & DEPO • PowerPoint program and field trip for NPS Fire Ecology Steering Committee • Compiled presentation used in RX-310 training (Siefkin) • Introduction and discussion on fire management and research to visiting Swedish scientists/fire managers • 2006 AFE Fire International Fire Congress presentations 1) Author of: *FIRE HISTORY OF LODGEPOLE PINE IN THE SOUTHERN SIERRA NEVADA, CALIFORNIA* 2) Coauthor of: *LONG-TERM EFFECTS OF THE 1992 RAINBOW FIRE, DEVILS POSTPILE NATIONAL MONUMENT, CALIFORNIA (A. Caprio, M. Keifer, and K. Webster)* 3) Coauthor presentation: *The Effects of Fire and Fire Surrogate Treatments for Ecological Restoration: A National Perspective (*D. Schwilk, USGS, E.E. Knapp, USFS S.M. Ferrenberg, USGS J.E. Keeley, USGS A.C. Caprio, NPS)
NPS Meetings/ Task Groups	7%	• Attended NPS Fire Ecology Steering Committee Meeting hosted by PWR in SEKI • SIEN I&M landscape/fire regime protocol development • SIEN I&M climate data assessment (fire representative) • SEKI digital photography data management workgroup • SEKI sequoia trees of special interest workgroup
Interagency Work	5%	• Region 5 Sierra Nevada LANDFIRE modeling workshop – high elevation forests • LANDFIRE data request for georeferenced vegetation plot data from SEKI
Fire Assignments and Fuels Projects	10%	Resource Advisor on Roaring-Ridge WFU (20 shifts), Silver Rx RA observer (one shift)
Research	5%	• Stand structure sampling (Sheep Cr. Kings Canyon) • SEKI fire ecology liaison to NASA/NPS project on fire and exotics, provided data on fire effects and CBI • Continued input into JFSP Wilderness Inst. "Retrospective Fire Analysis Study" for SEKI • Data or other research assistance to: USDA For. Service PW Research Station, Riverside Fire Lab, Pennsylvania State Univ., Colorado State Univ., UC Berkeley
Management or Research Document Reviews	8%	• Fire plan reviews (AM, Wall Spring, Silver, Horse Trail) • Review of JFSP USGS SEKI Fire and Fire Surrogate (FFS) publications • Professional review of paper for Canadian Journal of Forest Ecology • Responses to comment letters to SEKI on 1) sugar pine, 2) Cedar Grove Rx burns (Horse Trail/Roads End), 3) Ash Mtn. Rx fires, 4) fire and foxtail pines. • Internal review and response to fire and flooding in East Fork
Fx Field Work	5%	• Assisted fire effects crew with FMH plots and CBI sampling • Special projects • Cedar Grove cheatgrass – baseline sampling Roads End Rx Burn/Horse Trail Rx.
Data Entry	<1%	• Fire effects monitors completed all 2006 FMH data entry

Category	Time (%)	Accomplishments/Focus Areas
		• Roads End/Horse Trail cheatgrass • Error checking of 2006 CBI data
Data Management and Conversion	<5%	• Lead monitor completed data conversion to FEAT 2.4 • Data checks
Data Analysis	5%	• FMH data • DEPO fire history/age structure analysis • Fire climate analysis of East Fork Kaweah R. watershed fire regimes • Fx DEPO 10 yr post-Rainbow Fire
Reports/Publications	18%	• SEKI 2005 Div. Nat. Res. Fire Ecology Annual Report • 2005 PWR Fire Ecology Annual Report • Coauthored paper: *"Tree mortality from fire and bark beetles following early and late season prescribed fires in a Sierra Nevada mixed-conifer forest" (Schwilk 2006)* • AFE Congress extended abstract - *FIRE HISTORY OF LODGEPOLE PINE IN THE SOUTHERN SIERRA NEVADA, CALIFORNIA* • AFE Congress extended abstract - *LONG-TERM EFFECTS OF THE 1992 RAINBOW FIRE, DEVILS POSTPILE NATIONAL MONUMENT, CALIFORNIA* • DEPO 10 year postfire Fire Effects Report – "*Fire Effects Monitoring of the 1992 Rainbow Fire, Devils Postpile National Monument: Vegetation Response Ten Years Postfire"*
Supervision/Admin	5%	• Supervised lead monitor, completed evaluations • Travel and time paperwork
Training & Professional Development	<5%	• Firefighter refresher • Association for Fire Ecology International Congress, San Diego • 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 • PT – all PT was/is carried out on personal time
Miscellaneous	5%	miscellaneous other things, SEKI Resources & USGS input/coordination
Public Outreach	<5%	• Fire Information Cache, SEKI Fire Portal • Beetle Rock Education Center – Support to Family Nature Program

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	40%	Completed 35 reads, all were forest plots. Installed 4 plots (2 PIPO and 1 PIJE).
Mechanical Treatment plots	10%	Installed one new thinning plot and read three previously installed plots, one of which was in DEPO.
CBI plots	15%	Installed 29 plots for Highbridge Rx Burn and 50 plots for Comb Fire Use Fire
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	10%	Crew assisted on three prescribed burns, two suppression, and one fire use fire. One crewmember completed a two week fire assignment with the park's Type II handcrew during Level V national preparedness.
Data Entry	10%	• Completed data entry for 2006 data • Entered missing herb data from FMH into FEAT
Database Maintenance	10%	Error checked converted data and other database cleanup tasks.
Data Analysis	0%	
Training and Professional Development	15%	• 3 crewmembers attended S131 • 1 crewmember attended S212 and initiated FALA taskbook • 3 crewmembers completed S290 and initiated FEMO taskbooks • All crewmembers attended fire refresher training • All crewmembers participated in PT • All crewmembers attended mandatory park trainings (defensive driver, hazmat etc).
Miscellaneous		

Figure 2-5. Area of Jeffrey pine (PIJE) and mountain misery (CHFO) understory one year after the 2005 Comb WFU Fire showing rapid postfire recovery of the understory in these open stands.

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 35 reads, all were forest plots.
Mechanical Treatment plots	5%	Installed one new thinning plot and read three previously installed plots, one of which was in DEPO.
CBI plots	10%	Installed 29 plots for Highbridge Rx Burn and 50 plots for Comb Fire Use Fire
Other plot work	5%	Cheatgrass monitoring
Fire Assignments and Fuels Projects	<5%	Worked on two prescribed fires and one wildland fire use fire.
Data Entry	<1%	
Data Management and Conversion	30%	• Error checked converted data • Error checked data entered from 2006 • Corrected data conversion errors • Miscellaneous database upkeep – merging subsamples, renaming subsamples etc.
Data Analysis	<5%	• Provided analyses to Fire Ecologist • Provided other data as requested
Supervision/Admin	25%	• Hired and supervised four fire effects monitors; evaluations, time, travel and other administrative paperwork
Training & Professional Development	<5%	• Attended one week AFE Fire Ecology conference • Participated in FEAT training conference calls • Completed fire refresher training • Participated in PT
Miscellaneous		

