Sequoia and Kings Canyon National Parks
Fire Effects Monitoring Program - 2001 Annual Report

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EXECUTIVE SUMMARY

Highlights of recent findings:

- **Fuel reduction** objectives were met or exceeded for restoration burns in all monitoring types that have the required minimum sample size.
- **Stand densit**y objectives were met for restoration burns in the Giant sequoia-mixed conifer forest type. Other mixed-conifer forest types either do not yet have a sufficient sample size to make the assessment or do not meet stand density objectives for smaller diameter trees; conducting subsequent re-burns may help to achieve the restoration objectives in these types.
- **Giant sequoia regeneration** increases greatly following fire, while it is nearly absent in areas that have not burned in many decades. In addition, successful recruitment of postfire sequoia regeneration into larger diameter classes occurs by 10-years following fire. Subsequent re-burning of postfire sequoia regeneration leads to a mixed amount of mortality and survival that varies among patches.

PURPOSE AND HISTORY

The fire effects monitoring program is a critical component of Sequoia and Kings Canyon National Parks' (SEKI) fire management program. The purpose of the monitoring program is to evaluate the achievement of fire management objectives, to detect any unexpected or unwanted changes that may be a result of prescribed burning, and to provide this information to fire managers, other park staff, and the public.

Fuel and vegetation monitoring has been part of SEKI's fire management program for the last two decades. The monitoring program addresses fire effects on several ecosystem components (dead and downed fuel, overstory and understory vegetation). Until recently, few specific management objectives were developed for the prescribed fire program, other than those for fuel hazard reduction. To answer the question, "What would the resource look like if we achieved our goals?", target conditions are needed to describe resource goals more specifically and to serve as a standard by which to measure fire management program success. Therefore, over the last few years, park staff and local research scientists have developed preliminary target resource conditions and corresponding fire management objectives for each vegetation type where fire occurs.

Target conditions and management objectives were developed for two fire management program phases. First, restoration objectives describe structural attributes of the dominant vegetation (e.g. stand density) that apply in areas initially being treated with prescribed fire to restore conditions significantly altered by fire exclusion. Next, objectives for the maintenance phase of the program describe long-term, process-related attributes of the historic fire regime (e.g. fire frequency) and apply in areas that have not been greatly altered by fire exclusion or where conditions have been restored with prescribed fire. Corresponding monitoring objectives have also been developed to ensure an adequate method of assessing whether the management objectives are met.

PROGRAM BASICS

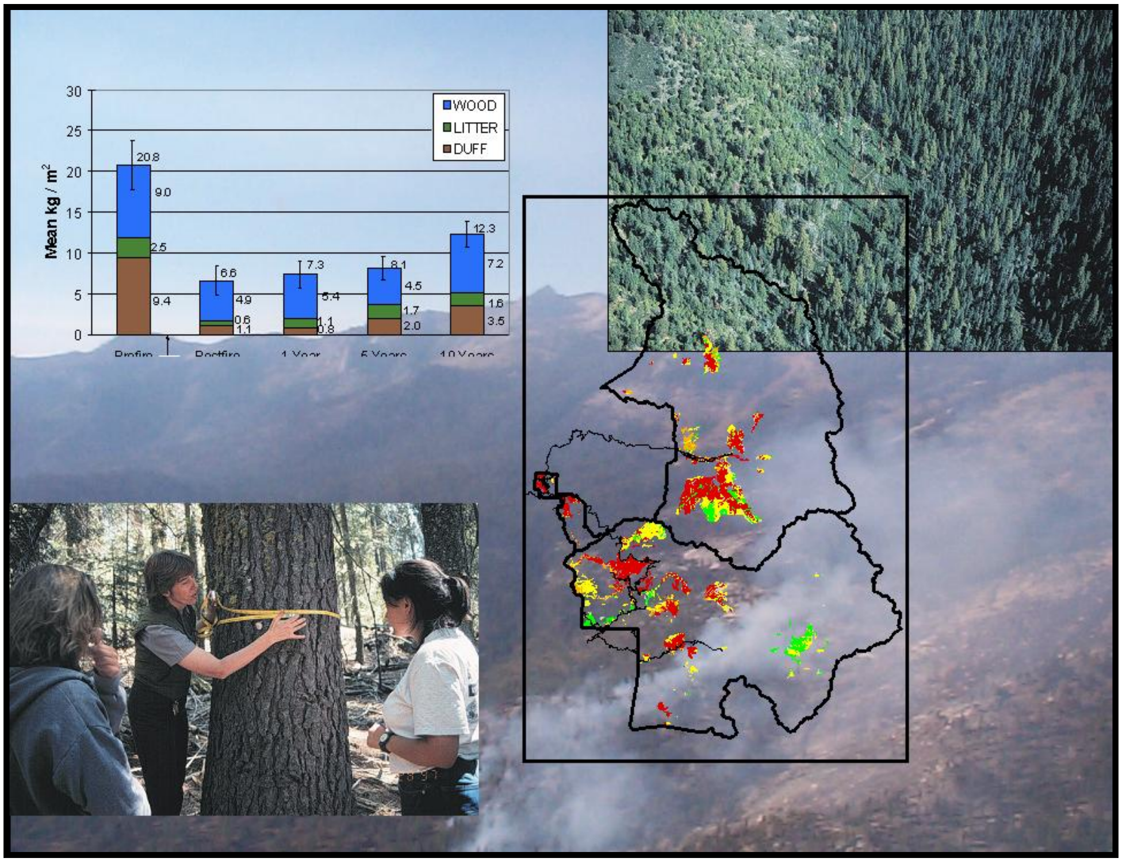
The monitoring program sampling design is intended to achieve the monitoring objectives as efficiently as possible. The vegetation and fuel monitoring methods generally follow the NPS Fire Monitoring Handbook (FMH; USDI National Park Service 2001) protocols, with some deviations because the parks' program was initiated prior to the NPS program.

Seven monitoring types occur in SEKI. Monitoring types are defined by vegetation, fuel, and site characteristics, and by burn prescriptions (the range of environmental conditions under which prescribed fires burn). The minimum sample size (number of monitoring plots) needed to meet the monitoring objectives is calculated for each monitoring type based on the variables that are defined in the management objectives. Plots are distributed using a restricted random method that randomly selects plot locations in areas scheduled for burning over the few years, while minimizing clumping of plot locations. Monitoring occurs according to the following schedule: preburn, immediately postburn (within 2 months of burning), and 1, 2, 5, and 10-years postburn, until the plot is burned again and the schedule restarts.

Attributes measured include fuel load, overstory and seedling tree density, shrub density or cover, and herbaceous vegetation cover, as well as postburn effects (bark char, crown scorch, and burn severity rating). Data collected from the monitoring plots are summarized annually after each phase in the monitoring schedule and updated results are distributed to park and agency staff and the public.

WORK ACCOMPLISHED IN 2001

Nineteen plot re-measurements were accomplished in 2001 in addition to data collected for several projects that provide supplemental information to the fire management program. No new plots were installed in 2001 because burn units where plots were planned for installation were not burned this year. Instead, additional time was dedicated to finish updating the species list, continuing the process of updating and maintaining the database, and assisting with monitoring wildland fires in the parks.



RESULTS – ARE WE MEETING OUR MANAGEMENT OBJECTIVES?

Analyses were updated to include data collected in 2001 and results were compared with objectives to determine progress towards achieving fire management objectives for each monitoring type (see Summary Table on next page). Management objectives and monitoring results are presented for the restoration phase of the program. Objectives related to the maintenance phase of the program are currently being refined and monitoring methods to address them will then be developed.

In the Summary Table below, fuel reduction objectives refer to mean reduction between preburn and immediate postburn total fuel load. Stand density objectives refer to 5-year postburn stand density. All results are presented as 80% confidence intervals of the mean. For example, if the 80% confidence interval for mean total fuel reduction is 71-81%, this means that there is an 80% probability that the true mean total fuel reduction is between 71% and 81%. There is, therefore, a 20% probability that the true mean is either less than 71% or greater than 81% reduction. If the entire confidence interval falls within the target range, there is an 80% probability that the objective has been achieved.

Summary Table. Monitoring program results showing progress towards achieving restoration management objectives by monitoring type. All results shown are 80% confidence intervals of the mean. Fuel reduction objectives/results are mean percent reduction from preburn to immediate postburn. Stand density objectives/results are for five-year postburn mean stand density. An underlined number of plots indicates that the minimum sample size has been attained for that variable.

Monitoring Type	Management Objective	Monitoring Results (80% confidence interval)	Objective Achieved?
Giant sequoia-mixed conifer forest	60-80% total fuel reduction	Total fuel reduction = 71-81% *(n=28 plots, 18 fires)*	**YES** (slightly exceeded)
	stand density: 50-250 trees/ha <80 cm DBH 10-75 trees/ha >80 cm DBH	Stand density = 174-252 trees/ha <80 cm DBH 36-49 trees/ha >80 cm DBH *(n=29 plots, 18 fires)*	**YES**
White fir-mixed conifer forest	60-80% total fuel reduction	total fuel reduction = 62-85% *(n=10 plots, 6 fires)*	**YES** (exceeded)
	stand density: 50-250 trees/ha <80 cm DBH 10-75 trees/ha >80 cm DBH	stand density = 272-356 trees/ha <80 cm DBH 28-44 trees/ha >80 cm DBH *(n=10 plots, 6 fires)*	**NO** for trees <80 cm DBH; **YES** for trees >80 cm DBH
Low elevation-mixed conifer forest	60-80% total fuel reduction	total fuel reduction = 75-93% *(n=5 plots, 3 fires)*	**YES** (exceeded)
	stand density: 50-250 trees/ha <80 cm DBH 10-75 trees/ha >80 cm DBH	stand density = 310-562 trees/ha <80 cm DBH 9-35 trees/ha >80 cm DBH *(n=5 plots, 3 fires)*	Uncertain – sample size too small
Ponderosa pine forest	60-80% total fuel reduction	total fuel reduction = 92-100% *(n=4 plots, 2 fires)*	Uncertain – sample size too small
	stand density: 50-250 trees/ha <80 cm DBH 10-75 trees/ha >80 cm DBH	stand density = 143-262 trees/ha <80 cm DBH NA >80 cm DBH *(n=4 plots, 2 fires)*	Nearly achieved
Red fir forest	60-80% total fuel reduction	total fuel reduction = 84-98% *(n=2 plots, 1 fire)*	Uncertain – sample size too small
	stand density: 50-500 trees/ha <80 cm DBH 10-75 trees/ha >80 cm DBH	stand density = 0-377 trees/ha <80 cm DBH 0-81 trees/ha >80 cm DBH *(n=2 plots, 1 fire)*	Uncertain – sample size too small
Chamise chaparral	objectives not yet defined	live chamise (*Adenostoma fasciculatum*) percent cover = 0-31.7% immed. postburn *(n=3, 1 fire)*	NA
Mixed chaparral	objectives not yet defined	live shrub percent cover = 77.9-87.1% one-year postburn *(n=2, 1 fire)*	NA

INTRODUCTION

The Sequoia and Kings Canyon National Parks' (SEKI) fire effects monitoring program had a productive season in 2001. The fire effects crew performed all scheduled fire effects plot rechecks in addition to each crew member taking 1-2 park fire assignments that varied in length from a few days to over 2 weeks. The crew also completed work on several additional projects during the 11 pay period (22 weeks) season which extended through September this year.

