1999 Annual Fire Report
Monitoring, Inventory, and Research

Sequoia & Kings Canyon National Parks
July 2000

Note: The **1999 Annual Fire Report on Research, Monitoring, and Inventory** is an expanded version of the four Annual Reports produced for the Mineral King Risk Reduction Project (MKRRP) from 1995 to 1998. It contains information about all research, inventory, and monitoring projects occurring in the Parks during 1999, including those associated with the MKRRP. This year in particular will be a year of transition for the Annual Report as it expands to include the whole of Sequoia and Kings Canyon National Parks. Copies of all the reports are being made available by web browser over the Internet. Full copies of the 1995 through 1999 reports can be downloaded in Adobe Acrobat PDF format from the ***Fire Information Cache*** (see section on the Cache in this report) on the Sequoia and Kings Canyon National Parks web site at www.nps.gov/seki/fire/indxfire.htm. If you do not have Internet access and would like to obtain one of the earlier reports from 1995 to 1999 contact Anthony Caprio at Sequoia and Kings Canyon National Parks, Division of Science and Natural Resources Management, 47050 Generals Highway, Three Rivers, CA. 93271-9651.

Cover Caption: Aerial view of a portion of the Atwell segment burning during the fall of 1995 with the Mineral Lakes in the near distance and the Great Western Divide in the far distance. The inset is a 3D ArcView image of the East Fork watershed showing overall topographic features of the drainage.

1999 Annual Fire Report
Research, Inventory, and Monitoring

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1999 Annual Fire Report - Research, Inventory, and Monitoring: Sequoia and Kings Canyon National Parks

Executive Summary

Sequoia and Kings Canyon National Parks have been a leader in fire research and the implementation of a fire management program emphasizing both prescribed management ignitions and prescribed natural fire (now called *wildland fire used for resource benefit* - WFURB). Objectives of the program were originally centered on the reduction of unnatural fuel accumulations but more recent emphasis has combined fuel reduction with restoration of ecosystem structure and function within ecosystems. Coupled with the fire management program has been an active research, inventory and monitoring program conducting a variety of fire related studies. These studies and their results are important in providing information about short- or long-term resource responses and impacts when burning and whether the planned objectives for the burn program are being met. This information feeds back into management planning and permits modification and fine tuning of the burn program. Additionally, it provides up-to-date information to the public and policy makers.

In past years this annual report summarized research, inventory, and monitoring activities within the East Fork drainage associated with the Mineral King Risk Reduction Project (MKRRP). Beginning in 1999 this and future reports will compile and describe work carried out from throughout the Parks, in addition to work relating to the ongoing MKRRP. Because of the research and monitoring emphasis placed on the MKRRP the majority of the projects described in this report focus on the East Fork. The MKRRP was originally initiated out of a need to assess the operational requirements and cost effectiveness of large scale prescribed burning for wildland management in a setting altered by a century of fire suppression. Because the scale of the project is unprecedented, a number of integrated monitoring and research projects were initiated to assess the impacts and responses of key components of the watershed to prescribed fire. Additional projects have also been initiated to utilize this opportunity to gain additional insights into fire's role in Sierran ecosystems.

Several noteworthy observations or findings were made by the various research and resource studies. Fire effects plots show overstory tree mortality vary by vegetation type: from 24% in red fir forest, to 49% in sequoia mixed-conifer forest (no mortality of overstory sequoias was noted), to 66% in low elevation mixed-conifer forest. Fuel reductions in the fire effects plots varied from 77% in sequoia mixed-conifer forest to 97% in ponderosa pine forest one year postfire. Watershed sampling completed its second full water year of sampling, providing preburn data on trends within the East Fork. Initial results suggest similar annual shifts in flow, pH, and ANC (acid neutralization capacity) when compared to other unburned Sierran watersheds. Fire history sampling indicates there were dramatic differences in the frequency of pre-Euroamerican settlement fire by aspect. Sampling in the East Fork drainage suggests differences were about three times greater in lower elevation conifer forest on south aspects than in comparable vegetation on north aspects. Research looking at fire and vegetation diversity indicates that in both ponderosa pine and mixed conifer forests patches of high fire intensity exhibit increases in species richness. Additionally, these patches are also the most susceptible to invasion by exotics.

The Park's area encompasses 349,676 ha (864,067 ac) with elevations ranging from 485 to 4,392 m (1,600 to 14,495 ft). Vegetation of the area is diverse, varying from foothills chaparral and hardwood forests at lower elevations to alpine vegetation at elevations above about 3,100 m (10-11,000 ft).Burning in the Parks during 1999 amounted to 2,437 ha (6,019.1 ac) with 554 ha (1,369 ac) in the East Fork drainage associated with the MKRRP. Of all park area burned 343 ha (848 ac) were wildland fires and 2,094 ha (5,171.1 ac) were prescribed fire.

1. Project Year Synopsis: Accomplishments for 1999 projects.

- **Fire Effects Plots -** Fuels and vegetation monitoring has been part of Sequoia and Kings Canyon National Parks' fire management program for the last two decades. The fire effects monitoring program is critical to: (1) evaluate the achievement of fire management objectives; (2) detect any unexpected or undesirable changes in vegetation that may be a result of prescribed burning; and (3) provide the above information to fire managers, other park staff, and the public. The plots provide feedback to park managers on whether they are meeting management objectives and help to refine goals of future burn plans. Twenty plot remeasurements and 5 immediate postburn visits were accomplished in 1999. An addition 2 new plots were installed, one in the Lower Deadwood unit and one in the Upper Deadwood unit of the MKRRP. The plot in the Lower Deadwood unit burned out of prescription (rainfall occurred while the plot was still burning) and will be removed. Data analysis showed overstory tree mortality varied by vegetation type: from 24% in red fir forest, to 49% in sequoia mixed-conifer forest (no mortality of overstory sequoias was noted), to 66% in low elevation mixed-conifer forest. Fuel reductions in the fire effects plots varied from 77% in sequoia mixed-conifer forest to 97% in Ponderosa pine forest one year postfire

- **Wildlife Monitoring -** Four permanent small mammal live-trapping plots have been established between 1995 and 1999 with three of these resampled during 1999. Understanding changes in the composition and numbers of common small mammals is important because they represent an important component in the food chain for less-common wildlife species and thus make good indicators of habitat status. Rodent populations respond readily to changes in vegetation structure and composition due to fire, they are easy to handle, and are a cost-effective tool for monitoring fire effects. The plots are located in sequoia/mixed-conifer forest (Atwell), chaparral/oak shrubland (Traugers), in ponderosa pine/black oak transition forest (Camp Conifer), and Jeffery pine (Mineral King). Both the Atwell sequoia-mixed conifer plot, burned in November 1995, and the ponderosa plots, burned in November 1997, have been resampled annually since the burns. Serendipity trapping (non-permanent trap locations) was also carried out at a number of locations in the watershed. Several additional colonies of *Aplodontia* have also been located extending the known range of the species.

- **Watershed Sampling: Stream Chemistry and Hydrology -** Stream chemistry and hydrological information have been collected in both the Middle Fork and East Fork drainages of the Kaweah watershed by the Sequoia and Kings Canyon Field Station - USGS (prior to 1994 work was conducted by the Park's Research Office). Work in the Mineral King drainage includes studies on large woody debris, annual runoff coefficients for the study catchments, and annual volume-weighted mean (VWM) solute concentrations. Analysis of post-fire hydrologic changes observed in the Giant Forest's Tharp's Creek following a 1990 burn show striking differences in runoff between a burned and unburned catchments monitored over a sixteen year period (pre-burn n=7, post-burn n=9). Reference forest stand data document changes in post-fire forest structure and are related to observed changes in post-fire hydrologic responses.

- **Fire History -** Fire history samples have been obtained from most elevation, aspects, and vegetation types within the East Fork from 1995 to 1999. These samples will become part of an effort to reconstruct the spatial scale and pattern of pre-European settlement fire events from throughout the East Fork watershed and to provide baseline data on past fire occurrence in a variety of habitats, vegetation types, and aspects in the drainage. Predictions of past fire occurrence in the Sierra Nevada based on computer models suggest differences in burn patterns/frequencies on different aspects with these differences most notable between south and north slopes. However, until this sampling almost no data existed on pre-European settlement fire history for north aspect forests in the southern Sierra Nevada. Thus information collected in the East Fork will be important in verifying these models, in addition to providing park staff with better information about fire over the landscape. The current analysis suggests striking differences in fire frequency between conifer forest low elevation south aspects (fire return interval (FRI) of ~9 yr) and similar locations on north aspects (FRI of ~30 yr).

- **Giant Sequoia Fire Scars and Fuel Loading -** A total of 60 giant sequoia trees (30 scarred and 30 unscarred) have been measured in the Atwell Grove to help determine the effects of prescribed burning on fire scar formation and how changes in fire scar dimensions and bark charring relate to the fuel accumulations and consumption of the fuels surrounding trees by prescribed burning. All trees examined within the study area burned during November 1995 and were resampled during 1996 with fuels remeasured during 1997. No sequoia mortality resulted from the fire although small new fire scars were noted on some trees.

- **Fuel Inventory and Monitoring -** The purpose of this study is to improve the parks GIS fuels theme and collect data on forest canopy characteristics that can be used to develop tree height and height to live crown based GIS themes. These will be used in *FARSITE* to model crown fire activity (torching, spotting, and crowning). Since 1995 forty permanent fuel plots have been established within the East Fork drainage with supplemental data gathered from photo series. In addition to estimating fuel loads at each plot, other forest attribute measurements were obtained on tree height, basal area, height to lowest branches, and on litter and duff depths.

- **Red Fir (Pitcher) Plots -** In the late 1970's Donald Pitcher (graduate student at UC Berkeley) established three permanent plots in red fir forest along the Tar Gap Trail near Mineral King to study forest structure and composition (what species are present and how are they arranged in a forest), and fuel dynamics (fuels available for burning). These plots were relocated in 1995 and where resampled prior to the burning of the Tar Gap segment. In 1999 these plots provide long-term data from red fir forest on changes in forest structure and composition, and fuel loads over a 20 year period. Initial preburn estimates indicate a significant increase in fuel loads and 22% mortality of all saplings/trees in the plots (most mortality, 75%, is a result of the death of young seedling and sapling as the forest naturally thins itself over time). Postburn sampling of these plots will also provide detailed information on forest changes and fire effects which have been little studied in this forest type.

- **Landscape Analysis - Fire and Forest Structure -** Kurt Menning's (graduate student at UC Berkeley) research will address questions revolving around the means and the landscape-scale consequences of selecting differing mechanisms for restoring forest structure to something near pre-Euroamerican conditions. Using high resolution aerial imagery and field sampling he will describe the current structure and pattern of mixed conifer forest over the landscape and then how the qualities of these change as fire is restored to the ecosystem.

- **Repeat Photography -** This project attempts to reconstruct historical changes in southern Sierran plant communities over the past 125 years. The general study area for the repeat photographs encompasses foothill and forest plant communities from the Stanislaus River south to the Kern River. Within this large large geographic area three foci have been established in order to better facilitate completion of a useable project in two field seasons. The focus projects center on Kings Canyon – Yosemite Valley comparison, the chaparral-conifer ecotone, and giant Sequoia groves.

- **Diversity and Invasive Plant Species in Sierran Forests -** Disturbances that create a disequilibrium in distribution of resources may alter species composition through shifts in resource availability, which in turn may create conditions favoring invasion of non-native species and deletions of native species. Two important disturbance factors in the Western U.S. are grazing and fire. Both have been linked to plant invasions. Within the Parks this research program has concentrated on the role of fire in both ponderosa pine and mixed coniferous forests. At the sites sampled in these vegetation types species richness is not immediately altered by fire but within the first three years, high fire-intensity patches exhibit highly significant increases in species richness. Concomitantly, these patches are also the ones most susceptible to invasion by non-native plant species.

- **Landscape Scale Fuels Management Planning for the southern Sierra -** This project focuses on developing and testing an approach to incorporate wildland fuels information management into an interagency, landscape-scale planning over 4.7 million acres in the southern Sierra. A spatial and attribute information system is being created for coordinated fuels management planning within an integrated Geographic Information System (GIS) framework. The primary goals are to reduce fiscal costs to government agencies and the public and to improve attainment of ecological and hazard reduction goals. The project focuses on utilizing geographic information and related technologies to overcome institutional and organizational barriers to interagency fuels management within large diverse ecosystems. Common geographic data is being developed including comprehensive planning maps and analyses that prioritize areas for treatment based on value, hazard, and risk criteria. This framework will develop and test procedures to manage and update complex spatial information and to institutionalize the coordinated planning efforts.

- **Vegetation Mapping -** 1999 marked the beginning of a multi-year initiative to classify and map the terrestrial vegetation of Sequoia and Kings Canyon National Parks. The need for a comprehensive, accurate vegetation map for resource planning, management and research has long been recognized by SEKI managers and cooperators. This is especially true for the fire management program, which relies on accurate vegetation mapping to drive predictive fuels models. The goal is to develop a highly accurate vegetation map that meets scientific Federal Geographic Data Committee (FGDC) standards, is based on a hierarchical classification scheme consistent with the National Vegetation Classification, and has a level of detail that is useful to park managers and cooperators. Initial funding for project has been provided by FirePro because of the importance of an accurate vegetation and fuels map in fire management planning and operations.

- **Cheatgrass -** Two reports are included on exotic annual cheatgrass. During the late summer of 1998, NPS resource managers became concerned about the apparent spread of cheatgrass (*Bromus tectorum* L.) following prescribed burning in the Cedar Grove area of Kings Canyon National Park. Prescribed burns were suspended until information could be gathered on the potential of this highly invasive species to spread in response to fire-related disturbance. In the fall of 1998, preliminary surveys were conducted to assess the distribution and abundance of cheatgrass on the valley floor. In the winter of 1999 a literature search was contracted and a recommendations report for the Parks was prepared compiling information from the literature, field survey data, and results from several other types of sampling carried out in Cedar Grove. In the early summer of 1999 a preliminary study looking at spring burning in cheatgrass was conducted in Cedar Grove. The study addressed two questions regarding cheatgrass abundance in the westside ponderosa pine community. First, whether burning cheatgrass that has cured just prior to seed drop significantly reduces the seed bank (and thus cheatgrass abundance) during the following year. And second, whether such early season burning has a negative effect on native perennial grasses. Results from resampling in the spring of 2000 suggest little impact from the burning on cheatgrass with negative impacts on the native perennials.

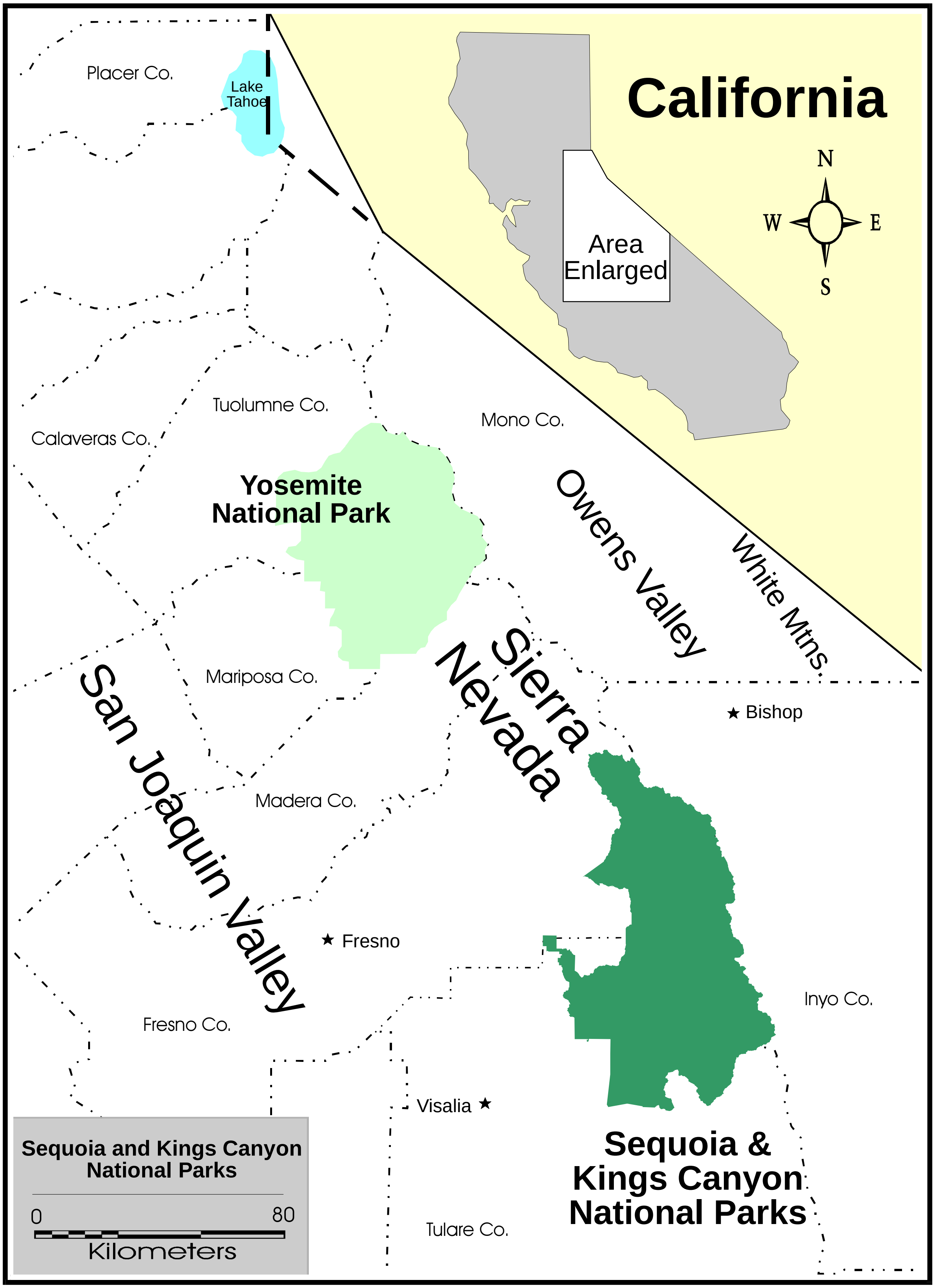


Figure 1-1. Location of Sequoia and Kings Canyon National Parks in the southern Sierra Nevada of california.

2. Park Burn Program

2.1 - Objectives

Overall Park Burn Program Objectives **-** The fire management policy of the National Park Service supports the overall resource management goal, which is to restore or maintain natural ecosystems. Fire management also provides for protection of public safety, cultural and natural resources, and developments from wildfire. Fire management operations include WFURB (formerly known as “prescribed natural fire”), prescribed burning, suppression, presuppression, and prevention activities (from 1991 revision Sequoia and Kings Canyon NP Fire Management Plan).

Fire is one of the most important processes affecting the ecosystems of these Parks, and its presence in past centuries in western forests is well established (Agee, 1973). Surface fires are thought to have been a common occurrence in the mixed-conifer region of California. These generally low intensity fires kept the forests open (Biswell 1961; Weaver 1967, 1974; Hartesveldt and Harvey 1967; Kilgore 1971, 1972).

Natural fire played a variety of roles that included: (1) seed bed preparation, (2) recycling of nutrients, (3) affecting plant succession, (4) providing a mosaic of age classes and vegetation types, (5) modification of wildlife habitat, (6) reduction of numbers of trees susceptible to attack by insects and diseases, and (7) reduction of fire hazard (Kilgore 1973).

Since the arrival of Europeans to the Southern Sierra in about 1858, vegetation has been influenced by such activities as logging, grazing, and fire suppression (Kilgore and Sando 1975; Kilgore and Taylor 1979; Parsons and DeBenedetti 1979; and Vankat 1970).

Concern over this resource exploitation led to the establishment of Sequoia and General Grant National Parks in 1890, to protect the natural resources but also to preserve their wilderness character and their vegetation, with emphasis on the giant sequoia forest. With establishment of these Parks came protection from all types of fire, including that of natural origin.

After some 50 to 80 years of fire exclusion, an understory buildup of fuel and young shade tolerant trees has occurred, threatening the giant sequoia with unnaturally intense wildfire (Bonnicksen and Stone 1978; Kilgore and Sando 1975). The changes in forest conditions were noted by the Advisory Board on Wildlife Management in the National Parks (Leopold et al. 1963), which stated:

"Today much of the west slope is a dog-hair thicket of young pines, white fir, incense cedar, and mature brush - a direct function of overprotection from natural ground fires. Within the four National Parks - Lassen, Yosemite, Sequoia and Kings Canyon - the thickets are even more impenetrable than elsewhere. Is it possible that the primitive open forest could be restored, at least on a local scale?"

In 1968, the Park Service changed its policy from fire control to fire management. Sequoia and Kings Canyon National Parks began a prescribed natural fire management program in 1968 and a prescribed burning program in 1969.

Within the framework of the National Park Service fire management policy, the overall goals of the fire management program at Sequoia and Kings Canyon National Parks are:

• protect public safety, cultural and natural resources, and developments from wildfire, through the use of prescribed burning around developments, as well as prevention, presuppression, and suppression activities, and

• restore or maintain the natural fire regime to the maximum extent possible so that natural ecosystems can operate essentially unimpaired by human interference. This will be done with prescribed natural fire and with prescribed burning, as well as through the suppression of wildfires.

“Fire regime" is defined as the interaction of fire and biotic and physical elements of the environment. It includes the timing, spatial distribution, size, duration, behavior, return interval, and effects of natural fires. It is not a goal to return to some historic point in time, but rather to allow natural fire to operate as a process as fully as possible without causing unnatural effects.

The goals will be accomplished through the following objectives:

A. Wildfire Suppression
• Protect human health, safety, and developments during all phases of the fire management program.
• Suppress all wildfires and minimize detrimental impacts on natural resources from wildfires.
• Maintain an active fire prevention program to reduce the incidence and threat of wildfire.

B. Prescribed Fire Management
• Allow prescribed natural fires to burn, provided they will achieve natural resource management goals and fire management objectives.
• Expand the prescribed burning program to all ecosystems that have been significantly affected by historic fire suppression, especially into lower mixed conifer forest and giant sequoia groves.
• Use prescribed fire to remove unacceptably high fuel loading, where natural ecosystems have been altered by human interference. Fuel surveys and hazard assessments will determine priorities for this activity.
• Use prescribed fire to reduce hazardous fuels around developed areas.

C. Research and Monitoring
• Monitor and evaluate the effects of fire management on park ecosystems to further refine objectives.
• Conduct research necessary to determine natural fire regimes, fire effects, lightning strike frequency, input for fire spread models, and other studies as necessary to more effectively implement the fire management program.

D. Special Management Areas
• Balance natural process restoration in giant sequoia Special Management Areas with the need to preserve the prime scenic value and vistas.

E. Interpretation
• Provide interpretive and educational programs designed to enhance public and staff understanding and awareness of the fire management program.

F. Public Involvement
• Provide periodic public review of the fire management program as needed as part of an on-going refinement process of the program.

• Provide current information on wildfire and prescribed fire activity to the public, neighboring agencies, and to the park staff.

G. Cultural Resources and Threatened and Endangered Species
• Mitigate or minimize impacts to archaeological and historic resources, and to threatened and endangered species unless cleared in advance by the proper authorities.

H. Air Quality
• Mitigate and prevent unacceptable impacts of the prescribed fire program on public health and visibility.
• Manage smoke from prescribed fire in accordance with Federal, State, and local regulations

Mineral King Risk Reduction Project - The direct objectives of the Mineral King Risk Reduction Project (MKRRP) for Sequoia and Kings Canyon National Parks (SEKI) focus on reducing unnatural fuel accumulations that have resulted from a century of both direct and indirect fire suppression activities in southern Sierran ecosystems (NPS 1995, Stephenson 1995). In many instances these fuel accumulations create hazardous conditions for visitors, developments, and natural resources. The overall objectives of the project are to assess the operational requirements and cost effectiveness of large scale prescribed burning for wildland management (NPS 1995). The latter evaluation will be accomplished through the use of information derived from the field operations and their outcome within SEKI.

The conditions resulting from unnatural fuel accumulations have resulted in wildland managers being called upon to modify fuels in order to reduce wildland fire hazard and restore ecosystems to some semblance of pre-Euroamerican conditions. Current national management issues are forcing land managers to use two main tools for fuels management: mechanical removal (cutting) and/or prescribed burning. However, both of these tools remain controversial and managers are being asked to justify their choices. These issues motivated a major effort by the National Interagency Fire Center (NIFC) to begin an assessment of the operational requirements and cost effectiveness of using large-scale prescribed burning as a tool in fuels management. As part of this effort NIFC funded Sequoia and Kings Canyon National Parks to carry out a watershed-scale burn program with an objective of prescribed burning about 12,000 ha (30,000 acres) over a five year period (1995-2000) in the East Fork of the Kaweah River (**Fig. 2.1-1**). A collateral objective of the burn project is to evaluate the cost effectiveness of a hazard fuel reduction program of this magnitude by Colorado State University.

Since the scale of the burn project is unprecedented a number of integrated resource related studies are being undertaken and are an integral part of the project. These research, inventory, and monitoring projects in the Mineral King burn are designed to meet the following objectives (Stephenson 1995) :

> ***To supply the information needed to practice adaptive management*** *(1) by determining whether the burn program's objectives are being met, (2) by identifying unexpected consequences of the program on the ecosystem, and (3) if objectives are not being met, by suggesting appropriate program changes.*
>
> ***To provide information for public education, response to public and governmental inquiries, and to document legal compliance.***

These research and monitoring objectives are particularly important because SEKI's watershed scale burn program will be one of the first national attempts at using fire on a watershed scale for fuels management. The various research and monitoring studies are being integrated with the project's management objectives. Support for new studies that compliment or enhance the currently implemented studies are being sought (for example, proposals for funding for a watershed sediment transport study are being developed by the Biological Resource Division of the USGS). Additionally, unsolicited studies by non-MKRRP funded researchers (primarily from universities) are also integrated with the overall project goals to the greatest degree possible consistent with the study objectives. Descriptions of studies and the East Fork are available in the 1995, 1996 and 1997 MKRRP Annual Reports (Caprio 1996, 1997, 1998).

2.2 - Project Area Descriptions

Park Project Area - Sequoia and Kings Canyon National Parks are located in the south central Sierra Nevada (**Fig. 1-1**) and encompass some 349,676 ha (864,067 ac) extending from the Sierra crest to the western foothills on the eastern edge of the San Joaquin Valley (**Fig. 2.2-1**). Topographically, the area is rugged, with elevations ranging from 485 to 4,392 m (1,600 to 14,495 ft). The Parks are drained by the Kern, Kaweah, Kings and San Joaquin Rivers. The elevation gradient from the foothills to the higher peaks is steep on both the east and west margins of the Sierra, with rapid transitions between vegetation communities. Three broad vegetation zones dominate the Parks (slightly over 200,000 ha are vegetated by forest, shrub or grassland communities)– foothills (485 to 1,515 m) composed of annual grasslands, oak and evergreen woodlands and chaparral shrubland, conifer forest (1,515 to 3,030 m) with ponderosa (Pinus ponderosa Dougl.), lodgepole (P. contorta Dougl. var Murrayana Englm.), giant sequoia (Sequoiadendron giganteum [Lindl.] Buchholz), white fir (Abies concolor Lindl. & Gord.) and red fir (A. magnifica Murr.) forests, and high country (3,030 to 4,392 m) composed of subalpine forests with foxtail pine (P. balfouriana Jeff.), white-bark pine (P. albicaulis Englm.), alpine vegetation and unvegetated landscapes. A variety of classification schemes have been defined for vegetation within the Parks (Rundel and others 1977; Stephenson 1988; Vankat 1982).

The climate is Mediterranean, with cool, moist winters and warm summers with rainfall limited to sporadic summer thunderstorms associated with monsoonal flow from the Southwest. Precipitation increases as elevation increases, to about 102 cm (40 in) annually, from 1,515 to 2,424 m on the west slope of the Sierra, decreasing as one moves higher and to the east (Stephenson 1988). Substantial snow accumulations are common above 1,515 m during the winter. Total annual precipitation during the period of record has varied from 30 to 130 cm at Ash Mountain in the foothills and from 38 to 214 cm in Giant Forest at a mid-elevation location.

European settlement of the area began in the 1860s with extensive grazing, minor logging and mineral exploration. Sequoia National Park and Grant National Parks (now part of Kings Canyon National Park) were founded in 1890 with the intent of protecting sequoia groves from logging. Over time, significant new areas have been added to the Parks, including the Kern Drainage (1926), while much of the upper portion of the upper Kings drainage was set aside as Kings Canyon National Park (1940 and 1965) (Dilsaver and Tweed 1990 ; Farquhar 1965).

East Fork Project Area - The East Fork watershed (**Fig. 2.2-2**) which encompasses the MKRRP is one of five major drainages comprising the Kaweah River watershed which flow west (historically but is now heavily diverted for agriculture) into the Tulare Lake Basin in the southern Central

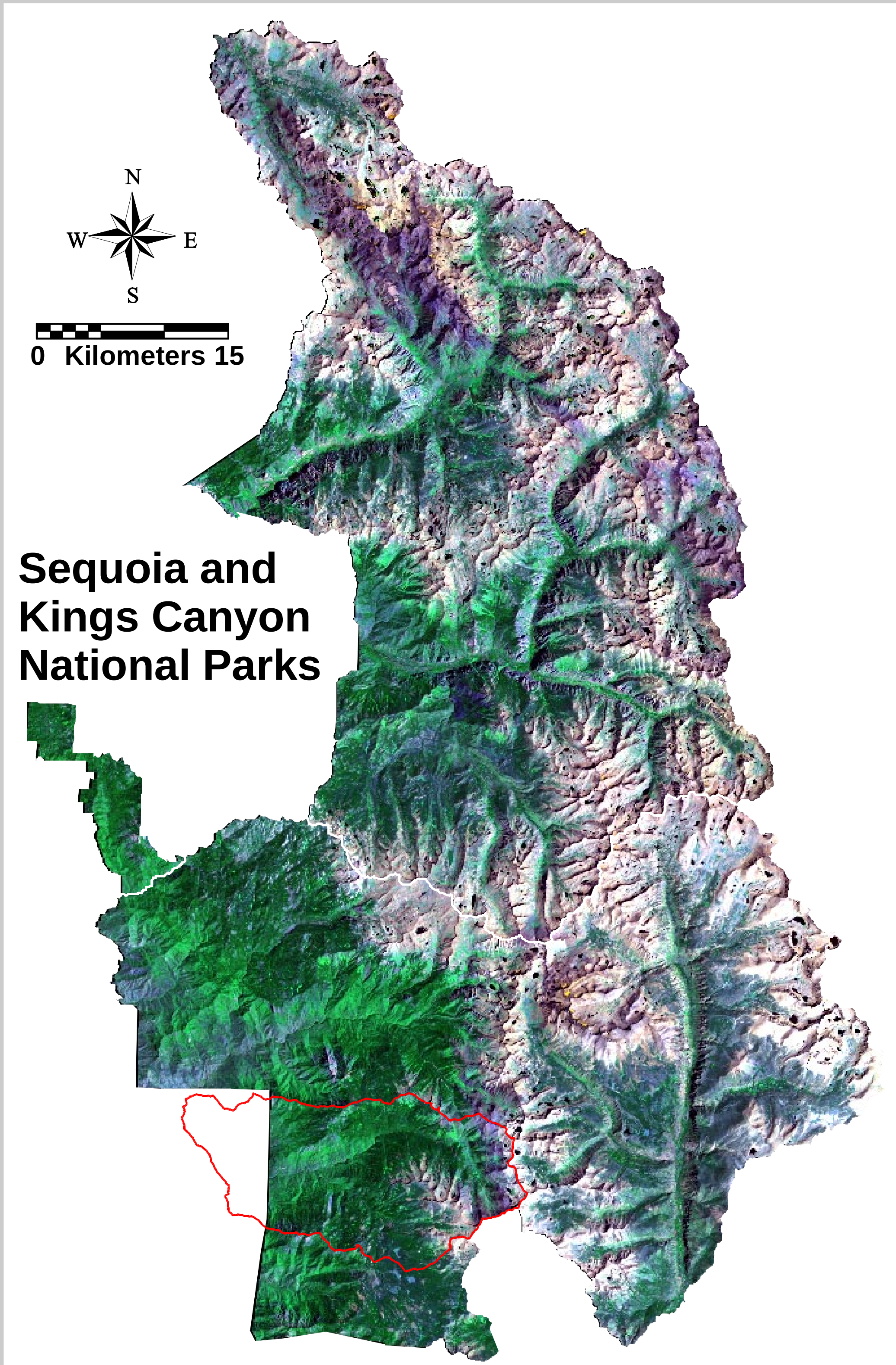


Figure 2.1-1. TM scene of Sequoia and Kings Canyon National Parks. Green areas are vegetated areas of the landscape. The East Fork drainage, where the Mineral King Risk Reduction Project is located, is outlined in red on the lower portion of the map.

Valley. Terrain in the watershed is rugged, elevations range from 874 m (2,884 ft) to 3,767 m (12,432 ft) within the project area. The watershed, 21,202 ha (52,369 ac) in size, is bounded by Paradise Ridge to the north, the Great Western Divide to the east, and Salt Creek Ridge to the south. Major topographic features of the watershed include the high elevation Mineral King Valley, Hockett Plateau, Horse Creek, the high peaks producing the Great Western Divide, and the Oriole Lake subdrainage (with an unusually low elevation lake for the Sierras at 1,700 m elevation).

Table 2.2-1. Segment number, size (approximate - revised 1999) and percent of area vegetated .

Segment	Hectares	(Acres)	% Veg.
Oriole Lake (#1)	2,352	(5,811)	94.4
Lookout Point (#2)	439	(1,084)	91.0
Atwell Grove (#3)	962	(2,377)	96.8
Redwood (#4)	289	(716)	98.5
Deadwood (#5)	121	(300)	100.0
Silver City (#6)	135	(335)	100.0
Purple Haze (#7)	989	(2,445)	93.7
High Bridge (#8)	121	(299)	96.9
Empire (#9)	2,917	(7,210)	34.1
Tar Gap (#10)	6,577	(16,252)	90.9
Eden Grove (#11)	5,325	(13,153)	94.3

Eleven burn segments have been outlined within the watershed by fire management staff (**Table 2.2-1** and **Fig. 2.1-1**). Eight segments were designated on the south facing slope (north side of the East Fork) and three large segments on the more remote north slope (south side of the East Fork). Segment locations were established to facilitate prescribed burning operations and protection of primary developments within the watershed.

Vegetation of the area is diverse, varying from foothills chaparral and hardwood forest at lower elevations to alpine vegetation at elevations above 10-11,000 feet (**Fig. 2.2-3** and **Fig. 2.2-4**). About 80% of the watershed is vegetated with most of the remainder rock outcrops located on steep slopes and at high elevations. Lower elevation grasslands and oak woodland, while common at low elevations in the Kaweah drainage, are uncommon within the park's portion of the East Fork watershed. Sequoia groves within the project area include Atwell, East Fork, Eden, Oriole Lake, Squirrel Creek, New Oriole Lake, Redwood Creek, Coffeepot Canyon, Cahoon Creek, and Horse Creek. Vegetation is dominated by red and white fir forest with pine and foothill types of somewhat lesser importance (**Table 2.2-2**). No endangered species are known from the watershed although several sensitive species have been located during surveys (Norris and Brennan 1982).

Vegetation Class	Hectares	(Acres)
Foothills Chaparral	1,119	(2,764)
Foothills Hardwoods &	1,432	(3,536)
Ponderosa Pine Mixed Conifer	1,919	(4,741)
White Fir Forest	3433	(8,479)
Red Fir Forest	4,042	(9,983)
Xeric Conifer Forest	1,342	(3,315)
Montane Chaparral	473	(1,167)
Mid-Elevation Hardwood Forest	170	(420)
Lodgepole Pine Forest	935	(2,310)
Subalpine Forest	96	(237)
Meadow	130	(320)
Giant Sequoia	994	(2,454)
Other (primarily water)	97	(241)
Barren Rock	4,092	(10,109)
Missing or No Data	130	(320)

Table 2.2-2. Updated vegetation type classification for the East Fork watershed and the area occupied by each class.

Access to the area by road is limited to the narrow winding Mineral King Road, 25 miles long. The Mineral King Valley is popular with backpackers and packers as a starting point for many high country trips. Higher elevations of the watershed receive considerable

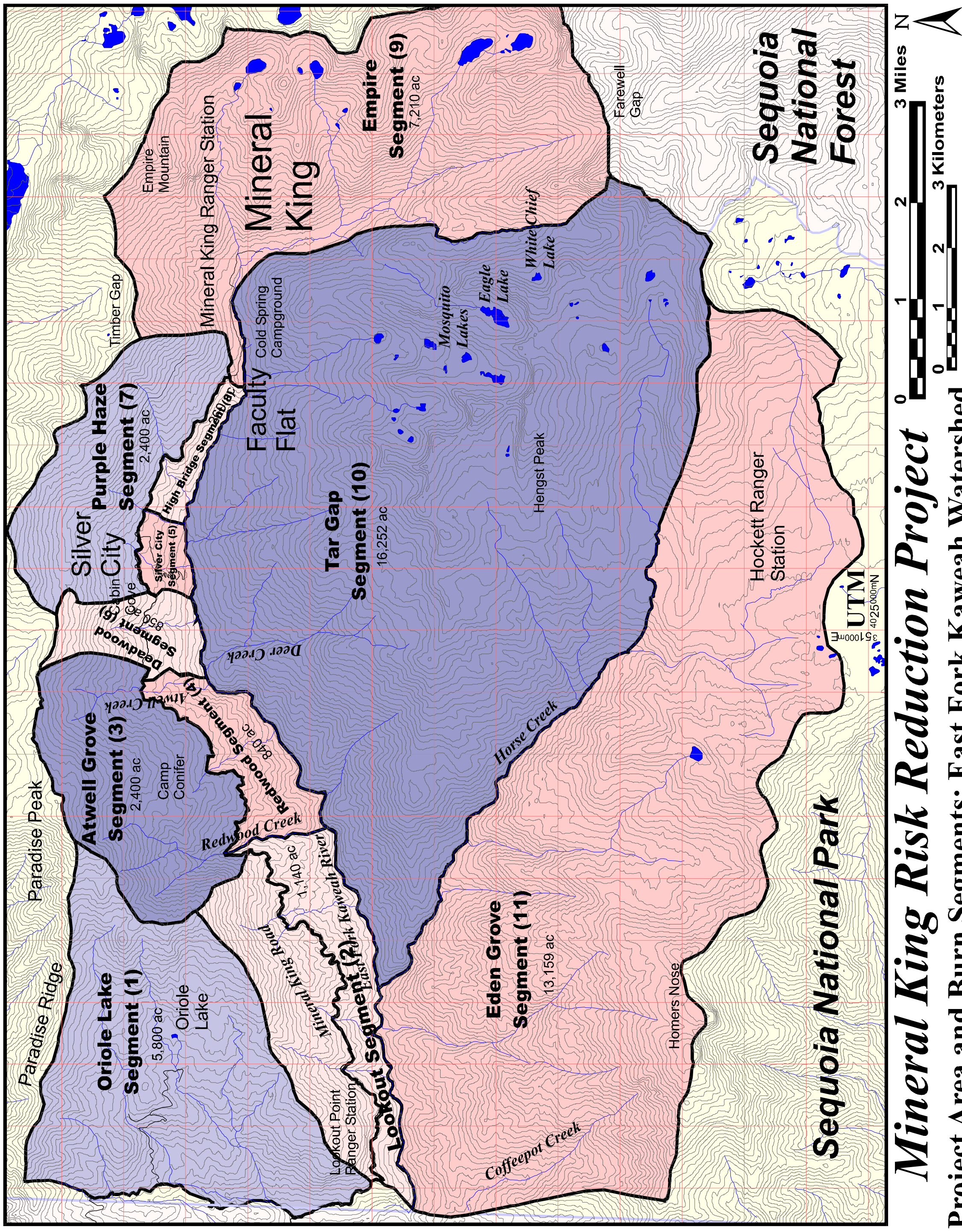


Figure 2.2-2. Mineral King Risk Reduction Project project area and segment boundaries. Not all area within the segments is burnable vegetation. Approximately 20% of the watershed within the Parks is barren rock.

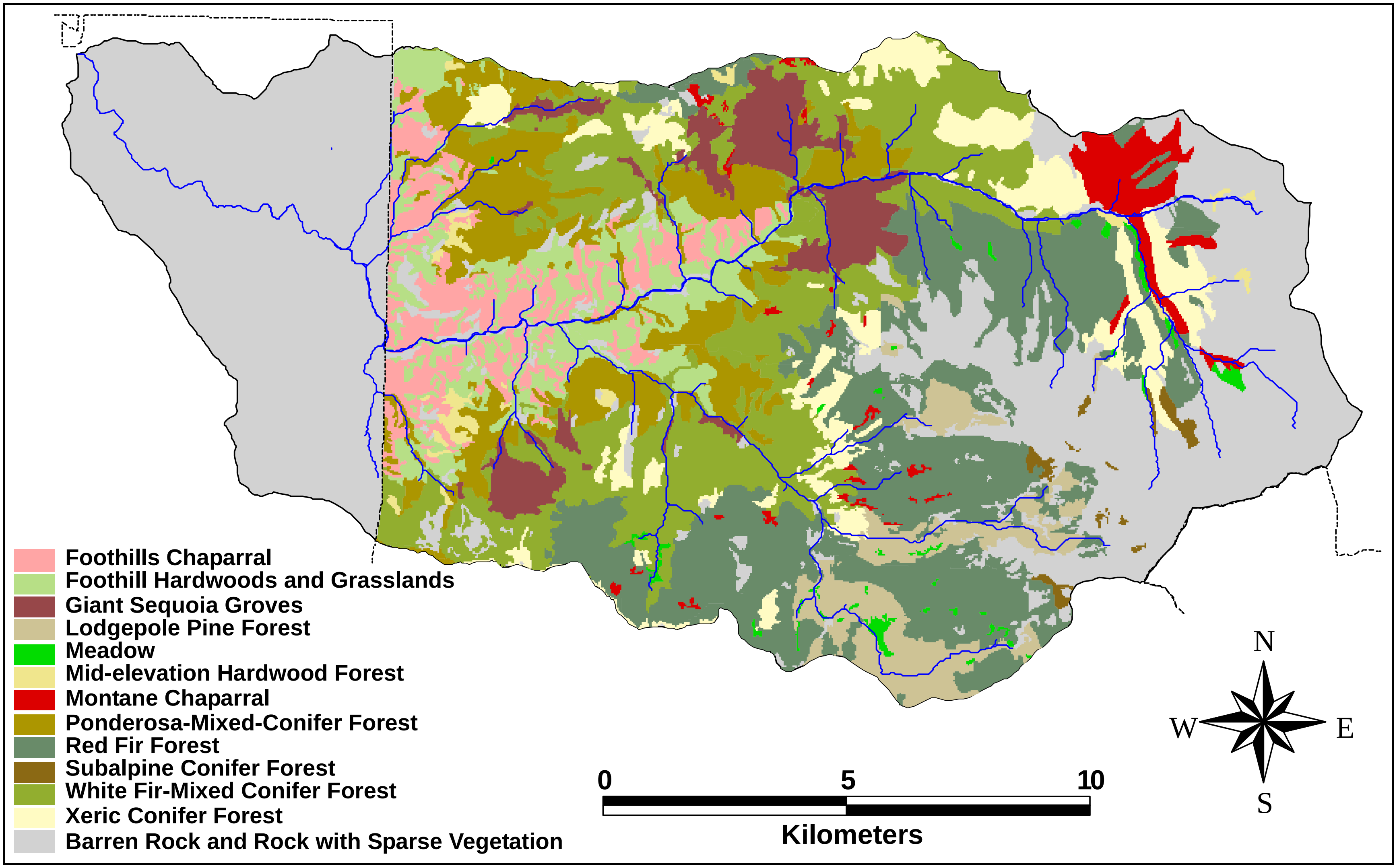


Figure 2.2-3. Major vegetation classes within the Park in the East Fork drainage

recreation use while lower elevations receive relatively little use. Developed or semi-developed areas within the watershed include Silver City, Oriole Lake (private lands), Cabin Cove, Mineral King, Faculty Flat (lease cabin sites), Lookout Point, and the Atwell Mill areas (administrative sites). NPS campgrounds exist at Atwell Mill and Mineral King.

References

Agee, J.K. 1973. Prescribed Fire Effects on Physical and Hydrologic Properties of Mixed Conifer Forest Floor and Soil. Water Res. Center, Univ. of California Cont. Rept. No. 143.

Biswell, H.H.. The Big Trees and Fire. 1961. National Parks Magazine. 35:11-14.

Bonnicksen, T. M., and E. C. Stone. 1978. An analysis of vegetation management to restore the structure and function of presettlement giant sequoia–mixed conifer forest mosaics. Contract report to the U.S. National Park Service, Sequoia and Kings Canyon National Parks, California, USA.

Dilsaver, L.M. and W.C. Tweed. 1990. Challenge of the Big Trees: A Resource History of Sequoia and Kings Canyon National Parks. Sequoia Natural History Association, Inc. Three Rivers, CA. 379 pp.

Farquhar, F.P. 1965. History of the Sierra Nevada. Univ. of Calif. Press, Berkeley, Calif. 262 pp.

Hartesveldt, R.J. and H.T. Harvey. 1967. The Fire Ecology of Sequoia Regeneration. Proceedings from the California Tall Timbers Fire Ecology Conference. Nov. 9-10, 1967

Kilgore, B.M. 1971. The Role of Fire in Managing Red Fir Forests. Trans. 36th North Amer. Wildlife and Nat. Res. Conf., pp. 405-416.

Kilgore, B.M. 1972. Fire's Role in a Sequoia Forest. Naturalist. 23:26-37

Kilgore, B.M. and R.W. Sando. 1975. Crown Fire Potential in a Sequoia Forest After Prescribed Burning. For. Sci.21:83-87.

Kilgore, B.M. and D. Taylor. 1979. Fire History of a Sequoia-Mixed Conifer Forest. Ecology 60:129-142

Norris, L.L. and D.A. Brennan, 1982. Sensitive Plants Species of Sequoia and Kings Canyon National Parks. USDI NPS, Coop. Nat. Park Resources Studies Unit Tech. Report No. 8.

NPS. 1991. Fire Management Plan Sequoia and Kings Canyon National Parks.

Parsons, D.J. and S.H. DeBennedetti. 1979. Impact of Fire Suppression on a Mixed-Conifer Forest. Forest Ecology 2:21-33.

Rundel, P.W., D.P. Parsons, and D.T. Gordon. 1977. Montane and subalpine vegetation of the Sierra Nevada and Cascade Ranges. pp. 559-599. In: M.G. Barbour and J. Major (eds.). Terrestrial Vegetation of California. Wiley & Sons, Inc., NY. 1002 pp.

Stephenson, N.L. 1988. Climatic control of vegetation distribution: the role of the water balance with examples from North America and Sequoia National Park, California. Dissertation, Cornell University, NY. 295 pp.

Vankat, J. L. 1970. Vegetation change in Sequoia National Park, California. Dissertation. University of California, Davis, California, USA.

Vankat, J.L. 1982. A gradient perspective on the vegetation of Sequoia National Park, California. Madroño 29:200-214.

Weaver, H. 1967. Fire and its relationship to ponderosa pine. Tall Timbers Fire Ecol. Conf. Proc. 7:127-149.

Weaver, H. 1974. Effects of fire on temperate forests; Western United States. In: Kozlowski, T.T. and C.E. Ahlgren. ***Fire and Ecosystems***. New York, Academic Press.

Figure 2.2-4 Main drainage of the East Fork of the Kaweah from Case Mountain. Photo does not show the Oriole Lake subdrainge (left of view). Photo by Linda Mutch.

3. Fire Year 1999

All Park Areas

Total acreage burned by all causes within the Parks during 1999 was 2,437 ha (6,019.1 ac). Of this total 14% were wildland fires which were unplanned fires started by humans or lightning. Human-caused fires are always suppressed while lightning-caused fires are evaluated to determine the appropriate management strategy. Some of these fires are allowed to burn for resource benefit, others are suppressed. Prescribed fires made up the bulk of the burning within the Parks during 1999. Prescribed burns are planned fires ignited under controlled conditions within defined burn units.

Wildland Fire (343 ha - 848 ac)

- Used for Resource Benefit (WFURB) (236 ha -581.9 acres) - Lightning caused, and actively managed to maintain natural ecosystem processes. Includes the large Williams fire near Cedar Grove (232 ha - 573 ac) and thirteen small fires (< 1.2 ha each totaling 3.6 ha - 8.9 ac).

- Suppressed (107 ha - 266.1 ac)

  - *Lighting Fires* - Lightning-caused fires, suppressed due to factors such as proximity to park boundary, unacceptable smoke impacts, unacceptable weather conditions, or competition for firefighting resources regionally or nationally. Includes five small fires totaling 1 ha (2.5 ac).

  - *Human-Caused Wildfires* - Unplanned and unwanted fires where various suppression tactics were used. These includes six small fires totaling 197 ha (263.6 ac).

Prescribed Fires - Prescribed fires are fires planned and ignited by NPS staff in designated areas to reduce hazardous fuels and/or restore natural conditions. During 1999 these included eleven fires totaling 2,094 ha (5,171.1 ac) (**Table 3-1**).

Table 3-1. Summary statistics for 1999 of area treated by each prescribed burn.

Units	Burn	Hectares (Acres)
Foothills	Ash Mountain	8.1 (20)
Cedar Grove	Maintenance	0.04 (0.1)
	Lewis Creek	1,107 (2,735)
Wuksachi	Halstead	356 (880)
Giant Forest	Hercules	67 (165)
	Restoration	0.81 (2)
Mineral King	Lookout	147 (363)
	Tar Gap	248 (613)
	Deadwood	159 (393)

Mineral King Project

The Mineral King Risk Reduction Project was initialized during March 1995 with inventory and monitoring field work and burn operations begun during the summer and fall [850 ha (2,100 ac) were burned in the Atwell Segment, **Fig. 2.1-2**]. No burns were conducted during 1996 due to the extent of resource demands during the summer of 1996 inside and outside the parks (more acres burned in the western USA than any year since 1920). The critical Redwood Segment, below and west of Atwell Mill, was burned during November 1997 [184 ha (455 ac)]. This completed the basic buffer of burned areas across the East Fork drainage (Atwell and Redwood Segments, and the Deer Creek Burn) which will provide better fire protection for Atwell, Cabin Cove, Silver City, and Mineral King from wildfires burning up out of the chaparral. Burning in the watershed during 1998 amounted to about 150 ha (371 ac) in two segments and in 1999 554 ha (1,369 ac) in three segments (**Fig. 3-1**).

