3.13) Fire Effects Monitoring

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INTRODUCTION

Fuels and vegetation monitoring has been part of the parks' fire management program for the last two decades. Fire effects monitoring information is used to assess whether the prescribed fire program is meeting intended objectives. The Mineral King Risk Reduction Project (MKRRP) represents a large step in the parks' move toward increased prescribed fire on a landscape scale. Fire effects monitoring in the project area is critical to: 1) evaluate the achievement of fire management objectives; 2) examine changes in vegetation structure and composition; 3) detect any unexpected or undesirable changes in vegetation that may be a result of the project; and 4) provide the above information to fire managers, other park staff, and the public.

Fire effects monitoring work within the MKRRP area is based on the relative need for information in various vegetation communities. Monitoring data are needed both to confirm that results in the Mineral King watershed are similar to those in other areas of the parks, as well as to fill in information gaps in certain vegetation communities.

High elevation vegetation types in the Sierra generally have longer fire-return intervals than at lower elevations. Consequently, unnaturally heavy fuel accumulation found at lower elevations due to exclusion of fire over the last century is not as common in higher elevation vegetation types. The effects of changes in fire regime, and subsequent increased risk, are not as critical at higher elevations. Although both ecological and life/property risk is likely to be lower, limited information is available for upper elevation vegetation types, therefore, moderate efforts to monitor vegetation change in these types is warranted in the project area.

Past research and monitoring efforts in the parks have concentrated on the mid-elevation forests, especially the giant sequoia-mixed conifer type. Although the mixed conifer forest has been monitored relatively intensively in the past, fire effects information for all vegetation types in the project area are needed for public information distribution. Accordingly, the mixed conifer forest vegetation types are monitored at a minimal level in the MKRRP area. Within the mixed conifer forest types, monitoring information is least available in the xeric, low elevation type, therefore, mixed conifer monitoring efforts will be increased in this type if time allows.

Historically, the lower elevation vegetation type fire regimes consisted of generally more frequent and/or higher intensity fire than at higher elevations. A disruption in this fire regime, such as fire exclusion attempts, may have had a great effect on vegetation structure and function in these lower elevation types. With few studies concerning lower elevation vegetation fire effects, more information is needed about the potential effects. Of the lower elevation types, chamise chaparral has been more thoroughly studied than other foothill vegetation communities (Rundel and Parsons 1979; Rundel 1982). Consequently, the MKRRP vegetation monitoring efforts focus on the lower elevation vegetation types of oak woodland and mixed evergreen chaparral.