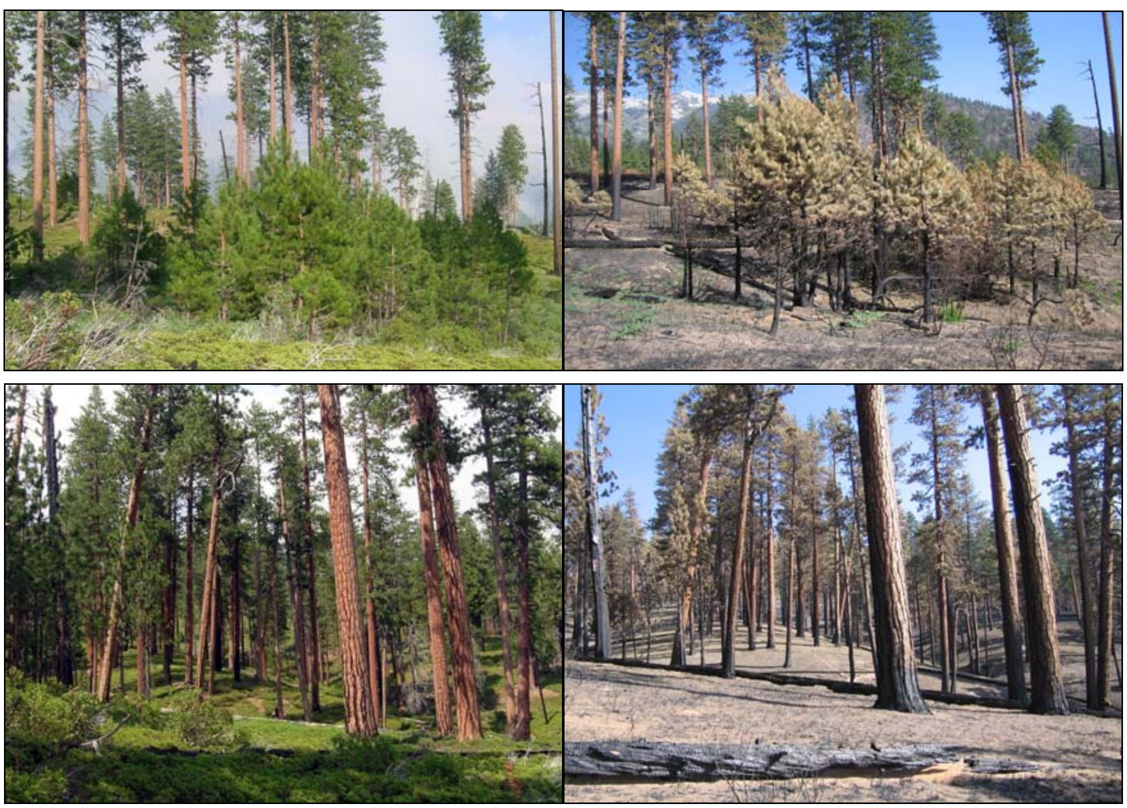

Figure 2-6. Prefire and immediate postfire images of two paired photo points (right to left) in the Comb WFU Fire showing fire effects on overstory (ponderosa pine) and understory (primarily mountain misery). The plots are shown being burned by a headfire in Fig. 4.4-1 that resulted in patches of crown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

III - Outlook for FY2007

The outlook for Fire Ecology in 2007 includes regularly scheduled rereads of about 34 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. CBI sampling will be conducted on the Roaring-Ridge and Burnt WFU fires (1,782 and 627 ac respectively) and Silver, Cabin and Upper Redwood prescribed burns (357, 435, 619 ac respectively). Because sampling of the Burnt WFU will occur adjacent to the 1968 Rattlesnake Rx (first large scale Rx fire in a western US NPS unit) we are planning to revisit plots Bruce Kilgore established in 1968 (at a minimum the original photo points will be rephotographed). Special projects will be continued (see ***Section 4.1*** for project list). Rapid assessment of cheatgrass occurrence and fire severity in Cedar Grove burn units (pre and postfire) will also be conducted. This will involve postfire sampling of the Horse Trail Rx unit and prefire sampling of the Zumwalt Rx unit. 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 in 2007 to collect data on distribution of bull thistle (***Cirsium vulgare***) and cheatgrass (***Bromus tectorum***). A substantial revision of the monitoring and research chapters in the SEKI Fire and Fuels Management Plan will be made in 2007 to bring the section up-to-date.

IV - Other Fire Ecology Accomplishments or Projects

A review of the SEKI fire ecology program was held in early 2006 and attended by staff from throughout the park (see ***Section 4.1***). The fire effects crew used the updated FEAT 2.4 software/database in both the field and office during 2006 with continued feedback given to the developers. The conversion to a new system of data collection had its ups and downs during the field season. Additionally, they were 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 Rx burn evaluations (see ***Section 4.2***). Fire ecology staff were 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 2006 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 was organized and implemented in February. The review, ***<u>Where Fire Ecology and Management Meet</u>***, was the fourth review since the Christenson Report reviewed the fire program in 1987 following the 1985 "black-bark controversy", and the first since 2000. One of the recommendations of the report 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 (see ***Appendix A*** for an agenda of 2006 review).

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.***

4.2 – Presentations, Reports, and Publications

Several presentations were given at professional meeting during 2006. Three papers were given at the Association for Fire Ecology International Fire Congress in San Diego. One incorporated data from the DEPO postfire fire effects sampling combined with more recent tree regeneration and fire history sampling in the monument. These data were used to evaluate impacts of the 1992 Rainbow Fire and make management recommendation on how fire might be used in the area in the future (an extended abstract can be downloaded from <http://www.nps.gov/archive/seki/fire/pdf/depo_rainbow-fire-fx_caprio-etal_afe2006.pdf>, also see details of the DEPO ten-year postfire report below and in ***Appendix E***). The second paper detailed findings from fire history sampling of lodgepole pine in the southern Sierra Nevada that provides an update and significant improvement in our understanding of the past fire regime in this vegetation type (an extended abstract can be downloaded from <http://www.nps.gov/archive/seki/fire/pdf/sierra_lodgepole_fire_history_caprio_afe2006.pdf >). A presentation was also coauthored with staff from the USGS Southern Sierra Field Station using data from the SEKI Fire and Fire Surrogates study sites evaluating seasonal tree mortality due to fire and bark beetles. Abstracts for all three papers are attached as appendices (***Appendix B, C, D***)

A report detailing long-term postfire changes in vegetation following the 1992 Rainbow Fire in Devils Postpile National Monument was also completed in 2006 (***Fire Effects Monitoring of the 1992 Rainbow Fire, Devils Postpile National Monument: Vegetation Response Ten Years Postfire***). The results are based on fire effects plots established immediate postfire, plus tree regeneration and fire history sampling conducted in 2004 and funded through small park NRPP funds. They suggest there may be value in restoring fire to some areas burned by the Rainbow Fire to maintain the benefits of this fire (areas of low-to-moderate severity) but that there are also some areas of high severity that should probably not be reburned since this would hinder recovery (see ***Appendix E*** for Introduction and Summary).

Two peer reviewed papers were published in 2006. One was coauthored with staff from the USGS Southern Sierra Field Station on "*Tree mortality from fire and bark beetles following early and late season prescribed fires in a Sierra Nevada mixed-conifer forest*" in **Forest Ecology and Management**, (Schwilk et el. 2006). Results showed no difference between early and late season burns with direct mortality due to fire associated with fire intensity. Probability of bark beetle attack on pines did not differ between early and late season burns, while attacks on firs were greater following early season burns. The second, *"Long-term surface fuel accumulation in burned and unburned mixed-conifer forests of the central and southern Sierra Nevada, CA"* in **Fire Ecology** (Keifer et al. 2006) utilized fire effects data from SEKI.

4.3 - Fire Ecology Projects

The Fire Ecology Program in SEKI/DEPO was directly involved in a variety of fire-related projects during 2006. 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

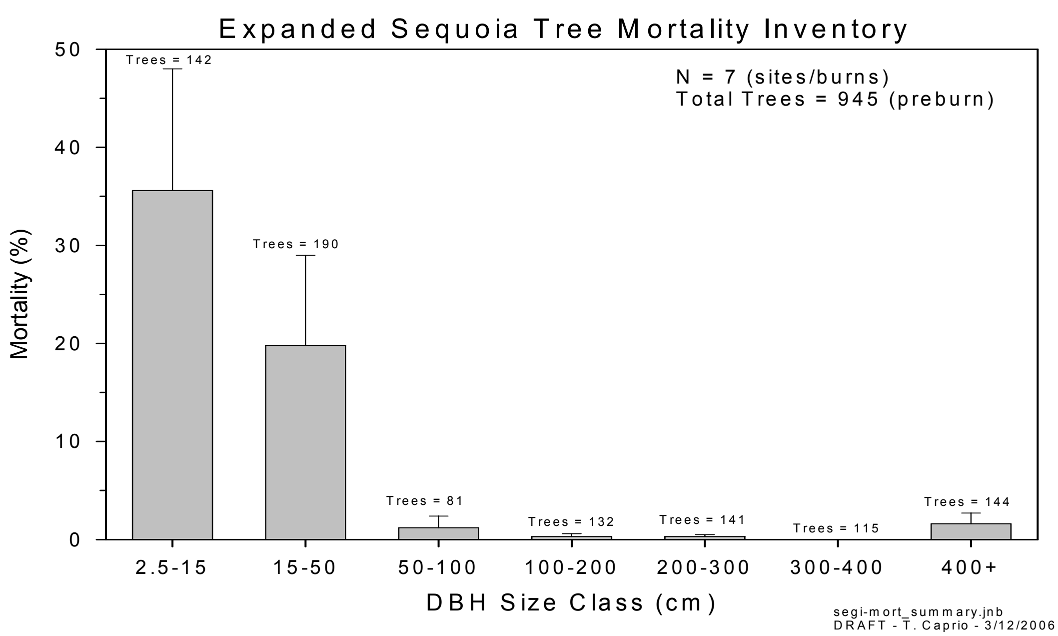

Figure 4.3.1-1. Percent mortality by diameter size class of giant sequoias following prescribed burns in Giant Forest (error bars ±1 SE).

