2000 Annual Fire Report
Monitoring, Inventory, and Research

Sequoia & Kings Canyon National Parks
August 2001

Note: The **2000 Annual Fire Report on Research, Monitoring, and Inventory** is the second 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 2000, including those associated with the MKRRP. Copies of all the reports are being made available by web browser over the Internet. Full copies of the 1995 through 2000 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 2000 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: Prescribed fire in the understory of giant sequoias immediately after ignition. Part of the Bear Hill prescribed burn in the Hazelwood Drainage of Giant Forest, Sequoia and Kings Canyon National Parks during late June 2001. The Bear Hill Burn was significant as the first prescribed burn in the western states following the NPS burn moratorium of 2000.

2000 Annual Fire Report
Research, Inventory, and Monitoring

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2000 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.

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 2000 amounted to 33.2 ha (81.9 ac). Area burned during 2000 was limited by the burn moratorium decreed by the Secretary of the Interior following the Cerro Grande fire (originally ignited as a prescribed burn) in the Jemez Mountains of New Mexico which escaped control in Bandelier National Park and burned a large number of homes in the nearby community of Los Alamos.

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 the reports began to compile and describe work carried out from throughout the Parks, in addition to work relating to the ongoing MKRRP. During 2000 there were 14 ongoing projects related to fire underway within the Parks and several major new projects in the initiation stage.

1. Project Year Synopsis: Accomplishments for 2000 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

- **Fire History -** Fire history sampling during 2000 concentrated on collecting sites on north and south aspects in the Marble Fork of the Kaweah River and Cedar Grove area of Kings Canyon. The purpose of the sampling was to verify whether or not differences in fire regime as were found by aspect in the East Fork occurred. In the East Fork fire history samples have been obtained from most elevation, aspects, and vegetation types within the East Fork from 1995 to 1999. These samples are part of an effort to the 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).

- **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 Tar Gap prescribed Burn. They will provide long-term data 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 (fuels and tree mortality) of the two burned plots (#1 and #2) was largely completed in 2000.

- **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 -** 2000 marked the second year 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.

- **Wildlife Monitoring -** Four permanent small mammal live-trapping plots have been established between 1995 and 2000 and all were 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. Over the last five year additional colonies of *Aplodontia*–a species originally of special concern within the parks–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 Middle Fork was discontinued during 2000 and analysis of the many years of sampling is being initiated. Work in the East Fork is continuing and being carried out by Andi Heard (graduate student) and John Stednick at Colorado State University. Analysis of post-fire hydrologic changes observed in the Giant Forest's Tharp's Creek–in the Middle Fork–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. Past work in the East Fork drainage includes studies on large woody debris, annual runoff coefficients for the study catchments, and annual volume-weighted mean (VWM) solute concentrations.

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

2.2 - Park Area Description

Sequoia and Kings Canyon National Parks are located in the south central Sierra Nevada (**Fig. 2.2-1**) 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. 2.2-2**). 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).

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.

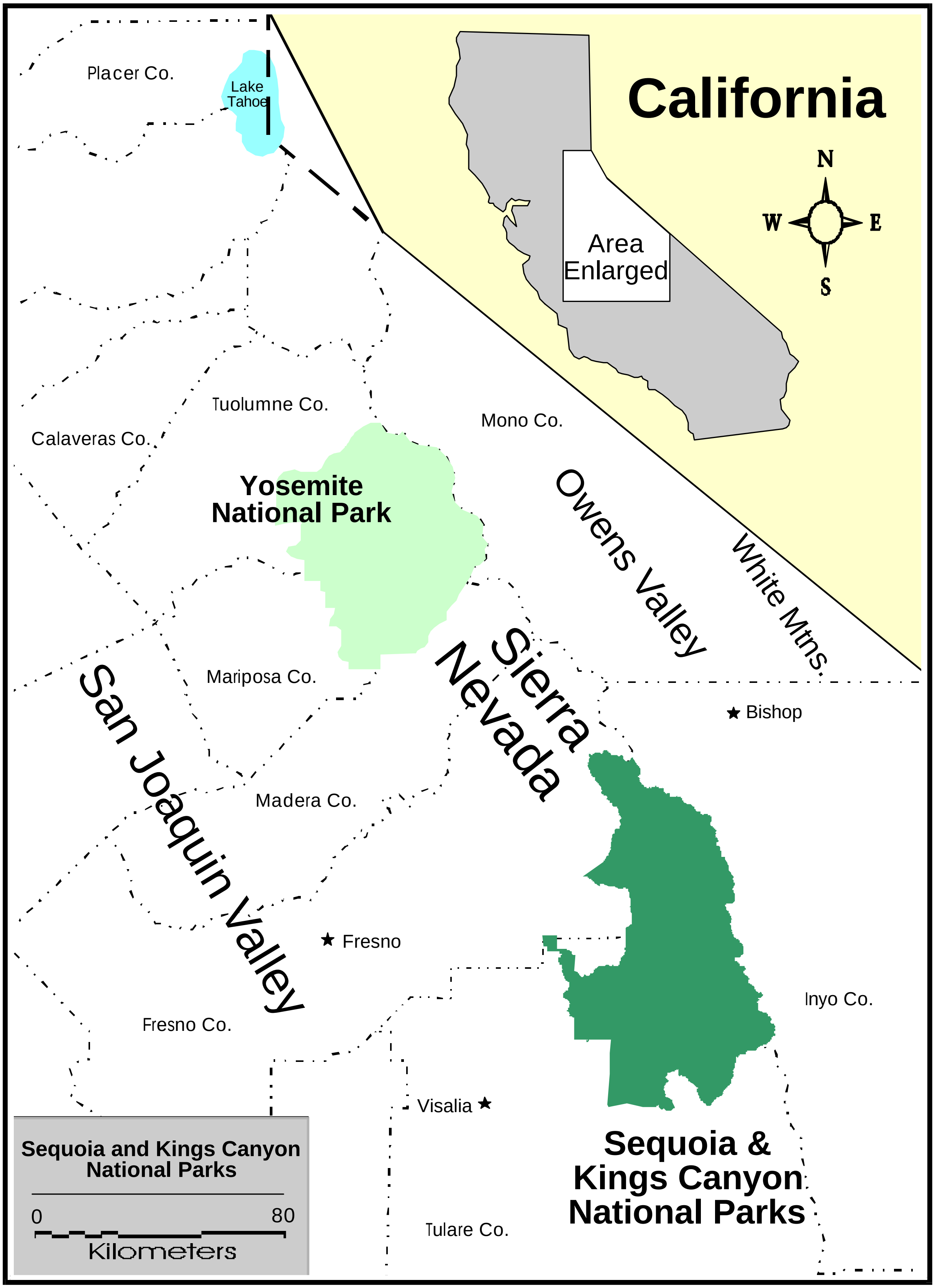


Figure 2.2-1. Location of Sequoia and Kings Canyon National Parks in the southern Sierra Nevada of california.

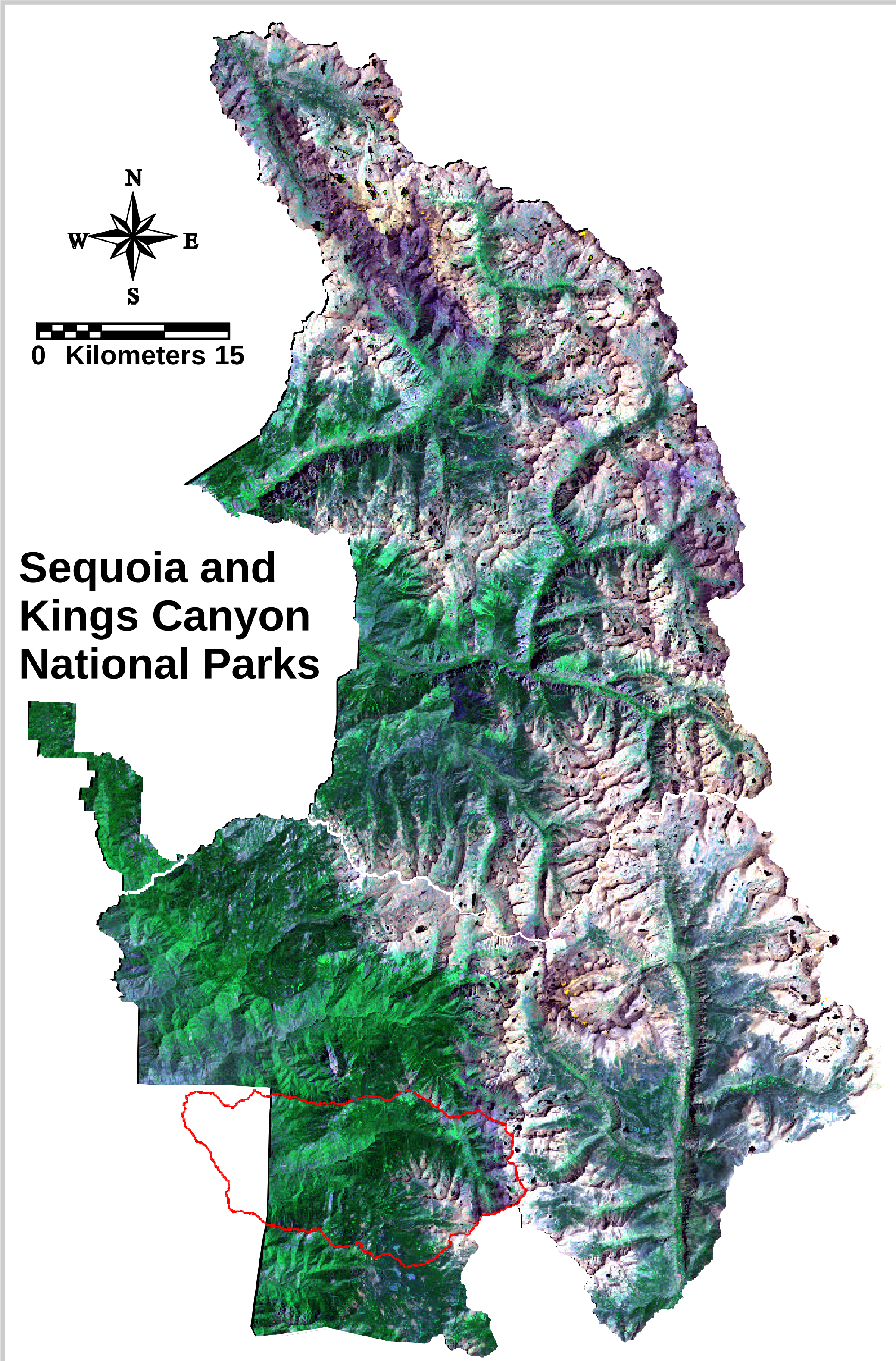


Figure 2.2-1. TM scene of Sequoia and Kings Canyon National Parks. Green areas are vegetated areas of the landscape. The East Fork drainage, where the Mineral King Risk Reduction Project is located, is outlined in red on the lower portion of the map.

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.

3. Fire Year 2000

All Park Areas

Total acreage burned by all causes within the Parks during 2000 was 33.2 ha (81.9 ac)**.** Due to the National Park Service moratorium on prescribed burning west of the 100 th meridian, Sequoia and Kings Canyon did not ignite fires during the summer of 2000.

Wildland Fires 22.2 ha (57.9 ac)

Wildland fires are unplanned fires started by humans or lightning. Human-caused fires are always suppressed. 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.

• Wildland Fire Used for Resource Benefit (WFURB) 0.1 ha (.3 acres) - Lightning caused and actively managed to maintain natural ecosystem processes.

• Suppressed 22.3 ha (57.6 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. Included fifteen small fires totaling 1.6 ha.

- *Human-Caused Wildfires* Unplanned and unwanted fires that were aggressively suppressed. Included five fires totaling 53.6 ac.

Prescribed Fires 9.7 ha (24 ac)

Fires planned and set by NPS staff in designated areas to reduce hazardous fuels and/or restore natural conditions. Due to the National Park Service moratorium on prescribed burning west of the 100^{th} meridian, Sequoia and Kings Canyon did not ignite fires during the summer of 2000.

The 24 ac that were burned in 2000 were the result of a prescribed fire that burned in January of 2000. The Deadwood Burn began on November 22, 1999 and continued to burn into January 2000 due to the delayed start of the winter rains. The fire totaled 169 ha (417 ac) 159 ha (393 ac) of which burned in 1999.

4. Projects – Year 2000

4.1 - Vegetation

4.11) Mineral King Landscape Assessment (MKLA) in support of the Mineral King Risk Reduction Project (MKRRP)

- *Lead: Kurt Menning*, Ph.D. Candidate, University of California, Berkeley;
Dr. Tracy Benning and Dr. John Battles, University of California, Berkeley

Field Crew: Danielle Bricker, Lucas Fortini, Zachary Kayler, Tim Maier, and Rebecca Wenk. Laboratory and remote image processing assistant: Tim Maier.

INTRODUCTION AND PROJECT OBJECTIVES

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 landscape-scale 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. 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 will be 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.

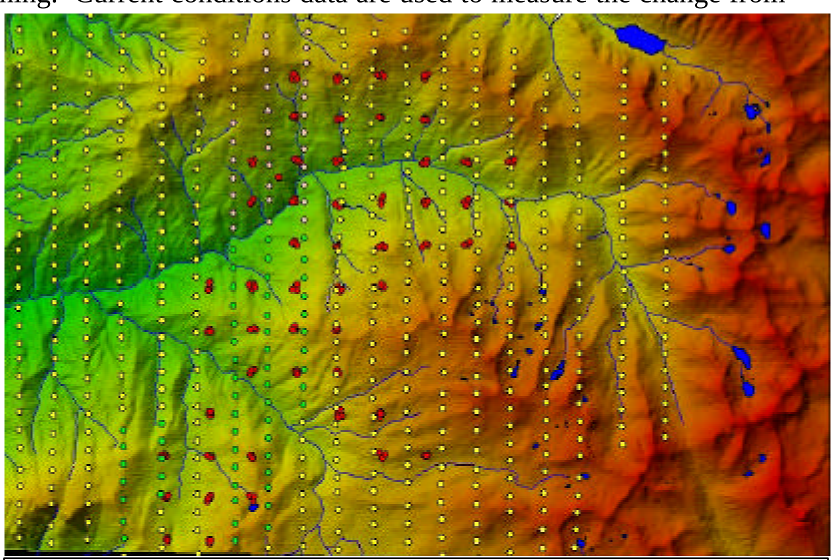


Figure 4.11-1: A digital elevation model (DEM) perspective of Mineral King. Green is low elevation and red is high elevation. Water is marked in blue. Yellow, green and pink dots represent center points of aerial images from 1997. Red dots (in tight clusters) represent MKLA forest inventory plots.

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

Figure 4.11-3: Hemispherical photography processing steps (images: raw, corrected,

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 four years only twenty-nine plots out of 205 have burned (14%).

Due to the limited 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.

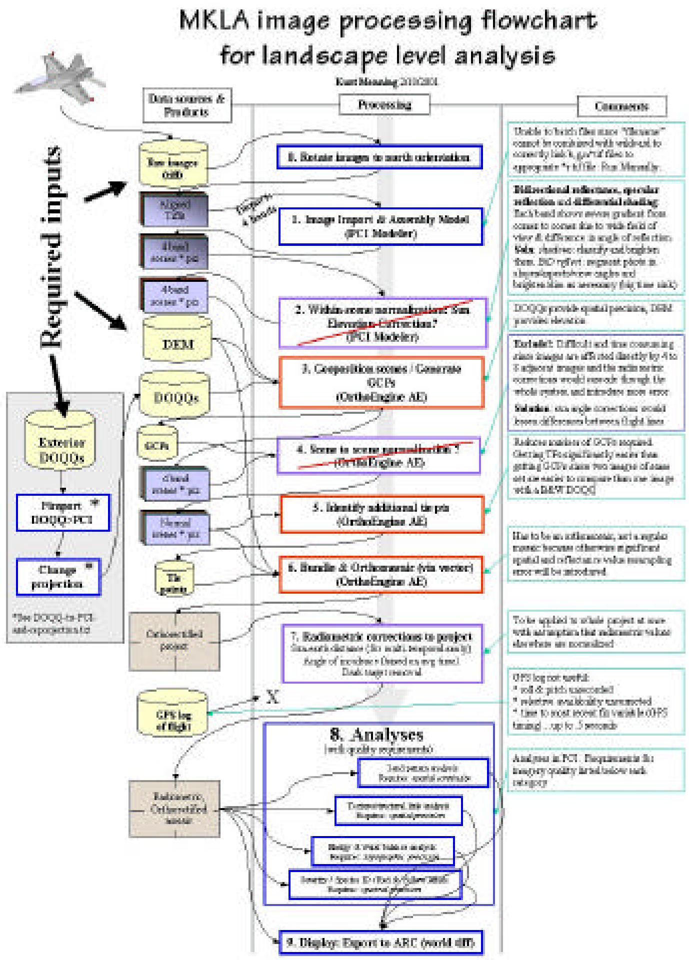
SUMMARY OF METHODS

Data on current conditions have been collected both within forests using an extensive forest inventory approach, and from the air in 1997 and 1999, using aerial photography. 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 broad inventories have 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. When fire has burned in a plot, we re-inventory the plot completely and also measure the degree of scorching and charring on each tree.

In addition, we have collected hemispherical photographs from three points in 141 of the plots. These photos are transformed into binary images and run through software that determines the amount of biologically useable light reaching the location the photo was taken over the course of the growing season (**figure 4.11-3**). In particular, we are interested in percent open canopy, percent direct transmitted light, percent diffuse transmitted light, and percent total transmitted light.

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 and image processing was delayed until this year.

Figure 4.11-4: Remote image processing flowchart

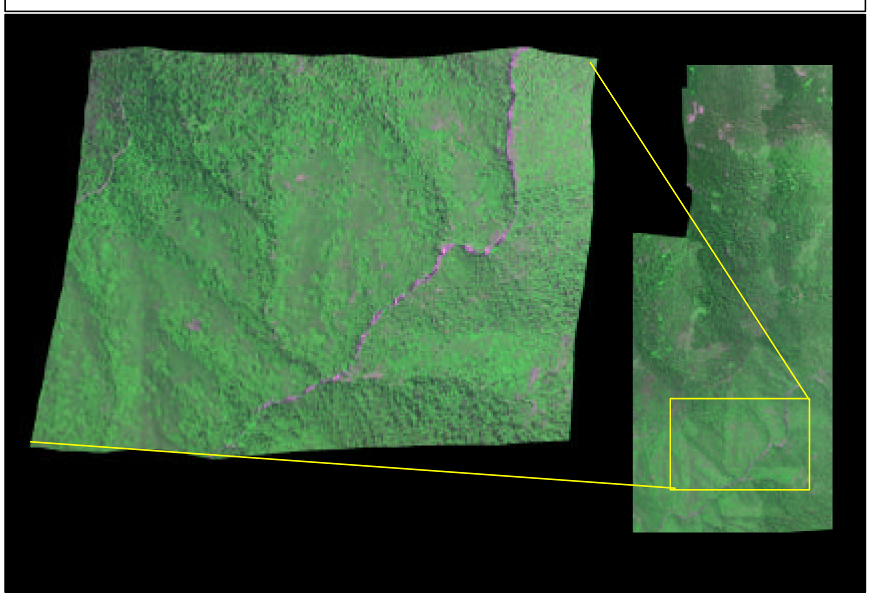


WORK ACCOMPLISHED IN 2000

Fieldwork

In the summer of 2000, we returned to the field for about three weeks to collect several kinds of data. First, we took hemispherical photographs in about a dozen plots in which we had problems with the camera in 1999. Second, our field crew re-inventoried twenty-four plots that we had reason to believe had burned. Twenty of them had been at least partially burned. Third, we collected additional samples from large (>80cm dbh) sugar pines (*Pinus lambertiana*) to further our assessment of the factors leading to the increased sugar pine mortality in the watershed.

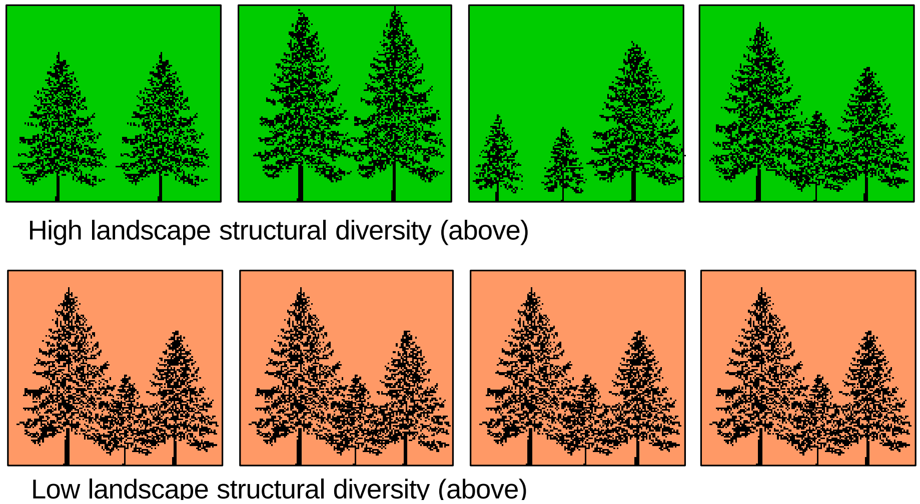
Figure 4.11-5: An Orthorectified image being integrated into a mosaicked landscape for continuous pattern analysis.



Remote image processing

With the arrival of USGS digital ortho quart quadrangle (DOQQ) files we were able to move through image processing and mosaicking, a rather complicated procedure

Figure 4.11-6: Landscape structural diversity illustrated



(**figure 4.11-4**). The result was a series of radiometrically- and geometrically-corrected images that are ready for assembly and analysis (**figure 4.11-5**). This image processing and assembly required a full-time assistant and full-time graduate student to work for approximately six months. The area completely encompassing the 205 field plots is now assembled and ready for analysis.

Additional analyses were continued on fire behavior and these are described below.

FINDINGS AND DISCUSSION

Remote sensing processing and analysis

A sub-selection of two hundred images from more than 700 have been turned into a continuous landscape mosaic of the watershed from 1997. This mosaic will be used in continuous landscape-level pattern analysis of forest structure. Currently, this is scheduled to be a chapter in Menning's dissertation and a subsequent paper.

In fall of 2000, we ran a test to determine if the spectral characteristics of the image could be used to help determine landscape structural diversity. By landscape structural diversity, we mean the variability of forest cover across the watershed (**figure 4.11-6**). To do this, we

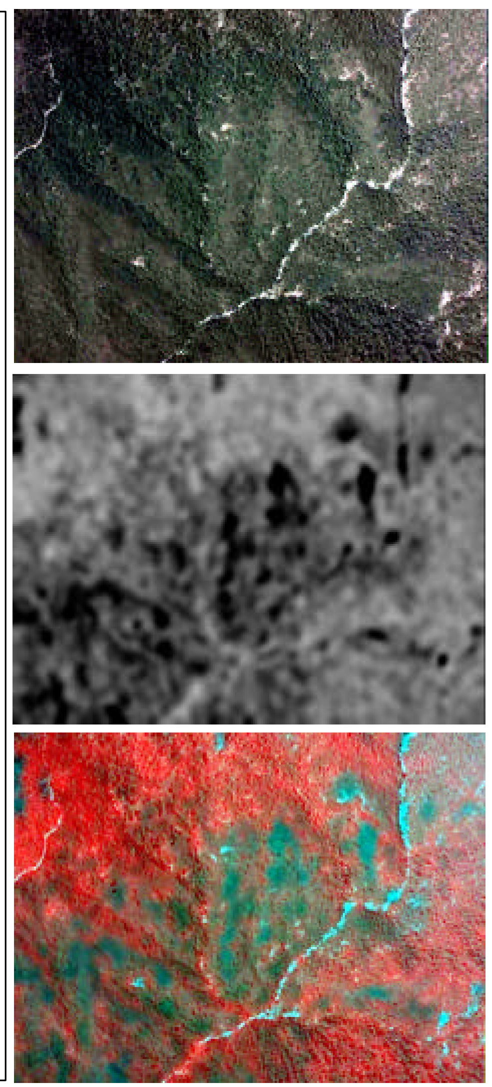


Figure 4.11-7: An example of the application of Spectral Chaos Indicator of Diversity (SCID): a) top—normal image, b) white indicating high diversity, c) projection of b over a.

developed

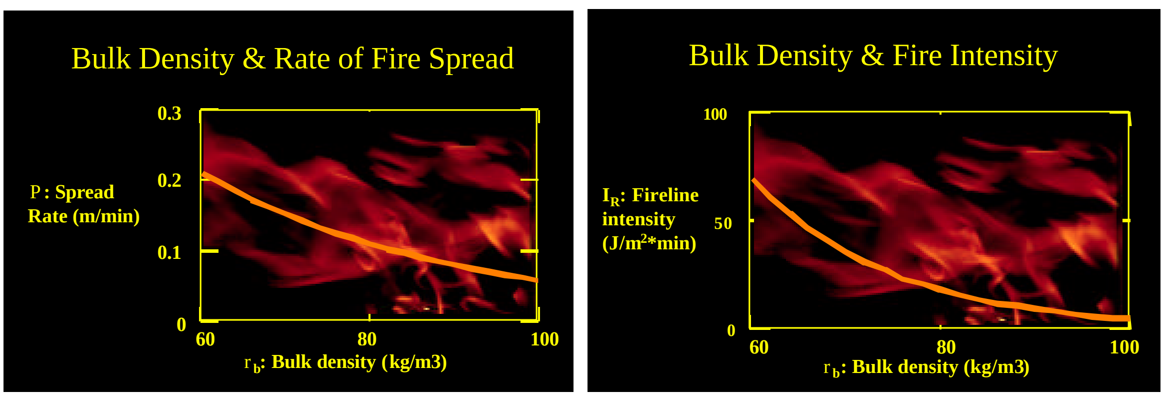
a new method, called the Spectral Chaos Indicator of Diversity (SCID). Because this is still in development, and forms the core of one chapter of Menning's dissertation, the details are not reported here. In short, however, the method allows us to create a continuous metric for the landscape representing structural diversity.

Starting with a multispectral image (**figure 4.11-7a**), we create a coverage that represents structural diversity below (**figure 4.11-7b).** In this second image, the degree of structural variability is represented by the intensity of the color. This can be reprojected over the original image and given a color such as red (**figure 4.11-7c**). In this case, what looks to be a vaporous red cloud floating over the landscape is actually a measure of the degree of variability in forest structure directly below. This method also forms the core of one chapter of Menning's dissertation and will be submitted as a paper next year.

Fire behavior analysis

In 2000, we continued our assessment of bulk forest litter density and its effects on fire behavior. These data were first presented last year in this forum and so are just briefly mentioned here (**figure 4.11-8).** They form half of one chapter in Menning's dissertation and will be presented as a paper in this coming year.

Figure 4.11-8: Diagrams of fire rate of spread and intensity as functions of litter bulk density



THE YEAR AHEAD

Currently, we have no plans to return to the field in the summer of 2001. The primary emphasis of our work at this point is simply to complete Menning's dissertation and provide copies of the final analyses to the National Park Service and USGS. A number of individual papers will be written and submitted over the course of the next few months.

We hope to return to the field in the summer of 2002 to collect additional post-fire data, if available.