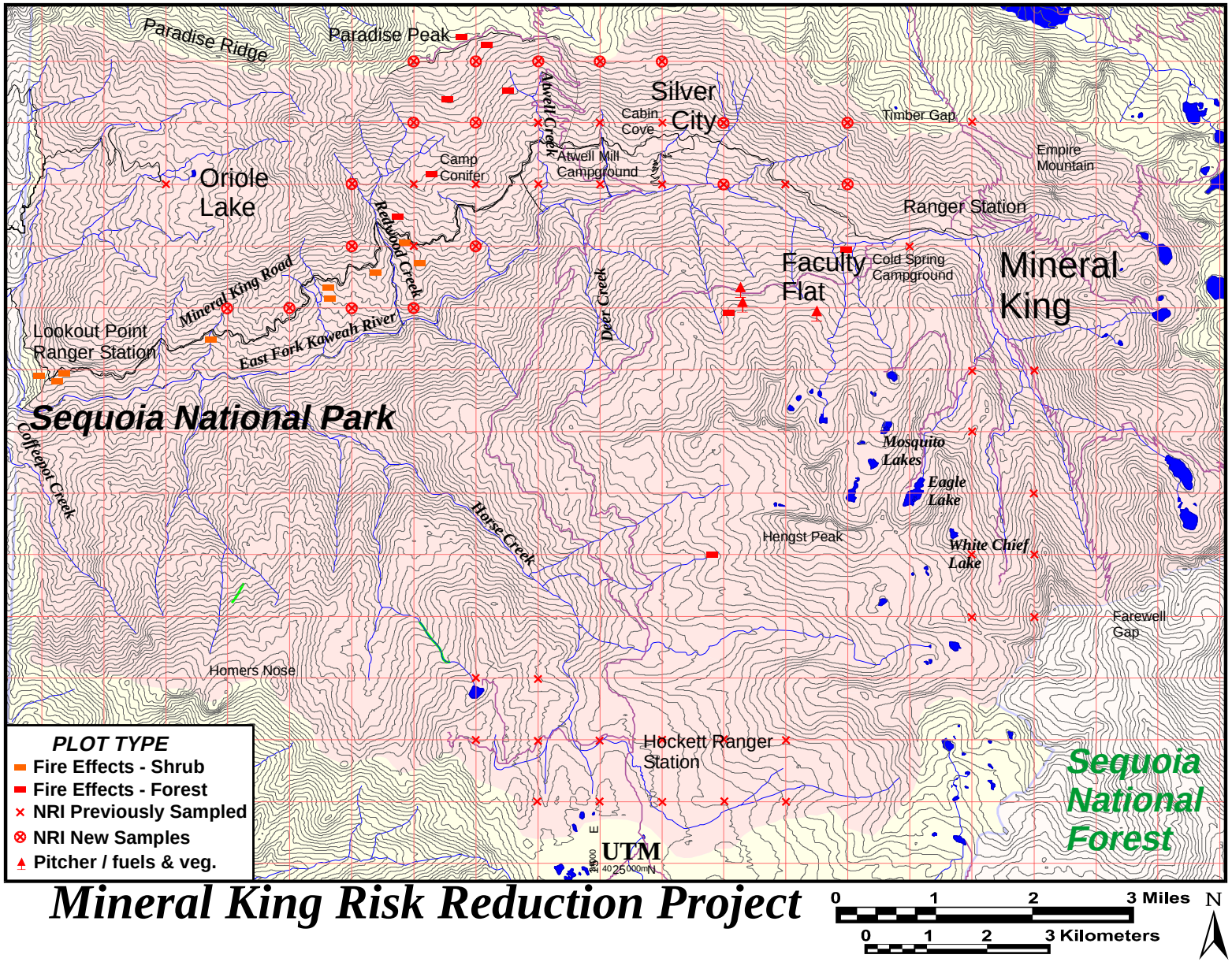

Figure 3.13-1. Plot location for vegetation sampling projects.

METHODS

The National Park Service's Western Region Fire Monitoring Handbook (1992) standardized methods are used for monitoring fire effects on vegetation and fuels. 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). Location of plots by burn segment, monitoring (vegetation) type, dominant species, and UTM coordinates are presented in **Table 3.13-1** and shown in **Fig. 3.13-1.**

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 for the project after each step of the monitoring schedule and results are promptly distributed to park staff and the public. The data may also be included in monitoring type summaries for the parks' overall fire effects monitoring program.

Unburned monitoring plots in other areas of the parks may be used to compare with burn project 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.

Table 3.13-1. Plot locations and information (an asterisk in the UTME column indicates the plot was geo-referenced using a global positioning system with an accuracy of ± 3-30 meters).

Plot ID	Monitoring Type	Dominant Species	Burn Segment	UTM-E	UTM-N
CADE 094	Low elevation-mixed conifer forest	incense cedar	Atwell (#3)	347570	4035590
SEGI 093	Giant sequoia-mixed conifer forest	white fir	Atwell (#3)	348280	4036200
SEGI 095	Giant sequoia-mixed conifer forest	white fir	Atwell (#3)	349513*	4037639
ABMA 096	Red fir forest	red fir	Atwell (#3)	349120*	4038347
ABMA 097	Red fir forest	red fir	Atwell (#3)	348428*	4037631
ABMA 098	Red fir forest	red fir	unburned	348602*	4038256
ABMA 100	Red fir forest	red fir	Tar Gap (#10)	352809*	4030052
ABMA 101	Red fir forest	red fir	Tar Gap (#10)	353059*	4034063
ABMA 102	Red fir forest	red fir	Tar Gap (#10)	354987*	4034922
ADFA 012	Chamise chaparral	chamise	Lookout (#2)	342251*	4032915
ADFA 013	Chamise chaparral	chamise	Lookout (#2)	342214*	4032867
ADFA 014	Chamise chaparral	chamise	Lookout (#2)	342233*	4032845
ARME 007	Mixed chaparral	manzanita	Lookout (#2)	347391*	4034592
ARME 008	Mixed chaparral	manzanita	Lookout (#2)	346596*	4034345
ARME 009	Mixed chaparral	manzanita	Lookout (#2)	346568*	4034144
ARME 015	Mixed chaparral	manzanita	Lookout (#2)	344635*	4033573
ARME 010	Mixed chaparral	manzanita	Redwood (#4)	348001*	4035021
ARME 011	Mixed chaparral	manzanita	Redwood (#4)	348112*	4034811

CHANGES IN MKRRP MONITORING PROGRAM SINCE 1997

A change that affects the fuel load results is the recent availability of equations to calculate litter load in addition to duff and woody fuel load. Litter depth measurements have been recorded in the field since the project began, and this year, litter load has been calculated for all previously collected data. As a result, the mean total fuel load values have increased in most cases, because of the added litter component. In addition, all fuel load values previously reported in tons per acre have been converted to, and graphically presented in, metric units for consistency.

WORK COMPLETED IN 1998

During the 1998 field season, two Mixed chaparral monitoring type plots were measured 1-year postburn and three Chamise chaparral type plots were burned and measured immediately postburn.

RESULTS TO DATE

Results are presented for: 1) three forest monitoring types that burned in 1995 and were monitored in 1996 and 1997 in the Atwell segment (#3); 2) one brush monitoring type that burned in 1997 and was monitored in 1998 in the Redwood segment (#4); and 3) one brush monitoring type that burned in 1998 in the Lookout segment (#2). Although the forest plots were not monitored this year, forest type results are presented to update the fuel information and add postburn condition results to the results previously described in the MKRRP 1997 annual report. The forest plot results include: dead and down fuel reduction and accumulation; burn severity estimates; overstory tree postburn conditions (maximum bark char height, maximum crown scorch height, crown scorch percent); changes in live overstory tree (>1.37 m in height) species composition and stand structure; and tree seedling (<1.37 m in height) density. The brush plot results include burn severity estimates and changes in percent cover by lifeform and by dominant species.