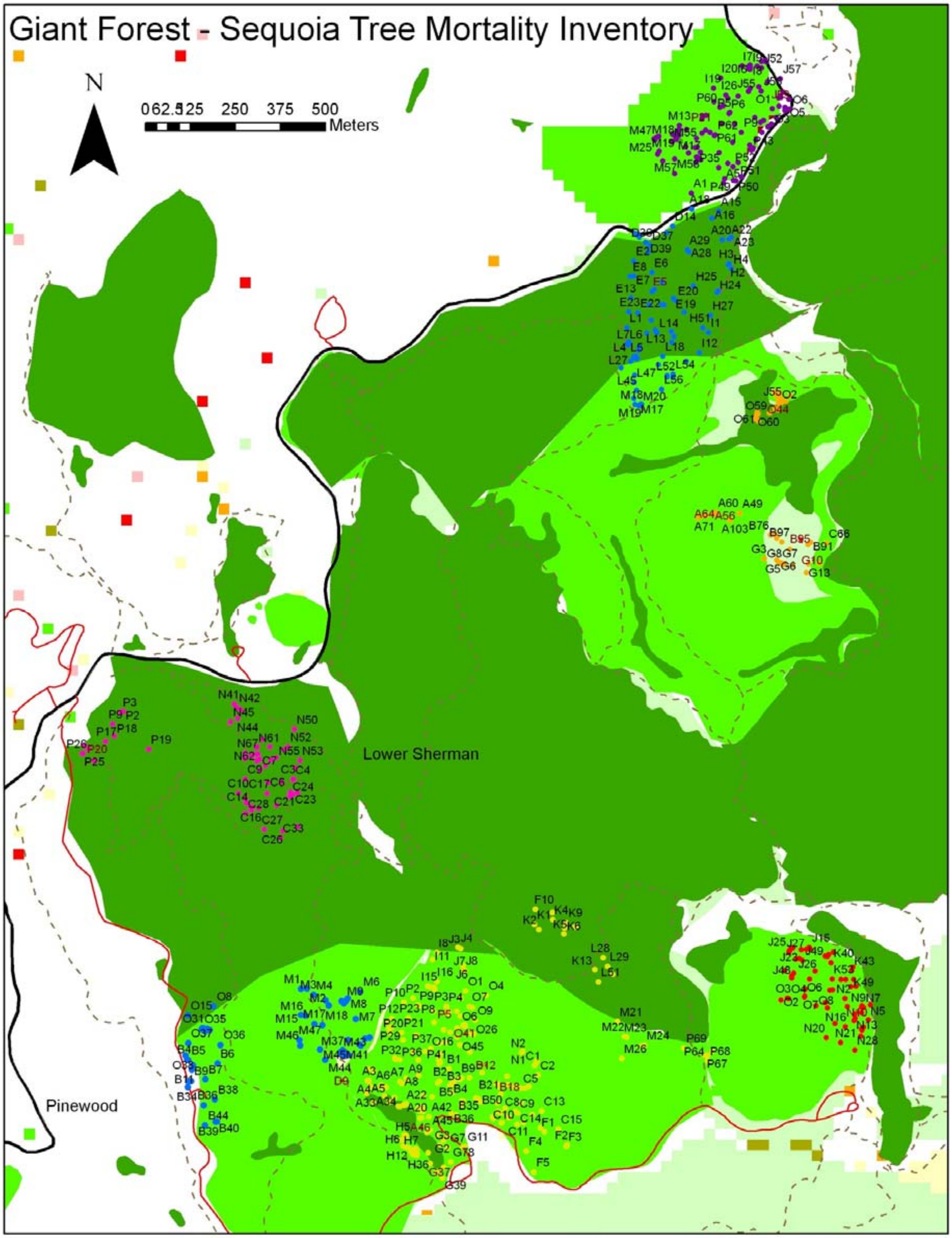

Figure 4.3.1-2. Giant sequoia mortality inventory sites and tree locations in Giant Forest used as an expanded data set for evaluating fire effects. Green shaded areas show locations of burns within the grove and labels correspond to sequoia tree inventory locations.

50 m 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 2006. Mortality has been low (<3%) in large size classes (DBH >50 cm) (***Fig. 4.3.1-1***). This information will provide sufficient sample depth to assess the long-term effects of prescribed fire on mature giant sequoia trees over a long period of time. While monitoring continues for trees currently in the study no additional giant sequoias in burn units were added in 2006. Because the current study lacks control trees that have remained unburned, to which mortality rates can be compared, three randomly located areas in Giant Forest have been selected in which all mature giant sequoia trees will be sampled. Since these areas were originally sampled in 1964 background mortality over the intervening period can be determined and compared to morality in burned areas.

(4.3.2) *Giant Sequoia Seedlings in Reburns*

There is interest in the fate of giant sequoia reproduction following second entry burns (following the initial restoration burn). Some areas of the parks where early-prescribed burning efforts were concentrated have surpassed the historic fire return interval without subsequent burning. In some of these areas, giant sequoia regeneration of varying density resulted from the initial burn. Knowledge about fire effects on these young trees following subsequent prescribed burns is important, especially given the importance of giant sequoias and their fire-dependent

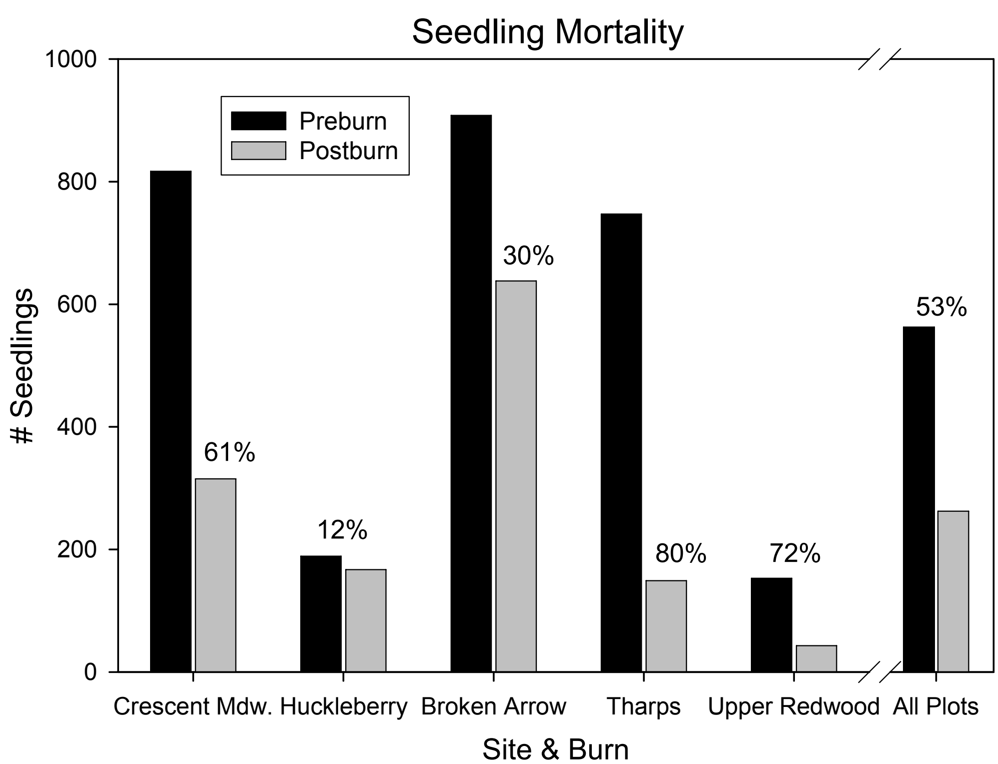

Figure 4.3.2-1. Seedling mortality following five second entry prescribed burns at five sites in Giant Forest. Average mortality for all plots pre- and postburn is shown at right