We continue to emphasize quality work and made improvements to our fire effects monitoring program by carrying out additional studies to obtain important fire effects information. The fire effects monitoring crew, led by their excellent supervisor, Georgia Dempsey, accomplished a great deal of work in a highly professional manner.

PLOT NETWORK INFORMATION

The total number of fire effects plots installed includes plots that were established prior to FMH protocol (Table 1). Listed separately are unburned plots and plots installed at Devils Postpile National Monument (DEPO) that were established using FMH guidelines following the Rainbow Fire in 1992 to assess post-fire changes. At SEKI, a number of plots were established pre-FMH that are identical in shape and size to FMH plots. All recommended variables were measured in pre-FMH plots, however, two of these recommended variables were measured using different methods. As these "old-style" plots reach re-burn status, all variables are measured using both the older methods as well as the FMH protocol. Both park objective variables (total fuel load and overstory tree density) are measured using methods essentially identical to FMH protocols.

TABLE 1. Plot installation by plot type.

Number of Plots Installed Previous Years				Number of Plots Installed 2001				Total Number Plots Installed			
G	B	F	Total	G	B	F	Total	G	B	F	Total
-	15	59 (20U) (8D)	74 (20U) (8D)	-	0	0	0	-	15	59 (20U) (8D)	74 (20U) (8D)

G = grassland, B = brush, F = forest
U= unburned plots
D = plots installed at Devils Postpile NM after the Rainbow Wildfire

No new plots were installed in 2001 because burn units where plots are scheduled for installation were not burned this year. Instead, additional time was dedicated to finish updating the FMH-6 species list and continuing the process of updating and maintaining the FMH database.

The number of plot remeasurements in 2002 will increase greatly from 2001 levels (Table 2). This remeasurement workload, combined with the additional project workload will make for a busy and possibly extended season for the fire effects monitors in 2002.

TABLE 2. Plot remeasurements by plot type for 2001 and 2002.

Total Plots Remeasured 2001				Total Plots to Remeasure 2002			
G	B	F	Total	G	B	F	Total
-	-	13 3 U	16 3 U	-	2 (3 P)	27 (3 P)	29 (6 P)

U = Unburned Plots

P = Immediate Postburn Remeasurements

In 2003, it appears that plot rechecks for plots *currently* installed will decrease and then plateau over the next several years (Table 3). However, other factors will have an effect on the future fire effects workload. We plan to install more plots to address fire effects in new or under-represented monitoring types. These types include the ponderosa pine and lower elevation-mixed conifer forest types, and the chaparral and oak woodland types where more burning may be planned. The projected workload does not include these new efforts (Table 3), however, they will be added to the projected workload as they are planned and installed. We will initiate monitoring in new vegetation types or increase monitoring in existing types as needed as our fire management program continues to evolve and progress.

TABLE 3. Five-year projected number of plot remeasurements by year.

Number of Plots					
2002	2003	2004	2005	2006	2007
29	13	15	13	12	14

Note: These numbers are conservative because they are based on plots currently installed and burned. They do not reflect remeasurements that will need to be done on existing or new plots that will be burned in the future.

Up to 9 new plots may be installed in 2002 for a projected total of 83 burn plots installed (Table 4). Not shown in Table 4 are an additional 38 plots that were installed early in the program immediately after fires to examine post-fire recovery and will be used only as such (ie. no preburn vs. postburn analysis). Also, 2 plots are located in a currently undefined monitoring type along a narrow roadside strip burned to prevent ignition of wildfires by motorized vehicles.

TABLE 4. Projected plot installation.

Plots to be Installed 2002				Projected Total			
G	B	F	Total	G	B	F	Total
-	0	9	9	-	15	68 (20 U)	83 (20 U)

U = unburned plots

The 2001 workload was slightly less than requested for plot remeasurements. Six plots (2 brush, 4 forest) in units that were scheduled for burning were not burned, therefore, immediate postburn remeasurements were not needed (Note: In our requests, I believe we no longer include immediate postburn remeasurements, which should eliminate this difference in the future). The workload for plot installation was also lower than what was requested; 12 plots were requested but none were installed. These plots were not installed because the units they were located in were not burned. Plot installation is more difficult to predict as burn projects may or may not get accomplished for a variety of reasons. We request the funding to cover the work in case it is needed.

TABLE 5. Workload difference between budget request and actual work accomplished.

Workload Difference in 2002			
G	B	F	Total
0	-4 (-2 I)	-2 (-10 I)	-6 (-12 I)

Numbers indicate differences in plot remeasurements unless designated I
I = difference in new plot installations

Of the plots that meet FMH standards for the parks' objective variables, 65 plots have burned, 11 of these have been treated with prescribed fire twice (Table 6).

TABLE 6. Number of plots that have burned.

Total Plots Burned 2001				**Total Plots Burned to Date**			
G	B	F	Total	G	B	F	Total
-	0	0	0	-	10	55 (11 R)	65 (11 R)

R = reburns

Of the 55 forest plots that have burned, 52 have reached one-year, 34 have reached two-year (pre-FMH plots were not visited two-years postburn), 44 have reached five-year, and 21 have reached ten-year postburn stages. Eleven plots have been reburned, seven of which reached the one-year post-reburn stage and two of which reached the two-year post-reburn stage (Table 7). A number of unburned plots have also reached each of the equivalent post-establishment stages and 11 brush plots have burned with eight reaching the two-year postburn stage and five reaching the five-year postburn stage (Table 7).

TABLE 7. Postburn plot summary.

	G	**B**	**F**	**Total**

Immediate Postburn	-	11	54	65
1-Year Postburn	-	11	52	63
2-Year Postburn	-	8	35	42
5-Year Postburn	-	5	44	49
10-Year Postburn	-	-	26	26
Reburn Immed. Postburn	-	-	14	14
Reburn 1-Year Postburn			7	7
Reburn 2-Year Postburn	-	-	8	8
Reburn 5-Year Postburn	-	-	2	2

Note: The number of plots reaching the two-year postburn stage is less than those reaching the five-year postburn stage because plots installed prior to the FMH were not usually measured two-years postburn.

The 55 standard FMH burn plots are divided among 6 monitoring types (Table 8). The Giant sequoia/mixed conifer forest monitoring type has the greatest number of plots (29), followed by White fir/mixed conifer forest (11), Red fir forest type (6), Low elevation-mixed conifer forest (5), and Ponderosa pine-dominated forest type (4). In the brush types, 5 plots are installed in the Montane chaparral, 3 plots in Chamise chaparral, and 6 plots in the Mixed chaparral.

TABLE 8. Number of plots installed by monitoring type in 2001.

Monitoring Type Code	Monitoring Type Name	Number of Plots Installed in 2001	Total Number of Plots Installed
FABCO1T08	White fir-mixed conifer forest	0	11
FABMA1T08	Red fir forest	0	6
FCADE1T09	Low elevation-mixed conifer forest	0	5
FPIPO1T09	Ponderosa pine-dominated forest	0	4
FSEGI1T08	Giant sequoia-mixed conifer forest	0	29
BADFA1D04	Chamise chaparral	0	3
BARME1D04	Mixed chaparral	0	6
BARPA1T05	Montane chaparral	0	5

PROGRAM INFORMATION

Staff Participants

Georgia Dempsey (crew leader), Darren Kane*, Joel Metcalfe*, Amy Schultz*, Teri Young*, MaryBeth Keifer (program manager).

* = seasonal employees

Length of Season

The fire effects field season was 11 pay periods in length (22 weeks). Fire effects work includes FMH training, new plot installation, plot rechecks, fire behavior observations in plots, computer data entry, and additional fire effects projects. Other work that accounted for up to 2 additional pay period per person included fire training (attending or instructing), prescribed fire project preparation, monitoring wildland fires, and assisting with other resource management programs.

TABLE 9. Number of pay periods in field season devoted to fire effects.

Monitor	Starting Date	Ending Date	Total # of Pay Periods	# of Pay Periods Devoted to Fire Effects
Georgia Dempsey	4/30/01	9/29/01	11	11
Darren Kane	5/29/01	10/27/01	11	9
Joel Metcalfe	5/29/01	9/22/01	8.5	7
Amy Schultz	5/29/01	10/13/01	10	9
Teri Young	5/29/01	9/29/01	9	7
MaryBeth Keifer	Year round	Year round		12

Changes in Protocol

No new deviations from FMH protocol occurred. A few long-standing protocol deviations remained in effect so as not to compromise long-term data consistency. The discrepancies lie primarily in the definitions of overstory, pole-sized, and seedling trees. SEKI tree size definition is as follows: overstory = trees at breast height and greater; no pole-sized trees; seedling = trees less than breast height. These categories have been maintained because: 1) they are standard parkwide definitions, and 2) they were in place prior to the FMH guidelines and long-term consistency is extremely important. The tree diameter breakdown can be changed relatively easily by data manipulation, if necessary, so that the protocol deviation only affects trees in the seedling size class. For brush monitoring types, density measurements are not recorded due to difficulty distinguishing among individuals of many species. In addition, our current efforts to develop management objectives for chaparral are focused on brush cover and not density, therefore, we will not collect brush density measurements in these areas unless our management objectives change.

Recommended Changes in Protocol

None.

Changes in Protocol following a Program Review

No program review took place this year.

Equipment Information

No new equipment information to note.

Status of Multi-Year Burn Plan

The SEKI multi-year burn plan was revised and approved on 6/1/01. The proposed burn unit boundaries have been digitized which greatly assists us in locating new plots for installation although an automated GIS method has not yet been developed.

Monitoring Plan

See the SEKI Fire and Fuels Management Plan, Appendix C, Monitoring Plan for the most current detailed information about the fire effects (fuels and vegetation) monitoring program.

PROGRAM OBJECTIVES

Fuels and vegetation monitoring has been part of Sequoia and Kings Canyon National Parks' fire management program for the last two decades. The Parks' fire effects monitoring program staff began installing permanent plots in 1982 in areas where prescribed burning was planned. Monitoring efforts first focused on the giant sequoia groves but expanded into other vegetation communities as the prescribed fire program grew.

Over the last few years, park staff and local research scientists have developed preliminary fire management objectives for each vegetation type. Corresponding monitoring objectives were then developed to ensure an adequate method of assessing whether the management objectives were met (Table 10).

Table 10. Vegetation and fuel management objectives and monitoring objectives. Restoration objectives are in unshaded cells and maintenance objectives are in shaded cells.