4.12) Red Fir Plots (Pitcher Plots)

- Anthony Caprio, Science and Natural Resources Management, SEKI

Lead: A. Caprio, field assistance: Greg Funderburk and Tom Moutsos (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***)

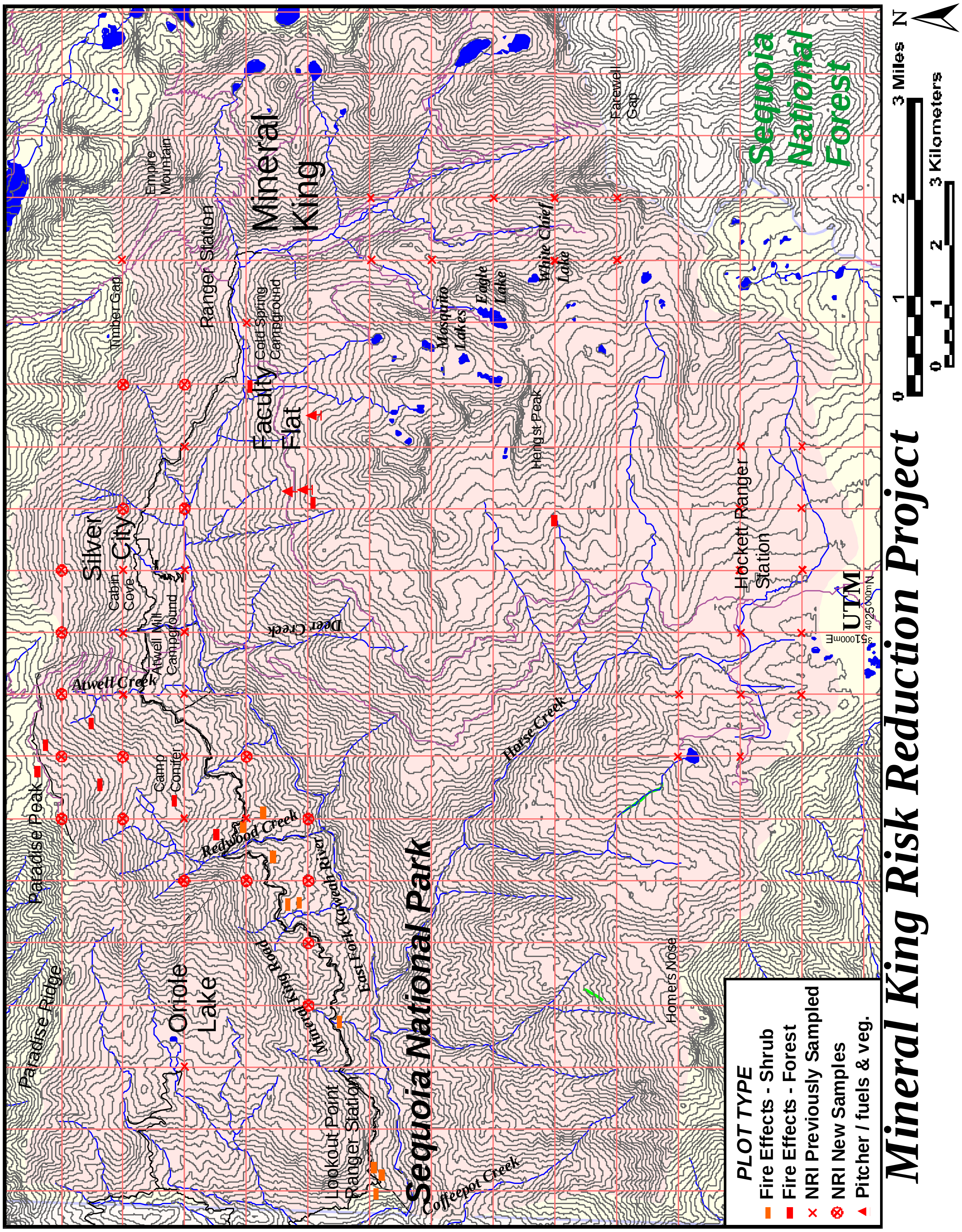


Figure 4.12-1. Plot location for vegetation sampling projects.

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

We were 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 has greatly facilitated comparisons

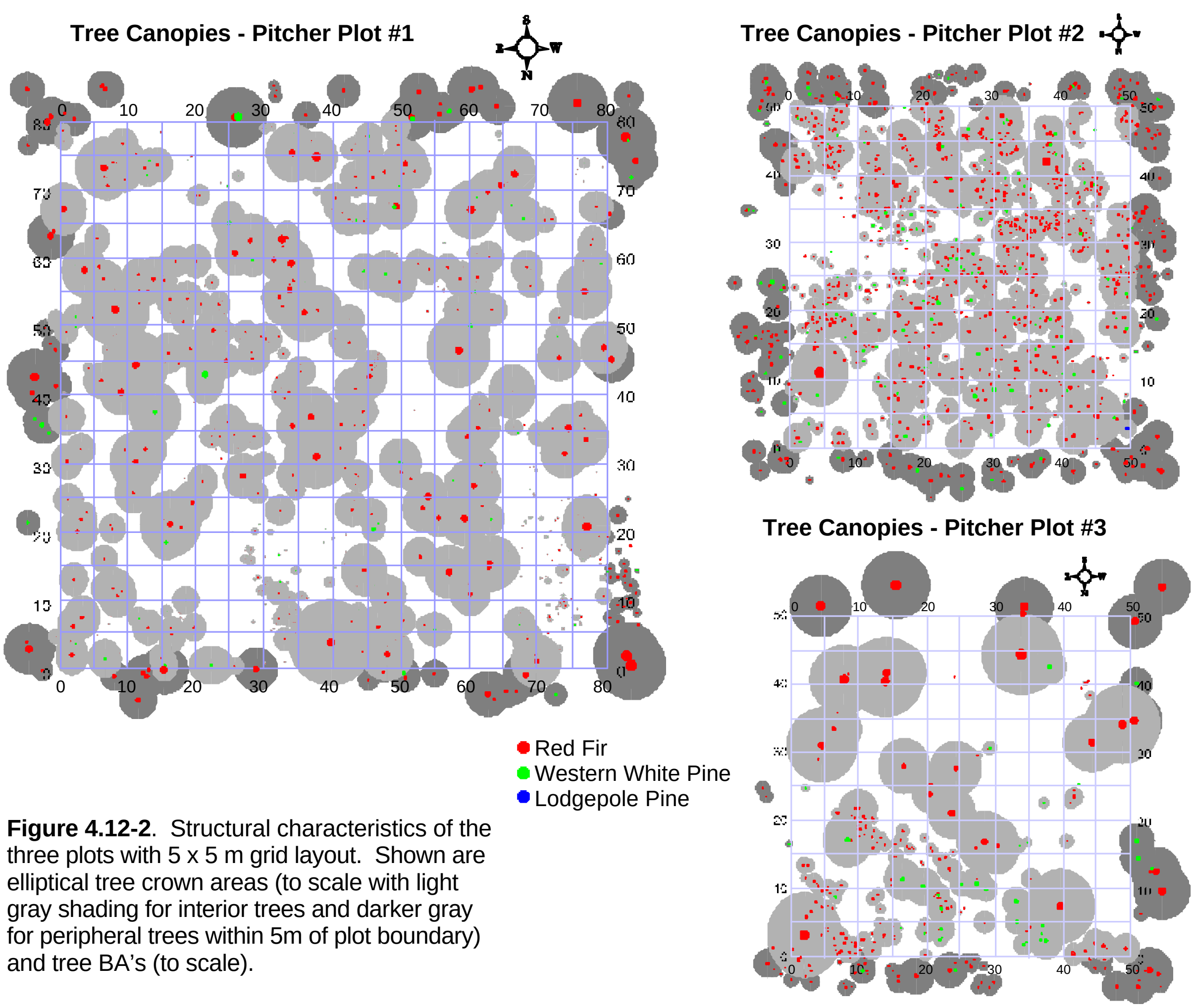


Figure 4.12-2. Structural characteristics of the three plots with 5 x 5 m grid layout. Shown are elliptical tree crown areas (to scale with light gray shading for interior trees and darker gray for peripheral trees within 5m of plot boundary) and tree BA's (to scale).

between the 1978 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).

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 (see Fig. 4.12-3 and 4.12-4 Caprio 2000**)**. Based on these burn maps surface area burned in the two plots was 74.6% and 38.7% 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).

During 2000 post-burn mortality checks were made and DBH's of all trees were retaken in plots #1 and #2. Mortality was most severe in the smallest size class in both of the burned plots (**Fig. 4.12-3**) based on preliminary analysis.

Table 4.12-2. Change in number of individual trees and percent mortality of ABMA and PIMO between 1978 and 1977 and due the 1999 burn.

Plot	Species	1978	1997	% Mort.	2000	% Mort.	% Total Mort.
	ABMA						
1		366	270	26.2	177	34.4	51.6
2		738	540	26.8	320	40.7	56.6
3		187	172	8.0	(172)	0.0	8.0
	PIMO						
1		82	71	13.4	41	42.3	50.0
2		105	76	27.6	47	38.2	55.2
3		32	32	0.0	(32)	0.0	0.0
Total		1510	1161	22.9	789	32.0	47.8

PLANS FOR 2002:

Postburn sampling will be completed during the summer of 2001. Trees will be tagged to facilitate future reference checks of the three stands. Having tagged trees to work from will greatly increase the accuracy of future mortality checks and stem mapping.

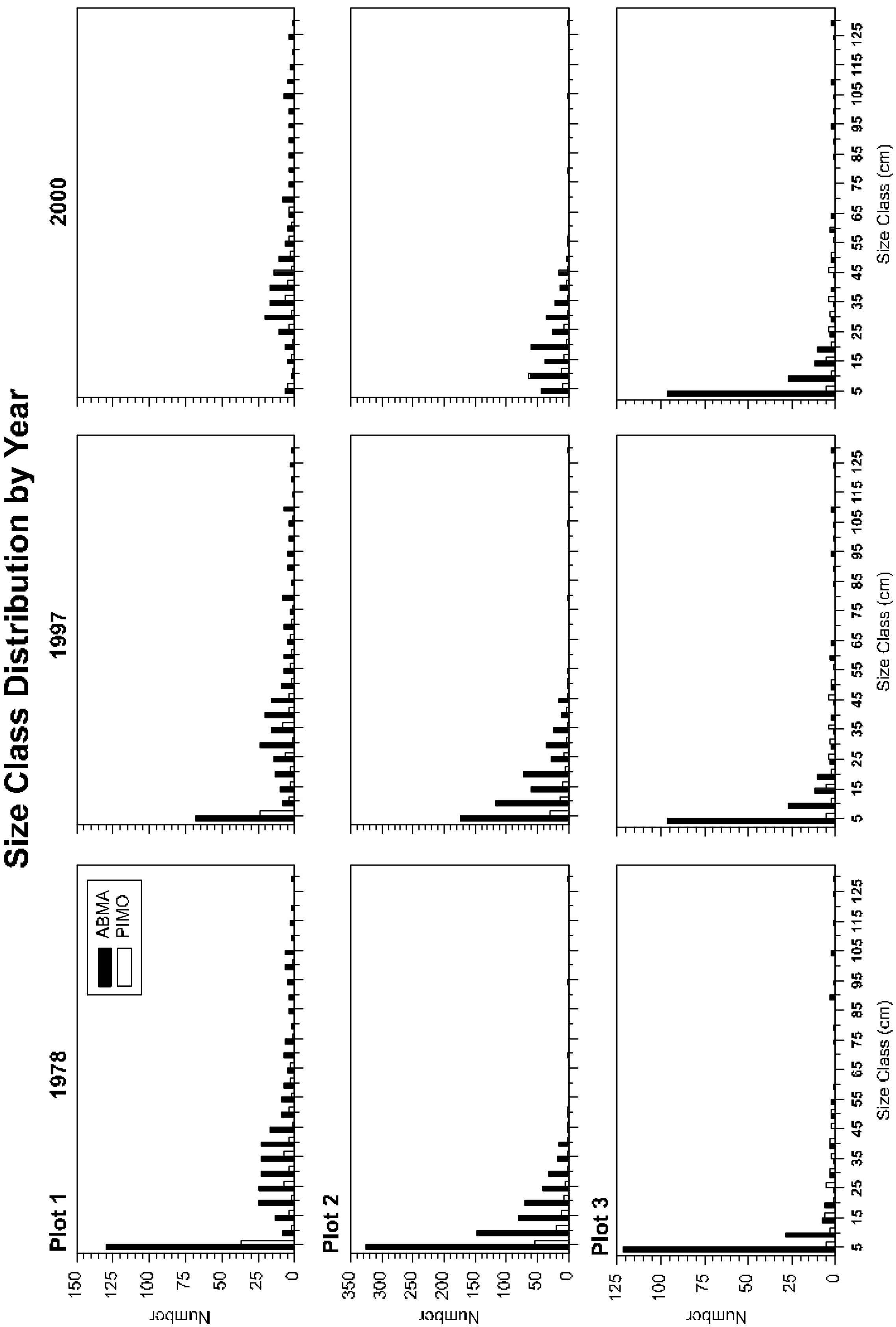


Figure 4.12-3. Size class distribution of all trees.

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.

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.

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: N. Breiter, N. Lozano, A. Schultz, T. Sokol.

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. Monitoring efforts first focused on the giant sequoia groves but have expanded into other vegetation communities as the prescribed fire program has grown.

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 (Table 4.13-1). 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.

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

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

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

WORK ACCOMPLISHED IN 2000

Twenty-five plot re-measurements were accomplished in 2000. No additional new plots were installed this year due to the prescribed fire moratorium imposed on the National Park Service after the escaped fire in Los Alamos, NM. Instead, additional time was dedicated to further update the FMH-6 species list, continue the process of cleaning the FMH database, assist fire management with burn preparation projects, and the mechanical thinning of an exotic plant in the Ash Mountain housing area.

PRELIMINARY FINDINGS AND PERTINENT DISCUSSION

Results to date are summarized below by monitoring type. All analyses consist of data collected through and including the 2000 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 ten years postburn, mean total fuel load was 54% of preburn levels, with wood, litter, and duff reaching 69%, 59%, and 39% of preburn levels, respectively, in this monitoring type (n=12 plots; Figure 4.13-2).

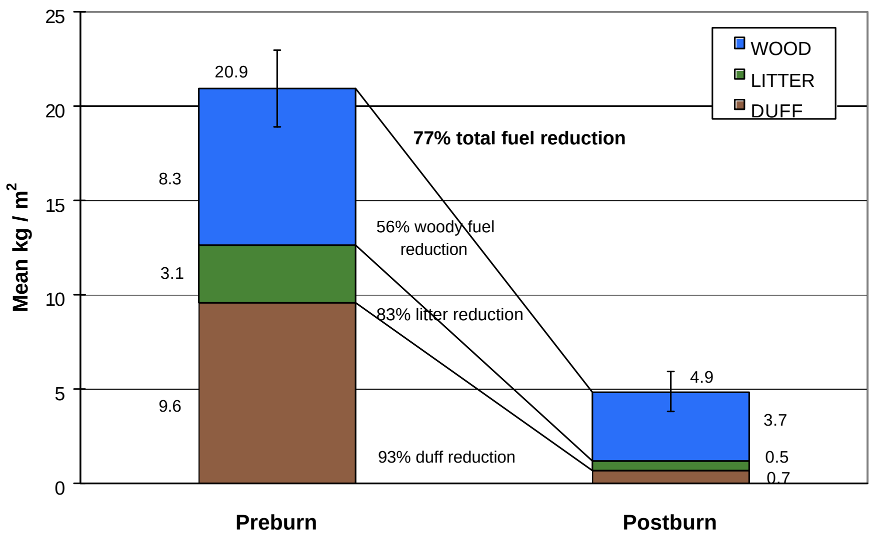


Figure 4.13-1. Fuel reduction in the Giant sequoia-mixed conifer forest type (n=29 plots).

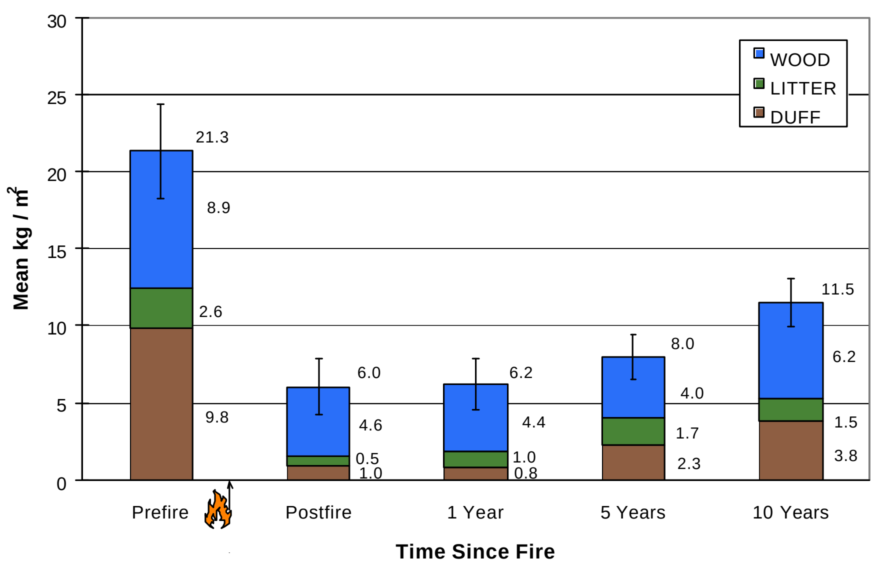


Figure 4.13-2. Fuel accumulation in the Giant sequoia-mixed conifer forest type (n=17 plots).

Four burn units containing 9 plots have been reburned in the Giant sequoia-mixed conifer forest type: one in 1996 (2 plots) that had originally burned in 1982; one in 1997 (1 plot) that first burned in 1989; one in 1998 that first burned in 1987 (2 plots); and one in 1999 that first burned in 1982 (4 plots). The 2 plots that burned in 1998 exceeded the prescription parameter for relative humidity, and, therefore, data from these plots were not included in the analyses.

Mean total fuel load for the 7 plots had reached 88% of the initial preburn level 8-16 years after the initial burn (Figure 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 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).

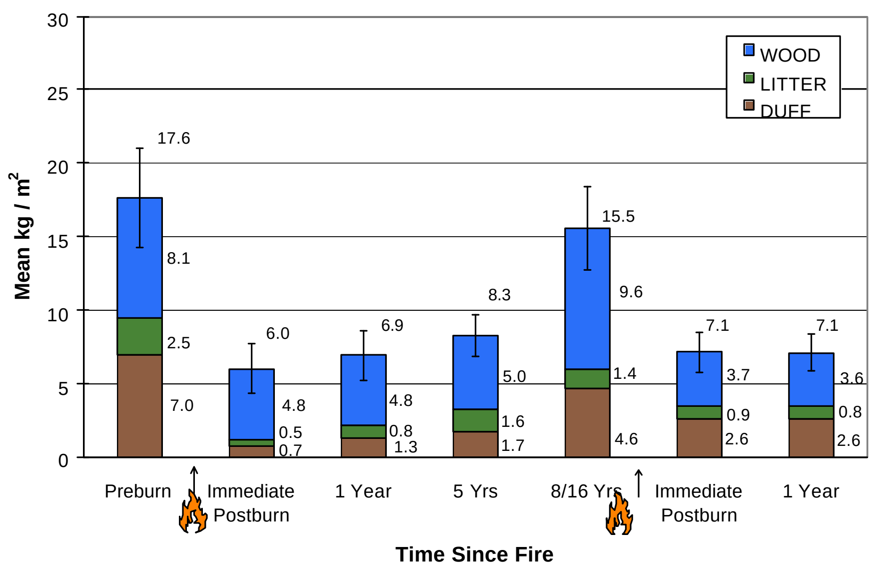


Figure 4.13-3. Fuel load in the Giant sequoia-mixed conifer forest type reburns (n=7 plots).

Stand structure and composition

Mean total tree density in the Giant sequoia-mixed conifer forest type was reduced by 56% ten years following the initial treatment with prescribed fire. Tree diameter distribution changed following fire, with the ten-year postburn mean density of the smaller diameter classes much reduced from preburn densities. Trees <80 cm in diameter at breast height (DBH) were reduced by 60% from 523 ± 135 trees/ha preburn to 210 ± 31 trees/ha ten-years postburn, while trees >80 cm DBH were reduced from 48 ± 9 trees/ha preburn to 43 ± 5 trees/ha 10-years postburn (n=17 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. This increase was due to the successful recruitment of postburn sequoia regeneration (seedlings) into the smallest diameter class of trees (0-10 cm).

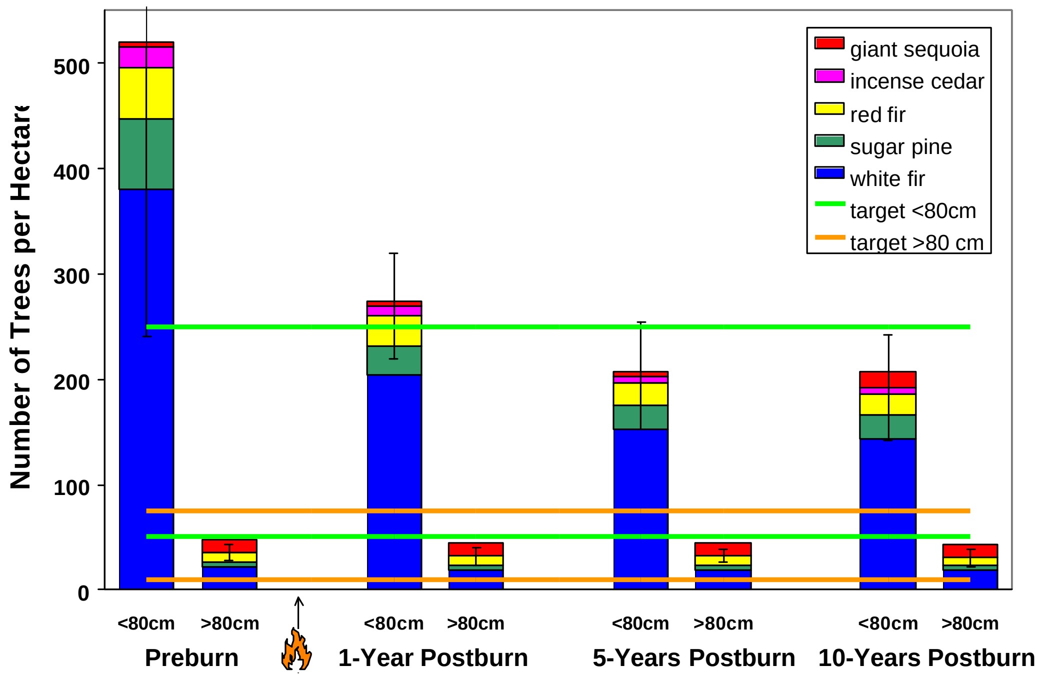


Figure 4.13-4. Stand density by species for two tree diameter classes in the Giant sequoia-mixed conifer forest type (n=17 plots).

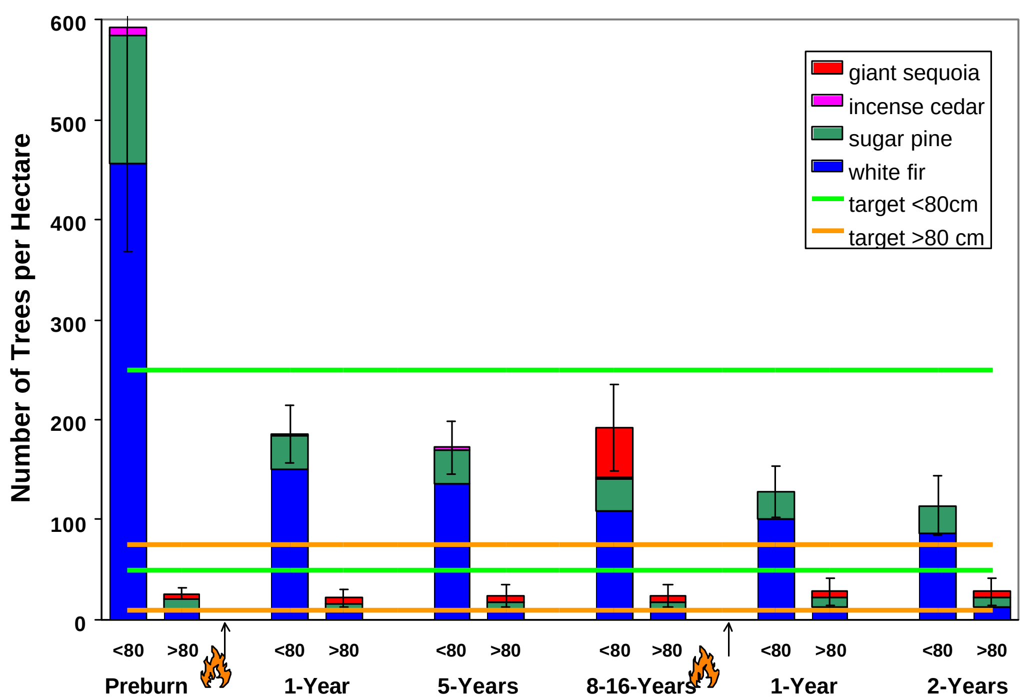


Figure 4.13-5. Stand density by species for two tree diameter classes in the Giant sequoia forest reburns (n=5 plots).

In 5 plots that were reburned and have reached the 2-year postburn stage, total tree density was further reduced from 192 ± 44 trees/hectare 8-16 years after the initial burn down to 114 ± 30 trees/hectare 2 years after the repeat burn (n= 5 plots; Figure 4.13-5). 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. 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 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 not expected in all areas reburned.

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 54% 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 for trees <80 cm in diameter at breast height (DBH), and 10-75 trees/hectare for trees >80 cm DBH. Trees 80 cm in diameter or larger indicates trees that were likely to be established prior to fire regime disruption. In all stand density figures horizontal lines indicate the preliminary minimum and maximum target density values for the two size classes (green for <80 cm and orange for >80 cm). For 17 plots in the Giant sequoia-mixed conifer forest type, preburn mean density for trees <80 cm DBH was 523 ± 138 trees/ha, which is over two times the maximum target value. The preburn mean density of trees >80 cm DBH was 48 ± 9 trees/ha, well within the target range of 10-75 trees/ha. While reduced from the preburn value by 48%, the one-year postburn mean density of trees <80 cm DBH was still higher than the target maximum of 250 trees/ha (274 ± 77 trees/ha). By five years postburn, however, the mean density of trees <80 cm DBH was further reduced to 210 trees/ha, which falls within the target range. The larger trees are only slightly reduced to 43 ± 7 trees/ha by ten-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 (11% reduction in density from preburn to ten-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 smallest diameter class indicates an increase in the relative density of giant sequoia. While a larger sample size is needed to adequately assess the effects of reburning on stand structure, these results will be useful to evaluate progress towards meeting the structural objectives (Keifer and others, 2000).

White fir-mixed conifer forest

Fuel load

In the White fir-mixed conifer forest type, mean total fuel load was 16.1 ± 3.79 kg/m^2 preburn (71.8 ± 16.9

tons/acre) and 3.4 ± 1.5 kg/m^2 immediately postburn (14.9 ± 6.8 tons/acre) (n=10 plots). The mean total fuel 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 4.13-6).

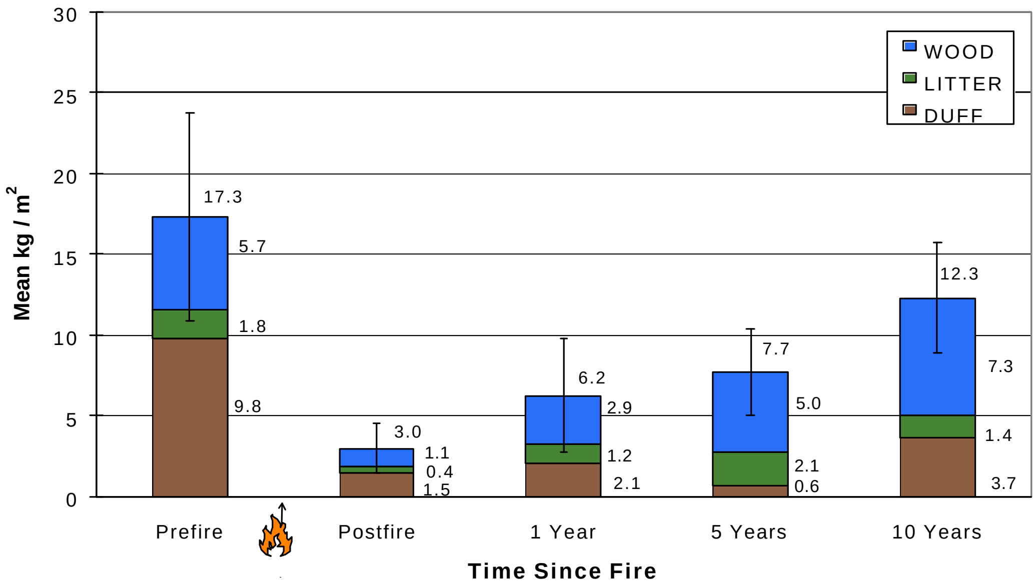


Figure 4.13-6. Fuel accumulation in the White fir-mixed conifer forest type (n=6 plots).