Burn operations during 1999 took place in the Tar Gap area, Lookout Point/Conifer Ridge, and the Deadwood segments. In the Tar Gap area three subunits of the segment located above the Tar Gap Trail were burned. The subunits had well defined topographic barriers which allowed easy control. Because of the elevation and aspect, burns were carried out over a several week period extending from mid-August to early September. This ignition pattern permitted better control of smoke production and allowed the burns to be turned on-or-off depending on the Park's smoke-budget needs. Burning this portion of the Tar Gap segment also burned plots from several fire related studies in red fir forest (fire effects, red fir regeneration, Pitcher plots, and landscape analysis). Early ignition of forest on this aspect at this elevation is generally

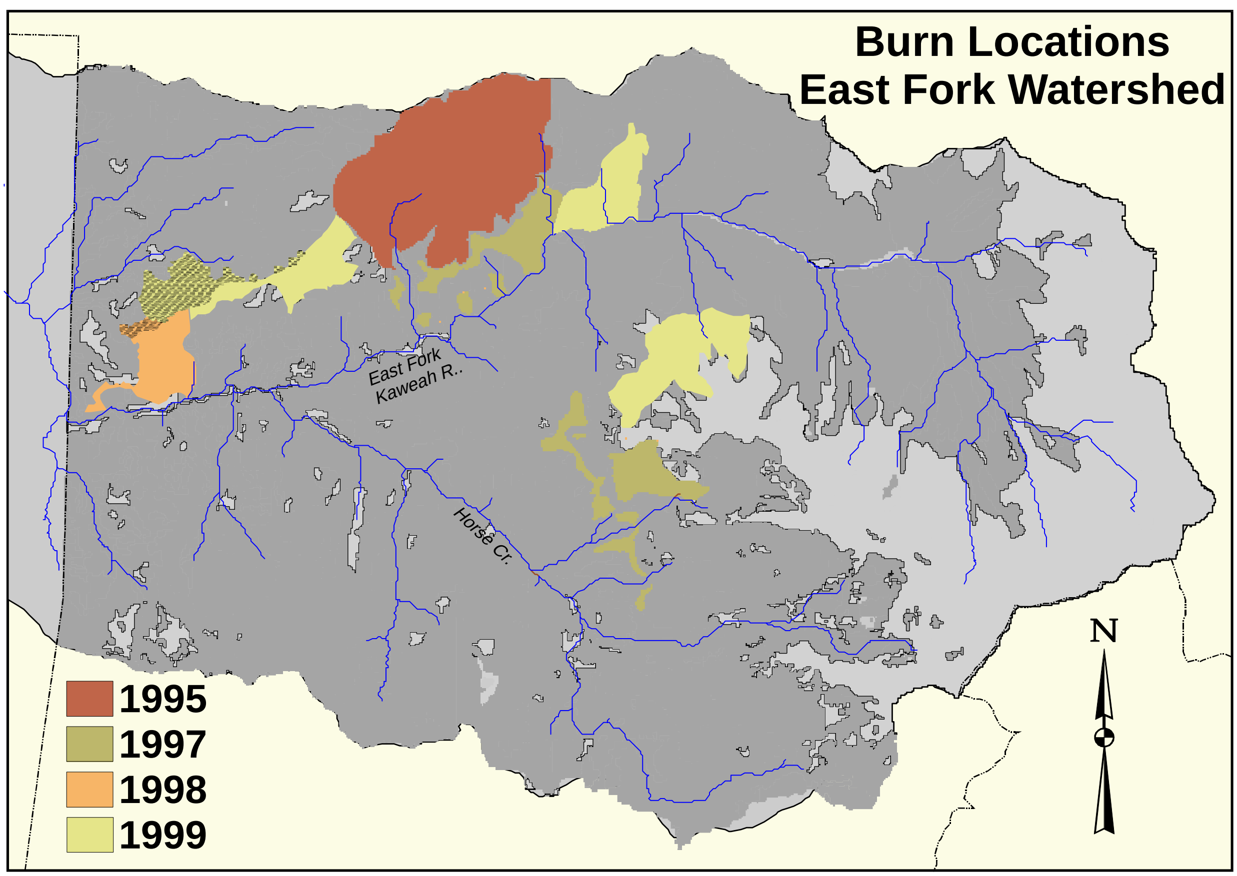


Figure 3-1. Locations of areas burned in the East Fork watershed from 1995 through 1999. Vegetated area within the Park is shown in dark grey. Areas burned by escaped prescribed fire are shown by hatching.

Figure 3-2. Fire in Newburn Plot located in north aspect red fir forest in the Tar Gap area. Photo shows typical fire behavior during late August burn.

needed for good burning conditions because as the sun angle declines in the fall the aspect cools rapidly and holds fuel moisture once precipitation occurs. Ignitions were begun within each subunit at the elevation where fuels roughly transitioned from moderate to light fuels. Light fuels in the upper portion of the subunits were not felt to require active ignition but were allowed to burn if fire carried into the area on its own. Total area burned in the three subunits was about 248 ha (613 ac). Ignitions in the Deadwood segment were begun in the late fall and were originally designed to blackline the western boundary of the unit. However, due to the heavy fuel load and the failure of winter rains to start until mid-January 2000 the fire continued to burn into the unit. Because it was within prescription and meeting burn objectives it was allowed to continue. As a result ~211 ha (~522 ac) of the lower half of the unit was burned. The remaining portions of the unit are scheduled to be completed during 2000. The third segment, Lookout Point, was also ignited. The objective was to burn off of a hand line that had been constructed down Conifer Ridge that tied in with the 1995 Atwell burn on the upper end and the 1998 Lookout burn on the lower end. However, a slop-over burned into heavy fuels on the Oriole Lake side of the ridge (to the north). Minimal suppression efforts were required to manage the burn in this area. However, the escape continued to burn for a considerable length of time due the extremely late arrival of winter rains (January 17, 2000). Total area burned in the unit was 147 ha (363 ac).

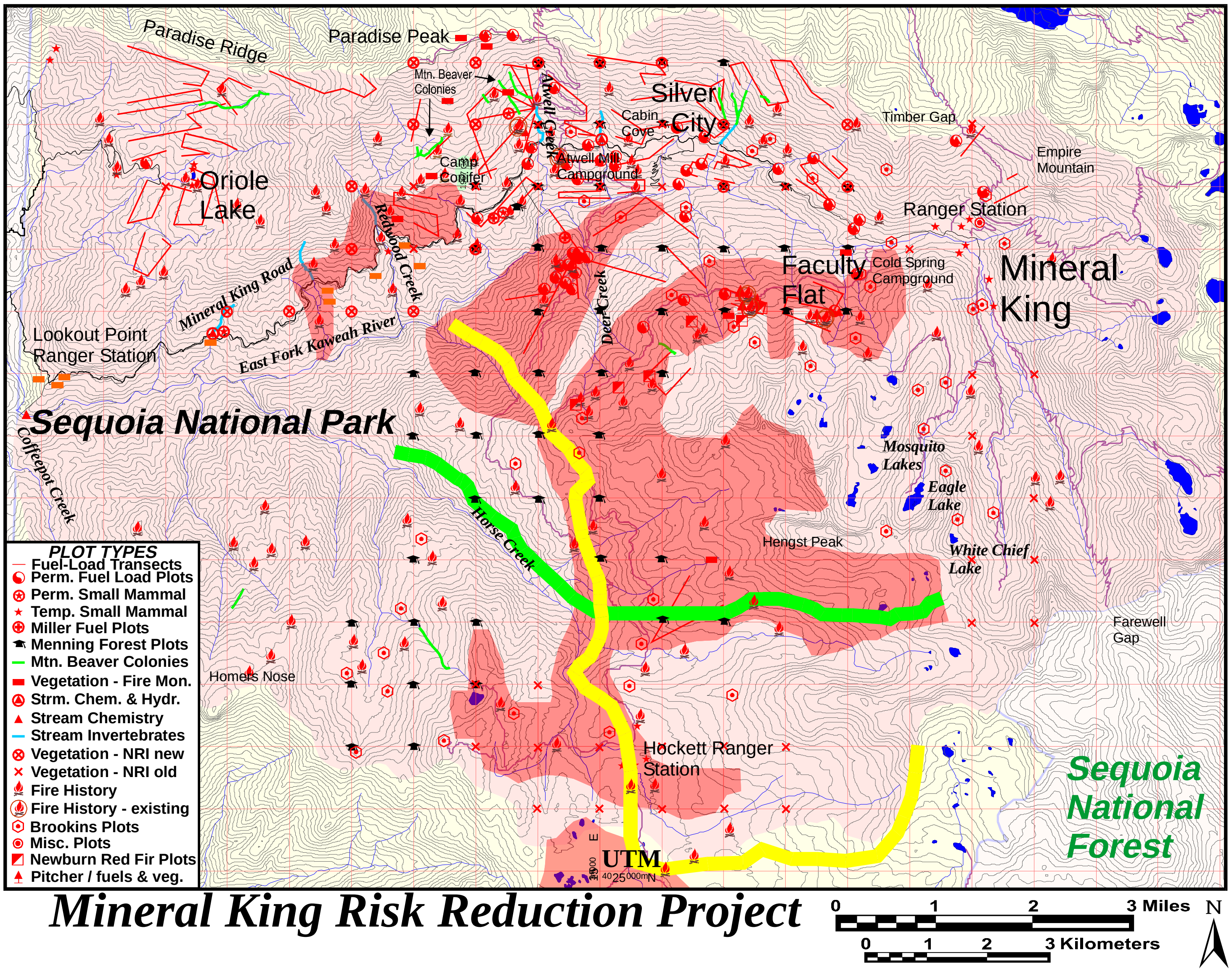


Figure 3-2. Location of all plots and transects sampled in the East Fork drainage.

4) Project Year 1999

4.1) Vegetation

4.11) Mineral King Landscape Assessment (MKLA)

Principle Investigators: *Kurt Menning*, *Dr. Tracy Benning*, and *Dr. John Battles*, University of California, Berkeley; in conjunction with *Dr. Nathan L. Stephenson*, Biological Resources Division of United States Geologic Survey, Sequoia and Kings Canyon Field Station.

1999 field crew: *Kurt Menning, Will Hopkins, Bob Fahey, Allison Tokunaga, and Rob York.*

Tony Caprio, John Battles and *Nate Stephenson* also assisted in the field during the first days of formulating the sugar pine mortality study.

Project objectives and background

As in many western forests, the suppression of wildfires over the last century has altered forests in Mineral King. It is believed that the lack of fire directly has affected regeneration of many tree species, availability of habitat for birds and wildlife, susceptibility of the forest to insect attacks and disease, and diversity of small forest plants. Many park managers and scientists believe we should restore these forests to within a range of historic conditions at the same time catastrophic fire risks are reduced. To examine the effects of restoring forests with the direct application of fire we are monitoring the effects of the Mineral King Risk Reduction Project (MKRRP) to discover how re-introduced fire alters this forest.

In order to address the questions of *when* and *where* prescribed fire can be used to restore some components of historic forest structure, pattern and composition, we need to understand first, what historic forests were like when these forests were experiencing more frequent fire; second, how these forests have changed up to the present with the suppression of fire; and third, what effect re-introduced fire has on altering current forest conditions. To answer these questions we need data from three time periods: past, present (pre fire), and post-fire (see figure below). Historic data are necessary to establish a baseline from the past to present and to act as targets for restoration through prescribed burning. Current conditions data are used to measure the change from historic conditions and to act as a benchmark for change to the post-fire state. Finally, post-fire data are used to determine the effect fire has on changing forest structure, composition and pattern, and to compare resultant forests with targets—states or range of conditions derived from past landscapes—established using the historic data.

By collecting data over several spatial scales and across these three time periods we hope to assemble many pieces of the puzzle of forest landscape change, disturbance and restoration. This large picture view of dynamics in this watershed will help us better understand:

- How variability in microclimate and topography in the forest affect stand heterogeneity

- How fires interact with stand heterogeneity to modify landscape mosaics of patches, gaps, and gradients
- What changes in structure and pattern have occurred in the system during the period of suppression
- What compositional shifts have resulted during fire's absence
- How a sampling strategy across a landscape could provide useful measures of landscape patterns and change (and perhaps could lay the groundwork for standard protocols for forested landscape monitoring)

And, as a result,

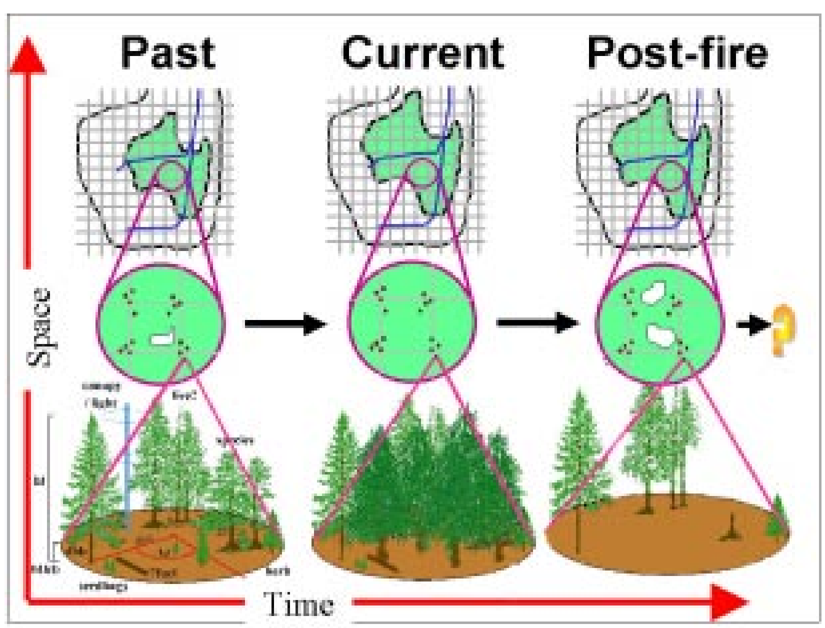
- When and where prescribed fire can be used as a restoration tool

In 1996 and 1997, over two hundred forest plots were established throughout the watershed. We hoped to inventory plots directly before the reintroduction of fire and immediately after. Unfortunately for this particular study, the schedule of burning has not matched the schedule of inventory. Over the last three years only nine plots out of 209 have burned. Seven of these burned plots were west of Atwell Creek and two were along the tar gap trail. Of the plots that did burn, five are mixed-conifer plots, two are mixed-conifer/oak woodland, and two are red fir. With such a small sample of burned plots we have been unable to draw meaningful conclusions about the landscape-level effects of re-introducing fire. We are hoping that this summer we may add 10 to 24 plots to the "burned" category after the Winter 1999-2000 burns.

Due to the small spatial extent of burning in the mixed conifer portion of the watershed, we have turned our short-term attention to a more robust examination of the current (pre-fire) conditions in the area. These analyses are described below.

Project Methods

Data on current conditions have been collected both within forests using an extensive forest inventory approach, and from the air in 1997, using aerial photography. Historic data have not yet been examined closely. Field data for pre- and post-fire conditions are collected from forest plots ten meters in radius. These are located precisely using a precision global positioning system (GPS) unit. Within each plot, relatively complete inventories have already been completed: trees were identified by species, measured and mapped; fuel conditions have been recorded; brush and plant cover were described; slope and aspect have been recorded; and light penetrating through the forest canopy was measured.

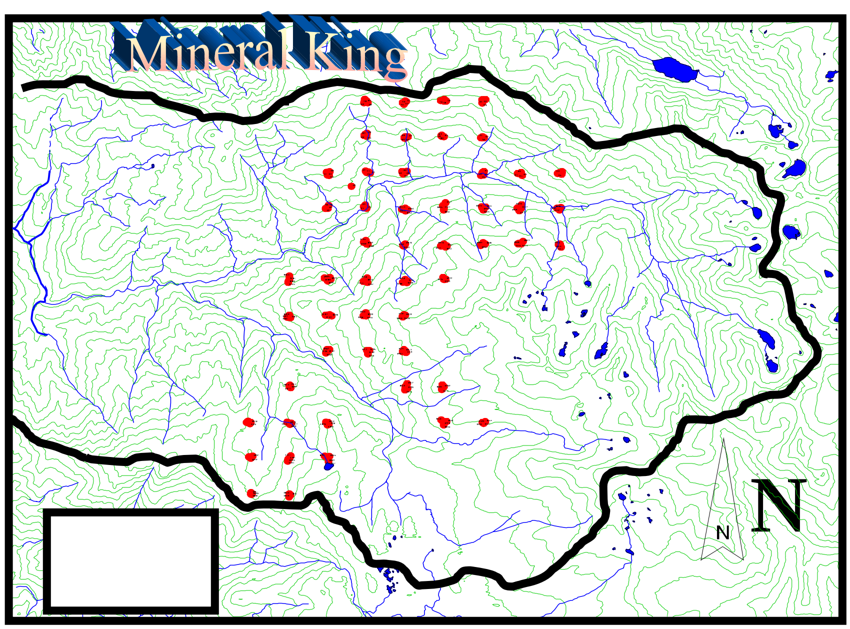


Collection of the remote imagery data involved a more elaborate process. High resolution, digital photographs were collected during an over-flight in the summer of 1997. The digital photographs, with a resolution of about one meter, are actually four simultaneous pictures in different bands of light—blue, green, red, and near infrared. The instrument digitally records the time, flight conditions and position of each set of photographs. It is hoped that this special imagery will allow us to determine individual tree species and detect subtle changes in forest conditions due to stress or insect attack. Unfortunately, Digital Orthorectified Quadrangle (DOQ) maps were not immediately available. When these became available in 1998 they allowed us to begin the orthorectification process.

Fieldwork completed in 1999

In the summer of 1999, despite the lack of burning in the mixed conifer forest in the autumn and winter of 1998, we set out to collect additional data from existing plots. We wished to better understand factors that create forest heterogeneity throughout the watershed. We believe that soil moisture holding capacity, forest canopy architecture[1], relative decomposition rates and other factors contributing to microclimatic variation between sites could be very important factors in affecting the variability in mixed conifer structure and composition. This variability, in turn, could greatly affect both the way in which fire burns through the forest and the patterns of severity that result.

In two and a half months, we revisited 160 of the plots previously established to collect these data. The only area with many plots we did not revisit was the Cahoon Creek watershed due to logistical constraints and heavy field equipment. *Soil depths* up to 1m deep were determined using a tile probe and slide hammer at three sites in each plot. Previous data on soil depth using hand-pushed rods had proved to be too dependent on the measurer to be reliable. *Hemispherical photographs* of the canopy of each plot were taken from these same three known points. In addition to the hemispherical photographs taken for the MKLA project, Will Hopkins took additional photos in the white fir-red fir interface zone to support his master's thesis study on factors affecting regeneration and species composition in this zone.[2] *Forest litter samples*—twigs, needles, cones and bark flakes—were collected from inside each plot for a study on bulk density of litter. In order to study the rates of ground fuel (litter and duff) *decomposition rates* we strung wooden popsicle sticks on fishing line and hid these beneath the litter layer. These will be recollected in several years if they survive or avoid fire.



In addition, we began a new piece of research on sugar pine (*Pinus lambertiana*) mortality. This study was designed in reaction to the views of many managers and scientists who believe that re-introducing fire directly can lead to increased mortality of large pines. During fieldwork in Mineral King we had observed another trend that complicated the argument that burning around

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[1] Using hemispherical crown photographs of each plot to create a permanent record of canopy architecture at each site. These photos provide an excellent baseline for examining changes caused by fire.

[2] In John Battles' Forest Community Ecology Laboratory, University of California, Berkeley.

old pines can kill them. In Mineral King, large sugar pines (*Pinus lambertiana*) appear to be dying with greater frequency than other large trees even *without* fire. It is probable that in the course of fire suppression individual large sugar pines are being out-competed by the many small white fir (*Abies concolor*) and other tree species that are normally killed in light or moderate fires. The death of large trees due to competition by many small trees during fire suppression has been the source of some conjecture but little direct research. High mortality may also result from manifestation of blister rust or climate change; however, mature trees are not as susceptible to blister rust and the wetter weather this century should favor mature sugar pines in the mixed conifer forest. Hence, we believe the increased mortality of large sugar pines to be due to elevated competition from fire suppression.

We selectively cored and geo-referenced large living and dead sugar pines. Our goal is to determine date of death (through cross dating) and recent rates of growth. If there is a substantial decrease in growth rate over this warmer, wetter century, we may intuit that it is due to increased competition. If this is observed and can be correlated with air photos showing an increased density of small trees in these locations we may be able to show a relationship between the absence of fire and compositional and structural change: the loss of the large pine component of this forest.

Our attempts to collect cores were somewhat complicated by the rate at which the outside layers of sugar pines decay. Attaining good cores was difficult and our sample size was relatively small. We hope to be able to cross-date these cores this spring.

Current status of MKLA research

Hemispherical photography

Analysis of the hemispherical photos is divided between two different projects. First, hemispherical photographs support the MKLA assessment of forest structure, especially forest canopies. We anticipate that these data also will be very helpful in our efforts to understand the water and energy balance in the watershed that is affecting forest structural development. The soil depth measurements taken will provide additional support for these analyses. These photos, approximately 400 in number, still are being scanned and processed using hemispherical light interpretation software; results are not yet available.

Second, Will Hopkins is examining light conditions within the permanent MKLA plots using a different series of hemispherical photographs. For this analysis we measured saplings of white fir and red fir (0.2 – 2.2 m height) to determine relative growth rate, an index for overall growth performance. The saplings were categorized as growing under a white fir dominated canopy, a red fir dominated canopy, or a mixed red fir – white fir ecotone canopy. We hypothesized that growth rates across the ecotone and between species would conform to the plant strategy theory of interspecific competition. Specifically, white fir, the lower elevation species, is presumably a better competitor than red fir on the higher quality sites, while red fir is presumably the better tolerator and able to out tolerate white fir in the harsh conditions of the upper elevation sites. Consequently, we would expect the white fir to perform better in the white fir zone than in the ecotone and for red fir to perform better in the ecotone than in the red fir zone.

After controlling for neighborhood level variations in light regime (a light index calculated from fisheye photos), basal area (existing MKLA data), and near neighbor density (using data from the MKLA seedling and sapling counts) we found growth rate patterns that conform to expectations. White fir growth rates decreased from 4.3% in the white fir zone to 3.7% in the red fir zone while red fir growth rates decreased from 3.1% in the ecotone to 2.9% in the red fir zone. The zone was a significant predictor ($p<0.05$) of growth rate in an Analysis of Covariance that included the above-mentioned independent variables.

Dominant Species	Density g/cm^3	n	sd
Oak	0.062	2	0.023
Sequoia/ cedar	0.084	14	0.027
White fir	0.091	57	0.030
Pine	0.10	14	0.043
Red fir	0.11	30	0.055

Litter Density Analyses

Litter bulk density analyses, while still underway, already have provided interesting results. Historically, the mixed conifer forest was regularly disturbed by frequent, low-severity fires with ground and surface fuels as important vectors of fire spread. The canopy species diversity in this forest should result in a similarly variable litter base. Our earlier studies of forest structure and fire history in the area revealed that topographic factors are important determinants of both forest structure and fire history patterns. However, the specific link between variability in forest composition and in fire regimes has not been identified.

To address one possible explanation we examined the density of the forest litter mat to determine if the dominant canopy species would affect litter density and could thereby help regulate fire behavior. Dense litter mats, for example, retain more moisture and have low air flow, resulting in slow fire spread. We sorted our mixed conifer plots into those dominated by red fir (*Abies magnifica*), white fir (*A. concolor*), sequoia or incense-cedar (*Sequoiadendron giganteum* and *Calocedrus decurrens*), and pine species (*Pinus ponderosa*, *P. jeffreyi*, *P. monticola*, *P. contorta*). Red fir litter was the densest at 0.11 g/cm^3 (n = 30), followed by pine (0.10 g/cm^3, n = 14), white fir (0.09 g/cm^3, n =57), and least dense, sequoia and cedar (0.084 g/cm^3, n = 14). Significant differences in litter density were observed between red fir and white fir ($p = 0.005$), and between red fir and sequoia/cedar ($p = 0.003$). The high density of pine litter in comparison to white fir litter was unexpected. We had anticipated that pine litter, composed largely of long needles, would have the lowest density. Red fir had the highest variability (by coefficient of variation) in litter density, which may be an important result for explaining patchy fire behavior in that vegetation type.

In order to determine whether these differences in bulk litter density could play important roles in fire behavior we ran a Rothermel fire behavior model to determine rates of spread and intensity with all other factors held constant.[3] The results were striking. The rate of spread in white fir, with the measured bulk densities, would be more than double that in areas dominated by red fir. The fire-line intensity would be more than five times as great.

[3] Basic assumptions included no slope, 10 mph wind, 25% fuel moisture content, a particle density of 30 lb/ft^3, and fuel depth 0.2ft.

While these results complement the analyses presented last year on forest structure and fuels distributions they are not yet complete. Some additional resorting and processing needs to be completed before these numbers are final.

Species	**Spread rate** (ft/min)	**Intensity** (BTU/ft^2*min)
Sequoia/ cedar	0.544	17.6
White fir	0.368	7.56
Pine	0.249	3.19
Red fir	0.169	1.33

Remote sensing
Currently, remote image processing and analysis is underway on the digital multi-spectral imagery collected in the summer of 1997. A case study is being developed to link, in a small geographic area, the imagery with its embedded information on canopy structure, with the ground data provided by the field plots. We expect to expand this analysis throughout the mixed conifer zone in the watershed. With over 700 images to be processed from 1997 and more than 400 from 1996 there will be many repetitions of the same basic processing. We have hired an assistant to work 10-20 hours a week on image processing.

Summer 2000 and beyond

In winter 1999-2000, prescribed fire may have burned as many as 24 plots in the MKLA study area. Our best estimate at this time is that fire reached 16 plots. We plan to revisit and re-inventory these plots to detect changes due to fire. To accomplish this we plan to spend two to three weeks in Mineral King collecting data this summer.

Within the next year, we also plan to begin analyzing historic data. The qualities of different kinds of historic data vary. Data on the *spatial* arrangement of trees within stands, for example, are quite limited.[4] In contrast, most sources probably do have some information on forest *composition* and *structure*. Fire histories dating back centuries are available and quite reliable for many slopes, elevations and aspects in the watershed.

At the landscape level, far fewer data exist. Aerial photographs prior to 1954 have not yet been located (NPS and Stephenson, personal communication). Even if earlier photos are not available, these 1954 photographs, when compared with current imagery, should provide almost fifty-year trends in mosaic pattern, gap size, and encroachment. A second source of landscape level data is historic landscape photographs taken from the ground. Many of these landscape photographs, which date from the turn of the century, are archived at Sequoia National Park headquarters. These photographs should be useful in showing large-extent landscape patterns of presence and extent of forest patches.

With the exception of the evaluation of the historical data, most of these analyses will be completed in the next year by the conclusion of Kurt Menning's dissertation.

[4] Bonnicksen and Stone present a limited analysis of spatial in-stand tree data but these have been described as underestimating forest conditions (Stephenson, personal communication).

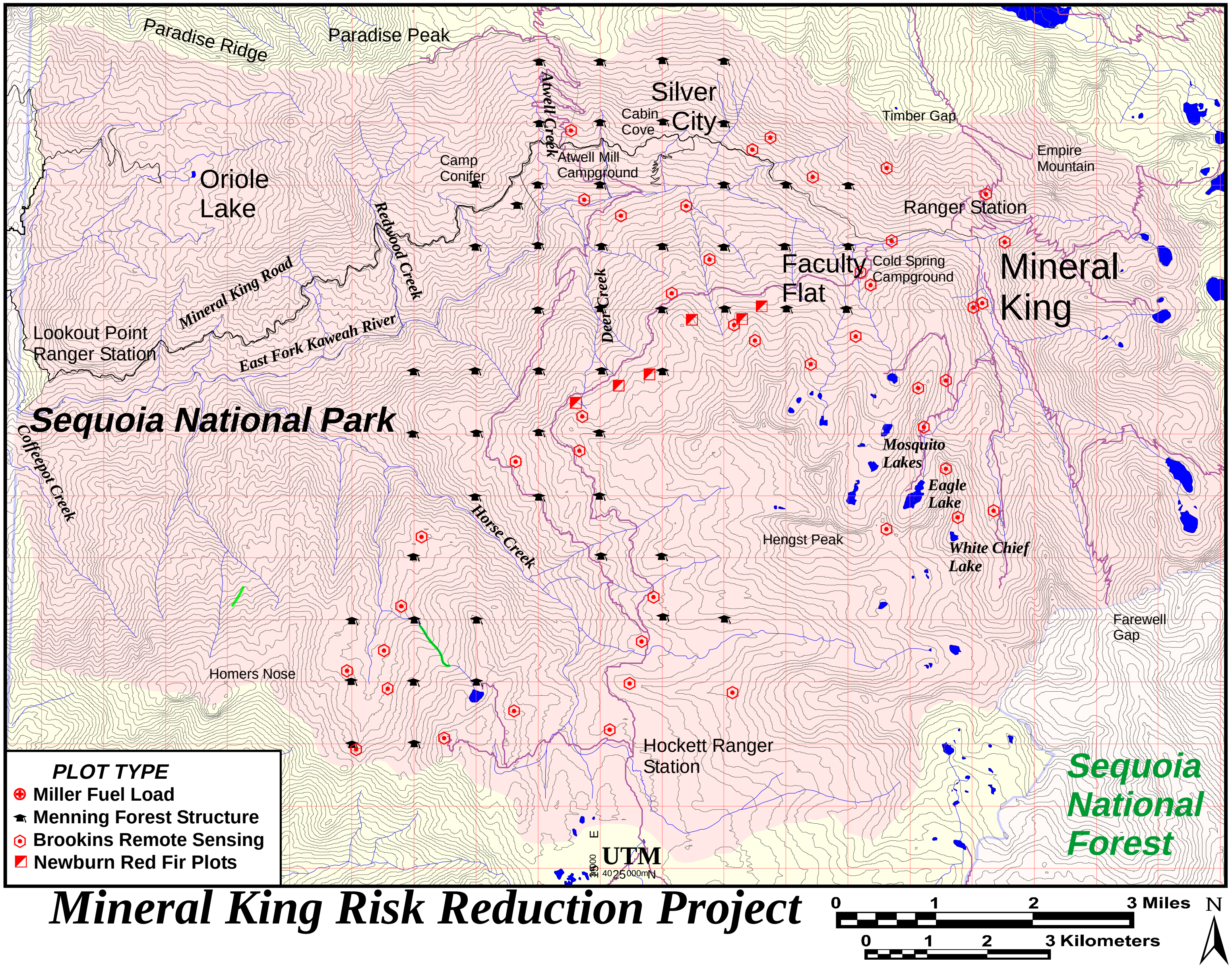


Figure 4.11-1. Location of plots by graduate students in the East Fork drainage.

4.12) Red Fir Plots (Pitcher Plots)

- Anthony Caprio, Science and Natural Resources Management, SEKI

Lead: A. Caprio, field assistance: Brian Knaus and Dylan Kreis (SCA volunteer)

INTRODUCTION

Ecological relationships and long-term stand dynamics of red fir forest have been poorly studied in the Sierra Nevada. Most studies have been descriptive, concentrating on composition, structure, and very basic biology (Oosting and Billings 1943; Pitcher 1981; Barbour and Woodward 1985; Laake et al. 1996). Similarly, fire effects information is sparse and poorly understood for this forest type in the Sierra, although the first prescribed burn of over a few acres in size in the western United States was carried out and studied in a red fir forest in Kings Canyon National Park (Kilgore 1971). Within Sequoia and Kings Canyon National Parks red fir forest comprise approximately 26,511 ha or about 13.2% of the parks' vegetation (based on parks' GIS vegetation maps). Within this forest type a range of natural burn severities and potential fire effects appear to exist, from understory burns with minor impacts on stand structure to severe burns that are stand replacing events (Pitcher 1981; Taylor 1993; Carl Skinner personal communication). The spatial scale of these events also appears to vary within stands.

Sequoia and Kings Canyon National Parks have been carrying out an expanding burn program which has included a substantial amount of prescribed burning in this forest type with even greater acreage planned for the future. This has led to the realization that a better understanding of both the long-term role and specific ecological effects of fire in this ecosystem is needed. This would include aspect differences, fuel load and its variability, fire behavior, variability in forest structure and demographics, and an improved classification scheme for this wide ranging vegetation type.

In the late 1970s Donald Pitcher (graduate student at UC Berkeley) established three permanent plots near Mineral King to study forest structure and composition (what species are present and how they are arranged in a forest), and fuel dynamics (fuels available to forest fire) (Pitcher 1981). Because little long-term data from red fir forest exist, resampling these plots will provide information to park managers on changes in forest structure and composition, and fuel loads over the intervening 20 year period. Additionally, postburn sampling will provide detailed information on forest changes and fire effects. When combined with the detailed spatial data (tree locations, fuel loads, crown dimensions) this data will provide an excellent opportunity to examine changes over time and fire effects at a degree of sophistication not usually available. Our understanding and interpretation of fire effects and longer-term postfire vegetation responses will be improved by having the 20 years of background information.

STUDY AREA

The three plots established by Pitcher (1981) are located in red fir forest along the Tar Gap Trail **(Fig. 4.12-1**). They were established in roughly three forest "age types" on a north aspect: plot #1 in "mature" red fir forest, plot #2 in "young" red fir forest, and a mixed stand with patches of young and old trees (plot #3). They were relocated in 1995 and have been resampled prior to the burning of Tar Gap Segment (segment #10) in 1999. UTM coordinates for each plot have been obtained using a PLGR to facilitate their relocation in the future (**Table 4.12-1**). Plots #1 and #2 are in close proximity to one another and plot #3 about 1.5 km away. At this time the latter plot is being maintained as a control by protecting the immediate plot area and a small surrounding buffer zone from burning.

Within the plots the dominant tree species is red fir (***Abies magnifica***) with a significant component of western white pine (***Pinus albicaulis***). Lodgepole pine (***P. contorta***) is present but very uncommon. Understory vegetation is extremely sparse with small patches of chinquapin (***Castanopsis sempervirens***)

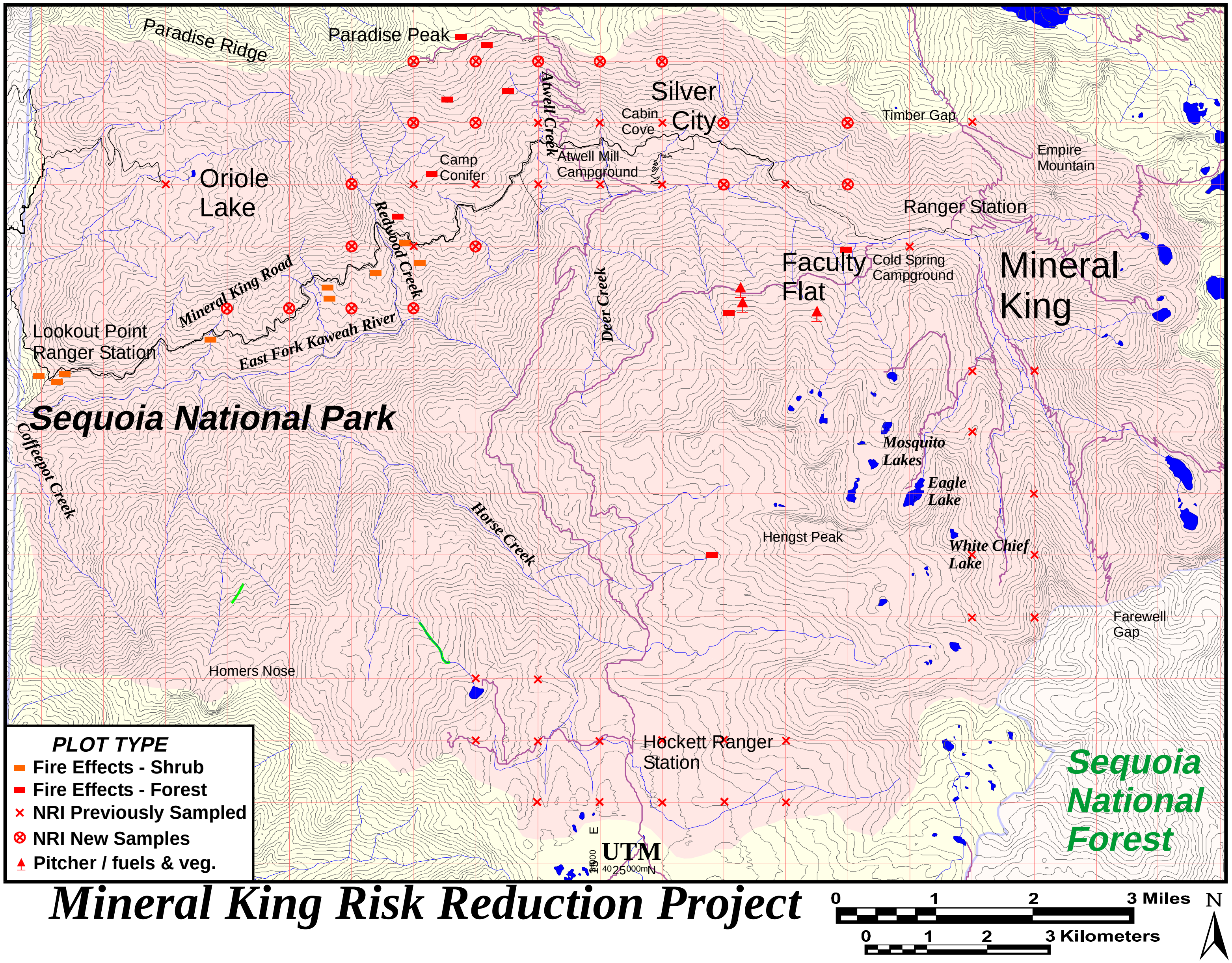


Figure 4.12-1. Plot location for vegetation sampling projects.

Table 4.12-1. UTM locations and elevation of the NE corner of each plot.

Plot	UTM North	UTM East	Elevation	Plot Size
Plot #1	4033980 N	353328 E	2545 m (8400 ft)	80 x 80 m
Plot #2	4034150 N	353273 E	2485 m (8200 ft)	50 x 50 m
Plot #3	4033910 N	354464 E	2612 m (8620 ft)	50 x 50 m

the most common. Herb species are widely scattered. Primary fuel model in the area is model 8; consisting mainly of red fir. Secondarily, model 5, composed mainly of greenleaf manzanita (***Arctostaphylos patula***) and chinquapin, represents the remainder of the area (on more open drier slopes). The fire history of the area was originally studied by Pitcher (1981, 1987) and recently expanded and updated (Caprio 1998, 2000). Plots # 1 and #2 last burned in 1886 and plot #3 in 1848 based on fire scarred trees sampled nearby. Between 1400 and 1899, at plots #1 and #2, nine fires with fire intervals ranging from 9 to 87 years was found, while at plot #3 five fires with fire intervals ranging from 27 to 119 years were found.

DATA COLLECTION

I was fortunate to be able to relocate Donald Pitcher and he was kind enough to provide us with a copy of his original data set which has been partially re-entered into digital format from the paper printout. This data set is being checked for errors, although portions were used to make preliminary estimates of changes in the plots. Utilizing the original data set will greatly facilitate comparisons between the 1978

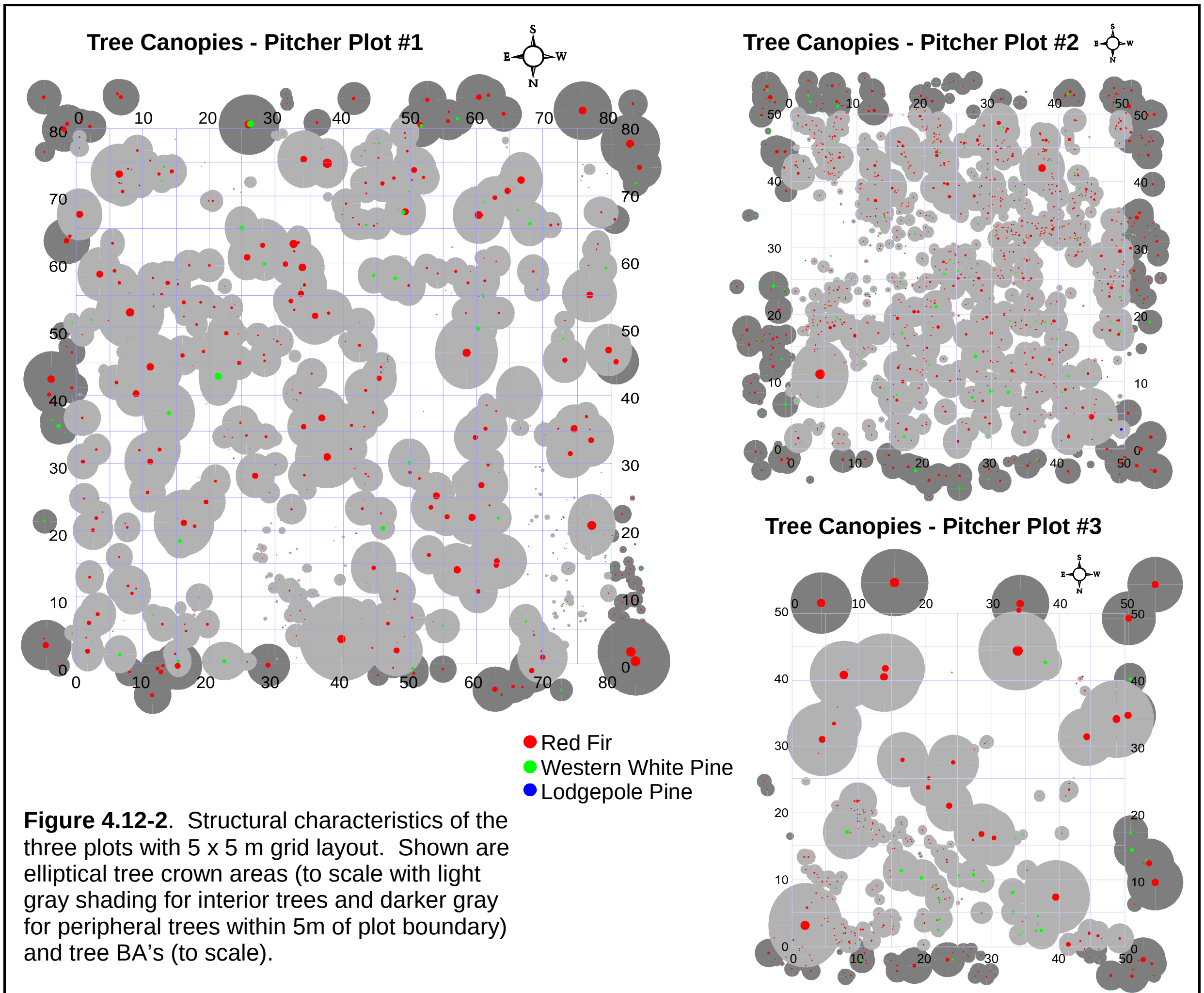


Figure 4.12-2. Structural characteristics of the three plots with 5 x 5 m grid layout. Shown are elliptical tree crown areas (to scale with light gray shading for interior trees and darker gray for peripheral trees within 5m of plot boundary) and tree BA's (to scale).

sampling and the current sampling, since we will have the exact measurements and locations for trees from the original data. As a result we will be able to describe changes in DBH, fuels, and stand structure over the intervening time very accurately.

Preburn resampling of all three plots was completed in 1999. Data recollected on the plots included: DBH, mortality checks (1978-1998), fuel, fuels, plus canopy cover, width and height . Additional data (location, species, and DBH) were also collected on peripheral trees, those trees > 1.4 m high that have stems within five meters of a the plot boundary, since these trees would influence trees in the outer subplots of each plot (see **Fig. 4.12-2**). For example, canopies of these peripheral trees overhang the outer subplots and mortality or fire effects in these subplots may be related to stand characteristics in adjacent areas (for instance tree density or size classes). Canopies of these trees were estimated using the relationship between BA and canopy cover of the internal plot trees.

During August 1999 plots #1 and #2 were burned in the Tar Gap Segment. Burning conditions were good through most of the burn operation (burn boss: Jeff Manley). Ignition was begun at 2,757 m elevation on August 17 with strip spot ignitions at 20-30 meter intervals down to the Tar Gap Trail. Ignition was completed on August 20 with the unit continuing to smolder into November due the unusual dry fall conditions. Total area burned in this unit was 54 ha (total area burned in the Tar Gap Segment was 170 ha).

Table 4.12-2. Fuel moisture.

Fuel Type	Percent
Duff	7%
Litter	12%
1 Hour	14%
10 Hour	11%

Table 4.12-3. Temperatures and relative humidity during burns.

Date	Maximum Temperature (time observed)	Minimum Relative Humidity (time observed)
8/17/99	69° (1530)	28% (1530)
8/18/99	66° (0945)	39% (0945)
8/19/99	70° (1200)	9% (0915)

Because of the Pitcher plots and a number of other research plots located in the area fire weather and burn operations were well monitored. Fuel moisture data was collected prior to the burn following monitoring protocols was tracked throughout the burn using 10 hour fuel sticks located adjacent to the Tar Gap trail. Fuel moisture samples for litter, duff, 1 hr, 10 hr, and 100 hr fuels were also collected (**Table 4.12-2**). Spot weather forecasts were requested each morning prior to ignition. On-site weather **(Table 4.12-3**), fire behavior (**Table 4.12-4**), and smoke observations were taken throughout ignition periods at regular intervals

Table 4.12-4. Fire behavior observations on days when plots were ignited (H = head fire, F = flanking, B = backing)

Date	Spread Direction	Avg. Rate of Spread	Avg. Flame Length	Avg. Flame Zone Depth	Avg. % Slope
8/17	H	.6 c/h	12-18´´	5-6´´	35%
8/17	B	.25 c/h	2-5´´	1-3´´	30%
8/18	H	.75 c/h	11-15´´	4-5´´	28%
8/18	F	.15 c/h	6-8´´	2-4´´	30%
8/18	B	.16 c/h	4-5´´	1-2´´	35%
8/19	H	.6 c/h	13-21´´	7-12´´	35%
8/19	F	.2 c/h	1-2´´	2-3´´	35%
8/19	B	.2 c/h	2-3´´	1-2´´	35%

Postburn fuel sampling was completed following the burning of plots #1 and #2 during September 1999. This included the modified Brown's transects and a detailed mapping surface fuels consumed during the burn (**Fig. 4.12-3** and **4.12-4)**. Based on these burn maps surface area burned in the two plots was 74.6% and 36.8% respectively for plots #1 and #2. The difference in area burned is probably a reflection of stand age, structure and fuel accumulation with significantly greater fuel load in plot #1 (see **Fig. 3.12-11** Caprio 1998). Total fuel reduction at a nearby (200 m) fire effects plot (FABMA1T08-101) was 57.9% (Keifer and Dempsey, personal communication).

PLANS FOR 2000:

Postburn sampling will be completed during the summer of 2000. This will include mortality checks and postburn canopy characteristics.

REFERENCES

Barbour M.G. and R.A. Woodward. 1985. The Shasta red fir forest of California. Can J. For. Res. 15:570-576.

Keifer, M. and G. Dempsey. 1999. Ecologist and Fire Effects Crew Leader, Sequoia & Kings Canyon National Park.

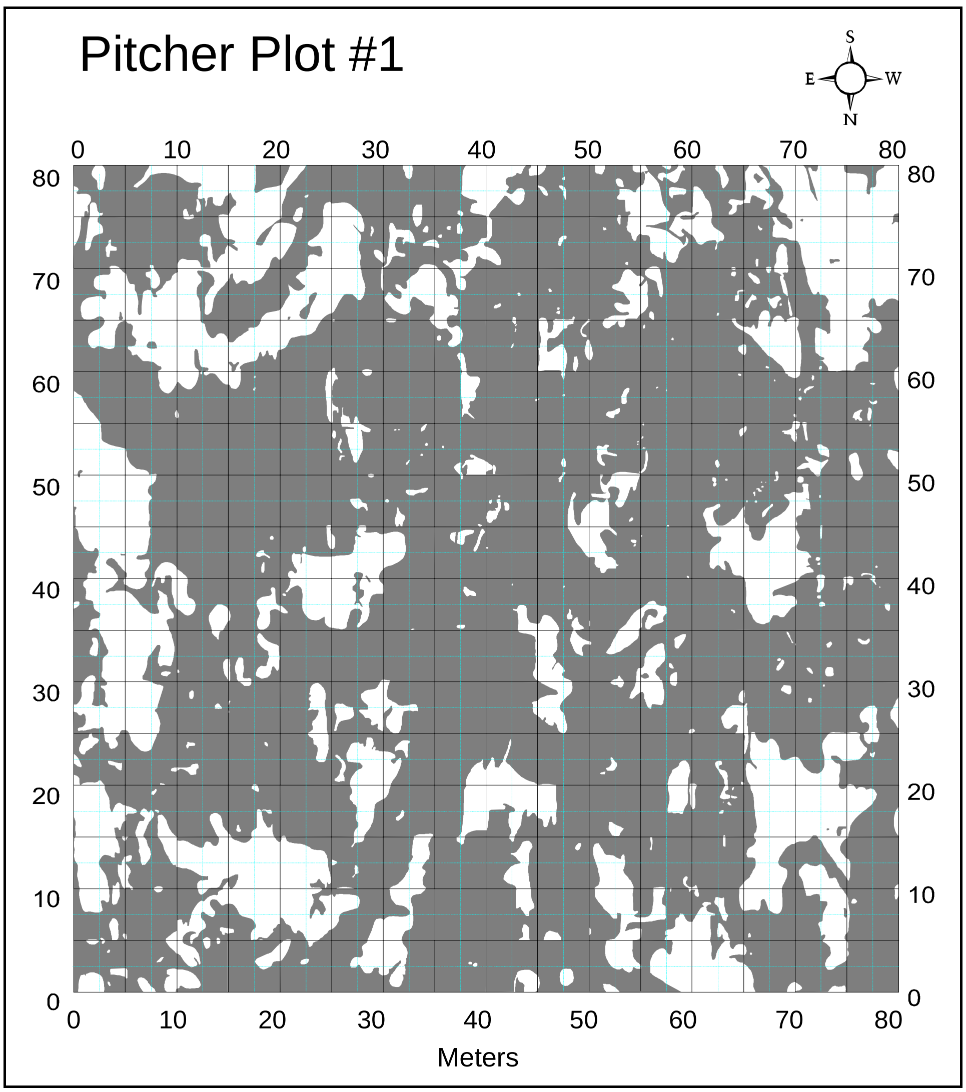


Figure 4.12-3. Surface area burned (grey shading) in plot #1.

