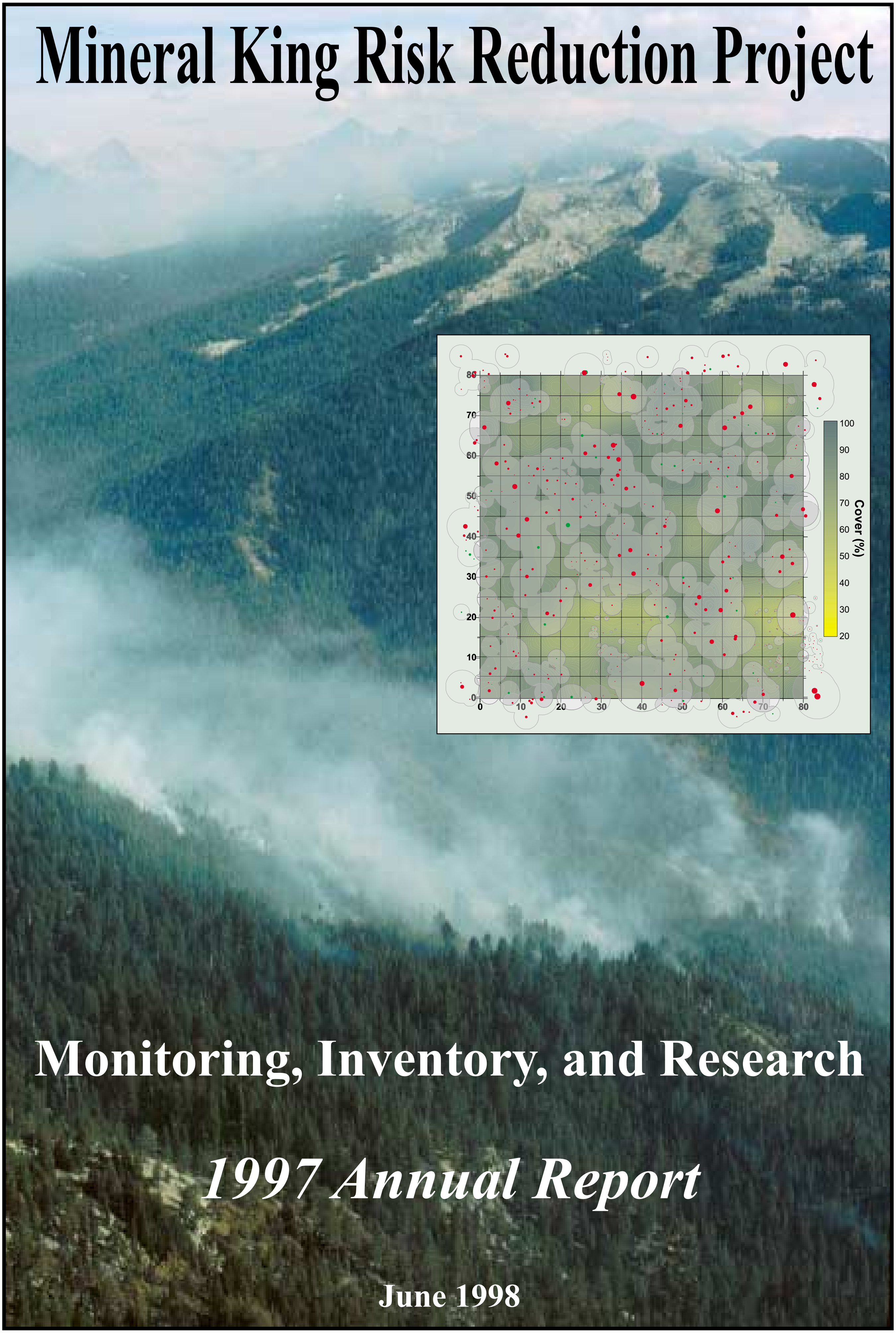
Mineral King Risk Reduction Project



Monitoring, Inventory, and Research

1997 Annual Report

June 1998

Note: The 1997 Annual Report on Research, Monitoring, and Inventory for the Mineral King Risk Reduction Project is the third annual report produced for the burn project. The earlier reports contain some introductory and additional background material that has not been duplicated in this report. Copies of all the reports are being made available by web browser over the Internet. Full copies of the 1995 and 1996 report can be downloaded in Adobe Acrobat PDF format from the ***Fire Information Cache*** on the Sequoia and Kings Canyon National Parks web site at www.nps.gov/seki/fire. PDF files require the Adobe Acrobat reader which can be downloaded free from Adobe www.adobe.com. If you do not have Internet access and would like to obtain one of the earlier reports from 1995 or 1996 contact Tony Caprio at Sequoia and Kings Canyon National Parks, Division of Science and Natural Resources Management.

Cover Caption: Aerial view of a portion of the Atwell segment (segment #5) burning during the fall of 1995 with the Mineral Lakes in the near distance and Great Western Divide in the far distance. The inset is a diagram of tree diameters and tree canopy size in one of the Pitcher Plots. Yellow and green background shading in the diagram shows canopy density measured at DBH height. The darker the green shading the greater the canopy density.

Annual Report 1997
Research, Inventory, and Monitoring
Mineral King Risk Reduction Project

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Executive Summary

The Mineral King Risk Reduction Project (MKRRP) was initiated out of a need to assess the operational requirements and cost effectiveness of large scale prescribed burning for wildland management in a setting altered by a century of fire suppression. The local objectives of the project are to initiate the reduction of unnatural fuel accumulations (these accumulations can create hazardous conditions for visitors, developments, and natural resources) and begin restoration of ecosystem structure and function within the East Fork drainage of Sequoia and Kings Canyon National Parks. However, because the scale of the project is unprecedented, a number of integrated monitoring and research projects were also initiated to assess the impacts and responses of key components of the watershed to prescribed fire. Additional projects have also been initiated to utilize this opportunity to gain additional insights into fire's role in Sierran ecosystems. These projects and their results are important in providing information about short- or long-term resource responses and impacts when burning at this scale, a relatively new management strategy, and whether the planned objectives for the MKRRP are being met. This information will feed back into management planning and permit modification and fine tuning of the burn program in addition to providing information to the public and policy makers.

Support for the monitoring and research projects is coming from a variety of sources. Projects funded directly out of the Mineral King Risk Reduction Project include fire effects monitoring, fuel and wildlife inventories, and a study on the relationship between fuel loads and fire impacts on giant sequoia fire scars. Other projects are using resources from within and the Sequoia and Kings Canyon Field Station (Biological Resources Division of the USGS). These include natural resource inventory, watershed hydrology, stream chemistry, resampling old vegetation plots, and fire history. Cooperative research projects are also underway using the dedication, energy, and support of graduate students from several universities (University of California, Davis; University of California, Berkeley). New research projects being initiated during 1997 include a fire effects/remote sensing study of red fir forest (UC Berkeley) and a watershed sediment transport study (BRD/USGS).

Several noteworthy observations or findings were made by the monitoring/research projects from 1995 to 1997. The small mammal trapping project found that small mammal populations roughly doubled in the burned sequoia plot compared to preburn population densities. Fire effects plots showed overstory tree mortality varied by vegetation type: 22% red fir forest (ABMA), 50% sequoia mixed-conifer forest (no mortality of overstory sequoias was noted), and 98% in low elevation mixed-conifer forest (CADE). These plots also showed total fuel reductions of 72% (CADE) to 94% (ABMA). A significant increase in giant sequoia seedlings was noted in the burned Atwell sequoia plots. Watershed sampling completed its first full water year of sampling, providing preburn data on trends within the East Fork. Initial results suggest similar annual shifts in flow, pH, and ANC (acid neutralization capacity) when compared to other unburned Sierran watersheds.

Burning in the watershed during 1997 amounted to 375 ha (925 ac). Most of the critical Redwood Segment (segment #4) was burned during the fall. This created a buffer of reduced fuels across the East Fork below Silver City and Cabin Cove. Additional burning along the Tar Gap Trail in Tar Gap Segment (segment #10) created a break in the continuous fuels across this segment.

The MKRRP area encompasses 21,202 ha (52,369 ac) within the East Fork watershed with elevations ranging from 874 m (2,884 ft) to 3,767 m (12,432 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). About 80% of the watershed is vegetated with most of the remainder being rock outcrops located on steep slopes and at high elevations.

1. Project Year Synopsis: Accomplishments for 1997 projects.

- **Fire Effects Plots -** Fire effects plots are being established within the Mineral King Risk Reduction Project (MKRRP) area to allow park staff to monitor both the short- and long-term effects of the management ignited prescribed burns on park vegetation and fuels (primary emphasis is placed on fuel loads and tree density). These plots provide important feedback to park managers on how well they are meeting their management goals and will help refine the goals of future burn plans. A total of 18 fire effects plots have been set up in the East Fork since 1995. These include seven forest plots (five in segment #3, three in segment #10, and a control plot adjacent to segment #3) and nine brush plots (located on the north side of the East Fork). Five forest plots burned following the ignition of segment #3 during the fall of 1995 with one and two year postburn rechecks completed during 1996 and 1997. The rechecks showed overstory tree mortality varied by vegetation type: 22% red fir forest, 50% sequoia-mixed conifer forest (no mortality of overstory sequoias was noted), and 98% in ponderosa pine forest. Total fuel reductions of 72% were found in ponderosa pine forest, 89% in sequoia-mixed conifer forest, and 94% in red fir forest. Additionally, giant sequoia seedlings increased from no seedlings preburn to 88,300 seedlings • ha^{-1} postburned in the Atwell sequoia plots.

- **Wildlife Monitoring -** Four permanent small mammal live-trapping plots have been established and sampled between 1995 and 1997. 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). The mid-elevation sequoia plot, located in segment #3, burned during November 1995 and was resampled in 1996 and 1997. Initial results indicate a doubling of small mammal biomass since the burn. The ponderosa plot burned during November 1997 and will be resampled during 1998. Serendipity trapping (non-permanent trap locations) was also carried out at a number of locations in the Mineral King Valley and Oriole Lake watershed.

- **Watershed Sampling: Stream Chemistry and Hydrology -** Stream chemistry and hydrological information have been sampled by staff of the Biological Resource Division of the USGS at regular intervals (weekly) since May 1995. Three sites are being sampled in the East Fork (the East Fork itself and two tributary creeks, one in chaparral and one in mixed-conifer forest) which will provide data to help assess the effects of watershed scale prescribed fire on important chemical components and flow characteristics. Data will be compared to the "reference" unburned Log Creek watershed in Giant Forest, sampled as part of another long-term watershed study. Watershed sampling completed its first full water year of sampling, providing preburn data on trends within the East Fork. Initial results suggest similar annual shifts in flow, pH, and ANC (acid neutralization capacity) when compared to other Sierran watersheds.

- **Watershed Sampling: Benthic Macro-Invertebrate Survey -** Ian Chan, Don Erman, Nancy Erman (UC Davis) are conducting a pre- and postburn survey of benthic macro-invertebrates in the East Fork. This study will assess the effects of prescribed fire on the structure of aquatic macro-invertebrate communities and provide baseline inventory of composition, abundance, and diversity. Six treatment streams (situated in areas that will be burned) and four non-treatment reference streams (which will remain unburned) have been located and sampled in the Middle Fork watershed. Benthic macro-invertebrates are collected through a combination of quantitative sampling and qualitative description in three habitat types: riffles, pools, and slickrock glides. In addition, several artificial substrates (unglazed clay tiles) were placed in slickrock area to help quantify colonization rates. The initial postfire sampling has been completed on the Redwood and Atwell Creek sites that burned during 1995.

- **Fire History -** Fire history samples were obtained from Atwell, Lookout, Redwood, Tar Gap, Oriole Lake, Eden Grove, Mineral King, and Purple Haze segments from 1995 to 1997. These samples will become part of an effort to reconstruct the spatial scale and pattern of pre-European settlement fire events from throughout the East Fork watershed and to provide baseline data on past fire occurrence in a variety of habitats, vegetation types, and aspects in the drainage. Predictions of past fire occurrence in the Sierra Nevada based on computer models suggest differences in burn patterns/frequencies on different aspects with these differences most notable between south and north slopes. However, at this time almost no data exists 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.

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

- **Fuel Inventory and Monitoring -** Fuel-load sampling was carried out during 1995 and early summer of 1996 to obtain field information on forest fuels (tons per acre) that are available to forest fires. During 1997 permanent fuel plots were established This information will provide improved fuel model data for input into the FARSITE fire spread model which will be used to more accurately predict fire spread following an ignition. Most sampling has concentrated on the south aspect of the East Fork and in segment #10. To date over 580 plots have been sampled including 44 permanent fuel plots established during 1997. In addition to estimating fuel loads at each plot, additional 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 are now being resampled prior to the burning of segment #10 (sampling of two plots is complete). Because of little long-term data from red fir forest these plots will provide important information to park managers on changes in forest structure and composition, and fuel loads over a 20 year period. Initial estimates indicate a significant increase in fuel loads and 22% mortality of all saplings/trees in the plots (most mortality, 75%, is a result of the death of young seedling and sapling as the forest naturally thins itself over time). Postburn sampling of these plots will also provide detailed information on forest changes and fire effects which has been little studied in this forest type.

- **Landscape Analysis - Fire and Forest Structure -** Kurt Menning's (graduate student at UC Berkeley) research will address questions revolving around the means and the landscape-scale consequences of selecting differing mechanisms for restoring forest structure to something near pre-Euroamerican conditions. Using high resolution aerial imagery and field sampling he will describe the current structure and pattern of mixed conifer forest over the landscape and then how the qualities of these change as fire is restored to the ecosystem. Field sampling was carried out this past summer in the Redwood, Tar Gap, Purple Haze, Deadwood, High Bridge, and Eden Grove Segments. Plots burned during 1997 will be resampled in 1998. High resolution digital multispectral imagery was recently acquired by an overflight over the East Fork. The imagery will have high enough resolution (one meter) that individual tree crowns should be discernable, allowing detailed observations on tree health and species to be made.

- **Natural Resource Inventory -** The Natural Resource Inventory (NRI) staff of the Biological Resources Division of the USGS (formerly NBS) have been establishing permanent inventory plots within the drainage. The general purpose of the NRI plots is to provide a systematic, plot-based inventory for detecting and describing the distribution of vascular plants, vertebrate animals, and soils throughout the Sequoia and Kings Canyon National Parks. Within the East Fork, the plots document the preburn floristic composition and structure of vegetation. Since 1995, 18 plots have been established as part of the MKRRP. These supplement 32 plots that already existed in the watershed. Plots that burned during 1995 have been revisited during 1996 (seven of nine were relocated) to assess burn impacts and first year postburn vegetation responses. An effort was made to also sample locations falling within the little known, dense chaparral vegetation of the East Fork. Plots burned during November 1997 will be resampled during 1998.