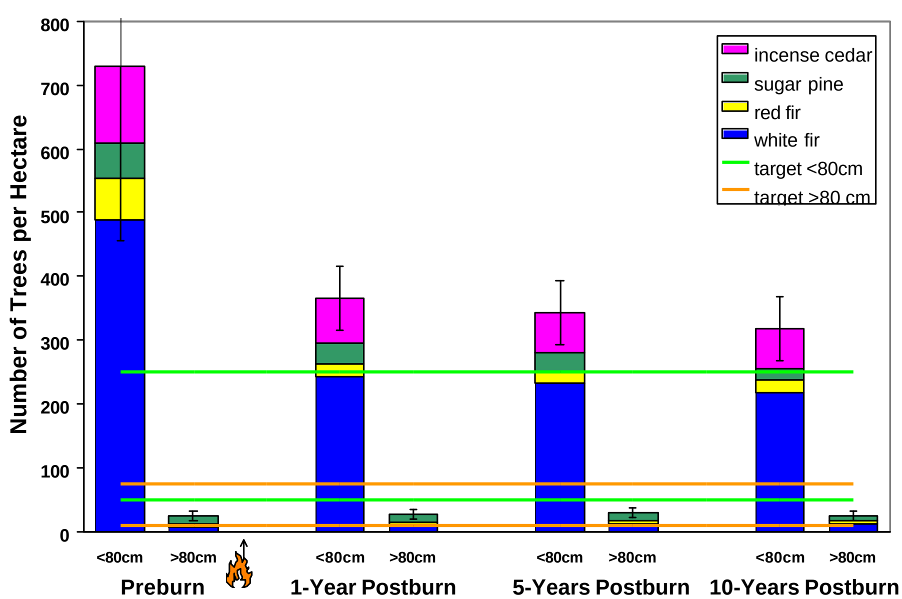


Figure 4.13-7. Stand density by species for two tree diameter classes in the White fir-mixed conifer forest type (n=6 plots).

Stand structure and composition

Mean total tree density in the White fir-mixed conifer forest type was reduced by 55% ten years following prescribed fire. Trees <80 cm DBH were reduced from 735 ± 275 trees/ha preburn to 320 ± 50 trees/ha ten-years postburn (n=6 plots; Figure 4.13-7). Species composition changed very little over this time period, with only 1-2% increases or decreases in species' relative density. Tree diameter distribution changed following fire, with the ten-year postburn mean density of the smaller diameter classes much reduced from preburn densities.

Management implications of results

The total fuel reduction objective of 60-80% is met in the White fir-mixed conifer forest. The mean tree density for trees <80 cm DBH is 320 ± 50 trees/hectare ten-years postburn (n=6 plots), still 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 4.13-8). 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. Five-years postburn, total fuel load accumulated to 58% of preburn levels (n=5 plots; Figure 4.13-8). By five-years postburn, wood exceeded preburn levels (118%), while duff accumulated at a slower rate, reaching 19% of preburn levels.

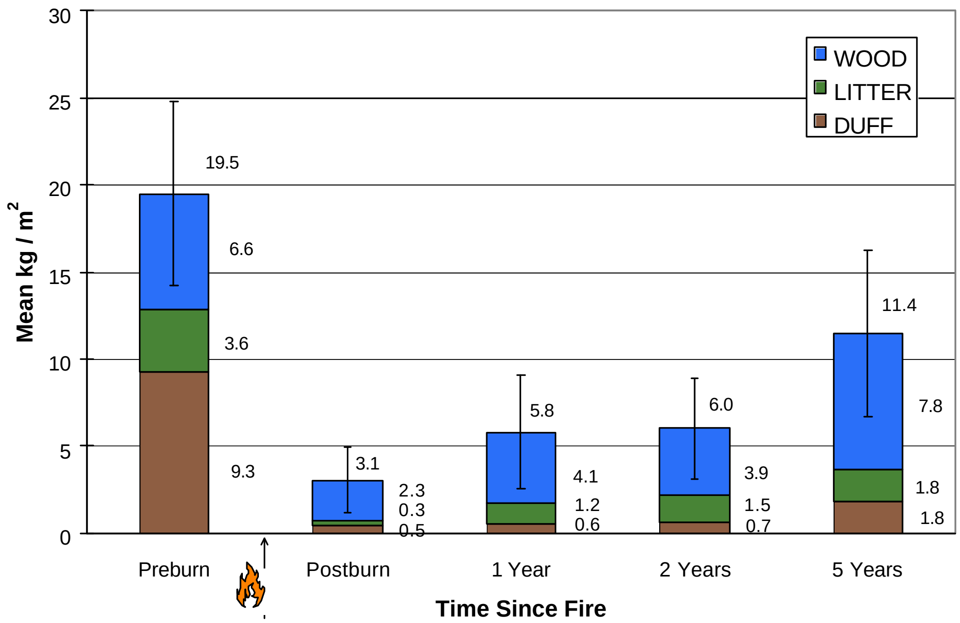


Figure 4.13-8. Fuel accumulation in the Low elevation-mixed conifer forest type (n=5 plots).

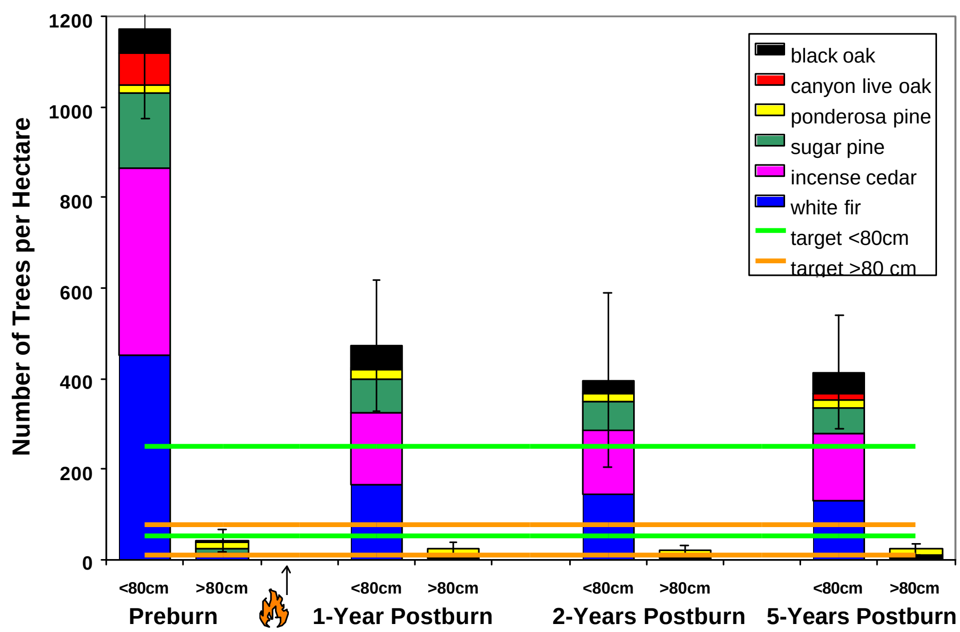


Figure 4.13-9. Stand density by species for two tree diameter classes in the Low elevation-mixed conifer forest (n=5 plots).

Stand structure and composition

Mean total tree density in the Low elevation-mixed conifer forest type was reduced by 63% five years following prescribed burning. Trees <80 cm DBH were reduced from 1194 ± 201 trees/ha preburn to 436 ± 126 trees/ha two-years postburn (n=5 plots; Figure 4.13-9). Some larger tree density reduction occurred in this type with trees >80 cm DBH decreasing by 48% from 42 ± 24 trees/ha preburn to 22 ± 13 trees/ha five-years postburn (Figure 4.13-9).

Management implications of results

The fuel reduction objective was exceeded in these plots and fuel accumulated faster than in other forest types, especially for woody fuels (118% of preburn woody fuel level by five-years postburn). This fuel accumulation is due to the high amount of postburn tree mortality that occurred in the plots. The mean tree density for trees <80 cm DBH is 436 ± 126 trees/hectare five-years postburn (n=10 plots), still well above the target range maximum of 250 trees/hectare and an increase in density from the two-year postburn level. Another burn may be needed to further reduce the small tree density to within the target range. While the sample size is small in this monitoring type, data from these five-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 4.13-10). 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 4.13-10). Woody fuel reached 13% of preburn levels five-years postburn, while litter and duff accumulated proportionally more quickly, reaching 37% and 45% of preburn levels respectively, in this monitoring type.

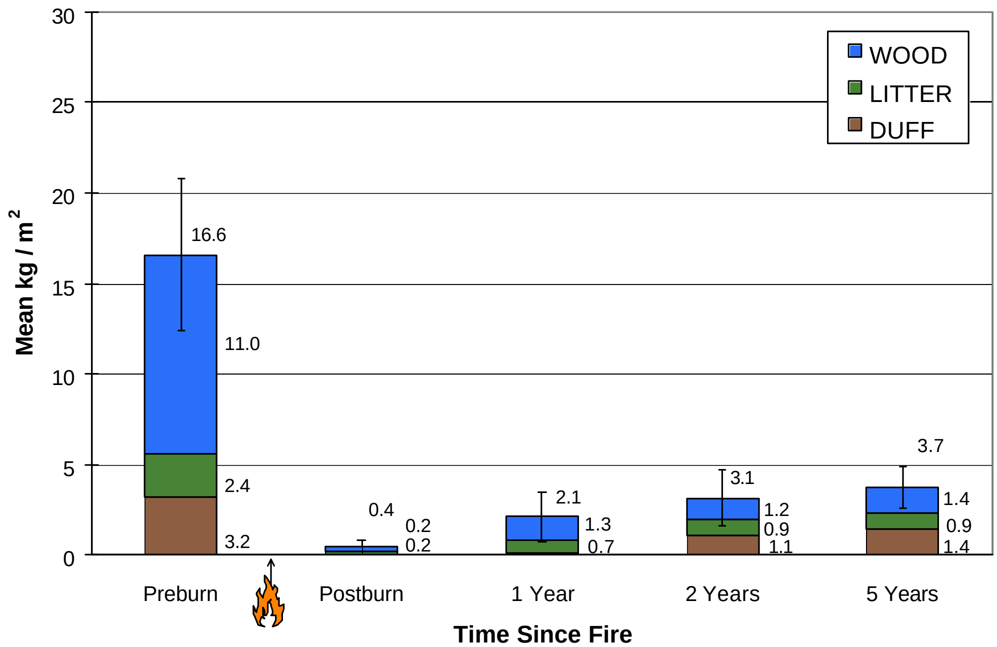


Figure 4.13-10. Fuel accumulation in the Ponderosa pine-dominated forest type (n=4 plots).

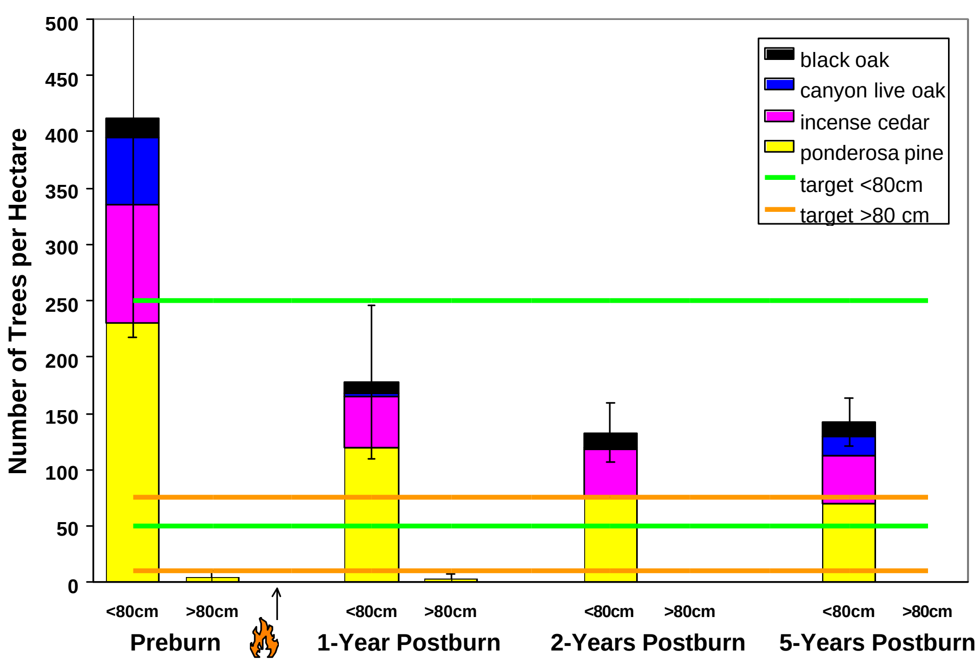


Figure 4.13-11. Stand density by species for two tree diameter classes in the Ponderosa pine-dominated forest (n=4 plots).

Stand structure and composition

Mean total tree density in the Ponderosa pine-dominated forest type was reduced by 66% five years following prescribed fire. Trees <80 cm DBH were reduced from 415 ± 196 trees/ha preburn to 143 ± 22 trees/ha five-years postburn (n=4 plots; Figure 4.13-11). 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. The two ponderosa pine trees >80 cm DBH did not survive by two-years postburn.

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.

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). 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 five years postburn, in two of the plots, little fuel accumulation had occurred (16% of preburn total fuel load). Woody fuels reached 4% of preburn levels, while 30% of preburn litter and duff accumulated by five-years postburn. Note that the preburn mean total fuel load is much higher in this type than any other monitoring type (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). 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). 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.

<u>Mixed chaparral</u>

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 4.13-12). Live tree (all tree species combined) and substrate mean percent cover also decreased slightly, while mean percent cover for grasses (all grass species combined) was slightly reduced one-year postburn but then returned to the preburn value two-years postburn. Substrate includes organic material (leaf litter or wood) as well as mineral soil, ash, or rock. Mean percent cover for forbs (all forb species combined) increased from 2.0 ± 6.2% preburn to 8.5 ± 23.1% one-year postburn and then a large increase to 41.5 ± 103.1% two-years postburn (Figure 4.13-12). Note that percent cover can total more than 100% as more than one lifeform (or species) can occur at a sampling point. These results indicate that the only major change in cover of vegetative lifeform categories was a large increase in forbs, however, with such a small sample size (2 plots), broad conclusions cannot be drawn from these data alone.

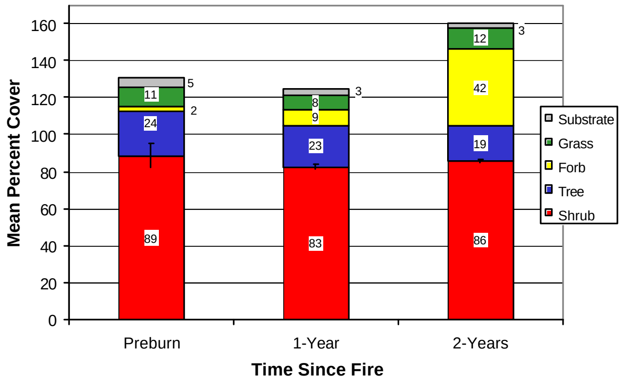


Figure 4.13-12. Percent cover by lifeform in the Mixed chaparral type (n=2 plots).

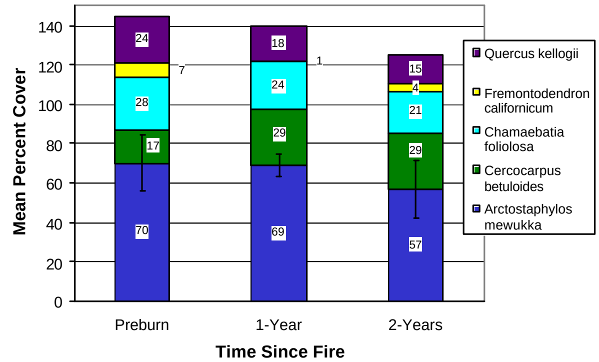


Figure 4.13-13. Percent cover by species in the Mixed chaparral type (n=2 plots).

Cover by species

Mean percent cover for live *Arctostaphylos mewukka*, the dominant species, changed very little between preburn (70.2%) and one-year postburn (69.0%) visits, but decreased by about 20% by two-years postburn (Figure 4.13-13). Black oak (*Quercus kellogii)* and bear clover (*Chamaebatia foliolosa*) decreased somewhat in mean percent cover. Flannelbush (*Fremontodendron californicum*) mean percent cover decreased one-year postburn but then increased two-years postburn (Figure 4.13-13). Mountain mahogany (*Cercocarpus betuloides*) mean percent cover increased from 16.5 ± 13.9% preburn to 28.5 ± 38.5% one-year postburn. The large increase in forbs can be attributed primarily to one species, miner's lettuce (*Claytonia perfoliata*) which was not detected preburn but had a mean percent cover of 37.0 ± 95.4% five years after the fire. Cheatgrass (*Bromus tectorum*), a highly invasive exotic grass, was found within these plots before burning. The mean percent cover of cheatgrass decreased slightly, from 2.5 ± 1.5% preburn to 1.5 ± 4.6% one-year postburn but then increased to 4.5 ± 4.6 two-years postburn. The sample size is too small to make any conclusions about changes observed in cheatgrass cover following burning.

Management implications of results

Newly developed target conditions for brush monitoring types are stated in terms of the amount of landscape within a certain 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.

Chamise chaparral

Postburn conditions

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

Cover by lifeform

Mean percent cover for live shrubs (all species combined) decreased by 84% from 93.0 ± 6.6% preburn to 15.0 ± 28.3% postburn. An increase to 26.0 ± 25.6% one-year postburn and 63.0 ± 14.6% indicates that vigorous postburn resprouting occurred and continues to grow (Figure 4.13-14). A corresponding increase in mean percent cover of substrate occurred immediately after burning, from 7.0 ± 3.5% preburn to 74.0 ± 16.1% postburn indicating that much of the vegetative cover was consumed during the burn. Two years since the burn, substrate mean percent cover was quickly reduced to an average of 20.0 ± 6.6% (Figure 4.13-14).

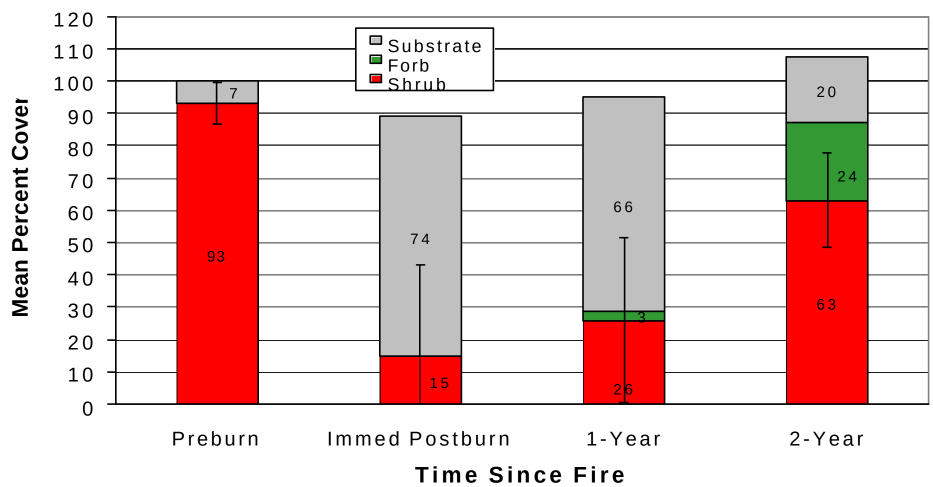


Figure 4.13-14. Percent cover by lifeform in the Chamise chaparral type (n=3

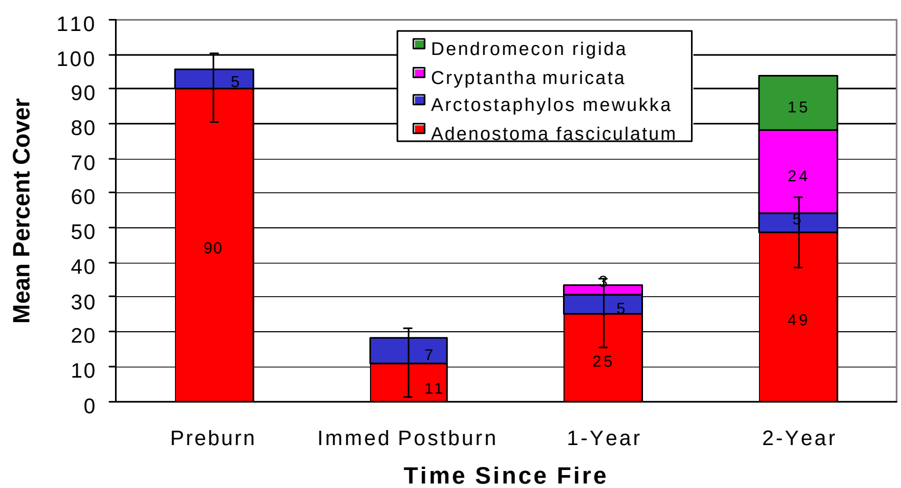


Figure 4.13-15. Percent cover by species in the Chamise chaparral type (n=3 plots).

Cover by species

Mean percent cover for live chamise (*Adenostoma fasciculatum*), the dominant species, was reduced by 88% from 90.3 ± 11.6% preburn to 11.0 ± 20.7% postburn (Figure 4.13-15). Mean percent cover increased to 25.3 ± 16.4% one-year postburn and 48.7 ± 23.5% by two-years postburn. *Arctostaphylos mewukka* mean cover increased slightly, between the preburn and immediate postburn measurements, likely due to slight differences in transect location from one visit to the next (an artifact of sampling). Two-years postburn, mean percent cover of *Cryptantha muricata* and bush poppy (*Dendromecon ridgida*) was 24.3% and 15.3%, respectively, and neither species had been recorded in the plots prior to the burn.

Management implications of results

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

Montane chaparral

Cover by lifeform

Live shrub cover (all species combined) was reduced from 68.3 ± 10.6% preburn to 0.5 ± 0.5% one-year postburn, increased to 2.3 ± 1.4% two-years postburn followed by a large increase to 18.0 ± 6.0% by five-

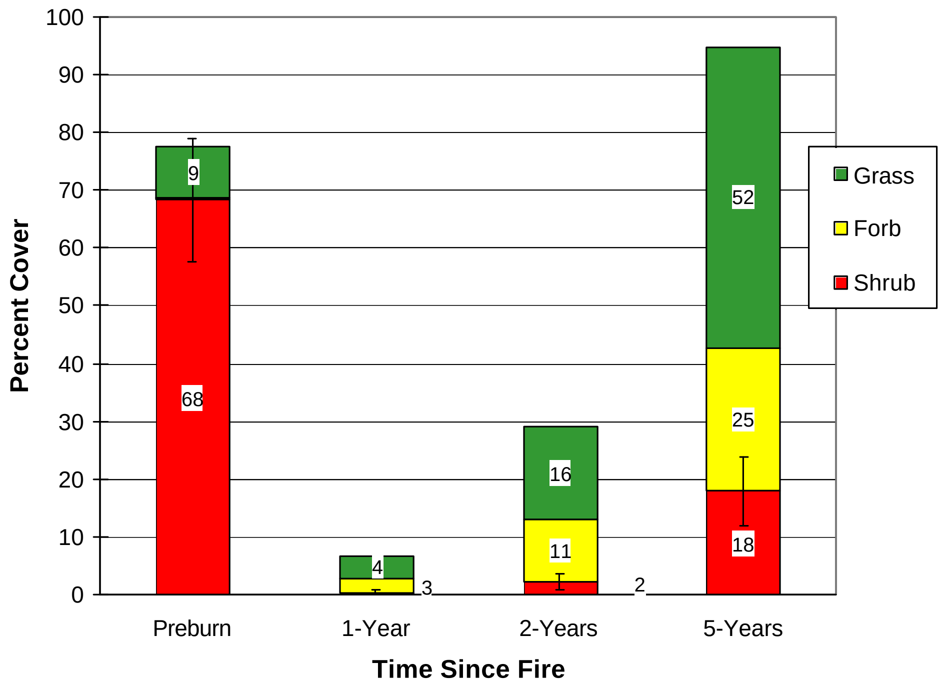


Figure 4.13-16. Percent cover by lifeform in the Montane chaparral type (n=4 plots).

years postburn (n=4 plots; Figure 4.13-16). Forb and grass cover increased steadily from 0.2 to 24.8% and from 9.0 to 52.0%, respectively, from preburn to fives years following fire. Species that decreased in percent cover include greenleaf manzanita (*Arctostaphylos patula*) and sagebrush (*Artemesia tridenta*). While mountain whitethorn (*Ceanothus cordulatus*) decreased slightly in the first years following fire, a large increase occurred by five years postburn. Western needlegrass (*Achnatherum occidentalis*), blue wildrye (*Elymus glaucus*), and broad-leaved lotus (*Lotus crassifolius*) all increased in relative cover.

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

PLANS FOR 2001

The number of plot visits will increase to 28 re-measurements and the potential for at least 8 immediate postburn plots next year. In addition, up to 9 new plots may be installed depending on the units that will actually burn in 2001.

REFERENCES

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

National Park Service. 2001. Fire Monitoring Handbook. USDI National Park Service.

4.14) Fuels Inventory and Monitoring

Corky Conover, Fire Management, SEKI

Lead: C. Conover. Crew Leader: L. Uhr. Crew: B. Dethlefs, D. Loveland, J. Seymour, and M. Wilson

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

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.

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" in the overstory and their diameter at breast height (DBH) was measured and recorded. An average value was being calculated from the three trees measured and used to represent the overstory trees at that sampling point.

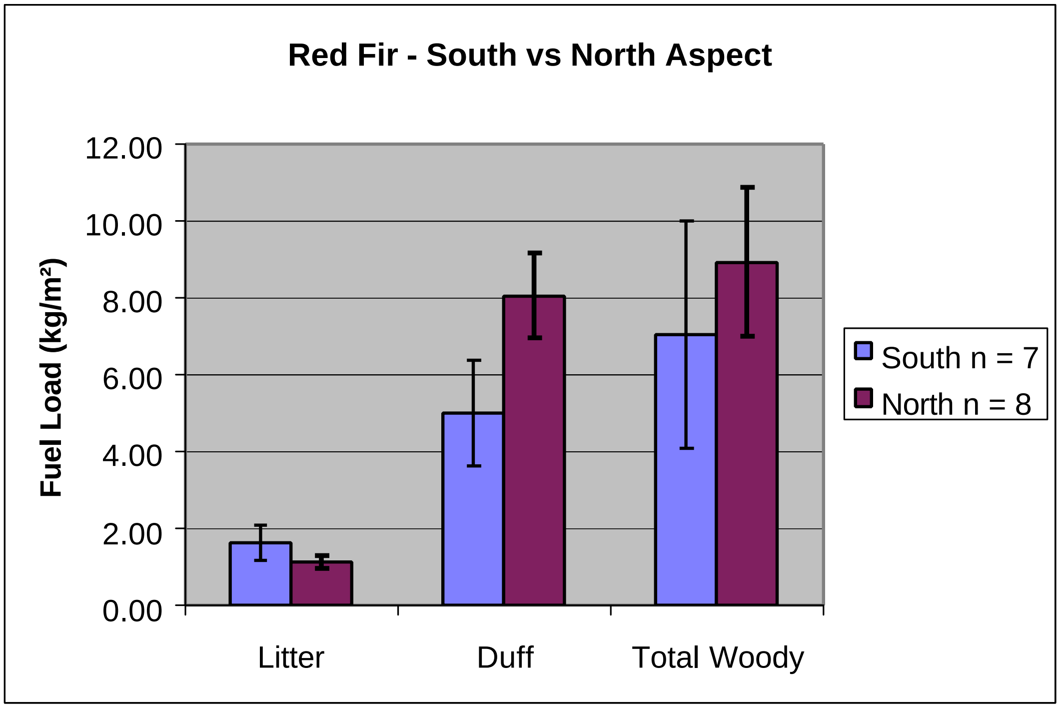
The following measurements were also taken at each permanent plot with a clinometer and recorded: overstory tree height, height to live crown base for each distinct canopy layer (dominate, intermediate, understory). Canopy cover was measured with a densiometer and recorded using the following codes: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

WORK ACCOMPLISHED IN 2000: The crew established three (1 Ponderosa Pine South Aspect and 2 Red Fir South Aspect) new permanent fuel plots in 2000. 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.