Kilgore, B.M. 1971. The role of fire in managing red fir forests. Trans. 36th N. Amer. Wildlife and Nat. Res. Conf., Mar. 7-10, 1971.

Laake, R.J. and J.C. Tappeiner. 1996. Red fir ecology and management. pp. 479-489. In: SNEP. ***Sierra Nevada Ecosystem Project, Final Report to Congress. Vol. III, Assessments, Commissioned Reports, and Background Information.*** University of California, Davis. Water and Wildland Resources Center Report No. 38, 1101 pp.

Miller, C. 1998. Forest pattern, surface fire regimes, and climate change in the Sierra Nevada, California. Dissertation, Colorado State University, 132 pp.

Oosting, H.J and W.D. Billings. 1943. The red fir forest of the Sierra Nevada: ***Abietum magnificae***. Ecol. Monographs 13:260-274.

Pitcher, D. 1981. The ecological effects of fire on stand structure and fuel dynamics in red fire forests of Mineral King, Sequoia National Park, California. MS Thesis, UC Berkeley, 168 pp.

Pitcher, D. 1987. Fire History and Age Structure in Red Fir Forests of Sequoia National Park, California. Canadian Journal of Forest Research 17:582-587.

Taylor, A.H. 1993. Fire history and structure of red fir (***Abies magnifica***) forests, Swain Mountain Experimental Forest, Cascade Range, northeastern California. Can. J. For. Res. 33:1672-1678.

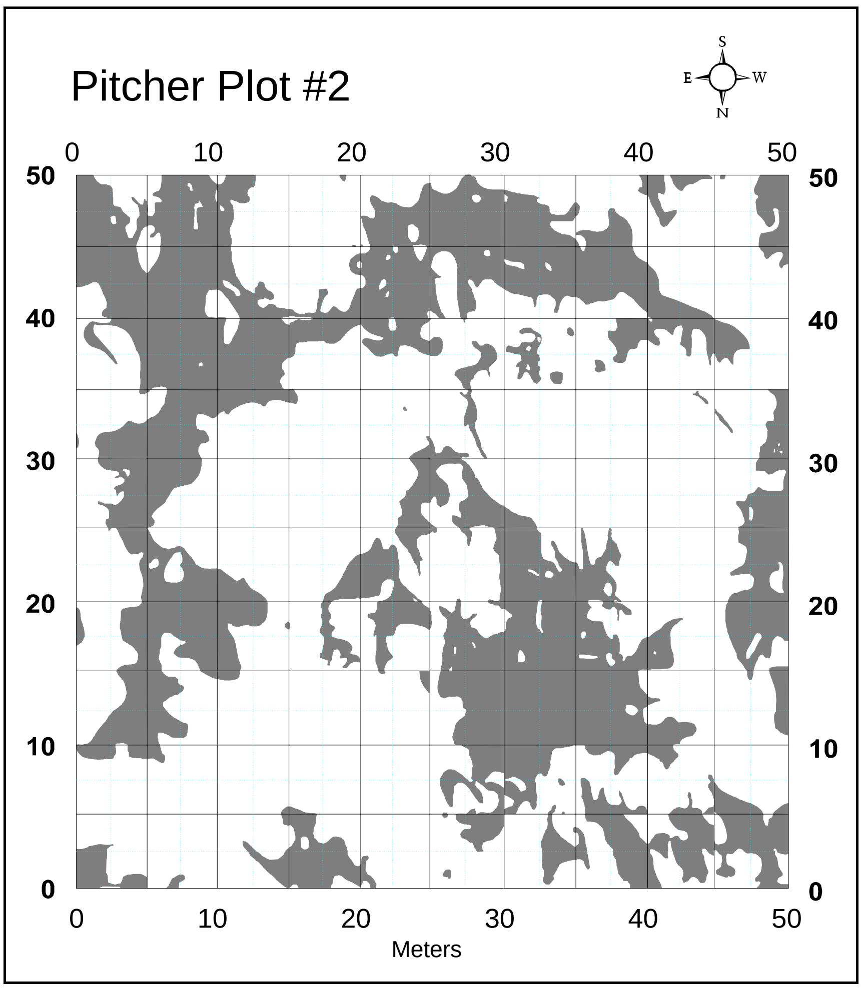


Figure 4.12-4. Surface area burned (grey shading) in plot #2.

4.13) Fire Effects Monitoring

- MaryBeth Keifer, Georgia Dempsey; Science and Natural Resources Management, SEKI

Lead: M. Keifer; Field crew supervisor: G. Dempsey; Field crew: C. Dickard, A. Huber, N. Jurjavcic, K Webster.

INTRODUCTION

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. The Parks' program was used to help develop standardized protocols for the National Park Service's Fire Monitoring Handbook (FMH), the service-wide program that began in 1989. In past years, two separate reports were written, one for the fire effects work done in the Mineral King Risk Reduction Project (MKRRP) area and one for the Parks' larger, overall fire effects program. Because significant progress has been made burning in the MKRRP project area, this year all work is fully integrated into one annual report presented here for the entire program. If specific results for the MKRRP area (or other areas of the Parks) are needed, they can be easily obtained from the fire effects monitoring database.

PROGRAM OBJECTIVES

The fire effects monitoring program is critical to:

1) evaluate the achievement of fire management objectives;
2) detect any unexpected or undesirable changes in vegetation that may be a result of prescribed burning; and
3) provide the above information to fire managers, other park staff, and the public.

SUMMARY OF 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). Specific location of individual plots (most geo-referenced) can be obtained from the Parks' plot location database (see **Fig. 4.12-1** for map).

Table 4.13-1. Number of fire effects monitoring plots by monitoring type.

Monitoring Type	Dominant Species	Number Of Plots Installed	Number of Plots Burned
Red fir forest	red fir	6	3
Giant sequoia-mixed conifer forest	white fir	29	29
White fir-mixed conifer forest	white fir	11	10
Low elevation-mixed conifer forest	incense cedar	5	5
Ponderosa pine-dominated forest	ponderosa pine	4	4
Chamise chaparral	chamise	3	3
Mixed chaparral	manzanita	6	2
Montane chaparral	manzanita	5	5

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 promptly 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.

WORK ACCOMPLISHED IN 1999

Twenty plot remeasurements and 5 immediate postburn visits were accomplished in 1999. An additional 2 new plots were installed, one in the Lower Deadwood unit and one in the Upper Deadwood unit of the MKRRP. The plot in the Lower Deadwood unit burned out of prescription (rainfall occurred while the plot was still burning) and will be removed.

PRELIMINARY FINDINGS AND PERTINENT DISCUSSION

Results to date are summarized below by monitoring type. All analyses consist of data collected through and including the 1999 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 10.0 ± 2.2 kg/m^2, then this means that there is an 80% probability that the true population mean total fuel load value is between 7.8 and 12.2 kg/m^2. The confidence interval is based on the standard error and the students' t-distribution for the sample size used (number of plots).

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=28 plots; **Figure 4.13-1**). The mean total fuel load was therefore reduced by 77% immediately postburn, meeting the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by 56%, while a greater proportion of litter and duff was consumed (83% and 93%, respectively) by the fires. By five years postburn, total fuel load accumulated to 48% of preburn levels (n=26 plots). Woody fuel reached 71% of preburn levels five years postburn, while duff accumulated at a slower rate, reaching only 26% of preburn levels. By ten years postburn, mean total fuel load was 59% of preburn levels, with wood, litter, and duff reaching 81%, 64%, and 37% of preburn levels, respectively, in this monitoring type (n=12 plots; **Figure 4.13-2**).

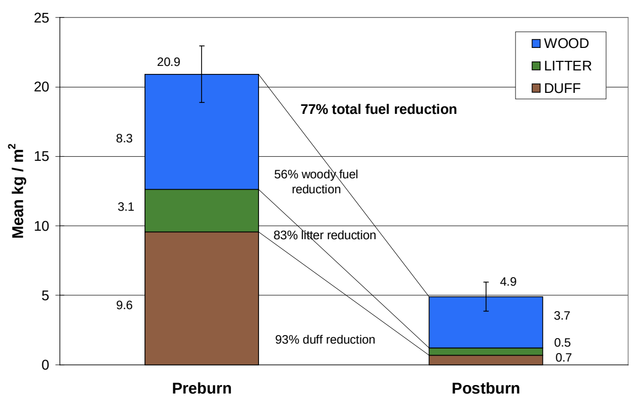


Figure 4.13-1. Fuel reduction in the Giant sequoia-mixed conifer forest type (n=29 plots).

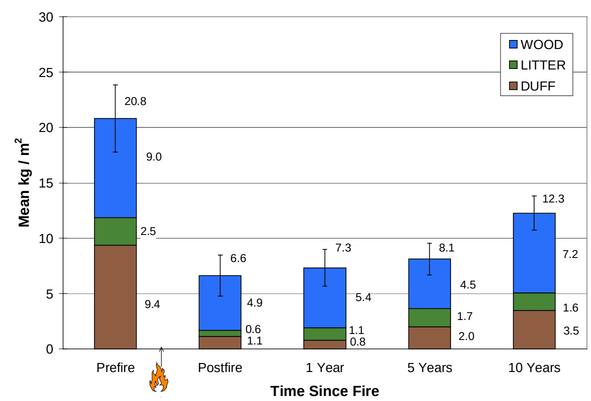


Figure 4.13-2. Fuel accumulation in the Giant sequoia-mixed conifer forest type (n=12 plots).

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.

Mean total fuel load for the 7 plots had reached 88% of the initial preburn level 8-16 years after the initial burn (**Figure 4.13-3**). Woody fuels were a much larger component (116% of initial preburn level) than duff (67% of initial preburn level). As a result of the repeat burns, total fuel

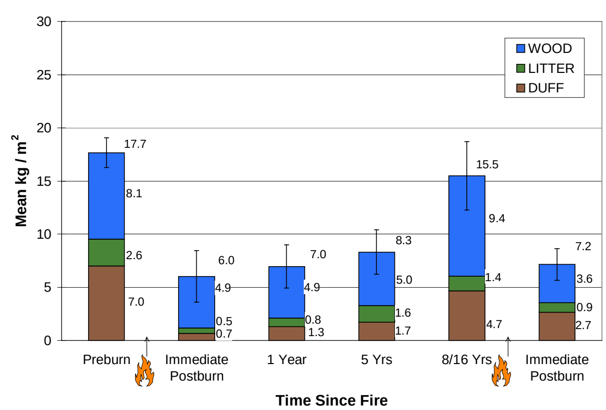


Figure 4.13-3. Fuel load in the Giant sequoia-mixed conifer forest type reburns (n=7 plots).

load was reduced by 54%, with a 62% reduction in woody fuel, 36% litter consumption, and a 43% reduction in duff (**Figure 4.13-3**). A greater proportion of woody fuel was consumed in the repeat burns than in the initial prescribed fires in these 7 plots (62% and 40%, respectively). Conversely, a much smaller proportion of duff was consumed in the repeat burns than in the initial prescribed fires (43% and 90%, respectively).

Stand structure and composition

Mean total tree density in the Giant sequoia-mixed conifer forest type was reduced by 49%, from 461 ± 63 trees/ha preburn to 234 ± 25 trees/ha ten-years postburn (n=12 plots; **Figure 4.13-4**). Species composition changed slightly over this time period, with white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), and red fir (*Abies magnifica*) relative density all decreasing by 3-4% while the relative density of giant sequoia (*Sequoiadendron giganteum*) tripled from 5% preburn to 16% ten-years postburn (**Figure 4.13-4**). This increase was due to the successful recruitment of postburn sequoia regeneration (seedlings) into the smallest diameter class of trees (0-10 cm). Tree diameter distribution changed following fire, with the ten-year postburn mean density of the smaller diameter classes much reduced from preburn densities. The preburn mean densities in the four smallest diameter classes were reduced by 41-74% ten years postburn (n=12 plots; **Figure 4.13-5**). This change includes mortality as well as live tree growth into larger size classes over time. The reduction in density was generally less as size class increased, with a 19% increase in mean density for trees >100 cm (**Figure 4.13-5**).

In the 7 plots that were reburned, total tree density was further reduced from 266 ± 32 trees/hectare 8-16 years after the initial burn down to 210 ± 37 trees/hectare immediately after the repeat burn (n= 7 plots; **Figure 4.13-6**). Even further reduction may occur in the next few years as tree mortality is often delayed following fire. Species composition had changed dramatically in these plots after the initial burn (54% white fir, 23% giant sequoia), primarily as a result of a patch of giant sequoia post-burn regeneration in one of the plots. Following the repeat burn, species composition shifted back again, however, giant sequoia relative density was still twice that present prior to the initial burn (4% prior to initial burn, 9% after two burns) (n=7 plots; **Figure 4.13-6**). A single patch of small giant sequoia trees located in one of the plots was completely scorched in the reburn. Observations from throughout the areas reburned reveal that patches of small giant sequoia trees had widely varying levels of scorch and mortality, including

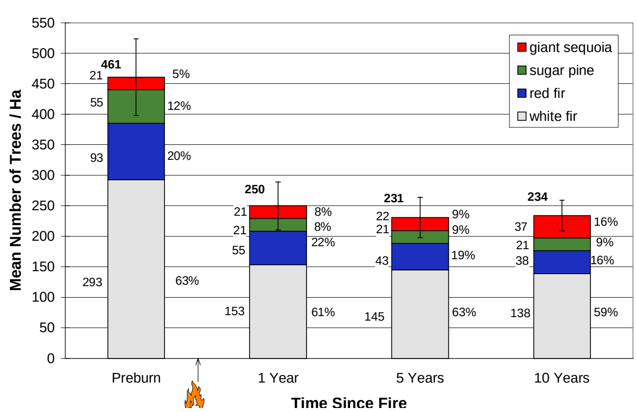


Figure 4.13-4. Stand density by species composition in the Giant sequoia-mixed conifer forest type (n=12 plots).

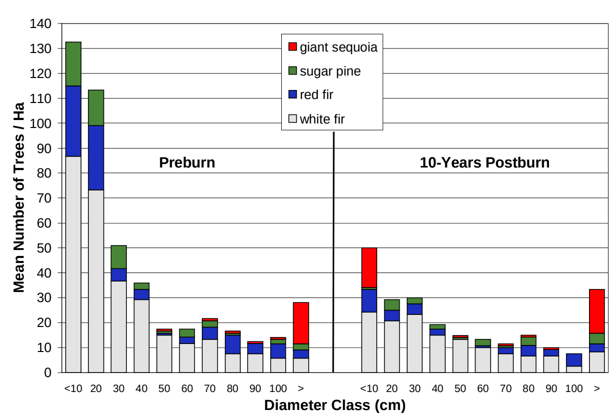


Figure 4.13-5. Stand density by diameter class in the Giant sequoia-mixed conifer forest (n=12 plots).

some patches that were not scorched at all in which all trees survived. A study monitoring giant sequoia regeneration in reburned areas corroborates these observations, and complete mortality in the 0-10 cm diameter class is <u>not</u> expected in all areas reburned.

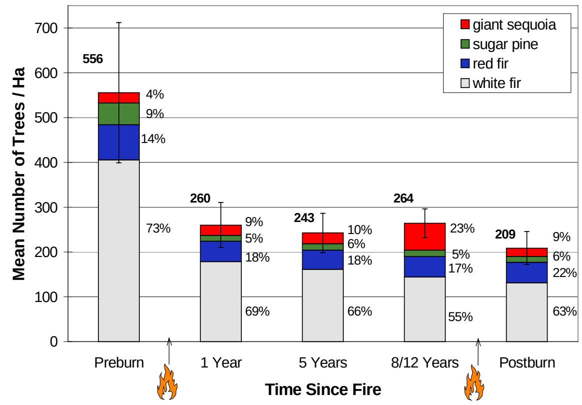


Figure 4.13-6. Stand density by species composition in the Giant sequoia forest reburns (n=7 plots).

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 59% of preburn levels indicating reburns for fuel reduction should be considered approximately 10 years following the initial burns to avoid a return to heavy preburn fuel load conditions. Reburn results show that total fuel reduction was lower in the reburn than in the initial burn (54% and 77% respectively), and the reduction by fuel component was quite different. The fuel complex prior to the repeat burns was made up of a larger proportion of woody fuel (61%) than that prior to the initial burns (46%) and a larger proportion of the woody fuel was consumed in the reburns than in the initial burns. Fuel reduction objectives for repeat 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 <80 cm DBH, and 10-75 trees/hectare >80 cm DBH. For 27 plots in the Giant sequoia-mixed conifer forest type, preburn mean density for trees <80 cm DBH was 625 ± 114 trees/ha, which is two and a half times the maximum target value (**Figure 4.13-7**). The preburn mean density of trees >80 cm DBH was 46 ± 7 trees/ha, well within the target range of 10-75 trees/ha. While reduced from the preburn value by 54%, the one-year postburn mean density of trees <80 cm DBH was still higher than the target maximum of 250 trees/ha (292 ± trees/ha; **Figure 4.13-7**). By five years postburn, however, the mean density of trees <80 cm DBH was further reduced to 222 trees/ha, which falls within the target range (**Figure 4.13-7**). The larger trees are only slightly reduced to 42 ± 7 trees/ha by five years postburn and remain within the target range of 10-75 trees/hectare. 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 (8% reduction in density from preburn to five-years postburn). No mortality of large giant sequoia trees occurred within the monitoring plots following prescribed burning. In addition, some recruitment of post-burn giant sequoia regeneration into the

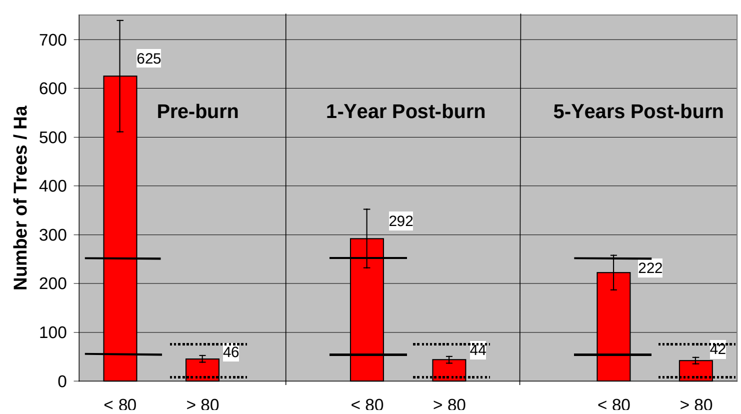


Figure 4.13-7. Stand density by diameter class in the Giant sequoia-mixed conifer forest type (n=27 plots).

smallest diameter class indicates an increase in the relative density of giant sequoia. These results will be useful to evaluate progress towards meeting the structural objectives (Keifer and others, in press).

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 load was therefore reduced by 79% immediately postburn, meeting the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by 63%, while a greater proportion of litter and duff was consumed (82% and 89%, 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 4.13-8**).

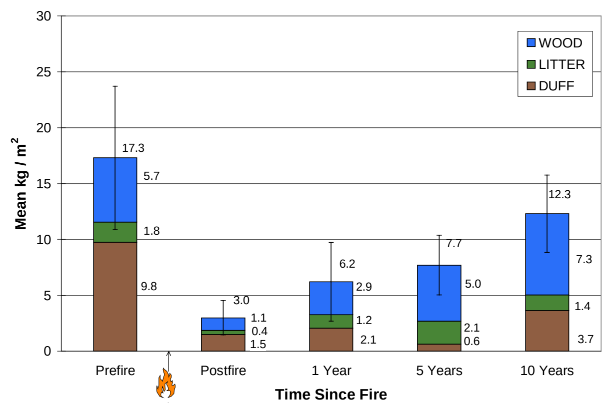


Figure 4.13-8. Fuel accumulation in the White fir-mixed conifer forest type (n=6 plots).

Stand structure and composition

Mean total tree density in the White fir-mixed conifer forest type was reduced by 63%, from 765 ± 280 trees/ha preburn to 345 ± 55 trees/ha ten-years postburn (n=6 plots; **Figure 4.13-9**). Species composition changed very little over this time period, with only 1-2% increases or decreases in species' relative density. Tree diameter distribution changed following fire, with the ten-year postburn mean density of the smaller diameter classes much reduced from preburn densities. The preburn mean densities of the four smallest diameter classes were reduced by 22-84% ten years postburn (n=6 plots). This reduction includes mortality, as well as live tree growth into larger size classes over time. The density reduction was generally smaller as size class increased, with a 14% increase in mean density for trees >100 cm.

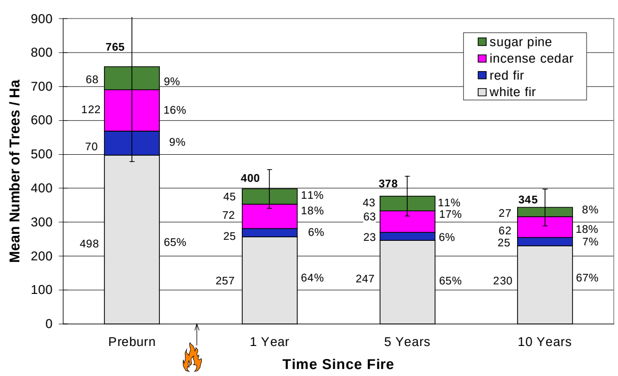


Figure 4.13-9. Stand density by species composition in the White fir-mixed conifer forest type (n=6 plots).

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 316 ± 43 trees/hectare five years postburn (n=10 plots), still well above the target range maximum of 250 trees/hectare. Another burn will likely be needed to further reduce the small tree density 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 4.13-10**). The mean total fuel load was, therefore, reduced by 84% immediately postburn, exceeding the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by 65%, while a greater proportion of litter and duff (93% and 95%, respectively) was consumed in the fires. Two years postburn, total fuel load accumulated to 31% of preburn levels (n=5 plots; **Figure 4.13-10**). By two years postburn, litter and wood reached 41% and 59% of preburn levels, respectively, while duff accumulated at a slower rate, reaching only 7% of preburn levels.

Stand structure and composition

Mean total tree density in the Low elevation-mixed conifer forest type was reduced by 66%, from 1236 ± 218 trees/ha preburn to 416 ± 193 trees/ha two-years postburn (n=5 plots; **Figure 4.13-11**). Relative species composition changed only slightly over this time period, with white fir and canyon live oak relative density decreasing by 2-5%, and sugar pine, black oak, incense cedar, and ponderosa pine increasing by 1-4% two-years postburn (**Figure 4.13-11**). Tree diameter distribution changed greatly following fire, with the two-year postburn mean density of the smaller diameter classes dramatically reduced from preburn densities. The preburn mean densities of the four smallest diameter classes were reduced by 27-86% two years postburn (n=5 plots; **Figure 4.13-12**). Some larger tree density reduction occurred in this type. Density reduction in the six largest diameter classes ranged from 0 to 56% (**Figure 4.13-12**).

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 (59% of preburn woody fuel level by two years postburn). This fuel accumulation is due to the high amount of postburn tree mortality (66%) that occurred in the plots. The mean tree density for trees <80 cm DBH is 396 ± 193 trees/hectare two years postburn (n=5 plots), still well above the target range maximum of 250 trees/hectare. Perhaps further mortality will occur by the five-year postburn visit and/or another burn may be needed to further reduce the small tree density to within the target range. While longer-term data does not yet exist for these plots, and the sample

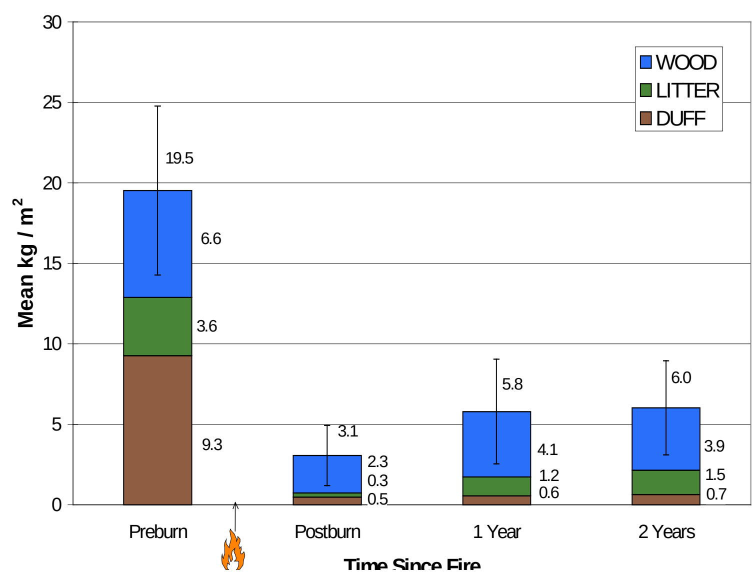


Figure 4.13-10. Fuel accumulation in the Low elevation-mixed conifer forest (n=5 plots).

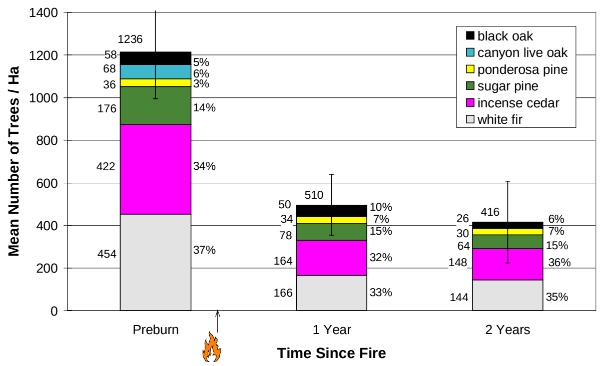


Figure 4.13-11. Stand density by species composition in the Low elevation-mixed conifer forest (n=5 plots).

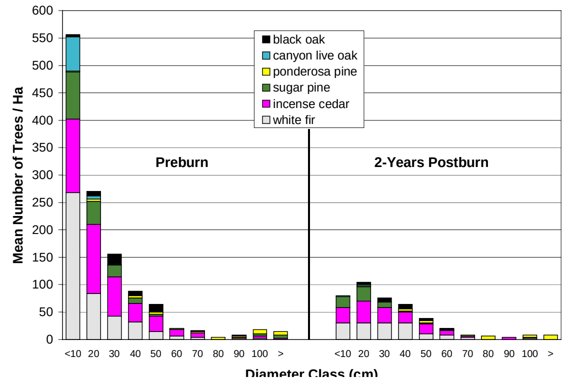


Figure 4.13-12. Stand density by diameter class in the Low elev.-mixed conifer forest (n=5 plots).

size is small, data from these two-year postburn plots indicate that reburning 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 4.13-13**). The mean total fuel load was therefore reduced by 97% immediately postburn, exceeding the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by 98%, while litter was reduced by 92% and the duff was completely consumed (100%) in the fires. Five years postburn, total fuel load accumulated to 22% of preburn levels (n=4 plots; **Figure 4.13-13**). 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.

Stand structure and composition

Mean total tree density in the Ponderosa pine-dominated forest type was reduced by 63%, from 420 ± 197 trees/ha preburn to 143 ± 22 trees/ha five-years postburn (n=4 plots; **Figure 4.13-14**). Species composition changed slightly over this time period. The relative density of incense cedar (*Calocedrus decurrens*) 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 (**Figure 4.13-14**). Tree diameter distribution changed following fire, with the five-year postburn mean density of the smaller diameter classes much reduced from preburn densities. The preburn mean densities of the four smallest diameter classes were reduced by 55-97% five years postburn (n=4 plots; **Figure 4.13-15**). Unlike the other forest monitoring types, reduction in tree density is relatively high in some of the larger size classes of trees in this type. Density reduction in the six largest diameter classes ranged from 18 to 100% (**Figure 4.13-15**).

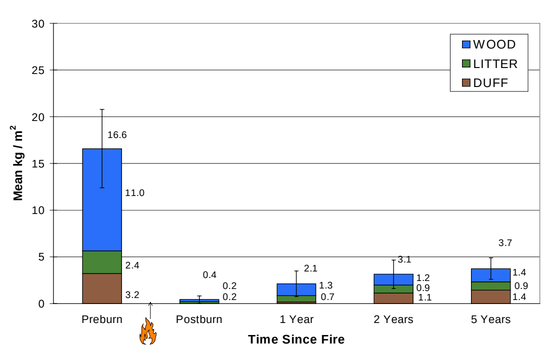


Figure 4.13-13. Fuel reduction and accumulation in the Ponderosa pine-dominated forest type (n=4 plots).

Nearly all of these larger trees are ponderosa pines; however, where 100% reduction occurred in a diameter class, the sample included only 1 tree.

Management implications of results

Fuel accumulation occurred somewhat more slowly in the Ponderosa pine-dominated plots than in the mixed conifer forest types. 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. One small area was burned in 1998 and additional data was collected by the parks' Plant Ecologist to get a preliminary assessment of cheatgrass response to burning. One fire effects plot was located in the area reburned and results 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. Since these results are from a single plot, no conclusions can be drawn from this information at this time, however, the additional data collected by the Plant Ecologist will be examined to see if the same trend occurred.

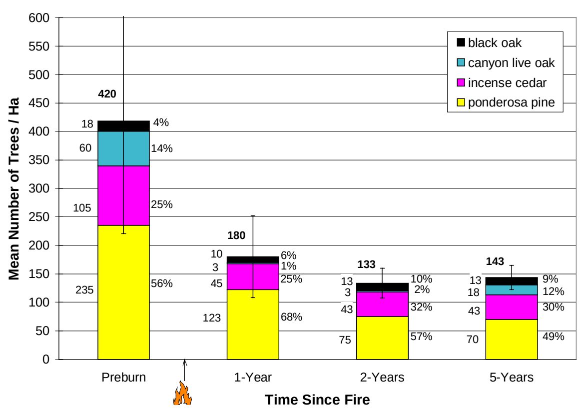


Figure 4.13-14. Stand density by species composition in the Ponderosa pine-dominated forest (n=4 plots).

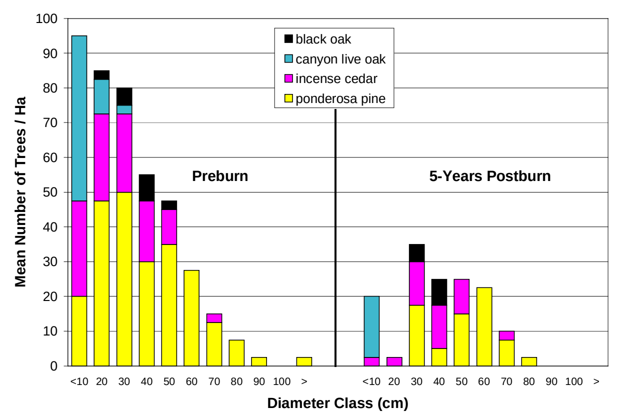


Figure 4.13-15. Stand density by diameter class in the Ponderosa pine-dominated forest (n=4 plots).

Red fir forest

Fuel load

In the Red fir forest type, preburn mean total fuel load was 27.6 ± 10.9 kg/m^2 (123.1 ± 48.6 tons/acre) and 5.0 ± 4.0 kg/m^2 one-year postburn (22.3 ± 17.8 tons/acre) (n=3 plots; **Figure 4.13-16**). The mean total fuel load was therefore reduced by 82% 1-yr postburn, slightly exceeding the parks' fire management objective of 60-80% total fuel reduction. Woody fuel was reduced by 92%, while 75% of duff was consumed in the fire. By two years postburn, in two of the plots, little fuel accumulation had occurred (14% of preburn total fuel load). Wood and duff reached 6% and 15% of preburn levels respectively, while 58% of preburn litter accumulated by two-years postburn (**Figure 4.13-17**). Note that the preburn mean total fuel load is much higher in this type than any other monitoring type (27.6 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. Apparently, two of the 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 24%, from 210 ± 189 trees/ha preburn to 160 ± 94 trees/ha two-years postburn (n=2 plots; **Figure 4.13-18**). Species composition changed little since this type is composed of nearly pure red fir. Tree diameter distribution changed somewhat following fire. The preburn mean densities of the four smallest diameter classes were reduced by 0-62% two years postburn (n=2 plots; **Figure 4.13-19**). Note that the third red fir plot that burned this year is not included in the tree density results as tree mortality is not often not detectable immediately postburn.

Management implications of results

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

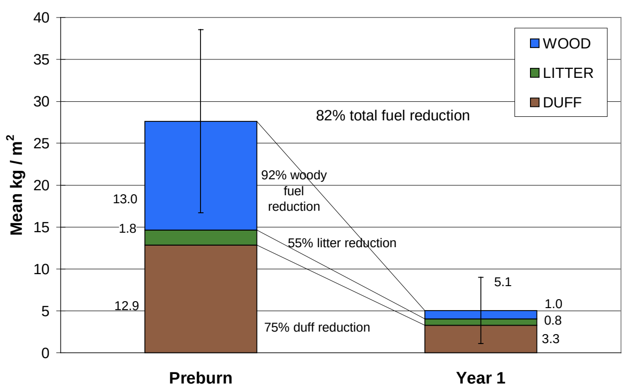


Figure 4.13-16. Fuel reduction in the Red fir forest type (n=3 plots).

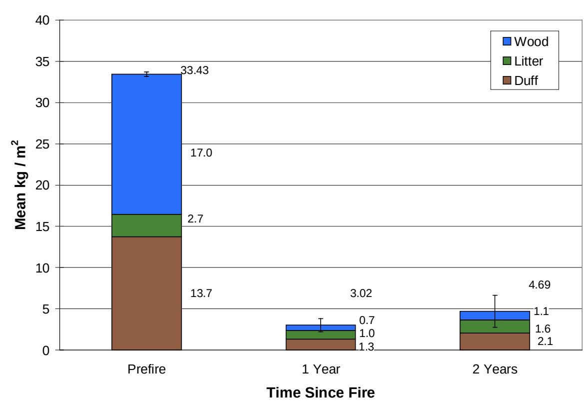


Figure 4.13-17. Fuel accumulation in the Red fir forest type (n=2 plots).

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 4.13-20**). 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 4.13-20**). 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.

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 4.13-21**). 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 4.13-21**). 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

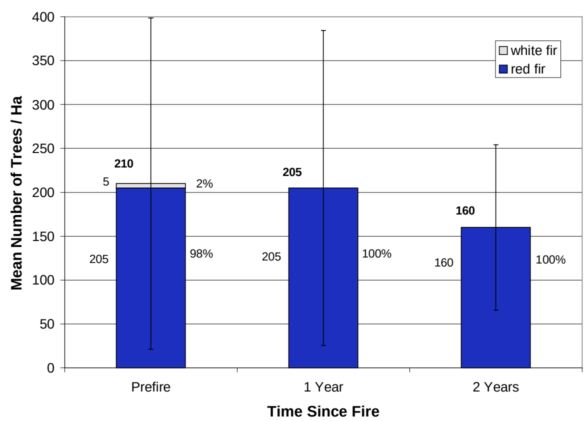


Figure 4.13-18. Stand density by species composition in the Red fir forest type (n=2 plots).

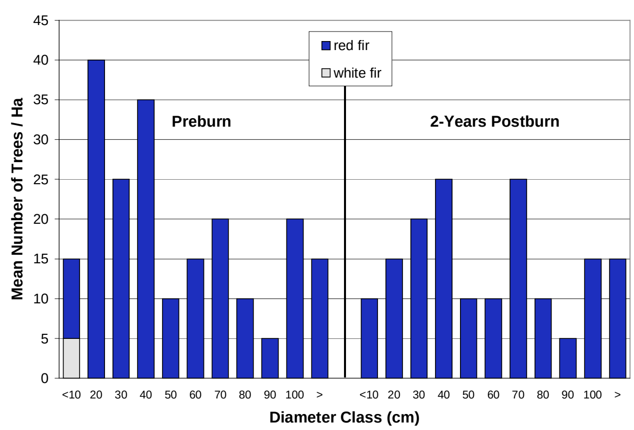


Figure 4.13-19. Stand density by diameter class in the Red fir forest type (n=2 plots).

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 range of shrub cover. These targets have not yet been translated 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, the fire severity will need to be higher in this brush type.

<u>Chamise chaparral</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 ± 6.6% preburn to 15.0 ± 28.3% postburn. An increase to 26.0 ± 25.6% one-year postburn indicates that postburn resprouting occurred (**Figure 4.13-22**). A corresponding increase in mean percent cover of substrate occurred, from 7.0 ± 3.5% preburn to 74.0 ± 16.1% postburn indicating that much of the vegetative cover was consumed during the burn.

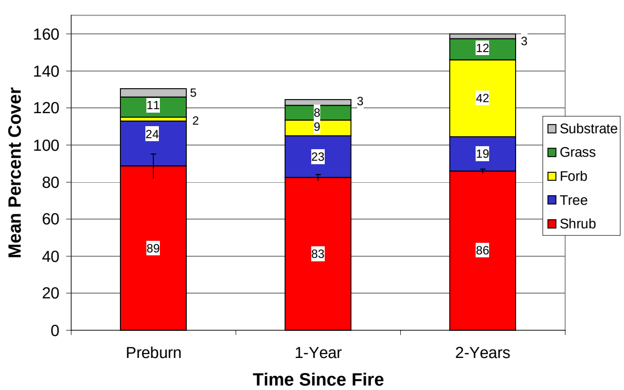


Figure 4.13-20. Percent cover by lifeform in the Mixed chaparral type (n=2 plots).

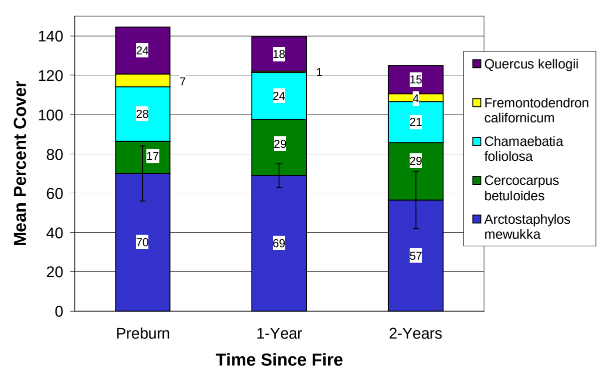


Figure 4.13-21. Percent cover by species in the Mixed chaparral type (n=2 plots).

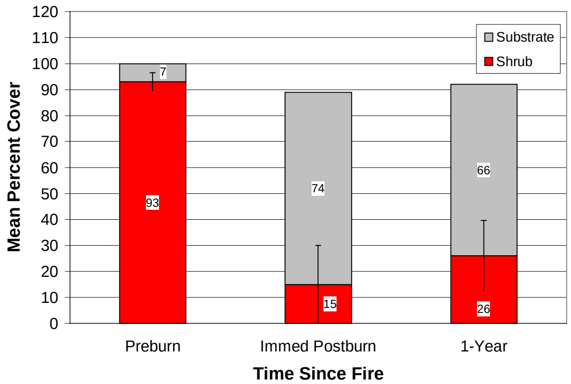


Figure 4.13-22. Percent cover by lifeform in the Chamise chaparral type (n=3 plots).

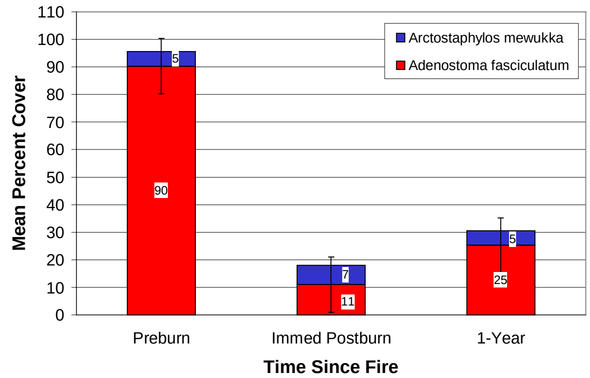


Figure 4.13-23. Percent cover by species in the Chamise chaparral type (n=3 plots).

Cover by species

Mean percent cover for live chamise, the dominant species, was reduced by 88% from 90.3 ± 11.6% preburn to 11.0 ± 20.7% postburn (**Figure 4.13-23**). Mean percent cover increased to 25.3 ± 16.4% one-year postburn, indicating resprouting occurred. *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 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 and with continued monitoring over time, the subsequent increase in shrub cover will be measured.

Montane chaparral

Brush cover

ve 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 4.13-24**). 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.

One plot could not be relocated this year and therefore is not included in the analysis. 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 generally occurs.

PLANS FOR 2000

The number of plot visits will increase to 26 remeasurements and the potential for at least 9 immediate postburn plots next year. In addition, up to 15 new plots may be installed depending on the units that will actually burn in 2000.

Figure 4.13-24. Percent cover by lifeform in the Montane chaparral type (n=4 plots).

REFERENCES

Keifer, M., N. Stephenson, and J. Manley. In press. 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.

Western Region Prescribed and Natural Fire Monitoring Task Force. 1992. Western Region Fire Monitoring Handbook. USDI National Park Service, Western Region, San Francisco, CA. 134 pp.

3.14) Prescribed Fire and Heavy Fuel Effects on Mature Giant Sequoia Trees

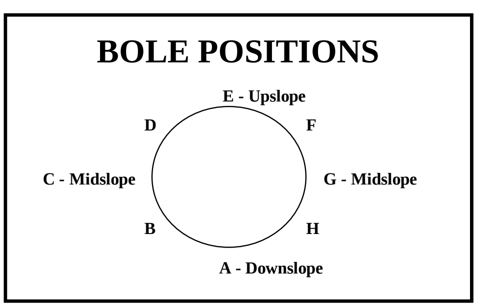
- Georgia Dempsey and MaryBeth Keifer, Science and Natural Resources Management, SEKI

In 1995, a pilot project was initiated in the Atwell Grove area of Sequoia National Park. This fire scar study was undertaken as one facet of the Mineral Kink Risk Reduction Project (MKRRP). The focus of this pilot project was to assess the impacts of fire on giant sequoias, (*Sequoiadendron giganteum*). Preliminary results obtained from data collected over the course of two summers (1995-1996) are presented below. Variables such as charring, the formation and positioning of new scars, fuel consumption, scorch height, and tree mortality were examined on a total of 60 study trees.

The impetus to conduct such a study has its basis in history. In 1986, no prescribed burns occurred in the sequoia-mixed conifer forests of the park due to a controversy focused around the charring of a sequoia tree within the Broken Arrow burn unit, located in Giant Forest. This incident spurred a review of the park’s burn program by a group of independent scientists. Though the burn program was deemed to be sound, the review panel suggested initiating more research projects to better determine the effects of fire on park resources (Christensen et al, 1987). Information gathered during this study should help managers to decide new policies regarding burning operations in this forest type.

Despite the one-year hiatus on burning, dendrochronolgy records have shown that fires were a natural and frequent element of these forests prior to the 1860’s. By examining fire scars that had formed in five different giant sequoia groves, along 160 km of transects, Swetnam et al.(1992) discovered that the longest fire return interval found between fires, was a period of 30 years. Often the return interval was less than 15 years, with the mean ranging between three and eight years depending upon site characteristics. These frequent fires were generally of a low to moderate severity (Kilgore 1981) but occasional flare-ups did occur where jackpots of fuel were encountered (Stephenson et al. 1991) thus creating vegetation mosaics.

Using this background knowledge, 60 giant sequoia trees were chosen for this study, based upon the criteria which follow. Initially, 30 trees were scarred; 15 of these had relatively high fuel loads and 15 had relatively low fuel loads. Conversely, 30 trees were unscarred with fuel loads that ranged similarly. Slope measurements ranged between 20 and 70% and aspect was between SE and SW. Rejection criteria included: slopes out of the range stated, aspects out of the range stated, the presence of heavy ladder fuels within a 25 ft. radius of each tree, trees with >75% of the basal circumference scarred by fire, twin trees, trees located within ten ft. of other sequoias, trees with extreme abnormalities such as an excessive lean or a highly irregular bole shape. Trees that passed this series of criteria were tagged at 8 fixed positions so that variables could be measured on each tree relative to the bole’s position with the slope, as shown in the diagram below.



One year, post-fire measurements indicate that one hundred sixty-three new scars formed on a total of thirty-four of the study trees. Close examination of these scars indicates that the average maximum width of the scars was 11.0 cm, during the yr-01 check, as compared to 12.2 cm the following year. The yr-01 data also reveals that, on the average, new scars started forming 105.9 cm above the ground and ranged to an average maximum height of 135.9 cm. Consequently, the actual, average height of the scars was approximately 30 cm.

Though the averages are meaningful in a broad sense, the ranges of these values are also telling since a wide variety of scar sizes and positions were used to obtain these typical results. For example, maximum width values ranged from .25 cm up to 131 cm across, when measured along a level plane. Likewise some scars started forming at the base of the tree while others sprang up 790 cm up the bole. Maximum height values displayed a similarly large range with one scar peaking at .75 cm above the ground while another ascended up the bole to a total height of 860 cm.

Bark charring was measured on 58 of the 60 study trees. Sampling indicates that the average distance covered by blackened bark, or char, was 367.3 cm. Maximum char height was also mapped and recorded on 57 of these trees by utilizing the 8 marked positions shown in the diagram above. Position "E," the most upslope position, received the greatest number of maximum char records with a total of 23. The average charred distance at this bole position was 1100.6 cm. This same position also accounts for the greatest number of newly formed scars (**Fig. 4.14-2**).

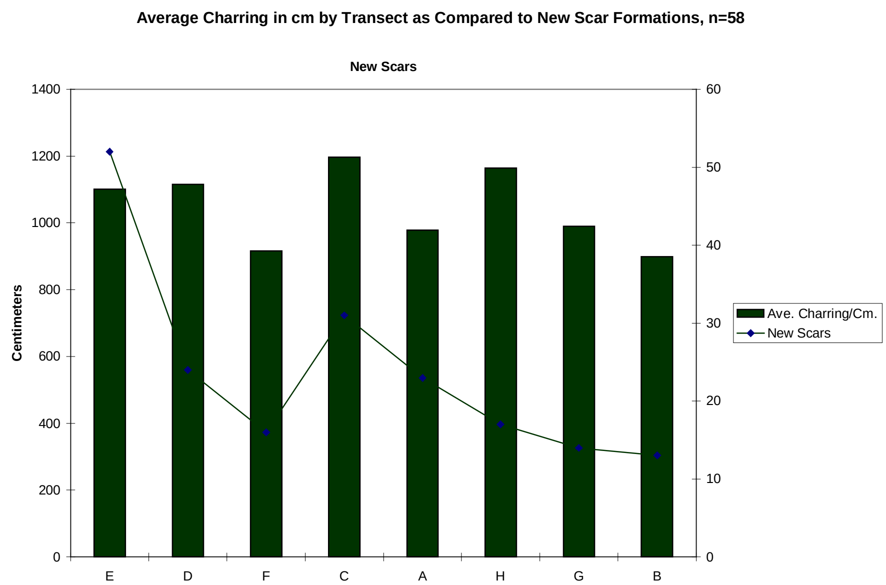
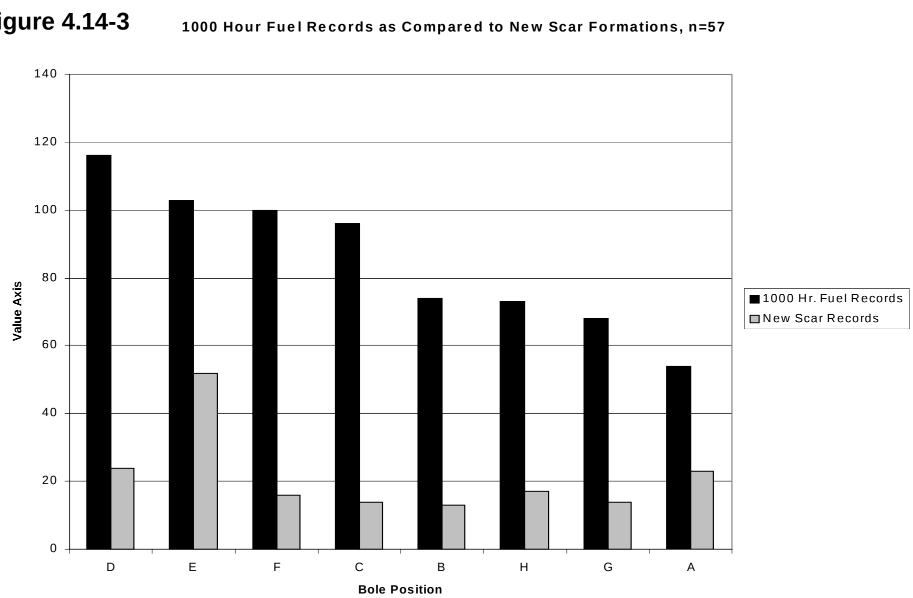


Figure 4.14-2

The appropriate location and orientation of 1000 hour logs was drawn in reference to the bole of each of the study trees, both pre and post-fire. This was intended to show large accumulations of fuel within a ten ft. radius of each sequoia. Likewise, the length and diameter of each log was also recorded on the map. To date, these maps have been analyzed by transect out to the two ft. and five ft. intervals. **Fig. 4.14-3** displays the findings for the 5-ft. interval. Note that positions E, C and D, which had the highest number of new scar records respectively, also ranked within the top four positions for having 1000-hour logs within 5 ft. of the bole.

Figure 4.14-3



The reduction of 1000 hr. time-lag fuels as well as litter and duff has been analyzed by bole position. The average percentage of reduction for this fuel category, is as follows: A=43%, B=97%, C=46%, D=50%, E=51%, F=75%, G=60% and H=57%. To date, tons per acre (tpa) have been estimated by using only the 1000 hour intercepts. This method reveals that position A had 11.95

tpa and ranked 4th for new scar formations; B had 31.96 tpa and ranked 8th; C had 207.37 tpa and ranked 2nd; D had 207.98 and ranked 3rd; E had 110.27 and ranked 1st; F had 79.15 and ranked 6th; G had 71.08 and ranked 7th; while H had 34.99 and ranked 5th. More comprehensive analyses are planned for the future and will examine fuel loadings by transect and by individual tree. Fine forest fuels such as litter and duff were reduced more uniformly, with all positions showing at least 95.9% of the material removed by the application of fire.

To date, only a very preliminary analysis has been run on this project's database. Further examination of the data and additional statistical tests should better illuminate the multi-faceted relationship that exists between scar formation and fuel consumption. Despite the infancy of this analysis, the pilot project did reveal that despite heavy fuel loads no mortality occurred within the trees sampled. Numerous scars did form as a result of the burn, however, they were typically small in size despite the buildup of fuels. Future work will entail monitoring these trees to watch for changes in scar size and shape over time as well as conducting a more detailed analysis.