Monitoring types are referred to by their dominant species common name. Where more than one plot is included in the analysis, results are presented as mean values ± one standard error. In the figures, only the error bars for the dominant species or category are displayed. Results related directly to quantitative fire management objectives are indicated in bold typeface. Note that the results are not representative of all areas within the monitoring type in the watershed or the park and only apply to the plot areas measured due to small sample sizes (at most, three plots per monitoring type).

<u>Low elevation-mixed conifer forest monitoring type (incense cedar)</u>

Fuel Reduction and Accumulation

In one incense cedar plot, the fire **consumed 77% of the total fuel load**, from 31.76 kg/m^2 (141.6 tons/acre) preburn to 7.39 kg/m^2 (33.0 tons/acre) immediately postburn (**Fig. 3.13-2**). The

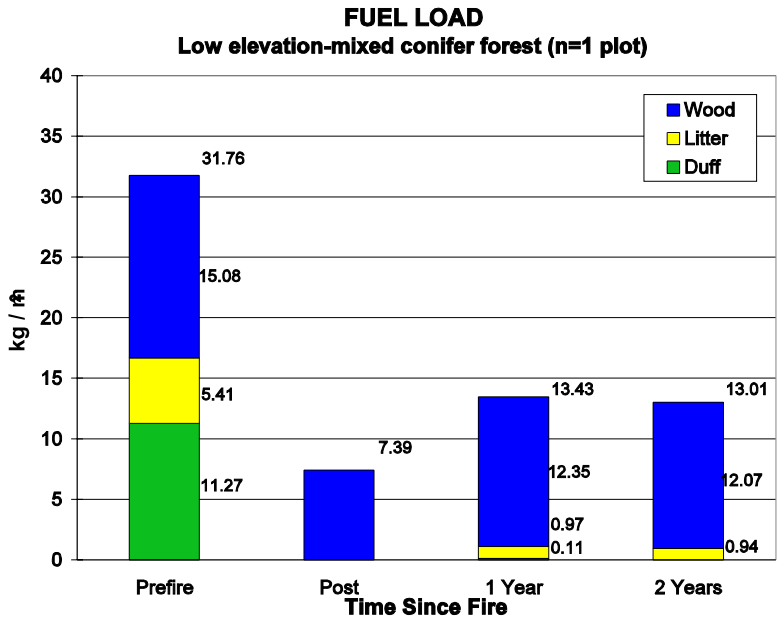

Figure 3.13-2. Fuel load changes in the low elevation-mixed conifer forest plot.

litter and duff components were completely consumed (100%) while woody fuels were reduced by 51%. Woody fuels increased by 67% over immediate postburn levels within 1-year, indicating that postburn branch and tree mortality was already contributing heavily to the downed woody fuel layer (**Fig. 3.13-2**). A small decrease in fuel load from 1- to 2-years postburn is likely due to slight differences in fuel transect locations repeated from one year to the next (error associated with the sampling technique).

Postburn Conditions

Using a burn severity scale from 1 to 5, where 1 is heavily burned and 5 is unburned, the mean burn severity for organic substrate in the incense cedar plot was 1.9 (moderately to heavily burned). Overstory tree mean bark char height varied by species ranging from 4.5 to 13.0 m (**Table 3.13-3**). Mean crown scorch height varied from 5.4 to 37.0 m while percent crown scorch ranged from 63.6 to 100% (**Table 3.13-3**).

Overstory Tree Density (Species Composition and Stand Structure)

Total overstory tree density was 1270 trees/ha preburn and 30 trees/ha 2-years postburn, indicating 98% overstory mortality* in the plot two years following fire (**Fig. 3.13-3**). Preburn composition was dominated by incense cedar (68% of all trees; **Fig. 3.13-3**), most of which were less than 50 cm in diameter at breast height (DBH) (**Fig. 3.13-4**). Incense cedar was reduced from 860 trees/ha preburn to 20 trees/ha 2-years postburn (98% mortality) while its relative species composition remained unchanged from preburn condition to 2-years postburn (68-67%; **Fig. 3.13-3**). Black oak, sugar pine, and white fir overstory tree densities were reduced to 0. The only ponderosa pine tree in the plot survived the fire, and therefore, ponderosa pine relative density increased from 1% to 33% (**Fig. 3.13-3**).

Table 3.13-2. Overstory tree postburn conditions by species.