regeneration. As a result of the parks' interest in this issue, plots were installed in reburn areas beginning in 1988 (expanded in 1997) to specifically assess the reburn mortality/survival of groups of giant sequoia seedlings established after the initial burn. This information is expected to be helpful in making decisions related to reburn scheduling in other areas in the parks. In addition to continued monitoring of established sites new sampling sites (additional replicates) were established in the Redwood Mountain area during 2005. 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. Pines, including sugar pine, seem to be especially susceptible to mortality following fire. Whether this mortality is directly related to returning fire after a long absence in short-return interval regimes, or a combination of fire and other previously existing stressors, is unknown at this time. Research scientists from the USDA Forest Service Riverside Fire Lab found that removing some of the deep organic layer around trees prior to burning reduces large tree mortality in some forest types in Arizona. This type of preburn fuel removal may be an option in areas where large tree mortality is an important sociological or ecological issue.

To examine whether a difference in mortality occurs between trees with fuels removed and trees without fuels removed and also to test the practicality of fuel removal methods, 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.

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 are coarse they provide information on spatial heterogeneity of burns and how fire interacts with vegetation and topography. The quantitative measure that is mapped is "burn severity", defined 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). The question ΔNBR/CBI attempts to answer is how ecologically important are consequences of a given fire or how much has fire altered the biophysical conditions of a site. CBI ratings incorporate such factors as condition and color of the soil, amount of vegetation or fuel consumed, resprouting from burned plants, establishment of new colonizing species, and blackening or scorching of trees. The primary goal of field sampling is to capture the range of variation found within burns, covering as many fire effects and biophysical settings as possible.

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. Two burns were sampled in 2006—the 3,949 ha (3,512 ha in park) Comb WFU in Kings Canyon and Highbridge Rx units (2,337 ha) in Sequoia. A total of 79 CBI plots were sampled in 2006.

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

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, and lodgepole fire regime reconstructions.

(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 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 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 Rx Burn was the first prescribed burn back on the valley floor since 1998. This was followed in 2006 by the Horse Trail Rx. 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 at least 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

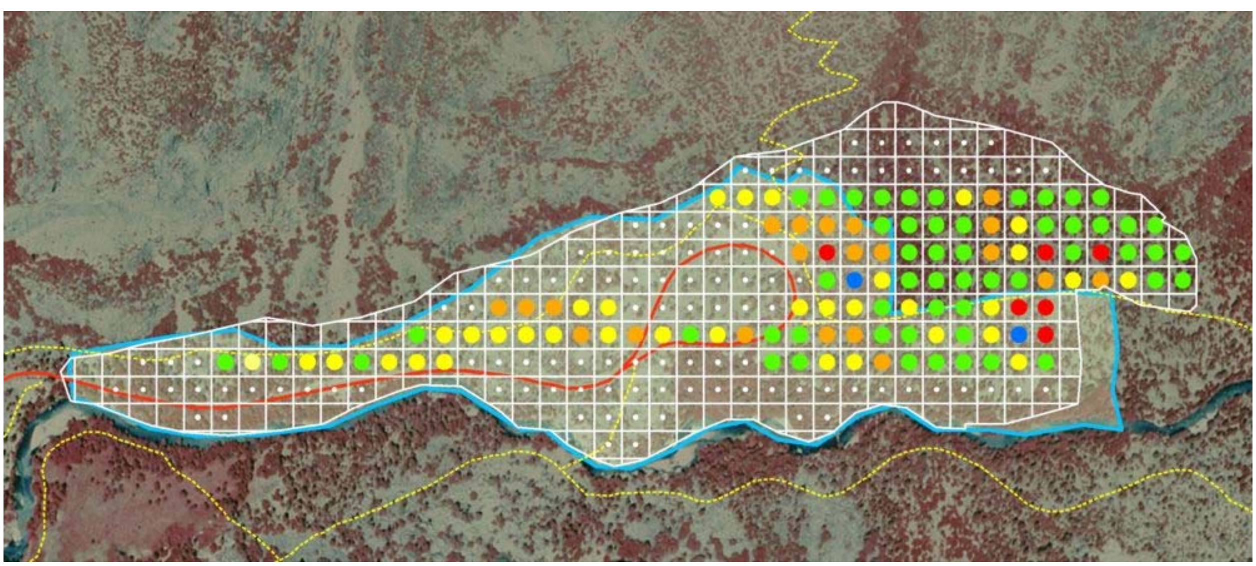

Figure 4.3.5-1. Results of preburn cheatgrass monitoring of the Roads End Rx Burn, Kings Canyon. Colored dots represent cheatgrass cover (%) detected within 50x50 m cells (green=not detected, yellow=present <1% cover, orange= 1 to <10%, red= 10 to <20%, blue= 20 to <40%). Original burn unit is outlined 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.

responses to be recorded). A crew of six (without experience) was able to collect data on ~120 cells in one work day. Horse Trail Rx sampling in 2006 was conducted with the assistance of staff from the SEKI Division of Natural Resources as an intradivisional work day.

Severity 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 (2006) of the Roads End Rx 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 due to the immediate effects of the burn. Overall, the burned area showed more cells (%) with increases and decreases than unburned areas. Longer-term responses

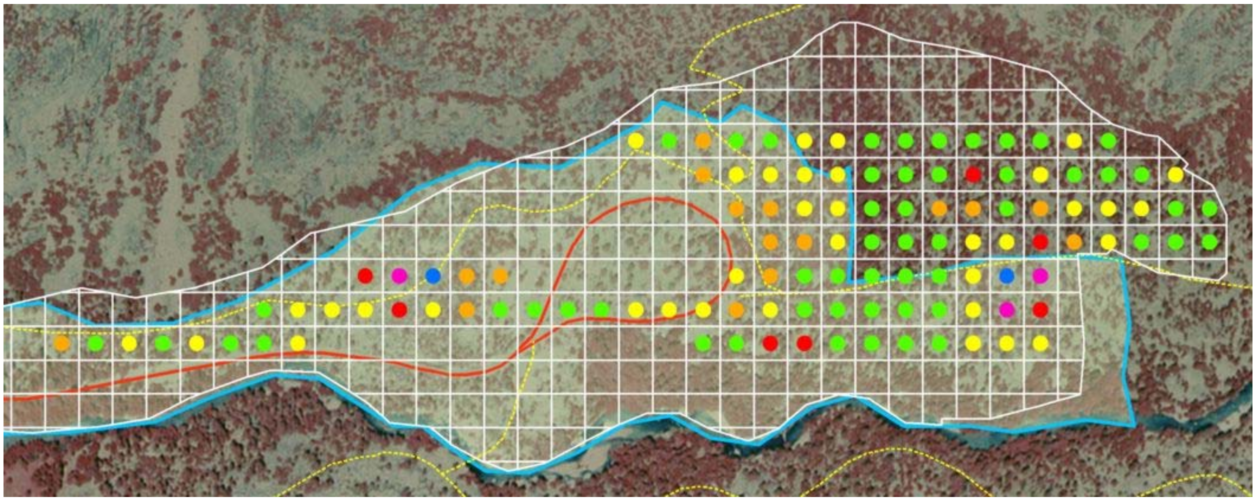

Figure 4.3.5-2. Results of postburn cheatgrass monitoring for the Roads End Rx Burn, Kings Canyon. Colored dots represent cheatgrass cover (%) detected within 50x50 m cells (green=not detected, yellow=present <1% cover, orange= 1 to <10%, red= 10 to <20%, blue= 20 to <40%, purple= ≥40%). Original burn 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.