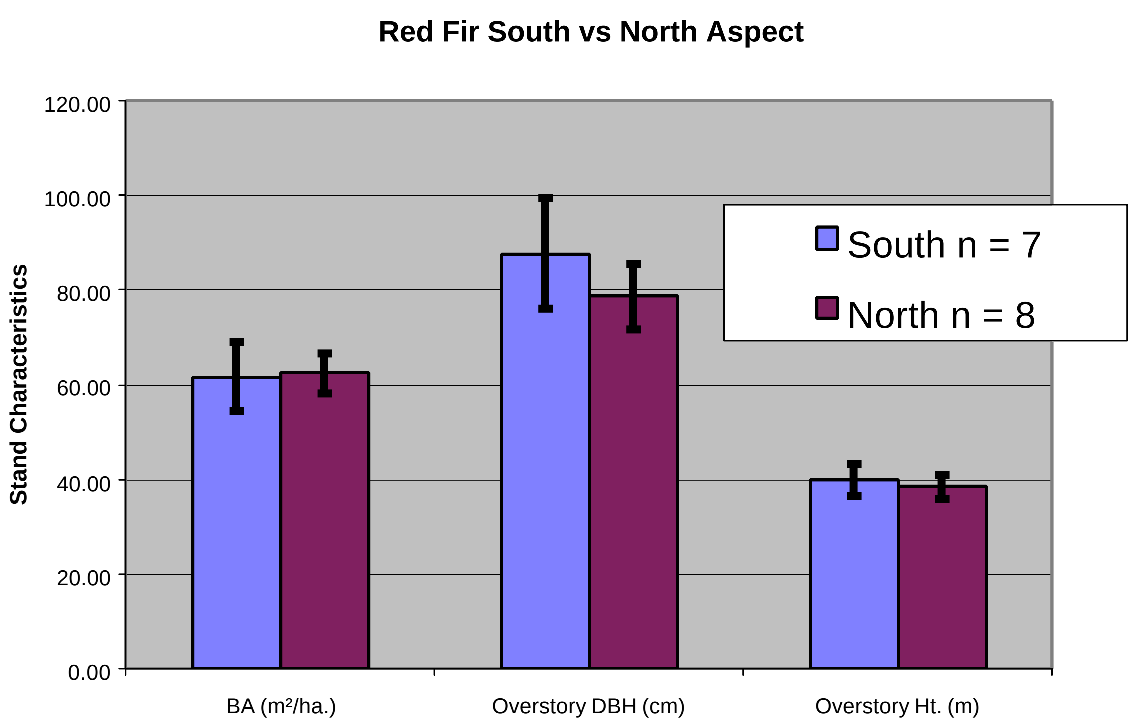
We decreased the percent error of the total fuel-loading estimate from 40.9% to 26.2% for the south aspect Red Fir Forest type, but we are still above our goal of twenty- percent. The Red Fir Forest had fuel loads of 1.6 kg/m² (litter), 5.0 kg/m² (duff), and 7.0 kg/m² (woody) for the south aspects (105-285°) and 1.1 kg/m² (litter), 8.1 kg/m² (duff), and 8.9kg/m² (woody) on the north aspects (286-104°).

Figure 4.14-1.



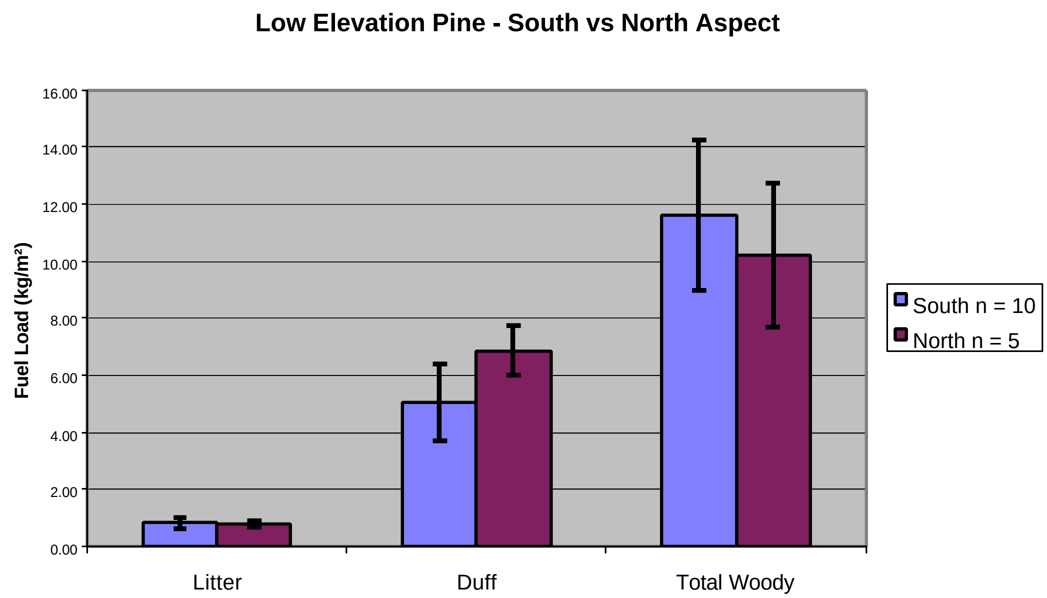
The basal area for the south aspects was 61.6 m²/hectare compared to 62.4 m²/hectare on the north aspects. The overstory tree heights were higher for the south (39.9 m) than for the north (38.5 m) aspects. The diameter at breast height (dbh) was larger for the south (87.6 cm) than for the north (78.7 cm) aspects.

Figure 4.14-2.



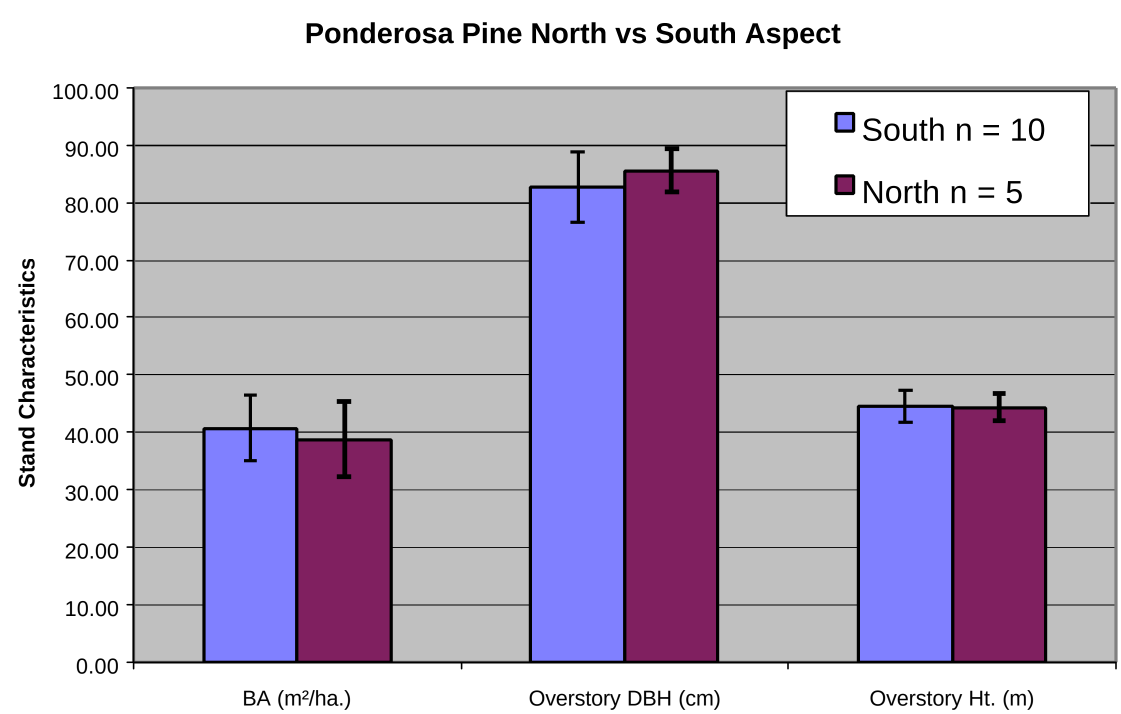
We decreased the percent error of the total fuel-loading estimate from 23.2% to 20.5% for the south aspect Ponderosa Pine Forest type, but we are still above our goal of twenty- percent. The Ponderosa Pine Forest had fuel loads of 0.8 kg/m² (litter), 5.0 kg/m² (duff), and 11.6 kg/m² (woody) for the south aspects (105-285°) and 0.8 kg/m² (litter), 6.9 kg/m² (duff), and 10.2kg/m² (woody) on the north aspects (286-104°).

Figure 4.14-3



The basal area for the south aspects was 40.7 m²/hectare compared to 38.8 m²/hectare on the north aspects. The overstory tree heights were slightly higher for the south (44.6 m) than for the north (44.3 m)

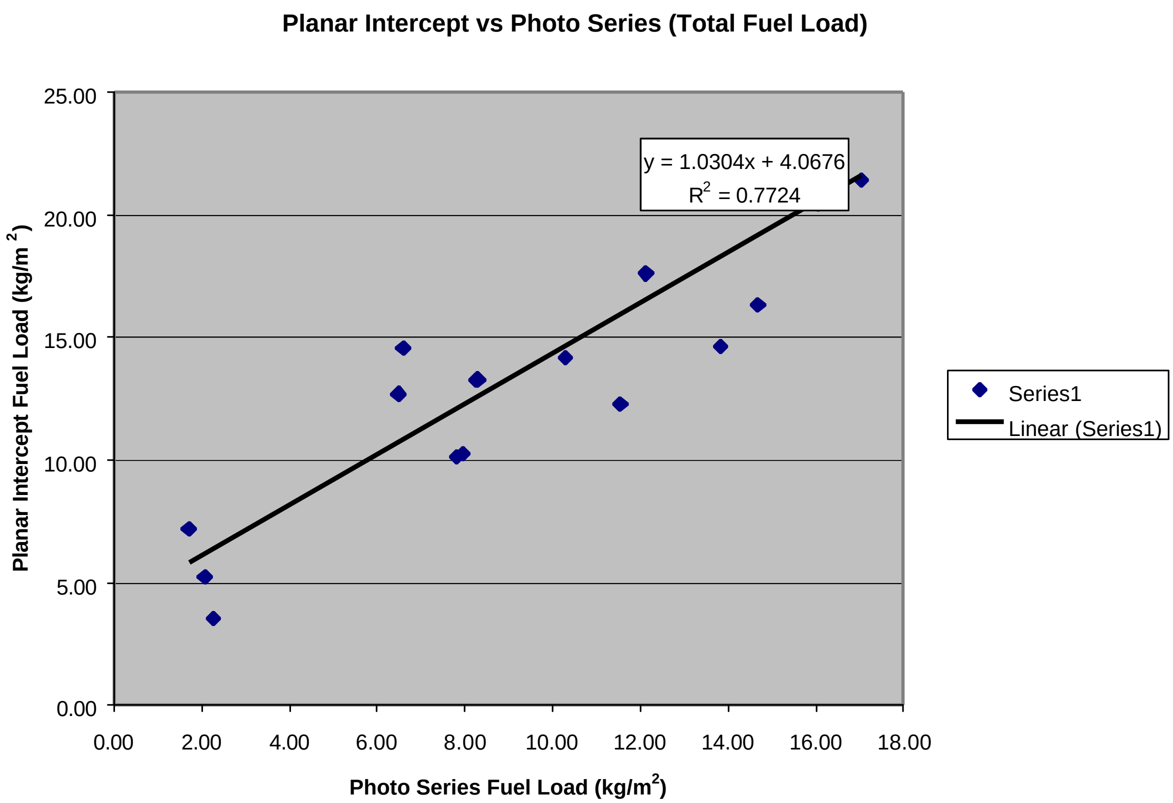
Figure 4.14-4.



aspects. The diameter at breast height (dbh) was smaller for the south (82.6 cm) than for the north (85.5 cm) aspects.

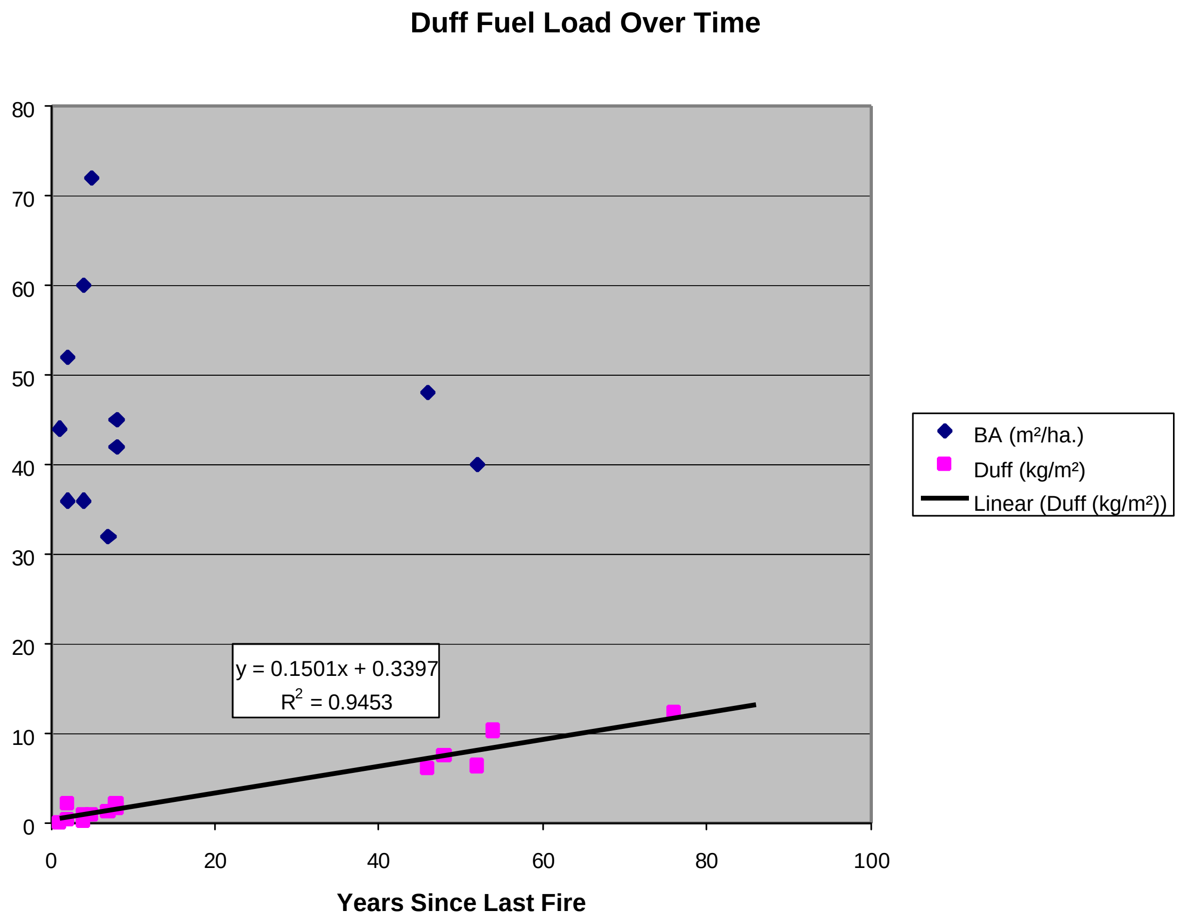
Previous years (98-99) reports indicated that we would take photo series estimates at the same location where we installed the permanent plots to see if a correlation exits between the two methodologies. If a correlation can be established, we will use this correlation to survey future areas because you can collect about five times as many sample points with the photo series when compared to the planar intercept method. The results are steadily improving and there appears to be a relationship between the two methods.

Figure 4.14-5.



When we compared the known fire history with our plot locations, we came up with fourteen plots that occurred in areas that we knew the date of the last fire. As stated in previous years (98-99) reports 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 fuel load over time. We increased our sample size from eleven to fourteen plots this season and we continue to show a good relationship (R^2 = .945) with duff load overtime (**figure 4.14-4**). With the additional data we have improved our linear relationship for litter fuel load over time (R^2 = .547 up from R^2 = .294). Last year we collected our new data in areas of older fires (>20 years), much of the earlier 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 for the other fuel categories.

Figure 4.14-6.



<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 1 new plot in the Low Elevation Pine South aspect forest type and between 2-3 new plots in Red Fir South aspect forest 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 locate 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.

4.15) Fire History

- Anthony Caprio, Science and Natural Resources Management, SEKI

Lead: A.C. Caprio, Field crew: Greg Funderburk and Tom Moutsos (SCA)

INTRODUCTION

Over the last three decades the Sequoia and Kings Canyon National Park's fire management program has evolved to where it is now attempting to restore fire at landscape scales. 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 can, at least temporarily, obtain fairly reliable information about past fire regimes from a proxy record based on fire scarred trees found in most of our forested plant communities. This record documents the minimal role of fire within the land units sampled. Dendroecological analyses of these samples provides a powerful additional tool to characterize attributes of past fire regimes, to examine their variability and to understand how they have shaped landscapes over time. This record about the past provides reference information that can supply guidance for ecologically sound fire management practices today and assist in understanding potential future changes in park ecosystems.

While fire history research has been carried out in Sequoia and Kings Canyon National Parks for many years (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 remain in our knowledge and understanding at many levels (Caprio and Lineback 1997). 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 2000) and to ecologists interested in understanding dynamics of pre-Euroamerican plant and wildlife communities.

A growing body of empirical 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.

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. The 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.

Fire history sites have been collected at an array of locations to help answer some of these questions. These include sites in the East, South, and the Marble Forks of the Kaweah River, and in Kings Canyon. The primary emphasis of the latter three collection areas has been to determine whether patterns of past fire occurrence in these landscapes was similar to that observed in the East Fork where the most intensive sampling has been carried out.

I - EAST FORK WATERSHED FIRE HISTORY COLLECTIONS

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 2000)

DATA COLLECTION and ANALYSIS

Sampling has been ongoing over the past five summer seasons in the coniferous forest zone within the East Fork watershed (**Fig. 4.15-1**). During 2000 only a few sites were collected with emphasis primarily placed on filling gaps in the network collected throughout the forested portions of the watershed.

Sites general consist of multiple trees collected in close proximity (~1 ha) in an area that is uniform vegetatively and topographically. Confining a sample site to a small area largely eliminates inflating fire frequency estimates that result from sampling large areas where multiple non-overlapping fires can occur (see Arno and Peterson 1983). The sampling scheme is designed such that each tree is considered a subsample and a site is considered a replicate representing a single location on the landscape. Stand characteristics have also been collected for the area where each specimen was obtained. This included information on species composition and cover, total canopy cover, BA, understory vegetation, fuel, and topographic features. Individual area specimen data is averaged into an overall site characterization. This information is of great value in interpreting the fire regime information. It also has value in documenting vegetation at a large number sites over the landscape that can be used in variety of resource or research projects. For example, the current vegetation mapping effort will be able to use the data to assist in assessing aerial photos when defining plant associations (see Haultain 2000).

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 1999.

Table 4.15-1. Summary of site collections within the East Fork by vegetation class through 2000.

Vegetation Class	Number of Sites
Ponderosa Pine	4
Ponderosa/Mixed Conifer	31
White Fir Mixed Conifer	23
Sequoia Mixed Conifer	9
Red Fir	40
Lodgepole Pine	12
Subalpine Forest	2
Xeric Conifer	2
Foothill	1
Chaparral*	**(7)**
Meadow	0
Total	**136**

*** Low elevation forested sites embedded in chaparral vegetation included in other vegetation totals above.**

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 (see **Fig. 4.16-2** Caprio 2000). 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 and high and low elevation conifer forest was separated at 2286 m elevation.

RESULTS and DISCUSSION - Preliminary Analysis

Forty-seven specimens (logs, stumps, snags, or trees) were collected from 8 sites during 2000. This supplements samples from 128 sites previously collected (Caprio 1997, 1998, 2000a, 2000b). The large number of sample sites are required to provide adequately replicated data sets from across vegetation type, elevation, and aspect. The data set is providing baseline information on how past fire regimes operated and varied throughout a watershed with complex topography and vegetation communities. Since 1995 samples from the drainage have been obtained from 10 of the 11 major vegetation classes currently designated in the Parks (**Table 4.15-1**). This includes sites from both north and south aspects and over a range of elevations (**Table 4.15-2**). 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 or little sampled in the Parks. These include Jeffery pine, lodgepole pine, foxtail, western juniper, and oak woodland while others,

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	28	20	8
2000-2250	28	19	9
2250-2500	19	11	6
2500-2750	33	12	21
>2750	14	8	6
Total	131	79	52

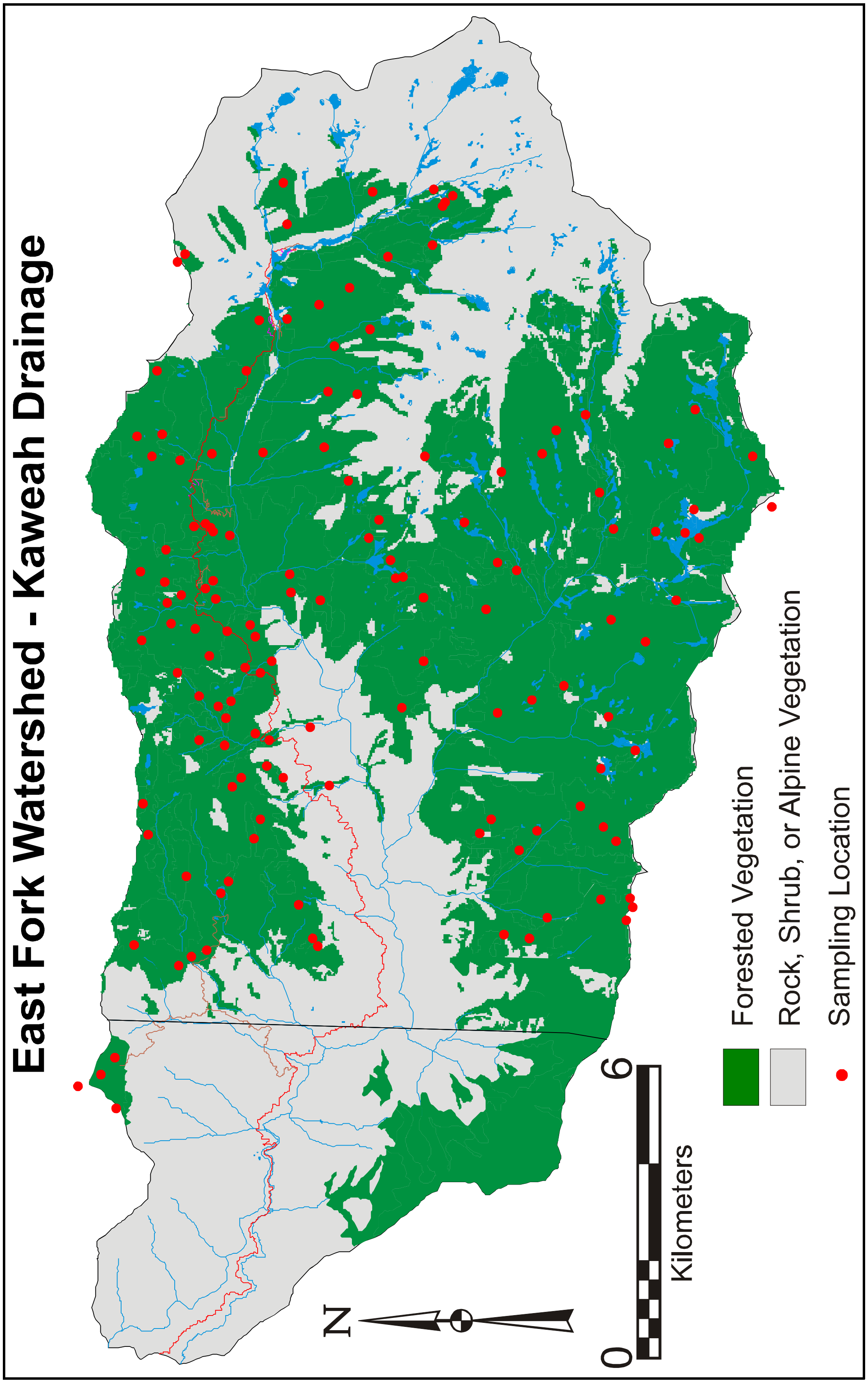


Figure 4.15-1. Fire history collection sites in the East Fork of the Kaweah Watershed.

such as red fir and nearly all vegetation types located on north aspects, which have been sampled sparsely at best.

Currently 136 sites have been collected [two of these were previously collection in the Atwell giant sequoia grove by Swetnam et al. (1992)] with 587 individual trees sampled (primarily logs and snags). The sites are located throughout the 12,887 ha watershed (**Fig. 4.15-1**) so that 82 % are within 1000 m of any other site. Mean number of samples collected at individual sites is 4.3 (SD=2.4). Fire dates have been determined from ~108 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 2722 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 (sampling in recent burns has been avoided or not possible because most fire history material at these locations has been destroyed by the fires).

Annual Area Burned

Striking patterns of past fire occurrence are emerging as more sites are collected and crossdated from a 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 or that the fire left no record--did not scar trees or a sample with the scar was not collected or the scar was destroyed by subsequent fires--even though a fire occurred.