Monitoring Type	Species	Number of Trees	Mean Bark Char Height (m)	Mean Crown Scorch Height (m)	Mean Crown Scorch %
Incense cedar (n=1 plot)	incense cedar	91	8.2	9.2	94.6
	black oak	17	5.8	6.9	63.6
	sugar pine	8	13.0	12.1	90.0
	California nutmeg	7	4.5	5.4	100
	white fir	2	5.5	6.5	100
	ponderosa pine	1	10.0	37.0	90.0
giant sequoia (n=2 plots)	white fir	90	2.2	4.9	43.1
	sugar pine	23	1.3	4.4	25.2
	giant sequoia	10	1.8	0.2	0.2
	red fir	9	1.5	7.0	40.6
	incense cedar	3	2.3	4.5	100
red fir (n=1 plot)	red fir	11	0.6	0	0

*Note on fire effects: Only one incense cedar plot has been established and burned in the East Fork watershed. This plot was located adjacent to a 0.8-1.2 ha (2-3 acre) area where 100% overstory mortality occurred in a draw above Redwood Creek (visible when driving up the Mineral King Road). The topographic influences, combined with weather and fuel conditions, resulted in fire effects that were more severe relative to effects normally observed in incense cedar plots elsewhere in SEKI. Additional incense cedar plots are being established within the project area in segments scheduled to burn in the future that may help determine whether these types of effects are common in this watershed.

Tree Seedling Density

Total tree seedling density increased by 62% from 3,280 seedlings/ha preburn to 5,320 seedlings / ha 2-year postburn.

<u>Giant sequoia-mixed conifer forest monitoring type (giant sequoia)</u>

Fuel Reduction and Accumulation

Total fuel load was reduced by 89% in one giant sequoia plot, from 40.65 kg/m^2 (181.3 tons/acre) preburn to 4.36 kg/m^2 (19.5 tons/acre) immediately postburn. The litter was reduced by 91%, duff was reduced by 92%, while 88% of the woody fuels were consumed. Due to the late season burn, the second giant sequoia plot was not measured immediately postburn and, therefore, was not included in the fuel reduction estimate. Woody fuel increased greatly 1-year postburn, surpassing the preburn woody fuel load (**Fig. 3.13-5a**). Note that standard error bars are very large, indicating high variability in total fuel load between the two plots for all visits

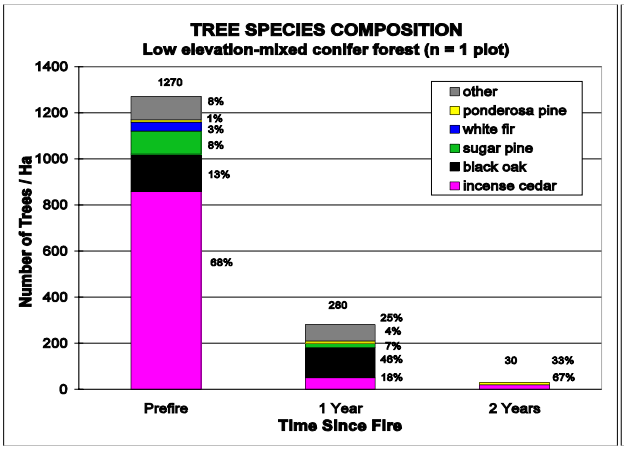

Figure 3.13-3. Overstory tree species composition changes (by density) in the low elevation-mixed conifer forest plot. Percentages indicate the relative density of each species.

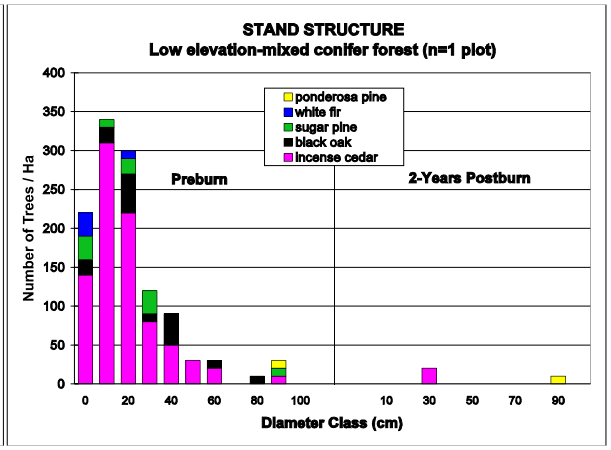

Figure 3.13-4. Stand structure changes between preburn and 2-years postburn by species and 10 cm diameter classes in the low elevation-mixed conifer forest plot.

(**Fig. 3.13-5**). The large postburn increase occurred in only one of the plots and is a result of a large fallen white fir that intercepted 3 of the 4 fuel transects. The arrangement of this downed tree gives the plot a very high fuel load which is not representative of the plot area in general and not typical of other plots throughout the parks in this monitoring type (**Fig. 3.13-5b**). Results from the second plot is much more representative of the postburn fuel accumulation pattern seen in the giant sequoia-mixed conifer forest type in the park (**Fig. 3.13-5c**).

Postburn Conditions

Organic substrate burn severity rating mean was 3.2 and vegetation burn severity was 3.4 for the giant sequoia plots (lightly to moderately burned). Overstory tree mean bark char height varied from 1.3 to 3.3 m (**Table 3.13-3**). Mean crown scorch height ranged from 0 to 7.0 m while mean percent crown scorch varied widely by species from 0.2% for giant sequoia to 100% for incense cedar. Giant sequoia postburn conditions were on the low end of the range for both bark char (1.8 m) and crown scorch measurements (0.2 m height and 0.2% crown scorch percent) (**Table 3.13-3**).