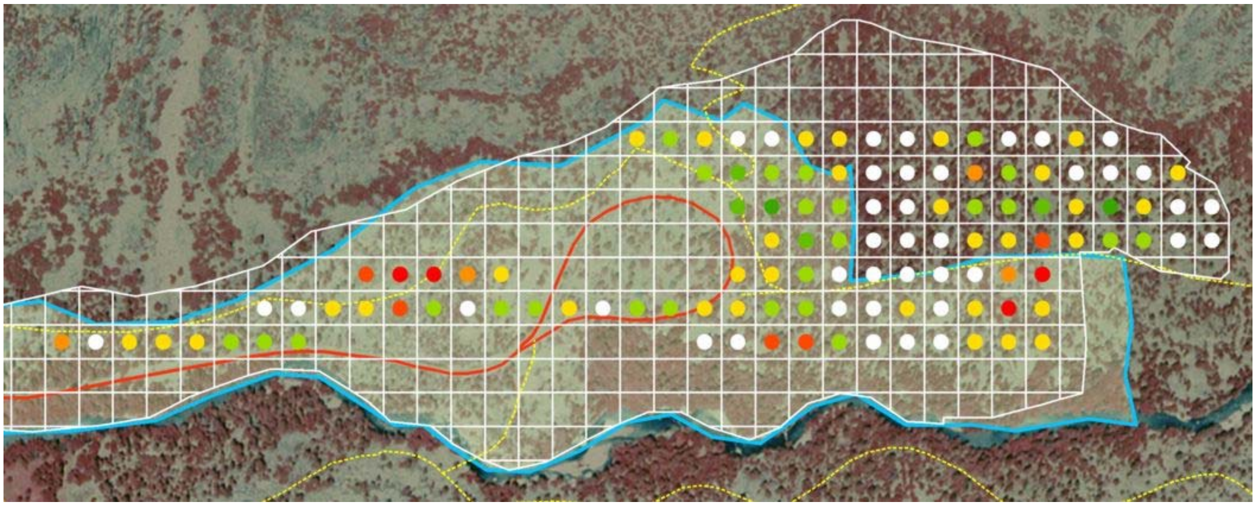

Figure 4.3.5-3. Change in cheatgrass cover from 2005 to 2006 in areas unburned and burned in 2005. Colored dots represent cheatgrass cover (%) detected within 50x50 m cells (white=no change, -0.1 to 0.1%, from 2005 to 2006, yellow= 0.1 to 5% cover increase, orange= 5 to 20%, and red= >20% increase, while 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.

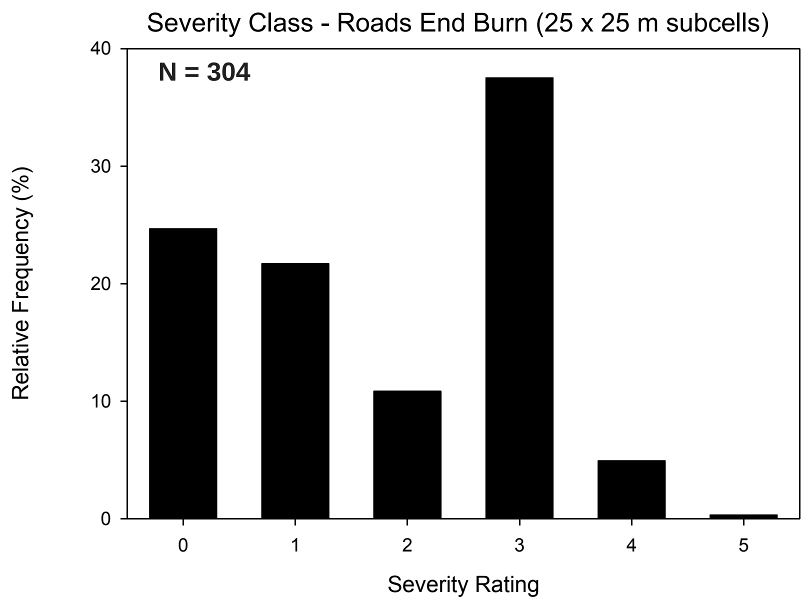

Figure 4.3.5-4. Relative proportion of sampled burned areas in Roads End Rx within each of six severity classes (from 0 or no fire evidence to 5 where complete overstory mortality occurred). Little of the unit showed evidence of high severity fire with class 3 "scorch of lower tree crowns" the most frequent.

will be further evaluated when the unit is resampled after three years (2008).

Additionally, the postfire severity data proved useful when the park received a letter criticizing 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 both fuels and tree densities are ecological objectives of the burning, important aspects of our attempts to begin returning these ponderosa pine forests back toward pre-fire exclusion conditions. The results indicate the objectives seem to be being achieved.

(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. 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

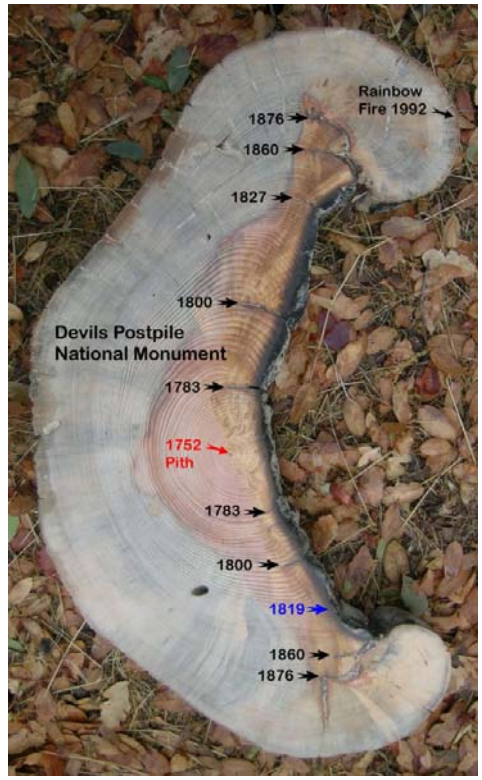

Figure 4.3.7-1. Fire history sample (cross-section from a PIJE log) collected near the southeast corner of Devils Postpile NM showing fire scars and dates of seven fires: 1783, 1800, 1819 (no scar visible on this section but found on other sections from the same tree), 1827, 1860, 1876, and 1992 (Rainbow Fire).

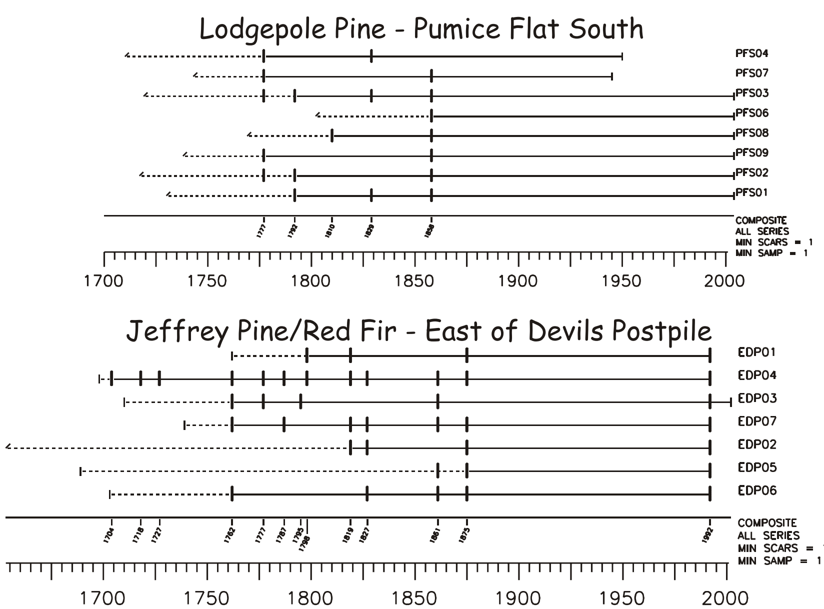

Figure 4.3.7-2. Fire history chronologies from two sites in DEPO. Greater frequency is being observed in Jeffrey pine/red fir and in lodgepole pine communities. Each horizontal line represents a single tree and the span of its record. Each vertical dash along each of these lines indicates a fire event 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 (see ***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) *Stand Structure Plots*