Variable and Vegetation Type	**Management Objective** (restatement of applicable target conditions from Table 1)	**Monitoring Objective**
Fuel Load [*restoration*] **All Forest Types**	Reduce total dead and down fuel load by 60-80% immediately following initial treatment with prescribed fire.	Measure total fuel load with a sample size sufficient to have an 80% probability of detecting at least a 40% reduction in mean total fuel load immediately postburn. A 20% chance that a change will be detected when a real change does not occur is acceptable.
Fuel Load [*maintenance*] **Mixed-Conifer Forest**	Use fire to maintain fuel load mosaic across the landscape as follows: 20-40% 5-30 tons/acre 20-50% 30-60 tons/acre 5-20% >60 tons/acre *Note: % is percent of landscape for all Mixed-Conifer Forest types.*	Measure total fuel load with a sample size sufficient to have an 80% probability of being within 25% of the true mean total fuel load for all time intervals of interest.
Fuel Load [*maintenance*] **Red Fir Forest**	Use fire to maintain fuel load mosaic across the landscape as follows: 1-25% 5-30 tons/acre 30-70% 30-60 tons/acre 5-20% >60 tons/acre *Note: % is percent of landscape in Red Fir forest.*	

Variable and Vegetation Type	**Management Objective** (restatement of applicable target conditions from Table 1)	**Monitoring Objective**
Stand Structure [*restoration*] **Mixed-Conifer Forest**	Use prescribed fire to restore mixed-conifer forest mean stand density to: 50-250 trees/ha for trees <80 cm DBH 10-75 trees/ha for trees =80 cm DBH by 5-years following initial treatment with prescribed fire. Species composition by forest type: Ponderosa pine – 50-80% pine, 5-20% fir, 10-20% cedar, 1-10% oak; White fir – 40-80% fir, 15-40% pine, 0-20% cedar; Giant sequoia – 40-80% fir, 10-40% sequoia, 5-20% pine.	Measure total tree density with a sample size sufficient to have an 80% probability that the 5-year postburn mean total density of trees <80 cm in diameter at breast height (DBH) and trees =80 cm DBH is within 25% of the true population means.
Stand Structure [*restoration*] **Red Fir Forest**	Use prescribed fire to restore red fir forest mean stand density to: 50-500 trees/ha for trees <80 cm DBH 10-75 trees/ha for trees =80 cm DBH by 5-years following initial treatment with prescribed fire. Species composition: 70-100% fir, 0-30% pine.	
Landscape Pattern [*maintenance*] **Mixed-Conifer Forest Types**	Use fire to maintain the distribution of gaps/patches across the landscape as follows: 75-95% 0.1-1 ha gaps/patches 5-25% 1-10 ha gaps/patches <1% 10-100 ha gaps/patches *Note: % is percent of landscape comprised of gaps of each size class.*	*Note: Specific monitoring methods for assessing landscape pattern objectives have not yet been developed.*
Landscape Pattern [*maintenance*] **Red Fir Forest**	Use fire to maintain the distribution of gaps/patches across the landscape as follows: 70-95% 0.1-1 ha gaps/patches 5-30% 1-10 ha gaps/patches <1% 10-100 ha gaps/patches	

Variable and Vegetation Type	**Management Objective** (restatement of applicable target conditions from Table 1)	**Monitoring Objective**
Stand Structure [*maintenance*] **Brush Types**	Use fire to maintain a shrub stand age structure mosaic across the landscape as follows: 20-30% 0-20 year old stands 40-60% 20-50 year old stands 20-30% >50 year old stands. *Note: species composition varies depending on fire return interval*.	Measure live shrub cover with a sample size sufficient to have an 80% probability of being within 25% of the true preburn mean live shrub percent cover. (*Note: This objective may be better monitored by using the time since last fire GIS layer; see Fire Regime section H; species composition may still require plot-level monitoring*).

SAMPLING DESIGN AND FIELD METHODS

The sampling design is intended to allow the program to achieve the monitoring objectives as efficiently as possible. The vegetation and fuel monitoring program generally follows the NPS Fire Monitoring Handbook (FMH; National Park Service 2001) protocols, with some deviations because the parks' program was initiated prior to the NPS program. Currently, eight monitoring types (combination of vegetation type, fuel model, and burn prescription) exist, of which seven describe the vegetation and fuels located in areas where prescribed burning occurs. One monitoring type is associated with an area burned in a WFU fire.

For each monitoring type, the minimum sample size was calculated to determine the number of plots needed to achieve the monitoring objectives. This information, along with the current plots installed and new plots planned, comprises the plot installation plan (Table 11).

Table 11. Vegetation and fuels monitoring plot installation plan.

Monitoring Type Name	Minimum Sample Size*		Current # of Plots	# of New Plots Planned	Total # of Plots Planned
	Total Fuel Reduc.	Density (<80 cm, >80cm) or % Cover			
Giant sequoia-mixed conifer forest	5	10, 9	29	1	30
White fir-mixed conifer forest	12	3, 7	11	2	13
Low elevation-mixed conifer forest	4	7, 29	5	5	10
Ponderosa pine-dominated forest	5	1, #	4	6	10
Red fir forest	#	# , #	6	4	10
Chamise chaparral	-	1	3	0	3
Mixed chaparral	-	2	6	4	10
Montane chaparral‡	‡	‡	4	0	4
TOTAL			**68**	**22**	**90**

Key:

* Minimum sample size was calculated for objective variables. In all forest types, calculations were performed for immediate-postburn total fuel reduction (precision R=25; confidence level= 80%, power=80%, minimum detectable change=40%) and 5-year postburn total tree density for trees <80 cm DBH and >80 cm DBH (precision R=25; confidence level=80%). In all brush types, calculations were performed for preburn live total shrub cover (precision R=25, confidence level=80%). Underline indicates minimum sample size has been met for that variable.

\# A minimum sample size for this category is not available because there are not enough plots or data to calculate.

‡ Monitoring type associated only with wildland fire use area; no minimum sample size calculated.

The National Park Service's Fire Monitoring Handbook (2001) methods are used for monitoring fire effects on vegetation and fuels, with some modifications due to program history and local conditions (see above section, Changes in Protocol). Monitoring plots in burn units are located randomly on a 100 x 100 meter grid within each of the vegetation types designated for monitoring. Criteria for grid point exclusion include proximity to roads/trails, riparian areas, anomalous physical or biological characteristics, and inaccessibility (both safety and time constraints). Specific location of individual plots (most geo-referenced) can be obtained from the Parks' plot location database located on the local area network (j:\data\study_sites\fire_effects).

Plots are installed in a sequence according to segments scheduled to burn. Monitoring occurs according to the following schedule: preburn, immediately postburn (within 2 months of burning), and 1, 2, 5, and 10 years postburn. Data from these monitoring plots are summarized after each step of the monitoring schedule and results are distributed to park staff and the public.

Unburned monitoring plots in other areas of the parks may be used to compare with burn program results. If existing unburned plots are not available, additional plots may be established adjacent to the project area in areas that are not currently scheduled for prescribed burning.

Additional Studies

The following studies complement SEKI's network of fire effects monitoring plots and provide additional information important to the fire management program.

Increasing giant sequoia sample size

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

Giant sequoia seedlings in reburns

The fate of giant sequoia reproduction in second entry burns (following the initial restoration burn) has become more timely. Some areas of the parks where early prescribed burning efforts were concentrated have surpassed the historic fire return interval without subsequent burning. In some of these areas, giant sequoia regeneration of varying density resulted from the initial burn. Knowledge about fire effects on these young trees following subsequent prescribed burns is critical, especially given the importance of giant sequoias and their fire-dependent regeneration. As a result of the parks' interest in this issue, plots were installed in reburn areas specifically to 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.

Sugar pine preburn litter/duff removal

Large tree mortality following prescribed fire is a concern for land managers attempting to reduce fuels and restore the process of fire in fire-dependent ecosystems. This information is especially critical in areas where fuels have accumulated following an unnaturally long fire free period due to past fire exclusion. Pines, including sugar pine seem to be especially susceptible to mortality following fire. Whether this mortality is directly related to returning fire after a long absence in short-return interval regimes, or a combination of fire and other previously existing stressors, is unknown at this time. Research scientists from the USDA Forest Service Riverside Fire Lab found that removing some of the deep organic layer around trees prior to burning reduces large tree mortality in some forest types in Arizona. This type of preburn fuel removal may be an option in areas where large tree mortality is an important sociological or ecological issue. To see whether a difference in mortality occurs between trees with fuels removed and trees without fuels removed in park forests, and also to test the practicality of fuel removal methods, fuel was removed around large sugar pines in several prescribed burn units between 1996 and 2001. In 2001, a subset of trees receiving treatments were instrumented by the Fire Lab to directly measure changes in soil and cambium temperatures resulting from fuel removal treatments.

Heavy fuel effects on giant sequoia

As a result of public concern about the visual effects of fire, giant sequoia trees located in restoration prescribed burn units were previously subject to pre-burn fuel removal treatment. Unnaturally heavy fuels had been removed around giant sequoia trees in order to limit bark char and crown scorch on trees four feet or larger in diameter. This study was undertaken to determine the relationship between the amount of heavy fuel and duff surrounding giant sequoia trees prior to burning and the resulting fire effects characteristics after prescribed burning. Sixty giant sequoias in the Atwell Grove were selected and studied prior to burning. Data collected include: in a 25 ft radius around each tree, mapping and tallying 1000-hr fuels and litter and duff depth; depth and width of all fire scars; bark char; crown scorch height; and crown scorch percent. Although the fuel clearance procedures are no longer in place, the results from this study provide information to address issues of fire effects on giant sequoia trees.

MONITORING RESULTS

Results to date are summarized below by monitoring type. All analyses were performed with data collected through and including the 2001 field season. Mean values ± an 80% confidence interval are reported. The 80% confidence interval means that there is an 80% probability that the true population mean falls within the range of the sample mean plus or minus the confidence interval width. For example, if the mean total fuel load is 20.9 ± 2.0 kg/m^2, then this means that there is an 80% probability that the true population mean total fuel load value is between 18.9 and 22.9 kg/m^2.

To use the monitoring results to determine whether specific management objectives are met, the confidence interval results were compared with the target ranges specified in the objectives. If the entire confidence interval falls within the target range, there is an 80% probability that the objective has been achieved. For a summary of fire management restoration objectives and monitoring results used to determine whether these objectives have been met, see the Summary Table on page 4.

Giant sequoia-mixed conifer forest

Fuel load

Mean total dead and down fuel load in the Giant sequoia-mixed conifer forest type was 20.9 ± 2.0 kg/m^2 preburn (93.3 ± 9.0 tons/acre) and 4.9 ± 1.0 kg/m^2 immediately postburn (21.8 ± 4.7 tons/acre) (n=29 plots; Figure 1). The mean total fuel reduction was 76%, meeting the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by an average of 57%, while a greater proportion of litter and duff was reduced (78% and 89%, respectively) by the fires. By ten years postburn, mean total fuel load was 52% of preburn levels, with wood, litter, and duff reaching 68%, 49%, and 42% of preburn levels, respectively, in this monitoring type (n=21 plots; Figure 2).

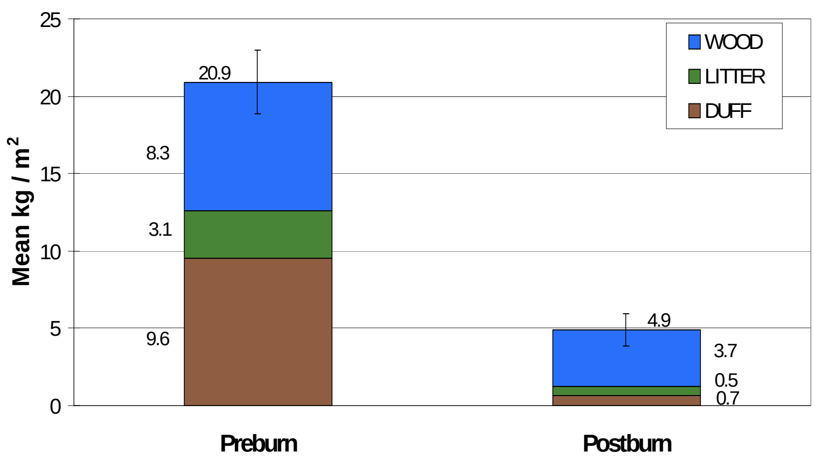


Figure 1. Fuel reduction in the Giant sequoia-mixed conifer forest type (n=29 plots).