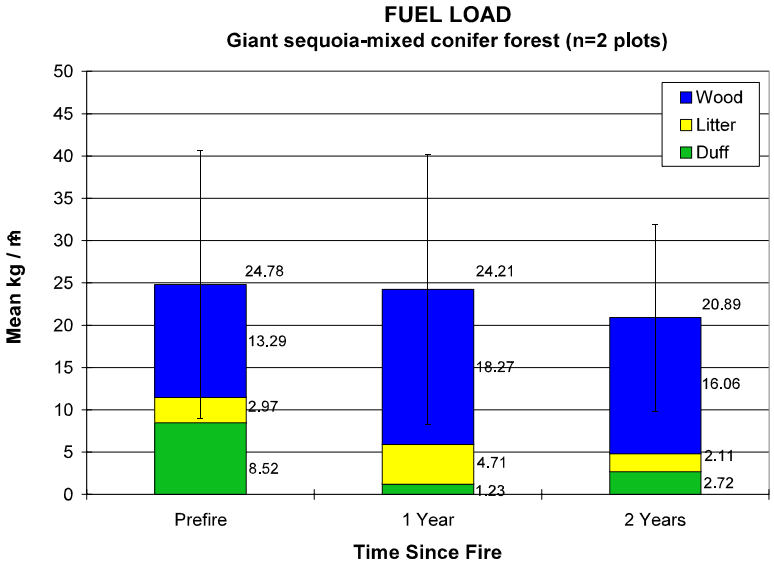

Figure 3.13-5. Fuel load changes in the giant sequoia-mixed conifer forest plots. Error bars represent ± one standard error of the mean for total fuel load.

Overstory Tree Density (Species Composition and Stand Structure)

In two giant sequoia plots, mean total overstory tree density was reduced by 50%,

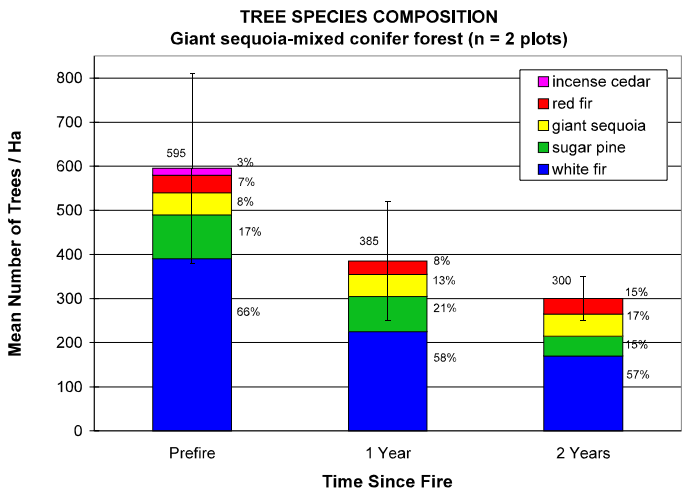

Figure 3.13-6. Overstory tree species composition changes (by density) in the giant sequoia-mixed conifer forest plots. Percentages indicate the relative density of each species. Error bars represent ± one standard error of the mean for total tree density (all species combined).

from 595 ± 215 trees/ha preburn to 300 ± 50 trees/ha 2-years postburn (**Fig. 3.13- 6**). White fir dominated preburn (66%) and most mortality occurred in the smaller diameter white fir (less than 30 cm; **Fig. 3.13-7**). Relative density changed from preburn condition to 2-years postburn. Incense cedar, white fir, and sugar pine decreased (from 3% to 0%, from 66% to 57%, and from 17% to 15% respectively) and relative increases occurred in red fir (from 7% to 15%) and giant sequoia (from 8% to 17%; **Fig. 3.13-7**). No mortality of any giant sequoia trees occurred in either plot.

Tree Seedling Density

Mean total seedling density for all species on two giant sequoia plots was 3,520 ± 2,080 seedlings/ha preburn. Density increased by 86% to 6,560 ± 5,880 seedlings/ha 2-years postburn. This increase was due to the postburn establishment of giant sequoia seedlings (from 0 preburn to a mean of 5,800 seedlings/ha 2-years postburn); for all other species, seedling density decreased by 2-years postburn. This result corroborates previous studies that show that fire greatly increases the establishment of giant sequoia seedlings. Seedling density is, however, highly variable between plots (evidenced by the high standard error values) and indicates that seedling establishment varies greatly at this spatial scale.