2. Overview of Project

2.1 - Objectives

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

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

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

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

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

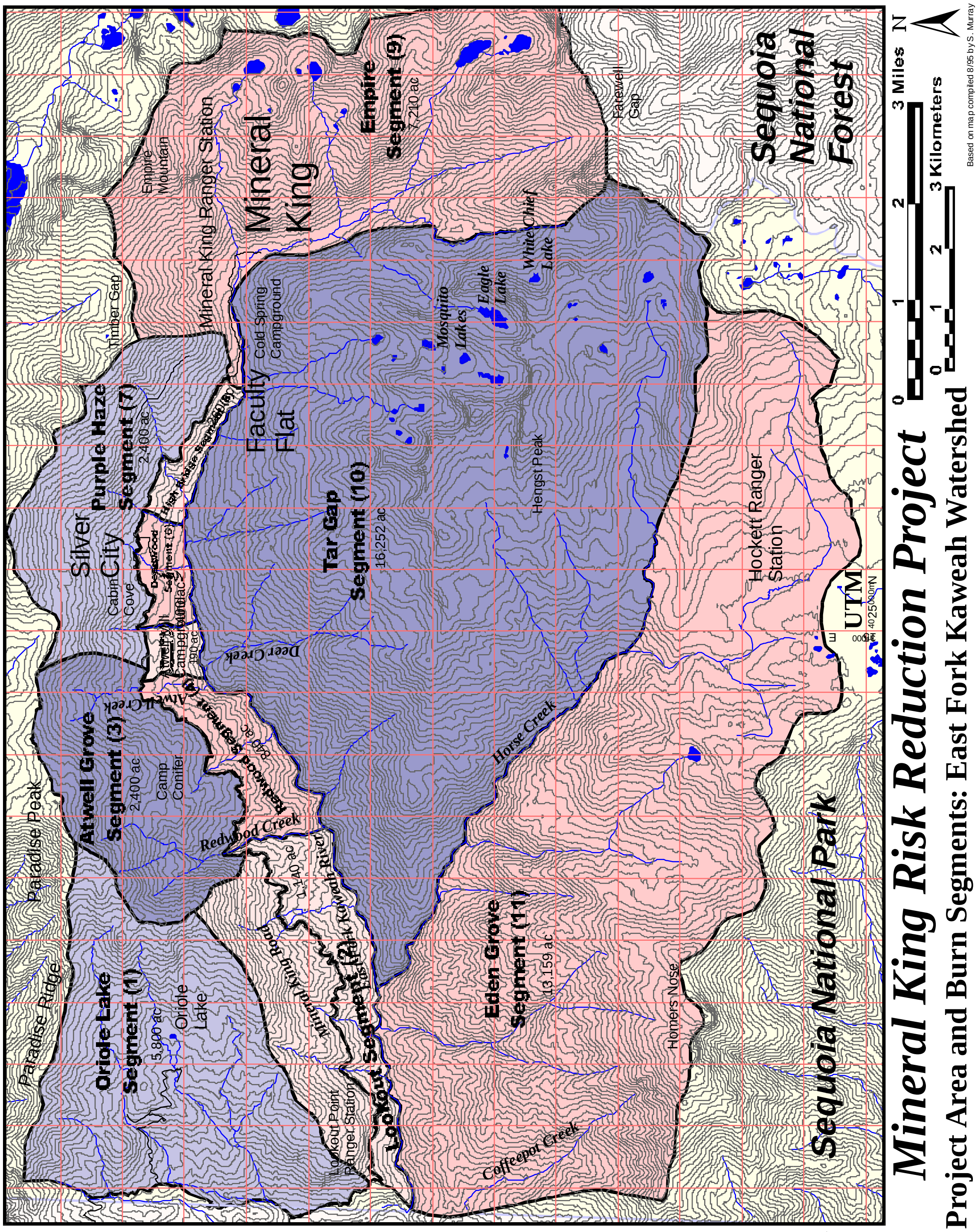


Figure 1.

Figure 2.1-1. Mineral King Risk Reduction Project project area and segment layout.

consistent with the study objectives. Descriptions of studies and the East Fork are available in the 1995 and 1996 MKRRP Annual Reports (Caprio 1995; Caprio 1996).

2.2 - Description - East Fork Project Area

The East Fork watershed (**Fig. 2.2-1**)which encompasses the MKRRP is one of five major drainages comprising the Kaweah River watershed which flow west (historically but is now heavily diverted for agriculture) into the Tulare Lake Basin in the southern Central Valley. Terrain in the watershed is rugged, elevations range from 874 m (2884 ft) to 3767 m (12,432 ft) within the project area. 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. Major topographic features of the watershed include the high elevation Mineral King Valley, Hockett Plateau, Horse Creek, the high peaks producing the Great Western Divide, and the Oriole Lake subdrainage (with an unusually low elevation lake for the Sierras at 1700 m elevation).

Table 2.2-1. Segment number and size.

Segment	Hectares	(Acres)
Oriole Lake (#1)	2352	(5811)
Lookout Point (#2)	439	(1084)
Atwell Grove (#3)	962	(2377)
Redwood (#4)	289	(716)
Deadwood (#5)	121	(300)
Silver City (#6)	135	(335)
Purple Haze (#7)	989	(2445)
High Bridge (#8)	121	(299)
Empire (#9)	2917	(7210)
Tar Gap (#10)	6577	(16252)

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

Vegetation of the area is diverse, varying from foothills chaparral and hardwood forest at lower elevations to alpine vegetation at elevations above 10-11,000 feet. About 80% of the watershed is vegetated with most of the remainder rock outcrops located on steep slopes and at high elevations. Lower elevation grasslands and oak woodland, while common at low elevations in the Kaweah drainage, are uncommon within the park's portion of the East Fork watershed. Sequoia groves within the project area include Atwell, East Fork, Eden, Oriole Lake, Squirrel Creek, New Oriole Lake, Redwood Creek, Coffeepot Canyon, Cahoon Creek, and Horse Creek. Vegetation is dominated by red and white fir forest with pine and foothill types of somewhat lesser

Vegetation Class	Hectares	(Acres)
Foothills Chaparral	1119	(2764)
Foothills Hardwoods &	1433	(3538)
Ponderosa Pine Mixed Conifer	1968	(729)
White Fir Forest	4034	(9964)
Red Fir Forest	4206	(10388)
Xeric Conifer Forest	1244	(3074)
Montane Chaparral	484	(1195)
Mid-Elevation Hardwood Forest	170	(420)
Lodgepole Pine Forest	967	(2387)
Subalpine Forest	99	(266)
Meadow	133	(328)
Other (primarily water)	100	(247)
Barren Rock	4198	(10368)
Missing or No Data	1050	(2593)

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

Figure 2.2-1. Main drainage of the East Fork of the Kaweah from Case Mountain. Photo does not show the Oriole Lake subdrainge (left of view). Photo by Linda Mutch.

importance (**Table 2.2-2**). No endangered species are known from the watershed although several sensitive species have been located during surveys (Norris and Brennan 1982).

Access to the area by road is limited to the narrow winding Mineral King Road, 25 miles long. The Mineral King Valley is popular with backpackers and packers as a starting point for many high country trips. Higher elevations of the watershed receive considerable recreation use while lower elevations receive relatively little use. Developed or semi-developed areas within the watershed include Silver City/Cabin Cove, Mineral King, Lookout Point, Oriole Lake, and the Atwell Mill areas. NPS campgrounds exist at Atwell Mill and Mineral King.

In early 1998 black-and-white DOQQs (digital orthophoto quarter quads) were made available for the East Fork drainage (**Fig. 2.2-2**). These can be accessed off the park computer system at Ash Mountain (see Pat Lineback, SEKI GIS Coordinator). They have an image resolution of 1 meter.

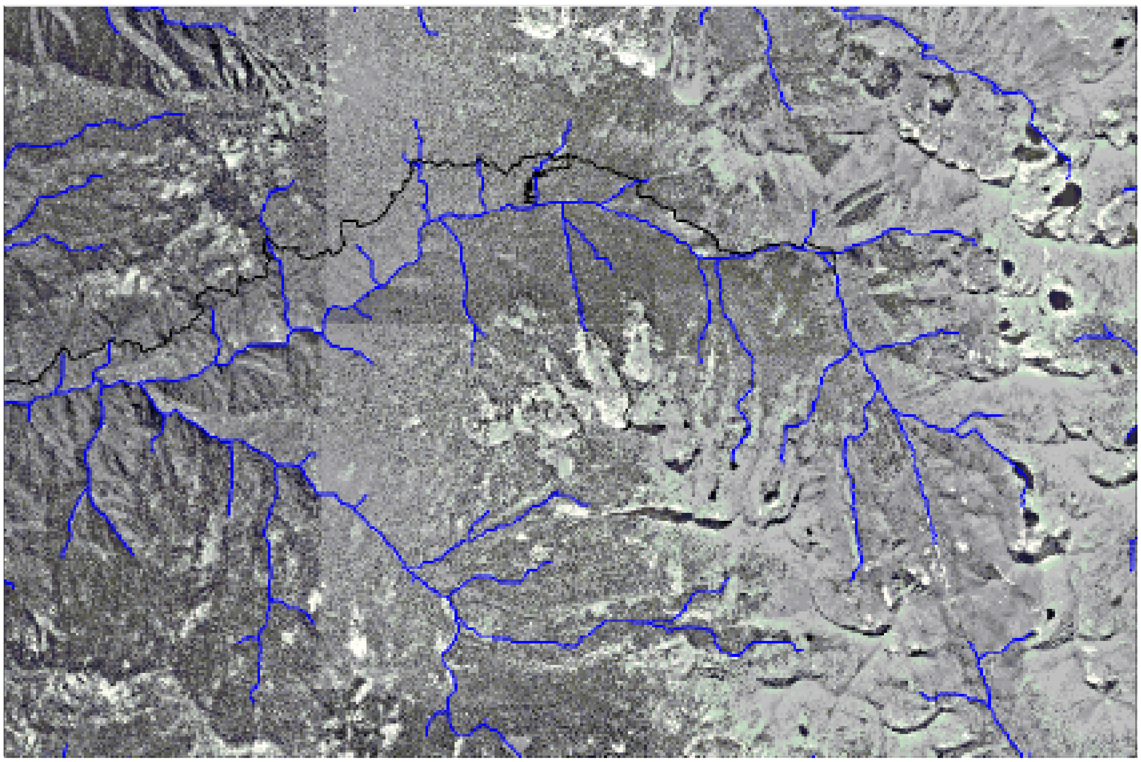


Figure 2.2-2. Image of the East Fork drainage derived from the eight DOQQs which cover the area. Hydrological features and roads were added in ArcView using park GIS data layers.

3. Project Year 1997

The Mineral King Risk Reduction Project was initialized during March 1995 with inventory and monitoring field work and burn operations begun during the summer and fall (2,100 ac/850 ha in the Atwell Segment (segment #3), **Fig. 2.1-1**). No burns were conducted during 1996 due to the extent of resource demands during the summer of 1996 inside and outside the parks (more acres burned in the western USA than any year since 1920). Burning in the watershed during 1997 amounted to 375 ha (925 ac) in two segments.

Burn operations plans developed by the Fire Management Office during the spring of 1997 called for burning portions of the Tar Gap, Redwood, and Lookout Segments (segments #10, #4, and #2 respectively) during the summer/fall. Ignitions in the Tar Gap Segment were planned to begin as fuels at higher elevations in the unit dried during the summer. The primary goal of the plan was to burn areas above the Tar Gap Trail with this trail being the main holding line. Depending on circumstances burning might continue below the Tar Gap Trail with the Hockett Trail being the secondary and lower holding line. The burn was to extend from the Mosquito Creek/Mineral Creek area in the northeast portions of the segment to Horse Creek to the south. The key unit planned for ignition during 1996 was the Redwood Segment, located between the East Fork and the lower portion of the Atwell Segment along the Mineral King Road. The upper forested portions of this unit were to be burned in the fall after most visitor use and local residents in Silver City and Mineral King had left for the season. Additional burning in chaparral and oak woodland in this unit and in the Lookout Segment were planned to take place following significant rainfall. The plan was for rainfall to wet heavy forest fuels while brush fuels would dry rapidly following precipitation. Eventually, a burn buffer between the lower East Fork drainage and the Silver City/Mineral King developed areas would be created.

The critical Redwood Segment, below and west of Atwell Mill, was burned during November 1997 (184 ha/455 ac). This completed the basic buffer of burned areas across the East Fork drainage (Atwell and Redwood Segments, and the Deer Creek Burn) which will provide better fire protection for Atwell, Cabin Cove, Silver City, and Mineral King from wildfires burning up out of the chaparral. Considerable prefire prep work was carried out in this segment because of its location below Atwell and Silver City. An extensive sprinkler system was installed around the developed area of Atwell to wet fuels and minimize disturbance from line construction while defendable holding lines were built on the east and west flanks of the unit from the Mineral King Road down to the East Fork. An addition internal line was constructed through the central portion of the unit down to the river to allow burning to be carried in two phases to enabled better control.

Ignitions at higher elevations in the Tar Gap Segment were initiated in August/September but burning conditions were poor due to late summer rainfall and fire spread was minimal. Burn operations were then moved down to the Tar Gap Trail. Burning off the upper side of the trail was carried out from the Horse Creek area northward until the trail swung around onto the north aspect above the old Deer Creek Burn (1991). Most of the fire spread was above the trail although it backed downhill below the trail in a couple of locations. A total of 190 ha (470 ac) were burned in this segment.

Attempts at burning the Lookout Segment were again curtailed when heavy rains fell after the Atwell Segment was completed.

Monitoring, inventory, and research progressed and expanded into a large portion of the watershed during 1997 (**Fig. 3-1**). The projects included studies begun during 1995 and several new investigations. The former include: (1) fire effects plots; (2) sequoia fire scars; (3) natural resource inventory; (4) fuels; (5) wildlife-small mammal populations; (6) fire history; (7) watershed-chemistry and hydrology; (8) watershed-aquatic macroinvertabrates; (9) resampling of red-fir plots established by Donald Pitcher. The latter include: (1) fire and red fir regeneration; (2) landscape analysis of changes in forest structure over time; (3) population and niche requirements of bark-foraging birds; and (4) establishing permanent fuel plots (for C. Miller); (5) remote sensing of fuels and vegetation;. A significant amount of information was collected from throughout the East Fork during summer of 1997. While field work was rushed during the 1996 season to collect data and establish sampling plots, the lack of burning in the East Fork during that summer created breathing room for the investigators. The delay provided a one field season lead for planning and implementing projects.