Forest structure has been identified in the Sequoia and Kings Canyon Fire and Fuels Management Plan (SEKI 2003) as an important component of forest communities that needs monitoring. Structural attributes could include such forest characteristics as tree density, size and age distributions, species composition, tree height, height to crown, among others. The park generally has very poor information to characterize the pre-fire exclusion range of variability of these attributes. However, some attributes of past forest structure may still be acquired if appropriate sampling sites and methods are selected. In 2006 help was made available by the DNR Chief that permitted two sites to be sampled in Sheep Creek, Kings Canyon, in mixed ponderosa/Jeffery pine-mountain misery. This is an unusual area where, what could be considered pre-EuroAmerican settlement fire regimes continued to operate through the first decade of the twentieth century (based on fire history sampling, Caprio unpublished data) so stand structure may be more representative of past conditions. The Roaring-Ridge WFU was also burning immediately upslope so it was deemed important to capture the information from the area before it was influenced by contemporary fire, particularly the loss of logs, snags and small trees (the fire was eventually held along Sheep Creek immediately below the area sampled).All trees in two half hectare plots, live and dead, were sampled and georeferenced with data collected on species, DBH, tree height (trees ≥ DBH height), height to lower crown, with each tree cored (base) to determine age (trees ≥ DBH height). A standard fire effects plot (NPS 2003) was also randomly placed within each structure plot.

4.4 - <u>Feedback to Fire Management Program</u>

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 during 2004 provided important information for plan development (they are provided in more detail in the 10 year DEPO report and 2006 Association for Fire Ecology 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 indicating that the 1992 Rainbow Fire, which resulted in large patches of complete overstory mortality, was an abnormal event. Prior to this study fire was generally thought to be rare in the area (SEKI 1982[1]) with stand replacing fires the rule. Plot data also indicated very limited tree regeneration in the high severity patches located away from seed sources with most regeneration present establishing within one or two years of the 1992 burn. As 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 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 third 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).

Direct feedback was also provided for a number of burn plans being developed in SEKI. This included development of five year burn plans. This included comments about portions of burn units that incorporated areas of vegetation that had limited fire occurrence in the past (for example, foxtail pine, western juniper, and piñon pine vegetation types) and where care needs to be used in planning so that these vegetation types are not negatively impacted. This was also useful resource input during the plan development for the 2005 Comb and 2006 Roaring-Ridge WFU fires because unusual stands of piñon pine exist on the west slope of the Sierra Nevada in this location. 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 ***Figure 4.3.5-1***) using rapid assessment sampling methods. Postfire changes were documented in the Roads End unit in 2006. This effort will continue in 2007 as burn plans are developed and implemented in Cedar Grove. Publication of results from the USGS SEKI Fire and Fire Surrogates study continues to provide valuable information for fire managers.

4.5 – SEKI/DEPO Fire Research Projects and Collaboration

This section on research projects and collaboration is been broken into three subsections; completed, current, and proposed projects (no proposed projects 2006).

[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.

(4.5.1) *Projects Completed 2005*

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

Abstract: We propose three research tasks that take advantage of a 25-year legacy of wildland fire use in the Sugarloaf-Roaring River (SRR) region of the Sequoia and Kings Canyon National Parks, California; the Illilouette Creek Basin (ICB) in Yosemite National Park, California; the Rincon Mountain Wilderness (RMW) in Saguaro National Park, Arizona; and the Gila/Aldo Leopold Wilderness Complex (GALWC) in the Gila National Forest, New Mexico using landscape-scale experimentation and simulation modeling. Individually, these tasks will address the following main research questions: 1) are there thresholds in pre-fire stand structure in ponderosa pine/Douglas-fir forests that lead to undesired levels of canopy mortality in wildland fire use operations 2) how has the introduction of wildland fire use programs in Sequoia and Kings Canyon, Yosemite, and the Gila National Forest affected the nature of fire spread in these areas over time and, 3) how do landscape composition, structure, and function vary under different fire management strategies? Together, the three proposed research tasks will quantify the effects of specific types of fires on landscape structure, composition, and function based on extensive field inventories, broad-scale ecological simulation modeling, and 25 years of well-documented wildland fire use in these four wilderness areas. No final report or review of the findings have been provided to the parks.

(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.

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

{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

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

{4.5.2.3} ***Setting Forest Structural Goals for Fire Management.*** NPS funded; PI USGS Nate Stevenson and Scott Martens; and SEKI, Anthony Caprio

Abstract: We aim to create a general approach to aid in setting quantitative and defensible forest structural goals for fire management, and apply the approach across all forest types in Sequoia and Kings Canyon National Parks (SEKI). To reach this end, this project is organized to accomplish four tasks. First, for a variety of species and forest types, we will use available age-size data (from tree cores that have already been collected) from at least ten separate studies within SEKI to determine diameter thresholds for trees likely to have established pre-1875, post-1875, and mixed pre- and post-1875 (1875 is the median date of last fire at more than 60 sites in a variety of forest types in SEKI). Second, across a range of spatial scales and by species for each of SEKI's eight forest types, we will determine the contemporary (unburned, at the time the plots were established) mean and range of densities of trees in the three key size classes determined in Objective 1. Third, we will use the combined age and density data to aid in setting forest structural restoration goals for fire management. The project is currently incomplete and inactive.

{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).

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

{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.

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. However, the pages are in need of a facelift to bring them up-to-date with current web standards.

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

V - References

Caprio, A.C. 2006. Fire history of lodgepole pine in the southern Sierra Nevada, California. Third International Fire Ecology and Management Congress. Association for Fire Ecology. Nov. 13-17, 2006, San Diego, California. 5 p. (extended abstract)

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Schwilk, D.W., E.E. Knapp, S.M. Ferrenberg, J.E. Keeley, A.C. Caprio. 2006. Tree mortality from fire and bark beetles following early and late season prescribed fires in a Sierra Nevada mixed-conifer forest. Forest Ecology and Management 232: 36–45. (full text is available at <http://jfsp.nifc.gov/documents/Schwilk_Knapp_etal_2006.pdf>).

<u>Appendix A</u>.

Where Fire Ecology and Management Meet

Sequoia & Kings Canyon NP and Devils Postpile NM
February 23, 2006

The purpose of the review is to provide an opportunity to examine and evaluate the status and future of the Parks' fire ecology program and "desired future conditions" with special emphasis on the use of and need for scientific data. This is the fourth in a series of reviews over the last 15 years that underscore the importance of periodically taking a fresh look at the program and its issues and needs.

Objectives

- Review program history and objectives.
- 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 can address primary issues in more detail.

Format

- The first section will provide context and background.
- This will be followed by series of structured presentations to ***briefly*** review and update participants on recent results and current projects related to inventory, monitoring, and research. ***Discussion will be held to a minimum***. (issues raised will be listed for later discussion)
- The third section will identify and ***briefly*** address issues. (issues raised will be listed for later discussion)
- Lastly, there will be an open discussion on the issues raised and "workgroups" developed to address primary issues and work out implementation strategies and processes in more detail.
- Bill Tweed will be the moderator.