4.15) Fuels Inventory and Monitoring

Corky Conover, Fire Management, SEKI

Lead: C. Conover. Crew Leader: L. Uhr. Crew: J. De Neau, D. Loveland, J. Sevier, and C. Thibault

INTRODUCTION

Recent advances in computerized technologies have given resource managers more tools to help make critical resource management decisions. The development of a Geographic Information System (GIS) based fire spread model called *FARSITE*, is an example of one of these new tools. The *FARSITE* model, like most models, requires quality-input data in order to produce reliable output. The fuels model and canopy characteristic data are the most important inputs to any fire growth model. Currently, the fuel model map for Sequoia and Kings Canyon National Parks is based on 1970's vegetation maps

Forest Stand Data				Height to Live Crown Base		
BA (m^2/ha.)	Canopy Code (0-4)	Overstory DBH (cm)	Overstory Height (m)	Dominant (m)	Intermediate (m)	Understory (m)
42	4	80	38.1	17.2	5	0.5

Fuel Load Data (kg/m^2)							
Litter	Duff	1 Hr.	10 Hr.	100 hr.	1000 Hr. Solid	1000 Hr. Rotten	Total Fuel Load
1.88	6.03	0.18	0.49	1.92	6.54	1.53	18.57

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PROJECT OBJECTIVE: The purpose of this study is to improve the parks GIS fuels theme and collect data on forest canopy characteristics. The canopy characteristics data will be used to develop tree height and height to live crown base GIS themes that are used within *FARSITE* to model crown fire activity (torching, spotting, and crowning).

DESCRIPTION OF THE STUDY AREA: The study is being conducted in the East Fork of the Kaweah watershed. Terrain in the watershed is rugged, elevations range from 874 m (2884 ft.) to 3767 m (12,432 ft.). The watershed, 21202 ha (52369 ac) in size, is bounded by Paradise Ridge to the north, the Great Western Divide to the east, and Salt Creek Ridge to the south. The Parks administrative boundary to the west defines the study area's western extent. The vegetation of the area is diverse, varying from foothills chaparral and hardwood forest at lower elevations to alpine vegetation at elevations between 3049-3354 m (10-11,000 feet). The study is being conducted in the mixed conifer belt and Red Fir Forest. Ponderosa Pine mixed conifer communities occur at lower elevations < 1982m (6500 ft). The middle elevations 1982-2439m (6500-8000 ft) are dominated by the White Fir mixed conifer community including the sequoia groves. The Red Fir Forest community dominates the higher elevations 2440-3049m (8001-10000 ft).

METHODS: Permanent fuel plots were established in order to track fuel accumulation over time. The permanent fuel plots were established using the planar intercept method (Brown, 1974). The plots consisted of four fifty foot transects running north, south, east and west from the center point. Ten litter and duff measurements were taken along each of the 50 foot transects. These plots will be re-read about every 5 years to track fuel accumulation. Based on previous years data the permanent plots were located in the short needle (includes sequoias) and long needle conifer forest types in the following elevation classes; low ≤ 1982m (6500 feet), mid 1982-2439m (6500-8000 feet) and high > 2440m (8001+ feet).

Tree basal area was measured at each permanent plot using Basal Area Factor (BAF) prisms. The prism was selected so that a minimum of five trees would be included. The prism was swung 360° around the sampling point and the number of trees that were "**in**"(edges still touching, not totally offset) was recorded along with the factor number of the prism used. Every other borderline tree was counted. Three trees were selected as being representative of the average diameter "in tree" and their diameter at breast height (DBH) was measured and recorded. An average value was be calculated from the three trees measured and used to represent the trees at that sampling point.

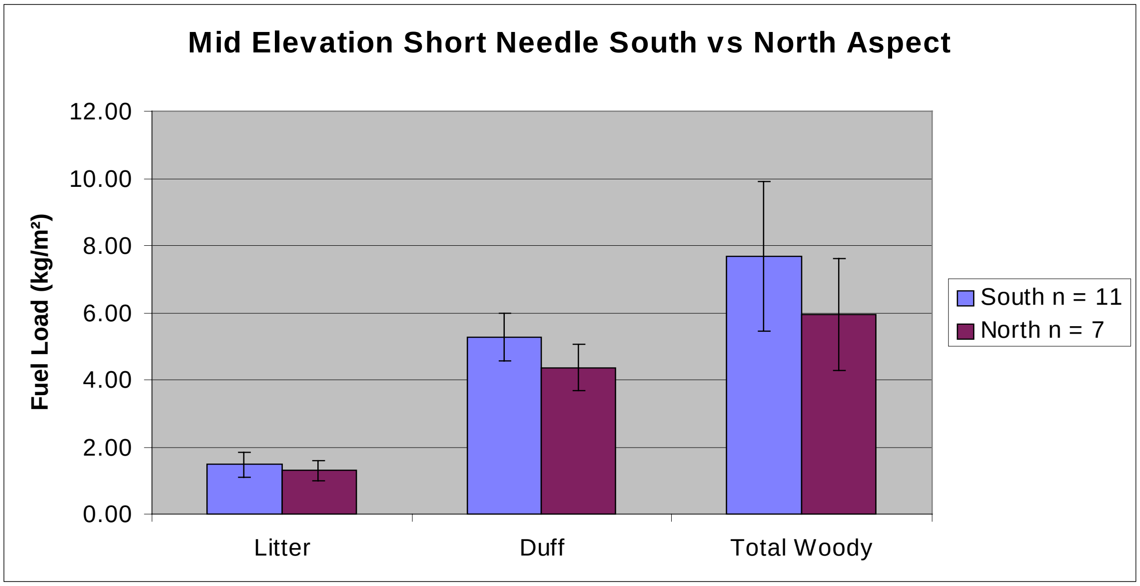
The following measurements were also taken at each permanent plot with a clinometer and recorded: overstory tree height, height to live crown base for each distinct canopy layer (dominate, intermediate, understory). Canopy cover was measured with a densiometer and recorded using the following codes: 0=0%, 1= 1-20%, 2= 21-50%, 3= 51-80%, 4= 81-100%.

WORK ACCOMPLISHED IN 1999: The crew established seven new permanent fuel plots in 1999. They revisited thirty-one plots to acquire digital photos of plots that were established prior to the crew having a digital camera. The emphasis for the new plots was to establish them in areas of known fire history and to increase the sample size for those types that had percent errors over twenty percent for the total fuel load estimate.

Results and Discussion: Results are presented in the graphs as mean values ± one standard error.

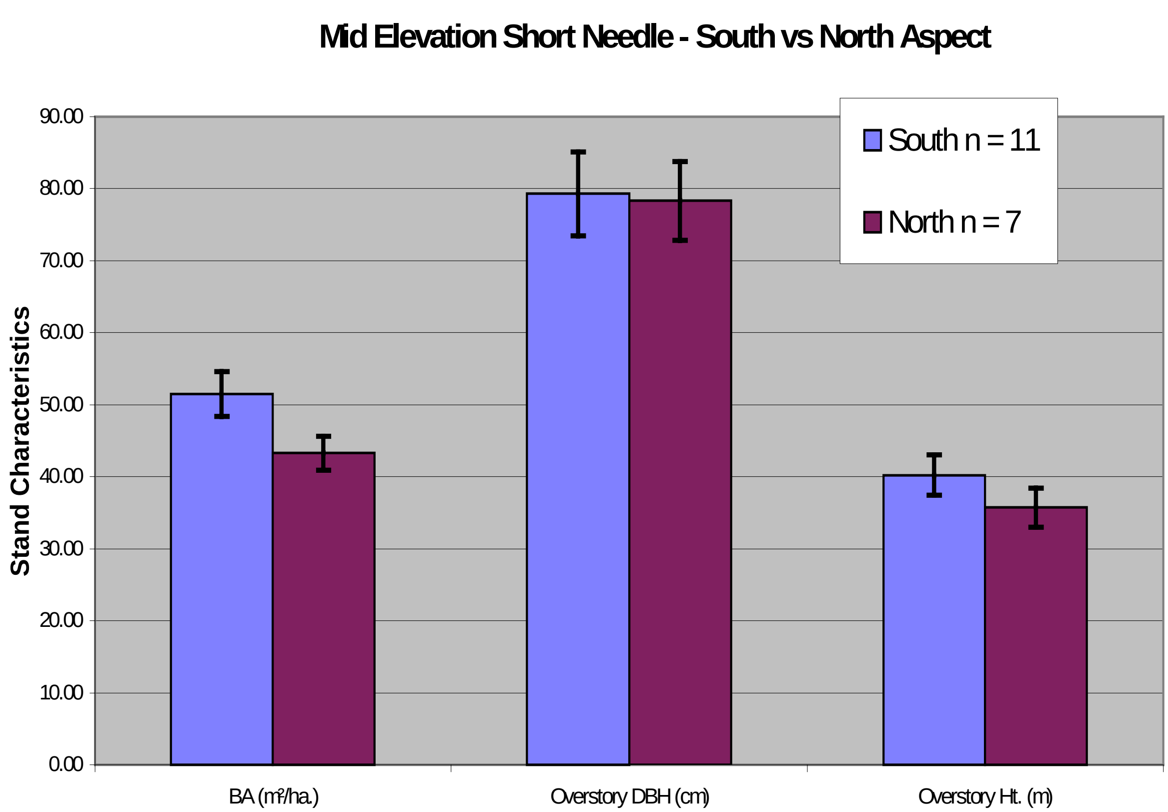
We decreased the percent error of the total fuel-loading estimate to less than our goal of twenty- percent (12.9% South, 13.6% north) for the middle elevation, fir forest type. The middle elevation fir forest had fuel loads of 1.5 kg/m² (litter), 5.3 kg/m² (duff), 7.7 kg/m² (woody) for the south aspects (105-285°) and 1.3kg/m² (litter) 4.4 kg/m² (duff) and 5.9kg/m² (woody) on the north aspects (286-104°).

Figure 4.15-2**.**



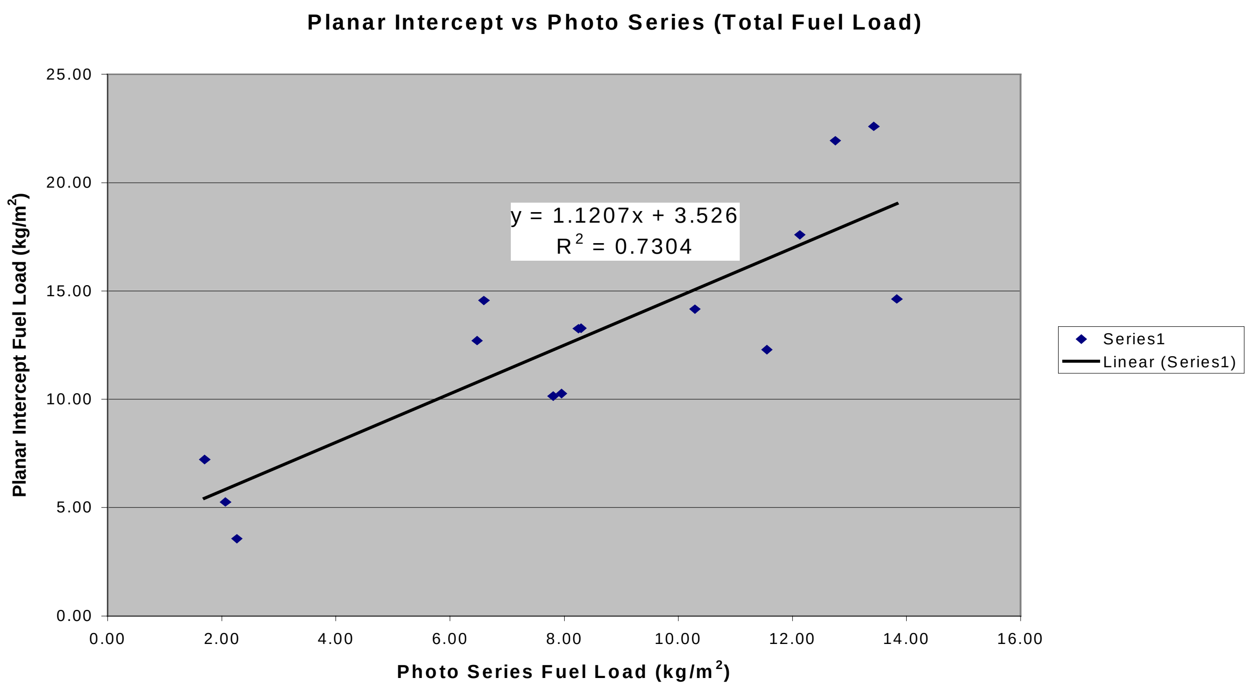
The basal area for the south aspects was 51.5 m²/hectare compared to 43.3 m²/hectare on the north aspects. The overstory tree heights was higher for the south (40.2 m) than for the north (35.7 m) aspects. The diameter at breast height (dbh) was slightly larger for the south (79.3 cm) than for the north (78.3 cm) aspects.

Figure 4.15-3.



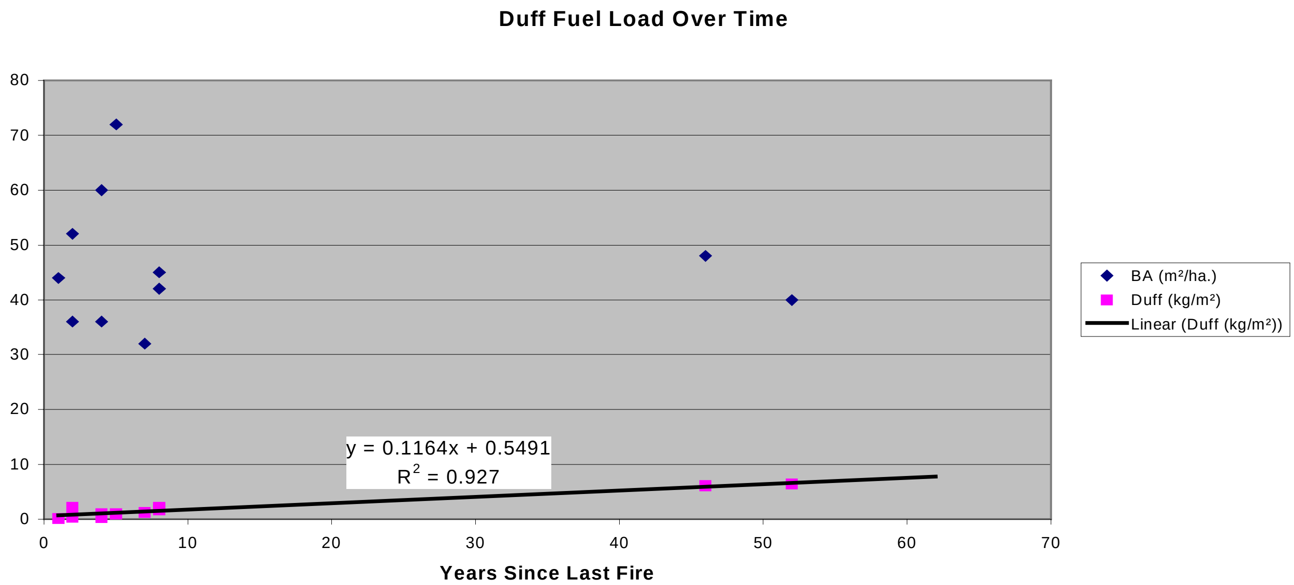
Last years report indicated that we would take photo series estimates at the same location where we installed the permanent plots to see if a correlation exits between the two methodologies. If a correlation can be established, we will use this correlation to survey future areas because you can collect about five times as many sample points with the photo series when compared to the planar intercept method. While the results are inconclusive, there does appear to be some promise of establishing a relationship between the two methods.

Figure 4.15-4.



When we compared the known fire history with our plot locations, we came up with eleven plots that occurred in areas that we knew the date of the last fire. As stated in last year's report we were going to see if a relationship exists between the number of years since the last fire and the fuel loading. Last years report indicated a good relationship for duff and total fuel load over time. We increased our sample size from six to eleven plots this season however, we now only show a good relationship (R^2 = .927) with duff load overtime (**Fig. 3.15-5**). Most of our new data is from areas of recent (last 2-5 years) fire events and this is probably not enough time to smooth out site specific differences in fire intensity and mortality.

Figure 4.15-5.



<u>Future Plans:</u> Our goal was to have enough permanent plots by elevation and forest type so that the percent error of our total fuel loading estimates was less than twenty percent. We will need to install some more plots in the Red Fir South aspect and Low Elevation Pine South aspect forest types to lower the percent error of the total fuel-loading estimate. It will probably take between 2-5 new plots in these fuel types to achieve our goal of less than twenty- percent error. When installing future permanent fuel plots, we will continue to take photo series estimates at the same location and record the data. We will try to install these new plots in areas of know previous fires in order to increase our sample size and improve on our correlation between time since last fire and fuel load. We will try to located these new plots in areas of older fire events (>10 years). We will also work with the fire history ecologist to obtain last know fire dates for previously installed plots.

References

Brown, J.K. 1974. Handbook for Inventorying Downed Woody Material. USDA Forest Service General Technical Report INT-16.

4.16) Fire History

- Anthony Caprio, Science and Natural Resources Management, SEKI

Lead: A.C. Caprio, Field crew: Brian Knaus and Dylan Kreis (SCA)

INTRODUCTION

Over the last three decades the parks' fire management program has evolved to where it now includes restoration of fire at a landscape scale. However, burning at such scales has raised a variety of new management and resource questions. Among these are questions about our understanding of pre-Euroamerican fire regimes at such large ecosystem scales. Unfortunately, written records or accurate descriptions of pre-Euroamerican settlement fire regimes do not exist from the southern Sierra Nevada. However, we are fortunate that, at least temporarily, we can obtain fairly reliable information about past fire regimes from a proxy record that can be obtained in most of our forested plant communities. This record is based on the sampling of fire scarred trees which document the minimal role of fire within the land units sampled. Dendroecological analyses of these samples provides a powerful tool to characterize attributes of past fire regimes, to examine their variability and to understand how they have shaped landscapes over time. This information provides clues from the past that can supply guidance for ecologically sound fire management practices today and into the future.

While substantial fire history research has been carried out in Sequoia and Kings Canyon National Parks (Kilgore and Taylor 1979; Pitcher 1987; Swetnam et al. 1992; Swetnam 1993; Caprio and Swetnam 1995; Swetnam et al. 1998) a considerable number of gaps still remain in our knowledge and understanding at many levels (Caprio and Lineback in press). Acquiring this information would be of great value to managers when planning and reintroducing fire in park ecosystems, in evaluating the success of the Park's burn program (Caprio and Graber in prep) and to ecologists interested in understanding dynamics of pre-Euroamerican plant and wildlife communities.

A growing body of evidence indicates considerable variation in pre-EuroAmerican fire regimes, both temporally and spatially, across the landscape. However, because reconstructing past fire regimes is difficult, requiring considerable effort and experience our current knowledge about this variation is sparse. For example, we have little information about past fire regimes at a scale that encompasses 1000+ hectares and includes varying slope, aspect, vegetation type, and elevation. This also includes a lack of knowledge about past fire regimes from several common vegetation types. An example best illustrates the difficulty in capturing this variation. Unlike our current terrestrial vegetation, where variation in species composition and structure are obvious and sampling strategies to adequately capture this variation are easily designed, the historical fire regime is largely hidden from direct view. As a result its attributes would be easily under sampled or overlooked. To capture some semblance of this variation a substantial effort is required to acquire a large number of sample size. Such sampling intensity would not be unexpected if variation in terrestrial vegetation were being sampled across diverse habitats.

The fire history information being developed in this study will have both a direct impact on fire management decision making and a less direct but equally important impact on park management over the long term. For example, fire history data forms the foundation on which fire management planning using GIS fire return interval departure (FRID) analysis is based (Caprio et al. in press). Using fire return interval information that is of poor quality, in some cases simply an estimate, may result undesired management consequences (Caprio and Lineback in press). A significant unknown is how past fire regimes varied spatially across differing aspects. Recently, Miller (1998) developed computer models that look at surface fire regimes and forest patterns across elevation gradients in the southern Sierra Nevada. The models examined connectivity and spatial extent of fire over elevational gradients.

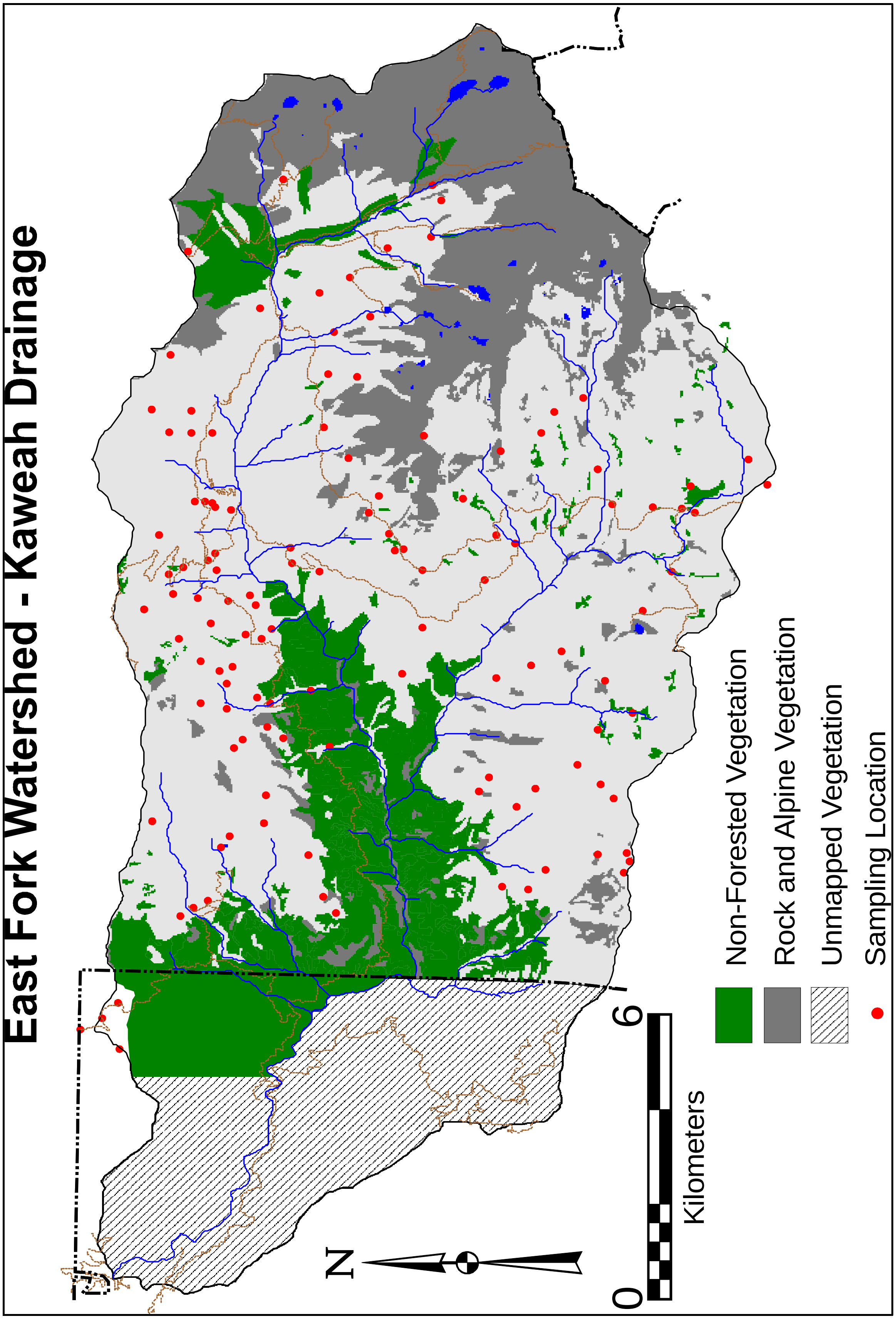


Figure 4.16-1. Fire history collection sites in the East Fork.

Their output suggests that differences in burn patterns/frequencies exist by aspect and these differ most notable between south and north slopes (Carol Miller personal communication). Structural and landscape differences in vegetation by aspect have also been suggested from the preliminary results of the Landscape Analysis Project (Kurt Menning personal communication) which may be related to differing fire regimes on the north versus south aspects. However, other than the preliminary results from the current fire history collections in the East Fork, little data exists on pre-European settlement fire history for north aspect forests in the southern Sierra Nevada. Thus the information collected in the East Fork will be critical in verifying these models and as input for more rigorous parameterization to improve their predictive ability.

Recent fire history collections have been made at several locations for four specific but interrelated projects. These include the East Fork Watershed Project, the Aspect Project and two special projects: Silliman Creek lodgepole pine/fir forest and the Cedar Grove Valley ponderosa pine collections (collected in 1998 but reported here as part of the expanded Annual Fire Report).

I - MINERAL KING WATERSHED FIRE HISTORY PROJECT

OBJECTIVES

The goal of this data collection effort is to: 1) obtain information on the spatial extent of pre-Euroamerican fire on a watershed scale (fire size, spread patterns, and frequency variation), 2) acquire data on pre-Euroamerican fire regimes from the wide array of vegetation types within a watershed, and 3) integrate this information with the Parks' fire management program. Specifically, these data will provide improved information on fire frequency regimes from a range of vegetation associations that are being used as input into fire/GIS analyses to reconstruct past fire frequency regimes throughout the parks (Caprio and Lineback in press). Additionally, reconstructing the large scale spatial pattern fire in the East Fork will assist managers in determining whether they are meeting management objectives in restoring fire as an ecosystem process (Caprio and Graber in prep)

DATA COLLECTION and ANALYSIS

Sampling has been ongoing over the past four summer seasons in the coniferous forest zone within the East Fork watershed (**Fig. 4.16-1**). During 1999, emphasis was placed on collecting sites in higher elevation conifer forest and on aspects or vegetation types for which we have little fire history information. New sites were sampled at higher elevations in the Timber Gap and Silver City area and at low-to-moderate elevations the Oriole Lake watershed.

Specimens are being dendrochronologically crossdated to determine precise calender years in which past fires occurred (Stokes 1980). Crossdated fire chronologies provide results with precise temporal information that allows consistent comparison of fire dates among sites separated spatially across the landscape. Additionally, intra-annual position (or approximate season) of fire dates are also being determined when scar quality makes this possible (Ahlstrand 1980; Caprio and Swetnam 1995). Sample preparation and crossdating are most advanced from sites collected from 1995 though 1998.

Area burned within a given year by pre-Euroamerican fires is being reconstructed using Thiesson polygons (Davis 1986). Each irregular polygon represents the area around a point (representing a single sample site), in a field of scattered points, determined by Euclidean distance, that is closer to that point than any other point. The resulting field of polygons represents the most compact division of area, given the specific arrangement of points. This approach is commonly utilized for rainfall gauging networks when stations are not uniformly distributed and strong precipitation gradients occur (Dunne and Leopold 1978), both characteristics of the network of fire history sites sampled in the East Fork. Its

use provides a valuable tool for quantifying and portraying spatial patterns of over a landscape. For the fire history sampling sites, polygons were
constructed around the center point of each site using ArcView 3.2 Spatial Analyst (ESRI 1999) and area of each polygon determined. This allowed maps of annual burn area to be created for the watershed. While not computed for this report, future iterations of polygon calculation will use aspect as a constraint on polygon boundary delineation.

Based on GIS analysis and topographic features the watershed landscape has been categorized by elevation and aspect (**Fig. 4.16-2**). North and south aspects were defined as: south has slopes facing from 106° to 285° and north facing >285° to <106° with level topography classes as south (**Fig. 4.16-3**) and high and low elevation conifer forest was separated at 2286 m elevation (**Fig. 4.16-4**)

RESULTS and DISCUSSION - Preliminary Analysis

Sixty-five specimens (logs, stumps, snags, or trees) were collected from 14 sites during 1999. This supplements samples from 109 sites previously collected (Caprio 1997, 1998, 2000). A large number of sample sites are required to provide adequately replicated data sets from across vegetation type, elevation, and aspect Within the drainage samples have been obtained from 10 of the 11 major vegetation classes currently designated in the Parks (**Table 4.16-1 and Fig. 4.16-5**). Sites have also been obtained from both north and south aspects over a range of elevations (**Table 4.16-2**). These collections greatly expand on previous work carried out in the watershed (Pitcher 1987; Swetnam et al.1992). Additionally, the collections are a source of new fire regime information for vegetation types not previously sampled in the Parks. These include Jeffery pine, lodgepole pine, and oak woodland while others, such as red fir and nearly all vegetation types located on north aspects, which have been sampled sparsely at best..

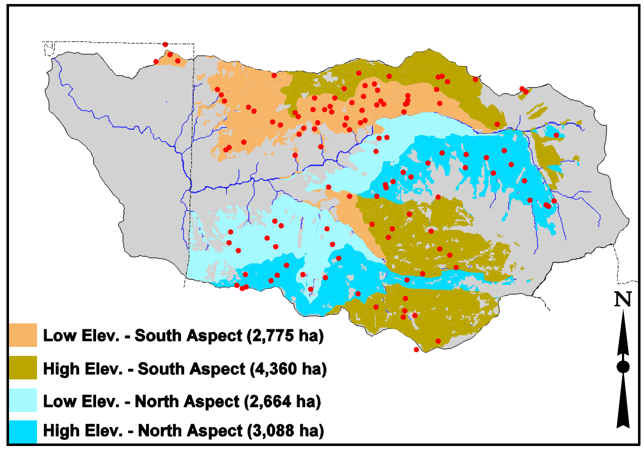


Figure 4.16-2. Vegetation classed by elevation (low vs high) and aspect (north vs south). Red dots are fire history sites.

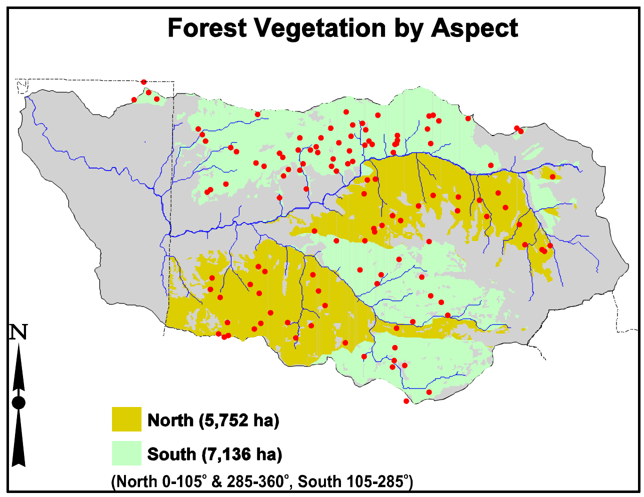


Figure 4.16-3. Forest vegetation within the East Fork classed by aspect (north vs south).

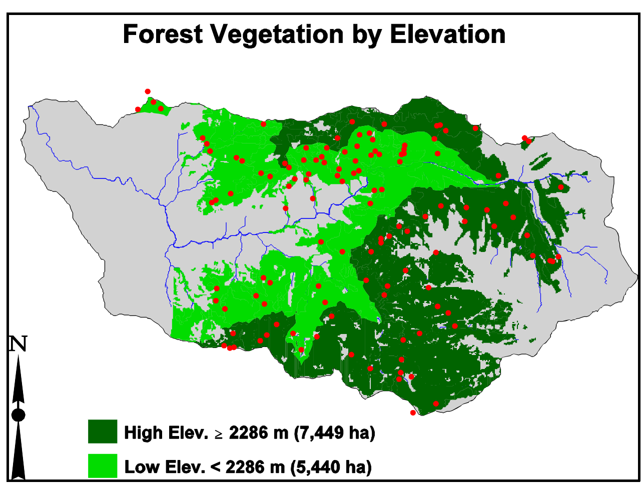


Figure 4.16-4. Forest vegetation classed by elevation (high vs low).

Table 4.16-1. Summary of site collections within the East Fork by vegetation class through 1999.

Vegetation Class	Number of Sites
Ponderosa Pine	4
Ponderosa/Mixed Conifer	31
White Fir Mixed Conifer	23
Sequoia Mixed Conifer	9
Red Fir	39
Lodgepole Pine	10
Subalpine Forest	2
Xeric Conifer	5
Foothill	1
Chaparral*	**(7)**
Total	**123**

Currently 123 sites have been collected [two of these were previously collection in the Atwell giant sequoia grove by Swetnam et al. (1992)] with 544 individual trees sampled (primarily from logs and snags). The sites are located throughout the 12,887 ha watershed (**Fig. 4.16-1**) so that 82 % are within 1000 m of any other site (**Fig. 4.16-6**). Mean number of samples collected at individual sites is 4.39 (SD=2.36). Fire dates have been determined from 92 sites and form the basis for the current fire return interval estimates and annual area burned reconstruction. A total of 255 dated samples were used in this analysis with over 2050 individual fire scar dates. A total of 304 fire event years (years in which a fire event was recorded somewhere in drainage) are recorded between AD 1400 and AD 1995 although fire dates extend back to 284 BC at the sequoia sites (Swetnam et al. 1992). For the primary period of analysis, 1700-1899, 151 fire event years are recorded within the drainage. The last fire of significant size occurred in 1889 (recorded at 5 sites) with 1994 the most recent fire date recorded.

Polygon construction for all sample sites yielded an average area of 104.1 ha per polygon (median 97.6). Irregular polygon shapes are the result of polygon boundaries being constrained by aspect, elevation, and vegetation categorization (**Fig. 4.16-7**).

The Twentieth Century Fire Record - Comparison of Fire Scars and Fire Records

During the twentieth century 17 fire dates were observed in the fire scar record. Comparison of these records to our modern fire records shows interesting similarities and differences. Four of the 17 fire scar dates predate the start of fire records in 1921 (1901 lower Atwell, 1911 Eden Grove, 1918 Squirrel Creek and 1920 upper Atwell). The 1911 date was recorded at two adjacent sites indicating a sizable fire. A review of the 1911 Superintendent's Report for Sequoia and General Grant National Parks (Major James B. Hughes First Cavalry 1911) by Ward Eldridge located a reference to a 600 ac

Figure 3.16-5. Distribution of fire history sites within the drainage across all major vegetation classes.

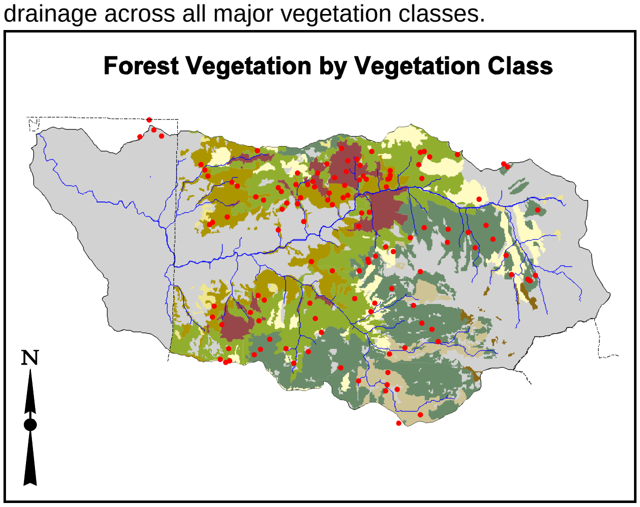


Table 4.16-2. Breakdown of sites collected in the East Fork by elevation and aspect through 1999.

Elevation (m)	Total	South	North
<1000	0	0	0
1000-1250	0	0	0
1250-1500	1	1	0
1500-1750	12	8	4
1750-2000	26	18	8
2000-2250	27	19	8
2250-2500	17	9	6
2500-2750	31	10	21
>2750	13	8	5
Total	123	73	50

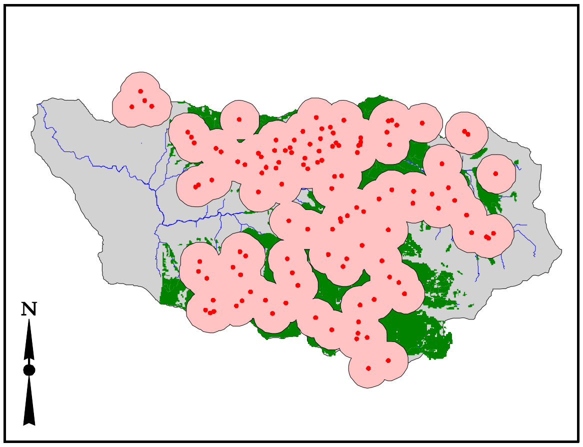


Figure 4.16-6. Intersite proximity and spatial coverage of fire history sites (red dots) with 1000m buffer.

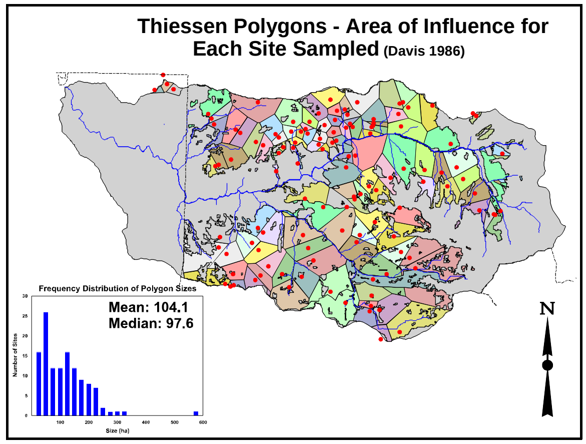


Figure 4.16-7. Thiessen polygons constructed around current set of fire history sites. Inset chart shows polygon size distribution.

lightning caused burn in Horse Creek (Horse Cr. is a subdrainage to the East Fork of the Kaweah). Although the report does not give a specific location for the burn in Horse Creek the fire history sites recording a 1911 event are located on the south side of the lower portion of the drainage. The fire burned between July 30 and September 13 and was suppressed by 20 soldiers and rangers. In the area where the 1918 scars were obtained hand cut stumps suggest fire suppression activities. A Superintendent's Report is not known to exist for this year (although archives have not been searched in Washington) (Ward Eldridge personal communication). No record of a 1920 burn above Atwell was found in the Park's archives although a list of fire reports was located and will be added to the Park's fire records database (by Karen Folger) which currently only extends back to 1921 (however, the fire reports only list location).

For the period for which we have fire records, six fire dates (for fires > 2 ha) correspond to fires listed in the fire records (1926 unknown (lower Silver City), 1946 Atwell Mill (upper), 1970 Lookout Point (Conifer Ridge area), 1979 Timber Gap, 1987 Silver [date matches a recorded fire but the mapped location of the burn is about one kilometer west from the location we obtained using a GPS with no other burns in the area matching this date] and 1994 (2) Farewell and Hockett). Dates from nine burns listed in the fire records, located in conifer forest, were not picked up by the fire scar record (1924 unknown (Oriole Lake), 1952 Mineral King, 1955 Conifer Tract, 1974 Lookout (Hockett Plateau), 1978 Eden Grove, 1988 (2) Hockett and Deer Creek, 1991 Deer Creek, 1994 Horse Creek). The lack of records from the more recent burns was primarily a result of sampling not being carried out these areas due to the poor or lacking fire history record. This is a result of recent burns destroying most fire history information (due to heavy fuels and the decayed nature of many catfaces, both of which result in catfaces being burned out or remnant logs/snags being completely consumed by the fire). The earlier burns, none of which were over 25 ha in size, appear to have been missed simply because of the spacing of sample sites. Of particular interest are the number of fire events recorded by fire scars that are not recorded in our fire records. These include six dates: 1924 upper Atwell Mill, 1935 Atwell/Redwood Cr. Ridge, 1954 Tar Gap, 1969 Milk Ranch south of Parks, and 1971 and 1985 in the area of Atwell Mill. The 1969 burn, although mapped within the Parks, included a large area outside the Parks which is missing from the fire record. The reason for the missing records for the most recent burns near Atwell is unknown although the occurrence of the latter burn is recalled by some park personnel.

<u>Annual Area Burned</u>

Striking patterns of past fire occurrence are emerging as more sites are collected and crossdated from a

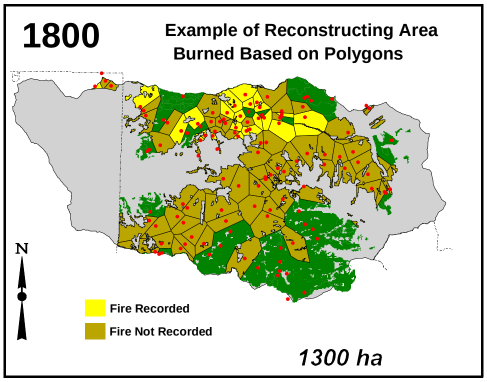


Figure 4.16-8. Reconstruction of area burned in 1800. Fire(s) appear to have been confined to the south aspect.

broad array of areas in the watershed. Initial mapping of fire occurrence indicates that patterns of area burned by past fires can be reconstructed over the landscape with some reliability. However, the resolution of the final burn map is commensurate with the sampling intensity and while rough estimates of past fire size can be obtained, specific locations of burn boundaries cannot be determined. Additionally, the distribution of point estimates over the landscape generally represent a minimal area burned by a particular fire or fires in a given year. This is because the presence of a scar is a definitive record of the occurrence of a fire while the lack of a scar could be the result of either the area not having been burned by a fire or that the fire left no record (did not scar trees or a sample with the scar was not collected) even though a fire occurred.

Several fire years provide good examples of the spatial pattern of reconstructed area burned. The map displaying the 1800 fire date (1,300 ha based on estimate from polygon reconstruction) shows a burn, or possibly more than one burn, with a well defined burn area confined to south aspect slopes (**Fig. 4.16-8**)(data based on those areas from which fire dates have been collected and dated). Other fire dates show different patterns of fire on the landscape. The maps for 1777 and 1829 (**Fig. 4.16-9**) indicate widespread burns (3,720 and 4,209 ha respectively) and show areas that burned in both the main East Fork drainage and the Horse creek drainage. In contrast only a small cluster of sites located in the Cabin Cove area (**Fig. 4.16-10**) recorded what was probably a single fire event in 1844 (255 ha).

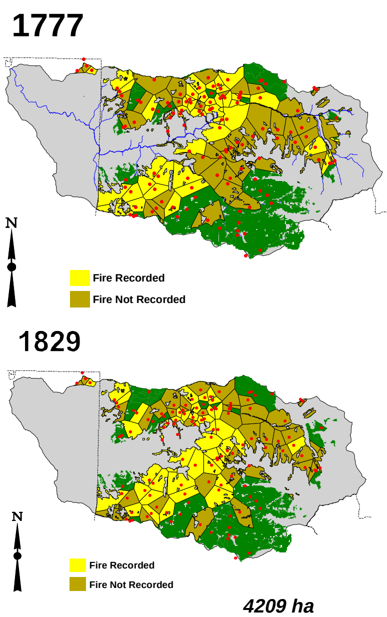


Figure 4.16-9. Large areas burned in 1777 and 1829 across much of the drainage suggesting a widespread fire(s).

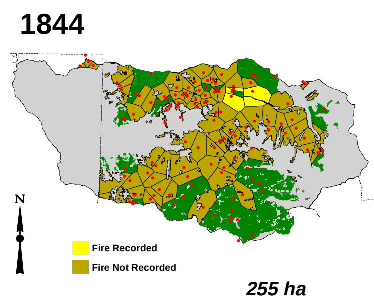


Figure 4.16-10. Area burned at a cluster of sites indicating a fire of limited extent.

Also of interest are comparative maps of the extent of the 1873 and 1875 burns (**Fig. 4.16-11**). The area of the 1873 burn shows that it was centered on the central portion of the Atwell Grove while the map for the 1875 burn indicates it burned predominantly to the east and west of this area and into lower portions of the north aspect. Overlaying burn maps of these two burns suggests that they were nearly 100% mutually exclusive indicating that fuel recovery in two years may not have been sufficient to permit extensive reburning.

There is also an interesting historical footnote for the 1875 burn. While traveling through the Atwell area in 1875 John Muir observed a fire that appears to be this 1875 burn (Muir 1878). He wrote that the fire burned intensely up-canyon through chaparral vegetation but with decreasing intensity once it entered the sequoia grove where fuel levels were low and consisted primarily of conifer needles. These observations, that the fire burned through the intervening chaparral vegetation, verify the burn pattern reconstructed on the burn map from the fire history samples.

Chronosequence of annual burn patterns back into the early 18th century will be developed for the

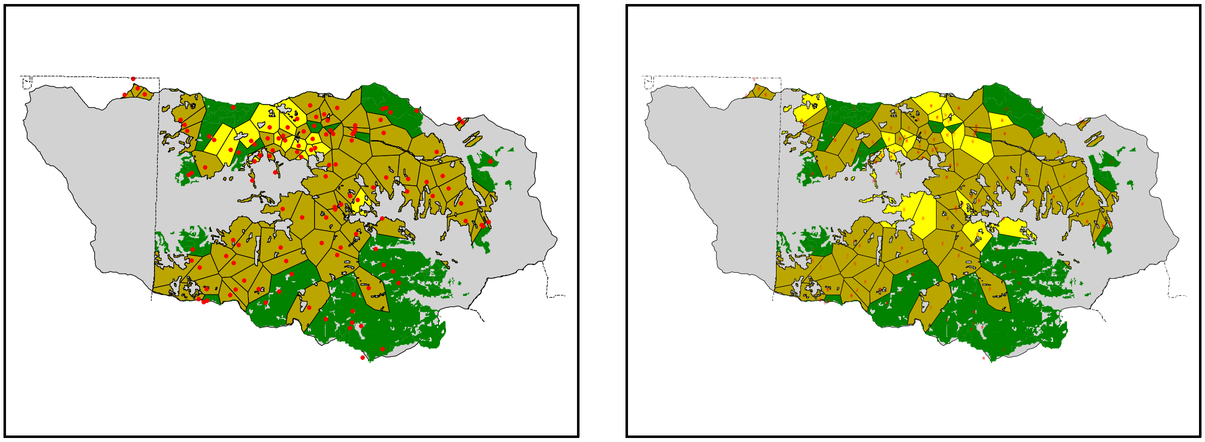


Figure 4.16-11. Reconstructed burn maps for 1873 (left) and 1875 (right) showing nearly complete lack of overlap in burns during the two years..

watershed. The sequences will provide rough estimates of area burned and spatial pattern of burns. An example the annual burn area for the East Fork is shown for the years from 1839 to 1849 (**Fig.4.16-12**). Apparent are a range of year types, with years when extensive fires occurred to years without fire to years when no fires were recorded. The temporal variation in annual area burned is examined in the following section "Frequency-Area Relationships". This chronosequence of burn maps will complement and extend the GIS fire records database back in time.

Fire-Return Intervals

Fire-return interval analysis looks at point estimates based on individual site data and is the typical method of looking at past fire history data (**Fig. 4.16-14**). Within the East Fork watershed considerable variation in fire-return intervals have been found among sites with obvious patterns apparent from individual site fire chronologies. For example, fire chronologies show (1) both differences in mean fire-return intervals (FRI) among the sites related to elevational differences, as described by Caprio and Swetnam (1995), and (2) occurrence of common fire years among sites--years such as 1848 and 1875. Further analyses are possible when these results are summarized into composite fire chronologies for each site.

Initial comparisons of FRI between north and south aspects for a subset of sites at low-to-mid elevations (1800-2200 m) have provided the most interesting results to date (**Fig. 4.16-13**). These data suggest that there were considerable differences in FRI between north and south aspects in this elevational range. FRI averaged about three-times greater on the south aspect relative to the north aspect (~9 years versus ~31 years) (**Fig. 4.16-15**). Sampling during 1999 will be partially directed at obtaining collections from north/south aspects in other drainages to determine whether such aspect differences can be generalized to larger areas of the Parks. If consistent, such differences in fire return intervals by aspect will have important implications for fire managers in terms of burn planning, on anticipating potential fire effects on these sites, and understanding mechanisms responsible for initiating or maintaining attributes of past forest structure.

Additionally, comparison of point fire frequency estimates, for the period from 1700 to 1899, across the elevational gradient in the drainage, for the sites on the south aspect versus the north aspect show dramatic differences (**Fig. 4.16-16**). A strong inverse relationship between number of fires and elevation was observed on the south aspect which corresponded very well with the results from previous sampling along an elevational gradient in the Giant Forest area (Caprio and Swetnam 1995).

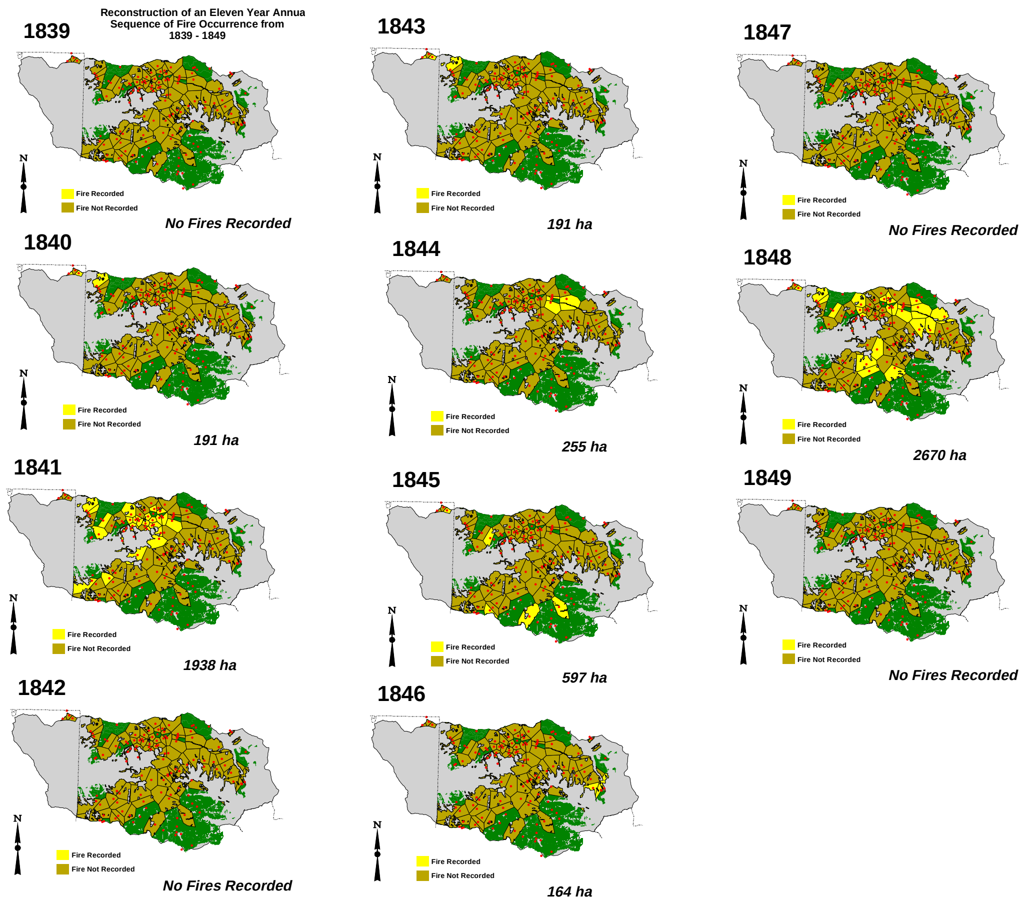


Figure 4.16-12. Chronosequence of reconstructed annual area burned between 1839 and 1849 showing variation in burn patterns across the landscape.