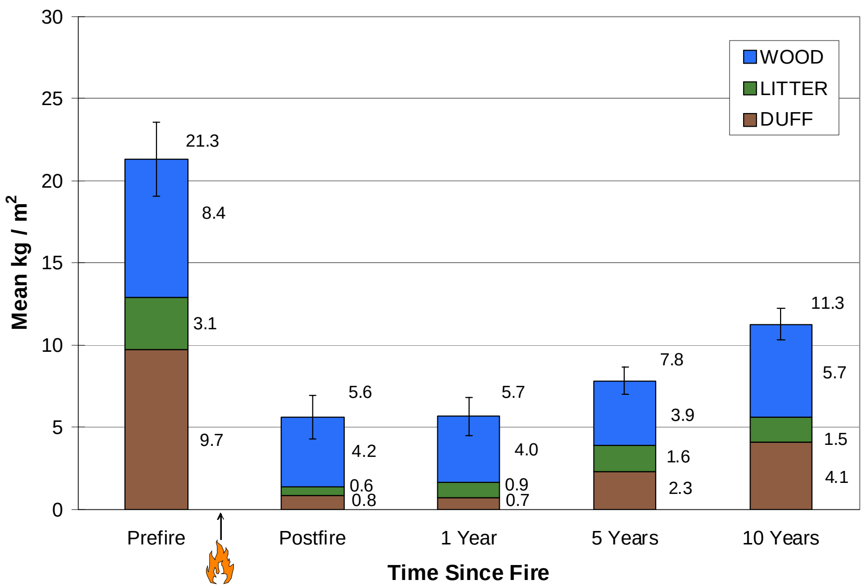


Figure 2. Fuel accumulation in the Giant sequoia-mixed conifer forest type (n=21 plots).

Four burn units containing 9 plots have been reburned in the Giant sequoia-mixed conifer forest type: one in 1996 (2 plots) that had originally burned in 1982; one in 1997 (1 plot) that first burned in 1989; one in 1998 that first burned in 1987 (2 plots); and one in 1999 that first burned in 1982 (4 plots). The 2 plots that burned in 1998 exceeded the prescription parameter for relative humidity, and, therefore, data from these plots were not included in the analyses. Mean total fuel load for the 7 plots had reached 88% of the initial preburn level 8-16 years after the initial burn (Figure 3). Woody fuels were a much larger component (117% of initial preburn level) than duff (59% of initial preburn level).

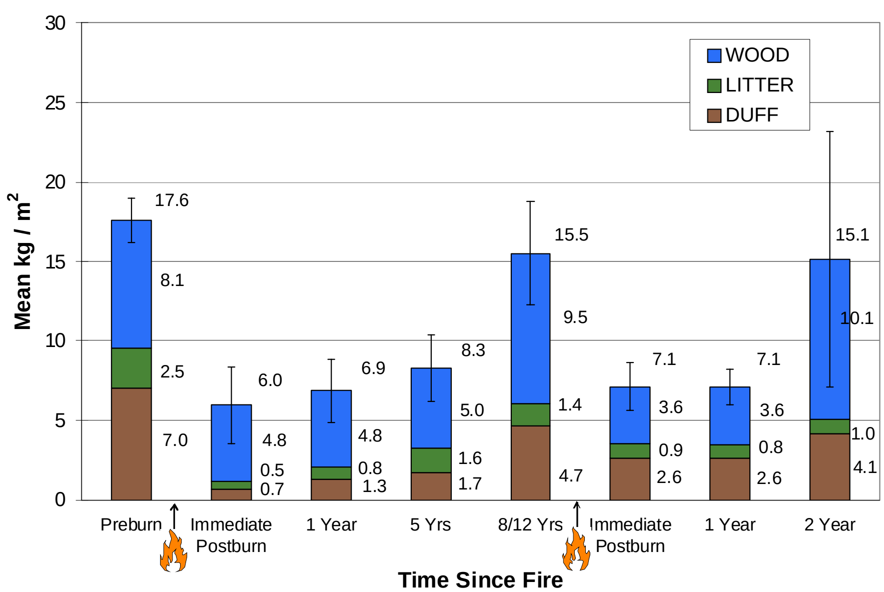


Figure 3. Fuel load in the Giant sequoia-mixed conifer forest type reburns (n=7 plots).

As a result of the re-burns, total fuel load was reduced by 48%, with a 59% reduction in woody fuel, 10% litter reduction, and a 47% reduction in duff (Figure 3). A similar proportion of woody fuel was reduced in the re-burns and in the initial prescribed fires in these 7 plots (59% and 57%, respectively). However, a much smaller proportion of duff was reduced in the re-burns than in the initial prescribed fires (47% and 89%, respectively). Two years later, the woody fuel mean has nearly accumulated to the level just prior to the second prescribed fire. While some dead trees are likely falling to the forest floor two years after the second prescribed fire, the large confidence interval indicates high variability among plots and is a result of one plot with several very large downed logs affecting the mean value.

Stand structure and composition

Mean total tree density in the Giant sequoia-mixed conifer forest type was reduced by 56% ten years following the initial treatment with prescribed fire. Tree diameter distribution changed following fire, with the ten-year postburn mean density of the smaller diameter classes much reduced from preburn densities. Trees <80 cm in diameter at breast height (DBH) were reduced by 60% from 525 ± 118 trees/ha preburn to 209 ± 35 trees/ha ten-years postburn, while trees >80 cm DBH were reduced from 45 ± 8 trees/ha preburn to 41 ± 6 trees/ha 10-years postburn (n=21 plots; Figure 4).

Species composition changed slightly over this time period, with sugar pine (*Pinus lambertiana*), incense cedar (*Calocedrus decurrens*) and red fir (*Abies magnifica*) relative density decreasing slightly while white fir (*Abies concolor*) increased slightly and the relative density of giant sequoia (*Sequoiadendron giganteum*) tripled from 7% preburn to 21% ten-years postburn. This increase was due to the successful recruitment of postburn sequoia regeneration (seedlings) into the smallest diameter class of trees (0-10 cm).

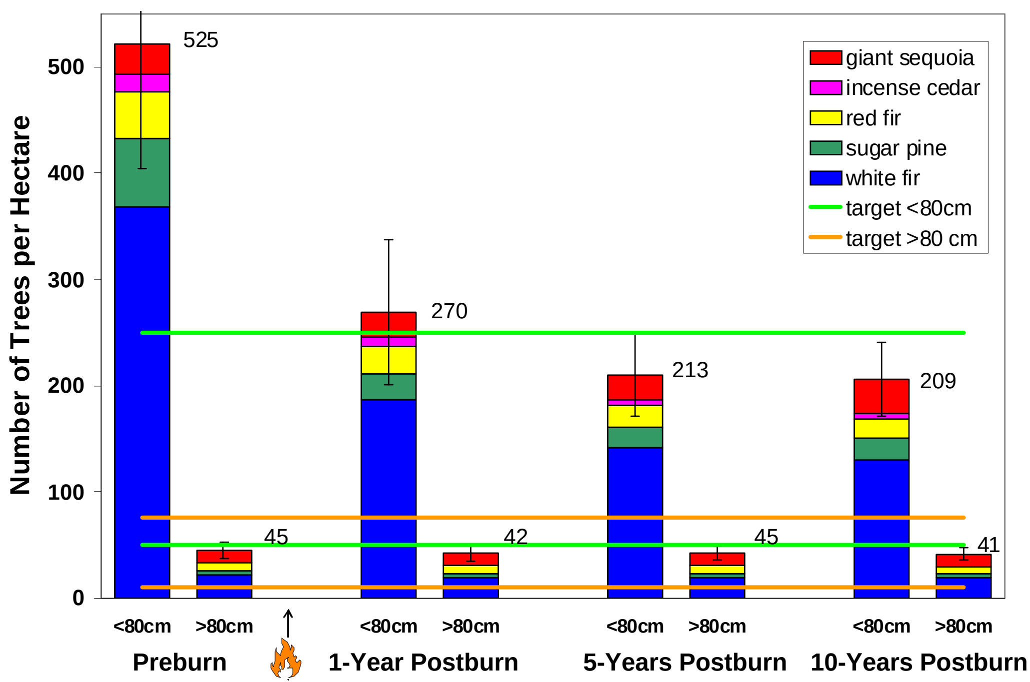


Figure 4. Stand density by species for two tree diameter classes in the Giant sequoia-mixed conifer forest type (n=21 plots).

Ir e density was

further reduced from 211 ± 26 trees/hectare 8-16 years after the initial burn down to 140 ± 28 trees/hectare 2 years after the re-burn (n= 7 plots; Figure 5). Species composition had changed dramatically in these plots 8-16 years after the initial burn (66% white fir, 26% giant sequoia), primarily as a result of a patch of giant sequoia post-burn regeneration in one of the plots.

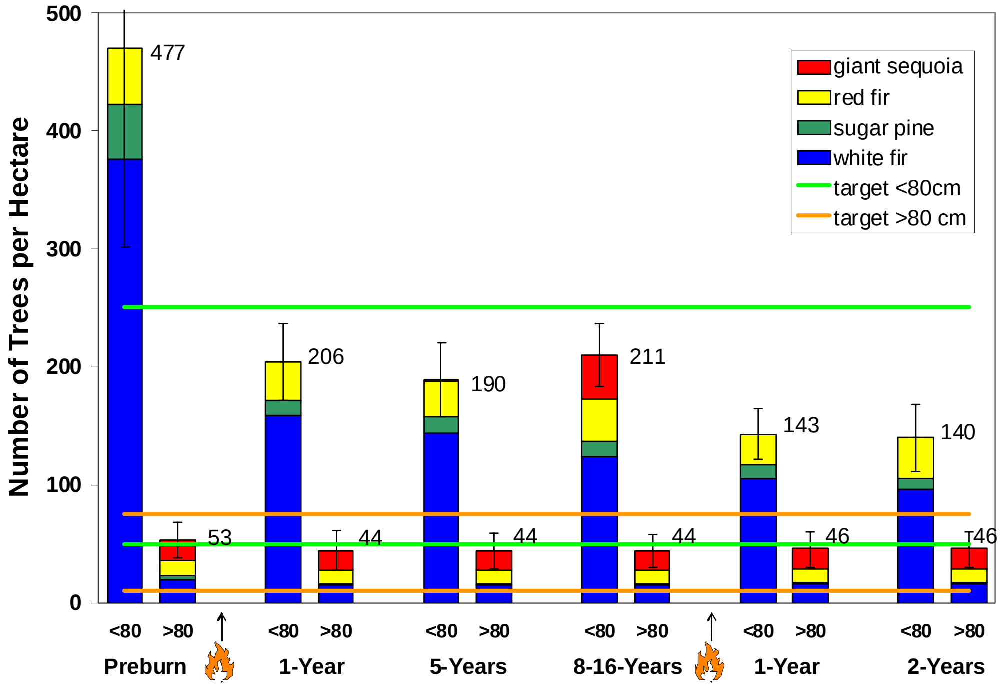


Figure 5. Stand density by species for two tree diameter classes in the Giant sequoia forest reburns (n=7 plots).