A chronosequence of annual burn patterns back into the early 18th century will be developed for the 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.4.15-2**). 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. 4.16-3**). 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. These data suggest that

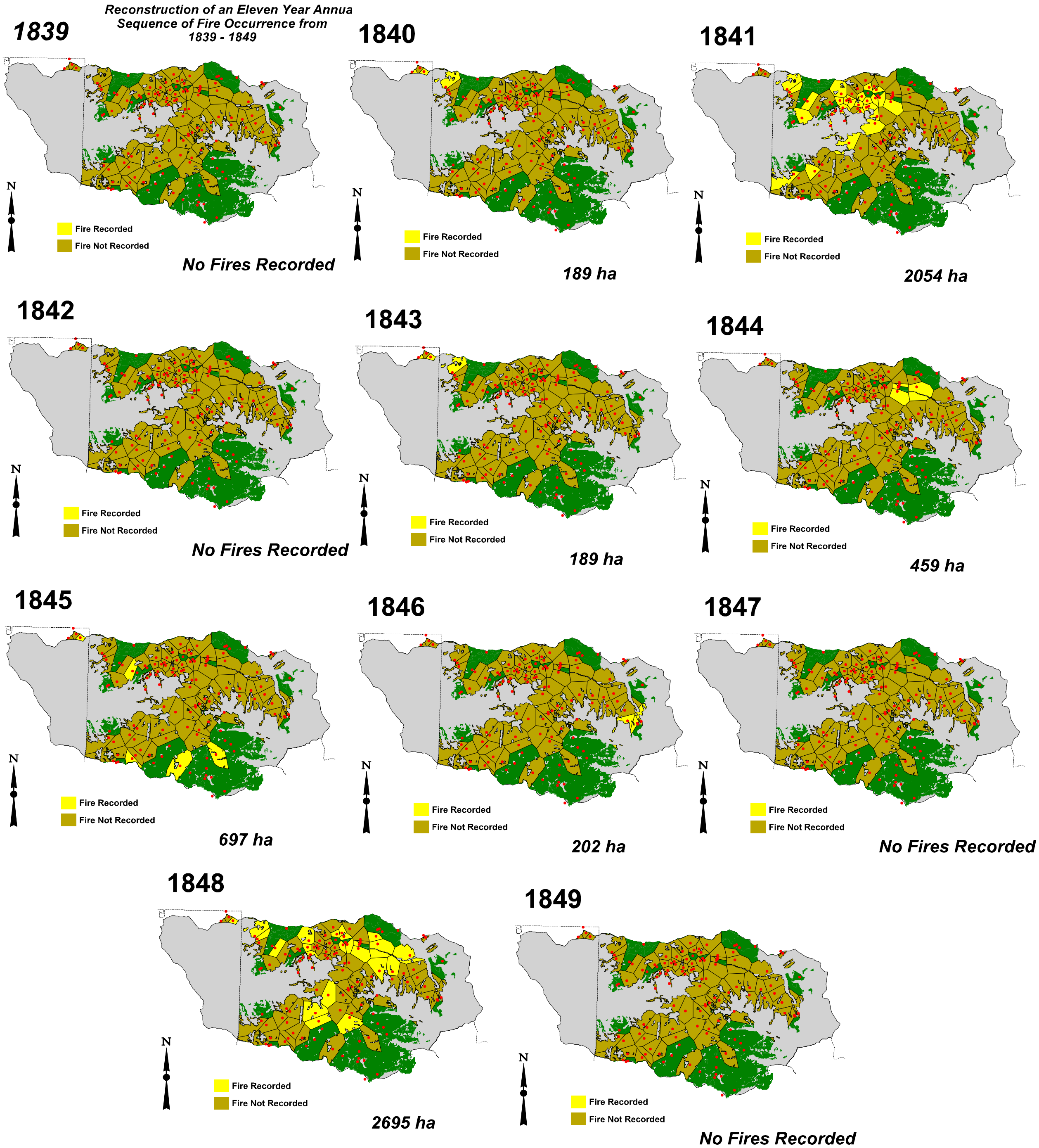


Figure 4.15-2. Chronosequence of reconstructed annual area burned between 1839 and 1849 showing variation in burn patterns across the landscape.

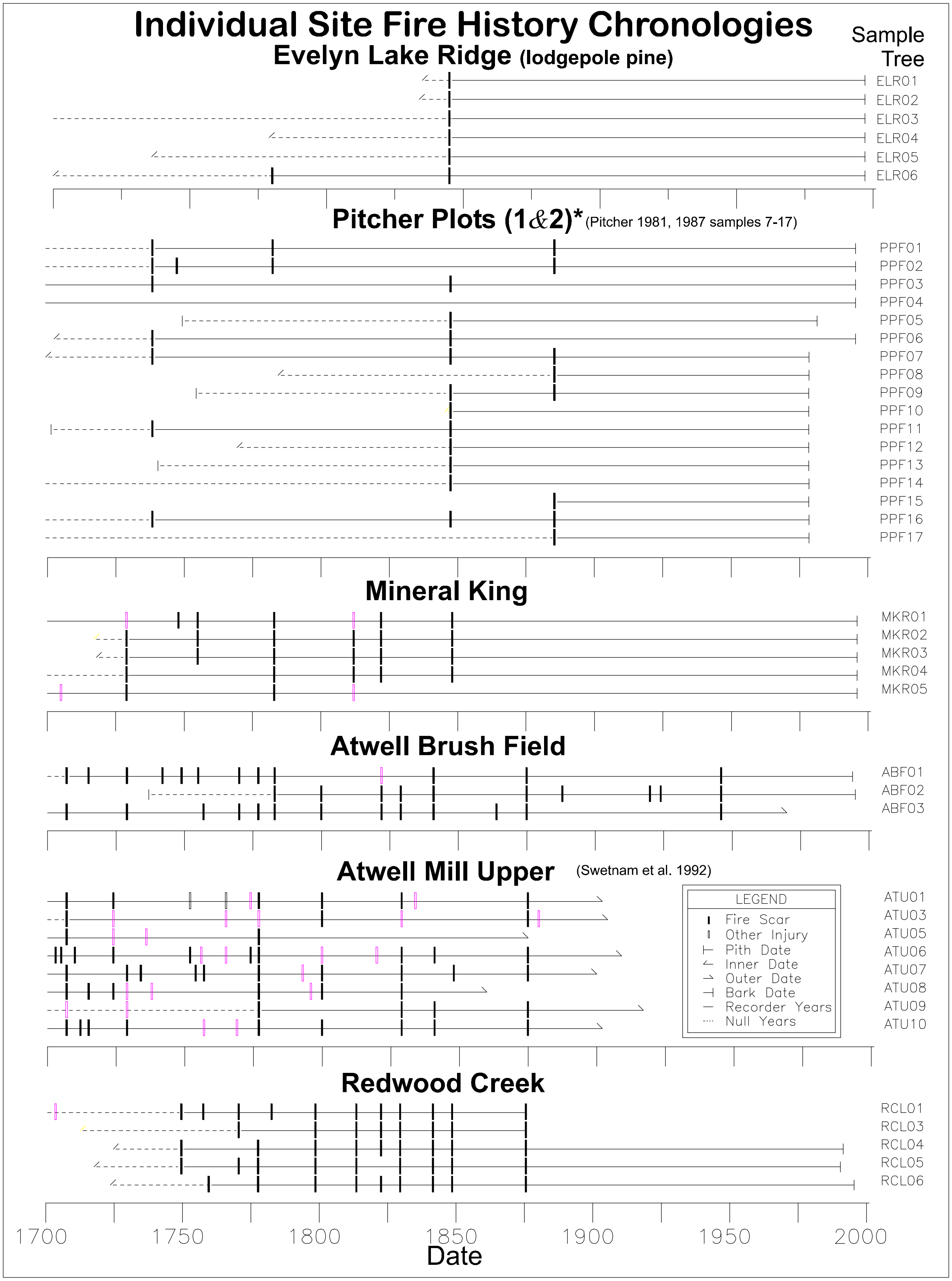


Figure 4.15-3. Examples of reconstructed fire history data from five sites in the East Fork drainage for the period from 1700 to the present. Sites illustrate varying pre-Euroamerican fire regimes from differing vegetation types and aspects in the watershed. Horizontal lines represent a particular sample (one tree) with vertical bars indicating crossdated fire dates.

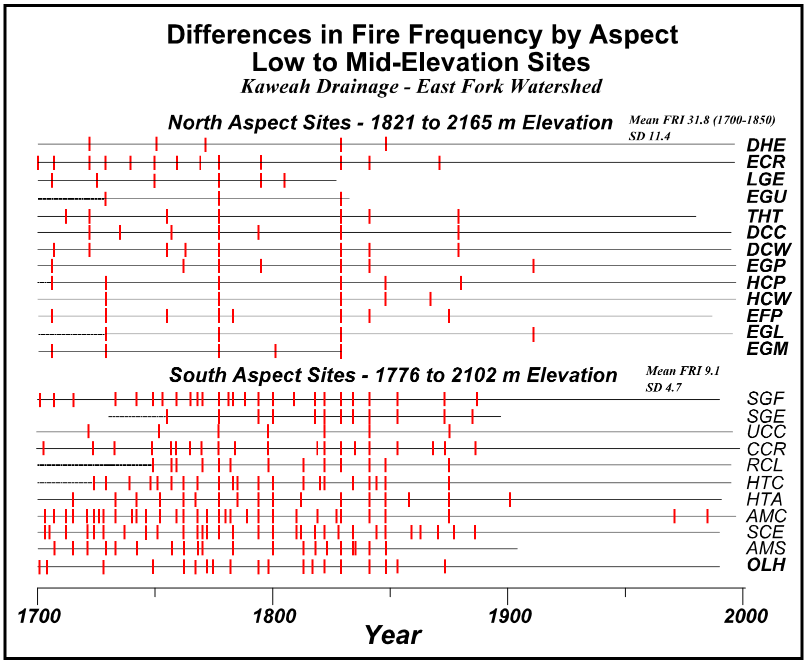


Figure 4.15-4. Differences in fire frequency by aspect for low-to-moderate elevation sites in the East Fork drainage. Each horizontal line represents a composite site chronology with verticle red lines indicating fire dates.

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. 4.15-4**). Sampling during 1999 and 2000 has been 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. 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). 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 (see **Fig. 4.16-16** Caprio 2000).

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. 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 coniferous forest area. The distribution of reconstructed area burned annually within the watershed from 1700 to 1899 shows an inverse J shaped distribution (**Fig. 4.16-5**). 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. 4.16-6**). 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. 1997, Caprio and Graber 2000).

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 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

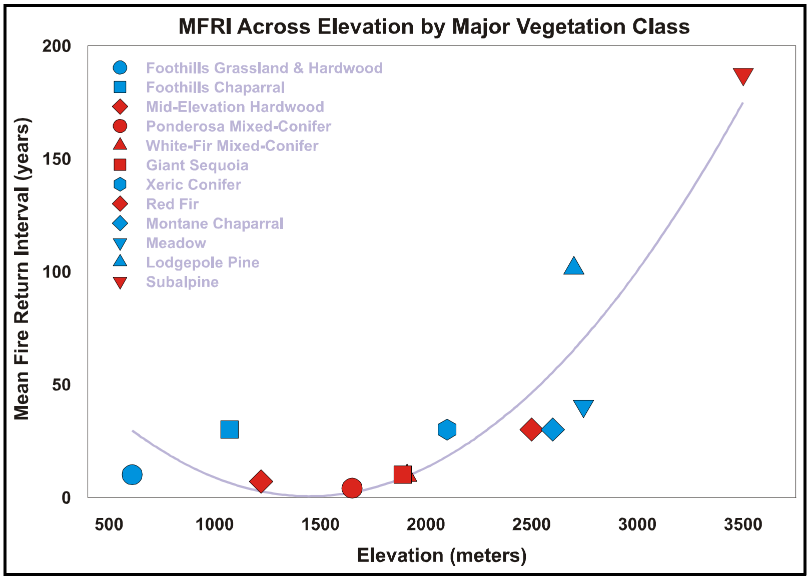


Figure 4.15-5. Relationship between mean fire return interval and elevation for the 12 major vegetation classes within Sequoia and Kings Canyon National Park (from Caprio and Lineback 1997).

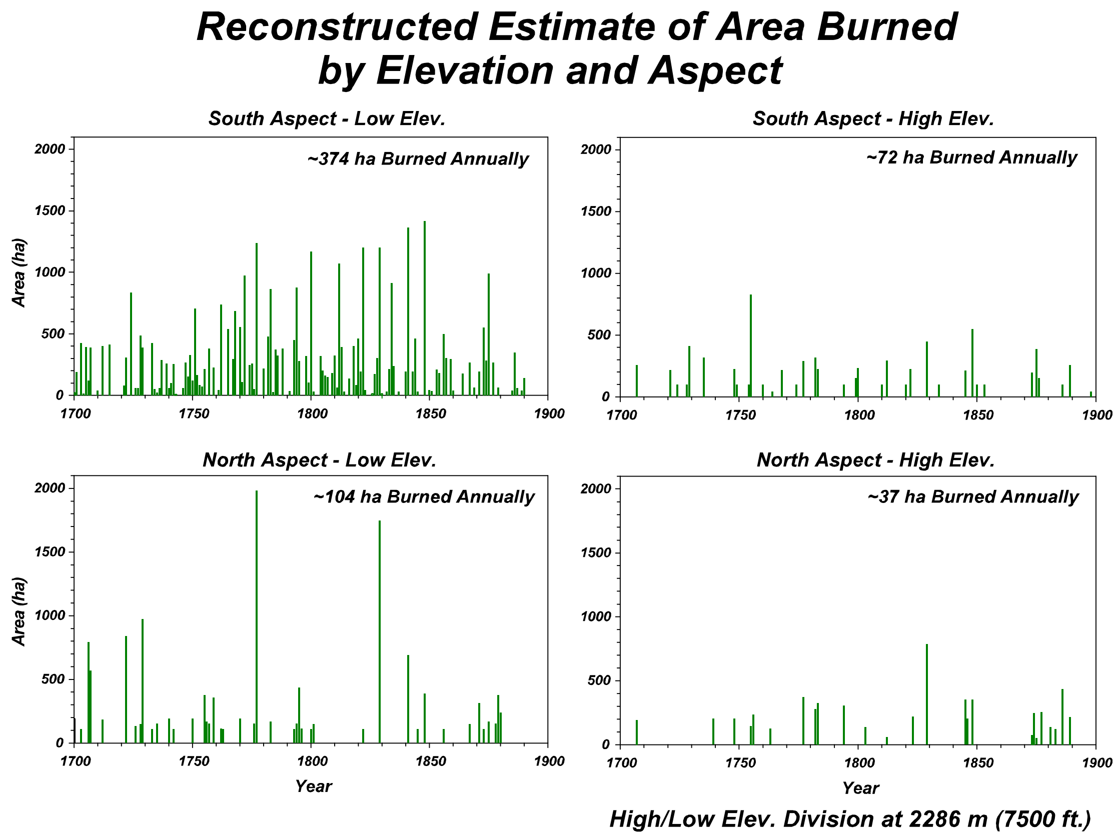


Figure 4.15-6. Reconstructed estimates of area burned annually in the East Fork drainage showing differences by aspect and elevation. The lower south aspect showed the greatest differences relative to the other aspect categories.

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.

II - ADDITIONAL SAMPLING

Objectives of additional fire history 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 4-6 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 the year 2000 aspect sampling was carried out in the Marble Fork of the Kaweah River (**Fig. 4.15-7**) and in Kings Canyon (**Fig. 4.15-8**).

Marble Fork - Over the last two years 15 sites have been collected in the Marble Fork drainage. These have addressed both aspect differences and questions posed by fire and resource managers (Bancroft and Manley 1997 personal communication) on the role of past fire in the mixed lodgepole/red fir forests located in the lower Silman Creek area northwest of Lodgepole (see Caprio 2000b for detailed description). Problems have been encountered in the aspect sampling when attempting to obtain samples from lower to mid-elevation locations on south aspects due to the extensive burning that has taken place at these elevations to reduce the risk of wildfire impacting Lodgepole or Wuksachi.

Kings Canyon - Sampling (nine sites) in the Sheep Creek area of Kings Canyon was carried out in 2000 following the initial sampling on the valley floor during 1998. The Sheep Creek sites run from low to mid-elevations and provide an excellent record of fire occurrence in this north aspect drainage. Recon for potential sites in the Lewis Creek drainage was also carried out. However, obtaining many samples from this drainage will be difficult due the number of wildfires and prescribed fires that have burned nearly all the drainage at least once and parts up to three times since 1980.

The specific goal of the Kings Canyon sampling is to provide more detail on past fire frequency and how it varied throughout the valley. The valley contains a ponderosa dominated forest community that is unusual in the Parks. North aspects are more typical ponderosa pine/white fir mixed conifer. Dry sites, particularly on south aspects, that are protected from fire starts or fire spread have mixed piñon pine/evergreen oak (*Pinus monophylla/Quercus chrysolepis*) forest. More mesic mid-elevation sites on this aspect are dominated by Jeffrey pine (*Pinus jeffreyi*). Of note: the only fire history material available in the valley was found in areas that had not been 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.

Preliminary dating of several samples from the Sheep Creek drainage indicate that in at least a portion of

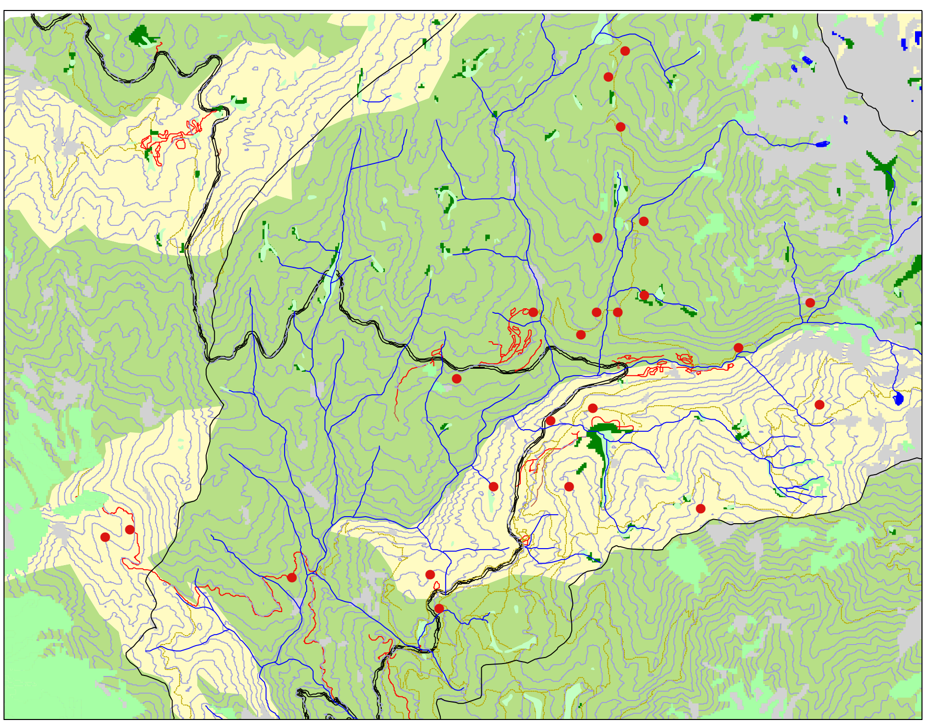


Figure 4.15-7. Fire history sites (red dots) sampled in the Marble Fork of the Kaweah drainage (light green is chaparral, grey is rock, dark green is meadow, yellow is north aspect vegetation, medium green is south aspect vegetation).

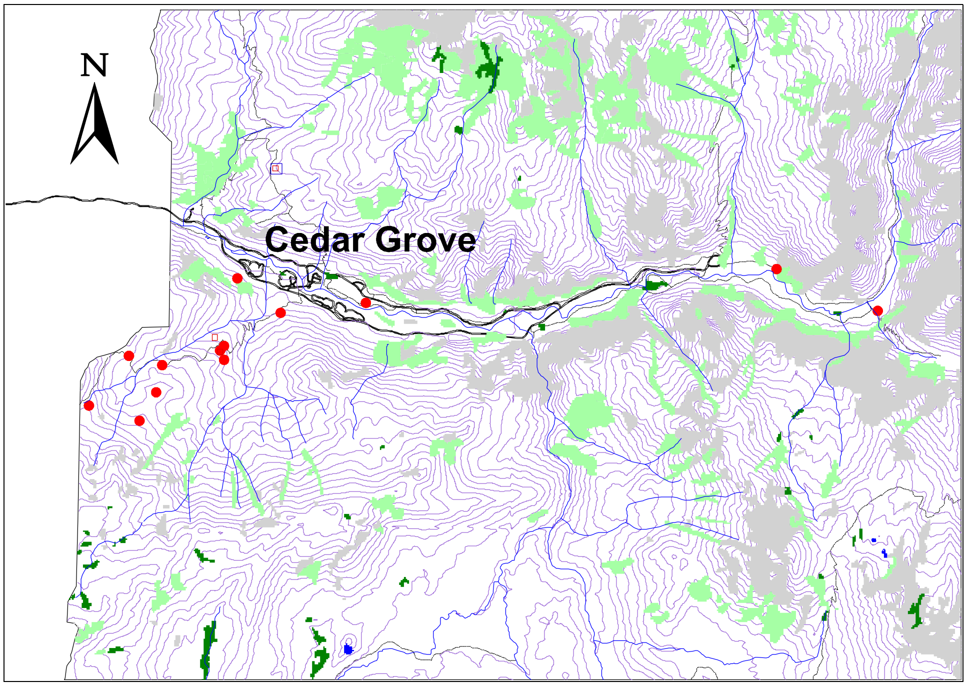


Figure 4.15-8. Fire history sample site locations (red dots) in Cedar Grove, Kings Canyon (light green is chaparral, grey is rock, dark green is meadow vegetation).

this drainage frequent fire occurred up through the start of the 20th century (1908). This is unusual and may be a result of its remote location and difficult access. At most Sierran sites fire frequency declines in the 1860's with only sporadic fires occurring through the late 19th century.

Prior to this sampling only one fire history site had been collected in Kings Canyon. These data collected by Warner (1980) show very short fire intervals, in the order of three-to-four years between fires and are about 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 ponderosa pine (*Pinus ponderosa*) and lowland sites by white fir (*Abies concolor*) although ponderosa pine 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.

Sampling in the Kings Canyon area will complement several research projects underway or being planned in the area. These include the USGS Repeat Photo study (Bueno et al. 2000 and this document) and the USGS Cheatgrass study funded by the JFSP which will be initialized during 2001 (see Caprio et al. 2000 and Section 4.6 of this document for details). 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.

III- PLANS FOR 2001

Sampling has largely been completed in the East Fork although a few gaps still exist in the spatial network that has been developed and additional sample depth is needed from high elevation vegetation types (western juniper currently part of the xeric conifer type and subalpine conifer). Crossdating of collected material will continue and should begin producing results about past fire regimes for individual vegetation classes.

Sampling will primarily concentrate on completing field work in the Marble Fork drainage and obtaining a more complete set of sites from Cedar Grove particularly on the south aspect. The latter sampling will complement a repeat photo study being completed by Bueno et al. (see this document) at the USGS Western Ecological Research Center. A trip is also planned for the lower Kern drainage within the Parks to: 1) complete previous sampling in lodgepole pine forest on Chagoopa Plateau, 2) investigate past fire regimes in the Kern trench where the Park's fire return interval departure (FRID) maps suggest high fire frequency in the past. This sampling will also provide data on past fire regimes from the drier east side of the Great Western Divide which is ecologically quite different than the west slope of the Sierras where the vast majority of fire history sampling has been carried out.

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. 1997. 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. 1997. In: *Proceedings of the Conference on Fire in California Ecosystems: Integrating Ecology, Prevention, and Management*. Nov. 17-20, 1997, San Diego, CA.

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. 2000. pp 233-241. In: Cole, David N.; McCool, Stephen F.; Borrie, William T.; O'Loughlin, Jennifer (comps). Proceedings: *Wilderness Science in a Time of Change-- Vol. 5 Wilderness Ecosystems, Threats, and Management*; 1999 May 23-27; Missoula, MT. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-15-VOL-5

Incorporating a GIS Model of Ecological Need into Fire Management Planning. M. Keifer, A.C. Caprio, P. Lineback, and K. Folger. 2000. *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. A.C. Caprio. in press. Paper presented at: *Conference on Fire Management: Emerging Policies and New Paradigms*. Nov. 16-19, 1999, San Diego, CA.

Reconstructing Attributes of Pre-Euroamerican Settlement Fire at a Watershed Scale, Sequoia and Kings Canyon National Parks. A.C. Caprio. Paper presented at: 2000 Annual Ecological Society Meeting. Aug. 5-9, 2000. Snowbird, UT.

Fire History Panel. Co-presenter on panel with: C. Allen, A.C. Caprio, C. Skinner, and T.W. Swetnam. Fire Conference 2000: *The First National Congress on Fire Ecology, Prevention and Management*. Nov. 27-Dec. 1, 2000. San Diego, CA.

REFERENCES

Arno, S.F. and T.D. Petersen. 1983. Variation in fire intervals: a closer look at fire history on the Bitterroot National Forest. USDA For. Serv. Res. Paper INT-301. 8 pp.

Bancroft, L. and J. Manley 1997. Chief Resources Management and Supervisory Resource Management Specialist. Sequoia & Kings Canyon National Park. Personal communication with A. Caprio.

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

Caprio, A.C. 1997. Fire History. pp 51-54. In: A.C. Caprio (ed). *Mineral King Risk Reduction Project: Monitoring, Inventory, and Research - 1996 Annual Report*. Sequoia and Kings Canyon National Parks, CA 75 pp.

Caprio, A.C. 1998. Fire History. pp 56-61. In: A.C. Caprio (ed). *Mineral King Risk Reduction Project: Monitoring, Inventory, and Research - 1997 Annual Report*. Sequoia and Kings Canyon National Parks, CA 91 pp.

Caprio, A.C. 2000a. Fire History. pp 48-56. In: A.C. Caprio (ed). *Mineral King Risk Reduction Project: Monitoring, Inventory, and Research - 1998 Annual Report*. Sequoia and Kings Canyon National Parks, CA 89 pp.

Caprio, A.C. 2000b. Fire History. pp 60-77. In: A.C. Caprio (ed). *1999 Annual Fire Report: Monitoring, Inventory, and Research*. Sequoia and Kings Canyon National Parks, CA 139 pp.

Caprio, A.C. and P. Lineback. (1997). 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. (1997). 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. (2000). 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.

Menning, K. 1999. Grad Student UC Berkeley and primary investigator in the Landscape Analysis Project. Personal communication with A. Caprio.

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.

4.16) Red fir forest dynamics: The interaction of fine-scale disturbances and prescribed fire

- John Battles and David Newburn, Ecosystem Sciences Division, UC Berkeley

Lead: J. Battles, graduate student researcher: D. Newburn

INTRODUCTION

Fire plays a major role in the dynamics of conifer forests of the Sierra Nevada. However just as the frequency and severity of fire vary with elevation, its function varies from forest to forest. In the high elevation stands dominated by red fir (*Abies magnifica*), the fire regime has been characterized as one where low-severity fires predominate (Kilgore 1973, Pitcher 1987). Fires capable of killing canopy trees are rare. According to Taylor (1993), the important ecological effects of fire in the red fir forest are the consumption of surface fuels, the exposure of mineral soil, and the thinning of understory trees. Presumably some understory trees must escape the periodic fires. These "escapees" represent the next generation of canopy trees.

Pitcher (1987) reported that red fir trees had a negative exponential age distribution, a result that suggests juvenile trees of various ages are equally susceptible to fire. However this result does not preclude the existence of spatial differences in an understory tree's susceptibility to being killed by fire. Based on our preliminary results, the density of small trees in the red fir forest is patchy with dense groups of young trees interspersed in a matrix of a relatively open understory. These patches of regeneration coincide with past canopy openings, openings that range in size from 25 m^2 to as large as 1,875 m^2. Fine fuel loads in the regeneration patches are half that of random plots in the red fir forest (**Table 4.16-1**). Thus canopy gaps may represent locations in the forest with more opportunities for establishment and less risk of mortality from fire.

Our fundamental contention is that successful recruitment to the canopy in the red fir forest depends on other disturbance agents in addition to fire, in particular agents capable of creating gaps in the canopy. According to Gordon (1973), wind, insects, and disease can all kill isolated adult trees (smaller gaps) and well as groups of trees (larger gaps) in the fir forest. Community dynamics in the red fir forest seem to be driven by two distinct disturbance and recovery processes: fire and canopy gaps. This research addresses the nature of the relationship between these two crucial processes.

PROJECT OBJECTIVES

The primary objective of this research was to answer to a single specific question – Do juvenile trees established in canopy gaps experience lower mortality during a prescribed fire than juvenile trees located in the understory matrix. Formally stated, the null hypothesis was: Prescribed fire in the red fir forest kills juvenile trees with equal probability regardless of neighborhood density.

SUMMARY OF METHODS

***Study site*.** The study area is in Mineral King Valley, Sequoia and Kings Canyon National Parks. The five plots were located near the Tar Gap Trail in red fir forest. The plots are within 2 km of each other and in the vicinity of "Pitcher Plots" 1&2 (Pitcher 1987).