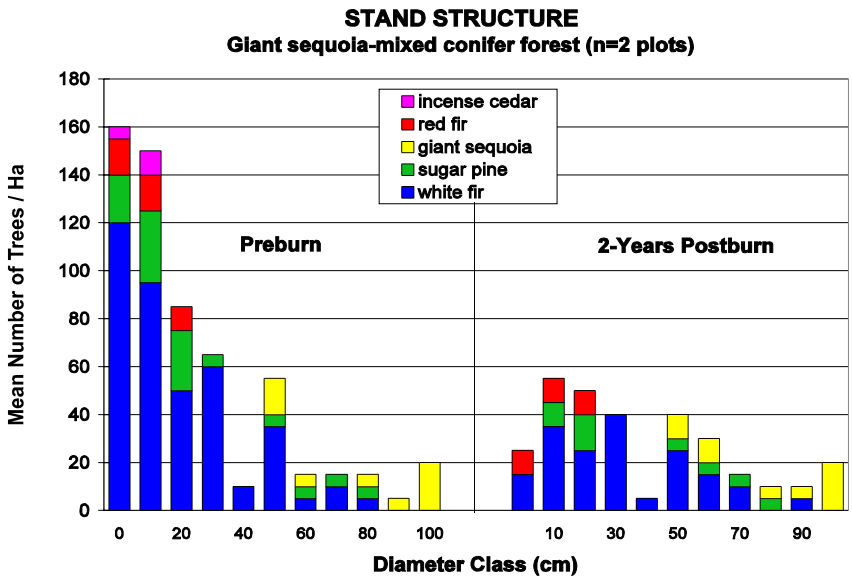

Figure 3.13-7. Stand structure changes between preburn and 2-years postburn by species and 10 cm diameter classes in the giant sequoia-mixed conifer forest plots.

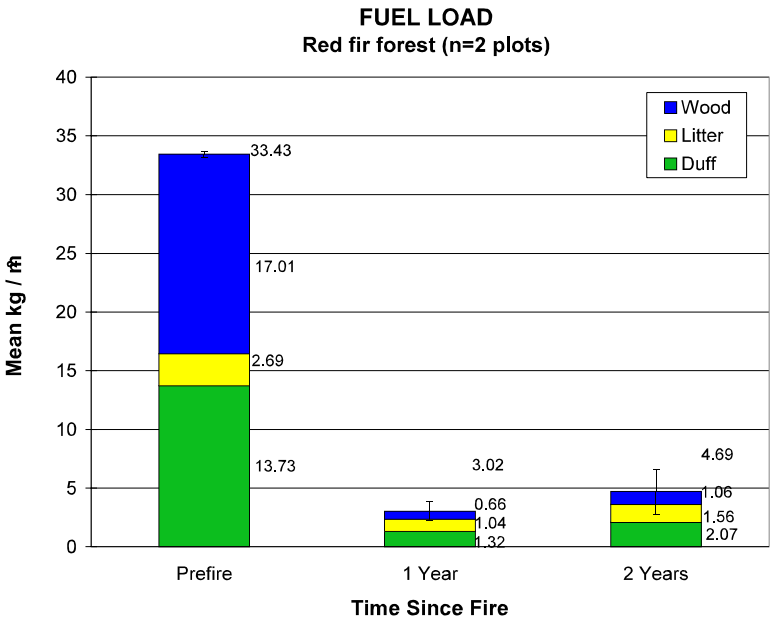

Figure 3.13-8. Fuel load changes in the red fir forest plots. Error bars represent ± one standard error of the mean for total fuel load.

Red fir forest monitoring type (red fir)

Fuel Reduction and Accumulation

In two red fir plots, the mean total fuel load was 33.43 ± 0.28 kg/m^2 (149.1 ± 1.3 tons/acre) preburn and 3.02 ± 0.80 kg/m^2 (13.5 ± 3.6 tons/acre) 1-year postburn, which indicates a **91% total fuel reduction** (**Fig. 3.13-8**). The plots were not revisited immediately postburn due to the late season burn and arrival of snow. Litter was reduced by 61%, duff was reduced by 90% and 96% of the woody fuels were consumed. Some fuel may have accumulated from the time the plots burned until they were measured the following summer, therefore, the fuel reduction results are conservative. Woody fuel, litter, and duff all accumulated slightly between the 1 and 2-years postburn (**Fig. 3.13-8**).

Postburn Conditions

Burn severity ratings estimated in the red fir plots are not included because they were not measured until 1-year postburn and therefore may not be representative of actual postburn conditions. Mean bark char height was 0.6 m, and crown scorch height and percent volume were both 0 (**Table 3.13-2**). Overstory tree postburn conditions may be conservative, especially for crown scorch, as scorched needles may have fallen during the 1-year before measurements were made.

Overstory Tree Density (Species Composition and Stand Structure)

Mean red fir overstory tree density for two plots was 205 ± 95.0 trees/ha preburn and 160 ± 50 trees/ha 2-years postburn (**Fig. 3.13-9**). While no overstory red fir mortality was detected in either of the red fir plots during the first year following the fire, 22% mortality occurred within

two years after the fire. Most of this mortality occurred in the smaller diameter red firs (**Fig. 3.13-10**).

Tree Seedling Density

Mean red fir seedling density for two plots was reduced by 99%, from 17,380 ± 3,900 seedlings/ha preburn to 100 ± 100 seedlings/ha 2-years postburn.