Context

Purpose:	TBD (15 minutes)	0830
Past:		
History and past meetings	-Stephenson (15)	0845
Present:		
Current goals		
DO-18 & RM-18 Wildland Fire Management	-Bartlett/Jacobs (5)	0900
SEKI/DEPO FFMP targets	-Lyle (10)	0905
o acres		
o structure/process		
Progress in meeting goals: data & graphics	-Caprio (10)	0915
Constraints: past/present/future	-Jacobs (10)	0925
Future:		
FPA and LANDFIRE – overview	-Birkholz (10)	0935

<u>BREAK</u> **(10 min.)** **0945**

Research, Inventory and Monitoring (updates & review)

Fire and exotics:		
Cheatgrass	-Keeley and McGinnis (15)	0955

Other invasive & NASA/NPS project	-Demetry (10)	1010
Blister rust and sugar pine	-Van Mantgem (5)	1020
Season of burning – effects of prescribed versus natural fire:		
FFS JFSP study	-Keeley and Schwilk (15)	1025
Chaparral	-Keeley (15)	1040
<u>BREAK</u> **(10 min.)**		**1055**
Global climate change and fire	-Stephenson (15)	1105
Fire effects monitoring:		
FMH: Rx and mechanical + other	-Webster and Caprio (15)	1120
Fire severity mapping (remote sensing)	-Caprio and Webster (15)	1135
Monitoring special status plant species	-Haultain (10)	1150
Mapping and Geographic Information Systems:		
New vegetation map	-Haultain (5)	1200
<u>LUNCH</u> **(40 min)**		**1210**
Fire GIS – treatment analysis, fuel models	-Folger (15)	1250
Fire regimes – patterns and processes, SEKI & DEPO	-Caprio (15)	1305
Other Fire Studies:		
Retrospective analysis – JFSP & Wilderness Inst.	-Caprio (5)	1320
Setting Forest Structural Goals for Fire Mgmt	-Stephenson (5)	1325
Fire Effects on Wildlife and Aquatic systems	-Werner (15)	1330
I&M Monitoring	-Mutch (10)	1345
<u>BREAK</u> **(10 min.)**		**1355**

Desired Future Conditions

Doom and Gloom	-Stephenson (15)	1405
Fuels:		
Maintenance objectives	-Jacobs (10)	1420
Mechanical treatments – objectives	-Jacobs and Allen (10)	1430
Achieving Goals – questions and practicality:		
Practical constraints to restoring a 'natural' fire regime	-Bartlett, Allen, Jacobs (15)	1440
Prioritization of restoration burns vs maintenance burns	-Jacobs (5)	1455
<u>BREAK</u> **(10 min.)**		**1500**

Where to Now – Discussion (30-45 min.) 1510

- Issues where NPS needs USGS research
    - Ability of prescriptions to emulate natural fires.
    - Global climate change and fire
- Issues that need to be addressed by NPS
    - Target conditions
- Where does NPS go from here?
- Where to go to next with this type of meeting?

- Issue - Does the program meet the intent of RM and DO-18 and NPS Management Policies

Adjourn 1620

Breakout Groups

Below are the six topics selected for further discussion by breakout groups with Chairs and members of each group listed. Each group will provide the FMC a report at the May 9th meeting on discussion and evaluation of the issue and any recommendations.

1) *Season of Prescribed Burning*
Dylan Schwilk (chair)

2) *Ash Mountain - Prescribed Fire in Foothills Vegetation*
Leslie Uhr (chair)

3) *Restoration vs Maintenance Burning*
Ben Jacobs (chair)

4) *Mechanical Fuel Treatments*
Tony Caprio (chair)

5) *Exotics and Fire*
Athena Demetry (chair)

6) *Long-Term Issues*
Dave Graber (chair)

An additional "workgroup" will discuss and plan how to evaluate and survey "sensitive" plant species in candidate burn units. Members are: Sylvia Haultain (lead), Karen Webster, and Tony Caprio.

Appendix B – Extended Abstract 2006 AFE

LONG-TERM EFFECTS OF THE 1992 RAINBOW FIRE, DEVILS POSTPILE NATIONAL MONUMENT, CALIFORNIA. Anthony C. Caprio, MaryBeth Keifer; and Karen Webster
(available at: <http://www.nps.gov/archive/seki/fire/pdf/depo_rainbow-fire-fx_caprio-etal_afe2006.pdf>

In August 1992 the Rainbow Fire burned much of Devils Postpile National Monument (DEPO). Following many decades of fire exclusion the burn resulted in large high severity patches with complete tree mortality hundreds of hectares in size. Management questions, such as whether the effects of the fire were within the natural range of variability and whether or how fire should be reintroduced, have been raised. However, little or no information exists for the area on pre-EuroAmerican settlement fire regimes or on postfire vegetation responses to such severe burns. Using fire effects plots established postfire and tree regeneration plots, we examined fuel and forest conditions and regeneration patterns at sites burned with varying severity. Additionally, fire history sampling provided information on past fire return intervals and insights on past fire severity.

Summary - Results indicated fuels (duff and dead and down woody debris) increased substantially between 5-to-10 years postfire and were approaching prefire levels at some sites. Vegetation data indicate responses or regeneration among different burn severities can be quite varied. Understory plant cover and diversity continued to increase 10 years postburn, especially the cover of grass and shrub species (high severity sites are becoming shrub dominated). Trees were regenerating, particularly at low-to-moderate severity sites with white fir the most prevalent. Jeffrey pine was establishing at low densities in areas where high severity fire had occurred, apparently from seed that survived the fire. Regeneration was lowest in areas >100 m from surviving prefire trees where a seed source seems limited.

Fire history reconstructions showed that fire frequencies were moderate (8 to 33 years between fires) prior to EuroAmerican settlement which indicates a surface fire regime predominated during the period of record. The plot data and fire history results suggest the extent of severe overstory mortality from the Rainbow Fire was unprecedented.

Results suggest application of fire to areas of low-to-moderate severity may be beneficial for restoring more natural conditions but in the large high-severity patches, it might lead to long-term persistence of shrubs. Limited tree regeneration in these areas may be susceptible to fire caused mortality. Fire management concerns related to the postfire recovery of the Rainbow Burn include the lack of a local seed source in areas burned by moderate and high severity fire in 1992. Of particular concern are areas where large unnatural patches of overstory were killed. In these areas another fire would kill most regenerating trees and severely limit future tree establishment because no local seed source would be present. However, areas where low severity fire occurred in 1992 might benefit from a second introduction of fire. A “second entry” management fire would help maintain fuel and forest density at a pre-EuroAmerican settlement level.

Appendix C – Extended Abstract 2006 AFE

FIRE HISTORY OF LODGEPOLE PINE IN THE SOUTHERN SIERRA NEVADA, CALIFORNIA. Anthony C. Caprio
(available at: <http://www.nps.gov/archive/seki/fire/pdf/sierra_lodgepole_fire_history_caprio_afe2006.pdf >

Lodgepole pine (***Pinus contorta***) is a wide-ranging species occurring throughout much of western North America across a diverse set of habitats (Critchfield 1980). In the Sierra Nevada, fire has been described as having a minor role in the dynamics of lodgepole (var. ***murrayana***) communities unlike much of the lodgepole (var. ***latifolia***) found in the Rocky Mountains (Lotan 1976; Rundel et al. 1988; Parker 1986, 1988). Although lodgepole is one of the most widespread forest types in the Sierra Nevada, fire regimes have not been well studied and fire's role prior to EuroAmerican settlement is poorly understood (Skinner and Chang 1996). Persistence has been primarily attributed to gap phase dynamics characterized by continuous or intermittent regeneration with fires depicted as being small and infrequent. In contrast, results from two recent studies (Keifer 1991; Stephens 2001) suggest fire's role in these communities may be quite different. To more fully ascertain and quantify fire regimes in this community a suite of sites have been sampled across the southern Sierra Nevada. Preliminary results are presented here for fire history sampling in Sequoia and Kings Canyon National Parks (SEKI) and Devils Postpile National Monument (DEPO).

Summary - The frequency of pre-EuroAmerican fires found at most lodgepole pine sites was not expected. These patterns of fire occurrence and severity suggest a mixed-severity fire regime and that large stand replacing fire events were rare in the southern Sierra. Additionally, there were mixed degrees of synchronization among associated sites with strong evidence that some fires covered large areas (many hundreds of hectares). Overall, the results suggest than at least in the southern Sierra Nevada, fire played an important direct role in the dynamics of most lodgepole pine forests.

Appendix D – Extended Abstract 2006 AFE

Interactions of bark beetles and tree mortality in mixed conifer forests at Sequoia National Park. Dylan Schwilk, Eric E. Knapp, Scott M. Ferrenberg, Jon E. Keeley, Anthony C. Caprio
(available at: <http://jfsp.nifc.gov/documents/Schwilk_Knapp_etal_2006.pdf >).