Procedures. Five 1 ha plots were located in an area of the red fir forest that was designated for prescribed burning. In each plot, all patches of red fir regeneration were identified and gridded into 5x5 m quadrats. Regeneration patches were defined as areas with 1) no live canopy-sized trees; and 2) an average density of more than 2000 understory trees/ha (5 per quadrat). Trees $\leq$20 cm in diameter at breast height (dbh: breast height = 1.37m) were considered understory trees. All live trees in the regeneration patches were measured to the nearest cm in dbh. The exterior corners of the patches were marked with stainless steel rods. In addition, we censussed all live understory trees outside of the regeneration patches. We refer to this area as the forest “matrix.” Fuel loads in the regeneration patches and random locations in the forest matrix were assessed along transects with a go-no-go gauge. Measurements were completed in August 1998.Fuel loads were significantly greater in the forest matrix (ANOVA, $F = 12.23$, $p < 0.001$, **Table 4.16-1**). In the fall of 1998, a prescribed fire burned in all five plots.

Table 4.16-1. Differences in 0" to 3" fuels in the red fir forest near the Tar Gap Trail before prescribed fire. Means are reported with standard deviations in parentheses.

Fuel size	Regeneration patches (tons ha^{-1})	Forest matrix (tons ha^{-1})
0 - 0.24"	0.27 (0.11)	0.60 (0.11)
0.25 - 0.99"	0.79 (0.28)	1.9 (0.60)
1-3"	0.84 (0.44)	1.9 (0.93)
> 3" sound	120 (130)	190 (52)
> 3" rotten	48 (85)	50 (58)

WORK ACCOMPLISHED IN 2000

Last summer we returned to the site to complete the post-fire measurements. We remeasured understory trees in the regeneration patches and the matrix. We assessed fire severity by char height and percent of forest floor burned. With these data we can test for any non-random patterns in juvenile mortality. We removed all the metal stakes with the exception of the four short metal stakes to mark the plot corners.

PRELIMINARY FINDINGS AND PERTINENT DISCUSSION

(Except for those just initializing field work)

Based on our preliminary analysis, we rejected our null hypothesis. Understory trees in regeneration patches experienced a significantly higher survival rate than similar sized trees in the forest matrix (**Table** 4.16-2, ANOVA, $F = 4.16$, $p = 0.048$). The response was particularly strong for the trees

Table 4.16-2. Comparison of survival for understory red fir trees following a prescribed fire in red fir forest near the Tar Gap Trail. Means are reported with standard deviations in parentheses.

Size class	Regeneration patches (% survival)	Forest matrix (% survival)
seedlings	40 (23)	43 (20)
0 - 5 cm	35 (21)	31 (22)
5 -10 cm	41 (23)	22 (23)
10 - 15 cm	58 (35)	33 (18)
15 - 20 cm	80 (40)	47 (35)
Total	**51 (32)**	**35 (24)**

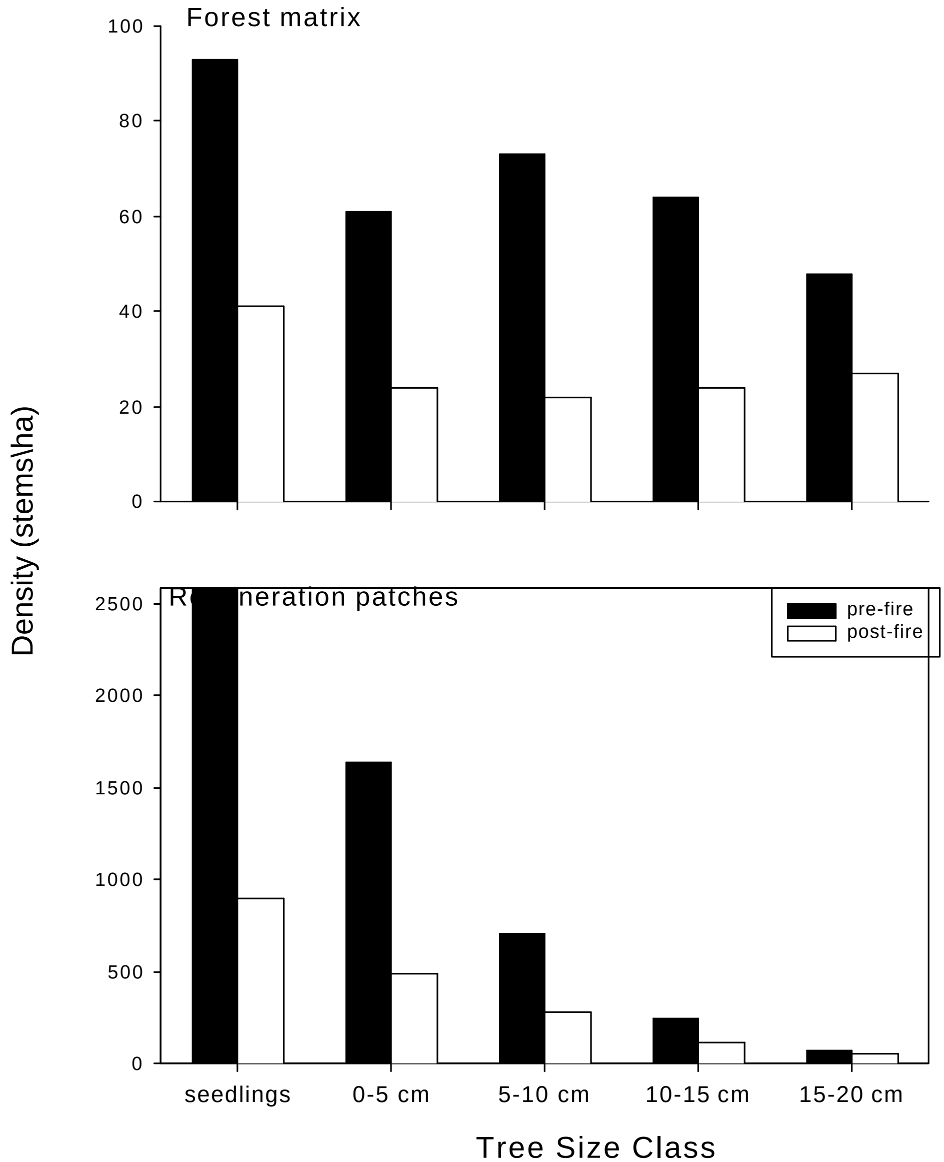


Figure 4.16-1. Comparison of red fir density before and after a prescribed fire in the red fir forests near the Tar Gap Trail.

in the larger size classes **-** red fir trees greater than 5 cm in dbh had a much better chance of surviving the fire if they were in regeneration patches. Thus Pitcher's (1987) prediction regarding the risk of fire mortality and size only holds for understory trees in the matrix, but not for trees in the regeneration patches.

This pattern of survival suggests that red fir establishment and recruitment are largely independent of the prescribed fire. The regeneration patches predated the fire and formed in locations where one or more canopy trees had died. These patches remain largely intact following the fire and represent the vast majority of potential canopy recruits (**Figure 4.16-1**).

PROBLEMS ENCOUNTERED

No problems encountered.

PLANS FOR THE COMING YEAR

We have completed the field work related to this research. We will complete our analyses and include estimates of plot-specific fire severity. Our plan is to incorporated the results into a peer-reviewed ecological publication on the dynamics of true fir forests in the Sierra Nevada.. All of the data and accompanying metadata will be archived as links to the project -- Landscape Analysis of Structure, Pattern and Fire Effects in the Mixed Conifer Forest of Mineral King (Menning et al.). A complete copy of this archive will be deposited at the Sequoia National Park Research Station at Three Rivers.

REFERENCES

Gordon, D. T. 1973. Damage from wind and other causes in the mixed white fir-red fir stands adjacent to clearcuttings. *USDA Forest Service* Research Paper PSW-90.

Kilgore, B. M. 1973. The ecological role of fire in Sierra conifer forests: its application to national park management. *Quaternary Research* 3: 496-513.

Pitcher, D. C. 1987. Fire History and Age Structure in Red Fir Forests of Sequoia National Park California USA. *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. *Canadian Journal of Forest Research* 23: 1672-1678.

4.17) The Southern Sierra Repeat Photography Project

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

The Southern Sierra Repeat Photography Project, centered on Sequoia and Kings Canyon National Parks but including foothill communities and Giant Sequoia groves outside these parks, attempts to reconstruct historical changes in southern Sierran plant communities over the past 125 years. The general study area for the project encompasses foothill and forest communities from the Stanislaus river south to the Kern River. Although the project comprises a large geographic area we have established three foci in order to better facilitate completion of a useable project in two field seasons. The foci include a comparison of vegetation change in Yosemite Valley and Kings Canyon; a look at changes in foothill chaparral communities and the chaparral-conifer ecotone; and an examination of early vegetation conditions and subsequent change in Giant Sequoia groves. A primary goal of our project is to use the photo pairs to describe past and present vegetation conditions and any vegetation change visible in the photos as objectively as possible. We will also develop a method to quantify the changes that are apparent from the photo pairs.

To date we have collected over 80 old photos and re-photographed approximately 40. Analyses of the photo pairs indicate several important vegetation changes but also, and maybe more interestingly, some pairs show little change. Photo pairs from the Kings Canyon of Kings Canyon National Park reveal what appears to be an increase in size and density of both the coniferous species of the valley floor and the oak/shrub species of the canyon walls from 1875 to the present. The oak woodlands of the Sierra Nevada foothills appear to be relatively the same as photos from the late 1800s and early 1900s but the chaparral communities seem to be undergoing a type conversion from dense chaparral to grasslands dominated by exotic annual grasses. In the photo pairs from the Giant Forest in Sequoia National Park (which date from the early 1900s) and the Mariposa Grove in Yosemite National Park (dating back to 1860) vegetation change depends on the photograph you are viewing. Some show a dramatic increase in the density of conifers, other than Giant Sequoia, within the groves and a subsequent decrease since the onset of prescribed burning and mechanical removal. While other old photos indicate that the Sequoia groves of the past were rather dense. One interesting point to mention from these photo pairs is that regardless of whether the forest shows an increased density or not, most do show a change in the structure of the canopy. The new photos show trees with limbs growing down the trunks and reaching the floor of the forest, whereas the trees in the old photos appear to be free of these lower limbs.

4.18) 2000 Annual Report for Biodiversity and Invasives Study

Jon E. Keeley, Daniel Lubin, and Sarah Hamman, U.S. Geological Survey, Western Ecological Research Center

Fire and Community Susceptibility to Invasive Plants, Fire and Community Susceptibility to Invasive Plants

Introduction

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 patterns of biodiversity and plant invasions.

Objectives

This research program objective is to evaluate the relative roles of grazing and fire on community invasibility and patterns of species richness and cover for vascular plants in low and mid-elevation communities of the southern Sierra Nevada Range, primarily in Sequoia and Kings Canyon national parks. We have restricted our attention to sites below 2000 m because in this region invasive plants are of limited occurrence at higher elevations.

Our focus has been on determining species richness patterns at different scales of relevance to these communities (1 - 1000 m^2). This is often critical to the detection of diversity 'hot spots' and separating effects that are evident at different grains. The tenth hectare plot is a widely used scale and appears appropriate for community level questions. In order to evaluate the role of plant cover and be able to distinguish alternative hypotheses driving richness patterns (e.g., null models of random placement we have also determined abundance and cover as well.

Results to Date

A total of 128 sites have been sampled from the foothill blue oak woodlands to mixed coniferous forests in both parks. Patterns of species richness and non-native plant abundance decreases with elevation. Within the blue oak community there are slightly significant differences in both of these parameters between cattle grazed, horse grazed and deer grazed sites. In the coniferous forests there are marked increases in species richness in response to fire with significant interactions between time since fire and fire intensity. In general the lowest species richness is in unburned forests and the highest plant species richness is found in gaps generated by intensity burning 3-5 years after fire.

Future Plans

No more field work is planned on this project and the data are currently being analyzed. The primary work remaining is to do regression analysis of soil nutrient changes in response to time and fire intensity and test for correlations with plant parameters. Writing is expected to be completed by June 2001 and will include a final report to be submitted to the Park along with a manuscript that will be simultaneously submitted for publication in a scientific journal.

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. The major stakeholder 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 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 most important seamless data is developed and complies with National Spatial Data Infrastructure requirements.
- Data is readily accessible and available.
- Standard business processes that optimize long-term interagency information collaboration are implemented and effectively communicated.
- Interagency consensus is reached regarding analysis methods and procedures.
- Develop/Implement Analysis Methods and Procedures.
- Project Plan is managed as a dynamic and useful guide for meeting the goals of Southern Sierra Geographic Information Cooperative (SSGIC).
- An interagency collaboration system based on web technologies is developed.
- Project meets the requirements of the Joint Fire Sciences Program.
- Written protocols and guidelines are drafted to facilitate Project replication.
- Use a fuels analysis to identify treatment areas (risk, hazard, and values) and develop a multi-year fuel treatment plan

SUMMARY OF METHODS

A Cooperative Agreement has been developed and will be signed by all major stakeholders. A goal-driven project plan has been developed that describes specific goals and links specific tasks/strategies required to achieve individual goals. The project plan contains a detailed budget strategy and roadmap 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 including Internet-based mapping. 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 developed and implemented. Interagency Fuels Management Plans will be developed based on completed analyses.

WORK ACCOMPLISHED IN 2000

Significant work was completed during the 2000 calendar year. A formal interagency agreement has been drafted and approved by the DOI solicitor. Final approval from agency participants is pending. This agreement will formalize SSGIC interagency relationships and provide a mechanism for the NPS to distribute funds to stakeholder agencies, if necessary.

A detailed goal-driven action plan was completed. This is a dynamic planning document that will be updated as the need arises. Milestones or deliverables for each activity/task were developed to measure project progress and provide accountability standards to the Joint Fires Sciences Program. Four interagency project groups were established: 1) Project Management, Lead - Dorothy Albright, 2) Data Development, Lead – Pat Lineback, 3) Analysis Methods and Procedures, Lead – Jeff Manley, 4) Interagency Fuels Planning, Lead – Aaron Gelobter. The implementation of the action plan was started with the following progress.

1) Project Management – This group facilitated the development of a detailed multi-year action plan. A workshop was held to identify appropriate architectural design strategies for Internet-based mapping. A summary report was generated and is available. An NT server has been purchased including appropriate software such as ArcIMS that will enable Internet based mapping. The USGS Mapping Division in Denver will be providing overall management for the SSGIC server, but the SSGIC technical representatives will provide the actual management of data, map, and web services.
2) Data Development – An SSGIC data technician was hired in July 2000. Her name is Karen Holmstrom and she is a USFS employee stationed out of the Porterville Supervisors Office. She has started developing "seamless" data and metadata based on data development and analyses priorities established by an interagency data group. This group identified 21 data development priorities that would be acquired or developed for each of the six watersheds. The six major watersheds comprising the 4.7 million acres of the SSGIC include Kings, Kaweah, Kern, Tule, Caliente, and Mojave. See Attachment A. Data development priorities include: vegetation, land ownership, elevation, slope, aspect, hillshade, digital orthophoto quads, digital raster graphics, paid protection areas, state responsibility areas, air basin areas, power grid, fire history, wilderness boundaries, roads, hydrography, watersheds, fuels, canopy cover, and special management zones. A technical fuels working group was established that will be focused on development of seamless and accurate fuels and canopy layers using the best available data.
3) Analysis methods and procedures – In May 2000 a two-day workshop was conducted to identify analysis needs across watersheds. Each agency presented the kinds of analysis currently used for individual agency burn planning and identified new interagency analyses priorities. Terminology was standardized. A summary report was generated including a conceptual approach for identifying

hazard, risk, and value priorities. The SSGIC Technician has initiated collection of data needed to conduct analyses.

4) Interagency Fuels Planning – This group is comprised of fire managers and planners and need analyses results BEFORE they can identify treatment areas and priorities. An action plan was developed and will be implemented as analysis is completed. Future activities include identification of treatment areas and treatment activities, NEPA and CEQA compliance, development of a fuels treatment plan and finally, implementation of the interagency burn plans.

PRELIMINARY FINDINGS

One of the major challenges of this project has been maintaining effective interagency collaboration. The major stakeholders continue to have a high interest in this project, but there have been delays because of scheduling conflicts and an extreme fire season in 2000 that diverted attention from this project. The project is behind schedule and cannot be complete by 12/2001 as originally agreed to in the JFSP task order. We will be requesting an extension to this project for one year to end around 12/15/2002.

Commensurate with the slow progress of this project, we've learned that this project is much more complex than we originally envisioned. We have learned a dedicated project manager position could better facilitate the complex coordination and organizational requirements. Nevertheless, progress is being made, but at a slower pace than we would like.

Although no significant analyses have been completed, the conceptual frameworks for analyses have been developed and data development has begun. Surprisingly, acquiring consensus on the hazard, risk, and value analyses to be used for joint burn planning was straightforward. However, it is not yet known how different agency missions will impact a consensus process and development of joint burn plans once the fire managers begin looking at analyses.

By keeping stakeholder agencies involved in the decision process, we have seen an increase in interagency coordination and cooperation in several different ways. In July 2000, a presentation was made to the Sierra Federal Managers that were well received. In December 2000, a similar presentation was given to the Southern and Central Fire Management Officers (FMO). The FMO's were very supportive of the SSGIC and there was talk of eventually expanding this initiative further up the Sierra Nevada to include additional agencies and watersheds.

PROBLEMS ENCOUNTERED

As anticipated, interagency coordination does require significant effort and commitment by agency stakeholders to make this project successful. Coordinating activities and meetings is difficult and requires significantly more effort than traditional single agency meetings.

We've discovered how difficult it is to get state, local, and federal agencies to sign off on a formal SSGIC agreement. The issues appear to relate to different agency agreement guidelines, rather than the content of an agreement.

It was extraordinarily difficult to identify a host agency and location for the SSGIC Web server. Numerous options were explored before the USGS agreed to host and support the server and the SSGIC as part of the larger GEOMAC project. A formal agreement has been drafted (not yet finalized) between the USGS and the NPS to support the SSGIC for a three-year period.

2001 WORKPLAN

In 2001, we expect to have a fully functional SSGIC online with significant Internet accessible services including mapping services, data/metadata download and access, and web information services. In May

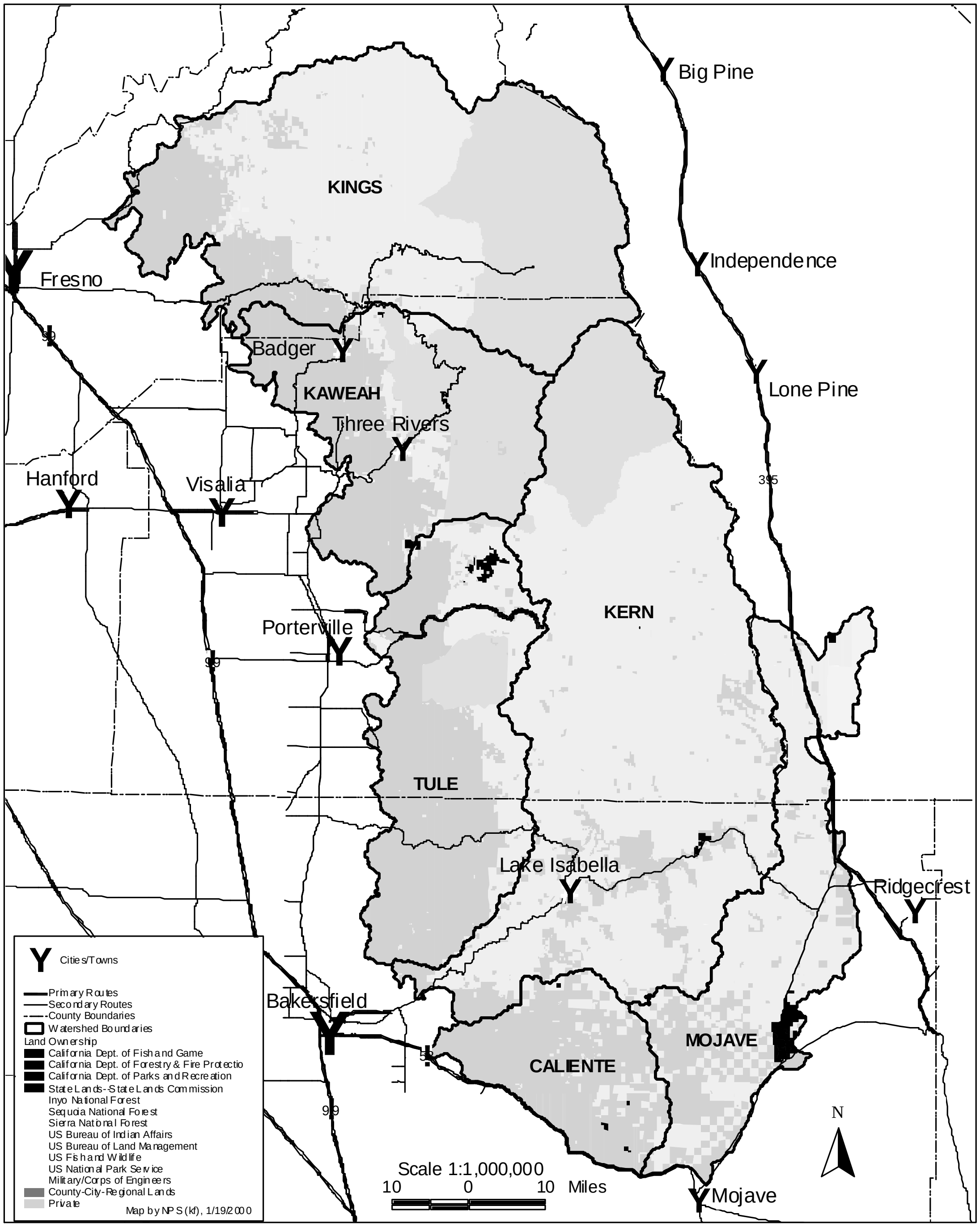
2001, the stakeholder agencies will meet to further develop and refine specific Web-based services to be provided by the SSGIC. Technical representatives from the stakeholder agencies will be trained to assist with the development and maintenance of the Web site.

We expect to have preliminary analyses completed in 2001 including FLAMMAP, Fire Occurrence Areas (FOA), and Fire Return Interval Departure. The data/metadata, as well as dynamic Internet map services will be made available via the SSGIC server.

The SSGIC interagency fuels group will conduct preliminary assessments of the analysis results and develop initial treatment area priorities in Fall 2001.

Southern Sierra Geographic Information Cooperative Area

Attachment A



4.20) Vegetation Mapping Initiative

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

Lead: S. Haultain (Project Coordinator)

INTRODUCTION

Park managers and cooperators have long recognized the need for comprehensive, accurate vegetation maps for resource planning, management and research. 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) initiated a multi-year effort to classify and map the terrestrial vegetation of Sequoia and Kings Canyon National Parks with two years of funding, provided that the national Inventory and Monitoring program commit to funding the project in subsequent years. In 2000, the project entered into its second year under FirePro funding.

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. 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, and with the Manual of California Vegetation (Sawyer and Keeler-Wolf 1995).

<u>Data acquisition</u>

Vegetation sampling
Plot-based vegetation data were collected using the protocols developed for the USGS-NPS Vegetation Mapping Program by TNC. Fuels were characterized on the vegetation plots according to protocols developed in Yosemite NP as a part of their vegetation mapping effort. Sampling locations were identified using a combination of local expert knowledge of gaps in existing plot data, and spatial data provided by a GRADSECT analysis (Austin and Heyligers 1989). Using work completed in Yosemite as a guide, the GRADSECT approach was used to develop an initial stratification of the landscape according to the primary environmental variables believed to drive the distribution of

Sierran vegetation (substrate, topography, elevation), which then provided a way of assessing both the geographic and ecological completeness of existing legacy datasets.

Photo acquisition/ Photo interpretation
Using a minimum mapping unit of 0.5 hectare, manual delineation of vegetation polygons will be based on 1:15,840 color infrared aerial photographs.

WORK ACCOMPLISHED IN 2000

Field Sampling/ClassificationDevelopment
At SEKI, the first full year of the project was 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. The field crew assembled for this project established a total of 179 exhaustive field plots, and 60 fuels plots. The team was made up of a lead biological technician (term), three GS-06 field botanists, and three Student Conservation Association (SCA) field assistants. California Dept. of Fish and Game Vegetation Ecologist Todd Keeler-Wolf assisted with training the crew in sampling methodology. Sampling was carried out in two backcountry locations within each park: southern Hockett Plateau/Quinn area and the Tablelands area in Sequoia, and LeConte Canyon and Kearsarge Lakes Basin in Kings Canyon. Although crewmembers were required to hike into these remote field locations, supplies and materials were transported via packstock and/or helicopter. Plot data were stored in a modified version of the PLOTS database developed by TNC for the NPS/USGS Vegetation Mapping Program.

Photo acquisition
Taking advantage of existing agreements in place through USGS and Bureau of Reclamation, a contract was obligated to Albuquerque based 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, the mission was postponed until summer of 2000. The mission was carried out during the week July 18, 2000. Flight lines encompassed the 863,000 acres within the two parks and an additional 88,000 acres of surrounding lands, for a total of 951,000 acres and 1,915 photographs. This contract also included a provision for duplicate images of the East Fork Study Area in support of the Mineral King Landscape Assessment (Menning *et al.*, this document).

Contracting for additional services
Funds were obligated and a contract awarded to secure collaboration of Dr. Todd Keeler-Wolf, CDFG vegetation ecologist, on the development of the SEKI vegetation classification and sampling strategy during FY2000 and FY2001.

Funds were obligated and a contract awarded to ESRI/AIS for two weeks of field reconnaissance for orientation/training of photo interpreters, and preliminary interpretation of 144 photographs during FY2001.

PLANS FOR THE COMING YEAR

Plans for 2001 include:

Continued development of preliminary vegetation classification

Completion of field sampling towards classification development

Initiation of preliminary photo interpretation of 144 CIR photographs in support of field sampling

Completion of two week-long reconnaissance trips to orient photo interpreters to park vegetation types and augment preliminary list of types

REFERENCES

Austin, M.P. and Heyligers, P.C. 1989. Vegetation survey design for conservation— GRADSECT sampling of forest in NE New South Wales. Biological Conservation 50:13-32.

Sawyer, J. O. and Keeler-Wolf, T. 1995. A manual of California vegetation. California Native Plant Society, Sacramento, CA.

USEFUL LINKS

The USGS-BRD vegetation-mapping site can be accessed at: http://biology.usgs.gov/npsveg/

The TNC vegetation classification can be accessed at:
http://www.tnc.org/frames/index.html?http://consci.tnc.org/index.html

4.21) Evaluation of Cambium and Soil Heating and Other Fire Effects During Prescribed Fire in Giant Sequoia/Mixed Conifer Stands

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INTRODUCTION

The use of prescribed fire in the Sequoia Kings Canyon National Park is well established. The natural occurrence of fire is accepted in this ecotype and the park's prescribed burning program has demonstrated national leadership in the use of prescribed fire. Our involvement began at the request of park managers in response to the Christensen Report, to study the extent of soil and cambium heating in Giant Sequoia/mixed conifer stands during SMA project burns in the Giant Forest area. Our first involvement was in 1988 with the measurement of soil and cambium temperatures of two SMA burns, the sampling of before and after ammonium- and nitrate-nitrogen changes, and the development of a fuel loading prediction equation. This information is contained in Haase and Sackett 1998. Subsequent burns of which we were a part are defined in Table1.