However, the relationship between elevation and aspect on the north facing slopes was much weaker suggesting that fire occurrence across the elevational gradient on this aspect was comparatively uniform relative to the south aspect.

Frequency-Area Relationships

Reconstructing annual area burned within the watershed permits us to view patterns and variation in area burned through time and in many ways provides a more realistic feel for past fire occurrence at a landscape level. A plot of reconstructed area burned (based on polygons) for the whole watershed shows considerable year-to-year variation (**Fig. 4.16-17**). Extensive area burned is apparent in a few years (1777, 1829 and 1848) with many years when a small-to-intermediate amount of area burned. Average area burned annually within the watershed was 320 ha (this value will probably increase as sampling and sample analysis for all area within the watershed are completed) or about 2.4% of the

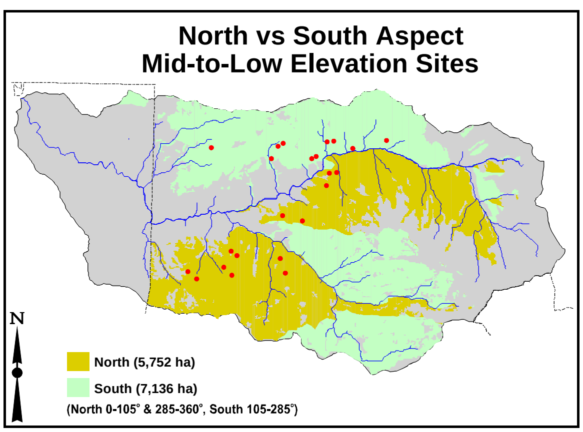


Figure 4.16-13. Low-to-mid elevation sites used in comparing aspect differences in fire frequency.

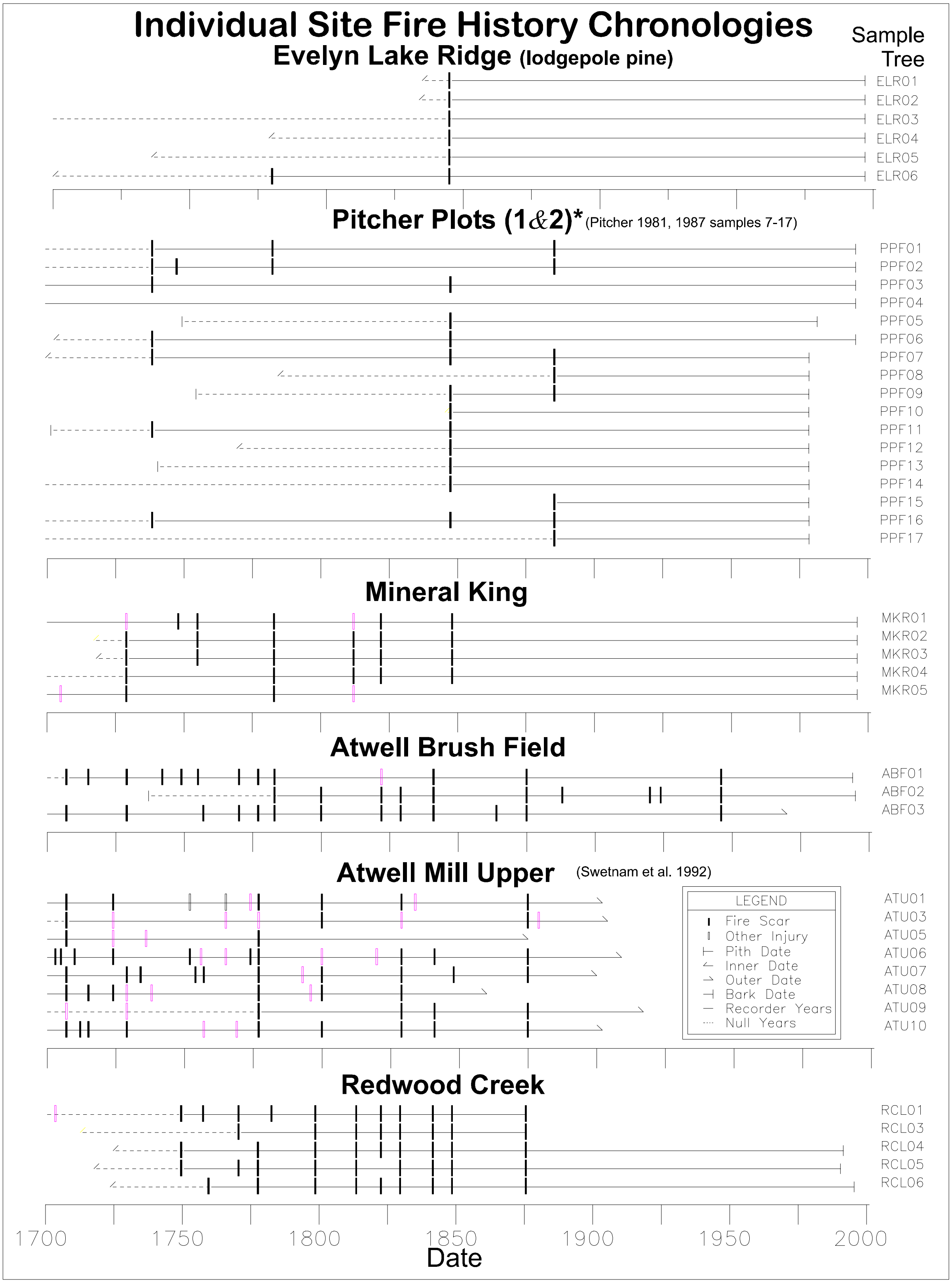


Figure 3.16-14. Examples of reconstructed fire history data from five sites in the East Fork drainage for the period from 1700 to the present. Sites illustrate varying pre-Euroamerican fire regimes from differing vegetation types and aspects in the watershed. Horizontal lines represent a particular sample (one tree) with vertical bars indicating crossdated fire dates.

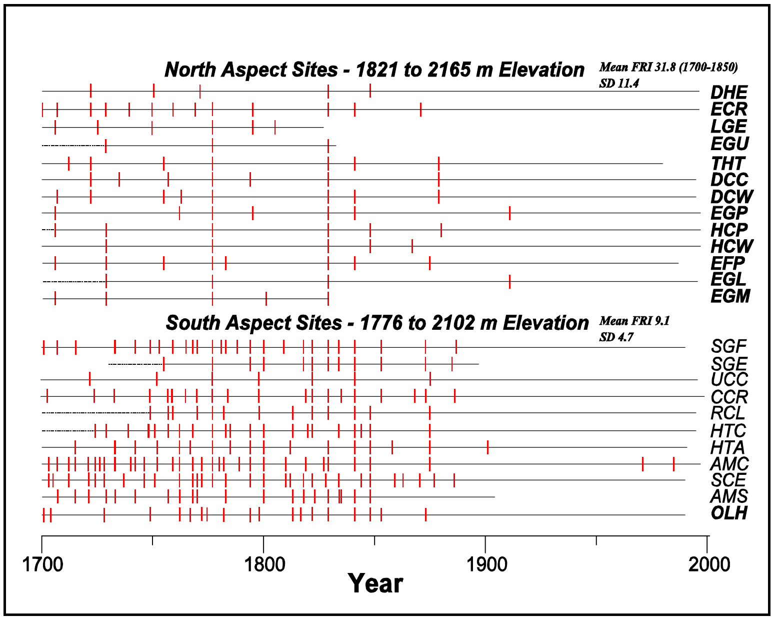


Figure 4.16-15. Differences in fire frequency by aspect for low-to-moderate elevation sites in the East Fork drainage. Each horizontal line represents a composite site chronology with vertical red lines indicating fire dates.

coniferous forest area. The distribution of reconstructed area burned annually within the watershed from 1700 to 1899 shows an inverse J shaped distribution (**Fig. 4.16-18**). Most fires were small with a few years when extensive fire occurred.

Considerable more detail was apparent when data were separated by elevation and aspect (**Fig. 4.16-19**). The analysis showed dramatic differences in area burned annually by aspect and elevation with patterns that were similar to the fire-return interval analysis described above. Differences were greatest between lower elevation north/south aspects (~ three-times) and decreased as elevation increased (~ two-times). Low elevation south aspect with high frequency of small to fairly large fires in contrast to low elevation north aspect where fire frequency was moderate-to-low but punctuated by very large fires at intermittent intervals. Between 1700 and 1899 two large fires occurred in 1777 and 1829 (based on tree-ring analysis these appear to have been dry to very dry years). On both the north and south aspect at higher elevation frequencies were low (lowest on north high). North high with similar freq to south low although was not punctuated by large fires.

SUMMARY

The current sample set greatly improves the resolution and spatial accuracy for reconstructing past burn history within the East Fork watershed. It is important that fire history information be obtained from a large set of areas to present a clear picture of past fire regimes over the landscape with less bias than previous sampling that centered on specific vegetation types, aspects, or elevations. As data from the current sample set are developed it will provide information about attributes of past fire regimes from throughout the watershed. Data will also be used as input into the GIS/Fire model (FRID) being developed for Sequoia and Kings Canyon National Parks (Caprio et al. in press, Caprio and Graber in prep.).

The fire history data will also be important baseline data set for improving our understanding of past fuels, forest structure, potential fire behavior (and fire intensity/severity) and its potential ecological influence on these aspects. Recent sampling in the Landscape Analysis Project by Kurt

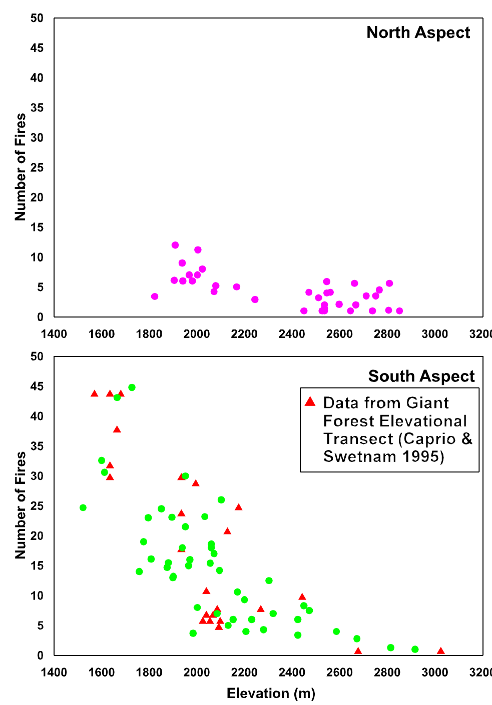


Figure 4.16-16. Relationship between number of fires (frequency) and elevation on north (top) and south (bottom) aspects. Graph indicates the greatest difference in frequency was at the lower elevations.

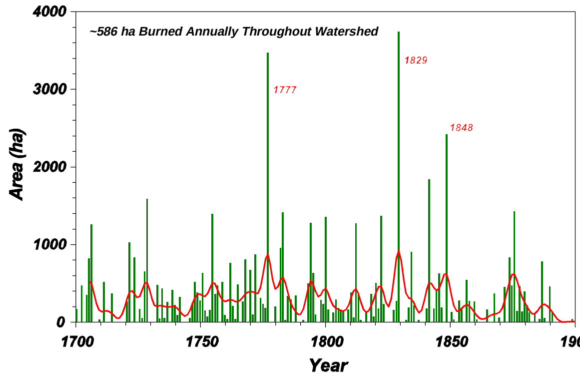


Figure 3.16-17. Reconstructed estimate of area burned annually within the East Fork (smoothed moving average using 13-weight low-pass filter).

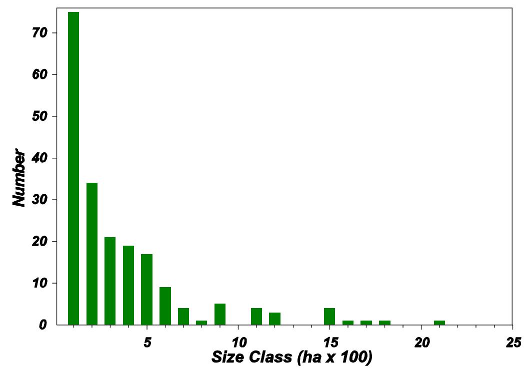


Figure 3.16-18. Distribution of area burned annually by size class showing that most fires were small.

Menning has focused on aspect differences in current fuels and forest structure. Such information may eventually provide clues about past differences in vegetation and fuel structure by aspect that can be interpreted in light of our knowledge about past fire history. Additionally, preliminary work on the relationship between area burned by aspect and climate suggests interesting relationships. Fires on south aspects appear to have occurred during just about any year (wet or dry) while fires on north aspects were more strongly associated with dry years. However, the years when large areas burned on either aspect were typically the driest. Such information can have operational value and be very important in understanding the relationship between fire occurrence and life history strategies and fire impacts on the biotic community (Bond and Wilgen 1996).

Main Findings

• ***Aspect difference*** - The current results show a dramatic difference in the length of fire return intervals between south and north aspects at low-to-mid elevations sites. Differences in average FRI indicate that intervals between fires were approximately three-times longer on north aspects compared to south aspects. If these differences occur consistently within other watersheds this information will provide valuable input into the fire management program.

• ***Estimates of past fire size*** - The results suggest that past fires can be reconstructed with a moderate amount of resolution and that distinct patterns can be observed across the landscape. These data will allow patterns of fire size over the landscape to be explored and include variation by aspect and vegetation type. The fire size data will also provide baseline information for contemporary and future investigations being conducted in the drainage.

PLANS FOR 2000

Limited sampling will continue in the East Fork during 2000 mainly to fill gaps in the spatial network of sites not completed in past years. A particular target area includes lodgepole pine forests on the Hockett Plateau where previous sampling was limited. Additional samples may also be obtained from the Oriole Lake drainage and in the Coffeepot Canyon area. Crossdating of collected material will continue and should begin producing results about past fire regimes for individual vegetation classes.

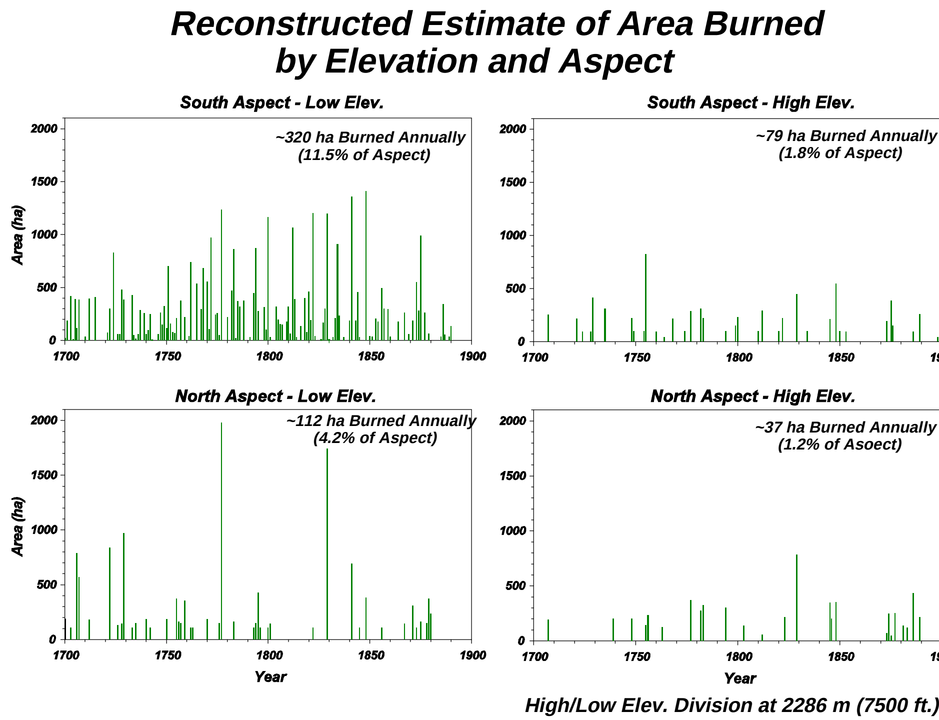


Figure 4.16-19. Reconstructed estimates of area burned annually in the drainage showing differences by aspect and elevation. The lower south aspect showed the greatest differences.

II - ASPECT SAMPLING

Objectives of the fire history aspect sampling are to (1) determine whether the differences in pre-Euroamerican settlement fire regimes on north and south aspects that have been detected in the East Fork "Watershed Fire-History Study" occur in other watersheds with similar aspect configurations and (2) if these differences exist whether the magnitude of the differences are similar to the those observed in the East Fork.

The sampling for this validation study is designed to be much less intense than the East Fork with only 3-4 sites collected on each aspect within a drainage. Obtaining this information and understanding potential differences among watersheds will eventually be incorporated into the FRID analysis and into fire management planning. Sampling procedures for individual sites were the same as described for the Mineral King Study above.

During 1999 aspect sampling was carried out in the South Fork (**Fig. 4.16-20**) and Marble Fork (**Fig. 4.16-21**) of the Kaweah River. Samples from two sites in the South Fork have been prepared and are in the process of being crossdated.

PLANS FOR 2000

In the South Fork up to two additional north aspect sites in the Garfield Grove area or along the old abandoned Devils Canyon Grove trail will be collected. In the Marble Fork two to three addition north and south aspect sites will also be located and sampled. Lastly, in Cedar Grove/Kings Canyon collections on north/south aspects sites are planned for the summer. Potential sampling locations include the Sheep Creek drainage on a north aspect and Lewis Creek drainage on the south aspect. Locating

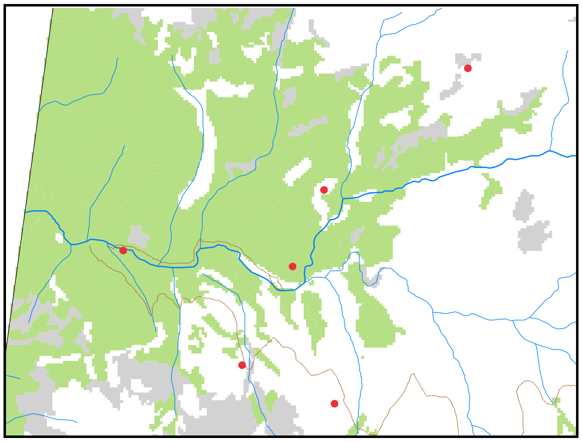


Figure 4.16-20. Sites sampled in the South Fork of the Kaweah drainage.

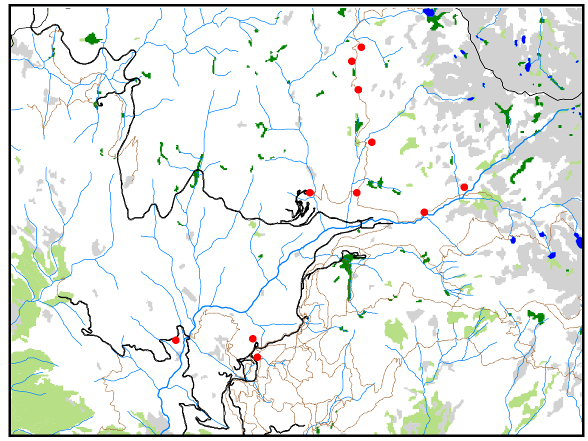


Figure 4.16-21. Sites collected in the Marble Fork drainage and in the Silliman Creek Flats area.

material at the latter area may be difficult due the number of recent burns that have occurred in the area.

III - SPECIAL PROJECTS

A) <u>Silliman Creek</u> - Questions have been raised about past fire frequency in the mixed lodgepole pine - fir forest found above Lodgepole and to the east of Silliman Creek.(Bancroft and Manley personal communication). The area is located on a bench north of Lodgepole composed of glacial til with a series of glacial moraine deposits incised by small drainages. The bench has a rolling surface with wet lowland areas currently dominated by lodgepole pine (***Pinus contorta*** - PICO) and fir (***Abies*** spp. - ***A. concolor*** - ABCO and ***A. magnifica*** - ABMA) with drier upland sites primarily dominated by fir. Current vegetation structure and composition suggest change in the vegetation over the last 100-150 years due to the absence of fire as an ecosystem process. In the lowland sites what appear to be post-fire suppression age fir have established in the understory and lower forest canopy and may eventually dominate these areas replacing the less shade-tolerant lodgepole pine (**Table 4.16-3**). Originally stands appear to have been more open with a greater dominance of PICO. Doghair thickets of ABMA mixed with some PICO now occur at many of the lowland locations (**Fig. 4.16-22**). Continuing change in the area without restoration of fire will probably produce drastic change in the fire regime as firs dominate and fuels increase.

Table 4.16-3. Stand composition of forest in the Silliman/Willow Meadow flats area based on data from three studies.

Study	Veg.Type	ABCO	ABMA	PICO	PIJE
	Values = Percent Cover				
Fire History	low	4.0%	44.9%	5.0%	2.1%
VanKat/Roy Plot	high	9.2	63.0	0	0
	Values = Number of Trees > 10cm DBH (% of stems by species)				
NRI plot 52	low		89* (52%)	11 (92%)	2 (100%)

* Original NRI data incorrectly identified these as white fir (ABCO).

During 1999 two sampling sites were located on the bench. Samples were collected form one of the bench sites with several additional reference sites sampled north of the bench (**Fig. 4.16-21**). Samples at this site possessed from one-to-four fire scars. Sample processing and crossdating of fire scars has not been completed. A second bench site with enough potential samples was located adjacent to Willow Meadow and will be sampled as a second replicate early in the summer of 2000.

B) **Cedar Grove** (1998) **-** During the fall of 1998 three fire history collections were made in Kings Canyon east of Cedar Grove. The valley contains a ponderosa dominated forest community that is unusual in the Parks which is experiencing colonization by the exotic and highly invasive annual grass ***Bromus tectorum*** (cheatgrass). The specific goal of the sampling is to provide more detail on past fire frequency and how it varied across throughout the valley. Warner (1980) sampled one site in the valley with the data showing very short fire intervals, in the order of three-to-four years between fires and the shortest recorded in the parks. However, although much of the valley is dominated by ponderosa pine forest there is considerable difference in site productivity within the valley with very strong gradients between these areas. Vegetation and productivity of sites located along lowland river terraces appear much greater than terraced upland locations such as the area known as the Gobi Desert (a large dry flat expanse east of Roads End). Site productivity appears to be associated with moisture availability in the highly permeable glacially deposited soils. Considerable differences in species composition and canopy cover exist by site and appears dependant on site productivity. Upland sites tend to be dominated by PIPO and lowland sites by ABCO (**Table 4.16-4** and **4.16-5**) although PIPO may have been more important historically. Because of these differences in site productivity fuel accumulations differ today and probably differed in the past. If fuel accumulation rates governed past fire occurrence (versus ignition source) then the drier upland terrace sites (such as Gobi Desert) should show longer fire return intervals than the lower river terraces. Baseline information about past fire regimes in the valley will be important in developing management strategies for dealing with the exotic cheatgrass.

The three sites collected were located just south of the housing area, in the Gobi Desert area, and immediately east of the footbridge across the Kings River Creek off the Bubbs Creek Trail (**Fig. 4.16-23**). Of note: the only fire history material available in the valley was found in areas that had not been

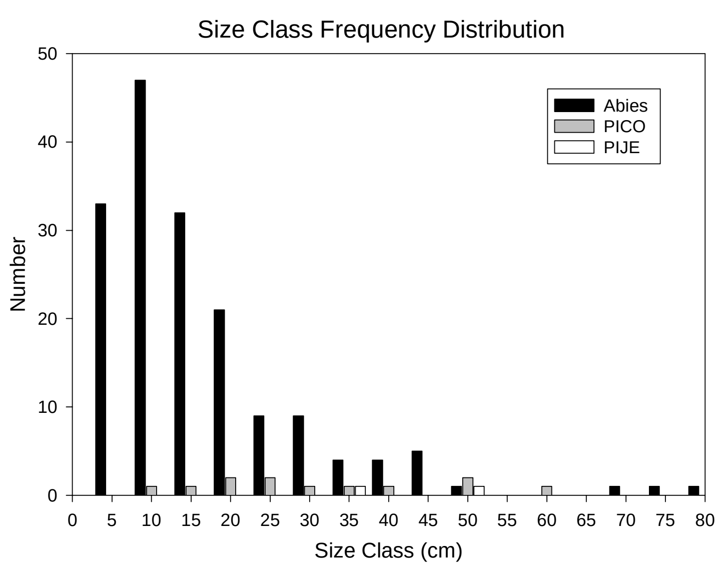


Figure 4.16-22. Size class distribution of trees in Silliman Creek Flats sampling area showing the dominance of small (young?) firs.

Table 4.16-4. Tree cover estimates for the three fire history sample sites.

Cover	Site 1	Site 2	Site 3
Tree	59.2	78.4	65.0
Herb	29.5	1.7	42.0
Shrub	39.5	0.3	13.0
Elevation	1409	1557	1568

Table 4.16-5. Relative cover of tree species at the three sites.

Rel. Cover (%)	Site 1	Site 2	Site 3
ABCO	0.3	50.1	0
PIPO	48.0	0.9	36.9
CADE	39.9	31.9	12.0
QUKE	11.8	13.7	24.6
QUCH	0	1.3	26.5

burned over the last 20 years. Fuel loads and condition of fire scarred trees from the pre-settlement period are such that the fire scar record is destroyed by any fires that occur. Thus the current samples will become an important historical record that document some attributes of past fire regime characteristics in the valley that would have been lost otherwise.

IV - PAPERS OR PRESENTATIONS BASED ON FIRE HISTORY SAMPLING

Pre-Twentieth Century Fire History of Sequoia and Kings Canyon National Parks: A Review and Evaluation of Our Knowledge. A.C. Caprio and P. Lineback. in press. In: Proceedings of the Conference on Fire in California Ecosystems: Integrating Ecology, Prevention, and Management. Nov. 17-20, 1997, San Diego, CA.

Fire Management and GIS: a Framework for Identifying and Prioritizing Fire Planning Needs. A.C. Caprio, C. Conover, M. Keifer, and P. Lineback. in press. In: Proceedings of the Conference on Fire in California Ecosystems: Integrating Ecology, Prevention, and Management. Nov. 17-20, 1997, San Diego, CA.

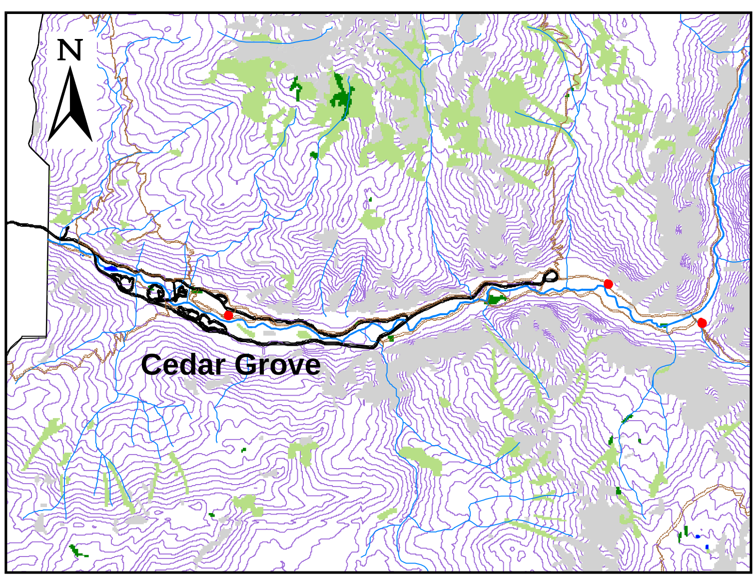


Figure 4.16-23. Sample site locations in Cedar Grove, Kings Canyon.

Returning Fire to the Mountains: Can We Successfully Restore the Ecological Role of Pre-Euroamerican Fire Regimes to the Sierra Nevada? A.C. Caprio and D.M. Graber. in press. 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.

Incorporating a GIS Model of Ecological Need into Fire Management Planning. M. Keifer, A.C. Caprio, P. Lineback, and K. Folger. in press. In: Proceedings of the Joint Fire Science Conference and Workshop, Crossing the Millennium: Integrating Spatial Technologies and Ecological Principles for a New Age in Fire Management, June 14-16, 1999, Boise, ID.

Temporal and Spatial Dynamics of Pre-Euroamerican Fire at a Watershed Scale, Sequoia and Kings Canyon National Parks. Anthony C. Caprio. Paper presented at: Conference on Fire Management: Emerging Policies and New Paradigms. Nov. 16-19, 1999, San Diego, CA.

REFERENCES

Bond, W.J. and B.W. van Wilgen. 1996. *Fire and Plants*. Chapman & Hall, London. 263 pp.

Caprio, A.C. and P. Lineback. (in press). Pre-Twentieth Century Fire History of Sequoia and Kings Canyon National Park: A Review and Evaluation of Our Knowledge. In: Conference Proceedings, Fire in California Ecosystems: Integrating Ecology, Prevention, and Management, November 17-20, 1997, San Diego, CA.

Caprio, A.C., C. Conover, M. Keifer, and P. Lineback. (in press). Fire management and GIS: a framework for identifying and prioritizing planning needs. In: Conference Proceedings, Fire in California Ecosystems: Integrating Ecology, Prevention, and Management, November 17-20, 1997, San Diego, CA.

Caprio, A.C. and D.M. Graber. (in prep). Returning fire to the mountains: can we successfully restore the ecological role of pre-Euroamerican fire regimes to the Sierra Nevada. In: D.N. Cole and S.F. McCool. *Proceedings: Wilderness Science in a Time of Change*. USDA, Forest Service, Rocky Mountain Research Station.

Caprio, A.C. and T.W. Swetnam. 1995. Historic fire regimes along an elevational gradient on the west slope of the Sierra Nevada, California. In: J.K. Brown, R.W. Mutch, C.W. Spoon, R.H. Wakimoto (tech. coord.). Proceedings: *Symposium on Fire in Wilderness and Park Management: Past Lessons and Future Opportunities, March 30-April 1, 1993, Missoula Montana*. USDA Forest Service, INT-GTR-320.

Davis, J.C. 1986. *Statistics and Data Analysis in Geology, Second Edition*. John Wiley and Sons, New York. 646 pp.

Dunne, T. and L.B. Leopold. 1978. *Water in Environmental Planning*. W.H. Freeman and Co., New York. 818 pp.

Kilgore, B.M. and D. Taylor. 1979. Fire history of a sequoia mixed-conifer forest. Ecology 60:129-142.

Miller, C. 1998. Forest pattern, surface fire regimes, and climate change in the Sierra Nevada, California. Ph.D. Dissertation, Colorado State University, 132 pp.

Muir, J. 1878. The new sequoia forests of California. Reprinted from ***Harper's*** in ***The Coniferous Forests and Big Trees of the Sierra Nevada*** in 1980 by OutBooks, Golden, Colorado. 40 pp

Pitcher, D. 1981. The ecological effects of fire on stand structure and fuel dynamics in red fire forests of Mineral King, Sequoia National Park, California. MS Thesis, UC Berkeley, 168 pp.

Pitcher, D. 1987. Fire History and Age Structure in Red Fir Forests of Sequoia National Park, California. Canadian Journal of Forest Research 17:582-587.

Stokes, M.A. 1980. The dendrochronology of fire history. pp. 1-3. In: M.A. Stokes and J.H. Dieterich. *Proceedings of the Fire History Workshop*. USDA Forest Service, GTR-RM-81, 142 pp.

Swetnam, T.W. 1993. Fire History and Climate Change in Giant Sequoia Groves. Science 262:885-889.

Swetnam, T.W., C.H. Baisan, A.C. Caprio, R. Touchan, and P.M. Brown. 1992. Tree-ring reconstruction of giant sequoia fire regimes. Final report to Sequoia, Kings Canyon and Yosemite National Parks, Laboratory of Tree-Ring Research, Tucson, AZ. 90 pp. + appendices.

Swetnam, T.W., C.H. Baisan, K. Morino, A.C. Caprio. 1998. Fire history along elevational transects in the Sierra Nevada, California. Final Report for Sierra Nevada Global Change Program to Biological Resources Division, USGS, Southern Sierra Research Station, Sequoia and Kings Canyon National Parks. 55p.

4.17) Repeat Photography Project - Sequoia Kings Canyon National Parks

- Monica Bueno, Jon Keeley, Nathan Stephenson, USGS, Western Ecological Research Center
Sequoia-Kings Canyon National Parks

FOCUS

This project attempts to reconstruct historical changes in southern Sierran plant communities over the past 125 years. The general study area for the repeat photography project encompasses foothill and forest plant communities from the Stanislaus River south to the Kern River. Although the project continues to comprise this large geographic area we have established three foci in order to better facilitate completion of a useable project in two field seasons. The focus projects are as follows:

Kings Canyon – Yosemite Valley Comparison

Several books and articles have been written about the vegetation changes that have occurred in Yosemite Valley since Euroamerican settlement. Repeat photography projects have made a convincing case that the Yosemite Valley floor is converting from low density forest with large open meadows to a more dense forest with meadow encroachment by coniferous species. Fire exclusion, among other factors, is the apparent cause of this change. We would like to determine if the same has occurred in the Kings Canyon area. Yosemite and Kings Canyon have similar geological as well as human histories and a comparison of vegetation change in the two areas could provide new information for management. The earliest photographs that we have found of the Kings Canyon and Tehipite Dome area are from 1875-1893. These photos are only about 15 years after Euroamericans first began making an impact in this part of the southern Sierra. The vegetation conditions shown in these photos may therefore be as close to pre-Euroamerican conditions as we are likely to determine from photographs.

Chaparral-Conifer Ecotone

The foothill regions of the southern Sierra have received less attention from plant ecologists than the Mixed Conifer ecosystems of the range. Fire suppression and climatic change may be altering chaparral vegetation. We will use photographs from the 1880s-1900 to determine if the chaparral/mixed conifer ecotone has shifted over the past 100-120 years. Mining, railroad and the Kaweah Colony photographs from these dates give

Figure 4.17-1. Repeat photos of Blossom Peak, Three Rivers, California. View from west in 1890 (left) and 2000 (right).

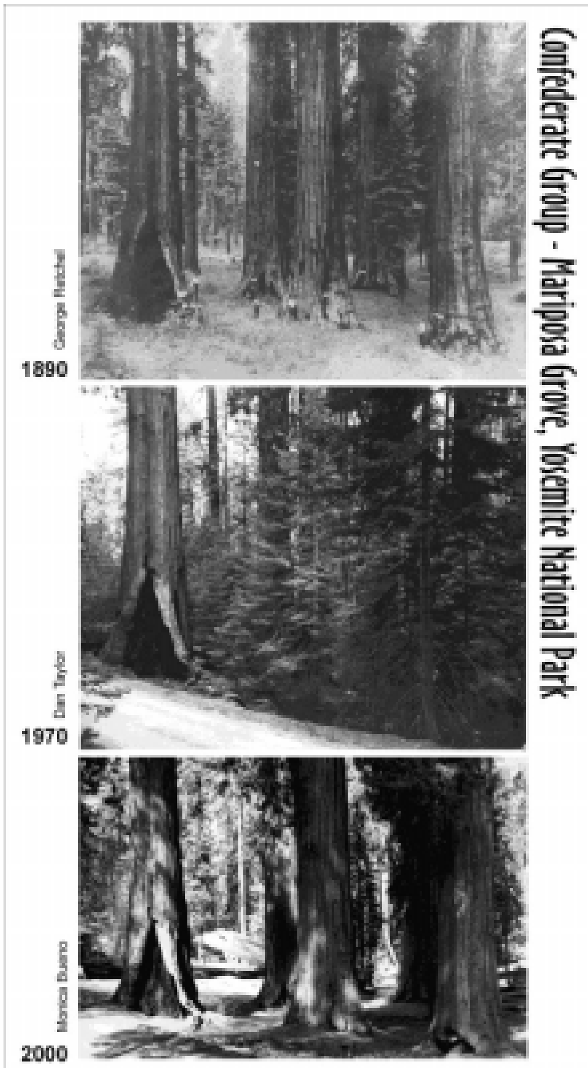


Figure 4.17-2. Repeat photo of Confederate Group in Mariposa Grove showing increased understory density in 1970 and reduced density by 2000 after mechanical and prescribed fire treatments.

clear views of foothill vegetation from areas west of Yosemite National Park to those west of Sequoia National Park . One photograph from a family album clearly shows the chaparral/pine ecotone near Mineral King taken in July 1900. A preliminary comparison of a photograph of Blossom Peak in Three Rivers, CA from 1889 and a photograph taken in November 1999 of the same view shows a type conversion from chaparral to grassland on the north-west slope of the mountain.

Big Trees Through the Ages

There is an abundance of photographs of the famous Big Trees of both Yosemite and Sequoia Kings Canyon. Due to the importance of Giant Sequoia Grove restoration we will use a sample of these photographs to determine understory, and vegetation conditions in general, around the Big Trees at the dawn of Euroamerican settlement. The earliest photographs are from 1860 of the Grizzly Giant in the Mariposa Grove of Yosemite National Park. The earliest photographs of the General Grant and General Sherman of Sequoia Kings Canyon National Parks are from the 1880s. Other photos of the Giant Forest and the Big Tree forests in Yosemite will also be used.

ARCHIVAL VISITS and PHOTOGRAPH PURCHASES

To date, approximately 80 photographs have been purchased for use in this project Finding old photos of Sequoia Kings Canyon National Park was facilitated by a card catalogue by John Vankat in 1970 which held information on all the known pre-1900 to 1910 photos of the Parks in public collections in 1970. This card catalogue has been entered into a Microsoft Access database and will be made available to future researchers.

Since October, Monica Bueno has visited many archives to view photo collections and make purchases. The archives visited include:

The Bancroft Library at UC Berkeley
The USGS photographic library in Denver, CO
The Oakland Museum of Art
The California Historical Society Archive
The Fresno City and County Historical Society Archive
The Tulare Historical Society Archive
The Tulare County History Museum
The Tulare County Free Library – California History Room
The Fresno County Free Library – California History Room
The California State Library – California History Room
The Yosemite National Park Archive
The Sequoia Kings Canyon National Park Archive

There are many more public collections to view but we are beginning to focus attention on private collections. Monica will pursue contacts for private collections throughout April and May and the remainder of the project.

Several relocations of original photo sites have been made in the Giant Forest and the foothills near the Kaweah Colony settlements. To properly match the original photo with a repeat photo the exact location of the original photographer is critical as is the season and time of day of the original. Relocation of the photographer's location is difficult for some photographs because of road and building construction or other severe changes to the area. We are working with archivists to find as much information about each photo so a proper repeat photograph will be taken.

SUMMER 2000 FIELD SEASON

Monica is currently in the process of preparing for the summer 2000 field season. Since most of the mixed-conifer forest photographs were taken in June, July and August, these will be the busiest months for field work (Foothill views appear to be from late fall and winter and will be relocated during those seasons). An SCA volunteer position was advertised in February and several applications have been received. A qualified volunteer will be chosen soon to accompany Monica during the summer field season. The focus areas for the summer will be Kings Canyon, the Tehipite Valley and the Giant Forest area. Mineral King and the Kearsarge Lakes area will also be visited as well as the Big Tree Groves of Yosemite.

4.18) Impact of Fire and Grazing on Diversity and Invasion in Sierran Forests

- Jon E. Keeley, Station Leader, USGS Biological Resources Division, Western Ecological Research Center, Sequoia-Kings Canyon Field Station

Disturbances that create a disequilibrium in distribution of resources may alter species composition through shifts in resource availability, which in turn may create conditions favoring invasion of non-native species and deletions of native species. Two important disturbance factors in the Western U.S. are grazing and fire and both have been linked to plant invasions.

Recent USGS research in the southern Sierra Nevada shows that grazing by different types of livestock (horses on NPS lands, cattle on BLM lands) in foothill woodlands alter species composition and distribution of plant functional types. However, these systems have already been so heavily invaded by non-native grasses and forbs that livestock grazing at low to moderate stocking densities is not tied to shifts in the native/non-native dominance.

This research program has concentrated a significant amount of attention on the role of fire in both ponderosa pine and mixed coniferous forests. Across these sites species richness is not immediately altered by fire but within the first three years, high fire-intensity patches exhibit highly significant increases in species richness. Concomitantly, these patches are also the ones most susceptible to invasive by non-native plant species.

In these Sierran ecosystems, the threat of invasives is most profound in the lower elevations and decreases with elevation. Part of the explanation for this pattern is the fact that the preponderance of invasives in this region are annual plants and this growth form declines in both species number and dominance with elevation. The lower elevation ponderosa pine forests are potentially most susceptible to new invasions and particularly troublesome is the apparently recent expansion of cheatgrass (*Bromus tectorum*) in these forests in Kings Canyon National Park. As is the case with species richness in general, the expansion of cheatgrass is strongly correlated with localized patch-level fire intensity. Because of this apparent relationship between fire and cheatgrass, prescribed burning has been temporarily halted in these forests. Early control of this apparent invasion is of concern to resource managers in these parks and a more detailed study of fire and other perturbations on cheatgrass invasion is currently being studied by USGS.

4.19) Develop a Landscape-Scale Framework for Interagency Wildland Fuels Management Planning

Principal Investigators:
Pat Lineback, GIS Coordinator, Sequoia and Kings Canyon National Parks
Dorothy Albright, Regional Fire GIS Coordinator, USDA Forest Service
Robin Marose, GIS Manager, Fire and Resource Assessment Program, California Department of Forestry
Bill Kaage, Fire Management Officer, Sequoia and Kings Canyon National Parks
Aaron Gelobter, Fire Management Officer, Sequoia National Forest
Mary Beth Keifer and Tony Caprio, Fire Ecologists, Sequoia and Kings Canyon National Parks

INTRODUCTION

This project is focused on developing and testing an approach to incorporate wildland fuels information management into an interagency, landscape-scale planning framework. The project area includes six major watersheds (Kaweah, Kern, Kings, Caliente, Mojave, and Tule watersheds) covering an area of about 4.7 million acres. A spatial and attribute information system is being created for coordinated fuels management planning within an integrated Geographic Information System (GIS) framework. The primary goals are to reduce fiscal costs to both government agencies and the public and to improve attainment of ecological and hazard reduction goals across jurisdictional boundaries. The project focuses on utilizing geographic information and related technologies including the Internet to overcome institutional and organizational barriers to interagency fuels management within very large, diverse ecosystems. The proposed framework will be both consistent and dynamic to meet the varied long-range ecological, fire hazard, and risk reduction goals of all impacted agencies. Common geographic data is being developed including comprehensive planning maps and analyses that prioritize areas for treatment based on value, hazard, and risk criteria. This framework will develop and test procedures to manage and update complex spatial information and to institutionalize the coordinated planning efforts. This is a funded two-year project by the Joint Fire Sciences Program.

PROJECT OBJECTIVES

- The project meets the requirements of the Joint Fire Sciences Program.
- Interagency GIS and information sharing in the Southern Sierra is effectively and efficiently managed.
- The most important seamless GIS data is developed, including development of compliant metadata.
- GIS data is readily accessible and available.
- Data utilization tools enhance and optimize use of data and analysis models.
- Appropriate analysis models have been defined, developed, and evaluated.

SUMMARY OF METHODS

A Cooperative Agreement will be developed and signed by all major stakeholder agencies – these agencies include: Sequoia and Kings Canyon National Parks, Sequoia National Forest, Bureau of Land Management – Bakersfield District, California Department of Forestry – Tulare Ranger Unit, and Kern County Fire Department. A project plan will be developed that describes specific goals and links specific tasks/strategies to achieve individual goals. The project plan will contain a detailed budget strategy for accomplishing individual goals.

A Web-based File Transfer Protocol (FTP) data clearinghouse will be established including deployment of host hardware/software at a designated clearinghouse location. A detailed long-term Web strategy will be developed and implemented. Project management strategies, including use of Internet technologies,

Southern Sierra Geographic Information Cooperative Area

Attachment A

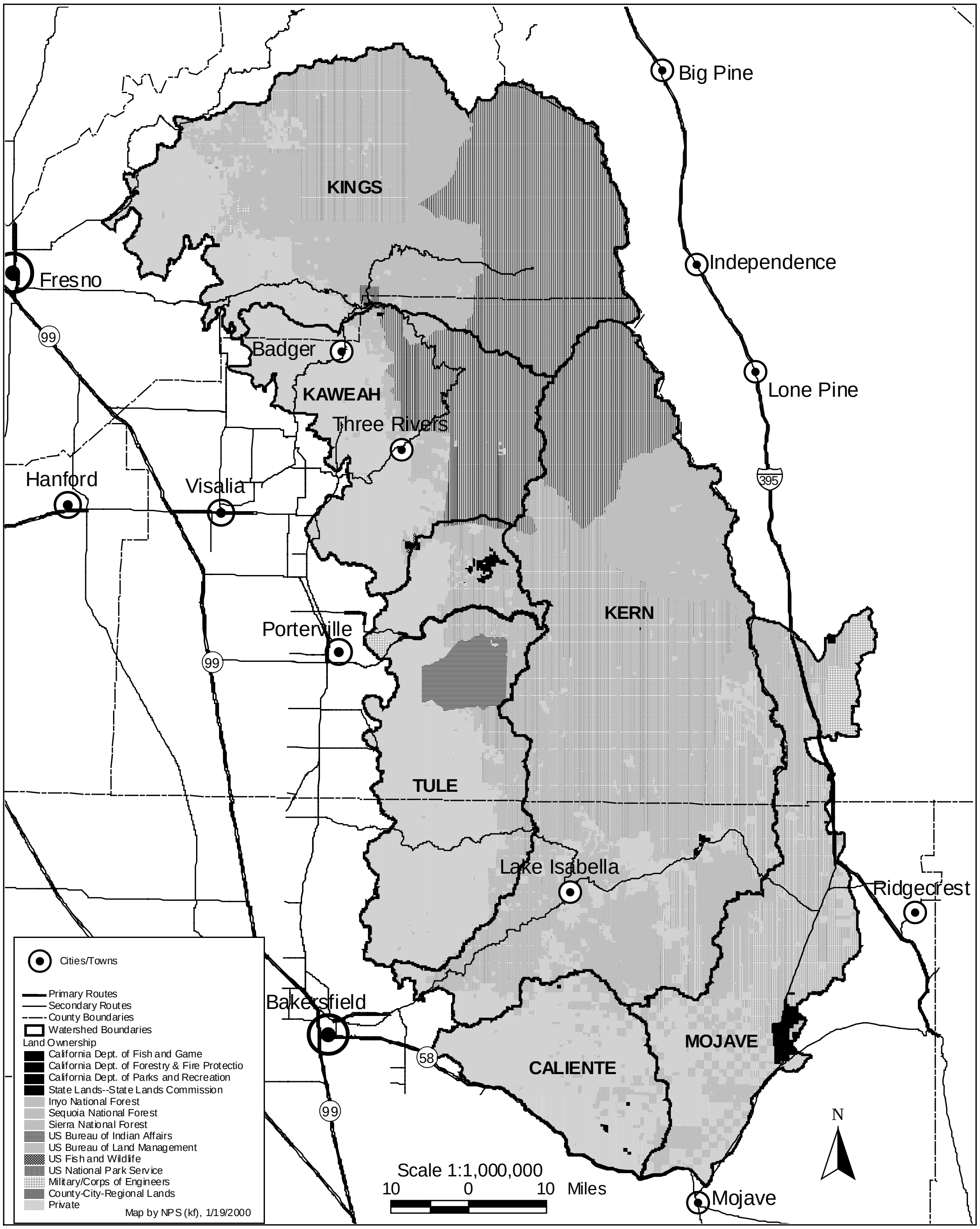


Figure 4.19-1. Southern Sierra GIS Study area.

will be evaluated and implemented in the most effective manner. Long-term business processes for optimizing interagency GIS coordination will be established by the end of the project.

Data development priorities will be established, prioritized, and developed. Federal Geographic Data Committee (FGDC) compliant metadata will be completed for all major data. Data utilization tools will be developed, as needed, to optimize use and management of data. Interagency GIS analysis models (e.g. Hazard, Value, and Risk) will be defined and implemented. Interagency Fuels Management Plans will be developed based on completed analysis.

WORK ACCOMPLISHED IN 1999

A project proposal was submitted and approved by the Joint Fire Sciences Committee with final funding authorization being completed near the end of FY1999. Only two kickoff interagency project planning meetings were completed in 1999; one was completed in October and another in December 1999.

PROBLEMS ENCOUNTERED

As anticipated, interagency coordination does require significant effort and commitment by agency stakeholders in order for this project to be successful. Coordinating activities and meetings is difficult and requires significantly more effort than traditional single agency meetings. It is not yet known how different agency missions will impact a consensus process and development of joint burn plans.

2000 WORKPLAN

The following projects will be either initiated or completed in 2000: a) Deploy FTP Data Clearinghouse, b) Develop data development priorities and initiate data development including hiring a term GIS Technician, c) Develop interagency analysis models and begin model development, d) Develop formal project plan and budget strategy, e) Write a Cooperative Agreement and all major stakeholder agencies sign agreement, f) Develop long-term Internet-Web strategies, and g) Develop a strategy for optimizing interagency business processes.

4.20) Vegetation Mapping Initiative

- Sylvia Haultain, Plant Ecologist, Science and Natural Resources Management, SEKI

Lead: S. Haultain (Project Coordinator)

INTRODUCTION

1999 marked the beginning of a multi-year initiative to classify and map the terrestrial vegetation of Sequoia and Kings Canyon National Parks. The need for a comprehensive, accurate vegetation map for resource planning, management and research has long been recognized by Park managers and cooperators. This is especially true for the fire management program, which relies on accurate vegetation mapping to drive predictive fuels models. In 1999, the national fire management program in Boise (Firepro) agreed to initiate the vegetation mapping effort with two years of funding, provided that the national Inventory and Monitoring program commit to funding the project in subsequent years. This agreement was reached, and in spring funds were transferred to the park to begin work.

PROJECT OBJECTIVES

Our goal is to develop a highly accurate vegetation map that meets scientific and Federal Geographic Data Committee (FGDC) standards, is based on a hierarchical classification scheme consistent with the National Vegetation Classification, and has a level of detail that is useful to park managers and cooperators. Using the USGS-NPS Vegetation Mapping Program as a model, the map layer will be based on 1:15,840 color infrared aerial photography, will rely on the national classification being developed by The Nature Conservancy (TNC) and Ecological Society of America (ESA), and will result in the generation of dynamic, digital products widely available on the world wide web.