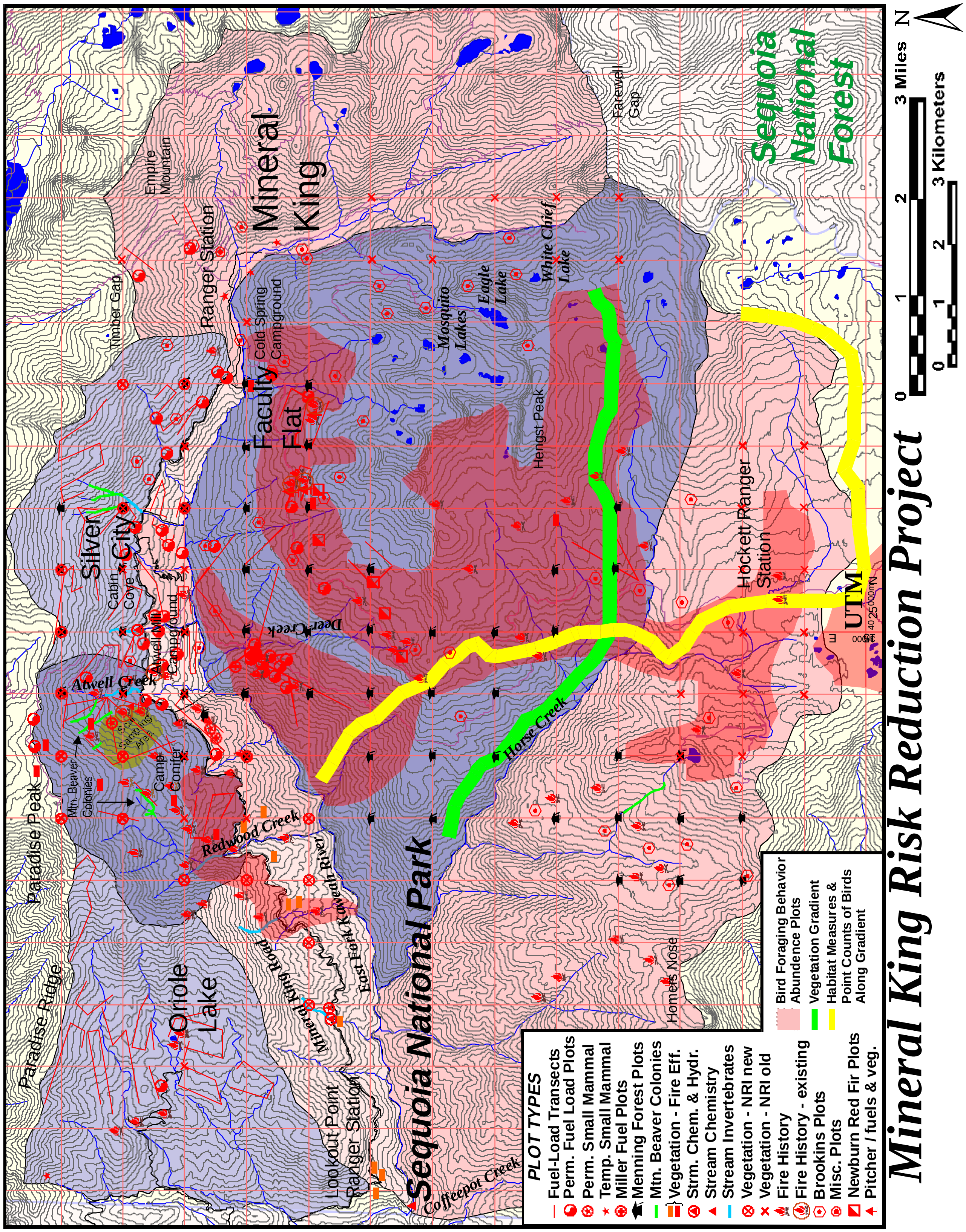


Figure 3-1. Location of all sample sites in the East Fork watershed that have been collected from 1995 to 1997.

3.1 - Vegetation Sampling

3.11) Landscape Assessment - Fire and Forest Structure

- Kurt Menning, University of California, Berkeley & Biological Resources Division, USGS, SEKI

Lead: Kurt Menning; Crew: H. Mikkelsen, C. Peterson, and B. Sullivan

PROJECT OBJECTIVES AND BACKGROUND

For much of the last century, fire has been kept out of the forests of Mineral King. This exclusion of fire from a forest in which it has been a dominant force for centuries has altered regeneration of many tree species, occurrences of habitat for birds and wildlife, susceptibility of the forest to insect attacks and disease, and biodiversity of small forest plants. For these reasons, many park managers and scientists believe we should restore forests to within some range of historic conditions at the same time we reduce risk.

Methods of forest restoration vary. *Structural restorationists* believe we should alter forest structure to historic conditions with silvicultural thinning followed by the reintroduction of fire. They argue that prescribed fire in unthinned stands could result in stand-replacing fires and that historic forest conditions could not be achieved since forests have changed so much during the period of suppression. *Process restorationists* would restore native processes—fire—directly, without first heavily modifying fuel loads, with the goal of recreating historic forest structures. Process restorationists maintain that one or two prescribed fires, carefully planned and managed, would begin to re-establish forest conditions with little risk of catastrophic loss to fire. The implications of this debate have profound significance to managers wishing to restore forest conditions and ecologists wishing to understand fire ecology, disturbance regimes and forest succession. In a national park, it is particularly important to know how effective a light-handed restoration approach--such as process restoration--can be.

Fortunately, the Mineral King Risk Reduction Project (MKRRP) offers an excellent opportunity to test this approach (**Fig. 3.11-1**). As fire is reintroduced to the forest a study is being conducted to determine both the current forest conditions and the effects of fire on this forest. The Mineral King Landscape Assessment (MKLA) completed its second summer of data collection in 1997. This research seeks to provide some answers to this forest restoration debate by examining landscape-level effects of fire. The project's

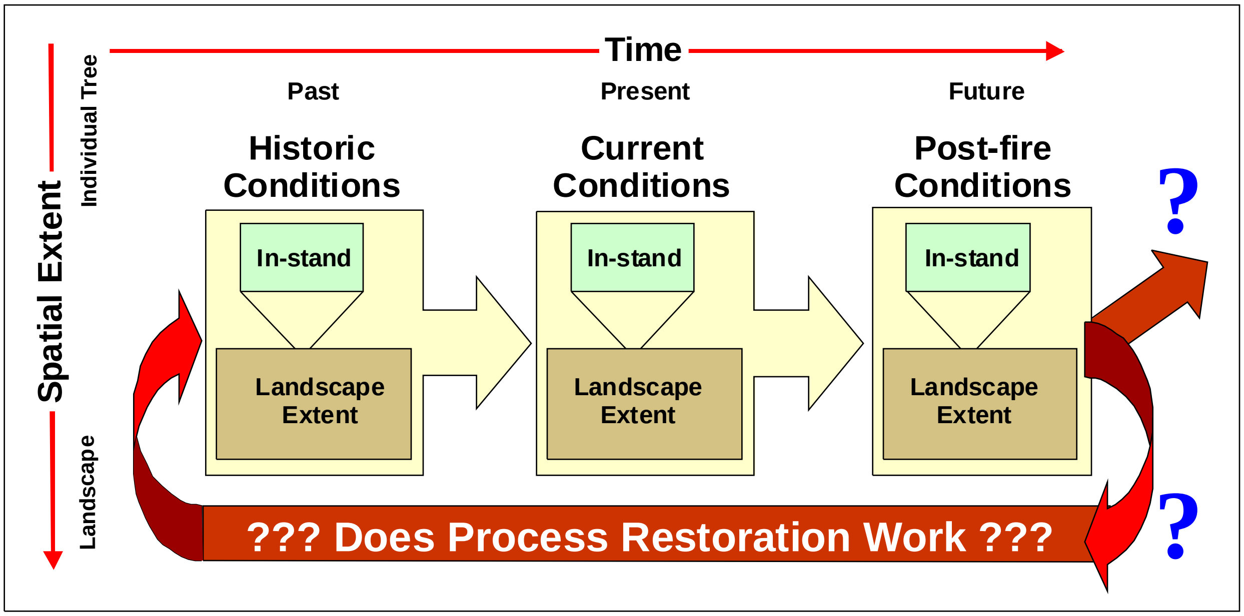


Figure 3.11-1.

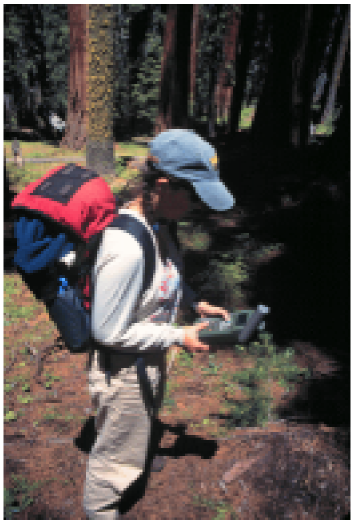


Figure 3.11-2. Locating plot with GPS unit.

Figure 3.11-3. Equipment used in sampling plots.

scope of inquiry can be divided into several questions. First, what is the historic structure and pattern of the mixed conifer forest in this area? Second, in what ways does prescribed fire result in a more structurally diverse and complex forest? Third, can prescribed fire be used to restore forest conditions to the state or range of variability described in the answer to the first question? A central concept being tested is whether burning increases structural and pattern diversity and complexity by breaking a more homogeneous, ingrown forest into a patchier mosaic. This more complex mosaic theoretically should have hot spots burned out containing no remaining forest cover, areas with the understory consumed by fire but little damage to the overstory, and other locations in which all size classes and species of trees remain relatively undisturbed by fire.

The Mineral King Landscape Assessment represents a broad collaborative effort involving Sequoia and Kings Canyon National Park; U. S. Geological Survey, Biological Resources Division; University of California, Berkeley's Laboratories of Forest Community Ecology (Dr. John Battles) and Landscape Ecology (Dr. Tracy Benning); and Dr. Dean Urban of Duke University. Kurt Menning, Ph.D. student at the University of California, Berkeley, is the lead analyst in the project.

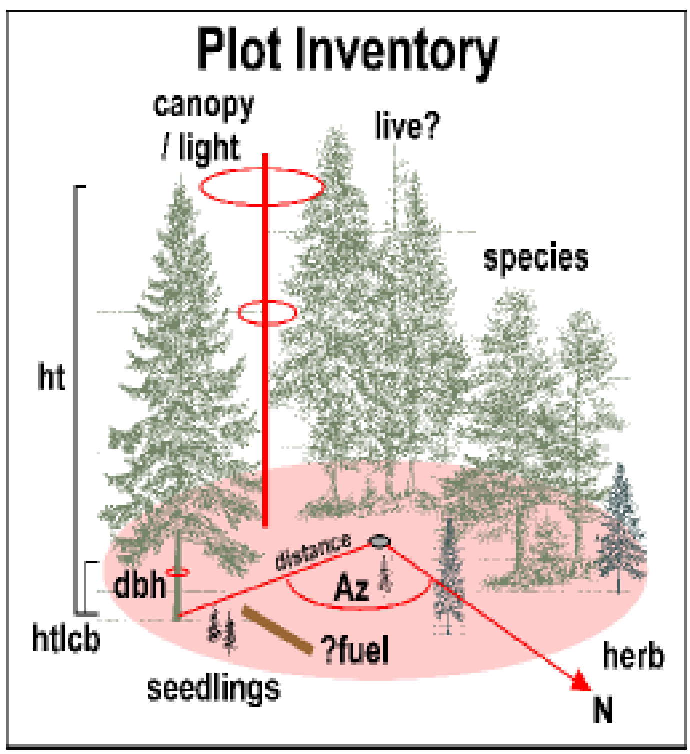


Figure 3.11-4.

METHODS

Data collected in support of these analyses come from three time periods—historic, pre-fire, and post-fire (**Fig. 3.11-1**). In addition, data are collected both within forests by use of an extensive but relatively traditional forest inventory approach, and from the air, using aerial photographs. Historic data have not yet been examined closely. To date, the focus has been on collecting data on the current condition of the

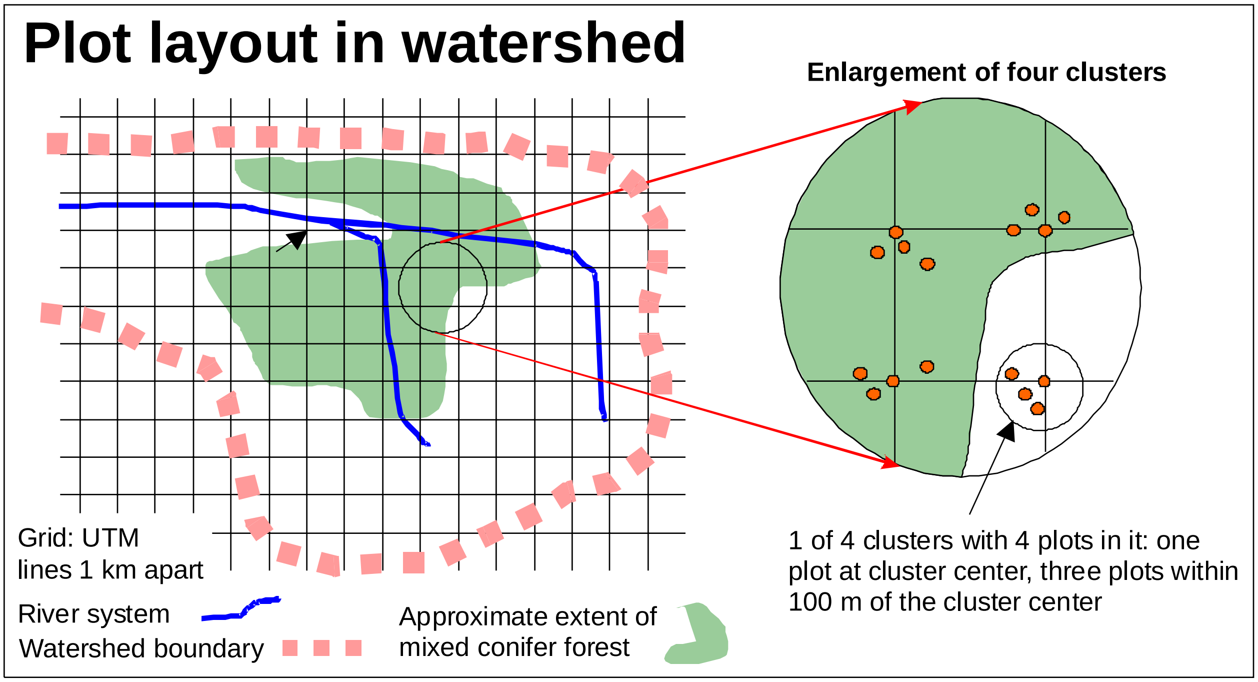


Figure 3.11-5.

forest before it burns and on re-inventorying the forest following the prescribed fires.

Field data for pre- and post-fire conditions are collected from forest plots ten meters in radius (**Fig. 3.11-4**). These are located precisely using a precision global positioning system (GPS) unit (**Fig. 3.11-2**). Within each plot, trees are identified, measured and mapped; fuel conditions are recorded; brush and plant cover are described; slope and aspect are recorded; and light penetrating through the forest canopy is measured (**Fig. 3.11-3** and **Fig. 3.11- 4**).

Collection and processing of the remote imagery data is a more elaborate process. High resolution, digital photographs were first taken during an overflight in September of 1996 but due to a flight planning error on the part of the flight contractor, the imagery had to be recollected 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.