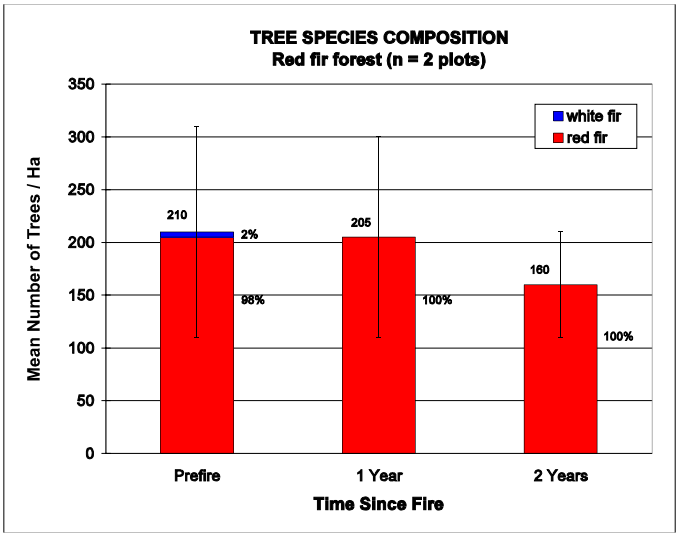

Figure 3.13-9. Overstory tree species composition changes (by density) in the red fir forest plots. Percentages indicate the relative density of each species. Error bars represent ± one standard error of the mean for total tree density (all species combined).

Mixed chaparral monitoring type (manzanita)

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.

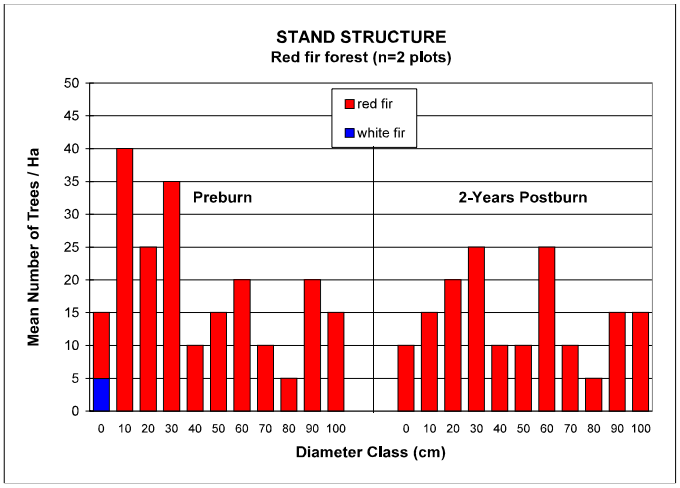

Figure 3.13-10. Stand structure changes between preburn and 2-years postburn by species and 10 cm diameter classes in the red fir forest plots.

Cover by lifeform

Mean percent cover decreased only slightly for live shrubs (all shrub species combined), from 88.6 ± 6.4% preburn to 82.5 ± 1.5% 1-year postburn (**Fig. 3.13-11**). Live tree (all tree species combined) and substrate mean cover also decreased slightly, while mean percent cover for grasses (all grass species combined) was reduced by about half. 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 ± 2.0% preburn to 11.0 ± 5.0% (**Fig. 3.13-11**). 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 major changes in cover of vegetative lifeform categories did not occur in these plots by 1-year postburn.

Cover by species

Mean percent cover for live *Arctostaphylos mewukka*, the dominant species, changed very little between preburn (70.2%) and 1-year postburn (69.0%) visits (**Fig. 3.13-12**). Black oak (*Quercus kellogii*), flannelbush (*Fremontodendron californicum*), and bear clover (*Chamaebatia foliolosa*) all decreased somewhat in mean percent cover. Mountain mahogany (*Cercocarpus betuloides*) mean percent cover increased from 16.4 ± 4.6% preburn to 28.5 ± 12.5% 1-year postburn. With

the small sample size (2 plots) and high variability between plots, these results indicate that the burn had little effect on changing species vegetative cover within these plots. 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 ± 0.5% preburn to 1.5 ± 1.5% 1-year postburn. The sample size is too small to make any conclusions about changes observed in cheatgrass cover following burning.

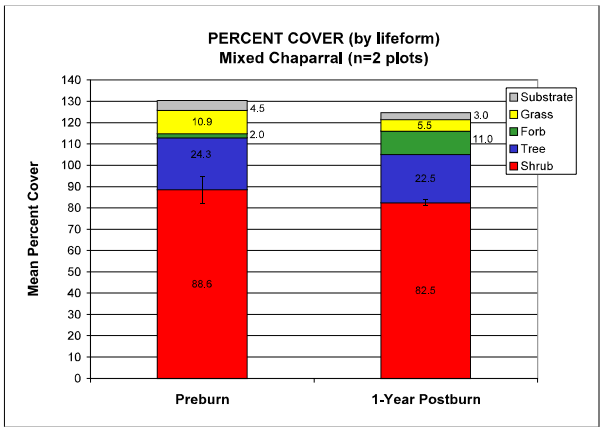

Figure 3.13-11. Percent cover by lifeform (all species combined) in the mixed chaparral plots. Error bars represent ± one standard error of the mean for shrub cover.