PROJECT OBJECTIVES

The initial objectives of the study have been 1) to determine soil temperatures at six different depths below the soil/duff interface during normal prescribed fires, 2) determine cambium temperatures in sequoia and sugar pine trees during prescribed fires, and 3) determine pre- and post-burn concentrations of the available forms of nitrogen (NH_4-N and NO_3-N) in the upper soil stratum. These objectives were initially applied to first entry prescribed burn projects and they have since been applied to the Nichols' Folly and the Tharp's II re-burn areas. This study will be officially amended to also cover the fuel mitigation work being conducted. The primary objective for this portion is to 1) determine cambium temperatures during prescribed fire of trees that have had the forest floor fuels removed a defined distance from their root collar, and 2) determine slope effects on cambium heating.

SUMMARY OF METHODS

Temperature Measurements

Soil and cambium temperatures are measured by inserting chromel-alumel thermocouples into the cambium of giant sequoia and sugar pine trees, and at six depths for each soil temperature site. The data is collected using Campbell Scientific data loggers and recorded on tapes that are later translated and analyzed. For initial entry burn projects, a representative sugar pine and giant sequoia tree are selected and thermocouples are inserted just beneath the cambium at six points around the tree. Soil temperatures are measured at six set depths starting at the soil/duff interface and going as deep as 20 inches. Three individual sites are selected that extend from the base of the selected tree to its dripline. A hole is dug and thermocouples are inserted horizontally in the soil profile so that the fuels directly above the thermocouples that produce the heat, are not disturbed in the set-up process. The temperatures are measured during and after the burn time in 10-15 minute intervals until they begin to cool. The time interval is then lengthened to cover the full length of the heating and cooling process. This can be for a week or more if fuels are extreme.

Cambium temperatures are measured by inserting the thermocouple between the outer bark and cambium. Originally, a small patch of bark was removed above the point being measured and the 18-inch thermocouple was pushed downward. The bark patch was returned, edges packed with glass insulation, and then a large heat protective patch made of a fire tent and glass insulation was secured over the thermocouple site. The method has now been modified on the sugar pine trees so that a slit the width of a chainsaw chain is used to slide the thermocouple down and on the giant sequoia the thermocouple is simply pushed at an angle so that the point of measurement is midway within the forest floor depth at that point. The patch marks the depth of the forest floor material and measurements are taken after the fire to limit the amount of disturbance to the fuels, which ultimately affects the fire behavior at that location. The dataloggers reading the cambium temperatures are set for the same time intervals as the soil temperatures.

Mitigation Temperature Measurements

The six points measured on the selected trees will correspond with the different slope effects being questioned, primarily uphill and down hill locations. Paired trees were located in the Bear Hill project burn in 1999, that were of the same size class and in close proximity to each other so that they would experience similar fire behavior. One of the pair was randomly selected to have the forest floor material removed using a garden spade to cut the forest floor material and then a leaf blower to do the final removal of material down to mineral soil. Forest floor depth was marked with aluminum nails prior to the removal of the forest floor material so that an estimate of fuel loading could be made for the individual tree. The depth of the remaining forest floor material at the “cut face” was also recorded to estimate the fuel loading that would be radiating heat to the bark surface. The non-mitigated trees also had aluminum nails placed at the top of the forest floor material so that the fuel loading could be estimated after the prescribed burn.

Soil Nutrients

Soil nutrients have been sampled for each of the areas where temperatures have been measured for a total of nine initial entry burns and two reentry burns. They are measured pre- and post-burn and then annually from then on with the exception of the Grant Grove burn where the sampling area was later determined to be a water treatment spray area. Ten samples are taken around each of the selected trees and each is a composite of 7 one-inch soil core samples. The sample cores are broken down into two depths (0-5 cm and 5-15cm). The samples are process in the field and then the KCl extract is sent to a soils laboratory to be analyzed for ammonium-nitrogen and nitrate-nitrogen.

WORK ACCOMPLISHED IN 2000

Soil nutrients were sampled July 8-11, 2000 for the ten sites and the control. Samples were processed in the field and kept on ice until they were sent to the soils laboratory. The same laboratory was used as the previous year for analysis (USDA-FS-Rocky Mountain Forest and Range Experiment Station, Flagstaff, AZ). A second sample was sent to an additional laboratory for comparison (Northern Arizona University – Bilby Research Center). The two analyses were comparable. The previous years (1999) samples are being evaluated further to see if they can be included in the database. Park personnel selected pairs of trees, mapped, and mitigated fuel around the base of the selected trees in 1999 after they received training. A training session was held July 20, 2000, to instruct new park personnel on the mitigation process for that summer. The paired trees were “refreshed” by blowing out the forest floor material that had accumulated in the cleaned out area during the winter. Nehalem Breiter, NPS, updated depth and condition information during the summer and entered the data into the data set for the mitigation study. She also standardized the field data sheet that will be used for any new mitigation studies.

PRELIMINARY FINDINGS AND PERTINENT DISCUSSION

The following is a summary of last year's (2000) soil nutrient information (see also **Table 4.21-1**). The values are very similar to and follow the same trends as the previous years. A complete evaluation is planned for this next year that will review all the previous sample periods. Sites with the larger Standard Deviations (SD) often include a single sample. One would be inclined to exclude these but they do show up regularly and indicate the extreme variability of soil nutrient levels that can be found following prescribed burns and in controls. The level of ammonium-nitrogen is still remaining at levels around the control or as in the latest burn, above the control level. The complete analysis will allow us to determine if there is any relationship between sites, fuel loading, and duration over time. The missing data for the giant sequoia entry for Tharp's II is due to the tree being re-sampled for the re-entry burn. The corresponding sugar pine for the initial burn of Tharp's II was not included in the second burn perimeter and a different sugar pine had to be selected that was included in the burn area.

The nitrate levels are similar to what we have seen in the past. This element is very dependant on the time and soil conditions when the soil microbes begin to convert the ammonium into nitrate. Therefore we may have missed the peak activity time this last year. Again, seldom is the SD smaller than the mean, which indicates there is most likely only one sample out of the ten taken that actually measured a nitrate-nitrogen level. But again, this is commonly found when sampling these soils.

PROBLEMS ENCOUNTERED

The only problem encountered this last year was the delay of burning the Bear Hill unit for the second time. Currently we may be evaluating the longevity of the mitigation treatment and the effect of simply removing the forest floor material around individual trees. Whether or not the simple removal of material will affect the health of the trees may need to be evaluated by doing several fresh mitigation treatments just prior to the burn. The removal of material may affect the moisture content beneath the bark so that the insulating properties may differ between newly mitigated trees and trees mitigated previously. We may be able to detect differences if we probe some newly mitigated trees at the time of the burn.

PLANS FOR THE COMING YEAR

We are planning to sample the eleven sites for soil ammonium-nitrogen and nitrate-nitrogen as we have in the past. This will give us a sample comparison for the evaluation of the laboratory we are now using for the analysis of samples. We have modified our temperature systems so that will be able to measure more trees than previously planned for on the Bear Hill project burn. We will have enough equipment to measure at least 21 trees, which we will distribute between old mitigated, newly mitigated and non-mitigated trees. We will also want to install several soil sites just to verify soil heating is similar to our other findings for the park. We are also planning on completing a second manuscript t of our soil temperature findings. This same data was used to produce the statistical process paper Preisler, H.K. et al. 2000. The soil temperature/risk model will be put on the web for easy access for managers of giant sequoia/mixed conifer stands.

Table . 4.21–1 Summary of the annually sampled soil nutrients, ammonium-nitrogen and nitrate-nitrogen, from all initial entry burn SMA's in the Giant Forest area. Dates of the initial or re-entry burns are included in the ( )'s following the name of the project.

		Ammonium-Nitrogen (NH_4-N)				Nitrate-Nitrogen (NO_3-N)			
		0-5 cm		5-15 cm		0-5 cm		5-15 cm	
		µg/gm soil	SD	µg/gm soil	SD	µg/gm soil	SD	µg/gm soil	SD
Giant Sequoia	**Initial Entry Burns**								
	Tharp's II (7/88)								
	Congress Trail (9/88)	.688	.154	.508	.105	.000	.000	.000	.000
	Tharp's Creek (7/89)	.637	.148	.636	.316	.000	.000	.000	.000
	Highway I (9/89)	.875	.218	.661	.067	.004	.009	.001	.004
	Highway II (9/90)	.899	.379	.499	.123	.003	.007	.000	.000
	Cloister (8/93)	.698	.157	.523	.115	.002	.004	.000	.000
	Upper Sherman (8/95)	2.049	3.290	.480	.112	.208	.356	.016	.019
	Pinewood (7/97)	1.892	1.172	.675	.182	.071	.103	.019	.009
	Re-entry Burns								
	Tharp's II (9/96)	.894	.228	.797	.187	.000	.000	.000	.000
	Nichols' Folly (9/96)	.547	.120	.513	.174	.000	.000	.000	.000
	Control*	1.825	1.182	.586	.163	.000	.000	.005	.014
Sugar Pine	**Initial Entry Burns**								
	Tharp's II (7/88)	.875	.324	.578	.127	.007	.022	.000	.000
	Congress Trail (9/88)	.578	.293	.383	.100	.002	.007	.000	.000
	Tharp's Creek (7/89)	.898	.229	.472	.269	.007	.023	.000	.000
	Highway I (9/89)	.743	.174	.560	.102	.005	.007	.003	.006
	Highway II (9/90)	.957	.390	.551	.123	.037	.115	.000	.000
	Cloister (8/93)	.573	.161	.310	.053	.006	.009	.001	.003
	Upper Sherman (8/95)	.711	.244	.485	.179	.015	.013	.010	.009
	Pinewood (7/97)	1.951	.949	.457	.067	.207	.272	.017	.010
	Re-entry Burns								
	Tharp's II (9/96)	1.028	.350	.614	.147	.000	.000	.000	.000
	Nichols' Folly (9/96)	.720	.332	.464	.104	.001	.004	.000	.000
	Control*	.934	.281	.493	.182	.000	.000	.000	.000

REFERENCES

Haase, Sally M. and Stephen S. Sackett. 1998. Effects of prescribed fire in giant sequoia-mixed conifer stands in Sequoia and Kings Canyon National Parks. Pages 236-243 *in* Teresa L. Pruden and Leonard A. Brennan (eds.). Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, FL.

Preisler, H.K., S.M. Haase, and S.S. Sackett. 2000. Modeling and risk assessment for soil temperatures beneath prescribed forest fires. Environmental and Ecological Statistics 7:3, pp 239-254.

4.2 Wildlife

4.21) Fire Effects Monitoring

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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 2000, 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 long-term monitoring plots were monitored in mature sequoia forest at Atwell Grove, in westside ponderosa pine forest, in Jeffrey pine forest, and in mixed chaparral. The 1,080 trapnights at the Atwell Plot produced 83 rodent captures. The population was estimated at 13 rodents. The 1996-1998 postburn increase in rodents began to decline in 1999. Sampling in 2000 showed the decline to be continuing. The lodgepole chipmonk (*Tamias speciosus*) has continued to increase its proportion of the rodent population and now is nearly codominant with deer mice (*Peromyscus maniculatus*). The only other rodent captures included a long-tailed vole (*Microtus longicaudus*).

The 2,098 trapnights at the Ponderosa Plot produced 148 rodent captures with a average population estimate of 19 rodents for the survey period. This was forty-six percent higher than the preburn population estimate. The preburn species composition changed from a nearly equal balance between deer mice (*P. maniculatus*) and brush mice (*Peromyscus boylii*) to a population that is predominantly deer mice (*P. maniculatus*). Lodgepole chipmunks (*T. speciosus*) immigrated to the plot and comprised forty-three percent of the individuals monitored in 2000. Other rodents present included a few captures of Botta's pocket gopher (*Thomomys bottae*) and long-tailed vole (*Microtus longicaudus*).

The Jeffrey plot in subalpine Jeffrey pine forest was a preburn resample to evaluate changes since the last survey in 1995. The 1,014 trapnights, produced 62 rodent captures. The estimated population of five rodents was about a quarter of the previous survey in 1997. The plot was dominated by deer mice (*P. maniculatus*) but also included lodgepole chipmunk (*T. speciosus*) and western flying squirrel (*Glaucomys sabrinus*).

The Traugers plot in mixed chaparral was a another preburn resample to evaluate changes since the last surveys in 1995 and 1999. The 420 trapnights, produced 62 rodent captures. The estimated population of 56 rodents was about the same as the previous survey in 1999. The species present in descending order of abundance were dusky-footed woodrats (*Neotoma fuscipes*), brush mice (*P. boylii*), California mice (*P. californicus*), pinyon mice (*P. truei*), California pocket mice (*Chaetodipus californicus*), and Merriam's chipmunk (*Tamias merriami*). This was the first observation of *T. merriani* within the plot.

Serendipity sampling was done in the following environments: mixed chaparral, mixed hardwood/conifer forest (recently burned and unburned), riparian area in sequoia grove (Deadwood Creek), mixed conifer forest, sagebrush/*Ribes* scrub, wet meadow, black cottonwood, Jeffrey pine, and chamise chaparral. Brush mice (*P. boylii*) dominated the mixed chaparral and mixed hardwood/conifer forest, but was also found in the mixed conifer. Deer mice (*P. maniculatus*) dominated the riparian area, but were also found

in the mixed conifer forest. The California mouse (*P. californicus*), California pocket mouse (*Chaetodipus californicus*) and dusky-footed woodrat (*N. fuscipes*) were only found in chamise chaparral. Lodgepole chipmunks (*T. speciosus*) were found primarily in mixed conifer forest, but also in Jeffrey pine and by Deadwood Creek. Long-tailed voles (*Microtus longicaudus*) were primarily found at the wet meadow, but also at Deadwood Creek. The western jumping mouse (*Zapus princeps*) was found in both the wet meadow and black cottonwood. Serendipity trapping for medium-sized mammals produced three captures of martin (*Martes americana*).

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 sixth 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 Jeffrey Plot was located in a Jeffrey pine forest with plot center at UTM coordinates 4035456 northing and 355264 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 18 nights from June 19, 2000 through July 21, 2000 (1,080 trapnights). The Jeffrey Plot was run for a total of 17 nights from August 28, 2000 through October 6, 2000 (1,014 trapnights). The Ponderosa Plot was run for a total of 35 nights from July 31, 2000 through September 29, 2000 (2,098 trapnights). The Traugers Plot was run for a total of eight nights from October 20, 2000 through November 9, 2000 (480 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 eleven areas in the Mineral King drainage: 1) mixed chaparral near Redwood Creek surveyed for ten nights (91 trapnights, UTM coordinates 4034590 northing, 347340 easting, May 24 - June 9, 2000), 2) a patch of mixed hardwoods/conifer forest was surveyed for nine nights (68 trapnights; UTM coordinates 4035180 northing, 347740 easting, May 24 - June 8, 2000), 3) a riparian herbeceous community along a perennial stream (Deadwood Creek) in a sequoia grove for ten nights (100 trapnights; UTM coordinates 4036800 northing, 351020 easting, May 24 - June 9, 2000), 4) the mixed conifer forest near Silver City for ten nights (110 trapnights; UTM coordinates 4036630 northing, 352740 easting, May 24 - June 9, 2000), 5) sagebrush/*Ribes* scrub for one night (4 trapnights; UTM coordinates 4034870 northing, 356850 easting, May 25-26, 2000), 6) meadow for nine nights (77 trapnights; UTM coordinates 4034950 northing, 356900 easting, May 25 - June 9, 2000), 7) a stand of black cottonwood for eight nights (52 trapnights; UTM coordinates 4035240 northing, 356150 easting, May 29 - June 9, 2000), 8) Jeffrey pine for eight nights (80 trapnights; UTM coordinates 4035230 northing, 355840 easting, May 29 - June 9, 2000), 9) a recently burned stand of mixed conifer/hardwood forest for seven nights (70 trapnights; UTM coordinates 4035200 northing, 348520 easting, July 3-13, 2000), 10) an unburned stand of mixed conifer/hardwood forest for seven nights (70 trapnights; UTM coordinates 4035110 northing, 348470 easting, July 3-13, 2000), and 11) chamise chaparral for six nights (72 trapnights; UTM coordinates 4032760 northing, 342100 easting, October 23 - November 2, 2000)

Sherman live traps were scattered loosely through these sites at approximately 15 m intervals (not measured). Serendipity surveys were conducted between May 24, 2000 and November 2, 2000 for a total of 794 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 1, 2000 through August 24, 2000.

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 empirically resembles the preburn condition except that the tree density is 56% less (Werner 2000).

Eighteen nights of trapping (1,080 trapnights) produced 83 rodent captures (28 different individuals) and one capture of non-rodents (*Sorex* sp.). The mean population estimate for the Atwell Plot during the survey period was 13 individuals (95% CI = 12-15 individuals) during the early summer sampling. This estimate is about half of the population estimate from late-spring/early-summer sampling the previous year (P = 0.004) and similar to the preburn condition (Figure 4.21-1). This is the second year in a row of declining rodent populations at the Atwell Plot. The cause of the decline is unknown, but it was typical of other trapping efforts in the forested region of the East Fork Kaweah throughout the summer.

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 in 1999		
Peromyscus maniculatus	83	94
Tamias speciosus	10	2
Glaucomys sabrinus	2	3
Peromyscus boylii	0	1
Fall Sampling in 1999		
Peromyscus maniculatus	61	65
Tamias speciosus	26	23
Glaucomys sabrinus	6	4
Microtus longicaudus	7	8
Early Summer Sampling in 2000		
Peromyscus maniculatus	54	53
Tamias speciosus	43	46
Microtus longicaudus	4	1

While the total plot population is similar to the preburn condition (15 rodents, Werner 1996), the species composition is different. Ninety-one percent of the preburn captures were *Peromyscus maniculatus*. During the early summer sampling in 2000, *P. maniculatus* comprised only fifty-three percent of the captures (54% of the individuals). During the last year, *P. maniculatus* have shown a steady decline in the portion of the rodent community they occupy (Table 4.21-1). Concurrently, *Tamias speciosus* has exhibited a steady increase from insignificant to nearly codominant. During 2000 sampling, *T. speciosus* comprised forty-six percent of the captures (43% of the individuals). The other species sampled are summarized in Table 4.21-1.

Catch rates for the three rodent species were 0.041, 0.035, and 0.004 captures/trapnight for *P. maniculatus*, *T. speciosus*, and *M. longicaudus*, respectively. The catch rate for *P. maniculatus* decreased from 0.226 captures/ trapnight in 1999 to 0.041 captures/ trapnight in 2000. Meanwhile *T. speciosus* remained similar at 0.035 captures/trapnight in 2000 comparted to 0.041 captures/trapnight in 1999.

The sex ratio for *P. maniculatus* sampled was nearly equal for the individuals sampled (female = 45%, male = 55%, n = 38). Sex ratios for other species included: *T. speciosus* (female = 41%, male = 59%, n = 32), and the sex of the one *M. longicaudus* was not recorded.

Fifty-seven percent of the *P. maniculatus* and all of the *T. speciosus* captured were adults (n = 35 and 34, respectively). Age was not identified for the one *M. longicaudus.*

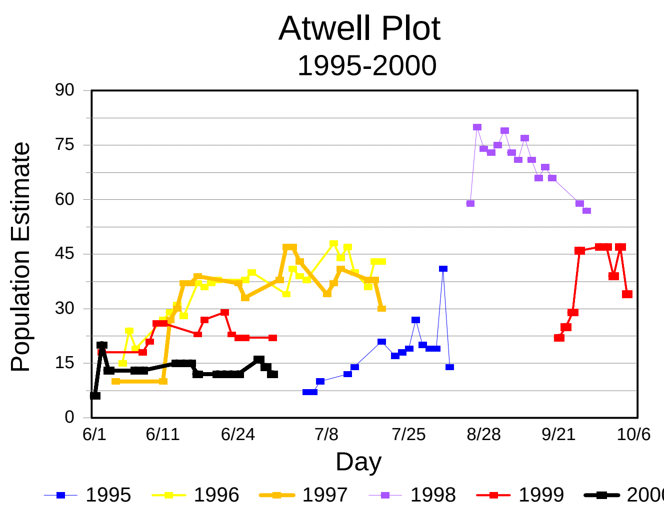


Figure 4.21-1. Population estimates at Atwell Plot, 1995 (preburn) through 2000.

Ponderosa Plot: 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 I 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 and 2000 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. The soil was covered by dense shrubs and herbaceous vegetation.

Thirty-five nights of trapping (2,098 trapnights) produced 148 rodent captures (53 different individuals). The mean population estimate during the survey period was 19 individuals (95% CI = 15 - 23 individuals). This is about half of the 1999 population estimate (41 individuals, Werner 2000; P = 0.00004) and similar (Figure 4.21-2) to the first summer post-burn (20 individuals, Werner 1999) as well as the early preburn population (28 individuals; Figure 4.21-2).

The postburn 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. However, as at the Atwell Plot, dominance by *P. maniculatus* has been declining (80 % of the individuals in 1998, 68 % in 1999, and 54% in 2000) while *Tamias speciosus* has become more abundant. *Tamias speciosus* first appeared in 1999 at which time it represented eighteen percent of the individuals surveyed. In 2000, *T. speciosus* increased to forty-three percent of the individuals surveyed (46% of captures). *Microtus longicaudus* (4 % of individuals) and *Thomomys bottae* (2 % of individuals) continued to have a minor presence on the plot.

Catch rates for the five rodent species were 0.042 captures/trapnight for *P. maniculatus,* 0.028 captures/trapnight for *T. speciosus,* 0.005 captures/trapnight for *P. boylii*, and 0.001 captures/trapnight for both *M. longicaudus* and *T. bottae*. There were two captures of a juvenile *Peromyscus* that was too young for identification to species.

The sex ratio for the sampled population of *P. maniculatus* was skewed toward males (female = 42 %, male = 58 %, n = 85). The sex ratio for the other species include: *P. boylii* (female = 62 %, male = 38 %, n = 8), *T. speciosus* (female = 45 %, male = 55 %, n = 31), *M. longicaudus* (female = 100 %, n = 2), and *T. bottae* (female = 100 %, n = 1) .

Sixty-six percent of the *P. maniculatus* captured were adults, twenty-three percent were subadults, and eleven percent were juvenile (n = 86). For the other species surveyed, *P. boylii* was forty-four percent adult (n = 9) with the balance for both species being subadults (22%) and juveniles (33%). All *T. speciosus* (n = 33), *M. longicaudus* (n=2), and *T. bottae* (n=1) were adults. The *Peromyscus* were much younger than the previous year (87% adult *P. maniculatus* and 93% adult *P. boylii* in 1999). The smaller populations and younger age of the captured mice suggest populations either recovering from a population crash or increased natality as a response to sustained higher mortality. Because capture rates and population estimates seemed to remain low throughout the summer, I suspect the latter postulate. The population estimates for 2000 (Figure 4.21-2) show the population as very low at the beginning of the summer, building up, and then crashing again.

Jeffrey Plot: The Jeffrey Plot was located in a Jeffrey pine forest classified as xeric conifer forest on vegetation maps used in the Mineral King Risk Reduction Project. The plot is described in Werner (1998). The plot was sampled to update the preburn data and to assess comparability to the previous sampling.

Seventeen nights of trapping (1,014 trapnights) produced 19 rodent captures (10 individuals). The mean population estimate during the survey period was 5 individuals (95% CI = 3-7 individuals). *Peromyscus maniculatus* dominated the sampled rodent population with seventy percent of the individuals (though only 42% of the captures). Other species included *Tamias speciosus* with twenty percent of the individuals, but fifty-three percent of the captures. The least frequently encountered species was *Glaucomys sabrinus* (10% of the individuals, 5% of the captures). Two species captured in low numbers in 1997, *Peromyscus boylii* and *Neotoma cinerea*, were not found in 2000.

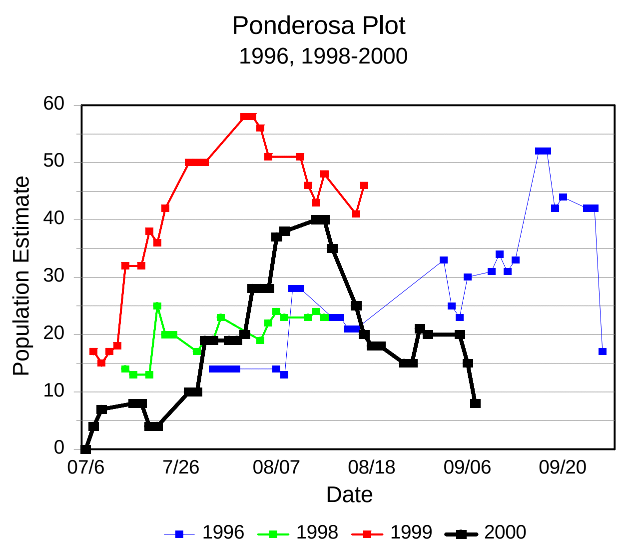


Figure 4.21-2. Population estimates at Ponderosa Plot, 1996 (preburn), 1998, 1999, and 2000.

The rodent population estimates for 2000 are only a quarter of what was present when the plot was sampled on 1996 (P = 0.001). Since then, the habitat has not been burned or subjected to any other obvious perturbation. Habitat tends to change little in the subalpine regions without a catastropic event like fire or avalanche. The decline appears to be entirely biological (e.g. disease) rather than a response to ecological change.

Catch rates for the three species of rodents were 0.008 captures/trapnight for *P. maniculatus*, 0.010 captures/trapnight for *T. speciosus*, and 0.001 captures/trapnight for *G. sabrinus*. Overall, trap success was unusually low compared to the Mineral King basin in general.

The sex ratios for the sampled population was predominately female (71%, n=14). Sex ratios for individual species are: *P. maniculatus* (female = 50%, male = 50%, n = 8), *t. speciosus* (female = 100 %, n=6), and the sex of the one *G. sabrinus* was not reported.

Most of the rodents captured were adults. This includes seventy-one percent of the *P. maniculatus* (21% subadults, 7% juveniles, n=8) and all of the *T. speciosus* and *G. sabrinus*.

Traugers Plot: 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.

Eight nights of trapping (420 trapnights) produced 62 rodent captures (41 individuals). The mean population estimate for the Traugers Plot during the survey period was 56 individuals (95 % CI = 33 - 78 individuals). This was about the same (P = 0.344) as when the plot was surveyed in 1999 (52 individuals; 95 % CI = 39 - 65 individuals). This was the only plot that did not appear to have unusually low population estimates in 2000.

In declining order of frequency, catch rates for the six rodent species were 0.062, 0.045, 0.024, 0.012, 0.002, and 0.002 captures/trapnight for *Neotoma fuscipes, Peromyscus boylii, Peromyscus californicus, Peromyscus truei*, *Chaetodipus californicus*, and *Tamias merriami*, respectively.

Table 4.21-2. Serendipity trapping results in the East Fork Kaweah River drainage.

Site Description	Species Capture Rate (captures/trapnight)								
	CHCA	MILO	NEFU	PEBO	PECA	PEMA	TASP	ZAPR	ALL
Mixed Chaparral				0.088					0.088
Mixed Hardwood/Conifer									0
Deadwood Creek		0.020				0.100	0.010		0.130
Mixed Conifer				0.009		0.027	0.045		0.082
Sagebrush/*Ribes*									0

Wet Meadow		0.078						0.065	0.143
Black Cottonwood								0.077	0.077
Jeffrey Pine							0.025		0.025
Mix Hard/Conifer Unburn				0.086					0.086
Mix Hard/Conifer Burned				0.014	0.011				0.014
Chamise Chaparral	0.014		0.028	0.028					0.153

CHCA = Chaetodipus californica, MILO = *Microtus longicaudus*, NEFU = *Neotoma fuscipes*, PEBO = *Peromyscus boylii*, PECA = *Peromyscus californicus*, PEMA = *Peromyscus maniculatus*, TASP = *Tamias speciosus*, ZAPR = *Zapus princeps*

The sex ratio for the rodents was predominantly female (64%, n=61). Sex ratios for individual species are: *N. fuscipes* (female = 76%, male = 24%, n = 25), *P. boylii* (female = 67 %, male = 33%, n=18), *P. californicus* (female = 56%, male = 44%, n = 9), *P. truei* (female = 20%, male = 80%, n = 5), *C. californicus* (unk=100%, n = 1), and *Tamias merrrami* (♂ = 100%, n = 1).