WORK COMPLETED IN 1997

In the second season of data collection, 157 plots were added to the 52 plots inventoried in 1996. This two-year total of 209 plots represents a broad coverage of the mixed conifer forest of Mineral King (**Fig. 3.11-6**). In total, over 2500 trees taller than breast height (1.37 m, or 4.5 feet) have been described and mapped covering a total area greater than six and a half hectares (16 acres). In addition, data from 1800 soil depths, litter and duff measurements, and seedling counts have been tallied. Collecting these data took four months of intensive fieldwork with a crew of two to four people (thanks to Dez Mikkelsen, Brian Sullivan, and Kris Peterson!). In the autumn of 1997 these data were compiled into a database for further analysis. test this contention prior to the reintroduction of fire, we examined the current structure and composition of the mixed conifer forest in Mineral King by comparing five elevational belts of plots. Seventy-nine of the 0.03 ha plots were selected for this analysis due to their locations. Tree density varied from 160 to 480 trees/ha per belt. Basal areas ranged from 47 m^2/ha to 72 m^2/ha. A variance-to-mean ratio between plots on

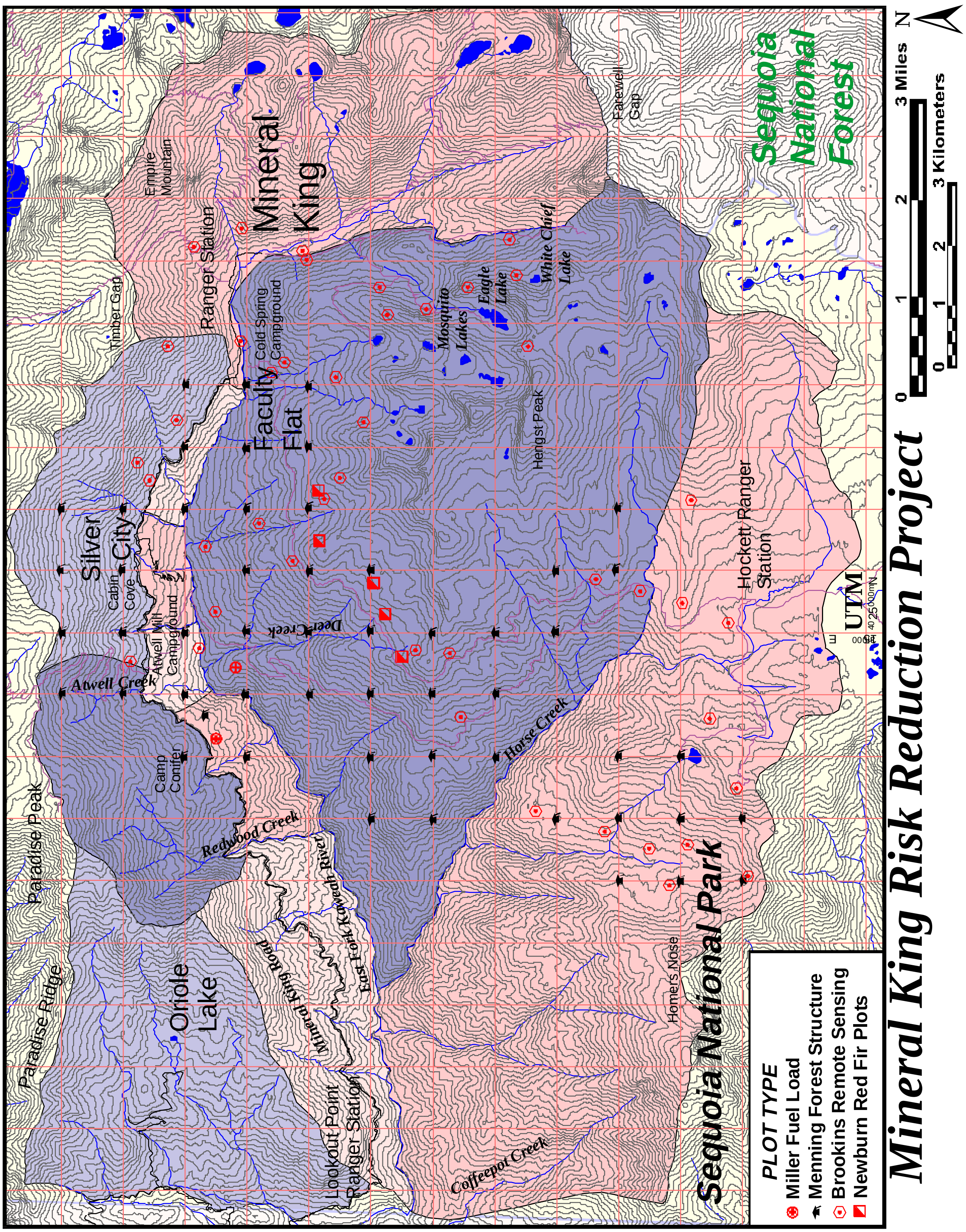


Figure 3.11-6. Plot locations for graduate students working on vegetation within the East Fork.

Evaluation of these field data is currently underway. Some fire scientists have contended, for example, that current forests are too evenly structured to experience highly variable mortality from fire. To

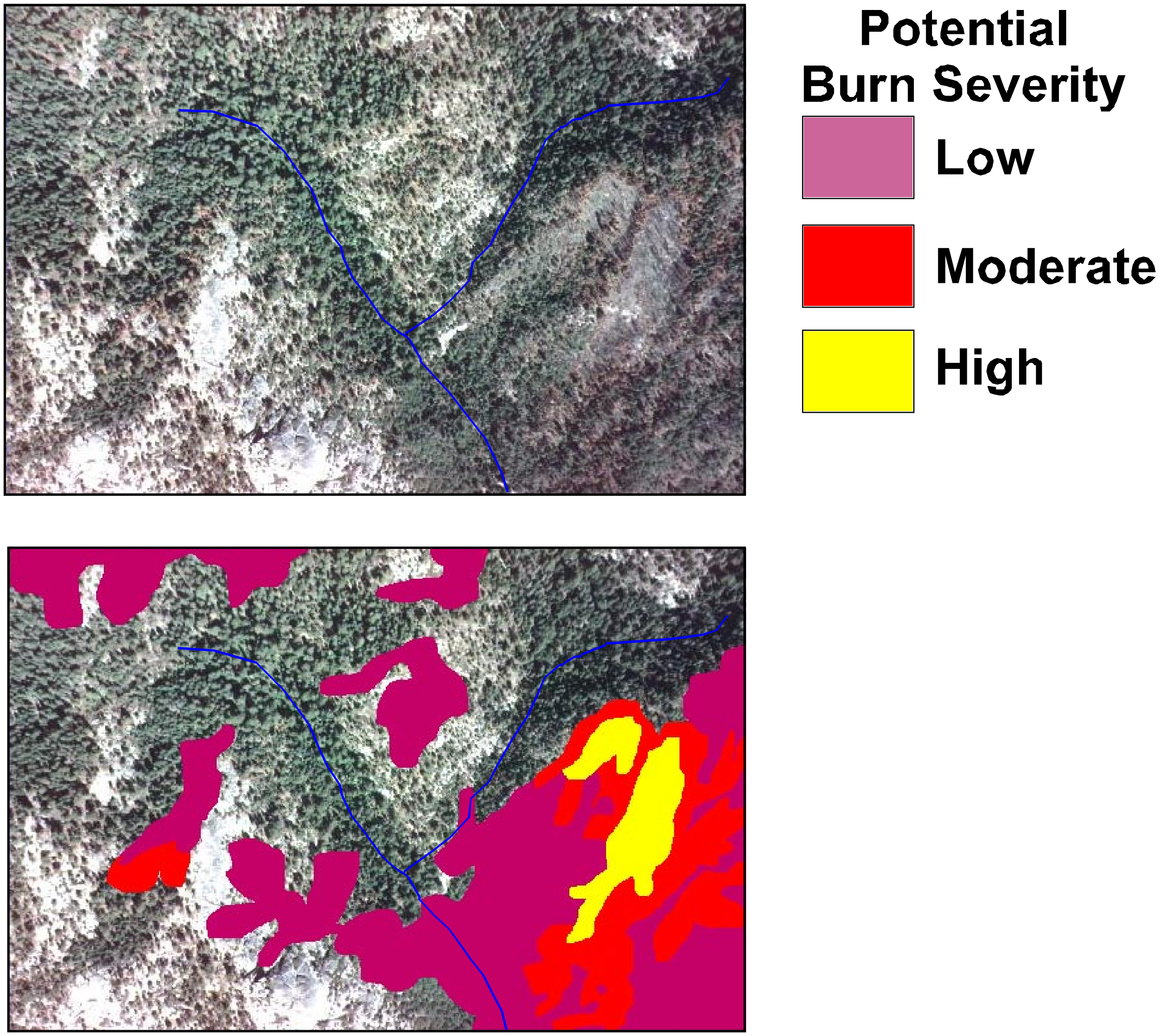


Figure 3.11-7. Preliminary classification of potential burn severity patches in the upper Redwood Creek area burned during October 1995. The high intensity patches (yellow) are visible from the Mineral King Road from below the Redwood Creek crossing.

each belt, used as a test of structural diversity, indicated the highest structural diversity was on the mid-elevational belt of the southern aspect (ratio 1.75, n=12). Structural diversity was lower on northern aspects (ratios 0.50, n = 20; 0.58, n = 23). High structural diversity on the southern aspect indicates post-fire structural diversity may be higher than comparable locations on the northern aspect, which have a more evenly distributed forest structure. Post-fire analysis will help us determine if this is true.

Over seven hundred digital aerial photographs were successfully taken in 1997. Processing and analyzing the images is not yet complete. A heavy workload with the field data and a lack of supporting terrain information from USGS has delayed the process. Exploratory analysis to obtain estimates of fire intensity from the digital air imagery has been carried out at a few burned locations (**Fig. 3.11-7**).

CURRENT STATUS

Currently, analysis of field data is a top priority. We are evaluating forest structure and pattern as these attributes vary across the watershed. Pattern analysis of the remote imagery will proceed in spring and summer of 1998.

SUMMER 1998

In summer 1998, the MKLA project will resume in the field. We expect six weeks of intensive fieldwork. During the six weeks, four field crew members will inventory the estimated 25-40 plots that burned in segments 4 and 10 during the prescribed fires of autumn, 1997. Second, a few previously inventoried plots will be revisited to assess the degree of change in plots from year to year. Third, quality assessments will be performed on current inventory efforts to determine our level of accuracy.

Fourth, fairly accurate soil depth measurements will be taken for an analysis of the moisture holding capacity of soils in the watershed. These data will support an effort to determine the variability in site-potential for tree growth across the landscape. During a long period of fire suppression, as much of Mineral King has experienced, site-potential differences may have resulted in uneven forest growth. This, in turn, may have resulted in highly variable fuel loads and could lead to a patchy fire pattern. By collecting these additional data we hope to be able to model these relationships.

3.12) Red Fir Plots (Pitcher Plots)

- Anthony Caprio, Science and Natural Resources Management, SEKI

Lead: A. Caprio, field assistance: Brian Knaus (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 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 forests 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 burn severities and potential fire effects appears 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 understand of both the long-term role and specific ecological effects of fire in this ecosystem are important.

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, these plots will provide information to park managers on changes in forest structure and composition, and fuel loads over a 20 year period. 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) were located in red fir forest along the Tar Gap Trail (**Fig. 3.12-2**). They were established in roughly three forest "age types" on a north aspect: plot #1 in

Figure 3.12-1. View of plots #1 and #2 showing structural differences. View is from the NE corner (lower left on maps) looking WSW into the lower portion of the plots.

"mature" red fir forest (**Fig. 3.12-1a**), plot #2 in "young" red fir forest (**Fig.3.12-1b**), and a mixed

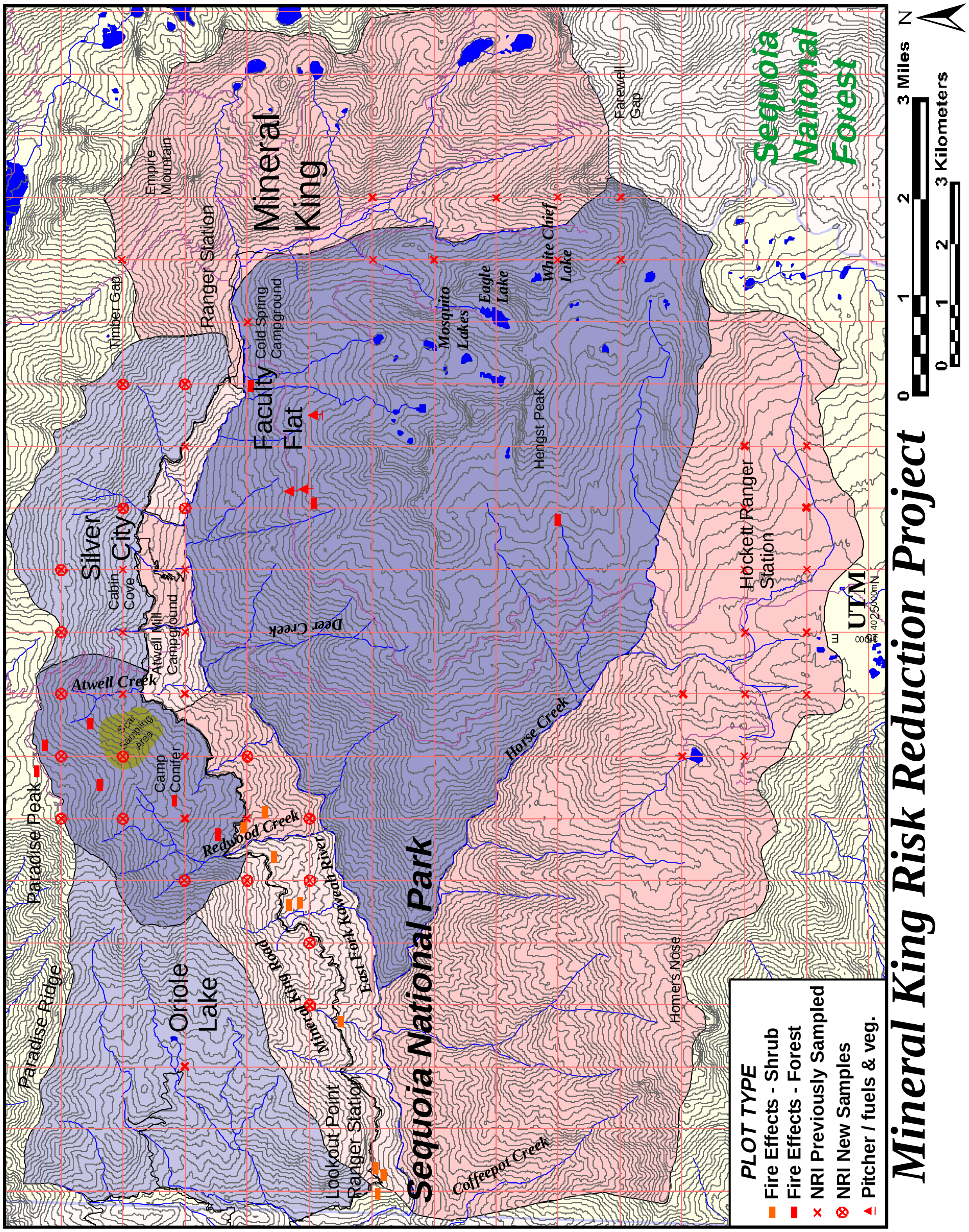


Figure 3.12-2. Plot locations for vegetation sampling projects.

Table 3.12-1. 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

stand with patches of young and old trees (plot #3). The plots were relocated in 1995 and are being resampled prior to the burning of Tar Gap Segment (segment #10). UTM coordinates have been obtained for each plot using a PLGR to facilitate future relocation (**Table 3.12-1**). Plots #1 and #2 are in close proximity and plot #3 about 1.5 km away. An attempt will be made to maintain the latter plot as a control, by protecting the immediate plot area and a small buffer zone from burning.