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. Stand composition has also been altered as shade tolerant tree species crowd out shade intolerant species. To restore forest structure and reduce the risk of large, intense fires, managers have increasingly used prescription burning. Most fires prior to EuroAmerican settlement occurred during the late summer and early fall and most prescribed burning has taken place during the latter part of this period. Poor air quality and lack of suitable burn windows during the fall, however, have resulted in a need to conduct more prescription burning earlier in the season. Previous reports have suggested that burning during the time when trees are actively growing may increase mortality rates due to fine root damage and/or bark beetle activity. This study examines the effects of fire on tree mortality and bark beetle attacks under prescription burning during early and late season. Replicated early season burn, late season burn and unburned control plots were established in an old-growth mixed conifer forest in the Sierra Nevada that had not experienced a fire over 120 years. Although prescribed burns resulted in significant mortality of particularly the smallest tree size classes, no difference between early and late season burns were detected. Direct mortality due to fire was associated with fire intensity. Secondary mortality due to bark beetles was not significantly correlated with fire intensity. The probability of bark beetle attack on pines did not differ between early and late season burns, while the probability of bark beetle attack on firs was greater following early season burns. Overall tree mortality appeared to be primarily the result of fire intensity rather than tree phenology at the time of the burns.

Appendix E

Fire Effects Monitoring of the 1992 Rainbow Fire, Devils Postpile National Monument: Vegetation Response Ten Years Postfire

Anthony C. Caprio and Karen Webster (April 2006)
(available at: <http://www.nps.gov/archive/seki/fire/pdf/depo_fire_effects_10yr_report.pdf>)

Introduction

Prior to the mid-1800's, fire ignited by lightning, Native Americans, and on rare occasions volcanic eruptions, had an integral role in shaping the Sierra Nevada ecosystem. The attributes of an areas fire regime (such as frequency, intensity, severity, size) significantly affect plant communities by selecting for species-specific fire adaptive traits, influencing plant dominance, diversity, and mosaic patterns (i.e. spotty fire spread leading to patchy plant distribution). Fire occurrence patterns and fire severity varied among plant communities and often from drainage to drainage within the same type of vegetation resulting in a complex local mosaic (Bond and Wilgen 1996; Kilgore and Taylor 1979; Skinner and Chang 1996). Prior to EuroAmerican settlement, fires were of predominantly low- and moderate-severity and resulted in patchy tree regeneration (Kilgore 1971, 1973), although uncommon high-severity fires have been documented (Caprio et al. 1994).

Many plant communities in the Sierra Nevada have undergone dramatic changes in composition and structure since about 1860. At that time the influence of Native American populations on Sierrian ecosystems was declining and EuroAmericans began heavy grazing of nearly all accessible areas in the mountains (Dilsaver and Tweed 1990). Another more subtle influence on vegetation during this period were background changes in climate from cooler and wetter to warmer and drier (Graumlich 1993; Bradley 1999). As a result, fire's role in the ecosystem changed. Some species increased whereas others have declined. Overall, most forest comminutes have become denser although some areas of formerly dense shrubland have converted to conifer forest. Given the lag time due to the slow response of long-lived species, changes continue in some vegetation types.

Another result of fire's changing role has been the accumulation of dead material, litter and duff, causing an unprecedented buildup of surface fuels (Agee et al. 1978, van Wagtendonk 1985). The burning of these heavy surface fuels may cause severe impacts to flora and fauna. Moreover, "ladder fuels" have increased, the result of increased forest tree densities and are now capable of carrying fire into the crowns of mature trees (Kilgore and Sando 1975; Parsons and DeBenedetti 1979). One of the more immediate consequences of these changes is an increased hazard of wildfires sweeping through mixed conifer forests with severities that were rarely encountered in pre-EuroAmerican times (Kilgore and Sando 1975; Stephens 1995, 1998).

Summary and Conclusions

In August 1992 the Rainbow fire burned 82% of the monument. Most of the fire burned at moderate to high severity and dramatically affected forest vegetation (***Fig. E1***). A century of fire exclusion had resulted in increased surface fuel loads and greater forest density, with many young trees creating greater surface-to-crown fuel continuity. This led to a fire in which the magnitude and extent of moderate and high severity fire effects were much greater than would have been expected under pre-EuroAmerican settlement conditions.

Immediately postfire, fire effects plots were established in burned and unburned sites. Burn sites represented low, moderate and high severity. Although the lack of prefire data and a small sample size make the drawing of firm conclusions difficult, these data do provide a baseline for monitoring long-term postfire recover of vegetation. The results from these monitoring plots indicate that fuels (duff and dead and down woody debris) increased substantially from 5 years to 10 years postfire. Trees are regenerating, especially in low severity burn areas (but see comments about regeneration away from surviving prefire overstory trees). White fir is the most prevalent species. Understory plant cover and diversity continue to increase 10 years postburn, especially the cover of grass and shrub species. Vegetation regeneration among different burn intensity plots can be quite varied.

In burned plots there was little surface fuel or understory vegetation immediately postfire (YR00). These, however, changed rapidly on the burned plots with no change on the unburned. Litter and duff increased substantially between YR00 and YR01 (18% to 66%), which was probably the result of needle cast from scorched trees. Cover of understory vegetation increased considerably between YR01 and YR02 on burned plots (with no change on unburned) and then more slowly through YR10. Between YR02 and YR10 cover shifted from dominance by forbs to dominance by graminoids and shrubs, although diversity of forbs continued to increase and exceed graminoids and shrubs.

During the first five years (YR00 to YR05) following the fire, total fuels ($kg{\cdot}m^{-2}$) increased slowly then accelerated with a four-fold increase over the next five years (YR10). The accelerated rate of accumulation between YR05 and YR10 was attributed to the falling of dead standing trees killed by the fire, beginning to fall. Total fuel load remained about 40% of the amount recorded in unburned plots. Coarse woody debris will probably continue to accumulate at a significant rate through at least YR20 (the next scheduled sampling in 2012) as remaining standing dead snags fail.

Unburned “comparison” plots and reconstructed species composition based on standing dead snags sampled immediate postfire allowed us to assess changes in overstory tree density and tree species composition relative to fire severity. Little change occurred in the two low severity sites, but at moderate severity sites there was a substantial decline in tree density, particularly of the two fir species (*A. concolor* and *A. magnifica*). The greatest change occurred on the high severity sites were only a few *P. jeffreyi* survived. *P. contorta* survived only at the sites experiencing a low severity burn. Delayed mortality of trees through YR05 was observed at the low and moderate severity sites. Patterns of changes in basal area mirrored changes in density.

Observations of tree seedlings indicated overall good regeneration within the fire effects plots with some species by severity interactions apparent. Firs tended to be more common at low-to-moderate severity sites while *P. jeffreyi* regeneration was more pronounced at high severity sites. *Pinus contorta* regeneration was only observed at low severity sites, which indicates a lack of a seed source on sites. This also suggests non-sorotiny in the cones of this population. Observations from areas outside the fire effects plots indicate limited regeneration in many of the large high severity patches following the fire. Additional sampling of a suite of "regeneration plots" in 2004 is addressing these observations.

The data indicate that before the fire most sites had little understory vegetation (cover or number of species on shrubs or herbs) and were primarily covered by litter and duff. Following the fire understory vegetation increased dramatically between YR01 and YR02 on the burned plots, with cover, primarily of forbs, exceeding 20%. Cover continued to increase, although slowly, through YR10. Forb cover declined during this interval while the cover of graminoid and woody vegetation increased. Patterns of species numbers generally paralleled cover. However, the composition of forbs continued to diversify during this interval (as did graminoids and shrubs but to a lesser degree) as more species were found on the plots.

Fire management concerns related to the postfire recovery of the Rainbow Burn include the lack of a local seed source in areas burned by moderate and high severity fire in 1992. Of particular concern are areas where large unnatural patches of overstory were killed. In these areas another fire would kill most regenerating trees and severely limit future tree establishment because no local seed source would be present. However, areas where low severity fire occurred in 1992, or that have some seed source remaining, might benefit from a second introduction of fire. A “second entry” management fire would help maintain fuel and forest density at a pre-EuroAmerican settlement level. This is an important consideration for preventing future severe fires and maintaining fire as a process in these forest communities.

1992

1993

1994

1997

2002

Figure E1. Plot 2 classed as moderate severity (FDEPO1T08-Plot 2 photo point: Q4-Q1)