Following the repeat burn, species composition shifted back again. A single patch of small giant sequoia trees located in one of the plots was completely scorched in the re-burn. Observations from throughout the areas re-burned reveal that patches of small giant sequoia trees had widely varying levels of scorch and mortality, including some patches that were not scorched at all in which all trees survived. A study monitoring giant sequoia regeneration in re-burned areas corroborates these observations, and complete mortality in the 0-10 cm diameter class is not expected in all areas re-burned.

Management implications of results

The objective of 60-80% total fuel reduction is met in the Giant sequoia-mixed conifer forest for initial prescribed burns. Ten-years postburn, fuel load had reached 53% of preburn levels indicating reburns for fuel reduction should be considered after 10 years following the initial burns to avoid a return to heavy preburn fuel load conditions. Re-burn results show that total fuel reduction was lower in the re-burn than in the initial burn (48% and 76% respectively), and the reduction by fuel component was quite different. The fuel complex prior to the re-burns was made up of a larger proportion of woody fuel (61%) than the fuel complex prior to the initial burns (46%). A larger proportion of the woody fuel was consumed in the re-burns than in the initial burns. Fuel reduction objectives for re-burns may need to reflect the difference in fuel complex following initial burning. This change in fuel complex may also be important for predicting reduced smoke emissions in successive burns over time.

Newly developed preliminary targets for total stand density in the mixed conifer forest types are as follows: 50-250 trees/hectare for trees <80 cm in diameter at breast height (DBH), and 10-75 trees/hectare for trees >80 cm DBH. Trees 80 cm in diameter or larger indicates trees that were likely to be established prior to fire regime disruption. In all stand density figures horizontal lines indicate the preliminary minimum and maximum target density values for the two size classes (green for <80 cm and orange for >80 cm).

For 21 plots in the Giant sequoia-mixed conifer forest type, preburn mean density for trees <80 cm DBH was 525 ± 118 trees/ha, which is over two times the maximum target value. The preburn mean density of trees >80 cm DBH was 45 ± 8 trees/ha, well within the target range of 10-75 trees/ha. While reduced from the preburn value by 49%, the one-year postburn mean density of trees <80 cm DBH was still higher than the target maximum of 250 trees/ha (270 ± 68 trees/ha). By five years postburn, however, the mean density of trees <80 cm DBH was further reduced to 213 trees/ha, with nearly the entire 80% confidence interval (174-252 trees/ha) falling within the target range. The larger trees are only slightly reduced to 41 ± 6 trees/ha by ten-years postburn and remain within the target range of 10-75 trees/hectare. Five-year postburn species composition (74% fir, 9% pine, and 14% giant sequoia) falls within the preliminary target ranges for the Giant sequoia-mixed conifer forest type (see Table 10).

Most of the density reduction occurred in the smaller trees, indicating that prescribed fire may reduce the potential for spread of crown fire in these forests by thinning smaller trees and ladder fuels, while minimizing effects on larger trees (9% reduction in density from preburn to ten-years postburn). Mortality of large giant sequoia trees did not occur within the monitoring plots following prescribed burning. In addition, some recruitment of post-burn giant sequoia regeneration into the smallest diameter class indicates an increase in the relative density of giant sequoia. While a larger sample size is needed to adequately assess the effects of re-burning on stand structure, these preliminary results will be useful to evaluate progress towards meeting the parks' structural objectives (Keifer and others, 2000).

White fir-mixed conifer forest

Fuel load

In the White fir-mixed conifer forest type, mean total fuel load was 16.1 ± 3.79 kg/m^2 preburn (71.8 ± 16.9 tons/acre) and 3.4 ± 1.5 kg/m^2 immediately postburn (14.9 ± 6.8 tons/acre) (n=10 plots). The mean total fuel reduction immediately postburn was 73%, meeting the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by 61%, while a greater proportion of litter and duff was consumed (80% and 75%, respectively) in the fires. By ten-years postburn in this monitoring type, mean total fuel load was 71% of preburn levels, with wood, litter, and duff reaching 127%, 77%, and 37% of preburn levels respectively (n=6 plots; Figure 6).

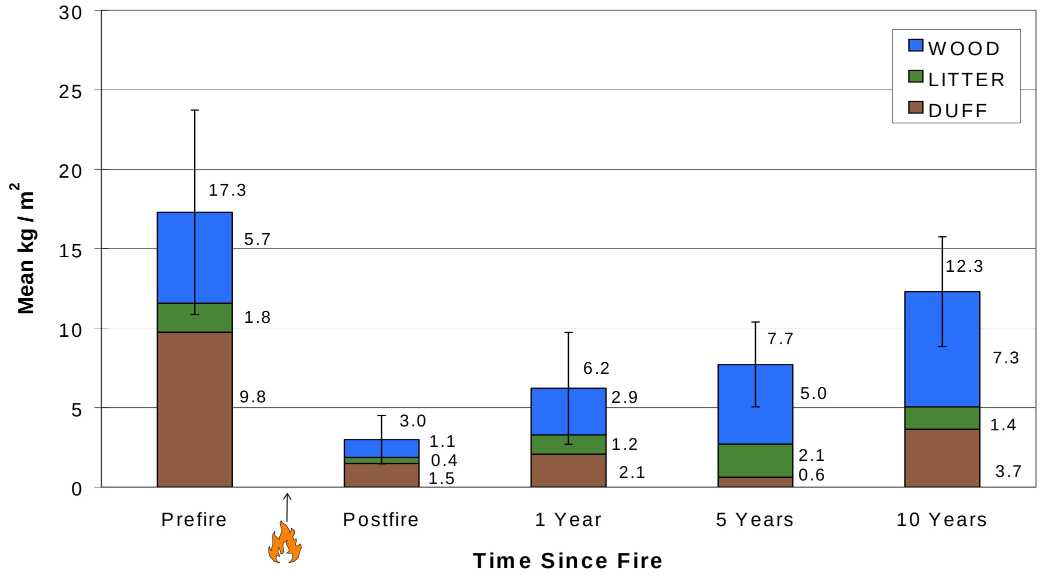


Figure 6. Fuel accumulation in the White fir-mixed conifer forest type (n=6 plots).

Stand structure and composition

Mean total tree density in the White fir-mixed conifer forest type was reduced by 55% ten years following prescribed fire. Trees <80 cm DBH were reduced from 735 ± 275 trees/ha preburn to 320 ± 50 trees/ha ten-years postburn (n=6 plots; Figure 7). Species composition changed very little over this time period, with only 1-2% increases or decreases in species' relative density. Tree diameter distribution changed greatly following fire, with the ten-year postburn mean density of the smallest diameter classes (0-30 cm) reduced by 66% from preburn densities.

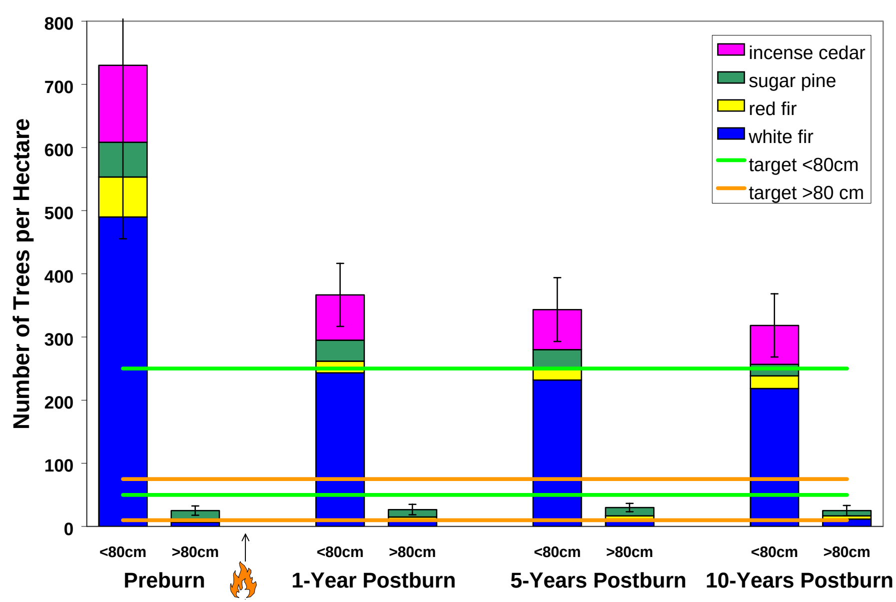


Figure 7. Stand density by species for two tree diameter classes in the White fir-mixed conifer forest type (n=6 plots).

Management implications of results

The total fuel reduction objective of 60-80% is met in the White fir-mixed conifer forest. The mean tree density for trees <80 cm DBH is 320 ± 50 trees/hectare ten-years postburn (n=6 plots), still above the target range maximum of 250 trees/hectare. The species composition target for fir is met, however, pine and cedar are under- and over-represented respectively by 7%. Mean total tree density is reduced by 55% in the White fir-mixed conifer forest type, nearly identical to the density reduction in the Giant sequoia-mixed conifer forest. However, due to a much higher pre-burn mean density in the White fir-mixed conifer forest (735 trees/ha compared to 525 trees/ha in the Giant sequoia-mixed conifer forest), the objective is not met five years after the initial burn in this type. Re-burning needs to be conducted in the White fir-mixed conifer forest to determine if small tree density will be further reduced to within the target range.

Low elevation-mixed conifer forest

Fuel load

In the Low elevation-mixed conifer forest type, mean total fuel load was 19.5 ± 5.3 kg/m^2 preburn (87.1 ± 23.4 tons/acre) and 3.1 ± 1.9 kg/m^2 immediately postburn (13.6 ± 8.3 tons/acre) (n=5 plots; Figure 8). The mean total fuel reduction immediately postburn was 84%, exceeding the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by 67%, while a greater proportion of litter and duff (both 92%) was consumed in the fires. Five-years postburn, total fuel load accumulated to 58% of preburn levels (n=5 plots; Figure 8). By five-years postburn, wood exceeded preburn levels (118%), while duff accumulated at a slower rate, reaching 19% of preburn levels.