METHODS

Donald Pitcher provided us with a copy of his original data set which has been re-entered into digital format from the paper printout. This data set is currently being checked for data-entry errors, although portions were used to make preliminary estimates of changes in the plots. Utilizing the original data set will greatly facilitate comparisons between the 1978 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

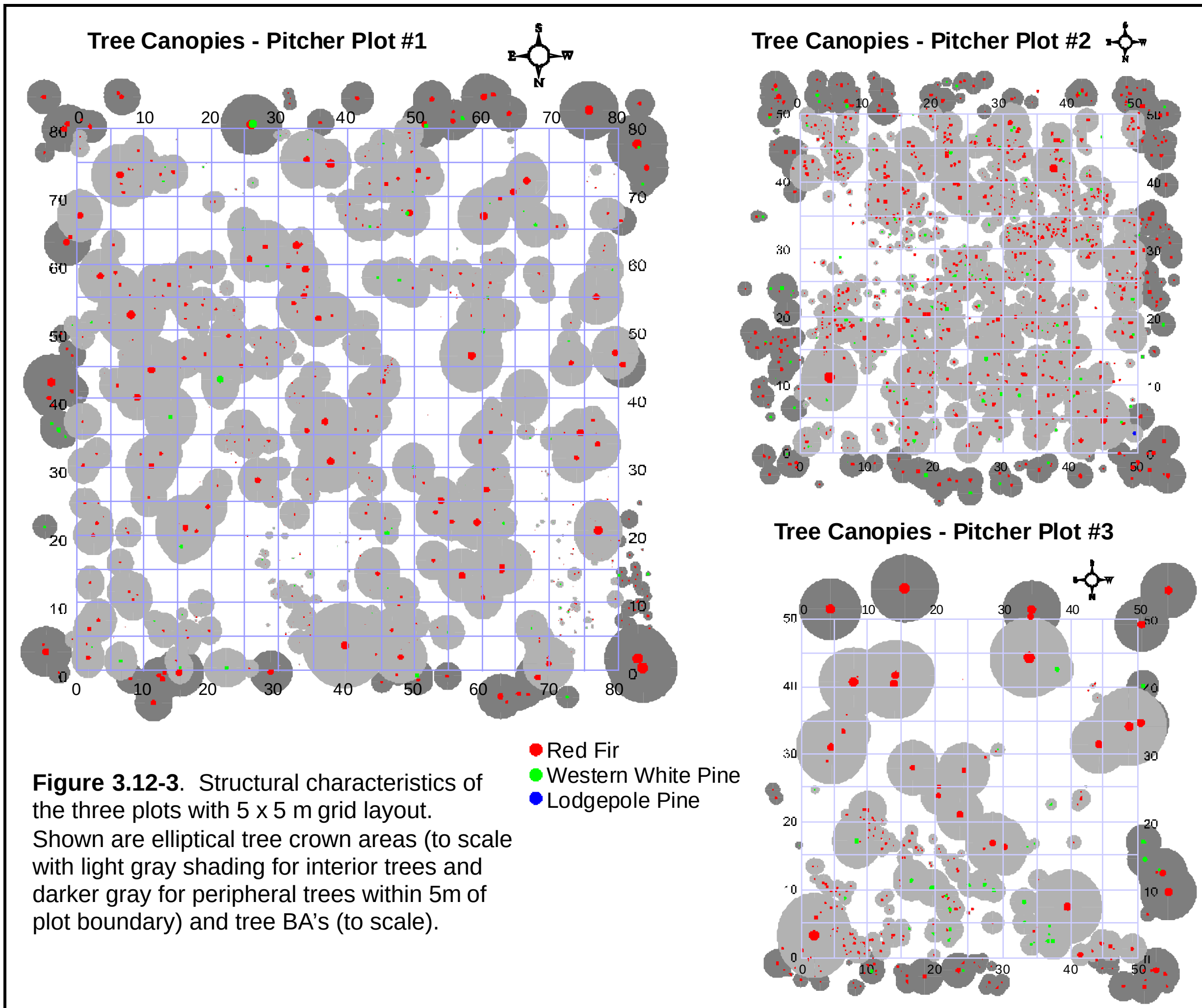


Figure 3.12-3. Structural characteristics of the three plots with 5 x 5 m grid layout. Shown are elliptical tree crown areas (to scale with light gray shading for interior trees and darker gray for peripheral trees within 5m of plot boundary) and tree BA's (to scale).

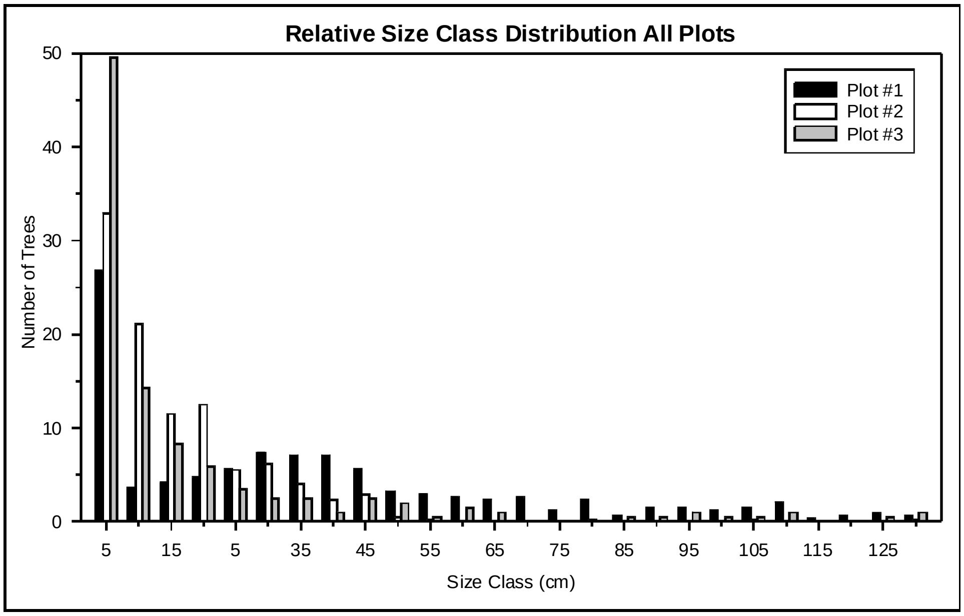


Figure 3.12-4. Comparison of relative size class distribution of trees between plots.

able to describe changes in DBH, fuels, and stand structure over the intervening time very accurately.

Resampling of all three plots has nearly been completed. Data recollected on the plots included: DBH, mortality checks, tree height of individuals <1.4 m tall, fuels, and canopy cover. Additional data (location, species, and DBH) were also collected on peripheral trees, those trees > 1.4 m high that have stems within 5 meters a the plot boundary, since these trees would influence trees in the outer subplots of each plot (see **Fig. 3.12-3**). 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..

RESULTS AND DISCUSSION

A preliminary summary of changes in size class (individuals greater-than 10 cm tall), mortality, and basal area (BA), for the period between 1978 and 1996 has been made. Additionally, preburn data on various stand characteristics have been summarized. Preliminary estimates of current (1996/7) fuel load and comparisons with the summarized 1978 data have been made. A more complete analysis will be carried out once original 1978 data set is available digitally.

Stand Structure

Size class distribution of trees varied between plots (**Fig. 3.12-4**) and by species within plots (**Fig. 3.12-5**). The distributions reflect disturbance history and severity on the stands (Pitcher 1981). Distributions were typical inverse J-shaped for plot #2 and plot #3 while plot #1 exhibited a more complex shape with a bimodal distribution of red fir. In the latter plot the spike in the smallest size class may represent a cohort of recent recruitment or more likely a large number of “oskars” present in the understory of the mature stand— “oskars” being stunted juveniles persisting at the photosynthetic compensation point for long periods and named after the main character in Gunter Grass’ *The Tin Drum* (Silvertown and Doust 1993). Height growth for the vast majority of trees <1.4 m tall was small or negligible between 1978 and 1997 and does show that young trees can persist for decades in the shade of a dominant canopy. Casual observations on the plots suggest that most trees that showed height growth were located in canopy openings. Future analysis should be able to quantify this. Plot #2 showed a strong negative exponential

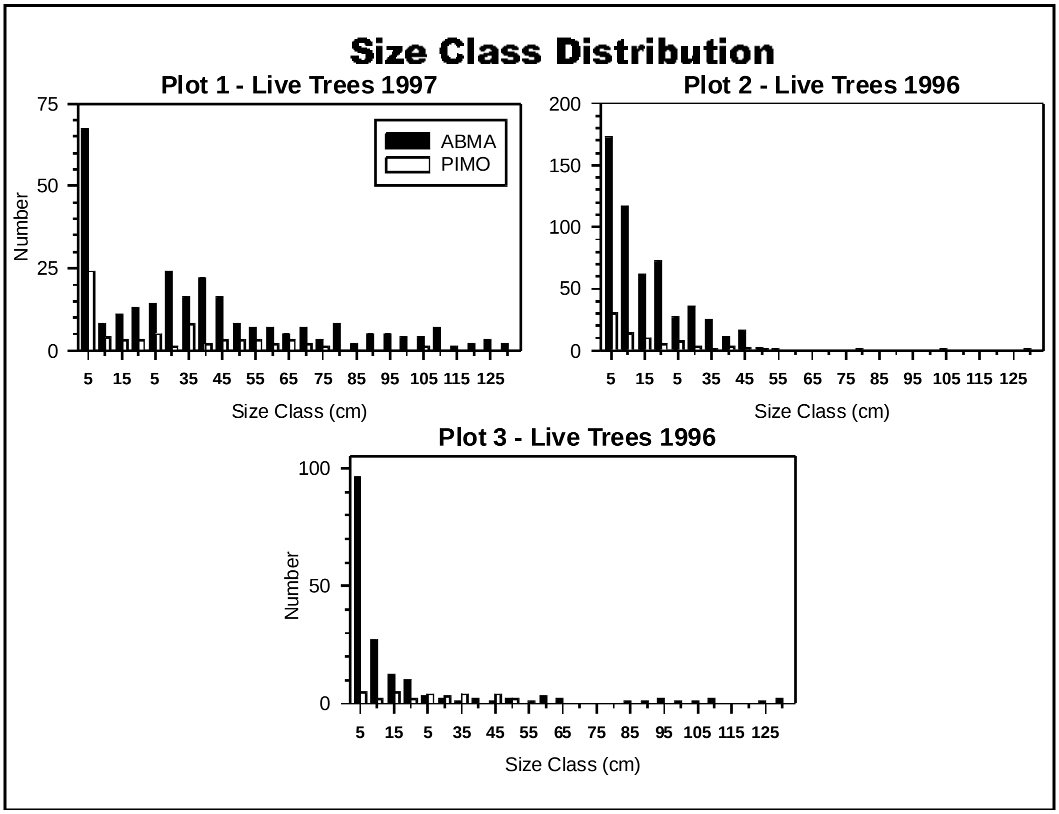


Figure 3.12-5. Size class distribution by plot and species showing differences in size class structure.

distribution with few large trees. Tree size distribution in plot #3 was also intermediate between the other two plots with a substantial number of large dominant overstory trees, with the exception of the smallest size class (**Fig. 3.12-4**).

Age structure and disturbance history varied among the three plots (Pitcher 1981). Reconstruction of tree age structure by Pitcher indicates a young even-aged stand in plot #2, that established following a severe fire. He attributed stand origin to both the 1848 and 1886 fires that occurred in the area (Pitcher 1987; Caprio 1997b). While the same two fires were recorded in plot #1 the impact was apparently more moderate without severe overstory mortality. Plot #3 had a mixed stand of young and old trees and did not appear to have been burned by the 1886 fire (Pitcher 1981). For all three plots, distribution of size classes by species also suggested variation within the red fir stands with ***Pinus monticola*** (western white pine) having fewer young trees (particularly in plot #3) (**Fig. 3.12-5**) than ***Abies magnifica***.

Total basal area and basal area by species (**Table 3.12-2**) increased between 1978 and 1996 although the total number of trees per plot declined. BA increased 4.49 $m^2 \cdot ha^{-1}$ in plot #1 [5%], 9.02 $m^2 \cdot ha^{-1}$ in plot #2 [16%], and 10.74 $m^2 \cdot ha^{-1}$ in plot #3 [22%]. BA and number of trees of ***A. magnifica*** dominated ***P. monticola*** in all plots.

Table 3.12-2. Change in basal area (BA $m^2 \cdot ha^{-1}$) and number of trees (number per hectare) by species at all plots between 1978 and 1996 (ABMA - ***Abies magnifica***, red fir; PIMO - ***Pinus monticola***, western white pine; PICO - ***Pinus contorta***, lodgepole pine).

Date		Plot #1			Plot #2				Plot #3		
		ABMA	PIMO	Total	ABMA	PIMO	PICO	Total	ABMA	PIMO	Total
78	BA	76.65	6.67	86.32	51.13	5.59	0.25	56.97	43.14	6.21	49.34
	No.	562	138	700	2948	424	4	3376	748	128	876
96	BA	80.26	10.55	90.81	59.47	6.26	0.26	65.99	52.30	7.78	60.08
	No.	411	119	530	2168	304	4	2476	688	128	816

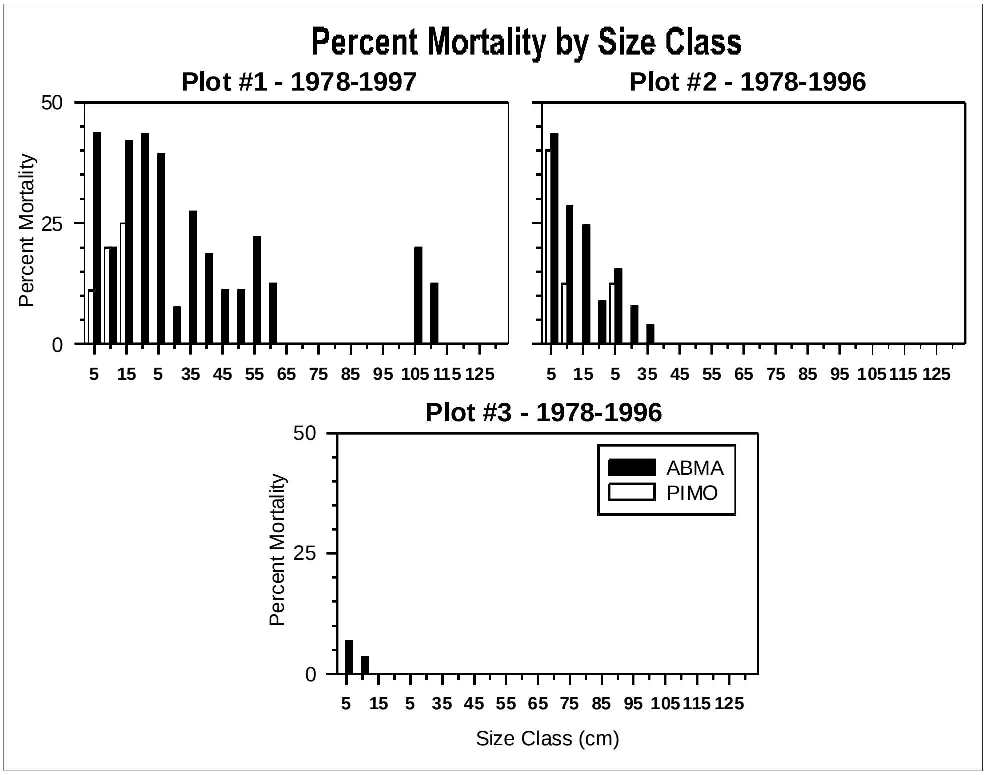


Figure 3.12-6. Percent mortality by species for size classes in the three plots from 1978 to 1997.