SUMMARY OF METHODS

<u>Classification</u>

The development of a comprehensive vegetation classification is by nature an iterative process, with field sampling and polygon delineation informing the classification and vice versa throughout the course of the project. The classification forms the basis for describing vegetation types both on the ground and on remote images, providing a powerful tool for delineating and understanding types. At SEKI, the first full year of the project will be dedicated in large part to the development of an initial classification based on existing plot data (nearly 1000 plots are currently available for this effort) and a season of intensive field sampling to increase its robustness. Where data allow, types will be described and mapped to the association level. Where subcanopy data are lacking or precise photo interpretation is not possible, we will take the classification and the map to the alliance level. The resulting classification will be based on and fully integrated with the national classification being developed by TNC and ESA.

<u>Data acquisition</u>

Vegetation sampling
Plot-based vegetation data will be collected using the protocols developed for the USGS-NPS Vegetation Mapping Program by TNC. Fuels will be characterized on the vegetation plots according

to protocols developed in Yosemite as a part of their vegetation mapping effort. The GRADSECT approach (citation) will be used to stratify the landscape according to the primary environmental variables believed to drive the distribution of Sierran vegetation (e.g. substrate, topography, elevation). Sample locations will then be allocated to these landscape units based on the availability or lack of existing plot data, with those types already adequately represented receiving the lowest priority for additional fieldwork.

Aerial photography
Using a minimum mapping unit of 0.5 hectare, delineation of vegetation polygons will be based on 1:15,840 color infrared aerial photographs. A contract is already in place with Pacific Western Technologies of Albuquerque, New Mexico, to obtain these images during summer of 2000. Timing of the flights will be based on minimizing snow cover in the high country while maximizing sun angle to decrease shadow effects that can plague images of mountainous terrain. Delivery of the completed aerial photography will then lead to the implementation of a contract for photo-interpretation services in fall of 2000.

WORK ACCOMPLISHED IN 1999

A scoping meeting was held in June of 1999 at SEKI headquarters to develop a plan for the vegetation mapping initiative. Representatives from Firepro, the USGS-BRD National Vegetation Mapping program, adjacent land management agencies (USFS, CDF), TNC, BRD-Yosemite, Pt. Reyes, and CDFG joined local park and USGS-BRD personnel for a three day meeting to set goals and objectives, discuss alternatives, establish a working timeline and identify potential points of collaboration.

After lengthy discussion and deliberation both during and following the scoping session, we decided to use color infrared aerial photography as the basis for identifying vegetation polygons. Taking advantage of existing agreements in place through USGS and Bureau of Reclamation, a contract was obligated to Pacific Western Technologies for acquisition of imagery. Delays in the transfer of funds resulted in successive delays in the flights, which were originally scheduled for August of 1999. As it became apparent that flights completed in late September could result in data loss due to topographic shading and diminished IR signals as vegetation senesced, we decided to postpone the mission until summer of 2000. This contract also includes a provision for duplicate images of the East Fork Study Area in support of the Mineral King Landscape Assessment (Menning *et al.*, this document).

A site visit was made to Yosemite NP in August to meet with project collaborators and to observe the fieldwork in progress there. S. Haultain spent a week in the field with USGS-BRD YOSE biologists, TNC field crews, contract air photo interpreters, and state vegetation ecologist Todd Keeler-Wolf becoming familiar with the photo interpretation process, sampling protocols, and the development of the local classification.

Funds were obligated and a contract put in place to secure the collaboration of Dr. Todd Keeler-Wolf, CDFG vegetation ecologist, on the development of the SEKI vegetation classification and sampling strategy during FY2000.

Office supplies and equipment, field equipment, and other support materials were purchased in anticipation of the commencement of fieldwork in 2000.

PLANS FOR THE COMING YEAR

Plans for 2000 include:

- Development of a preliminary classification of the vegetation of SEKI using existing plot data (winter/spring)
- Development of a GRADSECT based sampling strategy (spring)
- Hiring of a term field leader and 2-3 seasonal field teams (spring)
- A full season of field sampling, focused on establishment of 100-200 vegetation plots (spring/summer) and collaboration with NWI field crews to maximize efficiency
- Acquisition of aerial photography (summer)
- Award of contract for photo interpretation (summer/fall)

4.21) Problem Evaluation and Recommendations: Invasive Cheatgrass (*Bromus tectorum*) in Cedar Grove, Kings Canyon National Park

- Anthony Caprio, Sylvia Haultain, MaryBeth Keifer, and Jeff Manley, Science and Natural Resources Division, Sequoia and Kings Canyon National Parks

THE PROBLEM

During the late summer of 1998 extensive areas (**Fig. 4.21-1** and **4.21-2**) of dense cheatgrass or downy chess (***Bromus tectorum*** L.) were reported in the Cedar Grove area of Kings Canyon (**Fig. 4.21-3**). Employees and repeat visitors had commented on the substantial increase in extent and density of cheatgrass during the El Niño winter of 1997/1998. Because of the highly invasive nature of this species and its documented expansion in relation to fire (Young and Evens 1973; Pellant 1990;Whisenant 1990; Billings 1994; Monsen 1994; Young and Allen 1997), there was immediate alarm about its presence and abundance. Park managers were concerned that burning these dense patches or nearby areas would provide more disturbance which would promote its success and spread as documented elsewhere. Autumn burning on the valley floor of Cedar Grove was suspended until an evaluation of the situation was conducted. A field survey to document distribution and density of the species was conducted in the fall of 1998 along with several other types of preliminary or background sampling.

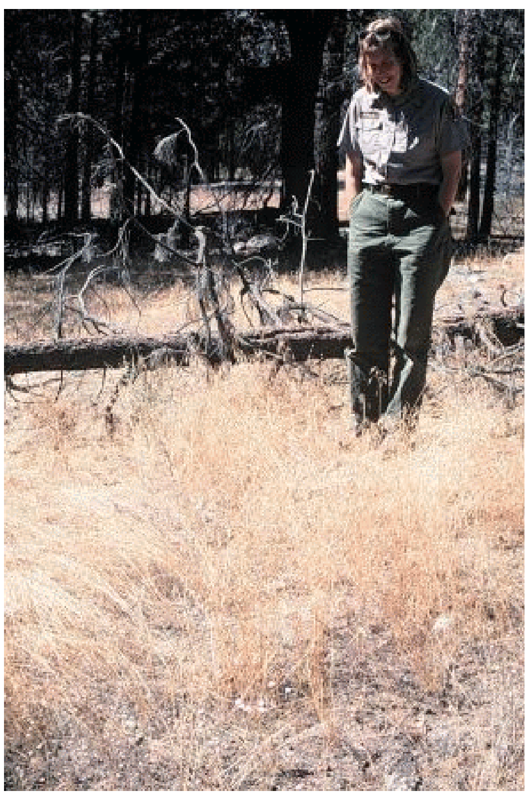


Figure 4.21-1. Moderately dense stand of cheatgrass near concession corrals (Oct. 1998).

Figure 4.21-2. Dense patch of cheatgrass in opening under dead pine in Roaring River area (Oct. 1998).

BACKGROUND

Bromus tectorum

Cedar Grove is a spectacular glacially carved valley occurring between about 1,450 m and 1,600 m in elevation. Climate of the area is strongly Mediterranean with considerable year-to-year variability in precipitation. Predominant vegetation on the valley floor is open ponderosa pine stands mixed with wet meadows and drier bunchgrass-dominated openings or manzanita shrubfields. Pine stands of this nature are very unusual in Sequoia and Kings Canyon National Parks and thus of significance. Fire suppression has resulted in changes in species composition and fuel load that are most apparent in the more productive forest stands on mesic benches along the
Kings River. An active fire restoration program has been carried out in the valley during the last 10 - 15 years with the majority of the valley floor having been burned at least once during this time and some areas several times (**Fig. 4.21-4**).

Cheatgrass has invaded and caused significant disruption of native plant communities in the Intermountain and Columbia River Basin Regions (Hulbert 1955; Billings 1994) where considerable research and management efforts have been undertaken over the last two-to-three decades (Young and Allen 1997). The species is highly invasive and can become dominant in nearly pure stands (**Fig. 4.21-5**) devoid of most native species (Morrow and Stahlman 1984; Whisenant 1990). Plant diversity declines in these communities along with associated resource values (Young and Evans 1978). In many instances communities are largely type-converted into simplified systems dominated by cheatgrass. The species is an aggressive and highly successful competitor with an array of features that contribute to its ability to dominate native species. Several case studies have documented impacts on rare and sensitive native species through direct or indirect competition (Rosentreter 1994). Degradation of native plant communities often occurs over an extended time, with sites initially occupied by scattered individuals of cheatgrass converted to pure stands through actions such as repeated

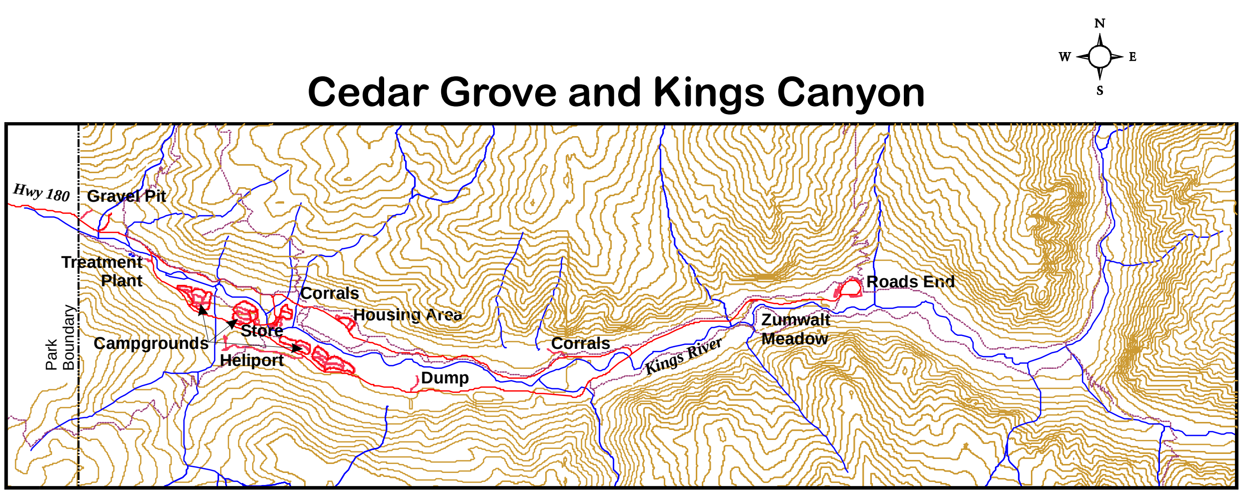


Figure 4.21-3. Overview of Cedar Grove area, Kings Canyon.

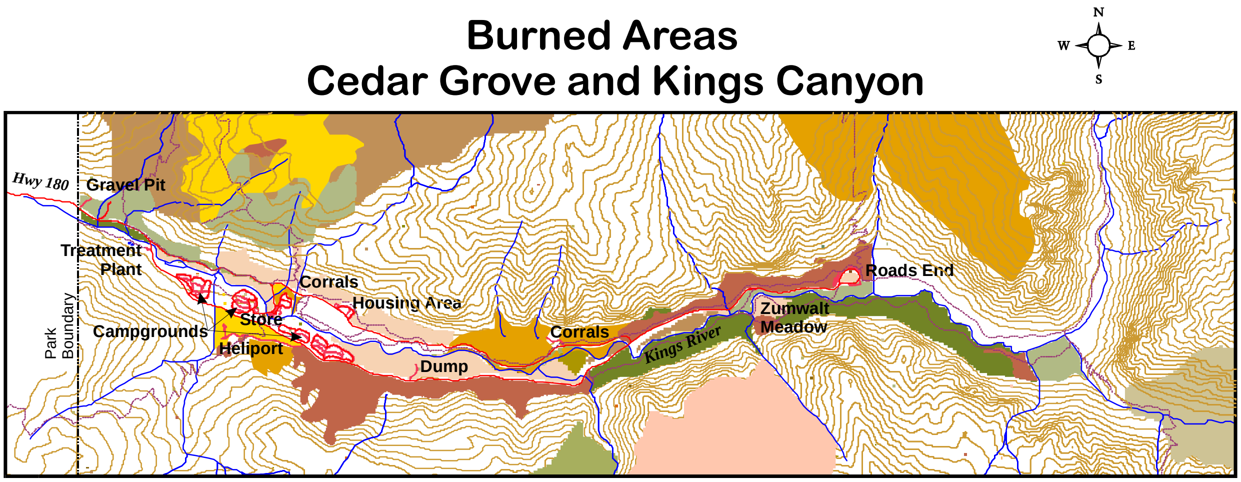


Figure 4.21-4. Burned areas (all fires back to 1970) in Cedar Grove area, Kings Canyon.

burning or grazing (Monsen 1994; Billings 1994).

Cheatgrass can also cause dramatic changes in fire regimes within a plant community. It is highly flammable and as its dominance increases the potential fire frequency in these communities increases, usually to the detriment of native species (Young and Evens 1973; Pellant 1990;Whisenant 1990; Billings 1994). Its dominance causes significant modification of ecosystem attributes by altering fuel load and fuel distribution, and changing extent and intensities of fire (Peters and Bunting 1994).

Cheatgrass is a winter annual with initial germination beginning at the start of fall rains and continuing into the winter or early spring (Mack and Pyke 1983). Germination usually occurs earlier than native species giving a competitive advantage (Frasier 1994) and growth can occur at lower temperatures than many native plants due to fructan metabolism (Chatterton 1994). Phenological growth characteristics, such as rapid root elongation and the ability to deplete soil moisture in dense stands, also provide competitive advantages (Melgoza, et al. 1990; Melgoza and Nowak 1991). Additionally, the species has an extremely plastic growth form permitting a few plants without competition to produce as many seeds as numerous plants under dense competitive conditions (Pyke and Novak 1994). Plants usually produce enough seed each year to repopulate a site, although abundance depends on annual climate variation (Monsen 1994). Reproduction of cheatgrass relies on a few large seeds (11 seeds/plant in one study) in a large number of plants and a concentrated seed drop (Larson and Sheley 1994). Some debate exists over longevity of seed banks and their importance in succeeding

Figure 4.21-5. Dense nearly pure stand of cheatgrass at photo point in Picnic Estates area (May 1999 - photo by Dave Ashe).

years, although 95 to 100% germination is reported for 11.5 year old seeds in one study (Billings 1994). Genetic plasticity of the species is also high, permitting rapid adaptation to local environments which has lead to difficulties in developing restoration measures applicable to wide areas (Novak and Mack 1993; Pyke and Novak 1994; Novak 1994).

Control measures for cheatgrass have met with varying degrees of success, with most being quite limited. In a few cases native species have recovered and reestablished dominance at a site when additional disturbance did not occur. A variety of control measures have been attempted including herbicides (Tanel et al. 1993; Ogg 1994; Whitson et al. 1997, Whitson and Koch 1998), grazing (Tausch et al. 1994), mechanical tillage (Mattise and Scholten 1994), biological using rhizobacteria (Mazzola et al. 1995; Skipper et al. 1996; Kennedy 1991, 1997) or competitive perennials (Whitson and Koch 1998), fire (many papers within Monsen and Kitchen 1994), and various combinations of these treatments. Some experiments in sagebrush communities suggest that prescribed burning will only decrease cheatgrass in the short run (Rasmussen 1994). Success in burns depends on species composition, fuel load, fuel condition, and weather. Other work indicates less success using fire to reduce cheatgrass (Hosten and West 1994), as occurred at Lava Beds N.P. (Steve Underwood, personal communication). It has been suggested (Kevin Rice, UC Davis) that burning at the point in time when plants have cured but prior to seed drop may reduce population density. However, since native bunchgrasses and other species may also be more susceptible to fire impact at this time fire frequency and timing of the burns over time would be critical.

PROBLEM ANALYSIS AND PRELIMINARY RESOURCE INVESTIGATIONS

Occurrence of Cheatgrass in Sequoia and Kings Canyon National Parks

In Sequoia and Kings Canyon National Parks cheatgrass is nearly always found at elevations above 900 m (Brent Johnson, BRD-USGS, personal communication) and not at lower elevations where diversity and density of other introduced winter annuals is high. Other species of ***Bromus***, such as ***B. hordeaceus*** L.**,**and ***B. diandrus*** Roth, form dense patches as part of the foothills annual grassland flora, along with ***B. madritensis*** L. ssp. ***rubens*** (L.) Husnot as a more scattered component (Sylvia Haultain, personal communication). Cheatgrass has been observed elsewhere in the Parks but not to the same extent and density as observed on the valley floor in Cedar Grove. In other areas of Kings Canyon small populations have been reported for tributaries to the Kings River, such as Roaring River (Dave Ashe, personal communication). In the East Fork of the Kaweah River it is common along the road at and above Lookout Point and uphill to about the Camp Conifer gate. Particular attention needs to be given to documenting any colonization of the Lookout Burn, ignited during October 1998, immediately above the Lookout Entrance Station (several fire effects plots are located in this area). In the 1996 NRI exotic plant survey cheatgrass was reported to be sparse and patchy along this road (Johnson et al. 1996) but was more continuous during 1998 (Caprio, personal observation). Additional small patches were also encountered on lower Paradise Ridge in the area of a 1970 burn (Caprio, personal observation 1998). The NRI survey also found populations at Camp Conifer and Redwood Creek in this drainage. In May 1999 it was observed growing off the Mineral King road shoulder forming patches in open areas of mixed black oak/chaparral in the 1995 Atwell burn (Caprio, personal observation). In the Middle Fork drainage the NRI exotics survey located substantial amounts of cheatgrass in the Bearpaw Meadow area. The report (Johnson and Whitmarsh 1996) states, "***B. tectorum*** *grew on many*

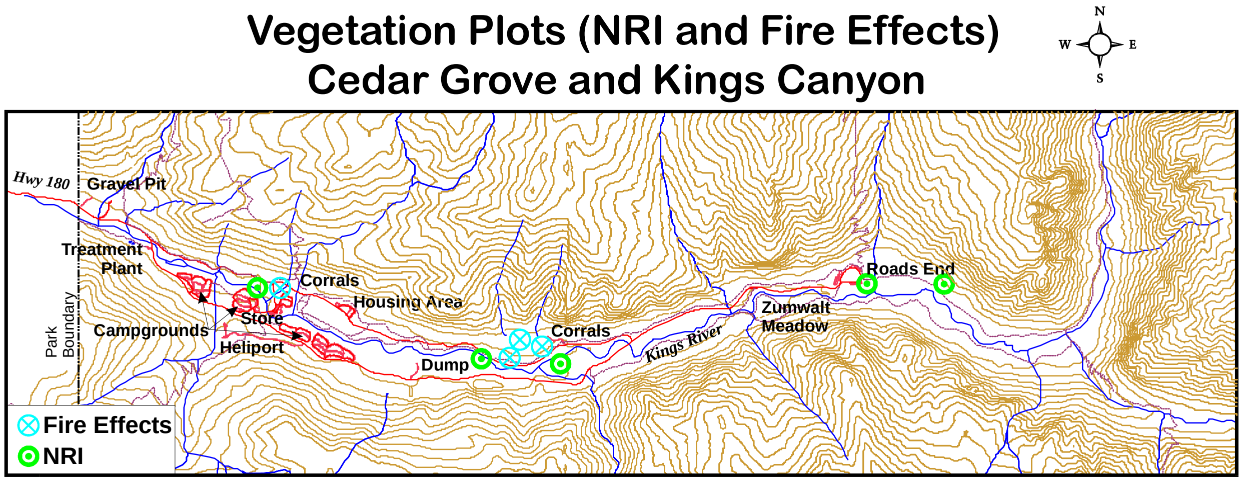


Figure 4.21-6. Vegetation plot (NRI and Fire Effects) locations in Cedar Grove area, Kings Canyon.

south-facing trail sides. We saw it ten meters and more off the trail in presumably undisturbed areas. Its densities were as high as twenty percent ground cover in some areas." The species was also found in Rattlesnake Creek above the Kern Canyon at elevations up to 2360 m although populations were not abundant and generally isolated (Johnson and Whitmarsh 1996).

Vegetation Plots

Fire effects (Keifer, NPS) and Natural Resource Inventory (NRI) (Johnson and Whitmarsh, BRD USGS) plots in Cedar Grove (**Fig. 4.21-6**) were resampled or recent data reviewed to determine whether they recorded past occurrence of cheatgrass and if an increase through time could be noted from this limited data source.

Four fire effects plots (**Table 4.21-1**) were re-read during 1998 (several unburned fire effects plots that exist in the area could not be used because they were installed before current sampling methods developed and information about cheatgrass cannot be extracted). Aggregate data from the four plots showed cheatgrass increasing from 0.15% cover pre-burn to 18% cover post-burn (Keifer and Dempsey, personal communication). Individually, two of the four plots showed increases in cheatgrass density and were responsible for the increase in the aggregate data. One of these increased 60% by two years post-burn but then dropped back to 25% by five years post-burn. In contrast, another plot showed little to no change. Results were qualified since some of the pre-burn and year one data for the herbaceous component on all plots appeared incomplete (it was not

Table 4.21-1. Vegetation plot identification and location.

Plot Type	Plot ID	utmE / utmN	Plot Type	Plot ID	utmE / utmN
NRI	157	$^{3}60$ / $^{40}73$	***Fire Effects***	89	$^{3}51^{229}$ / $^{40}73^{012}$
	156	$^{3}59$ / $^{40}73$		90	$^{3}54^{831}$ / $^{40}72^{226}$
	153	$^{3}55$ / $^{40}72$		91	$^{3}54^{5--}$ / $^{40}72^{3--}$
	158	$^{3}51$ / $^{40}73$		92	$^{3}54^{351}$ / $^{40}72^{044}$
	152	$^{3}54$ / $^{40}72$			

known whether some of the unknown grasses recorded when plots were censussed were cheatgrass or another species).

The data from the these plots indicate the increase in cheatgrass had already begun prior to the wet 1997/98 winter. For example, data taken in 1995, two-years post-burn, showed an increase in cheatgrass from pre-burn to one-year post-burn levels.

Five Natural Resource Inventory (NRI) plots (**Table 4.21-1**) were reread by BRD-USGS and NPS staff . One plot showed a small increase in cheatgrass, three showed no change post-burn. A qualitative observation from Sylvia Haultain, after an informal survey of the valley floor, was that the cheatgrass seems to have taken hold in open clearings that appear to have burned hot.

Trends from the NRI plots differed considerably from the fire monitoring plots. The fire effects plots were specifically set up in areas that were burned and are designed and monitored specifically to detect trends following fire. The type of data collected in NRI (Natural Resource Inventory) plots is different and in this case, does not always record quantitative change for a particular species. Additionally, sample size was very limited with one of the plots located in an area that has not burned with two of the others located in fairly moist areas with heavy forest cover (Brent Johnson felt that even with canopy removal cheatgrass would not readily establish at these sites because of soil or moisture conditions or competition from native species such as ***Pteridium***).

Soil Sampling

Soil sampling (Williams 1998) was conducted in Cedar Grove to determine if there was a relationship between K/Mg ratios and site susceptibility to cheatgrass invasion as found on the Colorado Plateau and California Deserts. At these sites K/Mg ratios have generally been found to be high (Jayne Belnap, personal communication). In Cedar Grove, eight sites (**Fig. 4.21-7**) were sampled with a single composite soil sample (derived from 30-60 individual auger samples) collected from each site. Samples were stratified into four groups (2 samples each):

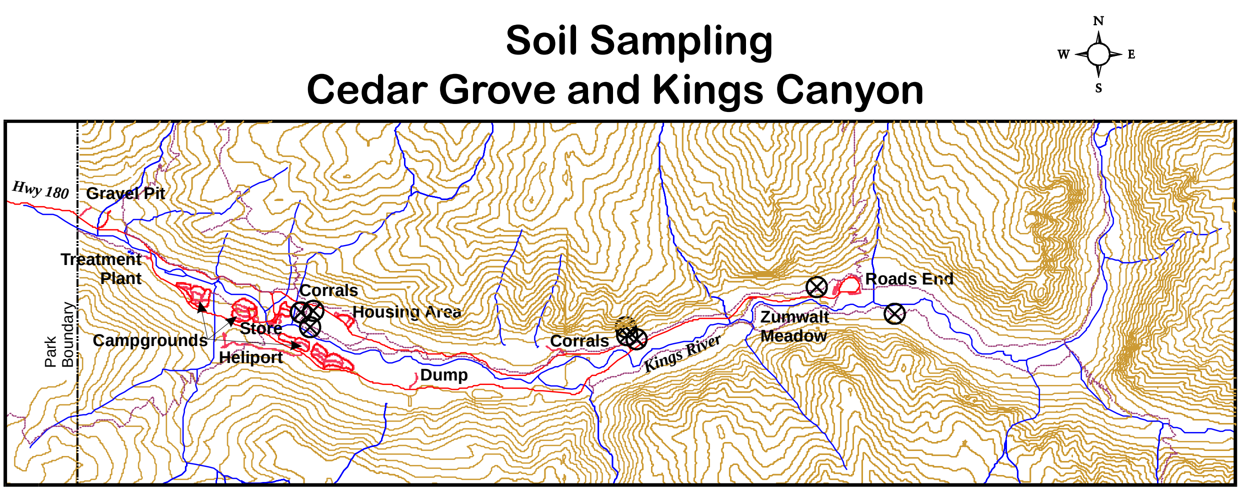


Figure 4.21-7. Soil sampling sites in Cedar Grove area, Kings Canyon.

1) Recently burned, with BRTE
2) Recently burned, without BRTE
3) Not burned recently, with BRTE
4) Not burned recently, without BRTE

Samples were sent to Jayne Belnap (NPS) in Moab for analysis. The results of the soil chemistry analysis were interesting and quite different from that expected (Jayne Belnap, personal communication). Unlike desert soils, K/Mg ratios were lower in areas where cheatgrass was located and higher at non-cheatgrass sites. However, she did not feel this was the explanation. The analysis also indicated significantly higher N levels (3x) in cheatgrass versus non-cheatgrass sites which she felt was a more probable cause. Additionally, there were no significant soil chemistry differences found between burned and unburned soils. These results suggested to her that cheatgrass occurrence is related to disturbance and high soil N levels. In other research on sagebrush grassland, soils with elevated N levels, were found to increase the density of annuals and lengthen the time the site is dominated by annuals (McLendon and Redente 1994). The high N levels were required to support the high biomass production of the annuals and allow them to dominate. However, among the annuals investigated, the authors also stressed that "***Bromus tectorum*** *has the potential for extending the dominance of annuals on semiarid disturbed sites longer than would be otherwise possible because of its low N requirements and early growth characteristics*".

Mapping Survey

On October 6-9, 1998 a field survey mapped the extent and density of cheatgrass occurrence in many susceptible areas in the valley. The objective was to identify the location and relative density of cheatgrass stands in Cedar Grove. The survey information was intended to be used to assess the locations of existing cheatgrass in relation to past burns, disturbances, its possible relationship with soil or vegetation types, and to provide some comparative documentation for future surveys.

The survey consisted of direct mapping of cheatgrass occurrence onto color infrared digital orthophotos (DOQ) generated by the park GIS Lab. The lab (Pat Lineback and Karen Folger)

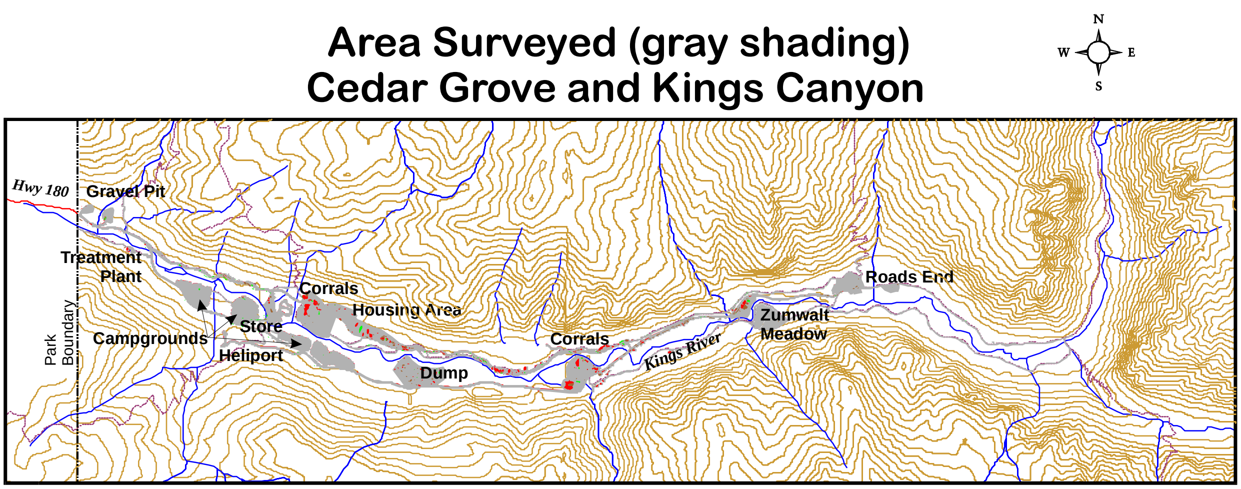


Figure 4.21-8. Area surveyed for cheatgrass occurrence (shaded gray) in Cedar Grove, Kings Canyon.

processed the photos to be consistent with the map projection (NAD27) of other park GIS data. The digital orthophotos of the survey area were produced at a 2,500:1 scale, and overlaid with road and trail information. Registration between the one meter orthophoto data and the USGS digital linear graph (DLG) road and trail data was imperfect, but useful. Ten to forty meter differences between the DLG overlay and occurrence of the same feature in the orthophoto data were evident.

An extensive survey of the much of the valley floor was conducted using the digital orthophoto maps, with individuals walking roads and trails and mapping cheatgrass occurrence (outline of patch) and density of patches (low, <10% cover; moderate, 10-50%; and high, >50%) visible from those corridors (**Fig. 4.21-8**). The only other attribute data collected for this extensive survey was relative density of patches. The survey concentrated on developed areas, stock trails, road corridors, and the Kanayers Loop out of Roads End to Bubbs Creek. Mapping along roads and trails allowed large areas to be mapped at a rapid pace. Several areas of high concentration, identified from roads and trails, were surveyed more intensively. All mapped cheatgrass patches were digitized and made available as an ArcView shapefile. Total area surveyed was also determined from field maps and by buffering areas visible from roads or trails (12.5 m and 10 m either side respectively).

Of the approximately 1,035 ha area of the Kings Canyon valley floor, -261 ha (-25% of possible

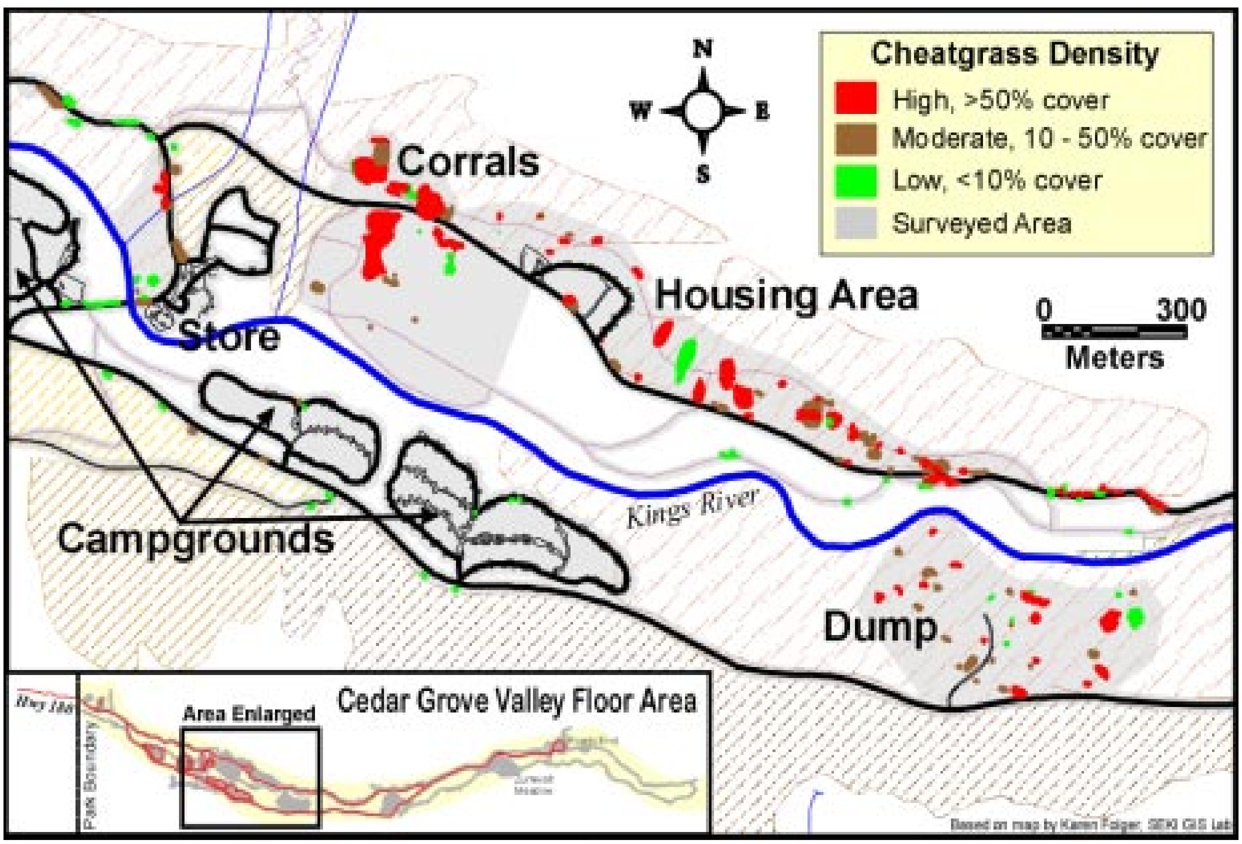


Figure 9. Surveyed areas (light gray shading) and cheatgrass density in Cedar Grove. Old manure dumping area is located south (across road) from corrals. Past burns are shown as diagonally hatched areas. Approximate valley floor area is shown in inset by light yellow shading. Trails are shown as dotted lines and roads as solid black lines.

area, light gray shaded areas **Fig. 4.21-8**) were surveyed with 0.9% covered by low density patches (<10% cover), 1.6% moderate density (10 - 50%), and 3.1% high density patches (>50%). Patches were almost always associated with some kind of disturbance such as fire, pack animals, mechanical, or water courses. Of these, the predominant disturbance appeared to be fire (**Fig. 4.21-4** and **4.21-9** - diagonally-hatched areas); however, not all burned areas had been invaded indicating confounding influences. The main areas of high density patches not associated with fire appeared to be associated with stock use and manure piles near the corrals. Additionally, of note was that little cheatgrass was found in campground areas. Although these areas are probably highly disturbed, the type and magnitude of disturbance may not facilitate cheatgrass invasion. Campgrounds tend to be extensively trampled and with compacted soils.

Picnic Estates Burn
In consultation with Jeff Manley, Dave Ashe burned three acres in the Picnic Estates area where one fire effects plot is located. Pre- and post-burn photos were taken by Dave from a permanently established photo point at this site (**Fig. 4.21-10**). This burn was to provide mostly qualitative data on the response of cheatgrass to burning during the summer. Due to the sparse fuels in some areas, burn intensities were not high in many areas, and a layer of unburned litter remained in places beneath a surface scorch of the top layer. Germination of cheatgrass was observed in the burn during the cheatgrass mapping survey in early October, 1998 (Anthony Caprio, personal observation). In early May 1999 observations by Dave Ashe (personal communication) suggested that cheatgrass in this area was smaller and not as mature as in non-burned areas.

Seed Banks
During the 1998 field survey surface soil and litter samples were collected from a variety of sites (**Fig. 4.21-11** and **Table 4.21-2**) to examine seed banks and potential germination and whether seed banks could be used as a means of monitoring the occurrence and density of the species. This approach has been used successfully in several studies (Billings 1994). Understanding seed bank dynamics is critical in developing long-term control methods if viable seeds are maintained in the soil over multiple years. Additionally, monitoring seed banks may be important if plant establishment is variable between years and thus not a reliable estimator of potential problems during any given year.

Results of the soil seed bank germination trial indicate that monitoring cheatgrass population densities is possible (**Figure 4.21-12**). There was a fairly strong association between adult plant density and seed bank as measured by seed germination, although there was some variation in the high category. Average germination density for the four adult plant density classes used in the mapping survey (low, <10% cover; moderate, 10-50%; high, >50%; and none) were: none=0.64 plants per sample, low=2.54, moderate=0 (only one location was sampled with this density), and high=32.17. The germination sample with the greatest seed density was obtained from the corral manure dump (141 seedlings in 237 cc of soil which is equivalent to about 594,000 seeds per cubic meter of soil).

Pack Station Manure Dump
In the fall of 1998 Jason DeNeau (1998) surveyed the extent of the manure dump at the Cedar Grove Pack Station where very high densities of cheatgrass is found. The historic dump site, 0.74

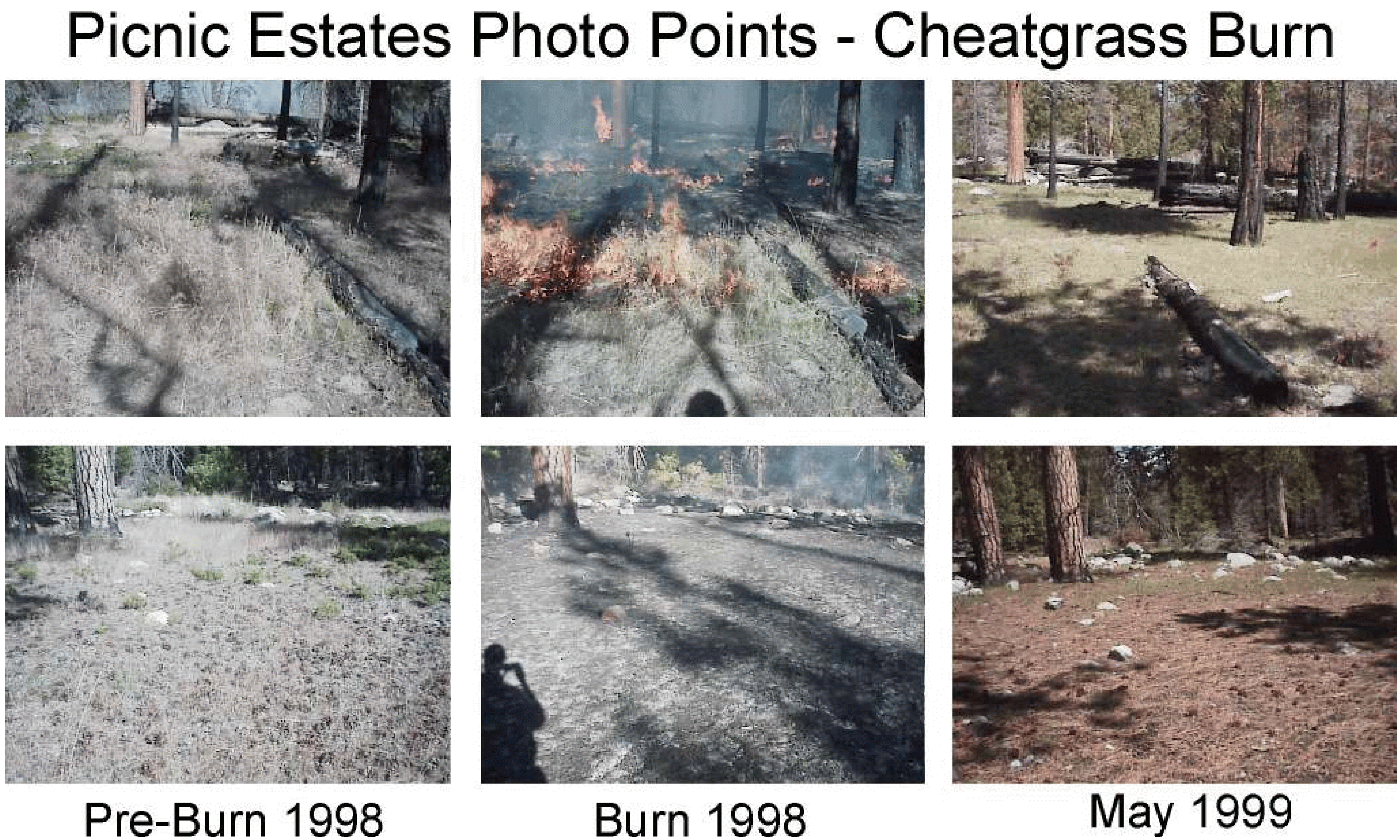


Figure 4.21-10. Repeat photography at two points showing occurrence and minimal change in cheatgrass density in burned area (photos by Dave Ashe).

Table 4.21-2. Location and description of soil seed bank samples.

Site Area Name	Plot Number	Utm E*	Utm N*	BRTE Density	Canopy
Roads End	0	358895	4073053	low	open
Roads End	2	359268	4073126	low	open
Roads End	3	359464	4073110	none	open
Roads End	4	359331	4073088	none	open
Roads End	5	359352	4073099	low	closed
Roaring River	6	355250	4072068	low	closed
Roaring River	7	355209	4071996	high	open
Roaring River	8	355200	4072076	low	open
Roaring River	9	355238	4072058	none	open
Zumwalt	10	357445	4073014	high	open
Zumwalt	11	357408	4072881	low	open
Zumwalt	12	357386	4072836	none	open
Zumwalt	13	357748	4072746	none	closed
Roads End Circle	14	358696	4073178	none	open
Hole in Wall Corral	26	354464	4072019	low	closed
Hole in Wall Corral	15	354464	4071969	high	open
Hole in Wall Corral	16	354592	4071966	mod	open
Hole in Wall Corral	17	354571	4071963	low	open
Manzanita Field	18	353479	4072262	low	open
Corral Manure Pile	19	351715	4072809	high	open
Corral Manure Pile	20	351711	4072819	none	closed
Corral Manure Pile	21	351801	4072798	low	open
Fire Effects Plot - Picnic Estates	22	351261	4072996	high	open
Fire Effects Plot - Picnic Estates	23	351291	4072963	unknown	open
Fire Effects Plot - Picnic Estates	24	351240	4073038	high	open
Fire Effects Plot - Picnic Estates	25	351224	4073007	unknown	open

* UTM coordinates are ± ~20 m.

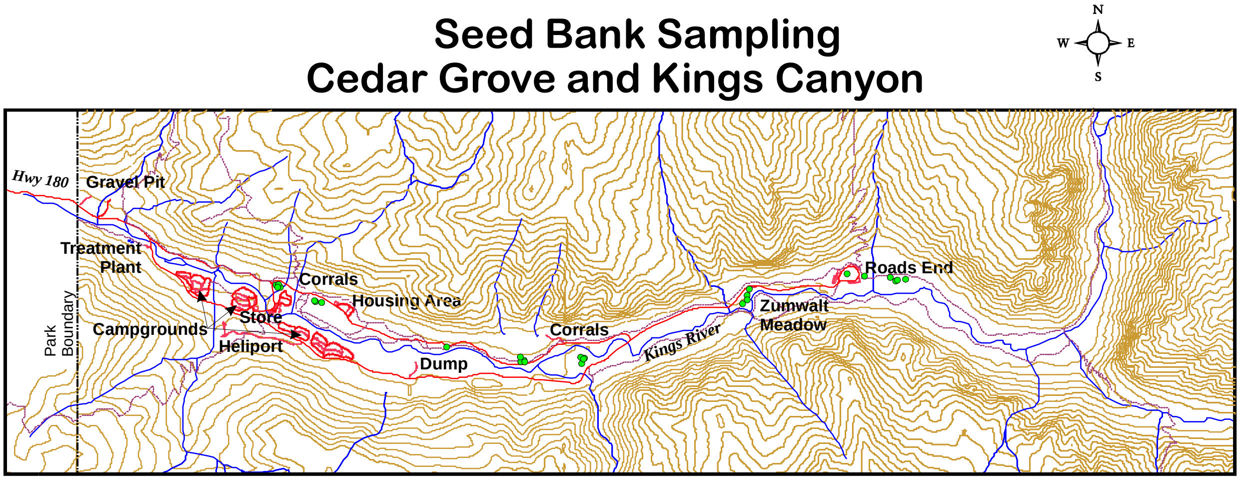


Figure 4.21-11. Soil seed bank sampling sites in Cedar Grove area, Kings Canyon.

ha in size and used for at least the last 18 years, has been identified as a significant cheatgrass seed source. DeNeau also reviewed the scientific literature for potential cheatgrass control measures that might be used to restore the dump site. Potential methods for control or eradication include:

- Physical removal
- Solarization
- Prescribed burning
- Chemical control
- Biological control
    - introduction of competitive perennial grasses
    - use of deleterious rhizobacteria

Cheatgrass Literature Search
A literature search of recent publications addressing cheatgrass management was contracted with Jason DeNeau. Concentration of the search was on articles referring to cheatgrass and fire and to cheatgrass and special management topics. This search was invaluable in providing up-to-date information on planning and for making recommendations.

Summary
The fall 1998 mapping survey documented the widespread occurrence of cheatgrass within Cedar Grove. Patches appeared to be associated with open areas and with disturbances, such as fire, pack animals, or mechanical. However, not all burned areas or sites with disturbance (campgrounds) have been invaded by cheatgrass. The current data collected from the various plots and the field survey mapping, combined with field observations suggests that cheatgrass on the valley floor of Kings Canyon tends to be limited to soils on drier well drained upland benches in contrast to moister areas along semi-perennial water courses (although it was observed in some ephemeral water courses). This was also noted by Brent Johnson during the NRI sampling. He felt that even opening the canopy of these lower wetter areas would not allow cheatgrass to invade (are relatively immune to cheatgrass invasion due to the moisture availability). Soil chemistry analysis points to

cheatgrass occurrence being related to disturbance and high soil N levels, although this needs further investigation, with a larger sample set and more extensive site descriptions and analysis.

RECOMMENDATIONS

Based on the limited data collected during 1998 and the available research literature, it appears likely that cheatgrass occurrence in Cedar Grove is at least partially associated with a combination of factors including: 1) high N concentration in soils, 2) soil disturbance, and 3) availability of a seed source. However, we want to stress that the current findings are still largely exploratory and were the result of sampling designed more to generate questions than to provide answers. Additional, more detailed field work is needed to provide thorough answers and verification of the current findings.

Of the three factors associated with cheatgrass occurrence, disturbance may be a result of any number of causes: fire, mechanical, stock, or water. High N in soils may be natural or artificial due to stock manure or other human sources. Seed source is probably due to vectors such as stock traffic and manure, human transport (vehicles or clothing), and possibly wildlife. At this time, we believe ***the most important consideration for reducing further spread of cheatgrass in the valley would be to minimize disturbances*** of any kind on the valley floor. However, it is not clear at this time what approach should be used to remove or reduce cheatgrass in areas where it has already become established.

A decision was reached to recommend limitations on burning on the valley floor in Cedar Grove (Maintenance and Hole-in-the-Wall Segments) during 1999 after examining these considerations. Our biggest obstacle to providing direction to burn operations is the lack of information about the basic biology of cheatgrass in this particular setting and how it might react or respond to various management actions. There is concern about two types of impacts. One is the direct resource impact caused by the occurrence of the species and the other is the more indirect but cascading impact of a curtailed or more limited burn program. However, because of the well documented association between cheatgrass expansion and fire we feel that caution needs to be exercised in the application of fire in the valley.

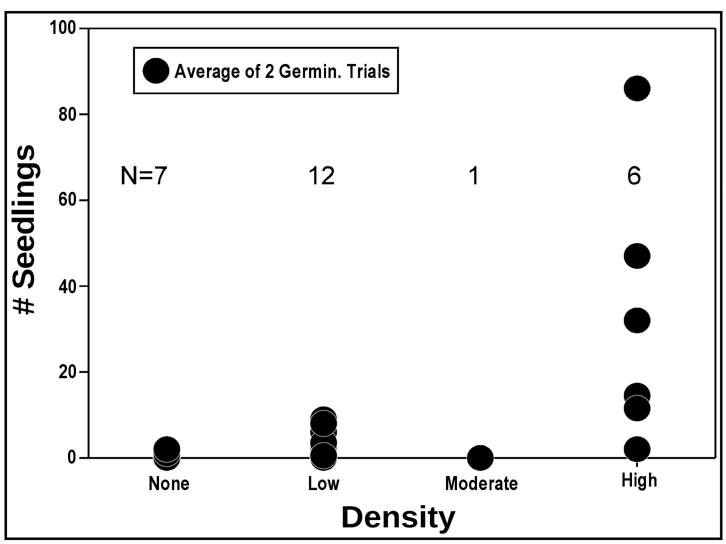


Figure 4.21-12. Soil seed bank germination results. Density categories correspond to values used in mapping survey (low, <10% cover; moderate, 10-50%; and high, >50%).

It is also important to address the issues surrounding manure disposal within the context of invasive weeds. The two-acre manure dump adjacent to the Cedar Grove Pack Station is likely a significant source of cheatgrass seed for the rest of the canyon. We recommend that action be taken to either treat or remove the accumulated manure from the corral site and the recently developed dumpsite (see Jason DeNeau's 1998 report re alternatives). In the long run, the issue of weed seed being brought into Cedar Grove through feed for both administrative and commercial pack stock must be evaluated. As weed free hay becomes available in California through the newly proposed certification program, requiring its use (or similar weed-free feed) in the park is strongly recommended. In the meantime, a proposal to have the manure from Cedar Grove trucked outside of the park is under preparation. Note that this is an imperfect solution, as it does not address the transport of weed seed by packstock as they travel into the backcountry after eating contaminated feed at frontcountry pack stations.

The literature on cheatgrass invasion and control also indicates that successful mitigation methods vary widely and are frequently site specific. For example, the strikingly different results from the soil chemistry analysis, when compared to desert areas, suggests that cause and responses of cheatgrass in the valley may be quite different from other more well studied locations. This highlights that care needs to be taken in extrapolating results to our area and that there is a need for more local studies to provide better information. It will be important to examine the relationship between cheatgrass and fire and other ecosystem components in Cedar Grove to provide information for long-term control or mitigation of the problem. Further, because this outbreak is occurring in a Mediterranean type climate regime, and most problems have been studied in the Intermountain and Columbia River Basin Regions, information from other regions may not apply or needs to be tested prior to broad application locally. Additionally, low background levels of cheatgrass have been observed in other areas of the park at low-to-mid elevations and any findings on mitigating the spread/impacts in Cedar Grove may have considerable value in managing this species in other locations. Lastly, because of the accessibility and layout of Cedar Grove, with good support facilities, it would be an ideal location for designing and carrying out experimental burning or other treatments. To follow are a number of suggested topics that may provide general guidance for further study.