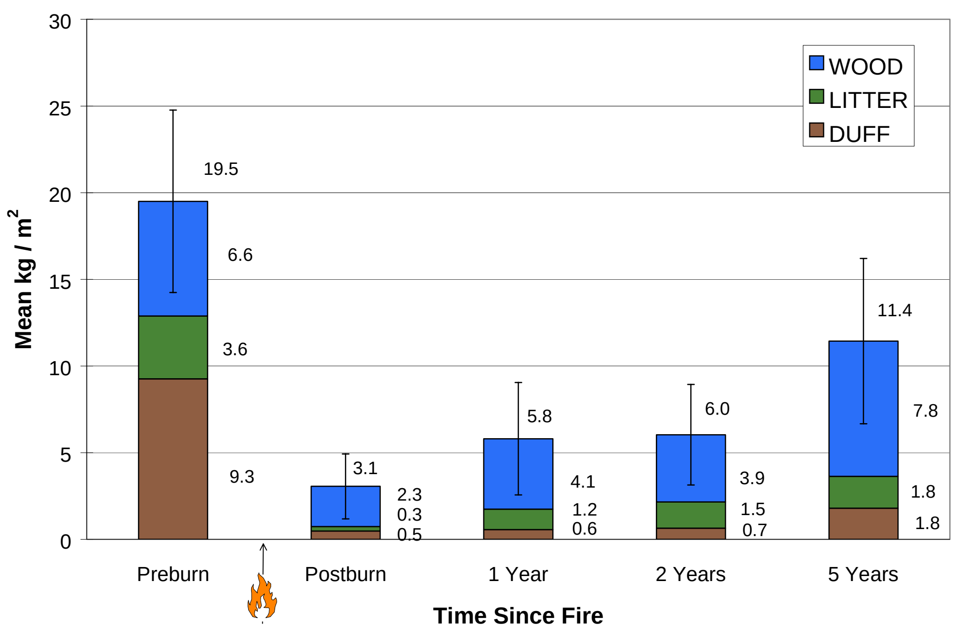


Figure 8. Fuel accumulation in the Low elevation-mixed conifer forest type (n=5 plots).

Stand structure and composition

Mean total tree density in the Low elevation-mixed conifer forest type was reduced by 63% five years following prescribed burning. Trees <80 cm DBH were reduced from 1194 ± 201 trees/ha preburn to 436 ± 126 trees/ha five-years postburn (n=5 plots; Figure 9). Some larger tree density reduction occurred in this type with trees >80 cm DBH decreasing by 48% from 42 ± 24 trees/ha preburn to 22 ± 13 trees/ha five-years postburn (Figure 9).

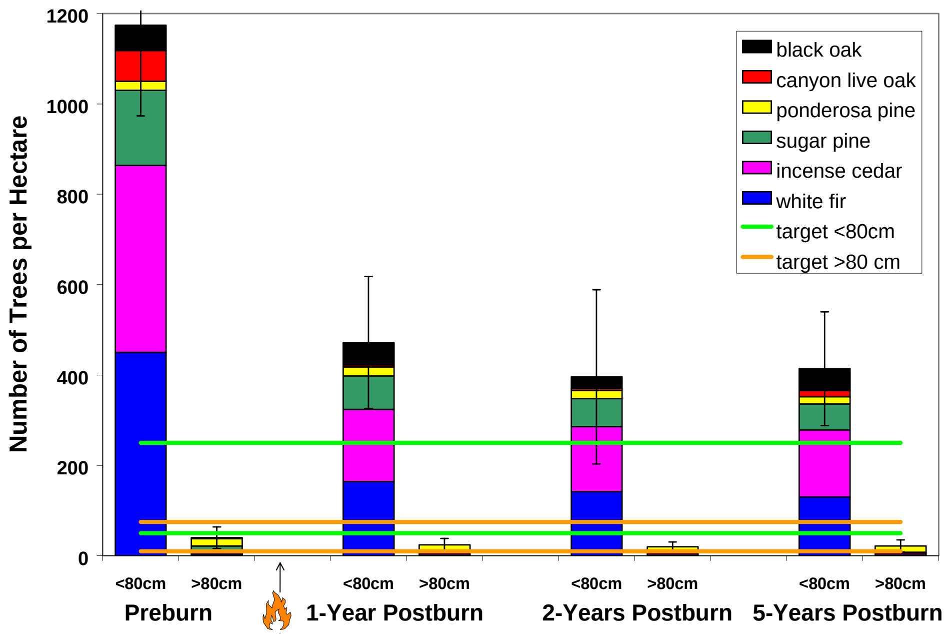


Figure 9. Stand density by species for two tree diameter classes in the Low elevation-mixed conifer forest (n=5 plots).

Management implications of results

The fuel reduction objective was exceeded in these plots and fuel accumulated faster than in other forest types, especially for woody fuels (118% of preburn woody fuel level by five-years postburn). This fuel accumulation is due to the high amount of postburn tree mortality that occurred in the plots. The mean tree density for trees <80 cm DBH is 436 ± 126 trees/hectare five-years postburn (n=10 plots), still well above the target range maximum of 250 trees/hectare and an increase in density from the two-year postburn level. Re-burns are needed to determine whether small tree density will be further reduced to within the target range. While the sample size is small in this monitoring type, data from these five-year postburn plots indicate that re-burning may be warranted sooner than in other forest types to prevent fuels from accumulating to preburn levels.

Ponderosa pine-dominated forest

Fuel load

Mean total fuel load in the Ponderosa pine-dominated forest type was 16.6 ± 4.2 kg/m^2 preburn (74.0 ± 18.7 tons/acre) and 0.4 ± 0.4 kg/m^2 immediately postburn (1.9 ± 1.8 ton/acre) (n=4 plots; Figure 10). The mean total fuel reduction immediately postburn was 96%, exceeding the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by 96%, while litter was reduced by 92% and the duff was completely consumed (100%) in the fires. Fuel accumulation occurred somewhat more slowly in the Ponderosa pine-dominated plots than in the mixed conifer forest types. Five years postburn, total fuel load accumulated to 22% of preburn levels (n=4 plots; Figure 10). Woody fuel reached 13% of preburn levels five-years postburn, while litter and duff accumulated proportionally more quickly, reaching 37% and 45% of preburn levels respectively, in this monitoring type.

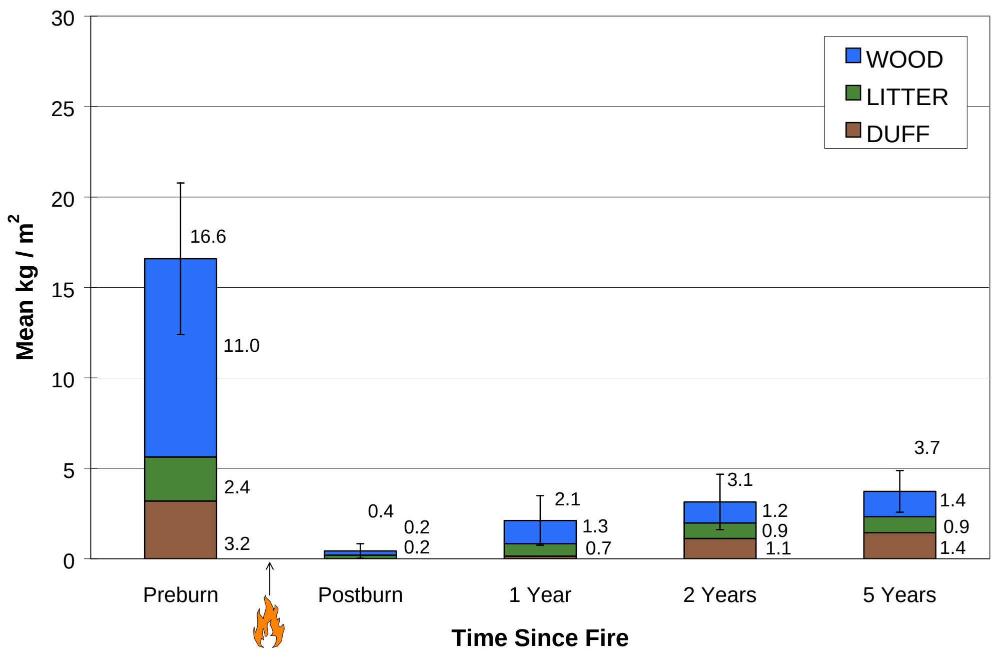


Figure 10. Fuel accumulation in the Ponderosa pine-dominated forest type (n=4 plots).

Stand structure and composition

Mean total tree density in the Ponderosa pine-dominated forest type was reduced by 66% five years following prescribed fire. Trees <80 cm DBH were reduced from 415 ± 196 trees/ha preburn to 143 ± 22 trees/ha five-years postburn (n=4 plots; Figure 11). Species composition changed slightly over this time period. The relative density of incense cedar and black oak (*Quercus kellogii*) increased by 5% each, while the relative density of canyon live oak (*Quercus chrysolepis*) decreased by 2% and ponderosa pine (*Pinus ponderosa*) decreased by 7% five-years postburn. The two ponderosa pine trees >80 cm DBH did not survive by two-years postburn.

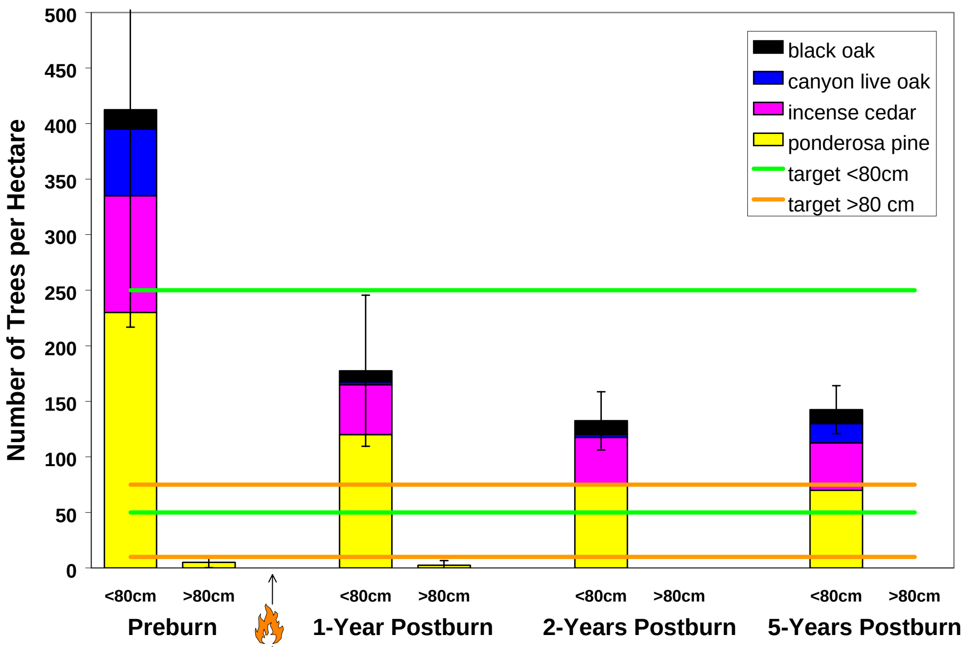


Figure 11. Stand density by species for two tree diameter classes in the Ponderosa pine-dominated forest (n=4 plots).

Management implications of results

The mortality of larger ponderosa pines following prescribed fire in this type prompted a separate study to determine the ages of the large pines killed. Data from this study has not been completely analyzed yet, but we hope to determine whether trees killed had been established before or after Euro-American settlement and resulting changes in the historic fire regime. We may also initiate a study in this forest type to determine whether removing some of the litter and duff at the base of the large tree boles reduces the amount mortality.

During the 1998 season, a dramatic increase in the abundance and vigor of cheatgrass (*Bromus tectorum*) was observed on the valley floor of Kings Canyon (comprised primarily of Ponderosa pine-dominated forest). Cheatgrass is a highly invasive, exotic species, which has impacted many areas of the west and until now, was present only in relatively small numbers within the parks. Burning in areas of dense cheatgrass has been suspended until an action plan can be developed to assess the effects that prescribed burning may have on the spread of this non-native species.