Considerable mortality was observed in both plots #1 and #2 between 1978 and 1997 (24% and 27% respectively), although the absolute number of trees dying was quite different and greater in plot #2 (900 vs 170 trees·ha^{-1}) (**Table 3.12-2)**. Minimal mortality was observed in plot #3 (7%), probably due to the open nature of the stand (see canopy map **Fig. 3.12-3**). Mortality (percent by size class) was concentrated in the small size classes in all plots with a greater proportion of ***A. magnifica*** than ***P. monticola*** (**Fig. 3.12-6**). It was roughly equivalent in plots #1 and #2, although there was slightly greater mortality in the larger size classes in plot #1.

Canopy area of each living tree within the plots was mapped using the crown canopy measures collected by Pitcher (1981) (**Fig. 3.12-3**). Crown cover of peripheral trees (trees outside but within five meters of the plot boundary) was determined using the relationship between basal area and crown area (r^2=0.892, n=1509) of the measured trees (**Fig. 3.12-7**). Total canopy cover (not corrected for slope), based on the crown size measurements and the estimated canopy of peripheral trees that extends over the plots, was 55.9% for plot#1, 66.8% for plot #2, and 48.8% for plot #3.

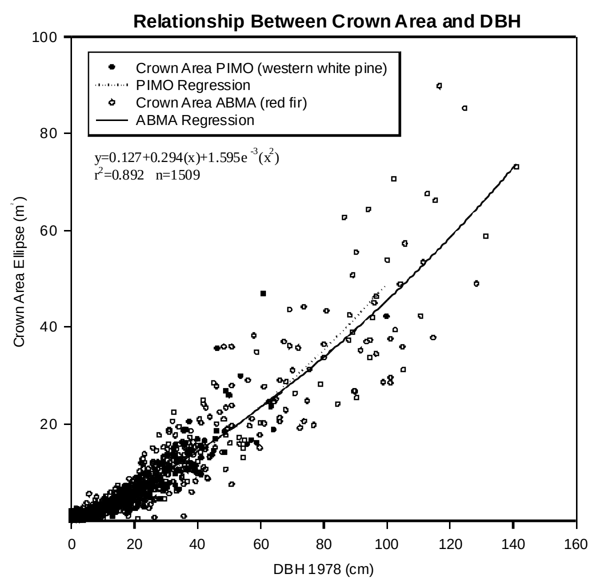


Figure 3.12-7. Relationship elliptical crown area and DBH of ABMA and PIMO (based on 1978 Pitcher data set) used to estimate crown area of peripheral trees. The final equation used combined data from both species.

Fuels Data

Fuel load sampling has been completed in all plots. Sampling methods followed Pitcher's procedures (Pitcher 1981), modified from Brown (1974), which sampled 5 x 5m subplots within each plot. This intensive sampling (912 modified Brown's transects in 456 subplots) provided extremely detailed spatial information about fuel loads across the plots (**Fig. 3.12-8**). This will provide excellent baseline spatial information for the interpretation of fuel accumulation rates and varied fire effects that might be observed following burning of the plots.

Fuel sampling has also provided information on change in fuel load over the intervening two decades since the plots were originally sampled. Fuel load increased in all plots (**Fig. 3.12-9**) with the greatest increases in the >3" diameter fuel class. The increase was most pronounced in plot #1. The increase may be partially the result of an atypical amount of tree breakage (mostly upper portions of crowns) during the winter on 1994/95 that occurred in upper red fir forests (this has also been noted in long term demography plots being monitored by the SEKI Research Office near Panther Gap, (personal observation). This breakage appeared to have been most pronounced in stands of moderate age and density (such as plot #1), and not as common in stands with fewer large old trees (plot #3) or smaller younger trees with greater stand density (plot #2).

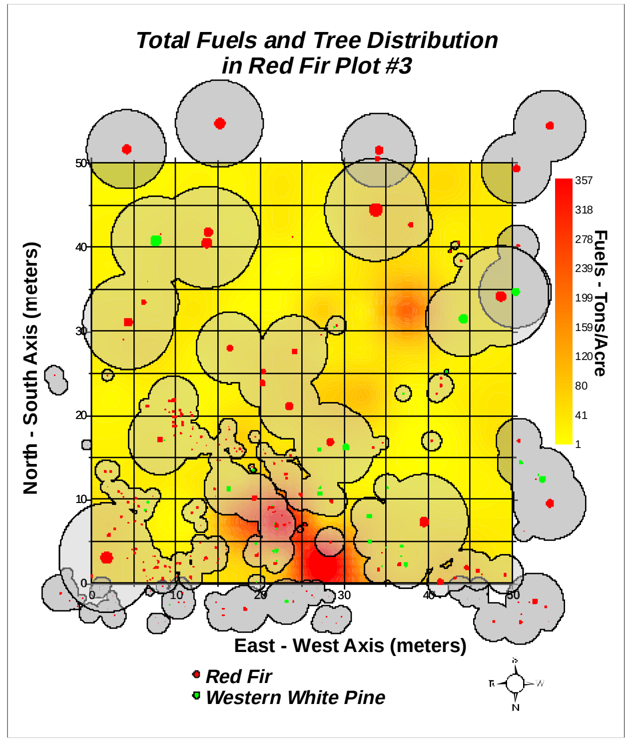


Figure 3.12-8. Spatial distribution of total fuels and tree crowns and DBH across plot #3. Total fuels tended to be heavier in areas where tree mortality has occurred, often areas with a low canopy density (see Fig. 3.12-10).

Locations of all downed sound or rotten logs, or logs visible as duff outlines were mapped for plot #3 and will be completed for plots #1 and #2 during 1998 (**Fig. 3.12-10**). These data will be compared to similar maps produced by Pitcher (1981) and will used to better understand fire caused mortality and damage to living trees. It has been suggested that proximity to a fallen log may substantially increase the probability of adult tree mortality (Dave Newburn, personal communication). This information would allow us to better predict overall tree mortality and potential changes in stands due to fire.

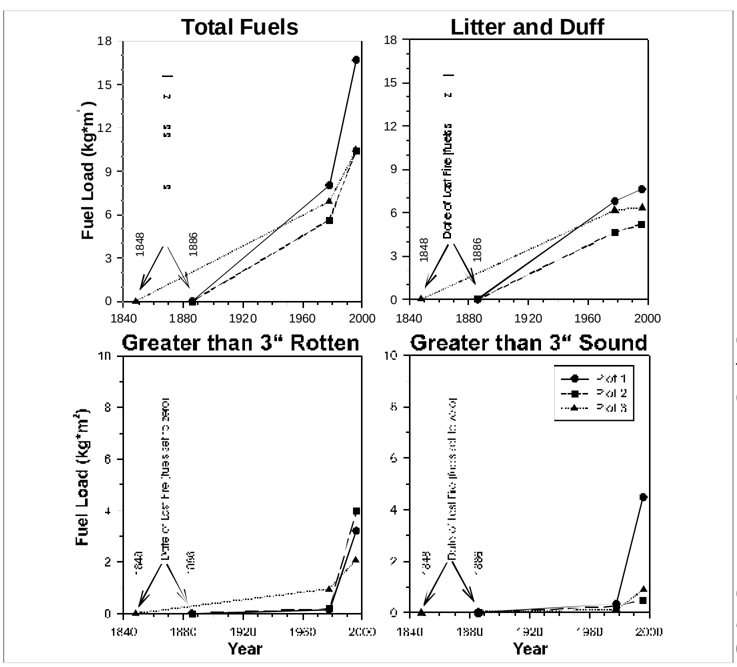


Figure 3.12-9. Preliminary estimates of fuel load changes in the three plots for four fuel categories. Initial zero value is based on the last recorded fire that burned through the plots (see Fire History). Estimates from 1978 and 1996 are based on modified Brown's inventory techniques (Brown 1974). Formula for conversion of values to tons per acres is: tons/ac = g/m^2 * 0.0044613.

Spatial distribution of fuels across each plot showed considerable variation by major fuel component: total, above ground, and litter/duff fuel (**Fig. 3.12-8**). The frequency distribution of fuel loads for the subplots was highly skewed in a positive direction, as observed by Pitcher (1981, see page 97). This type of distribution, with a long tail to the right, is common for fuel load measurements (Jeske and Bevins 1979; See and Brown 1980). For the three Pitcher Plots, mean fuel load was 62.21 kg·m^{-2} and median was 37.61 kg·m^{-2} (**Fig. 3.12-11**). This suggests the median or mode may be a better estimator of central tendency for fuels (Kessell 1979). The difference between the mean and median may also account for some of the differences that are being observed between fuel loads obtained using photo series and estimates from Brown's transects in the East Fork drainage (see section 3.16 - Fuel Inventorying and Monitoring). Estimates based on Brown's transects would be calculated using mean values whereas estimates from the photo series might be more similar to estimates based on the median (an ocular estimate would be strongly influenced by the predominate fuel covering an area).

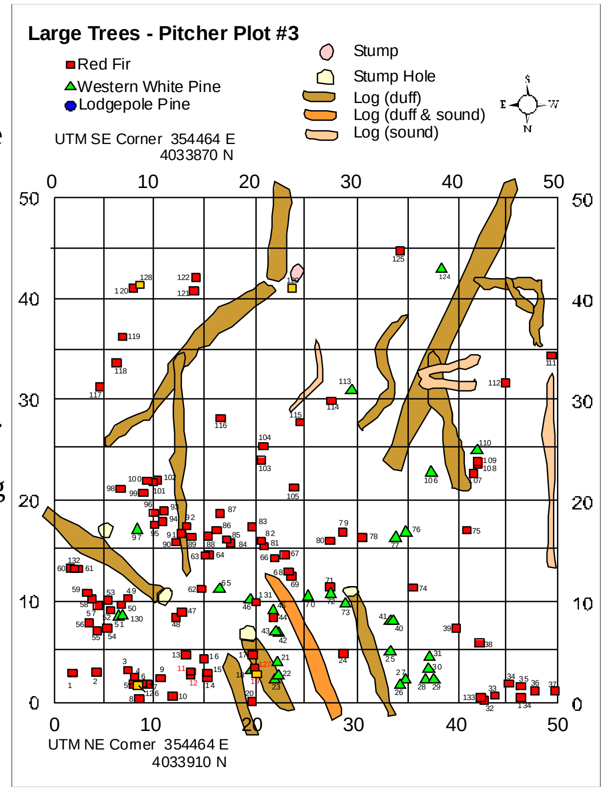


Figure 3.12-10. Location of downed logs and stumps in plot #3. Decay state of logs was also noted.

Preliminary examination of relationships between fuel loads and various plot stand characteristics has been started. Comparison of total fuel weights to basal area measures for each 5 x 5 m subplots resulted in a somewhat unexpected observation. Areas of greatest fuel accumulation were found in subplots with the lowest basal area, while areas of low fuels accumulations were observed in subplots with both low and high basal area (**Fig. 3.12-12**). This relationship may be a result of canopy tree

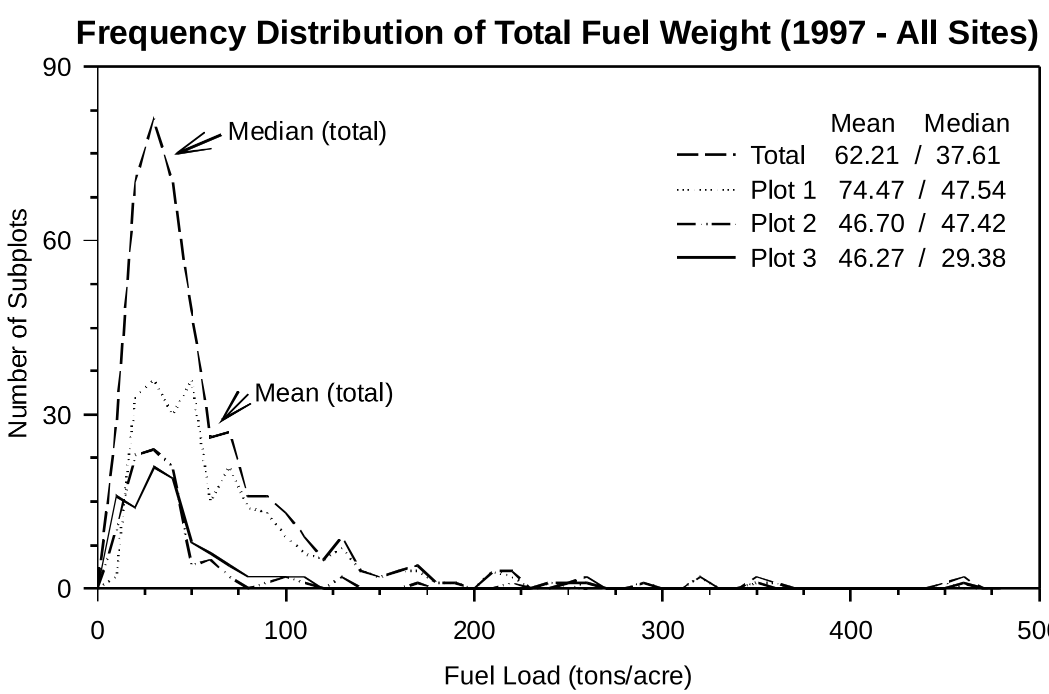


Figure 3.12-11. Frequency distribution of total fuel weights for subplots for 1997 data. Graph shows that very high fuel loads were uncommon and that the median fuel value was a better estimator of the central tendency of the distribution.

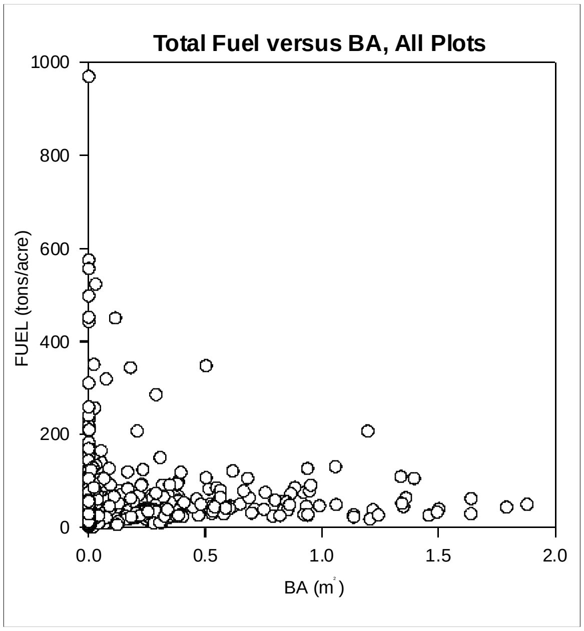


Figure 3.12-12. Relationship between total fuel and BA for each subplot. The greatest fuel loads were found in subplots of low BA.