1) <u>Document Changes in Spatial Distribution and Abundance</u>

Use field survey and GIS techniques to reassess extent and cover estimates of the species during 1999 to ascertain whether further increases in extent and cover occurred since the 1998 survey. Develop monitoring protocols and methods to assess future spread and occurrence of the species in the valley or in other areas of the parks. For example, sampling during 1999 should be carried out to provide an objective estimate of the distribution of cheatgrass on the valley. The objective of the survey would be a complete survey of the valley floor to document extent of cheatgrass occurrence with subsampling carried out to obtain quantitative data at large number of sites that could be revisited over time.

2) <u>Document and Analyze Relationship and Between Site Factors and Cheatgrass Abundance</u>

Carry out studies to examine whether a relationship exists between fire intensity, canopy scorch, soil N concentrations, or other factors and the present occurrence and density of cheatgrass. Examine the influence of other types of disturbance, especially stock corridors, and how these interact with fire. These efforts will provide quantitative information and insights on the relationship between fire and the occurrence of cheatgrass in the valley. These studies will require field surveys, GIS, and statistical analyses. Data could be partially provided by the subsampling carried out during the survey sampling.

3) <u>Mitigating Resource Impacts</u>

It is not known whether the current cheatgrass problem will expand in Cedar Grove or reoccur in other portions of the parks, but beginning to develop potential methods to deal with the immediate threat in Cedar Grove is critical. What is learned about mitigating the problem here may have direct application in other portions of the Parks and in other California parks. Control methods used could be those that have been applied elsewhere or developed specifically for this area. However, developing appropriate mitigation methods will require understanding the basic biological attributes of the species to help identify key points when these methods should be applied.

A) *Relationship to Fire* - The current occurrence and the potential spread of cheatgrass, not just in Cedar Grove but in other areas of the parks, could have significant impacts on the fire management program and the restoration of fire into key Sierran plant communities. Potential experimental burn treatments might include:

a) **season of burning**
b) **pattern of burning** - broadcast vs jackpotting
c) **combined treatments** - burning combined with native vegetation seeding or planting

B) *Relationship to Native Species* - What are the current and potential impacts on understory and overstory species? Are there ways to promote or restock natives so that they limit or out-compete cheatgrass? For example, would direct control of cheatgrass by physically removing individuals reduce its density and allow natural or artificial restocking of natives?

C) *Relationship to Soil Chemistry and Moisture* - The soil samples collected in 1998 have provided interesting preliminary data on differences in soil chemistry between areas with and without cheatgrass. They provide suggestions for further study and insight into the complexity of the problem. Additional soil sampling may be needed to further investigate the possible relationship between soil N concentrations and disturbance in order to better understand why some areas are more susceptible to high N levels and thus to cheatgrass invasion. For example, is the N/cheatgrass relationship actually cause and effect or simply correlative and what is the cause or source of the increased N in the soils? Is it due directly to mechanical disturbance and the loss of vegetation (St. John 1999) or to other factors such as release of N by burning, stock manure, atmospheric deposition of N from anthropomorphic sources, or a combination of these?

Several possible experiments have been suggested to test the N/cheatgrass relationship (Jayne Belnap, personal communication). One would be to add N to areas with low density or no cheatgrass and see if this results in a patch formation. Conversely, soil N could be reduced in current cheatgrass patch areas to determine if this reduces the cheatgrass density. This may be fairly easy to accomplish, as some experimental work suggests that adding organics to soils with high N content will reduce N concentrations temporarily through the immobilization of soluble nutrients in microbial biomass (St. Johns 1999). This temporary N reduction must be followed by the reintroduced and established of rapidly growing native species and an associated mycorrhizal host network in the soil to maintain the site.

Additionally, we should investigate the relationship between patterns of soil moisture across the valley which may also be important in understanding susceptibility of sites to colonization and success of cheatgrass. Considerable variation exists across the valley floor, from the moist lower benches located along the Kings River to much drier flats (such as the area locally known as the Gobi Desert) located away from the river.

D) *Life History Strategies and Population Dynamics* - Understanding basic population dynamics and life history strategies of this species in Cedar Grove could provide insight into strategic timing or points in the species life cycle when mitigation efforts are best applied. These attributes have been well described from the Intermountain and Columbia River Basin but are largely unknown from the Sierra Nevada where a distinctly different climate regime prevails.

a) **phenology** - Assessment of the relationship between synoptic weather patterns and cheatgrass phenology and response is needed to examine the potentially interacting effects of year-to-year moisture regimes on this invasive species. Dave Ashe has begun to implement basic monitoring of this type for 1999.

a) **life cycle** - What is the year-to-year variation in germination, establishment, and reproduction of the species? Are there certain “year types” related to climate variation or other factors when the species would respond better to control measures?

b) **seed banks** - Description of seed bank dynamics is vital to understanding cheatgrass life history (Pyke 1994). Important components include: long-term viability, germination fraction within and between years, spatial variability, and potential predators. Understanding seed bank dynamics is critical in long-term control if viable seeds are maintained in the soil for any length of time. Pyke (1994) lists several specific questions that should be addressed in order to design effective control measures.

- Do seeds persist in the soil or litter, and if they persist for how long?
- How quickly does the seed bank decline over a growing season (and between growing seasons)?
- Does dispersal occur immediately after maturation of seeds or are seeds dispersed over an extended period?

For example, in Cedar Grove the noticeable flush of cheatgrass during 1998, an El Niño year, may have been due to a residual seed bank built up over several years (a previous flush may have occurred during the 1982/84 El Niño event [Scott Williams, personal communication]).

REFERENCES

Billings, W.D. 1994. Ecological impacts of cheatgrass and resultant fire on ecosystems in the western Great Basin. pp. 22-30. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Bunting, S.C. 1994. Effects of fire on juniper woodland and ecosystems in the Great basin. pp. 53-55. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Chatterton, N.J. 1994. Fructan metabolism and cool-temperature growth in cheatgrass. pp. 333-336. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

DeNeau, J. 1998. Invasion of cheatgrass (***Bromus tectorum***) at the Cedar Grove Pack Station manure dump and potential alternatives for remediation. Report filed at Sequoia and Kings Canyon National Parks, SNRM. 14 pp.

Frasier, G.W. 1994. Establishment characteristics of cheatgrass under various wet-dry watering sequences. pp. 225-228. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Hosten, P.E. and N.E. West. 1994. Cheatgrass dynamics following wildfire on a sagebrush semidesert site in central Utah. pp. 56-62. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Hulbert, L.C. 1955. Ecological studies of ***Bromus tectorum*** and other annual brome grasses. Ecol. Monographs 25:181-213.

Kennedy, A.C. 1991. Rhizobacteria suppression to the weed downy brome. Soil Sci. Soc. Am. J. 55:722-727

Kennedy, A.C. 1997. ***Ecological Interactions and Biological Control***. pp. 164-175. Westview Press, Boulder, CO.

Larson, L.L. and R.L. Sheley. 1994. Ecological relationships between yellow starthistle and cheatgrass. pp. 92-94. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Mack, R.N. and D.A. Pyke. 1983. The demography of ***Bromus tectorum***: variation in time and space. J. Ecol. 71:69-93.

Marrow, L.A. and P.W. Stahlman. 1984. The history and distribution of downy brome (***Bromus tectorum***) in North America. Amer. Weed Sci. 32:2-6.

Mattise, S.N. and G.Scholten. 1994. Mechanical control of undesirable annulas on the Boise Front, Idaho. pp. 190-193. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Mazzola, M., P.W. Stahlman, and J.E. Leach. 1995. Application method affects the distribution and efficacy of rhizobacteria suppresive of downy brome (***Bromus tectorum***). Soil Biol. Biochem. 27:1271-1278.

McLendon, T. and E.F. Redente. 1994. Role of nitrogen availability in the transition from annual-dominated to perennial-dominated communities. pp. 352-362. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Melgoza, G. and R.S. Nowak. 1991. Competition between cheatgrass and two native species after fire: implications from observations and measurements of root distribution. J. Range Mgmt. 44:27-33

Melgoza, G., R.S. Nowak, and R.J. Tausch. 1990. Soil water exploitation after fire: competition between ***Bromus tectorum*** (cheatgrass) and two native species. Oecologia 83:7-13

Monsen, S.B. 1994. The competitive influence of cheatgrass (***Bromus tectorum***) on site restoration. pp. 43-49. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Novak, S.J. 1994. Quantitative variation within and among cheatgrass populations: the role of multiple introductions. pp. 103-108. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Novak, S.J. and R.N. Mack. 1993. Genetic variation in ***Bromus tectorum*** (Poaceae): comparison between native and introduced populations. Heredity 71:167-176.

Ogg, A.G. Jr. 1994. A review of the chemical control of downy brome. pp. 194-196. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Pellant, M., 1990. The cheatgrass-wildfire cycle– are there any solutions?. pp. 11-18. In: E.D. McArthur, E.M. Romney, S.D. Smith, and P.T. Tueller (comps.). ***Proceedings–Symposium on Cheatgrass Invasion, Shrub Die-Off and Other Aspects of Shrub Biology and Management. April 5-7, Las Vagas, NV.*** USDA For. Serv. INT-GTR-276.

Peters, E.F. and S.C. Bunting. 1994. Fire conditions pre- and postoccurrence of anual grasses on the Snake River Plain. pp. 31-36. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Pyke, D.A. 1994. Ecological significance of seed banks with special reference to alien annuals. pp. 197-201. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Pyke, D.A. and S.J. Novak. 1994. Cheatgrass demography–establishment attributes, recruitment, ecotypes, and genetic variability. pp. 12-21. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Rasmussen, G.A. 1994. Prescribed burning considerations in sagebrush anual grassland communities. pp. 69-70. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Rosentreter, R. 1994. Displacement of rare plants by exotic grasses. pp. 170-175. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Skipper, H.D., A.G. Ogg, Jr., and A.C. Kennedy. 1996. Root biology of grasses and ecology of rhizobacteria for biological control. Weed Technology 10:610-620.

St. John, T. 1999. Nitrate immobilization and the mycorrhizal network for the control of exotic ruderals. CalEPPC News, 4-5, 10-11.

Tanel, P.J., D.R. Gealy, and A.C. Kennedy. 1993. Inhibition of downy brome (***Bromus tectorum***) root growth by phytotoxin from ***Pseudomanas fluorescens*** strain D7. Weed Techology 7:134-139.

Tausch, R.J., R.S. Nowak, A.D. Bruner, and J. Smithson. 1994. Effects of simulated fall and early spring grazing on cheatgrass and perennial grass in western Nevada. pp. 113-119. In: S.B. Monsen and S.G. Kitchen (comps.). ***Proceedings–Ecology and Management of Anual Rangelands; May 18-21, 1992; Boise, ID.*** USDA For. Serv. INT-GTR-313.

Young, J.A. and F.L. Allen. 1997. Cheatgrass and range science: 1930-1950. J. Range Mgmt. 50:530-535.

Young, J.A. and R.A. Evans. 1973. Downy brome– intruder in the plant succession of big sagebrush communities in the Great Basin. J. Range Mgmt. 26:410-415.

Young, J.A. and R.A. Evans. 1978. Population dynamics after wildfires in sagebrush grasslands. J. Range Mgmt. 31:283-289.

Whisenant, S.G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. pp. 4-10. In: E.D. McArthur, E.M. Romney, S.D. Smith, and P.T. Tueller (comps.). ***Proceedings–Symposium on Cheatgrass Invasion, Shrub Die-Off and Other Aspects of Shrub Biology and Management. April 5-7, Las Vagas, NV.*** USDA For. Serv. INT-GTR-276.

Whitson, T.D., M.E. Majerus, R.D. hall, and J.D. Jenkins. 1997. Effects of herbicides on grass seed production and downy brome (***Bromus tectorum***). Weed Techology 11:644-648.

Whitson, T.D. and D.W. Koch. 1998. Control of downy brome (***Bromus tectorum***) with herbicides and perennial grass competition. Weed technology 12:391-396.

Williams, K. 1998. Soil sampling in Cedar Grove, Sequoia - Kings Canyon National Park for Bromus tectorum occurrence. Report on file at Fire Effects Office, SNRM Division, Ash Mountain, Sequoia and Kings Canyon Nat. Parks, CA. 5 pp.

4.22) Effect of early season burning on cheatgrass abundance and survivorship of native perennial associates in Cedar Grove, Kings Canyon National Parks—a pilot investigation

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INTRODUCTION

During the late summer of 1998, NPS resource managers became concerned about the apparent spread of cheatgrass (*Bromus tectorum* L.) following prescribed burning in the Cedar Grove Area of Kings Canyon National Park. Prescribed burns were suspended during 1998 and 1999 until information could be gathered on the potential of this highly invasive species to spread in response to fire-related disturbance. In the fall of 1998, preliminary surveys were conducted to assess the distribution and abundance of cheatgrass on the valley floor. As little work has been done on the role of disturbance and cheatgrass spread in a ponderosa pine community located on the west slope of the Sierra Nevada, efforts to obtain research funds were initiated. The pressing need for information coupled with a lack of funds to begin work led us to design the small and informal experiment discussed here. It is our hope that this pilot study will generate preliminary results to inform further investigations as well as any decisions regarding prescribed fire management in the area.

PROJECT OBJECTIVES

We chose to address two primary questions regarding early season burning and cheatgrass abundance in the westside ponderosa pine community of Cedar Grove. First, we would like to know if burning cheatgrass that has cured just prior to seed drop significantly reduces the seed bank (and thus cheatgrass abundance) during the following year. This leads to the second question, which is whether or not such early season burning has a negative effect on native perennial grasses. If early season burning can be used to manage cheatgrass levels without negatively impacting native associates, it may be possible to conduct fall burns intermittently between spring burns in an attempt to achieve fuel reduction goals while minimizing spread of cheatgrass.

SUMMARY OF METHODS

Pre-treatment sampling **-** To assess the effect of early season burning on cheatgrass abundance during the following year, we set up one pair of plots just east of the Cedar Grove Pack Station. We chose this site because 1) it was dominated by almost pure cheatgrass, allowing us to use dry weight of above-ground biomass as a response variable, and 2) it was already cleared for burning under an existing burn plan. A central transect was established between the two plots. Ocular estimates of relative cover of cheatgrass and any other associated dominant plant species were recorded in twenty randomly selected 25 x 25 cm quadrats located on either side of this transect. Above ground biomass was clipped and weighed from each quadrat before being returned to headquarters to determine water content.

To assess the effect of early season burning on survival of native perennial grasses, a second pair of plots was located on the north side of the motor nature trail, just east of the NPS housing area. A site was chosen with an even mix of cheatgrass and native perennials (***Eriogonum wrightii***, ***Lupinus*** sp., ***Stipa*** sp.)

and that was already included in an established burn plan. The two plots were divided by a central 25 m transect. At each one meter interval along the transect, the nearest individual of each of the three species of interest was tagged and assigned to a size class. Numbered aluminum tags were affixed to a pin flag placed to the west side of each plant; after species and size class data had been recorded, the flags were removed to decrease the visibility of the plot. Cheatgrass abundance was assessed by clipping biomass samples from 20 x 20 cm quadrats at two m intervals along the central transect. Each plot was photographed and georeferenced using the PLGR global positioning system.

***Treatment* -** Cedar Grove ranger staff carried out pre-treatment monitoring of cheatgrass seed set. In early June, when the cheatgrass had headed out and conditions were conducive to burning, crews ignited one of each of the pairs of plots. The burns were conducted in such a way as to destroy the cheatgrass prior to seed drop, using torches to ignite those areas that did not readily burn.

WORK ACCOMPLISHED IN 1999

Two pairs of plots were established in the Cedar Grove area according to the methods described above. One plot out of each pair was then burned during early June in an attempt to destroy the standing crop of cheatgrass seed.

PLANS FOR THE COMING YEAR

Both sites will be revisited during May of 2000 for re-evaluation. Cheatgrass abundance will be assessed in all four plots through clipping of above ground residual biomass, and survivorship of native perennials will be recorded from the second set of plots. The potential effects of early season burning on subsequent cheatgrass abundance and on survival of native perennials will then be evaluated. These preliminary results may then help guide further investigations into the role of early season burning in the Cedar Grove Area.

REFERENCES

Caprio, A. C. 1999. Problem evaluation and recommendations: Invasive cheatgrass (*Bromus tectorum* L.) in Cedar Grove, Kings Canyon National Park. Unpublished National Park Service file report, Division of Science and Natural Resources Management, Sequoia and Kings Canyon National Parks.

4.2 - Wildlife

4.21) **Wildlife Monitoring** - Science and Natural Resource Management, SEKI

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EXECUTIVE SUMMARY

Wildlife fire effects monitoring was initiated in the East Fork Kaweah River drainage as part of the Mineral King Risk Reduction Project. The monitoring focused on rodents because of the large number of species present, their specificity to habitat structure and composition, and their importance to the ecosystem. In 1999, the monitoring concentrated on two components: 1) permanent monitoring plots to document long-term changes in rodent populations at a few of the most widespread or important habitats, and 2) serendipity surveys to determine the species and relative abundance of rodents in a majority of the drainage's major habitats for drainage-wide evaluation of fire effects.

One-hectare plots were monitored in mature sequoia forest at Atwell Grove, in westside ponderosa pine forest, and in mixed chaparral. The 1,362 trapnights at the Atwell Plot produced 381 rodent captures. The postburn population estimate of 23 rodents in the late spring/early summer sampling and 37 rodents in the fall survey. The population estimate for both survey periods combined was fifty-nine percent less than the previous year, but it was ninety-three percent higher than the preburn population. The 1996-1998 postburn increase in rodents began to decline in 1999. Rodent diversity increased. Since monitoring began in 1995, the deer mouse (*Peromyscus maniculatus*) dominated the rodent population. In the fall of 1999, twenty-six percent of the individuals captured were lodgepole chipmunk (*Tamias speciosus*), a species that was not present during the preburn sampling. The arrival and success of lodgepole chipmunks (*T. speciosus*) is believed to be linked to the decrease in tree density from an estimated 362 trees/ha preburn to an estimated 158 trees/ha in 1999. Other rodents included a few captures of northern flying squirrels (*Glaucomys sabrinus*), long-tailed voles (*Microtus longicaudus*), and brush mice *(Peromyscus boylii*).

The 1,427 trapnights at the Ponderosa Plot produced 424 rodent captures with a average population estimate of 41 rodents for the survey period. This was forty-six percent higher than the preburn population estimate. After the plot burned in 1997, the species composition changed from a nearly equal balance between deer mice (*P. maniculatus*) and brush mice (*P. boylii*) to a population that is predominantly deer mice (*P. maniculatus*). Domination by deer mice (*P. maniculatus*) continued in 1999, and lodgepole chipmunks (*T. speciosus*) immigrated to the plot and comprised eighteen percent of the individuals monitored. As at the Atwell Plot, the arrival of lodgepole chipmunks (*T. speciosus*) is believed due to the reduction in tree density. There were two captures of Botta's pocket gopher (*Thomomys bottae*).

The Traugers plot in mixed chaparral was a preburn resample to evaluate changes since the last survey in 1995. The 713 trapnights, produced 245 rodent captures. The estimated population of 52 rodents was about twice as high as the previous survey, but the estimated rodent biomass, 2,633 gm, was nearly the same as the 1995 value (2,680 gm). The species present were nearly identical, but the relative abundance changed. A large portion of the large dusky-footed woodrats (*Neotoma fuscipes*) that dominated the plot in 1995 were replaced with mice that formerly were less abundant. These included brush mice (*P. boylii*), California mice (*P. californicus*), and pinyon mice (*P. truei*). The California pocket mouse (*Chaetodipus californicus*) was scarce in both 1995 and 1999. The California vole (*Microtus californicus*), which was rare in 1995, was not captured in 1999.

Serendipity sampling was done in the following environments: live oak near Redwood Creek, sagebrush, montane chaparral, subalpine prairie (formerly montane chaparral and sagebrush before it burned in 1994), red fir forest, subalpine meadow, lodgeple pine forest, and lodgepole pine forest that burned in 1994. Brush mice (*P. boylii*) dominated the live oak forest, and deer mice (*P. maniculatus*) dominated the remaining sites except for the subalpine meadow and the unburned lodgepole pine which was dominated by long-tailed voles (*M. longicaudus*). The burned lodgepole pine was codominated by deer mice (*P. maniculatus*) and long-tailed voles (*M. longicaudus*), and lodgepole chipmunks (*T. speciosus*) were present. A single specimen of montane vole (*Microtus montanus*) was captured in both the unburned lodgepole pine and in the subalpine meadow. A few brush mice (*P. boylii*) were found in the montane chaparral, but it was dominated by deer mice (*P. maniculatus*).

Serendipity trapping for medium-sized mammals occurred in a variety of vegetation types as an collateral activity to the rodent trapping. Ringtail (*Bassariscus astutus*) were captured in the hardwood-conifer forest (0.333 captures/trapnight) and live oak forest (0.250 captures/trapnight). Martin (*Martes americana*) were captured in sequoia forest (0.238 captures/trapnight), mixed conifer forest (0.182 captures/trapnight), and westside ponderosa pine forest (0.143 captures/trapnight). A black bear cub (*Ursus americanus*) was also captured in one of the traps in the sequoia forest. Two yellow-bellied marmots (*Marmota flaventris*) were captured in two nights of trapping in Jeffrey pine forest.

INTRODUCTION

This work was initiated to evaluate the effects of the Mineral King Risk Reduction Project (MKRRP) on selected fauna. There is considerable existing literature on fire effects on wildlife, and it demonstrates a broad range of responses from favorable to unfavorable for individual species. It is very likely that fire will cause changes in the small mammal community. To understand local responses, it is prudent to have local data under conditions typical of local burns. This report summarizes the fifth year of field surveys.

This work concentrated on small mammals for several reasons. a) First, the Mineral King area contains a relatively large number of sympatric native rodents. There are at least eleven species of rats and mice present. They range from generalists like *Peromyscus maniculatus* which occurs in a wide range of habitats and elevations to other species like *Chaetodipus californicus* which has much more specificity in its habitat requirements. b) Most rodents consume significant quantities of vegetation, and some are arboreal or otherwise dependent on plants for cover. This links them to floral composition and structure, two things that are normally affected by fire. c) Rodents do not have large home ranges. The species of rats and mice present in the East Fork Kaweah drainage typically have home ranges that are under 0.6 ha (Zeiner *et al.* 1990). Because the individuals do not roam far, rodent populations can be correlated to more discrete features of their environments than animals occupying larger areas. d) Rodents have short life histories with rapid development and maturation. Some of the species present in the MKRRP have been reported to be reproductive in about 50 days after birth, and most small mammals survive little more than a year in the wild (Orr 1976), some even less. Young disperse after being weaned. This all contributes to high potential for measurable adjustments to the rodent population structure as the habitat changes. e) Rodents are a major source of food for predatory birds, mammals, and reptiles. Rodent success or failure has a major influence on the success or failure of many larger animals. f) Finally, rodents are easy to trap, handle, and mark. It takes little time to become familiar with the local species, and there is an abundant literature on them. Until the recent discovery of hantavirus, their handling seemed to present little risk to the investigators.

Because fire can have significant effects to both the structure and vegetative composition of the habitat and because rodents present a diverse array of easy to handle respondents to habitat changes, they make good cost-effective, ecologically-significant animals for monitoring fire effects. Other major groups for which we would like to have local data, but which was not collected on this study for lack of resources include terrestrial amphibians, birds, and insects. Two of the these groups are represented by large numbers of species. Their documentation requires more observer skill, and larger plots are needed to monitor birds.

There are a number of smaller groups for which we have special interest. These include mountain beaver, forest carnivores (e.g. martin, fisher, ringtail, etc.), mule deer, bats, and brown-headed cowbirds. These represent a range of public and agency interests.

METHODS

Rodent populations were investigated from two perspectives: 1) long-term monitoring of select areas, and 2) serendipity surveys of the most common and unique habitats. The long-term monitoring is intended to document long-term changes in rodent populations and their habitat following fire under known conditions. Serendipity surveys inventory rodent species and their relative abundance within both common and unique environments to facilitate large-scale assessment of potential fire effects.

Three one-hectare permanent long-term monitoring plots were surveyed. The Atwell Plot was located in mature sequoia forest in Atwell Grove with plot center at UTM coordinates 4037147 northing and 349506 easting. The Ponderosa Plot was located in westside ponderosa pine forest with plot center at UTM coordinates 4035466 northing and 349415 easting. The Traugers Plot was located in mixed chaparral with plot center at UTM coordinates 4033776 northing and 344925 easting. Plot locations and elevations were determined with a Rockwell AN/PSN-11 PLGR geographic positioning system (GPS) on averaging mode. The plots are 75 m by 135 m (flat distance) with 6 mm diameter steel stakes marking the trapping grid at 15 m intervals. Each plot contains 60 trap stations with one Sherman live trap (Model LFATDG, 7.6 x 8.9 x 22.9 cm, except at the Traugers Plot where the crew used Model XLK, 7.6 x 9.5 x 30.5 cm) normally within one meter of each station stake. The traps were normally run four nights per week. The Atwell Plot was run 23 nights. This was directed into two trapping periods: thirteen nights in spring/summer (May 31, 1999 through June 29, 1999; 769 trapnights) and ten nights in the fall (September 20, 1999 through October 6, 1999; 593 trapnights). The Ponderosa Plot was run for a total of 24 nights from July 6, 1999 through August 19, 1999 (1,427 trapnights). The Traugers Plot was run for a total of 12 nights from October 12, 1999 through October 29, 1999 (713 trapnights). The traps were baited with a dry mixture of rolled oats and peanut butter. A high-low thermometer was located in each plot at a shady location about 1.5 m above the ground, and a rain gage was located nearby.

Captured rodents were marked with numbered self-piercing 1 monel ear tags (Style # 1005-1 from National Band and Tag Company). Captured rodents were ear tagged, and recorded information included tag number, species, sex, age (adult, subadult), weight, hind foot length, ear notch length, tail length, and general comments. The handlers wore respirators, rubber gloves, and eye protection for hantavirus protection (Mills *et al.* 1995).

Plot populations were estimated using a modified Jolly-Seber Method (Buckland 1980). Data was stored in dBase III$^+$ files.

Serendipity trapping for rodents was done in three areas in the Mineral King drainage: Near Redwood Creek, a live oak (*Quercus chrysolepis*) forest was surveyed for eight days (120 trapnights; UTM coordinates 4035400 northing, 347400 easting). Near the Monarch Lake/Sawtooth trailhead, the crew surveyed sagebrush for seven days (85 trapnights; UTM coordinates 4035300 northing, 356800 easting); for seven days, a subalpine prairie that was montane chaparral (*Arctostaphalus patula*) and sagebrush (*Artemisia* sp.) before it burned in 1994 (90 trapnights; UTM coordinates 4035400 northing, 357100 easting); and for seven days, montane chaparral dominated by *Arctostaphalus patula* (79 trapnights; UTM coordinates 4035700 northing, 357000 easting). On the Hockett Plateau, the crew surveyed lodgepole pine for five days (100 trapnights; UTM coordinates 4025800 northing, 351400 easting); for five days, lodgepole pine burned in 1994 (100 trapnights; UTM coordinates 4026600 northing, 351000 easting); for five days, red fir forest (66 trapnights; UTM coordinates 4026100 northing, 351200 easting); and for six days, a subalpine meadow (85 trapnights; UTM coordinates 4026600 northing, 351800 easting).

Sherman live traps were scattered loosely through these sites at approximately 15 m intervals (not measured). Serendipity surveys were conducted between July 21, 1999 and September 15, 1999 for a total of 725 trapnights in the Mineral King drainage. Catch per unit effort (captures/trapnight) was used as a measure of relative abundance among sites. An ink spot on the fur was used to recognize recaptures.

Serendipity surveys also included some trapping for medium-sized mammals (e.g. forest carnivores) using mid-sized Tomahawk traps baited with meat and covered with burlap bags. This sampling was done from June 2, 1999 through November 17, 1999. It amounted to 108 trapnights. This trapping included blue oak woodland (8 trapnights), chamise chaparral (4 trapnights), Jeffrey pine forest (2 trapnights), live oak forest (4 trapnights), lodgepole pine forest (7 trapnights), mixed chaparral (6 trapnights), mixed conifer forest (11 trapnights), mixed hardwood/conifer forest (9 trapnights), palustrine wetland forest (8 trapnights), red fir forest (3 trapnights), sequoia grove (21 trapnights; an additional 9 trapnights baited with fruit and lupine in an attempt to capture *Aplodontia rufa*), westside ponderosa pine forest (14 trapnights), and white fir forest (2 trapnights). Vegetation density was determined at the Atwell Plot using T-square procedures as described in Krebs (1989). The station stakes were used for random points making the procedure systematic. The same plots surveyed for density were used to characterize the species composition and size. Trees were measured at chest level. Only living stems >1 cm diameter at point measured were surveyed.

RESULTS AND DISCUSSION

Permanent Plots:

Atwell Plot: The Atwell Plot was located in a mature giant sequoia forest. The plot was burned on or about November 20, 1995. The plot's location, topography, preburn vegetation (trees only), preburn rodent population, and duff/litter consumption is described in Werner (1996). The postburn condition is described in Werner (1997). Since 1997, the herbaceous vegetation empiracally resembles the preburn condition.

Trees on the plot were estimated at 158 trees/ha (95% CI = 130 - 202). This is fifty-six percent less than the preburn density (Werner 1996). The mean basal area of trees surveyed increased fifty-three percent from 0.52 m^2 in 1995 to 0.80 m^2 in 1999. This is the type of change that would be anticipated since most of the observed postburn mortality was among the youngest trees. As a consequence of the burn, *Abies concolor* decreased numerically from eighty-three percent of the sample in 1995 to seventy-nine percent in 1966. *Sequoiadendron giganteum* increased from five to eight percent. *Pinus lambertina* remained at twelve percent, and *Calocedrus decurrens* was a new addition to the sample at slightly less than one percent. Though *S. gigantuem* was only eight percent of the individuals in the sample, their basal area accounted for fifty-five percent of the total. *Abies concolor* was very close in mass with forty-three percent of the basal area. *Pinus lambertina* only accounted for two percent of the basal area, and *C.*

decurrens was negligible at one-hundredth of a percent.

Twenty-three nights of trapping (1,362 trapnights) produced 381 rodent captures (100 different individuals) and eleven captures of non-rodents (*Sorex trowbridgii*). The mean population estimate for the Atwell Plot during the survey period was 23 individuals (95% CI = 20-25 individuals) during the late spring/early summer sampling. The mean population estimate during the fall sampling increased to 37 individuals (95% CI = 29-45 individuals).

Not only did the plot population increase significantly (P = 0.008) from late spring/early summer to fall , but domination of the rodent community became more diverse. In 1999, *P. maniculatus* comprised eighty-three percent of the individuals (94% of the captures) marked in the spring/summer, but only sixty-one percent of the individuals (65% of the captures) marked in the fall. This was not due to a decline in the *P. maniculatus* population, but due to an big increase in the population of *Tamias speciosus* from ten percent of the individuals (2% of the captures) in the spring/summer to twenty-six percent (23% of the captures) in the fall. Between the late spring/summer sampling and fall sampling, population estimates increased for both species. While *T. speciosus* more than doubled from only a few individuals ($\leq$4 individuals) to an average of nine individuals, the mean population estimate for *P. maniculatus* only increased twenty-nine percent from 21 to 27 individuals. While the two species probably compete for some of the same food resources, their periods of activity are separated by *P. maniculatus* being nocturnal and *T. speciosus* being diurnal. In twenty years of experience at Sequoia and Kings Canyon National Parks, I tend to associate my observations of *T. speciosus* with the less-dense portions of forests. The increase in *T. speciosus* may be attributable to the postburn loss of tree density from 362 trees/ha when the plot was burned to 158 trees/ha in 1999.

The other species sampled are summarized in **Table 4.21-1**. The most important information about the other species sampled is that *Microtus longicaudus* comprised seven percent of the individuals in the fall sampling. These were the most observations of this species since the plot was burned. This is similar to its abundance in the preburn sampling in 1995.

Table 4.21-1. Species composition of rodents captured at the Atwell Plot during 1999.

Species	Percent of Individuals	Percent of Captures
Late Spring/Early Summer Sampling		
Peromyscus maniculatus	83	94
Tamias speciosus	10	2
Glaucomys sabrinus	2	3
Microtus longicaudus	0	0
Peromyscus boylii		1
Fall Sampling		
Peromyscus maniculatus	61	65
Tamias speciosus	26	23
Glaucomys sabrinus	6	4
Microtus longicaudus	7	8
Peromyscus boylii	0	0

Rodent populations at the Atwell Plot were much lower than in 1998. While sampling in 1999 was done at a slightly different time of year, population estimates were much lower where survey dates overlapped (**Fig. 4.21-1**). Combining both 1999 sampling periods, the estimated rodent population at the Atwell Plot was fifty-nine percent less than in 1998. For the dominant species, *P. maniculatus*, the decrease was sixty-six percent. In spite of this decrease over last year, the rodent population estimate is still ninety-three percent higher than the preburn (1995) condition. The *P. maniculatus* population estimate in 1999 was forty-seven percent higher than the preburn condition.

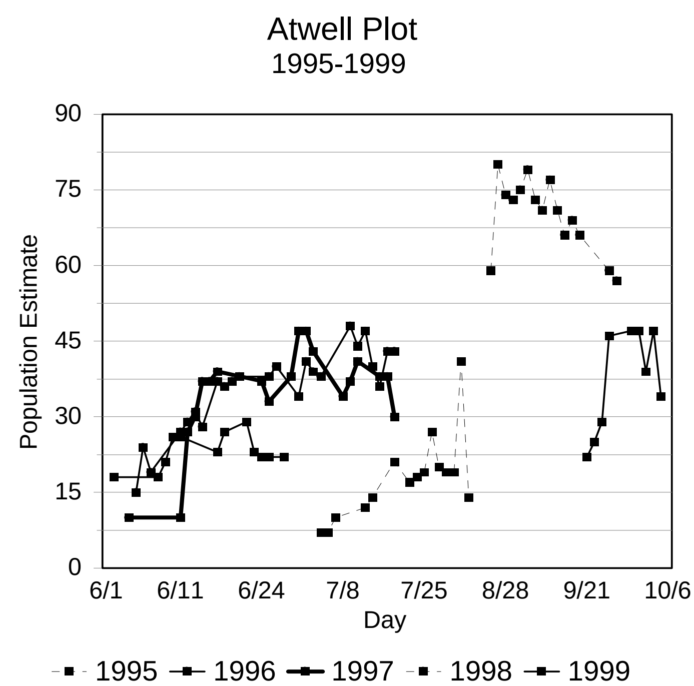

Figure 4.21-1. Population estimates at the Atwell Plot, 1995 (preburn) through 1999.

Catch rates for the five rodent species were 0.226, 0.041, 0.012, 0.009, and 0.001 captures/trapnight for *P. maniculatus*, *T. speciosus*, *M. longicaudus*, *G. sabrinus*, and *P. boylii*, respectively. The catch rate for *P. maniculatus* decreased from 0.593 captures/ trapnight in 1998 to 0.226 captures/ trapnight in 1999.

The sex ratio for *P. maniculatus* sampled was nearly equal for the individuals sampled (♀ = 58%, ♂ = 42%, n = 304). Sex ratios for other species included: *T. speciosus* (♀ = 51%, ♂ = 49%, n = 47), *M. longicaudus* (♀ = 19%, ♂ = 81%, n = 16), *G. sabrinus* (♀ = 75%, ♂ = 25%, n = 12), and *P. boylii* (♂ = 100%, n = 2).

Eighty-nine percent of the *P. maniculatus* captured were adults (n = 307). For the other species, the percent that were adult were: *T. speciosus* (100%, n = 54), *G. sabrinus* (100%, n = 12), *P. boylii* (50%, n = 2), and *M. longicaudus* (100%, n = 16).

<u>Ponderosa Plot:</u> The Ponderosa Plot was located in westside ponderosa forest. The plot was burned during the week of November 2, 1997. The plot's location, topography, preburn vegetation (trees and shrubs only), and the preburn rodent population are described in Werner (1997). In 1998, the vegetation was very different from the preburn condition. In 1998, the crew counted 24 live trees (Live is defined here as having green leaves in the preburn canopy.) in this plot which we estimated to have 1,456 trees and shrubs in 1996 (preburn; Werner 1997). Those live trees included 24 *Calocedrus decurrens*, 17 *Pinus ponderosa*, and eight *Quercus kelloggii*. Many of the oaks appeared to be regrowing from stump sprouts. The immediate postburn condition of the plot is described in Werner (1998). During the 1999 sampling period, the forest continued to look denuded except for the sprouts around the base of oaks and the twenty-four trees that retained green canopies. Much of the soil was covered by herbaceous vegetation and shrubs.

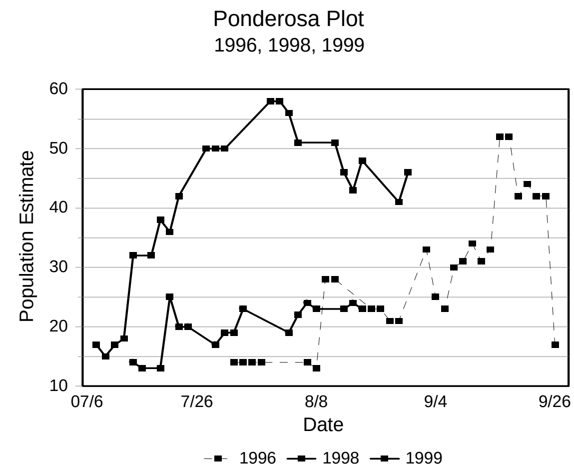

Figure 4.21-2. Population estimates at Ponderosa Plot, 1996 (preburn), 1998, and 1999.

Twenty-four nights of trapping (1,427 trapnights) produced 424 rodent captures (88 different individuals). The mean population estimate during the survey period was 41 individuals (95% CI = 35 - 47 individuals). This is over twice as high as the mean first-summer-postburn population estimate for 1997, and forty-six percent higher than the mean preburn population estimate in 1996. The slight difference in the preburn and initial postburn sampling may be a time-of-year effect (**Fig. 4.21-2**), but the rodent population clearly increased during the second summer after the burn (**Fig. 4.21-2**). This contrasts with the Atwell Plot which showed a similar increase during the first summer after it burned.

The immediate response observed at the Ponderosa Plot was the change in species composition. Prior to the burn, both *Peromyscus boylii* and *P. maniculatus* were codominant species. Since the burn, *P. maniculatus* has dominated the rodent community (80 % of the individuals in 1998 and 68 % in 1999). *Tamias speciosus* first appeared in 1999 and was a significant portion of the population representing eighteen percent of the individuals surveyed. This was also the first time that *Microtus longicaudus* was seen at the Ponderosa Plot. Only two specimens were captured (3 % of the individuals). Pocket gophers (*Thomomys* sp.) were captured in 1996, and two *Thomomys bottae* (3 % of the sample individuals) were captured in 1999.

Catch rates for the four rodent species were 0.797 captures/trapnight for *P. maniculatus,* 0.123 captures/trapnight for *T. speciosus*, 0.068 captures/trapnight for *P. boylii*, and 0.005 captures/trapnight for both *M. longicaudus* and *T. bottae*. There was one capture of a juvenile *Peromyscus* that was too young for identification to species.

The sex ratio for the sampled population of *P. maniculatus* was skewed strongly toward females (♀ = 67 %, ♂ = 33 %, n = 336). The sex ratio for the other species include: *P. boylii* (♀ = 63 %, ♂ = 37 %, n = 27), T. speciosus (♀ = 44 %, ♂ = 56 %, n = 34), and *M. longicaudus* (♀ = 100 %, n = 1).

Eighty-seven percent of the *P. maniculatus* captured were adults, nine percent were subadults, and four percent were juvenile (n = 333). For the other species surveyed, *P. boylii* was ninty-three percent adult (n = 28), and *T. speciosus* was fifty-nine percent adult (n = 27) with the balance for both species being subadults. Both *M. longicaudus* were adults.

<u>Traugers Plot:</u> The Traugers Plot was located in mixed chaparral. A description of the vegetation and topgraphy can be found in Werner (1996). This plot has not been burned since it was established in 1995. This sampling was done to update the preburn data and to assess comparability to the previous sampling. These data provide an indication of preburn variability. Empirically, the plot looked the same as in 1995.

Twelve nights of trapping (713 trapnights) produced 245 rodent captures (83 individuals). The mean population estimate for the Traugers Plot during the survey period was 52 individuals (95 % CI = 39 - 65 individuals). This was about twice as many individuals as when the plot was surveyed in 1995 (26 individuals; 95 % CI = 23 - 28 individuals). This difference was significant both when comparing each entire survey (P = 0.005) or only comparable dates (P = 0.012) for both years. Even though the rodent population doubled, the rodent biomass remained nearly identical (**Table 4.21-2**). This is because the large *Neotoma fuscipes* were replaced by more numerous but smaller rodents. Either this is coincidence, or it suggests that the most abundant rodents are competing for and limited by the same resources (especially food, though not necessarily the same foods). It also assumes that the sum of those resources and predation are relatively constant.

Table 4.21-2. Comparison of individual population estimates and rodent biomass at the Traugers Plot for surveys in 1995 and 1999.

Species	**1995 Surveys**			**1999 Surveys**		
	$\bar{x}$ Pop. Estimate	**$\bar{x}$ Wt. (gm)**	**Biomass (gm)**	**$\bar{x}$ Pop. Estimate**	**$\bar{x}$ Wt. (gm)**	**Biomass (gm)**
Neotoma fuscipes	16	154	2,464	9	158	1,422
Peromyscus boylii	1	25	25	23	24	552
Peromyscus californicus	3	41	123	14	36	504
Peromyscus truei	3	22	66	6	25	150
Microtus californicus	0.02	35	1	0	0	0
Chaetodipus californicus	0.05	21	1	0.2	24	5
Total			2,680			2,633

Capture success was much higher in 1999 than 1995 (**Table 4.21-3**). Two things are believed to have contributed to this. First, populations were twice as dense. With more individuals, one would expect more captures per trapnight. Second, the traps were more efficient for two reasons: 1) because the frequency of bears and other predators springing the traps was less in 1999 (4 % disturbed) compared to 1995 (6 % disturbed) and 2) because the longer traps used in 1999 seemed to largely prevent rats from stealing cotton or bait without getting caught. Trap disturbance and bait/cotton thievery were both big problems in 1995 and not in 1999. Though the species ratios have changed, the basic species composition has remained the same. The only species that did not appear in 1999 was *Microtus californicus*, and it was rare on the plot in 1995.

Table 4.21-3. Comparison of capture success at the Traugers Plot between 1995 and 1999.

Species	1995 Survey	1999 Survey
	Captures/ trapnight	Captures/ trapnight
Neotoma fuscipes	0.067	0.073
Peromyscus boylii	0.004	0.157
Peromyscus californicus	0.012	0.067
Peromyscus truei	0.009	0.042
Microtus californicus	0.002	0
Chaetodipus californicus	0.002	0.004

The sex ratio for the most abundant rodent sampled, *P. boylii,* was sym-metrical (♀ = 50 %, ♂ = 50%, n=110). Sex ratios for other species included: *N. fuscipes* (♀ = 54%, ♂ = 46%, n = 52), *P. californicus* (♀ = 73%, ♂ = 27%, n = 48), *P. truei* (♀ = 27%, ♂ = 73%, n = 30), and *C. californicus* (♀ = 33%, ♂ = 67%, n = 3).

Ninety-five percent of the *P. boylii* captured were adults and five percent were subadults (n = 111). For the other species surveyed, *P. californicus* was eighty-eight percent adult (n = 48), *P. truei* was completely adult (n = 30), *N. fuscipes* was ninety-six percent adult (n = 52), and *C. californicus* was entirely adult (n = 3). The balance of these last four species were subadults.

<u>Serendipity Surveys</u>:

<u>Rodents:</u> The results of serendipity surveys for rodents in the East Fork Kaweah drainage are summarized in **Table 4.21-4**. In addition, several non-rodents were captured. These included: two *Sorex trowbridgii* in Hockett Meadow and one in the lodgepole pine forest at Hockett; one *Pipilo chlorurus* in sagebrush at Mineral King, and one *Elgaria coerulea* in the subalpine prairie that was montane chaparral and sagebrush before it burned in 1994.

There were few surprises in the serendipity surveys. *Peromyscus boylii* was abundant in the dense stand of live oak (*Quercus chrysolepis*). This was expected since *P. boylii* is the most common mouse in another foothill forest type, black oak, that occurs at a similar elevation. Finding *P. boylii* in montane chaparral was a little surprising because of the elevation. However, in a previous year, a specimen was captured at a much higher elevation in a foxtail pine forest. In all of the high elevation sites, *Peromyscus maniculatus* was the dominant rodent except in lodgepole pine and subalpine meadow, where *Microtus longicaudus* dominated the rodent population. This is logical because lodgepole pine forest and the

Table 4.21-4. Serendipity trapping results in the East Fork Kaweah River drainage.

Site Description	Species Capture Rate (captures/trapnight)					
	PEMA	PEBO	MILO	MIMO	TASP	ALL
Redwood Creek, Live Oak (120 TN)		0.633				0.633
Mineral King, Sagebrush (85 TN)	0.318		0.012			0.329
Mineral King, Subalpine Grassy Prairie (90 TN)	0.344					0.344
Mineral King, Montane Chaparral (79 TN)	0.405	0.051				0.456
Hockett, Lodgepole Pine (100 TN)	0.050		0.290	0.010		0.350
Hockett, Lodgepole Pine burned 1994 (100 TN)	0.170		0.190		0.040	0.400
Hockett, Red Fir Forest (66 TN)	0.545		0.030			0.576
Hockett, Subalpine Meadow (85 TN)	0.012		0.035	0.012		0.059

PEMA = *Peromyscus maniculatus*, PEBO = *Peromyscus boylii*, MILO = *Microtus longicaudus*, MIMO = *Microtus montanus*, TASP = *Tamias speciosus*, TN = trapnight

meadow site are more mesic than the other high elevation sites sampled, and *M. longicaudus* is a species that shows a preference for moist areas. The capture data does indicate that recent fires may enable *P. maniculatus* to attain significant populations in some *M. longicaudus* habitat. Where the lodgepole pine forest was burned in 1994, *M. longicaudus* shared its domination with *Peromyscus maniculatus*. *Tamias speciosus* was also only captured in the lodgepole pine forest burned in 1994. This too is likely to be a fire effect since the same species now inhabits both the Atwell and Ponderosa Plots, and they were not observed in either plot prior to burning. The driest sites where *M. longicaudus* was observed were the sagebrush and the red fir forest. They were relatively rare at both sites and could have drifted in from nearby moist areas. The crew captured two specimens of *Microtus montanus* in the Hockett area. One was in the meadow, and the other was in a grassy area in the lodgepole pine forest. This was the first time that this species was encountered in any habitat sampled since this project began in 1995.

Mid-sized Mammals: The results of trapping mid-sized animals is summarized in **Table 4.21-5.** Sometimes traps catch animals that they were never intended to catch. The small Tomahawk traps that we use to catch medium-sized mammals were never intended to capture large carnivores like *Ursus americanus*, but one was in the trap on June 24, 1999. It was a cub, and it was released unharmed. As is typical, the *Bassariscus astutus* were found in the upper foothill environments and the *Martes americanus* were in the lower-elevation conifer habi-tats.

Table 4.21-5. Summary of serendipity trapping results for mid-sized mammals.

Site Description	Species Captures/Trapnight			
	BAAS	MAAM	MAFL	URAM
Hardwood-conifer Forest (9 TN)	0.333			
Jeffrey Pine Forest (2 TN)			1.000	
Live Oak Forest (4 TN)	0.250			
Mixed Conifer Forest (11 TN)		0.182		
Sequoia Forest (21 TN)		0.238		0.048
Westside Ponderosa Pine Forest (14 TN)		0.143		

BAAS = *Bassariscus astutus*, MAAM = *Martes americana*, MAFL = *Marmota*

The table only shows data for vegetation types in which trapping was successful. There was an additional nine trapnights in sequoia forest with the traps baited with lupine and fruit in an attempt to capture *Aplodontia rufa.* The effort was unsuccessful. Other unsuccessful trapping effort included: white fir forest (2 trapnights), lodgepole pine forest (7 trapnights), palustrine wetland forest (8 trapnights), red fir forest (3 trapnights), chamise chaparral (4 trapnights), mixed chaparral (6 trapnights), and blue oak woodland (8 trapnights).

Additionally, a new colonies of *Aplodontia rufa* were located in the upper portion of Squirrel Creek (Caprio personal communication) expanding the range of this species into the Oriole Lake drainage and in a tributary of Deer Creek near Tar Gap (just above the Tar Gap Trail) (Manley personal communication) (**Fig. 4.21-3**)

PLANS FOR 2000

1. Conduct postburn survey of the Atwell and Ponderosa Plots.
2. Depending on when the Traugers Plot is likely to burn, conduct preburn and immediate postburn sampling.
3. Conduct serendipity surveys in Sierra juniper and other high-elevation sites.
4. Continue development of guide to wildlife fire environments.
5. Continue postburn sampling of the Kaweah Fire if time permits.