In 1998, a small area with dense cheatgrass was re-burned for research purposes and one fire effects plot was located in the area re-burned. Results from this single plot indicate that cheatgrass percent cover was 28% prior to the reburn, reduced to 3% immediately postburn, and then increased to 32% one-year following the reburn. A slight decrease to 28% cover in the plot occurred by two-years postburn. Since these results are from a single plot, no conclusions can be drawn from this information at this time; however, some additional data collected by the parks' Plant Ecologist will be examined to see if the same trend occurred. A Joint Fire Science funded project to study cheatgrass response to various treatments, including burning, was initiated this year in Cedar Grove. Results from this work will be useful in helping to determine what management actions can be taken to reduce cheatgrass in areas already invaded and to minimize the further spread of cheatgrass in the area.

Red fir forest

Fuel load

In the Red fir forest type, preburn mean total fuel load was 33.4 ± 0.9 kg/m^2 (149.0 tons/acre) and 3.0 ± 2.5 kg/m^2 one-year postburn (13.4 tons/acre) (n=2 plots). The mean total fuel reduction 1-yr postburn was 91%, exceeding the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by 97%, while 90% of duff was consumed in the fire.

By five years postburn, little fuel accumulation had occurred (17% of preburn total fuel load). Woody fuels reached 4% of preburn levels, while 30% of preburn litter and duff accumulated by five-years postburn. Note that the preburn mean total fuel load is much higher in this type than any other monitoring type (33.4 kg/m^2). When including 3 other Red fir forest plots that have not yet burned, the preburn mean is only 18.56 ± 7.33 kg/m^2. The two plots that have burned, both located on south-facing slopes, have much higher fuel loads when compared to plots located on north-facing slopes in this monitoring type.

Stand structure and composition

Mean total tree density in the Red fir forest type was reduced by 47% two years following fire. Trees <80 cm DBH were reduced from 310 ± 290 trees/ha preburn to 153 ± 88 trees/ha two-years postburn (n=3 plots). Tree density for trees >80 cm DBH were slightly reduced from 40 ± 11 trees/ha preburn to 33 ± 23 trees/ha two-years postburn. A third plot that burned in 1999 but that had not been remeasured one-year postburn is included in this analysis. Species composition changed little since this type is composed of nearly pure red fir, however, stand structure changed drastically with the density of trees <80 cm DBH reduced by half.

Management implications of results

The sample size is too small to make any general statements about implications for management at this time.

Mixed chaparral

Postburn conditions

The burn severity rating mean was 4.5 (unburned to scorched) for organic substrate and 4.0 (scorched) for vegetation indicating very low severity fire burned through these two plots.

Cover by lifeform

Mean percent cover changed only slightly for live shrubs (all shrub species combined), from 88.6 ± 20.0% preburn to 82.5 ± 4.6% one-year postburn to 86.0 ± 3.1 two-years postburn (Figure 12). Live tree (all tree species combined) and substrate mean percent cover also decreased slightly, while mean percent cover for grasses (all grass species combined) was slightly reduced one-year postburn but then returned to the preburn value two-years postburn. Substrate includes organic material (leaf litter or wood) as well as mineral soil, ash, or rock. Mean percent cover for forbs (all forb species combined) increased from 2.0 ± 6.2% preburn to 8.5 ± 23.1% one-year postburn and then a large increase to 41.5 ± 103.1% two-years postburn (Figure 12). Note that percent cover can total more than 100% as more than one lifeform (or species) can occur at a sampling point. These results indicate that the only major change in cover of vegetative lifeform categories was a large increase in forbs, however, with such a small sample size (2 plots), broad conclusions cannot be drawn from these data alone.

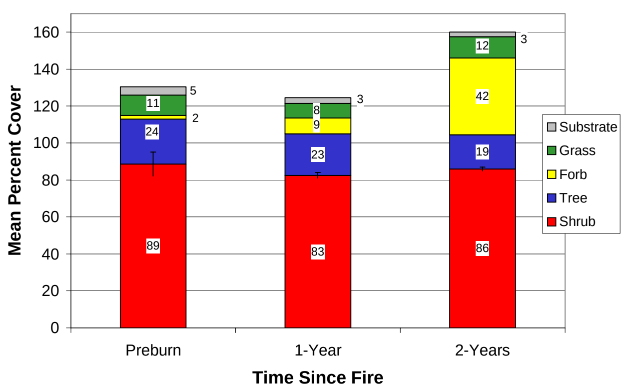


Figure 12. Percent cover by lifeform in the Mixed chaparral type (n=2 plots).

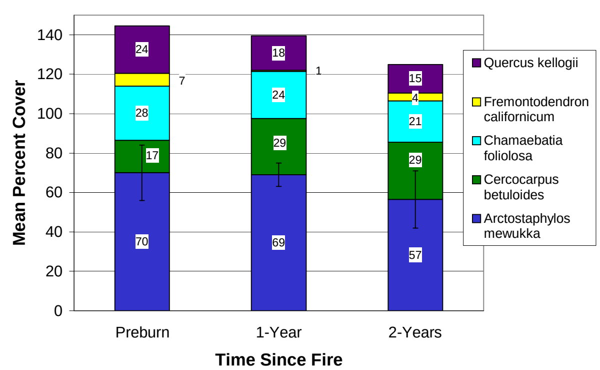


Figure 13. Percent cover by species in the Mixed chaparral type (n=2 plots).

Cover by species

Mean percent cover for live *Arctostaphylos mewukka*, the dominant species, changed very little between preburn (70.2%) and one-year postburn (69.0%) visits, but decreased by about 20% by two-years postburn (Figure 13). Black oak (*Quercus kellogii)* and bear clover (*Chamaebatia foliolosa*) decreased somewhat in mean percent cover. Flannelbush (*Fremontodendron californicum*) mean percent cover decreased one-year postburn but then increased two-years postburn (Figure 13). Mountain mahogany (*Cercocarpus betuloides*) mean percent cover increased from 16.5 ± 13.9% preburn to 28.5 ± 38.5% one-year postburn. The large increase in forbs can be attributed primarily to one species, miner's lettuce (*Claytonia perfoliata*) which was not detected preburn but had a mean percent cover of 37.0 ± 95.4% five years after the fire.

Cheatgrass (*Bromus tectorum*), a highly invasive exotic grass, was found within these plots before burning. The mean percent cover of cheatgrass decreased slightly, from 2.5 ± 1.5% preburn to 1.5 ± 4.6% one-year postburn but then increased to 4.5 ± 4.6% two-years postburn. The sample size is too small to make any conclusions about changes observed in cheatgrass cover following burning.

Management implications of results

Newly developed target conditions for brush monitoring types are stated in terms of the amount of landscape within a certain shrub age class. These targets have not yet been more defined into specific objectives for a monitoring type. Although the sample size is small (2 plots), little change in shrub cover was observed in the two plots as a result of the low severity of the burn. If a reduction in shrub cover is desired, fire severity will need to be higher in this brush type.

Chamise chaparral

Postburn conditions

The burn severity rating mean for both organic substrate and vegetation was 1.9, indicating that the estimate of severity ranged from moderately to heavily burned.

Cover by lifeform

Mean percent cover for live shrubs (all species combined) decreased by 84% from 93.0 ± 6.6% preburn to 15.0 ± 28.3% postburn. An increase to 26.0 ± 25.6% one-year postburn and 63.0 ± 14.6% indicates that vigorous postburn resprouting occurred and continues to grow (Figure 14). A corresponding increase in mean percent cover of substrate occurred immediately after burning, from 7.0 ± 3.5% preburn to 74.0 ± 16.1% postburn indicating that much of the vegetative cover was consumed during the burn. Two years since the burn, substrate mean percent cover was quickly reduced to an average of 20.0 ± 6.6% (Figure 14).

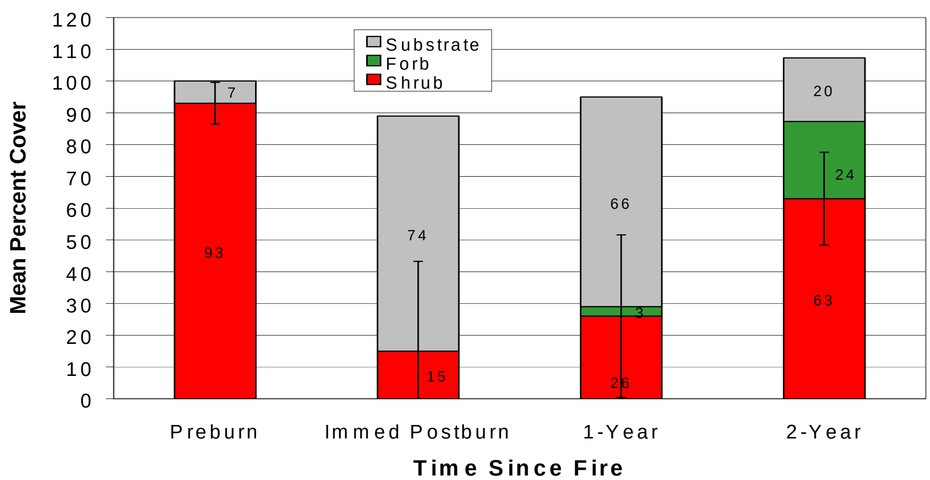


Figure 14. Percent cover by lifeform in the Chamise chaparral type (n=3 plots).

Cover by species

Mean percent cover for live chamise (*Adenostoma fasciculatum*), the dominant species, was reduced by 88% from 90.3 ± 11.6% preburn to 11.0 ± 20.7% postburn (Figure 15). Mean percent cover increased to 25.3 ± 16.4% one-year postburn and 48.7 ± 23.5% by two-years postburn. *Arctostaphylos mewukka* mean cover increased slightly, between the preburn and immediate postburn measurements, likely due to slight differences in transect location from one visit to the next (an artifact of sampling). Two-years postburn, mean percent cover of *Cryptantha muricata* and bush poppy (*Dendromecon ridgida*) was 24.3% and 15.3%, respectively, and neither species had been recorded in the plots prior to the burn.

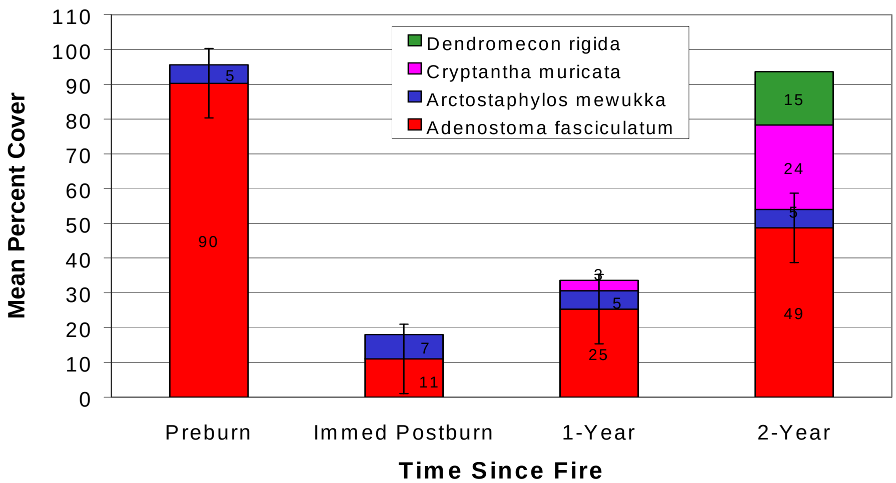


Figure 15. Percent cover by species in the Chamise chaparral type (n=3 plots).