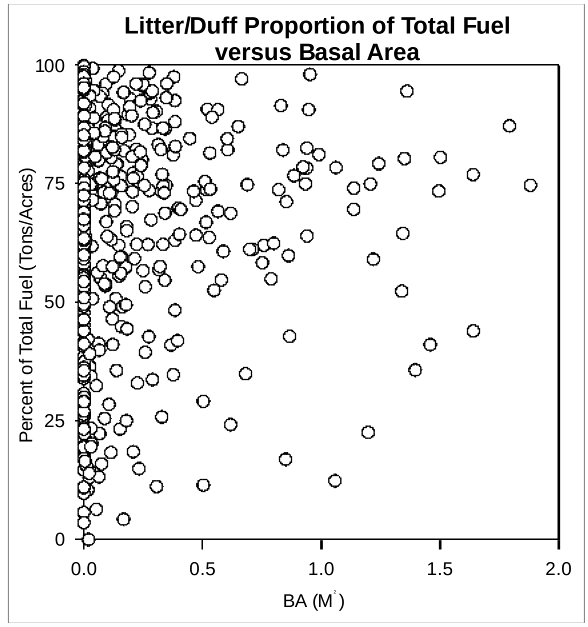


Figure 3.12-13. Relationship between BA and the proportion of litter/duff fuel of total fuel. Subplots with small amounts of litter/duff were generally not observed in areas of high BA.

mortality which causes overstory openings and heavy fuels in and near these locations as the dead overstory trees collapse and decay. This was also suggested when I examined the proportions of litter/duff fuel to above ground fuel (**Fig. 3.12-13**). A high proportion of litter/duff fuel was observed across all subplot basal areas but only in areas of high basal area were high proportions of litter/duff observed. This means that only a small amount of above ground fuel was being produced in these locations since the overall amount of fuel produced was small. At low basal area the proportions of litter/duff and above ground fuel was variable.

The same basic pattern was observed for both above ground and litter/duff fuels. However, at lower fuel levels (<15 kg/m2) a slight upward trend in litter/duff fuel with an increasing basal area was observed (**Fig. 3.12-14**). This trend may actually represent the input litter/duff fuel component from living trees (as apposed to input from canopy mortality) which would reflect canopy size.

A copy of the preliminary fuel data has been provided to Carol Miller (Aldo Leopold Institute) for analysis and possible use in her fire model (Miller 1998). The data may be particularly useful because the subplot or patch size, 5 x 5 m, is unusually small and could capture spatial variation in fuels not available elsewhere.

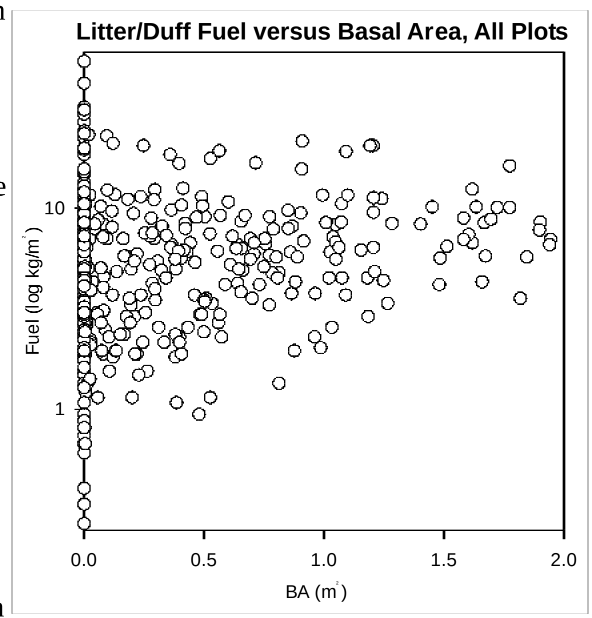


Figure 3.12-14. Relationship between litter/duff fuel (log scale) and BA for each subplot.

PLANS FOR 1998:

Preburn sampling will be completed during the summer of 1998. This will include mapping of all logs in plots #1 and #2, measuring a subsampling of crown diameters (20 trees each in 5cm size classes) and tree height to determine change since the original measures were made in 1978. We will also measure lower crown height on a subsampling of trees. This will assist in understand fire impacts on tree crowns.

3.13) Fire Effects Monitoring

- MaryBeth Keifer, Science and Natural Resources Management, SEKI

Lead: M. Keifer; field crew supervisor: G. Dempsey; field crew: M. Cox, D. Haskamp, G. Indindoli, K. Williams

INTRODUCTION

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

Fire effects monitoring work in various vegetation types within the MKRRP area is based on the relative need for information. Past research and monitoring efforts in other areas of the park have concentrated on the mid-elevation forests, especially the giant sequoia-mixed conifer type. Information about the effects of fire is least known in the lower and upper elevation vegetation types, and therefore, the MKRRP fire effects monitoring efforts are focused on these lesser understood areas.

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

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

Although the mixed conifer forest has been monitored relatively intensively in the past, fire effects information for all vegetation types in the project area are needed for public information distribution. Accordingly, the mixed conifer forest vegetation types are monitored at a minimal level in the MKRRP area. Within the mixed conifer forest types, monitoring information is least available in the xeric, low elevation, therefore, mixed conifer monitoring efforts will be increased in this type if time allows.

METHODS

The National Park Service's Western Region Fire Monitoring Handbook (1992) standardized methods are used for monitoring fire effects on vegetation where appropriate. Monitoring plots in burn units are located randomly on a 100 x 100 m grid within each of the vegetation types designated for monitoring. Criteria for grid point exclusion include proximity to roads/trails, riparian areas, anomalous physical or biological characteristics, and inaccessibility (both safety and time constraints). Location of plots by burn segment, monitoring (vegetation) type (with corresponding dominant species), and UTM coordinates are presented in **Table 3.13-1** and shown in **Fig. 3.12-1**.

Plots are installed in chronological order according to segments scheduled to burn. Monitoring occurs according to the following schedule: pre-burn, immediately post-burn (within two months), and one, two, five, and 10 years post-burn. Data from these monitoring plots are summarized for the project after each step of the monitoring schedule and results are promptly distributed to park staff and the public. The data may also be included in monitoring type summaries for the parks.

Unburned monitoring plots in other areas of the parks may be used to compare with burn project results. Additional plots may be established in areas that are not currently scheduled for prescribed burning adjacent to the project area if existing unburned plots will not suffice.

Changes in MKRRP Monitoring Program since 1996

Due to highly variable species composition, the ponderosa pine-mixed conifer forest monitoring type was split into two different types for the parks' fire effects monitoring program, the ponderosa pine forest and the low elevation-mixed conifer forest types. This change (in name only) affects one MKRRP fire effects plot in the Atwell Segment (segment #3), which is now identified as FCADE1T08094; this change does not affect the data collected or reported in past years.

A change that affects the fuel load data is that new species-specific bulk density constants are now used in the calculation of duff load. These new constants are a result of long-term research by Jan van

Table 3.13-1. Plot locations (an asterisk in the UTME column indicates the plot was geo-referenced using a global positioning system with an accuracy of ± 3-30 meters). See Fig. 2.1-1 for segment locations. Filled rows are plots added during 1997.

PLOT ID	MONITORING TYPE	DOMINANT SPECIES	BURN SEGMENT	UTME	UTMN
CADE 094	Low elevation-mixed conifer	incense cedar	Atwell	347570	4035590
SEGI 093	Giant sequoia-mixed conifer	white fir	Atwell	348280	4036200
SEGI 095	Giant sequoia-mixed conifer	white fir	Atwell	349513*	4037639
ABMA 096	Red fir forest	red fir	Atwell	349100	4038310
ABMA 097	Red fir forest	red fir	Atwell	348428*	4037631
ABMA 098	Red fir forest	red fir	unburned	348602*	4038256
ABMA 100	Red fir forest	red fir	Tar Gap	352809*	4030052
ABMA 101	Red fir forest	red fir	Tar Gap	353059*	4034063
ABMA 102	Red fir forest	red fir	Tar Gap	354987*	4034922
ADFA 012	Chamise chaparral	chamise	Lookout	342251*	4032915
ADFA 013	Chamise chaparral	chamise	Lookout	342214*	4032867
ADFA 014	Chamise chaparral	chamise	Lookout	342233*	4032845
ARME 007	Mixed chaparral	manzanita	Lookout	347391*	4034592
ARME 008	Mixed chaparral	manzanita	Lookout	346596*	4034345
ARME 009	Mixed chaparral	manzanita	Lookout	346568*	4034144
ARME 015	Mixed chaparral	manzanita	Lookout	344635*	4033573
ARME 010	Mixed chaparral	manzanita	Redwood	348001*	4035021
ARME 011	Mixed chaparral	manzanita	Redwood	348112*	4034811

Wagtendonk to further refine fuels information for Sierran mixed conifer forests. The change in these constants has resulted in higher fuel load estimates for duff in all forest monitoring types. The new constants have been applied to previously collected data to obtain new estimates for fuel reduction and accumulation.

Work Completed in 1997

During the 1997 field season, five forest plots that burned in the Atwell Segment (segment #3) of the Mineral King burn unit and one forest plot located outside the segment (unburned) were remeasured two-years postfire (**Fig. 3.12-1**). Two new plots were installed in the Tar Gap Segment (segment #10) in the red fir forest monitoring type.

RESULTS TO DATE

Results are presented for plots that burned in the Atwell Segment (segment #3) in three forest monitoring types. The results include dead and down fuel reduction and accumulation, live overstory tree (>1.37 m in height) density changes by species (species composition) and diameter class (stand structure), and tree seedling (<1.37 m in height) density. Where more than one plot is included in the analysis, results are presented as mean values ± one standard error. Results related directly to quantitative fire management objectives are indicated in bold typeface. Note that results may not be representative of the entire monitoring type and only apply to the plot areas measured due to the small sample sizes (at most, two plots per monitoring type).

Low Elevation-mixed Conifer Forest (CADE)

Fuel Reduction and Accumulation: In one CADE plot, **72% of the total fuel load was consumed** by the fire, from 117.6 tons/acre (26.37 kg/m^2) prefire to 33.0 tons/acre (7.39 kg/m^2) immediately postfire (**Fig. 3.13-1**). The duff was completely consumed (100%) and woody fuels were reduced by 51%. Woody fuels increased by 67% over immediate postfire levels within one-year, indicating that branch and tree mortality was already contributing to the downed woody fuel layer (**Fig. 3.13-2**). A small decrease in fuel load from one- to two-years postfire is likely due to slight differences in fuel transect locations repeated from one year to the next (error associated with the sampling technique).

Overstory Tree Density (Species Composition and Stand Structure): Total overstory tree density was 1270 trees/ha prefire and 30 trees/ha two-years postfire, indicating 98% overstory mortality in the plot two years following fire (**Fig. 3.13-3**). Prefire composition was dominated by incense cedar (68% of all trees; **Fig. 3.13-3**), most of which were less than 50 cm in diameter at breast height (dbh) (**Fig. 3.13-**

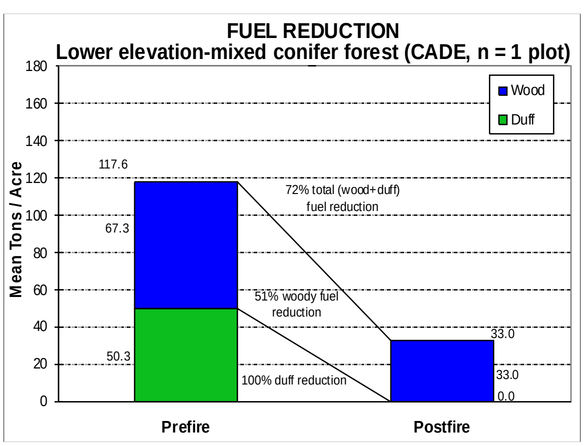
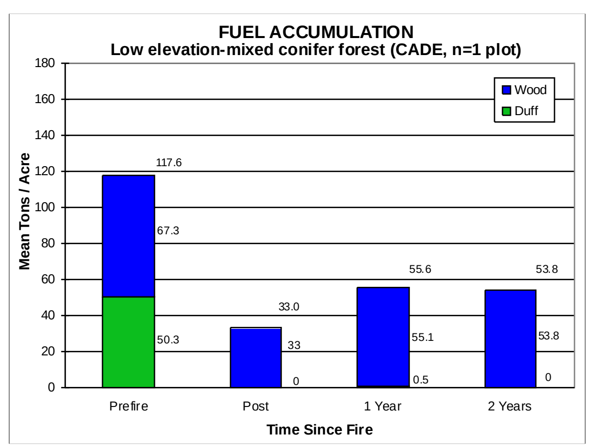


Figure 3.13-1.



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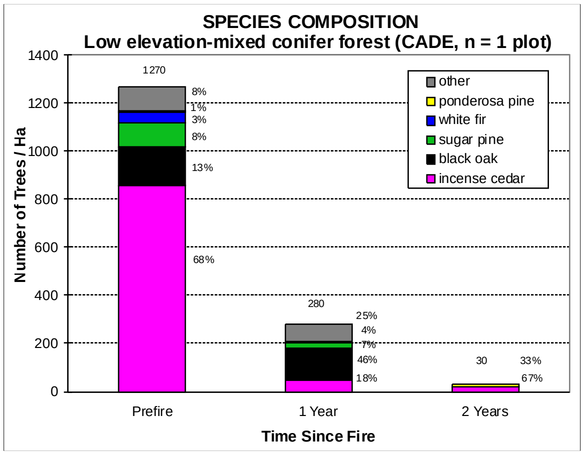


Figure 3.13-3.

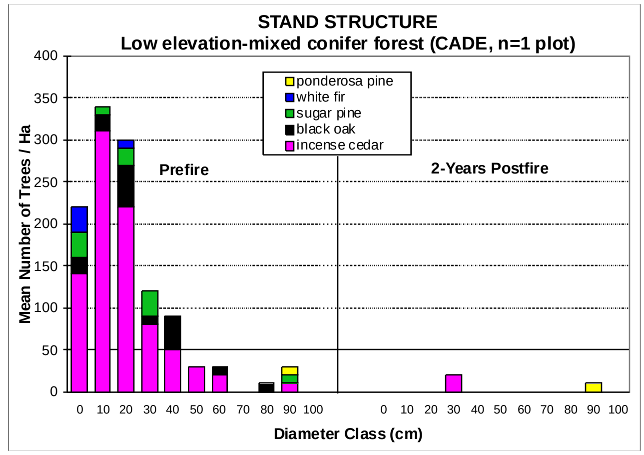


Figure 3.13-4.

4). Incense cedar was reduced from 860 trees/ha prefire to 20 trees/ha two-years postfire (98% mortality) while its relative species composition remained unchanged from prefire condition to two-years postfire (68-67%; **Fig. 3.13-3**). Black oak, sugar pine, and white fir overstory tree densities were reduced to zero, while the only ponderosa pine tree in the plot survived the fire, and therefore, ponderosa pine relative density increased from 1% to 33% (**Fig. 3.13-3**).

Tree Seedling Density: Total tree seedling density increased by 62% from 3,280 seedlings/ha prefire to 5,320 seedlings/ha two-year postfire.

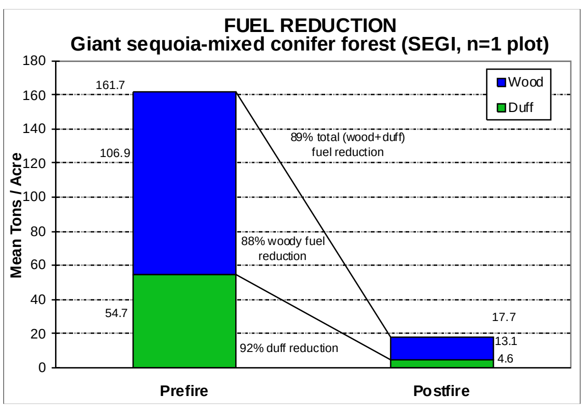


Figure 3.13-5.