<u>Chamise chaparral monitoring type (chamise)</u>

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 ± 3.5% preburn to 15.0 ± 15.0% postburn (**Fig. 3.13-13**). A corresponding increase in mean percent cover of substrate occurred, from 7.0 ± 3.5% preburn to 74 ± 16.1% postburn indicating that much of the vegetative cover was consumed during the burn.

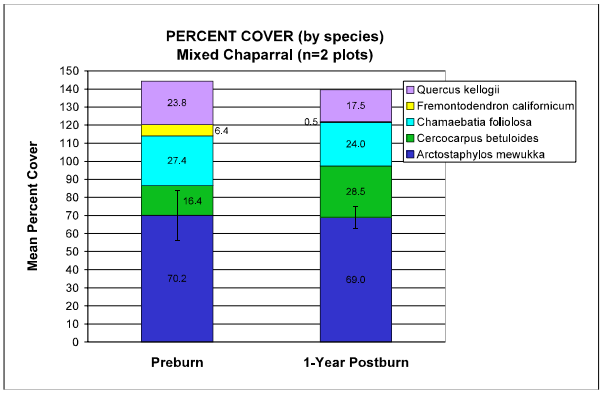

Figure 3.13-12. Percent cover by major species in the mixed chaparral plots. Error bars represent ± one standard error of the mean for *Arctostaphylos mewukka* cover.

Cover by species

Mean percent cover for live chamise, the dominant species, was reduced by 88% from 90.3 ± 6.2% preburn to 11.0 ± 11.0% postburn (**Fig. 3.13-14**). *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).

MANAGEMENT IMPLICATIONS

While the plot results do not represent results for the entire burn unit or monitoring type, the results are an indication of the effectiveness of burning within a smaller area. In the forest types, the parks' 60-80% total fuel reduction objective was met or exceeded within the monitoring plots. The park staff is in the process of developing objectives to address forest structure and process in addition to fuel reduction.

Currently, quantitative fire management objectives do not exist in the parks' brush types. 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. At the same time, fire management objectives for chaparral will need to be developed in order to assess whether prescribed burning is effective in these types.

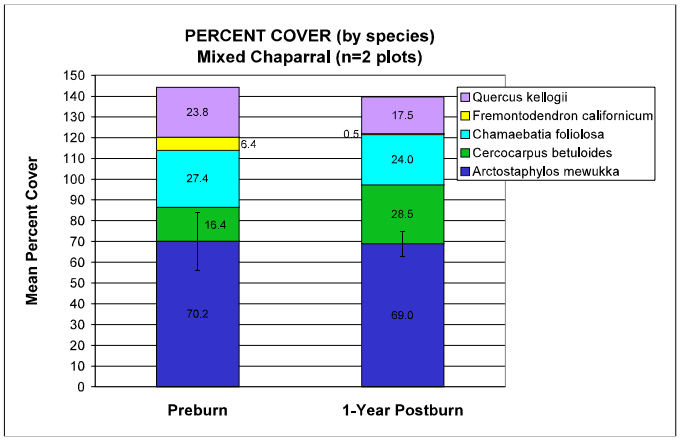

Figure 3.13-13. Percent cover by lifeform (all species combined) in the chamise chaparral plots. Error bars represent ± one standard error of the mean for shrub cover.

PLANS FOR 1999

Two Mixed chaparral plots that burned in 1997 will be visited for 2-year postburn assessments and three Chamise chaparral plots that burned in 1998 will be visited for 1-year postburn measurements. If the remaining four Mixed chaparral plots in the Lookout segment (#2) burn next year, they will be visited to record the immediate postburn measurements. New plots will continue to be installed as necessary as the burn segments are scheduled.

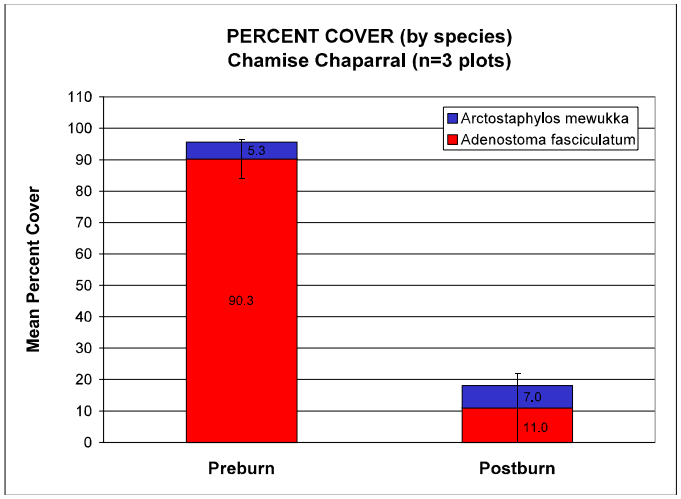

Figure 3.13-14. Percent cover by major species in the chamise chaparral plots. Error bars represent ± one standard error of the mean for chamise cover.

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