Management implications of results

Newly developed target conditions for brush monitoring types are stated in terms of the amount of landscape within a certain range of shrub cover. These targets have not yet been translated into specific objectives for a monitoring type. The park staff recognizes the need for burning in chaparral to reduce fuel hazard and to restore fire to vegetation communities where fire has historically been an important component. Shrub cover in the Chamise chaparral type was greatly reduced immediately postburn but the shrub cover is quickly recovering. With continued monitoring over time, the subsequent increase in shrub cover and any changes in species composition will be measured.

Montane chaparral

Cover by lifeform

Live shrub cover (all species combined) was reduced from 68.3 ± 10.6% preburn to 0.5 ± 0.5% one-year postburn, increased to 2.3 ± 1.4% two-years postburn followed by a large increase to 18.0 ± 6.0% by five-years postburn (n=4 plots; Figure 16). Forb and grass cover increased steadily from 0.2 to 24.8% and from 9.0 to 52.0%, respectively, from preburn to fives years following fire. Species that decreased in percent cover include greenleaf manzanita (*Arctostaphylos patula*) and sagebrush (*Artemesia tridenta*). While mountain whitethorn (*Ceanothus cordulatus*) decreased slightly in the first years following fire, a large increase occurred by five years postburn. Western needlegrass (*Achnatherum occidentalis*), blue wildrye (*Elymus glaucus*), and broad-leaved lotus (*Lotus crassifolius*) all increased in relative cover.

These plots were all opportunistically located within one prescribed natural fire, therefore, results do not apply to other areas that may fit the monitoring type description. Specific objectives do not exist for Montane chaparral because it is not a monitoring type where prescribed burning has historically occurred.

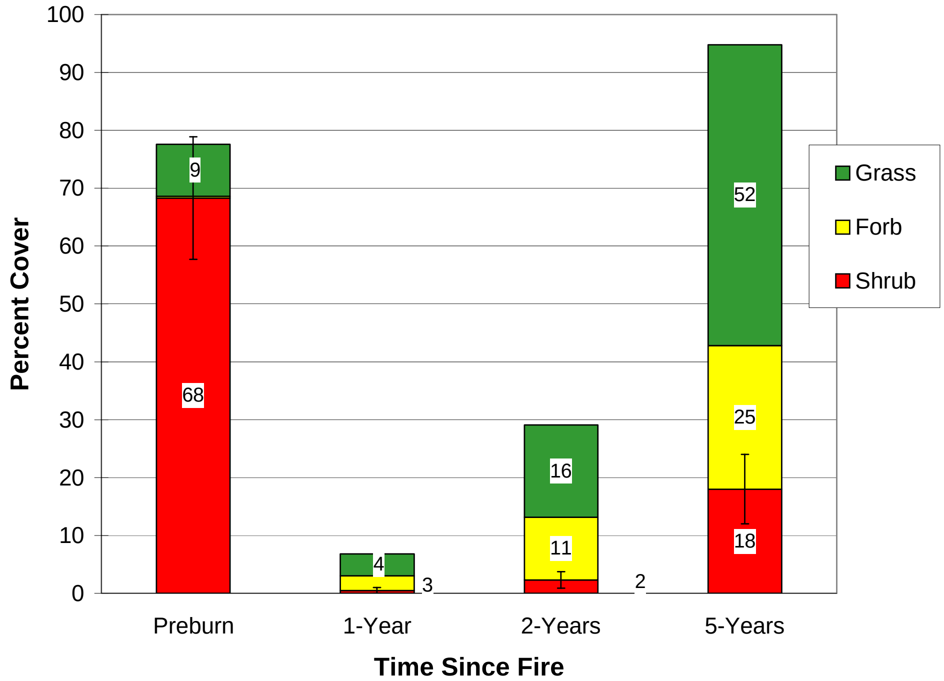


Figure 16. Percent cover by lifeform in the Montane chaparral type (n=4 plots).

APPENDIX A – PLOT DISTRIBUTION

Table 12. Plot distribution by burn unit and monitoring type.

Burn Unit Year Burned	Monitoring Type							
	FABCO 11 plots 7 fires	**FCADE** 5 plots 3 fires	**FPIPO** 4 plots 2 fires	**FSEGI** 30 plots 18 fires	**FABMA** 6 plots 4 fires	**BADFA** 3 plots 1 fire	**BARME** 6 plots 2 fires	**BARPA** 4 plots 1 fire
Hercules 1982,*1999	-	-	-	*1,2,3,4	-	-	-	-
Fire Class 1984,*1996	13,14	-	-	11*,12*	-	-	-	-
Garfield 1985	-	-	-	22	-	-	-	-
Muir PNF 1986	34	-	-	30	-	-	-	
Upper Garfield 1986	-	-	-	32	-	-	-	-
Keyhole 1987,*1998	-	-	-	15,24*	-	-	-	-
Tharps 1987,*1998	-	-	-	42*,43	-	-	-	-
Halstead 1987	44,45	-	-	-	-	-	-	-
Buckeye WF 1988	26	-	-	-	-	-	-	-
Huckleberry 1989 ,*1997	53*	-	-	52*	-	-	-	-
Crystal 1989	-	60	-	-	-	-	-	-
Tharps 1990	-	-	-	68	-	-	-	-
Highway 1990	-	-	-	79,80	-	-	-	-
Suwanee 1990	-	-	-	69	-	-	-	-
Grant West 1990	-	-	-	74	-	-	-	-
President SMA 1991	-	-	-	81	-	-	-	-
Tharps 1991	-	-	-	82	-	-	-	-
Deer Creek PNF 1991	-	-	-	87,88	-	-	-	-
Grant West 1992	-	63	-	72,73,75	-	-	-	-
Suwanee 1992	76,77,78	-	-	70,71	-	-	-	-
Picnic Estates 1993,*1999	-	-	89*	-	-	-	-	-

Burn Unit Year Burned	Monitoring Type							
	FABCO 11 plots 7 fires	**FCADE** 5 plots 3 fires	**FPIPO** 4 plots 2 fires	**FSEGI** 30 plots 18 fires	**FABMA** 6 plots 4 fires	**BADFA** 3 plots 1 fire	**BARME** 6 plots 2 fires	**BARPA** 4 plots 1 fire
Hole-in-the-Wall 1993	-	-	90,91 92	-	-	-	-	-
Empire PNF 1994	-	-	-	-	-	-	-	B2,3,4,5
Swale 1995	-	62,65	-	-	-	-	-	-
MK – Atwell 1995	-	94	-	93,95	96,97	-	-	-
MK - Lookout 1997	-	-	-	-	-	B12, 13,14	-	-
MK - Redwood 1997	-	-	-	-	-	-	B10,11	-
MK - Tar Gap 1999	-	-	-	-	101	-	-	-
MK - Redwood	-	-	-	-	-	-	B7,8,9, 15	-
MK - Tar Gap	-	-	-	-	100,102?	-	-	-
MK - Upper Deadwood	105	-	-	-	-	-	-	-
Wuksachi	-	-	-	-	103	-	-	-

Note: numbers indicate the FMH plot number; MK = Mineral King.

APPENDIX B – Fuel Reduction by Monitoring Type and Fuel Size Class

Monitoring Type	Size Class	Average Fuel Load (tons/acre) Preburn	Postburn	% Reduction
ponderosa pine-dominated forest (n=4 plots)	1-hr	0.0	0.0	-
	10-hr	0.5	0.0	100%
	100-hr	1.2	0.0	100%
	1000-hr	47.1	1.0	98%
	litter	10.8	0.9	92%
	duff	14.3	0.0	100%
	total	**74.0**	**1.9**	**97%**
low elevation-mixed conifer forest (n=5 plots)	1-hr	0.3	0.1	67%
	10-hr	0.9	0.2	78%
	100-hr	2.0	0.8	60%
	1000-hr	26.4	9.2	65%
	litter	16.2	1.1	93%
	duff	41.3	2.1	95%
	total	**87.1**	**13.6**	**84%**
white fir-mixed conifer forest (n=10 plots)	1-hr	0.5	0.1	80%
	10-hr	2.0	0.6	70%
	100-hr	2.0	1.0	50%
	1000-hr	18.9	7.0	63%
	litter	8.9	1.6	82%
	duff	39.4	4.7	88%
	total	**71.8**	**14.9**	**79%**
giant sequoia-mixed conifer forest (n=28 plots)	1-hr	0.4	0.1	75%
	10-hr	1.4	0.4	71%
	100-hr	2.8	0.6	79%
	1000-hr	32.4	15.3	53%
	litter	13.6	2.3	83%
	duff	42.7	3.0	93%
	total	**93.3**	**21.8**	**77%**
red fir forest (n=3 plots)	1-hr	1.3	0.2	85%
	10-hr	4.0	0.2	95%
	100-hr	4.5	0.1	98%
	1000-hr	48.2	3.5	93%
	litter	8.0	3.7	54%
	duff	57.4	15.0	74%
	total	**123.3**	**22.8**	**82%**
reburn giant sequoia-mixed conifer forest (n=7 plots)	1-hr	0.6	0.2	67%
	10-hr	1.8	0.8	56%
	100-hr	3.1	0.7	77%
	1000-hr	36.7	14.5	60%
	litter	6.1	3.9	36%
	duff	20.9	11.9	43%
	total	**69.1**	**31.9**	**54%**

APPENDIX C - Recent Publications

van Mantgem, P., M. Schwartz, and M. Keifer. 2001. Monitoring fire effects for managed burns and wildfires: Coming to terms with pseudoreplication. Natural Areas Journal. Vol. 21, No. 3.

Keifer, M., N. Stephenson, and J. Manley. 2000. Prescribed fire as the minimum tool for wilderness fire regime restoration: a case study from the Sierra Nevada, California. In: Cole, David N.; McCool, Stephen F. 2000. Proceedings: Wilderness Science in a Time of Change. Proc. RMRS-P-000. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.Wilderness Science in a Time of Change. Missoula, MT, May 23-27, 1999.

Keifer, M., N. Stephenson, J. Manley, and G. Dempsey. In prep. Restoring forest structure with prescribed fire in Sequoia and Kings Canyon National Parks. Proceedings of Fire Management: Emerging Policies and New Paradigms. November 16-19, 1999, Bahia Hotel, San Diego, CA.

Keifer, M., K. Folger, and P. Lineback. In prep. Scaling up: Are plot data useful to assess landscape-level goals? Proceedings of Fire Management: Emerging Policies and New Paradigms. November 16-19, 1999, Bahia Hotel, San Diego, CA.

Keifer, M. and J. Manley. In press. Beyond initial fuel reduction in the giant sequoia-mixed conifer forest: Where do we go from here? Proceedings of Fire in California Ecosystems: Integrating Ecology, Prevention, and Management. November 17-20, 1997, Bahia Hotel, San Diego, CA.

Keifer, M. 1998. Fuel load and tree density changes following prescribed fire in giant sequoia-mixed conifer forest: The first 14 years of fire effects monitoring. Pages 306-309 *in* Teresa L. Pruden and Leonard A. Brennan (eds.). Fire in Ecosystem Management: Shifting the Paradigm from Suppression to Prescription. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, FL.