Of the predominate rodents, eighty-eight percent of the *Neotoma fuscipes* captured were adults and twelve percent were subadults (n=25. Ninety-four percent of the *P. boylii* captured were adults and six percent were subadults (n = 18). For the other species surveyed, *P. californicus* was seventy-eight percent adult (n = 9), *P. truei* were eighty percent adult (n = 5), *Tamais merrami* was adult (n=1), and the age class of the *Chaetodipus californicus* was not recorded (n = 1). The balance of the captured *P. californicus* and *P. truei* were Subadult.

<u>Serendipity Surveys:</u>

Rodents: The results of serendipity surveys for rodents in the East Fork Kaweah drainage are summarized in Table 4.21-2. In addition, there was a capture of *Sorex* sp. at Deadwood Creek and at the mixed conifer site. Mid-sized Mammals: The results of trapping mid-sized animals resulted in three captures of *Martes americana*. Two were at Deadwood Creek (June 2 and 6, 2000), and one was in the manzanita Jeffrey pine ecotone east of the Mineral King Ranger Station.

PLANS FOR 2001

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.

ACKNOWLEDGMENTS

This work was possible because of funding from the National Interagency Fire Center. Barak Shemai and Alicia Bacci did the trapping and data entry.

LITERATURE CITED

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

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. 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.

Werner, H.W. 2000. Fire effects monitoring on wildlife, 1999. Unpub. Report, Sequoia and KingsCanyon National Parks, Three Rivers, Ca. 12 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 – Watershed Studies

4.31) Watershed Sampling

- Claudette Moore, Ecologist, Sequoia-Kings Canyon Field Station, U.S. Geological Survey, Biological Resources Division

Lead Technician: Andi Head

INTRODUCTION

The Sequoia watershed program was established in 1983 as 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 elevation 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.

In 2000, the watershed program was temporarily halted due to lack of funds. All stream sampling, flow measurements and meteorological data collection ceased in May 2000 and all equipment was removed form the field.

The 1999 Watershed Report provides detailed information on watershed findings to date including post-fire changes in hydrology as observed in Tharp's Creek, preliminary findings in pre-burn stream chemistry in the East Fork sites, and results from the large woody debris survey conducted in the East Fork sites.

METHODS

The watershed research program has followed the original watershed study protocol, developed by the NPS Water Resources Division in 1982, to study key aspects of the hydrological and biogeochemical cycles. This holistic approach has produced an 18year data set in which the variability in watershed processes is now being reviewed for a monograph publication summarizing the Sequoia NP watershed program.

2000 WORK

Sampling continued in all study watersheds though May 2000 at which time all field equipment was removed, catalogued and stored for future watershed sampling. All watershed staff was terminated in June 2000. In October, USGS contracts were awarded to Claudette Moore and James Sickman to continue data analysis for incorporation into the watershed monograph. Limited stream sampling and flow monitoring was re-established in September by SEKI Resources Management staff and volunteers to maintain continuity in the East Fork drainage.

PLANS FOR 2001

Plans for graduate student Andi Heard of Colorado State University are in the works to continue with the original proposal to monitor post-fire stream chemistry changes in the East Fork watersheds. Future watershed work conducted in Sequoia will likely be initiated and managed by the SEKI Resources Management Division.

4.32) The Effects of Prescribed Burning on Stream Water Chemistry at Different Spatial and Temporal Scales

-Andi Heard and Dr. John Stednick, Colorado State University, Fort Collins, CO

INTRODUCTION

This research will investigate the effects of prescribed burning on stream water chemistry at different spatial and temporal scales in the East Fork of the Kaweah River in Sequoia National Park, California. Pre- and post fire concentrations of sulfate, nitrate, orthophosphate, chloride, calcium, magnesium, potassium, and sodium will be analyzed and pH, specific conductivity, alkalinity and temperature will be measured. To investigate the potential effects of prescribed fire at different scales these constituents will be measured in large (i.e. 20,000 ha) and small (i.e. 100 ha) catchments treated with prescribed fire over the past several years. This study will test the hypothesis that changes in stream water chemistry as a result of prescribed burning will be the same at different spatial and temporal scales.

Federal agencies are using prescribed burning as a tool to reduce fuel loads and restore ecological integrity in forests. In order to establish objectives for prescribed fire programs and methods to monitor if these objectives are met, a better understanding of the effects of fire and fire exclusion on forested watersheds is needed (Dissmeyer 2000). This study will provide a further understanding of how prescribed burning may be affecting stream water chemistry in Sequoia National Park. The results of this study will be useful in determining what water quality parameters may be included in a monitoring program and the most effective scale at which these parameters may be monitored.

OBJECTIVES

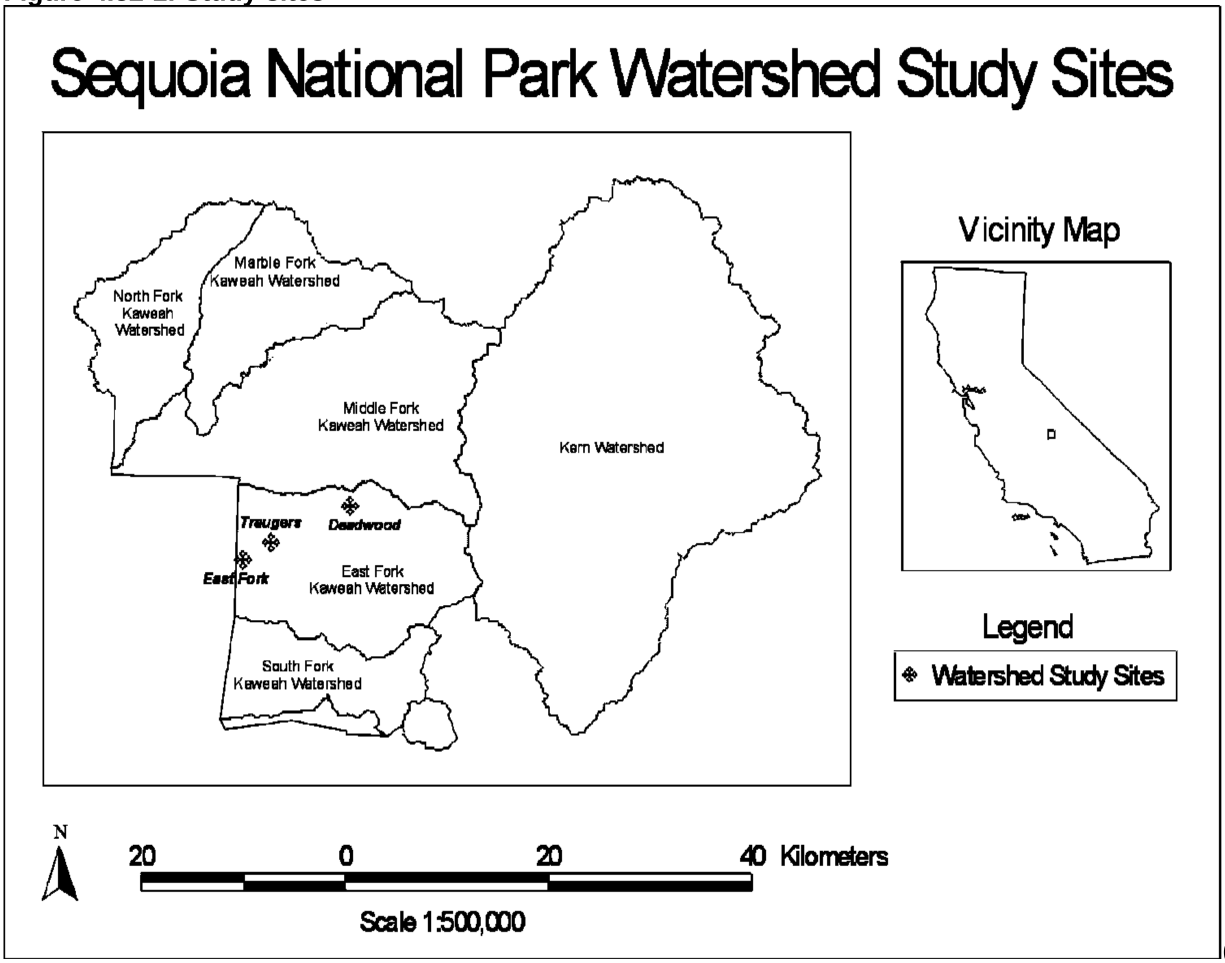
There are three study objectives. The first objective is to quantify any change in the precipitation-runoff relationship following the fire. The second objective is to quantify any change in solute concentrations and export. The third objective is to determine if the water quality responses of each constituent at different spatial scales are statistically different.

STUDY SITES

The research will be conducted in the East Fork of the Kaweah River in Sequoia National Park in conjunction with the Mineral King Risk Reduction Project. In an effort to look at the effects prescribed fire has at the landscape-scale versus in a small first order watershed, sampling will be conducted at three sites: East Fork of the Kaweah River (20,000 ha catchment), Trauger’ s Creek (106 ha catchment) and Deadwood Creek (100 ha catchment). Trauger’s Creek is a transition zone between the chaparral-hardwood zone and the mixed conifer zone and the elevation ranges from 1390 m to 1970 m. Deadwood Creek is in a sequoia mixed-conifer zone and the elevation ranges from 1985 m to 2660 m (Caprio 1999) (Figure 4.32-1).

Prescribed burning in the East Fork has been occurring since 1995. Deadwood Creek was partially burned in December of 1999. Trauger’s and Deadwood are scheduled to be burned in the summer or fall of 2001. Hydrology and water chemistry data have been collected at the three sites since 1996.

Figure 4.32-1: Study sites



(modified from Caprio 1999)

SUMMARY OF METHODS

Stream water stage will be continuously measured using Global Water dataloggers and pressure transducers at Trauger's and Deadwood Creek. A stage-discharge rating curve has already been established for both sites. Southern California Edison measures discharge data for the East Fork Kaweah River.

Daily precipitation amounts for the East Fork drainage are available from the National Park Service and Army Corps. of Engineers.

Stream water grab samples for chemical analysis will be collected at all three sites. The sampling schedule will be dependent on changes in the hydrographs and the timing of the prescribed fires. Routine sampling will occur at least twice a month for each site. In order to capture the stream chemistry at different stages of the hydrograph, additional samples will be collected during storm events and periods of snowmelt runoff.

Temperature and conductivity will be measured in the field at the time of sampling. Specific conductivity, pH and alkalinity will be measured at the Ash Mountain Water Lab in Sequoia National Park. Samples will be filtered in the lab with a 0.45 μ membrane. The samples will be shipped to the US

Forest Service Rocky Mountain Experiment Station in Fort Collins, Colorado for analysis of sulfate, nitrate, orthophosphate, chloride, calcium, magnesium, potassium and sodium.

The total monthly and annual export of the constituents will be determined for each site. This will be accomplished by calculating volume weighted means (VWM) for each constituent.
The total export and mean solute concentrations will be compared between the East Fork, Trauger's and Deadwood Creek in order to determine if the magnitude of the post-fire response for sulfate, nitrate, orthophosphate, chloride, calcium, magnesium, potassium, sodium, pH, conductivity, temperature and alkalinity are the same at different spatial and temporal scales.

PROJECT TIMELINE

PROJECT TIMELINE		
Season	**Year**	**Phase**
Winter	2001	Begin intensive winter and post-burn water sampling
Summer/Fall	2001	Trauger's and Deadwood Creek scheduled to be burned
		Less intensive sampling and complete pre-burn analysis
Winter	2002	Intensive winter and post-burn sampling period
Spring	2002	Continue intensive post-burn sampling period through snowmelt
Summer/Fall	2002	Analyze data, complete thesis and submit an article for publication

REFERENCES

Caprio, A.C. 1999 Annual Fire Report on Research, Monitoring, and Inventory. National Park Service, Three Rivers, CA.

Dissmeyer, G.E. 2000. Drinking water from forests and grasslands: a synthesis of the scientific literature. Gen. Tech. Report SRS-39, U.S. Department of Agriculture: Forest Service.

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.
  - **Research Needs and Proposed Projects:** A page detailing research needs is under development. It will focus on describing specific high priority fire related research needs that have been identified by researchers, resources specialist, and fire managers within the parks. Additionally, other potential studies targeting specific fire related topics that are of interest but lower priority will be proposed. These may be of particular interest to graduate students or other researchers
  - **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**.

Reprint of - Paper from Symposium on Fire Economics, Policy, and Planning: Bottom Lines, April 5-9, 1999 in San Diego, California, Session Vl. USDA Forest Service Gen.Tech.Rep. PSW-GTR-173. 1999.

4.5 - An Analytical Approach for Assessing Cost-Effectiveness of Landscape Prescribed Fires[1]

Philip N. Omi,[2] Douglas B. Rideout,[2] Stephen J. Botti[3]

Abstract

Analytical tools are needed for assessing the cost and effectiveness of large-scale prescribed fire programs. Cost and effectiveness trade-offs for LLS. Department of Interior (USDI) fuels treatment programs were analyzed, with particular emphasis on National Park Service (NPS) hazard fuel reduction projects. A prototype simulation model was developed for the Mineral King study area in Sequoia-Kings Canyon National Parks (SEKI), California. Our prototype process used the FARSITE™ simulator to examine fire size and intensity (with and without fuel treatment) to develop a cost-effectiveness frontier. Managers can use this frontier to select the nrost effective fuel treatment strategy subject to the available budget. Other trade-offs can be examined by transforming simulator outputs (e.g., fuel treatment expenses versus suppression cost savings).

Hazardous fuels have built up on many U.S. Department of Interior (USDI) lands as a result of cultural and ecological processes. Although USDI bureaus (National Park Service, Bureau of Land Management [BLM], Fish and Wildlife Service, and Bureau of Indian Affairs) have reduced fuels through prescribed burning and mechanical manipulation for many years, data are still lacking relating treatment prescriptions to reductions in wildfire risks and hazards. Agencies also lack the ability to identify the most cost-effective fuel treatment for a given budget.

Our project has focused on development of a cost-effectiveness analysis (CEA) system for USDI hazard fuels reduction programs (Omi and others 1998). Analysis tools are needed that will enable the USDI to model the effectiveness of incremental increases to hazard fuel reduction funding in terms of protecting resources at risk, reducing wildfire suppression costs, and restoring natural ecosystems.

Assessing the cost-effectiveness of fuel treatments presents many challenges. These challenges are accentuated when the fuel treatment under consideration is prescribed fire, especially when proposed fires will be applied over a large geographic area such as a watershed. Anecdotal evidence may point to

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[1]An abbreviated version of this paper was presented at the Symposium on Fire Economics, Policy, and Planning: Bottom Lines, April 5-9, 1999 in San Diego, California.

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prescribed fire as the fuel treatment of choice for an area, especially in areas managed for ecosystem sustainability or restoration of natural patterns and processes. However, analytical tools are needed for justifying the appropriate level of fire application for an area. Although prescribed fire treatments generally are lower in cost than other fuel treatments (i.e., mechanical thinning, fire also is more variable in its effects; Omi and Kalabokidis 1998). This variability in treatment effect is especially evident (and often desired) in the spatial mosaic created by large-scale fire applications. Further, mechanical methods may not be suitable where land management objectives call for restoring or imitating natural patterns and processes over the landscape, such as in a national park.

This paper summarizes initial efforts aimed at constructing a prototype cost effectiveness simulator for the Mineral King study area in Sequoia-Kings Canyon National Parks (SEKI), California.

Methods

Initially we hoped to rely on the existing USDI 1202 database of historical fires to obtain cost and effectiveness estimates. We had hoped that historical evidence would confirm that prescribed fire had reduced wildfire frequency and management costs. When the data proved to be of questionable quality, we relied on a survey of fire managers to provide estimates for fuel load reductions made possible by prescribed fire treatments. These estimates were used to construct custom fuel models representing

Table 1 – *Summary of treatment combinations and outcomes for the Mineral King study area, Sequoia-Kings Canyon National Park.*[1]

Treatment	Area treated (ha)	Treatment cost ($)	Reduction in area burned (ha)	Cost difference ($)
1	2,348	$16,008	1,196	$31,704
1,2	2,810	$16,934	1,264	$33,283
1,2,3	3,781	$18,400	1,849	$58,507
1,2,3,4	4,105	$18,860	2,092	$62,059
1,2,4	3,134	$17,145	1,628	$46,560
2	462	$9,929	391	$7,967
2,3	1,433	$13,877	940	$24,337
2,4	785	$11,621	813	$21,889
2,3,4	1,757	$14,713	988	$25,283
3	972	$12,360	603	$13,383
3,4	1,296	$13,472	600	$12,140
1,3	3,320	$17,712	1,846	$54,082
1,3,4	3,644	$18,270	1,859	$54,015
4	324	$8,952	396	$9,096
1,4	2,672	$16,632	1,658	$48,199

[1]Estimates based on FARSITE™ simulations with and without fuel treatment, and cost estimates from Omi and others (1992, 1995).

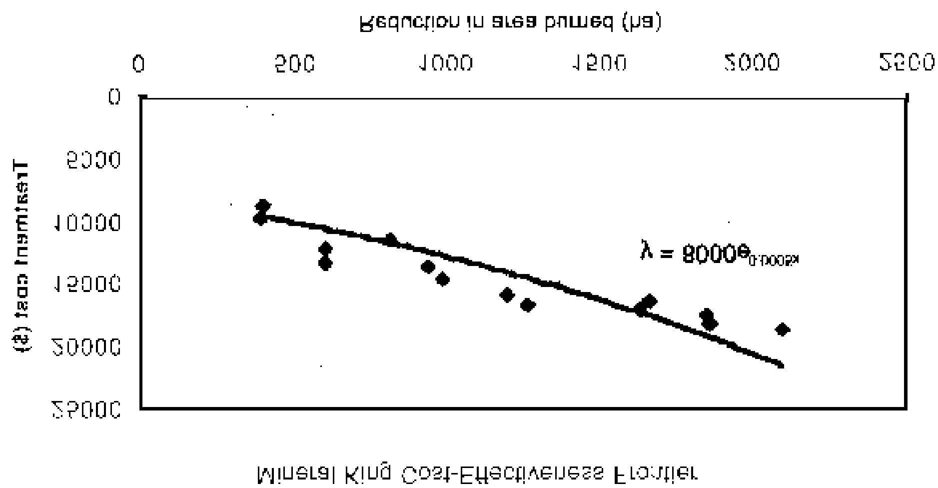

Figure 1.
Cost-effectiveness frontier for large-scale prescribed fire treatments, Mineral King watershed, Sequoia-Kings Canyon National Park, based on FARSITE™ simulations. with and without fuel treatment.

fuelbeds after treatment for running the FARSITE™ model[4] (Finney 1998).

For the prototype simulation four wildfires were ignited on an untreated landscape and allowed to burn for 12 hours. Fuel treatment levels were simulated by considering the different statistical combinations of four segments or zones that could be treated in the potential path of wildfires in the Mineral King watershed (i.e., a total of 15 potential treatment levels and one control or untreated level). To simulate fire spread after treatment, the four wildfires were re-ignited in the same locations and allowed to burn for the same time periods. Fire behavior outputs from all runs were saved in column-delimited format for export into a spreadsheet file. Fire behavior outputs compared included fireline intensity and size.

Acres burned by wildfires after treatment were subtracted from acres burned before treatment, yielding acres reduced. Historical costs for BLM suppressed fires (Omi and others 1995) were used to determine the costs of wildfires. RXCOST (Omi and others 1992) was used to determine cost of the treatments. Prescribed fire costs for treating fuel segments plus subsequent wildfire costs were added together and compared to the wildfire cost without any treatment. Cost and effectiveness tradeoffs between different levels of fuel treatments were assessed graphically.

Results

The simulation results from the 15 treatment combinations were summarized, including reductions in area burned and (treatment plus suppression) cost savings, with and without treatment ***(table 1)***. Simulated burned area reductions ranged from 391 to 2,092 ha with approximated cost reductions from about $8,000 to $62,000.

[4]Mention of trade names or product is for information only and does not imply endorsement by the U.S. Department of Agriculture.

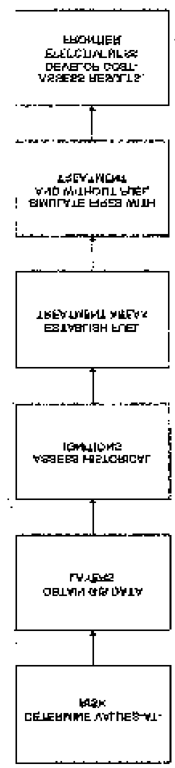

Figure 2.
Flow chart for prototype cost-effectiveness simulator.

Results were analyzed graphically ***(fig. 1)***. The "cost-effectiveness frontier" identifies the trace of greatest reductions in burned area per dollar spent in fuel treatment. In this example one point on this path involves treatment of segment 4 with a cost of $8,952 and burned area reduction of 396 ha ***(table 1)***. Alternatively, a manager could treat segments 2 and 4 for a cost of $11,621 and realize a burned area reduction of 813 ha; or he/she could treat segments 1 and 4 for a cost of $16,632 and burned area reduction of 1,658 ha. The most expensive alternative, treatment of all segments (1-4), would cost $18,860 and reduce burned area by 2,092 ha. Treatment levels interior to the frontier are less cost-effective.

Further, with a limited budget the most cost-effective treatment combination will be that which lies on the frontier and fits within the funding constraint. In this example, if the decision-maker had a fuel treatment budget of $12,000, the best treatment combination would be segments 2 and 4. With a $19,000 budget, the most cost-effective decision would be to treat all four segments. Thus, the choice of treatment alternative is left to the manager, and the cost-effectiveness frontier with the budgetary constraint identifies the best choice.

Treatment and suppression cost savings with the different alternatives were identified ***(table 1)***. These can be graphed and analyzed similarly, along with other outputs from the simulation, e.g., reductions in fire intensity.

Discussion

Construction of the prototype yielded considerable insight into problems associated with simulating cost-effectiveness in the Mineral King study area. Although the prototype was restricted to four fires burning into four treated segments, we were able to demonstrate the feasibility of the process.

Results from the FARSITE™ runs indicate that it is possible to establish a cost-effectiveness frontier for a fuels treatment program involving large-scale prescribed fires. Inferences derived from considering fire area are more reliable than intensity data, but problems with intensity measurements will be addressed in the second phase of this project. Other prescribed fire outcomes that should also be considered include smoke emissions, effects on nonmarket resource, and probability of escape. A more comprehensive framework for evaluating a prescribed fire program can be designed *(fig. 2)*. Precise estimates for values-at-risk incorporated in a geographic information system (GIS) may not be needed for our analysis if we identify their spatial location. Further, our work on this prototype suggests that fuel treatments can be analyzed relative to other meaningful indicators (e.g., suppression cost savings, changes in smoke emissions, or any other outcome where estimates are available with and without fuel treatment).

Conclusions

The first phase of this project has assessed problems and established the feasibility of carrying out a cost-effectiveness analysis of hazard fuel reduction programs. The project addressed general issues related to conducting a cost- effectiveness analysis, limitations of available databases, and restrictions resulting-from incomplete understanding of fire behavior, especially large-scale landscape fires. The feasibility of conducting a cost-effectiveness analysis was addressed through the development of a prototype simulator, based on the FARSITE™ simulator with and without fuel treatments proposed for the Mineral King study area. The Mineral King study provides a good test for the prototype because of its fire history, fuel profiles, and ongoing experimentation with large- scale prescribed fires. The prototype's greatest applicability will be to assess areas with aggressive fuel treatment programs, such as Mineral King. However, the methods developed during this project may have broader applicability if analysis units maintain good records on historic fires and fuel treatments. Continued improvement in GIS-based inventories will also rehne our prototype's capabilities.

Acknowledgments

This project was initiated as part of the U.S. Department of Interior Competitive Fire Research Program, with support from the U.S. Fish and Wildlife Service (Contract 14-45-0009-1552 WO50). The National Park Service (CA 1268-2-9004 TASK CSU-165) has provided support for ongoing work.

References

Finney, M.A. 1998. FARSITE: Fire area simulator – model development and evaluation. Res. Paper RM-RP-4. Rocky Mountain Research Station: USDA Forest Service; 47 p.

Omi, P.N.; Kalabokidis, K.D. 1998. Fuels modification to reduce large fire probability. In: Viegas, D.S., ed. Proceedings III international conference on forest fire research and 14’” conference on fire and forest meteorology, Vol. II; 1998 November 16-20; Luso, Portugal; 2073-2088.

Omi, P.N.; Rideout, D.B; Haynes, N.L. 1998. Cost effectiveness analysis of hazard reduction programs. Phase 1: feasibility. Ft. Collins, CO: Western Forest Fire Research Center (WESTFIRE), Colorado State University; 39 p.

Omi, P.N.; Rideout, D.B.; Stone, J.S. 1992. Cost contxols in NPS prescribed f,ire management. Final report submitted to National Park Service-NIFC. Ft. Collins, CO: Western Foxest Fire Research Center (WEST’FIRE), Colorado State Univexsity; 11 p.

Omi, P.N.; Rideout, D.B.; Stone, J.S. 1995. Cost-effectiveness of fire prevention. Final report submitted to USDI Fire Research Coordinating Committee-NIFC. Ft. Collins, CO: Western Forest Fire Research Center (WESTFIRE), Colorade State University; 48 p.

4.6 - Other

! **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. Planning continued during 2000 and a project coordinator position was filled by Eric Knapp. Eric will develop detailed protocols and sampling stratagies for the project area. 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. Current plans are to carry out fall burning during the 2001 and spring burning during 2002. (Jon Keeley, Nate Stephenson, and Eric Knapp - USGS)

! **Fire and Invasive Annual Grasses in Western Ecosystems: Cheatgrass** - Preliminary planning was begun in 2000 by the USGS Southern Sierra Research Station within the Parks for the this project, funded by the Joint Fire Sciences Program. Within the Parks the work will primarily focus on the cheatgrass invasion in the Cedar Grove area of Kings Canyon that may be related to fire and other disturbances. (Matt Brooks[1], Jayne Belnap[2], Jon E. Keeley[3], and Robert Sanford[4])

Project Abstract from JFSP proposal

Annual grasses have invaded shrub and forest ecosystems in western North America and are linked to changes in both ecosystem structure and function and in some cases have altered fire regimes. This has occurred over vast expanses of public lands in the Great Basin and the Mojave Desert, and is a threat to lower elevation yellow pine forests. The investigators hypothesize that fire has the potential for contributing the most to annual grass invasion in low nutrient soils, where postfire increases in their availability are more effectively exploited by invasive grasses than by the native flora. Soil nutrient changes can vary widely depending on soil properties and the amount and duration of soil heating. In forested ecosystems such impacts of fire on soil nutrients and light solar radiation are potentially more profound now than under historic conditions because of unnaturally high fuel loads.

They propose to investigate the interactions between fire and soil nutrients over three ecosystems currently dominated or threatened by invasive annual grasses in western North America -- Great Basin shrubland, Mojave Desert scrub and Sierra Nevada yellow pine forest. Common factors driving the fire/annual grass cycle in these ecosystems will lead to generalizations widely applicable beyond the ecosystems under study. In addition, each of these systems has unique features that contribute to the dominance of invasive annual grasses, and elucidation of these will contribute to a broader understanding of the problem.

They will use intensive field manipulations at representative sites in these three regions that will couple burning, nutrients, fuels and light treatments. In addition, extensive surveys will be conducted across these regions to assess the soil nutrient status associated with invaded and non-invaded sites. These field studies will be coupled with laboratory studies to examine in detail the relationship between soil heating and nutrient availability for invasive grasses. With this information, managers could determine in advance if habitats are naturally vulnerable or resistant to invasions, enabling limited resources to be more effectively deployed both during and after fires. Fire prescriptions could be designed to avoid creating conditions susceptible to invasion, plus, restoration techniques could be better targeted, saving both time and money.

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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.