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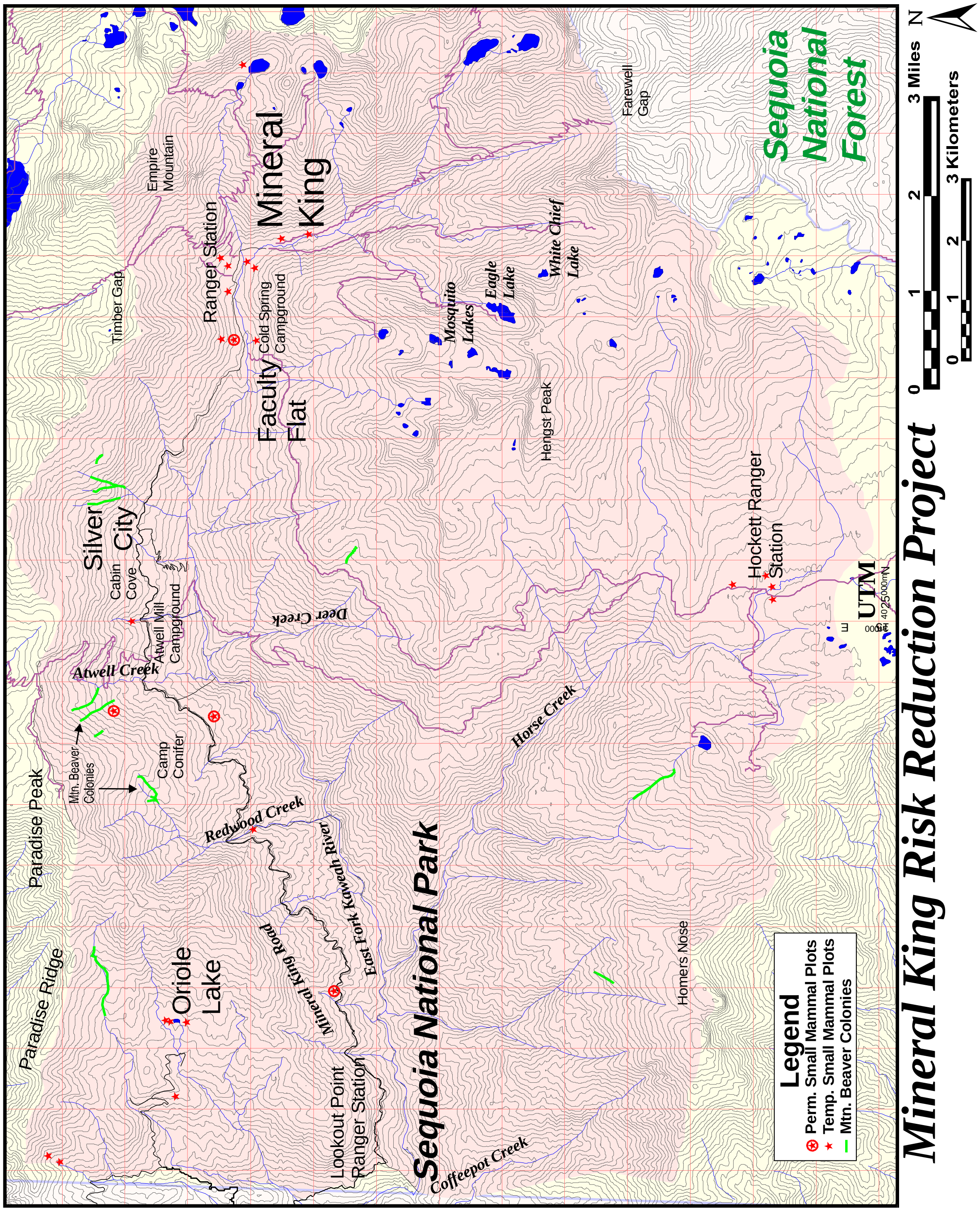

Figure 4.21-3. Locations where wildlife was sampled and riparian areas where mountain beaver have been found.

LITERATURE CITED

Buckland, S. T. 1980. A modified analysis of the Jolly-Seber capture-recapture model. Biometrics 36:419-435.

Krebs 1989. Ecological methodology. Harper Collins *Publisher* Inc., New York, NY. 654 p.

Mills, J. N., T. L. Yates, J. E. Childs, R. R. Parmenter, T. G Ksiazek, P. E. Rollin, and C. J. Peters. 1995. Guidelines for working with rodents potentially infected with hantavirus. J. Mammol.76:716-722.

Orr, R. T. 1976. Vertebrate biology. W. B. Saunders Company, Philadelphia, Pa. 472 p.

Werner, H. W. 1981. Interim report on long-term monitoring of fire effects on small mammals in a chamise chaparral community. Unpub. Report, Sequoia and Kings Canyon National Parks, Three Rivers, Ca. 16 p.

Werner, H. W. 1982. Interim report on long-term monitoring of fire effects on small mammals in a chamise chaparral community, second postburn year. Unpub. Report, Sequoia and Kings Canyon National Parks, Three Rivers, Ca. 13 p.

Werner, H. W. 1996. Fire effects monitoring on wildlife, 1995. Unpub. Report, Sequoia and Kings Canyon National Parks, Three Rivers, Ca. 13 p.

Werner, H. W. 1997. Fire effects monitoring on wildlife, 1996. Unpub. Report, Sequoia and Kings Canyon National Parks, Three Rivers, Ca. 11 p.

Werner, H. W. 1998. Fire effects monitoring on wildlife, 1997. Unpub. Report, Sequoia and Kings Canyon National Parks, Three Rivers, Ca. 11 p.

Werner, H.W. 1999. Fire effects monitoring on wildlife, 1998. Unpub. Report, Sequoia and KingsCanyon National Parks, Three Rivers, Ca. 12 p.

Wright, J. W. 1969. Mountain beaver (Aplodondia rufa) behavior: extreme southern limits. Unpub. MA Thesis, Fresno State College, Fresno, Ca. 113 p.

Zeiner, D. C., W. F. Laudenslayer, Jr., and K. E. Mayer. 1988. California's wildlife, vol. III, mammals. Calif. Dep. Fish and Game, Sacramento, Ca. 407 p.

4.3) 1999 Annual Sequoia Watershed Report

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INTRODUCTION

The Sequoia and Kings Canyon (SEKI) watershed program is a long-term cooperative study of anthropogenic effects on Sierran ecosystems. The SEKI program was designed to collect a set of core baseline measurements on surface water chemistry, vegetation dynamics, precipitation inputs, meteorology, and soil mapping. Initially, the SEKI program focused exclusively on sites along an elevational gradient in the Middle Fork drainage of the Kaweah River. In 1990, the Tharp's watershed was burned as a pilot study to determine the effects of fire on biogeochemical and hydrologic processes in a mixed-conifer forest. Coinciding with the start of the Mineral King Risk Reduction Project in 1995, the SEKI watershed program expanded its efforts to determine the effects of fire on stream chemistry and hydrology. Two first order watershed sites were established in the East Fork drainage and sampling was initiated in the East Fork at Lookout Point.

The present goal of the watershed program is to build upon our long-term research base to understand the interacting effects of fire and fire exclusion, air pollution and climatic change on key ecosystem elements and processes in Sierran watersheds. In recent years the program has been plagued by budget cuts, so much of this year was spent writing proposals to augment current funding.

This report presents results from ongoing work conducted in both the Middle Fork and East Fork. Results from the analysis of post-fire hydrologic and forest structure changes observed Tharp's Creek following the 1990 burn are presented. Comparisons in runoff are made between a manipulated and control catchment for a sixteen year period (pre-burn n=7, post-burn n=9). Annual precipitation totals and the influence of antecedent moisture conditions on stream discharge are discussed. Reference forest stand data are also presented to document changes in post-fire forest structure and are related to observed changes in post-fire hydrologic responses. The discussion of Mineral King includes the results of the 1999 large woody debris survey, annual runoff coefficients for the study catchments, and annual volume-weighted mean (VWM) solute concentrations. Previous reports and publications (Williams and Melack 1997a, Williams and Melack 1997b, Chorover et al. 1994) summarize the effects of fire on biogeochemistry in the Tharp's catchment following the 1990 prescribed fire and the seasonal variation in pre-burn stream chemistry in the East Fork study sites (Moore 1999).

STUDY SITES

Watershed research is conducted in Middle Fork Kaweah and the East Fork Kaweah, large adjacent drainages (**fig. 4.3-1**). Vegetation in both drainage areas is diverse, ranging from chaparral and hardwood forests at the lower elevations to mixed-conifer and giant sequoia forests at mid elevations. Alpine vegetation is found above 3,100 m.

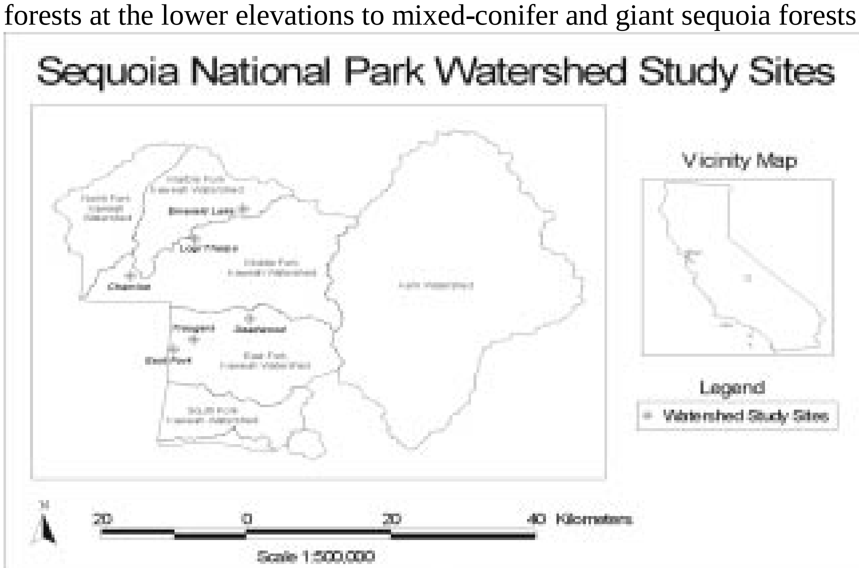


Figure 4.3-1 Location of watershed sampling sites in Sequoia National Park.

<u>Middle Fork</u>

The Middle Fork study sites were part of a larger program established in 1982 to study atmospheric deposition along an elevational gradient in the Middle Fork Kaweah River drainage in Sequoia National

Park. Selected areas were located in low elevation chaparral and mid elevation mixed-conifer forest communities.

Log Meadow is dominated by white fir (*Abies concolor*) and giant sequoia (*Sequoiadendron giganteum*). Precipitation averages 100 cm annually, with half falling as snow during the winter months. **Tharp's Creek** (13.1 ha) has a southeast aspect and ranges in elevation from 2067 – 2397 m. **Log Creek** (49.8 ha) has a northwest aspect and ranges in elevation from 2067 – 2255 m. These creeks are sampled as paired first- and second-order watersheds.

East Fork

The East Fork is sampled at Lookout Point (4,200 m) as a representative of downstream accumulation from a large-scale watershed. In addition two first order watersheds are sampled as representatives of the different vegetation types found in the East Fork drainage.

Trauger's Creek (106 ha) is in a transition zone between the lower mixed-conifer zone and the upper chaparral-hardwood zone. The dominant species is canyon live oak (*Quercus chrysolepis*). Average annual precipitation based on available records is 92 cm. Elevation ranges from 1390 m to 1970 m and aspect is south facing.

Deadwood Creek (100 ha) is characterized by white fir (*Abies concolor*), red fir (*Abies magnifica*), giant sequoia (*Sequoiadendron giganteum*), and incense cedar (*Calocedrus decurrens*). Annual average precipitation based on available records is 136 cm. Elevation ranges from 1985 m to 2660 m and aspect is south facing.

METHODS

The watershed approach requires that many key aspects of the hydrological and biogeochemical cycles be measured and sampled to get a full understanding of the variability in watershed processes. The Sequoia watershed program has used a holistic approach by establishing co-occurring sites to measure meteorology, stream discharge, and hydrochemistry.

Meteorology

Meteorological data were collected at established sites in the Middle Fork and East Fork watersheds. These stations were co-located with primary study sites, providing more accurate climatic data for the individual study sites, and whole watersheds, than could be obtained by a single station within a watershed. Meteorological stations were managed by several federal agencies including: USGS/BRD, NPS, NOAA, and the U.S. Army Corps of Engineers. Most stations measured precipitation, temperature, relative humidity, wind speed and direction, and solar radiation.

Precipitation Chemistry

Precipitation depth and chemistry samples were collected weekly in accordance with National Atmospheric Deposition Program (NADP) protocols in Aerochem Metrics Model 201 samplers located at Lower Kaweah in the Giant Forest area and at Ash Mountain (Dossett and Bowersox 1999). Belfort rain gauges were located at each site. Samples were shipped to California Air Resources Board (CARB) and NADP labs for chemical analysis. Deposition chemistry was used to determine mass balances for solutes entering Sierran catchments -- information needed for understanding fire, air pollution, and climatic change.

Hydrology

The study catchments were equipped with Stevens type A/F records and Omni Data loggers and/or chart recorders to record hourly discharge. The Middle Fork sites were fitted with weirs that provided direct stage-discharge relationships, which were established by USGS/WRD. Discharge data for the East Fork was obtained from Southern California Edison Power Company, which maintains several gauging stations in the Southern Sierra. Stage-discharge relationships were developed for Trauger's and Deadwood Creeks using dilution methods developed by Kilpatrick and Cobb (1985).

Hydrochemistry

Stream samples were collected weekly throughout the year. Additional samples were collected during periods of high flow (storm events and snowmelt runoff). This sampling frequency allowed us to look at both inter- and intra-annual variation. Samples were collected and processed according to protocols outlined by Dr. Stottlemeyer (1987). Samples were filtered at the Ash Mountain Water Lab (AMWL) and shipped to the Biogeochemistry Laboratory at the Rocky Mountain Station Experiment Station in Fort Collins, Colorado, for analysis of base cations, ammonium, nitrate, sulfate and phosphorus. Alkalinity, pH and conductivity were measured at the AMWL.

Stream Morphology

A large woody debris (LWD) survey was conducted following protocols outlined by Robinson and Beschta (1990). These measurements were compared with LWD measurements made by Chan in 1996 to determine the effects of the January 1997 flood. We thought that this event would decrease the total volume of woody debris in the creeks. The 1999 woody debris survey also included photo points and stream mapping for post-burn follow-up.

RESULTS and DISCUSSION

Tharp's Creek Post-Burn Runoff Analysis

Pre- and post-burn stream discharge was analyzed for data collected between 1983 and 1999 in Tharp's Creek and Log Creek, and runoff coefficients were calculated for each catchment. Runoff was expressed as (1) a coefficient of annual precipitation using the equation:

$$RC = \frac{[Q\ (m^3) \div a\ (m^2)] \times 1000\ (mm)}{ppt\ (mm)}$$

where RC = runoff coefficient, Q = total annual discharge, a = area of catchment, and ppt = total annual precipitation. Total annual values were given by water year (10/1 – 9/30); and (2) as the runoff ratio of Tharp's:Log. During the analysis, the importance of antecedent precipitation patterns became apparent in explaining runoff totals for any given year. Thus, a discussion of pre- and post-burn runoff responses during wet and dry years is also presented.

Runoff Patterns

Average runoff coefficients increased 325% and 139% in post-burn dry and wet years, respectively, in Tharp's catchment (**fig. 4.3-2**). In Log catchment, average runoff coefficient decreased by 20% in the post-burn wet years. The decrease is a likely response to the seven-year drought. In the post-burn years, annual runoff in Tharp's Cr. has increased steadily. In 1998 the runoff ratio exceeded 1.0, and was 1.32 in 1999, the fourth driest year of the study period. By comparison, in 1985 – a drought year, preceded by a four year wet period, the runoff ratio was 0.43. This increased runoff has led to a major shift in the post-fire runoff relationship between the two catchments (**fig. 4.3-3**).

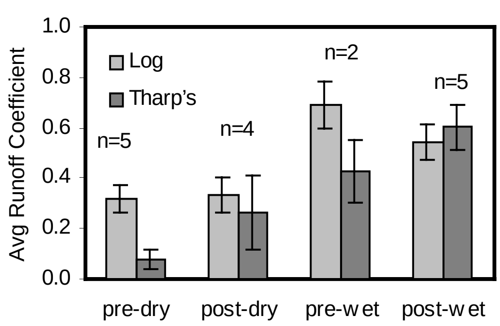


Figure 4.3-2. Average runoff coefficients before and after fire in Tharp's and Log Creeks.

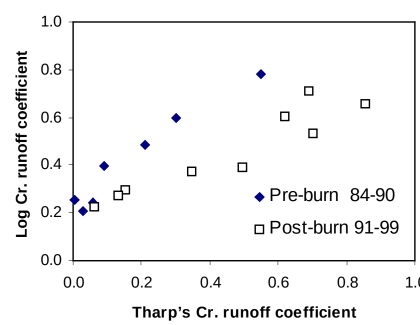


Figure 4.3-3. Increases in Tharp's Cr. runoff following the 1990 burn resulted in a dramatic shift in the runoff relationship between Tharp's and Log Creeks.

Prior to the burn, base-flow discharge contributed the least to the annual runoff in Tharp's Creek, and the creek was dry for much of the summer and fall. In 1990 after four consecutive years of moderate to severe drought, the creek was dry for a record 299 days (**fig. 4.3-4**). In the post-burn years, the contribution of base-flow increased corresponding to an increase in the number of flow days in the summer months. Tharp's Cr. was dry for a record low of 28 days in 1999 despite moderate drought conditions.

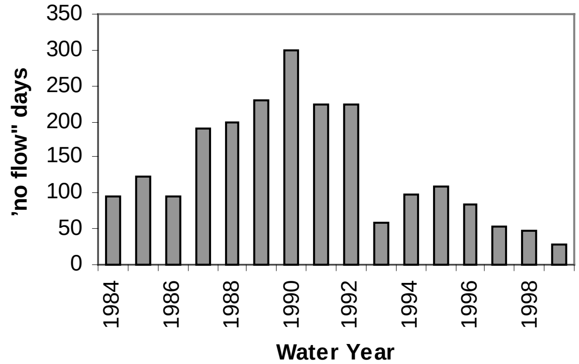


Figure 4.3-4. Following the 1990 prescribed burn the number of "no flow" days has decreased

Post-fire Changes in Forest Structure

The paired watershed analysis revealed that in post-fire years the burned and control catchments both had an increase in annual runoff, and that much of the increase can be explained by an increase precipitation. However, there was a much greater response from the Tharp's catchment. The results of a companion study on forest mortality and recruitment in these catchments between 1986 to 1995 provide a unique opportunity to correlate post-fire changes in forest structure as a means of explaining some of the observed increases in annual runoff.

In the pre-burn years mean annual mortality for all tree species and size classes was <1% in both catchments. In the post-burn period (1991-1995) annual mortality increased slightly to 1.4% in Log Cr. catchment, whereas Tharp's Cr. catchment had an annual mortality of 17.2% (Mutch and Parsons 1998). The highest mortality in Tharp's catchment occurred in 1992 and 1993 (**fig. 4.3-5**). The increase in

mortality in Log Cr. catchment was attributed to drought stress, which reduced tolerance to pathogens and insect outbreaks. Tree mortality in Tharp's catchment was significantly correlated with fire-caused crown scorch, which resulted in a 75% decrease of the trees <u><</u>50 cm dbh (diameter at breast height) and a 25% decrease of trees >50 cm dbh. Although the highest morality averages occurred in the subcanopy class

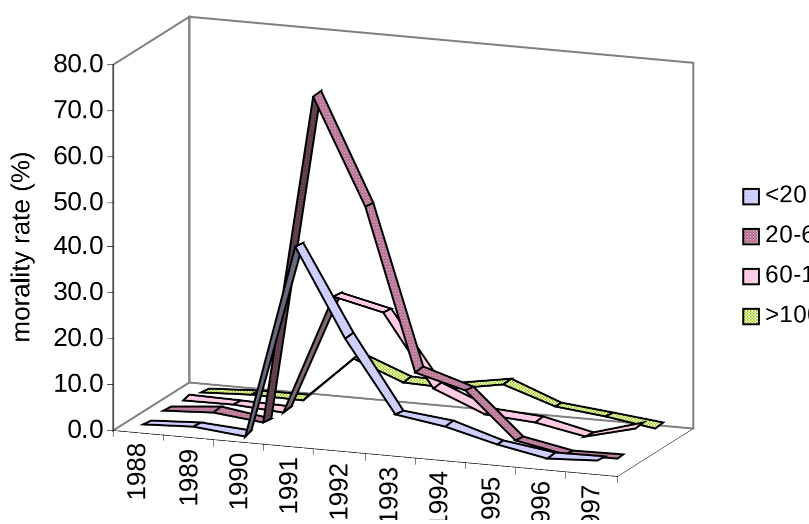


Figure 4.3-5. Sharp increases in mortality rates were observed in Tharp's catchment following the 1990 prescribed burn. Rates remain elevated eight years after the burn.

(28%), dominate and co-dominate trees had average mortality rates of 7% a year from 1991-1995. In 1997, mortality rates for the dominate and co-dominate size classes were 1.45% and 4.23% and 0.0% and 1.89% in Tharp's and Log catchments, respectively (unpublished data).

Management Implications
Interception measurements were not made during either study, but results from the forest study strongly suggest that tree mortality in the large size classes resulted in a decrease in interception and evapotranspiration losses in Tharp's catchment. Other studies have shown that these losses can be substantial, ranging from 15 to 30% annually (Fujieda et al. 1997, Cienciala et al. 1997, Llorens 1997). In the post-burn years, source contributions from snow-melt and base-flow in Tharp's Creek were 10 to 15% greater than in pre-burn years.

The overall mortality rate in Tharp's catchment between 1996 and 1998 was 3.9% (unpublished data), which was more than twice the rate of 1.5% observed in Log catchment. Increased runoff coefficients in Tharp's catchment suggest that the continued mortality is contributing to the additional annual runoff. The continued trend of elevated mortality eight years following the prescribed fire indicates that severe fire behavior can have a prolonged effect of forest structure and hydrologic response.

Results of this analysis indicate that the effects of fire on the hydrologic response of a small mixed-conifer catchment are a complex interaction of biological and physical factors. Paired watersheds and long-term precipitation data are necessary to understand the variation in hydrologic before and after fire. The benefits of companion studies such as the forest mortality study are clearly seen here where detailed information on the changes in forest structure following a prescribed fire provided the information necessary to explain the continued increase in Tharp's catchment annual runoff. The results of this analysis also suggest the need for long-term monitoring in catchments where fire intensity is severe.

Mineral King Pre-Burn Analysis

Runoff Coefficients
Annual runoff coefficients were calculated for each catchment for water years 1996 – 1999 using the above equation. The East Fork coefficient values were under estimated due to the lack of data for the alpine area of the catchment. Trauger's Creek had the highest values overall for the pre-burn period for the four-year period (**fig. 4.3-6**). Runoff in the small catchments did not seem to be affected by the low precipitation totals for WY 1999. Runoff coefficients are expected to increase in the initial years following the application of fire. Much of the burning in the Mineral King Project has been light to moderate in intensity, thus, we expect that increases in runoff will be slight and short-term. We don't expect to see significant changes in East Fork runoff due to the patchy nature of burning within the watershed and the time span of the burns.

Stream Chemistry
Annual volume-weighted mean (VWM) solute concentrations show little inter-annual variability for most anions (H^+, SO_4^{2-}), base cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) and nutrients (PO_4^{2+}) with standard error (SE)

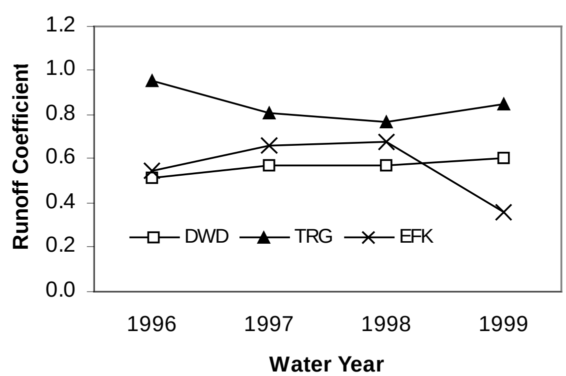


Figure 4.3-6. Annual runoff coefficients for East Fork study sites. The East Fork was most affected by the lower precipitation total in 1999

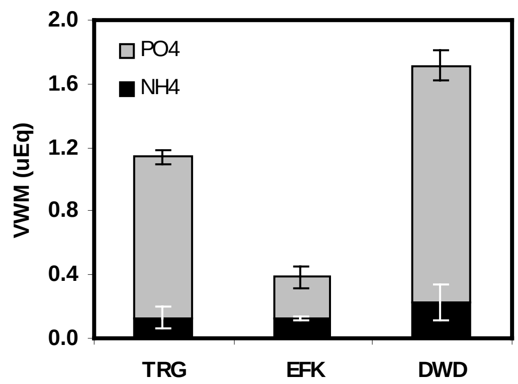


Figure 4.3-7. Phosphate exceeds ammonium in all catchments. Ammonium in undetectable for much of the year

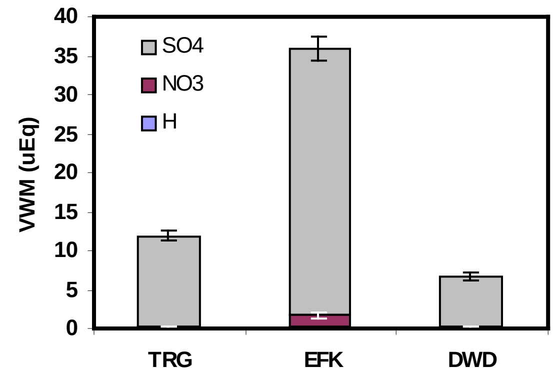


Figure 4.3-8. Sulfate is the dominant acid anion in all catchments.

values ranging from 0.00 to 0.10. Due to the highly variable concentrations of NH_4^+, and NO_3^- , higher SE values were observed. The Mineral King catchments appear to be nitrogen limited as annual VWM ammonium concentrations were significantly less than phosphate concentrations (**fig. 4.3-7**). Phosphate VWM concentrations were highest in Deadwood Cr. Sulfate contributed the highest acid anion VWM concentration in all catchments (**fig. 4.3-8**). High concentrations in the East Fork were correlated with mineral springs in the upper canyon. Nitrate and hydrogen ion accounted for <2.0 µEq in any of the study catchments. These concentrations were contra-indicated by atmospheric deposition patterns where average nitrate concentrations were 25% greater than sulfate concentrations (NADP 1998). The study sites appeared to be well buffered with alkalinity concentrations > 500 µEq. Slightly lower alkalinity concentrations were observed in the East Fork, which may be due in part to higher sulfate concentrations. The dominant cation order was Ca>Na>Mg>K (**fig. 4.3-9**), which is typical of Sierran systems with metamorphic terrain and granitic geology (Melack et al. 1987). Sodium and calcium were reversed in Trauger's Cr., which also had higher chloride concentrations. This may be due to the influence of marine onshore air-flow during the winter, when most of the rain falls.

Large Woody Debris

The LWD survey indicated that most of the downed wood is suspended across the creeks – extending up onto the stream bank; <10% of the woody volume was within the bankfull zone - stage height during the 2 year flood (**fig. 4.3-10).** This finding was consistent with results from similar-sized catchments in the northwest (Robison and Beschta 1990).

In 1996 Chan conducted a LWD survey as part of his aquatic invertebrate study. Starting from the road, he walked up stream and measured the first 50 pieces of wood meeting his standards for minimum length and diameter. He traveled 114m and 111m in Deadwood and Trauger's creeks, respectively, to measure 50 pieces of downed wood. Assuming cylindrical shapes the following equation was used (Lienkaemper

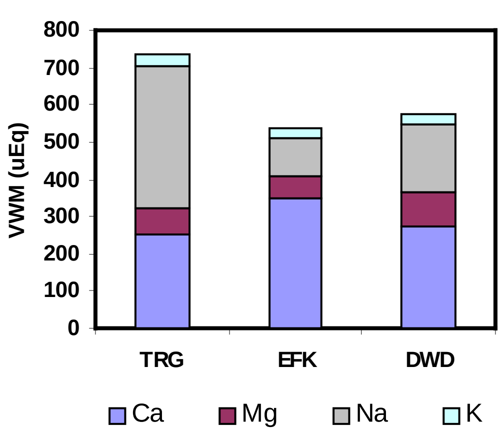


Figure 4.3-9. Calcium and sodium are the dominant base cations. Concentrations did not vary much from year to year

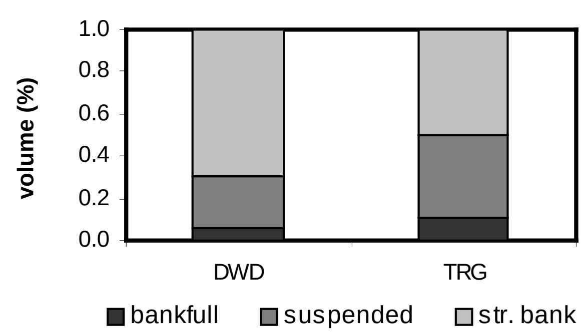


Figure 4.3-10. Percent of LWD by zone.

and Swanson 1987):

$$Volume = \frac{\pi(D_1^2 + D_2^2)L}{8}$$

We followed his protocols in Trauger's (1998) and Deadwood (1999a) to compare results following the Jan 1997 flood, which was rated as a 35-40 year event by the California Water Resources Dept. Comparisons with the 1996 survey showed a substantial decrease in total volume, and an increase in bankfull width (**table 4.3-1**), suggesting that the 1997 flood waters eroded stream banks and carried away much of the wood measured in the lower 100 m of Trauger's and Deadwood Creeks.

As the creeks were surveyed, we realized that slope influences how wood is positioned in the creeks. In the lower portion of the creeks the gradient is lower, increasing the potential for woody debris accumulation within the bankfull area. To account for this we randomized 50m surveys (1999b) for a more accurate representation of the entire stream. Results of the 1999b surveys were mixed. In Trauger's Cr. where is upper 2/3 of the creek is very steep (slopes range from 20% – 35%), the total volume of woody debris was only 0.69 m^3 - much lower than the 1996 and 1998 results. In Deadwood Creek, where slopes are less steep overall and more varied throughout the short stretch of stream (≈ 400 m), the results showed an increase in total volume over the 1999a survey, but were still significantly lower than the 1996 results. The increased volume was due to a number of large downed trees that were located in the upper 50m survey, where the slope was less than 10%. The results of the randomized survey suggest that more accurate total volumes of LWD are obtained because the slope affects on woody debris accumulation are better represented in the sampling.

Table 4.3-1. Results of Large Woody Debris surveys comparing pre- and post-flood volumes and randomized versus non-random surveys.

	Bankfull	Dist.	Dia.	Length	Vol/dist	totVol
DWD			**Avg.**	**Avg.**		
1996	1.28	114	0.32	2.34	0.17	19.36
1999a	1.26	111	0.17	1.46	0.01	0.64
1999b	1.33	100*	0.28	4.86	0.02	2.08
TRG						
1996	0.69	111	0.22	3.23	0.11	12.26
1998	1.22	167	0.17	2.22	0.02	3.84
1999b	1.06	200*	0.15	3.60	<0.01	0.69

* sum of 50 m random surveys in each creek.
All measurement in meters, volume in m^3

Management Implications

Approximately half of the Deadwood catchment and a much smaller portion of the Trauger's catchment were burned in late 1999. Increased phosphate and conductivity values were observed almost immediately in Deadwood Creek. We have not observed changes in stream chemistry in the East Fork, despite all the burning that has taken place. It may be that the effects of mosaic burning over time in large drainage areas does not alter the seasonal fluctuation in stream solute concentrations. Every effort should be made to continue the sampling through the burn and post-burn phase of the MKRRP. These watershed results are extremely valuable in understanding the variation in watershed response to fire. For instance, as we observed in Tharp's catchment precipitation patterns can strongly influence post-burn watershed response to fire. The Mineral King pre-burn data were collected during a period of wet years – completely opposite the dry years that dominated the pre-burn data collection in Tharp's catchment. This shift pre-burn in precipitation patterns will likely influence the magnitude and duration of the fire effects in the East Fork sites.

We are fortunate to have a long-term data base on stream chemistry, hydrology and meteorology from the Log Meadow catchments. These data allow us to understand how long-term anthropogenic influences affect watershed function and help us to tease out the affects of short-term disturbance such as fire. We should continue to build upon this knowledge base by funding studies such as the Mineral King project.

1999 ACCOMPLIMENTS

- Conducted Large Woody Debris survey in Trauger's and Deadwood Creeks, and compared results with 1996 pre-flood survey.

- Submitted paper entitled "Hydrologic Response of a Forested Catchment before and after Fire" to American Water Resources Association conference: Water Resources in Extreme Environments. Paper will be presented at the May 2000 meeting in Anchorage, AK.

- Submitted proposal to CalFed entitled "Effects of Fire on Sediment Processes in Sierra Nevada Forested Watersheds". This proposal presented an experimental approach to studying fire effects on sediment transport and storage, and hillslope erosion in small (<100 ha) forested catchments in the Sierra Nevada in various stages of fire reintroduction. (not funded)

- Submitted proposal to U.S. Geological Survey entitled "Effects of Fire on Sediment Processes in Sierra Nevada Forested Watersheds". This proposal presented a scaled down version of the CalFed proposal to study fire effects on sediment transport and storage, and hillslope erosion in the East Fork study sites. This was a joint proposal with co-authors from Water Resources and Geologic Divisions. (not funded)

- Submitted proposal to NPS Resources Management unified call for FY 2000 entitled "Effects of Fire on Watersheds". This proposal sought funds to continue long-term stream and precipitation sampling with an emphasis on fire effects. (not funded)

2000 PLANS

The watershed account will be zeroed out for FY2000 and all monitoring will be phased out. A three-phase plan is underway to close out the program. In Phase I sampling will cease at all Middle Fork sites as of Feb. 2000. Sampling will continue in the East Fork through April 2000 to capture the winter/snowmelt runoff period in the recently burned watersheds. Final chemistry analysis will be performed for all remaining stream and precipitation samples. In Phase II equipment will be removed from the field, including all data loggers and meteorological stations. During Phase III equipment will be inventoried and stored, all data sets will be updated and reviewed, and all metadata will be completed.

Plans are also underway to complete a draft synthesis of the watershed program. This document will summarize all research and monitoring in the Middle Fork (1984-1998), and will include an overview of fire effects in the Tharp's catchment, and a trends analysis on the long-term stream chemistry and hydrology data sets.

REFERENCES

Chan, I. A. 1998. *Aquatic Macroinvertebrates of Small Streams in Mineral King Region of Sequoia National Park: Baseline Communities and Response to Prescribe Fire.* Thesis. University of California, Berkeley. 111 pp.

Chorover, J., P. M. Vitousek, D. A. Everson, A. M. Esperanza and D. Turner. 1994. Solution chemistry profiles of mixed-conifer forests before and after fire. *Biogeochem*. 26:115-144.

Cienciala, E.; J. Kucera, A. Lindroth, J. Cermak; A. Grelle, S. Halldin, 1997. Canopy transpiration from a boreal forest in Sweden during a dry year. Agricultural and Forest Meteorology, v. 86, n. 3-4:157-167.

Dossett, S. R. and V. C. Bowersox. 1999. National trends network site operation manual. National Atmospheric Deposition Program Office, Illinois State Water Survey. NADP Manual 1999-01. Champaign, IL

Fujieda, M.; T. Kudoh,, V. De Cicco,; and J. L. De Calvarcho. 1997. Hydrological processes at two subtropical forest catchments: The Sierra do Mar, Sao Paulo, Brazil. J. of Hydrology, v. 196, n. 1-4:26-46

Lienkaemper, G. W. and F. J. Swanson. 1987. Dynamics of large woody debris in streams in old-growth Douglas-fir forests. *Can. J. For. Res*. 17:150-156.

Llorens, P. 1997. Rainfall interception by a *Pinus sylvestris* forest patch overgrown in a Mediterranean mountainous abandoned area: II. Assessment of the applicability of Gash's analytical model. J of Hydrology, v. 199, n. 3-4:346-359.

Melack, J., S.D. Cooper, R.W. Holmes, J.O. Sickman, K. Kratz, P. Hopkins, H. Hardenbergh, M. Thieme and L. Meeker. 1987. Chemical and biological survey of lakes and streams located in the Emerald Lake watershed, Sequoia National Park. Final Report to the California Air Resources Board, Contract A3-096-32, Sacramento, CA. 345 pp.

Moore, C. M. 1999. 1999 Annual Sequoia National Park Watershed Report. U.S. Geological Survey. Three Rivers, CA. Unpublished report. 15 pp.

Robison, E. G. and R. L. Beschta. 1990. Characteristics of coarse woody debris for several coastal streams of southeast Alaska, USA. Can J. Aquat. Sci. 47:1684-1693.

Williams, M. R. and J. Melack. 1997a. Effects of prescribed burning and drought on the solute chemistry of mixed-conifer forest streams of the Sierra Nevada, California. *Biogeochem*. 39:225-253.

Williams, M. R. and J. Melack. 1997b. Atmospheric deposition, mass balances, and processes regulating streamwater solute concentrations in mixed-conifer catchments of the Sierra Nevada, California, *Biogeochem*. 37: 111-144

4.4) The Park's Fire Web Site "Fire Information Cache"

- Anthony Caprio, Science and Natural Resources Management Division, Sequoia and Kings Canyon National Parks

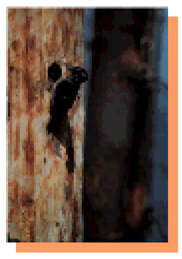
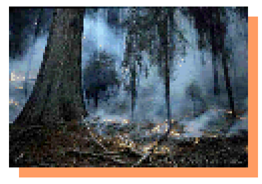
The ***Fire Information Cache*** Web site was developed in order to provide easy access to high quality information about fire and park resources to a large audience via the World Wide Web. It provides a variety of materials but emphasizes policy and natural resource issues and information pertinent to Sequoia and Kings Canyon National Parks. The site was designed to be useful to the public, resource and fire management professionals, park staff, and scientists, for addressing issues and answering questions related to fire in the region. The site is dynamic and is updated or expanded as new information becomes available.

Specific topics on which the site focuses include:

- **Fire Policy:** Policy statements for Sequoia and Kings Canyon National Parks and the National Park Service are made available.
- **Fire and Park Resources**
  - **Fire Bibliography:** A detailed bibliography lists references pertaining to fire in the region or of general importance. Most current documents produced in the Park are made available for downloading as PDF or HTML documents. Additionally, a variety of older relevant documents have been converted into electronic format and made available.
  - **Current Research Projects:** Descriptions of current fire related research projects underway in the Parks are provided. Examples include studies by the USGS, results from the Parks fire monitoring program, and regional interagency projects funded by the Joint Fire Sciences Program.
  - **Annual Reports:** Copies of annual reports on fire related resource/research studies by NPS, USGS, and other researchers are available to view or download. These provide up-to-date information on what projects are underway, their objectives, accomplishments or preliminary results, and current status.
- **Annual Burn Program Planning and Results:** Maps of potential burn units are provided at the start of each year, updated periodically during the fire season, with a final "Burn Atlas" and burn summary produced at the end of the fire season.
- **Historic Fire Maps:** Maps documenting resource burning in developed sequoia groves (Giant Forest, Redwood Mountain, Grant Grove) are provided along with downloadable GIS databases of pertinent fire information and records.
- **Fire Links:** A variety of links to other fire related information and web sites, both within the NPS and around the world, are provided.

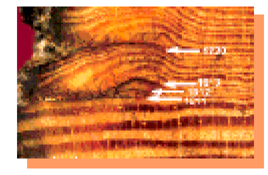
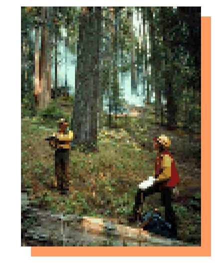
The site has provided a valuable source of information supporting the fire management program in the Parks. Based on statistics from the NPS server hosting the pages the site has received considerable interest. The site is averaging slightly over 2,100 requests monthly with an average of 250 MB of information (documents, data, or maps) also downloaded during this time interval. Several examples of pages are provided on the following pages.

The URL for the Fire Information Cache is: HTTP://WWW.NPS.GOV/SEKI/FIRE/INDXFIRE.HTM.

Fire Information Cache

Sequoia and Kings Canyon National Parks
Three Rivers, California

Why Does the National Park Service Use Fire?

Fire has been a natural part of the Sierran ecosystem for centuries. Natural fires swept through these plant communities at intervals that provided conditions for many plant species to regenerate. Fire thins competing species, recycles nutrients into the soil, releases and scarifies seeds, and opens holes in the forest canopy for sunlight to enter. All of these are critical to forest health and natural cycles of growth and decomposition.

Plants are not the only living things that have evolved with and adapted to fire. Animal species are just as much a part of the "fire environment." With the increased forage that results after a fire, many animals low on the food chain experience increases in their populations; therefore species above them on the food chain also benefit.

Despite the evidence that fire is a necessary element in the Sierra Nevada, over most of the past century people have feared and suppressed it whenever possible. Especially in the western United States, the accumulation of dead forest litter and duff during that time now presents extreme hazards to the health of the trees, soil, and wildlife, to humans living in these areas, and to the taxpayer who has to fund the fighting of catastrophic wildfires.

Prescribed fire is used in Sequoia and Kings Canyon National Parks to restore this natural process to the forests. These fires are strategically used to reduce the risks that unnaturally heavy fuels pose to humans and ecosystems.

You can learn more about wild and prescribed fire in this overview. For more technical information about fire, fire research and fire management, select from the following links:

- Sequoia and Kings Canyon Fire Management Policy: Excerpts from the parks' management plan pertaining to fire and fire management.
- NPS Wildland Fire Management Policy: The section of the National Park Service's Management Policies concerning fire use.
- Fire in the Parks. What do You Think?: Responses to the fall 1998 survey concerning fire management in Sequoia and Kings Canyon National Parks.
- Mineral King Risk Reduction Project: A multi-year project to reduce the risk of intense wildfire in the Mineral King area.
- Fire and Park Resources: Papers and other sources of information on fire research, fire effects and fire monitoring.
- Fire Maps and GIS (Geographic Information System) Data: A visual database of park fire history.
- Sierra Nevada Ecosystem Project (SNEP): SNEP was a Congressionally mandated study of the Sierra Nevada ecosystem by an independent panel of scientists. This page links to the sections of the SNEP report relating to fire.
- Other sites with information about fire and fire research

- Information for Kids About Fire in the Parks. This file is in Adobe Acrobat format [96kb download size] that requires Acrobat Reader to view. The page was taken from the ***Sequoia Seeds*** - to see all the articles in the newspaper go to the KID'S and TEACHER'S pages.

- LINK to 1998 Fire and Aviation Management Operations Guide (FAMOG)

http://www.nps.gov/seki/fire/index.htm

Last update to site: April 6, 2000

Mineral King Risk Reduction Project?

Beginning in 1995, Sequoia National Park embarked on a series of prescribed burns in the Mineral King area. Fires such as these reduce hazardous forest fuel buildup, protect public safety, and restore ecosystems to a more natural state. The Mineral King Risk-Reduction Burn Project is a multi-year plan to reduce the potential for intense wildfires as well as the high cost of fighting them. Burning adjoining areas over a number of years will create a patchwork of areas with less fuel and younger growth; these will slow the spread of inevitable future fires.

1998 Annual Report

Executive Summary (HTML)
Table of Contents, with links to download the complete report in Acrobat PDF format.

1997 Annual Report

Executive Summary (HTML)
Table of Contents, with links to download the complete report in Acrobat PDF format.

1996 Annual Report

Executive Summary (HTML)
Table of Contents, with links to download the complete report in Acrobat PDF format.

1995 Annual Report

Executive Summary (HTML)
Table of Contents, with links to download the complete report in Acrobat PDF format.

http://www.nps.gov/seki/fire/mk_intro.htm
Last update: April 6, 2000

ia and Kings National Parks

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NAT. PARK SERVICE

THREE RIVERS FIRE SURVEY

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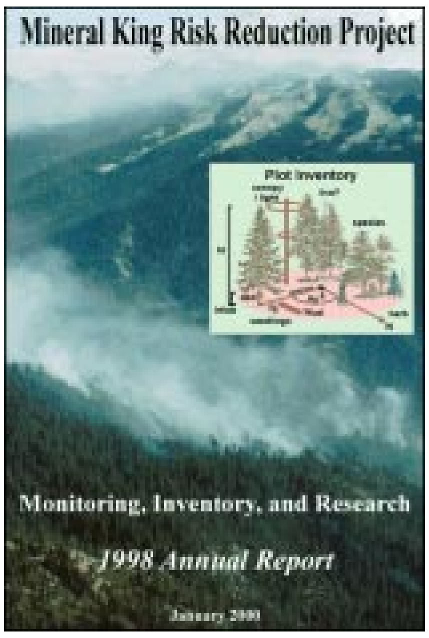

Annual Report 1998

Research, Inventory and Monitoring

Mineral King Risk Reduction Project

Compiled by Anthony Caprio

The Executive Summary of the 1998 Mineral King Risk Reduction Project Annual Report is available in HTML format. The entire report is available in Adobe Acrobat PDF format. To view these files you will need a free Acrobat Reader. If you do not have one, you can download it from Adobe here.

Download the full report as one file here (8.75 MB - PDF file)

The report is divided into multiple sections for easier downloading.

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4.5 - Other

- **<u>Effects of Prescribed Burning on Forest Floor Fuels and at the Bases of Giant Sequoia Trees</u>** - This has been a long-term research project by Steve Sackett and Sally Haase of the USDA Forest Service, Riverside Fire Lab. Current objective of this study are to *(1)* determine soil temperatures at different depths below the soil/duff interface during normal prescribed fires, *(2)* determine cambium temperatures in sequoia and sugar pine trees during prescribed fires, *(3)* determine pre- and postburn concentrations of the available forms of nitrogen (ammonium and nitrate) in the upper soil stratum and to trace them over time, *(4)* determine prediction equations for forest floor fuel loading through depth measurements, and *(5)* to determine in situ root live-to-dead ratios for roots up to 3.8 cm in diameter prior to and after prescribed burns in a giant sequoia/mixed conifer ecosystem.

Results to date indicate that concentrations of nitrogen changed around the giant sequoia as follows: for the 0-5cm depth, before burn= 4.58, after burn=67.71 and spring after burn=41.70. For 5-15 cm depth, before burn=1.79, after burn=18.63, and spring after burn=14.06. Soil and cambium temperatures during the SEKI-VII fire have been translated and are similar to previous burns. Spring samples of inorganic soil nitrogen showed abnormal changes taking place in both the levels of nitrate- and ammonium-nitrogen. Ten years of record now exist for inorganic soil nitrogen after burning. Ammonium-nitrogen around the giant sequoia on each study site, had increased from the previous year with the exception of SEKI-VI at 0-5 cm in which they had decreased. Nitrate-nitrogen had also increased from the previous year on all giant sequoia sites for both sampling depths except for SEKI-VI. Results varied for the sugar pine ammonium- and nitrate-nitrogen for the two depths. Ammonium decreased for all sites except SEKI-II and IV at 0-5cm depth and increased for all sites except SEKI-I for the 5-15cm depth.

See also: Haase, S.M. and S.S. Sackett. 1998. Effects of Prescribed Fire in Giant Sequoia-Mixed Conifer Stands in Sequoia and Kings Canyon National Parks. In: Leonard A. Brennan, and Teresa L. Pruden (eds.). Fire in ecosystem management: shifting the paradigm from suppression to prescription. Proceedings of the Tall Timbers Fire Ecology Conference, No. 20. Tall Timbers Research Station, Tallahassee, FL. pp 236-243.

- **<u>Bark-Foraging Bird Species</u>** - Todd Dennis (graduate student University of Virginia) conducted research that focused on understanding possible mechanisms that may limit bird species distributions (his emphasis is on the bark-foraging guild - some 14 species of woodpeckers, nuthatches, etc. inhabit the west slope of the Sierra Nevada). Over 600 foraging behavior plots were sampled along with some 450 descriptive vegetation plots during 1996 and 1997. Much of his field sampling was undertaken within the East Fork watershed and has included the examination of species within a number of recent burns in the drainage. He found a number of bark-foraging species to prefer these recent burned areas: northern flicker (*Colaptes auratus*), white-headed woodpecker *(Picoides albolarvatus)*, hairy woodpecker (P. villosus), Williamson's sapsucker, and black-backed woodpecker (*P. arcticus*). The latter species was only observed in recent burns which appear to be critical habitat for its presence. Other species on which field observations were made include Nuttall's woodpecker (*P. nuttallii)* and Downy woodpecker *(P. pubescens).* The reference and abstract for the dissertation are given below.

> **<u>Foraging behavior of Sympatric *Picoides* Woodpeckers of the Sierra Nevada: The Relative Importance of Competition and Habitat Structure.</u>** Todd Dennis 1999. PhD Dissertation,

University of Virginia. - Although there has been substantial interest in how interspecific competition and habitat structure individually affect the foraging behavior of birds, no one to date has explicitly considered which of these two factors is a more important influence for coexisting, ecologically similar species. In order to address this issue, I characterized the foraging- behavior and habitat structure/floristic composition of the five species of *Picoides* woodpeckers inhabiting the Pacific slope of the Sierra Nevada mountains (*P. pubescens, P. nuttallii, P. albolarvatus, P. villosus,* and *P. arcticus).* With these data, I answered four questions: (1) Which of these species are sympatric? (2) How do sympatric species differ in foraging behavior and habitat characteristics? (3) For the two species with adequate sample sizes *(P. albolarvatus* and *P. villosus),* how is foraging behavior related to the structure of the foraging substrate? and (4) Are sympatric species more or less similar than what one would expect by chance? Comparison of elevation and habitat data showed that there were three strongly sympatric species-pairs: (1) *pubescens/nuttallii;* (2) *albolarvatus/villosus:* and (3) *villosus/arcticus.* Multiple response permutation procedures (MRPP – a type of randomization analysis) indicated that the members of two of these pairs were significantly different in foraging heights but a null-model analysis showed that these differences were no greater than what one would expect by chance. MRPP and X^2 tests demonstrated that the foraging heights and locations of *P. albolarvatus and P. villosus* were associated with foliage characteristics of the foraging substrate. Lastly, a null-model analysis showed that the foraging behavior of sympatric species was more similar than what would be expected by chance. thereby supporting the habitat structure hypothesis. Other evidence suggestive of a lack of strong exploitative and contest competition was also presented. The results of this study provide a demonstration of convergent foraging behavior and show that for these *Picoides* species habitat structure is a more important influence of foraging behavior than is interspecific competition.

- **Fire and Fire Surrogates Project, JFSP** - Preliminary planning by the USGS Southern Sierra Research Station within the Parks for the Fire and Fire Surrogates Project was begun in 1999. This project will examine effects of burning in lower mixed-conifer forest during differing seasons and will be one subsite in a national network of sites being funded as part of the Joint Fire Sciences Program to investigate the consequences of fire and fire surrogate treatments. The study will use a subset thee standard experimental design and protocol developed for the national study. These methods will allow evaluation of fuel treatments so that results are comparable across agencies, fuel types, and geographic areas. (Jon Keeley and Nate Stephenson - USGS)

- **Resampling Redwood Mountain Kilgore Plots** - Kathleen Williams (UC Humboldt) has resampled plots established by Bruce Kilgore at Redwood Mountain in the 1970s to look at fire effects. She is comparing differences between burned and unburned plots since the time of the burns.

5. Acknowledgments

Assistance in the tedious task of compiling and checking of the report was provided by Jeff Manley. I would also like to thank everyone who contributed individual project sections for this report or helped in some other capacity by providing information or assistance during the last year that has been used in this report.