Giant Sequoia-mixed Conifer Forest (SEGI)

Fuel Reduction and Accumulation: **Total fuel load was reduced by 89%** in one SEGI plot, from 161.7 tons/acre (36.24 kg/m^2) prefire to 17.7 tons/acre (3.96 kg/m^2) immediately postfire (**Fig. 3.13-5**). The duff was reduced by 92%, while 88% of the woody fuels were consumed. Due to the late season burn, the second SEGI plot was not remeasured immediately postfire and, therefore, was not included in the fuel reduction estimate. Woody fuel increased greatly one-year postfire, surpassing the prefire woody fuel load (**Fig. 3.13-6a**). Note that the error bars (± one standard error) are large, indicating high variability in total fuel load between the two plots for all visits (**Fig. 3.13-6**). The large postfire increase occurred in only one of the plots and is a result of a large fallen white fir that intercepted three of the four fuel transects. The arrangement of this downed tree gives the plot a very high fuel load which is not representative of the plot area in general and not typical

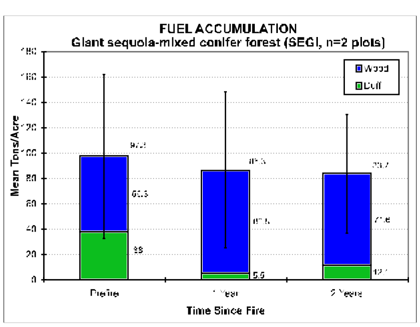


Figure 3.13-6a.

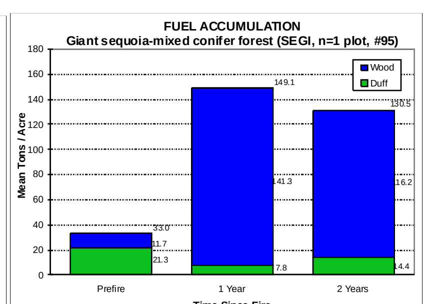


Figure 3.13-6b.

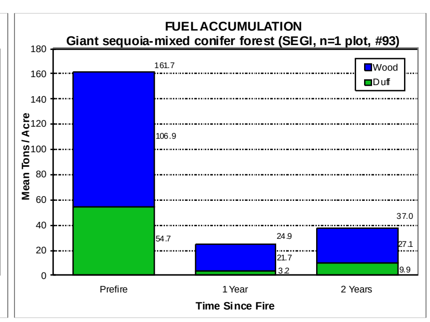


Figure 3.13-6c.

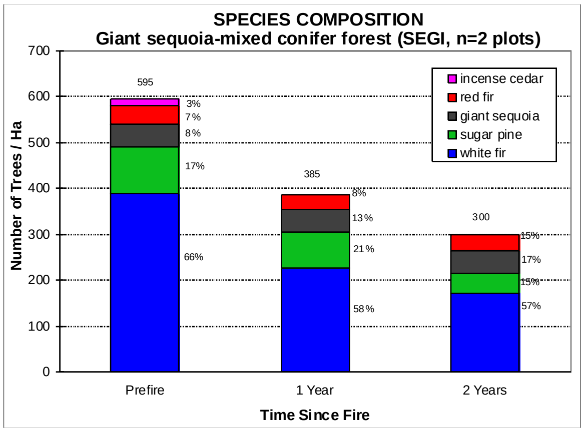


Figure 3.13-7.

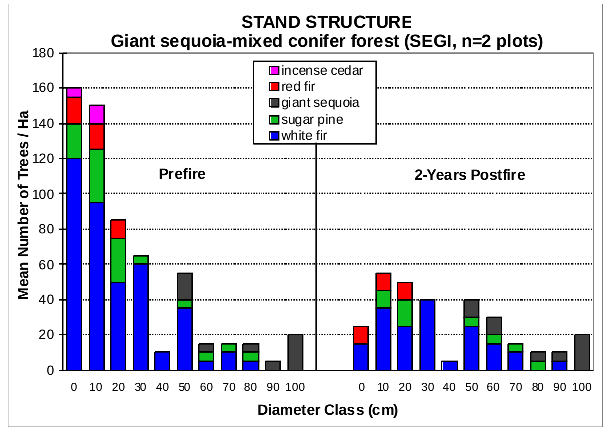


Figure 3.13-8.

of other plots throughout the parks in this monitoring type (**Fig. 3.13-6b**). Results from the second plot is much more representative of the postfire fuel accumulation pattern seen in the giant sequoia-mixed conifer forest type in the park (**Fig. 3.13-6c**).

***Overstory Tree Density (Species Composition and Stand Structure)*:** In two SEGI plots, mean total overstory tree density was reduced by 50%, from 595 ± 215 trees/ha prefire to 300 ± 50 trees/ha two-years postfire (Fig. 3.13-7). White fir dominated prefire (66%) and most mortality occurred in the smaller diameter white fir (less than 30 cm; Fig. 3.13-8). Relative density changed from prefire condition to two-years postfire. Incense cedar, white fir, and sugar pine decreased (from 3% to 0%, from 66% to 57%, and from 17% to 15% respectively) and relative increases occurred in red fir (from 7% to 15%) and giant sequoia (from 8% to 17%; Fig. 3.13-8). No mortality of any giant sequoia trees occurred in either plot.

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

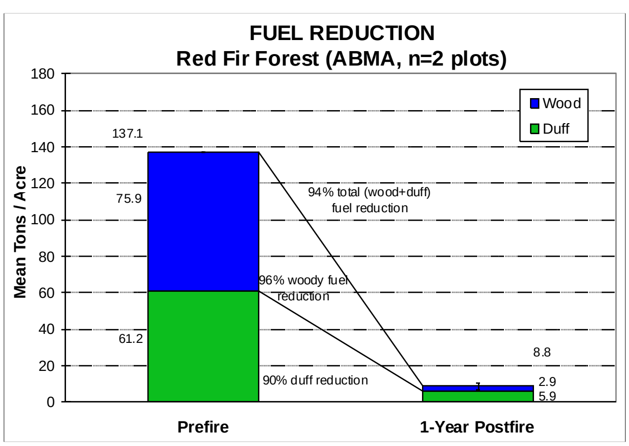


Figure 3.13-9.

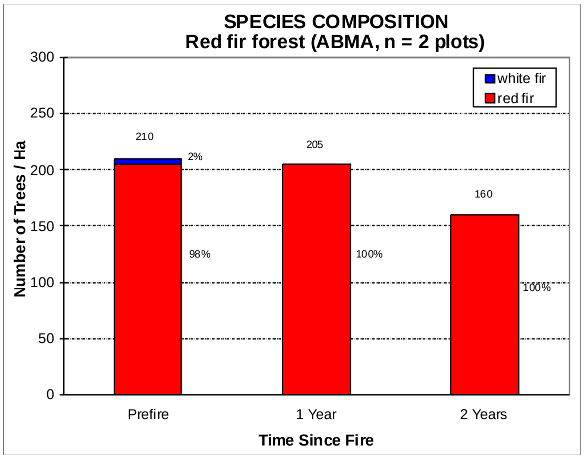


Figure 3.13-11.

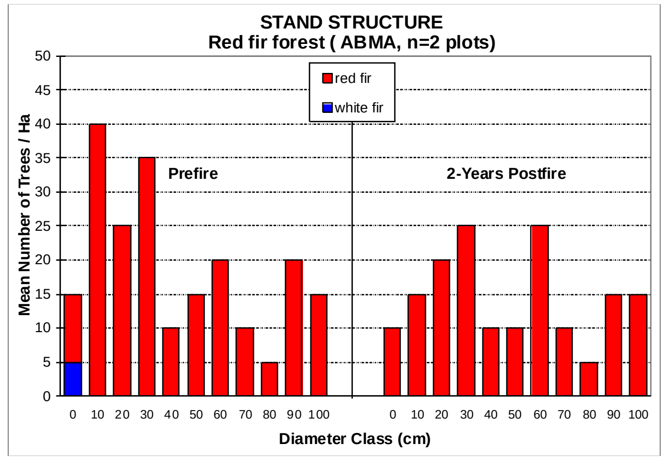


Figure 3.13-12.

Red Fir Forest (ABMA)

Fuel Reduction and Accumulation: In two ABMA plots, the mean total fuel load was 137.1 ± 0.2 tons/acre (30.74 ± 0.04 kg/m^2) prefire and 8.8 ± 1.7 tons/acre (1.98 ± 0.39 kg/m^2) 1-year postfire, which indicates **94% total fuel reduction** (**Fig. 3.13-9**). The plots were not revisited immediately postfire due to the late season burn. Some fuel may have accumulated from the time the plots burned until they were remeasured the following summer, therefore, the fuel reduction results may be conservative. The duff was reduced by 90% and 96% of the woody fuels were consumed. Woody fuel and duff accumulated slightly between the one- and two-years postfire (**Fig. 3.13-10**).

Overstory Tree Density (Species Composition and Stand Structure): Mean red fir overstory tree density for two plots was 205 ± 95.0 trees/ha prefire and 160 ± 50 trees/ha two-years postfire (**Fig. 3.13-11**). While no overstory red fir mortality was detected in either of the ABMA plots during the first year following the fire, 22% mortality occurred within two years after the fire. Most of this mortality occurred in the smaller diameter red firs (**Fig. 3.13-12**).

Tree Seedling Density: Mean red fir seedling density for two plots was reduced by 99%, from 17,380 ± 3,900 seedlings/ha prefire to 100 ± 100 seedlings/ha two-years postfire.

PLANS FOR 1998

According to burn perimeter maps, three of the Mixed chaparral plots burned last year, therefore,

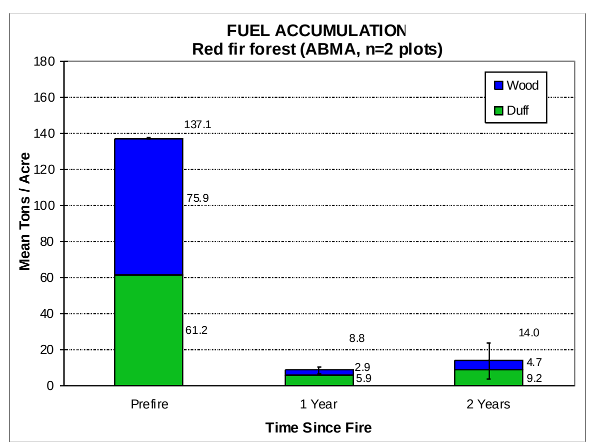


Figure 3.13-10.

they will each be revisited for the one-year postfire check in 1998. Three new plots are also scheduled to be installed in the Tar Gap Segment (segment #10), including one plot in the Red fir forest type and two plots in the Low elevation-mixed conifer forest type.

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

- MaryBeth Keifer, Science and Natural Resources Management, SEKI

Lead: MaryBeth Keifer; field crew supervisor: Georgia Dempsey; field crew: M. Cox, D. Haskamp, G. Indindoli, K. Williams

OBJECTIVES

This study was designed to assess the relationship between the amount of fuel surrounding giant sequoias prior to burning and the resulting fire effects (**Fig. 3.12-1**). The specific objectives of the study are to: 1) determine the amount of heavy fuels surrounding giant sequoia trees prior to and following prescribed burning, and measure the resulting fire effects characteristics; 2) from these measurements, determine the relationship between the amount of large fuel and duff surrounding giant sequoia trees and resulting changes in fire effects characteristics (bark char, crown scorch, fire scars, and mortality); 3) provide the fire management staff with the study results to assist in making decisions regarding heavy fuel clearance in giant sequoia groves. As a result of public concern about the visual effects of fire, giant sequoia trees located in SMA (special management areas) restoration burn units are subject to prefire fuel removal as specified in Appendix H of the SEKI Fire Management Plan. The appendix states that unnaturally high fuel levels around sequoia trees must be removed prior burning to limit bark char and crown scorch in trees greater than four feet in diameter. This study will provide information to managers about the actual impacts of burning these unnatural fuels are on sequoias. A waiver of Appendix H requirements was obtained for this research project in 1995. In 1996 Appendix H was ammended to relax this internal SEKI policy requirement. For the complete study plan for this investigation see Keifer (1995) Appendix 1 in the MKRRP 1995 Annual Report.

Figure 3.14-1. Measuring preburn giant sequoia scar.

WORK COMPLETED IN 1997

All 60 trees in the giant sequoia fuel and fire effects study located in segment #3 were revisited 2-years postfire and changes in new fire scar size was recorded. Results for the giant sequoia fuel and fire effects study are still being processed, however, no mortality occurred in any of the 60 study trees within 2-years following the fire.

3.15) Red Fir Regeneration and Fire

- Dave Newburn, Science and Natural Resources Management, SEKI

Lead: David Newburn, UC Berkeley, California

INTRODUCTION

Gap-phased dynamics have been used as a framework to understand forest successional pathways (Pickett and White 1985). Forest stands are often comprised of populations of similar-aged trees which can be associated by groups each composing a successional stage in the complex forest mosaic. Forests typically have several disturbance agents (i.e. fire, disease, windthrow) which form canopy gaps within intact forest canopy, ranging in scale from individual canopy trees to several hectares. In many forest types, regeneration occurs in patches following gap-initiating disturbances.

In the higher elevations of the Sierra Nevada, red fir (***Abies magnifica***) comprises nearly monospecific stands (Barbour and Woodward 1985). Groups of red fir trees may be even-aged, resulting from synchronous post-disturbance establishment, or multi-aged, reflecting continuous recruitment of seedlings moderately tolerant of shade. Red fir seedlings, saplings, and small understory trees exhibit clumping at scales roughly equivalent to the size of canopy gaps (Taylor 1991). Even though fire is the major disturbance within red fir forest, little has been studied regarding the persistence of these regeneration clumps after fire and their importance in forming later successional seres.

This study will attempt to understand the role of fire in thinning red fir understory trees within regeneration patches (**Fig. 3.15-1** and **Fig. 3.15-2**). To this end, we will measure the distribution and intensity of patch regeneration within red fir forest. The understory tree survival rates after fire also will be evaluated to determine the relative importance of patch and non-patch areas in forming later successional seres. Lastly, canopy gap sizes will be measured before fires to see how regeneration patch area correlates with gap size.

RATIONALE AND SIGNIFICANCE

Red fir forest dynamics are still poorly understood and any additional knowledge will be beneficial for both applied and theoretical reasons. Fire suppression over the last 100 years in most Western states has increased fuel load and stand densities, resulting in forests more susceptible to insect and disease outbreaks and catastrophic fires (Parsons and Debenedetti 1979). Restoration of fire within forested ecosystems has become an increasingly important tool for land managers. However, many questions remain unanswered regarding the regeneration processes that result in the presence of fire events.

Ecological studies in forested ecosystems, such as red fir forests, that experience fires with moderate frequency (mean fire return interval 25-100 yrs) and high variation of intensity are lacking compared to ecosystems with infrequent high-severity fires (Heinselman 1981) or frequent low-severity fires (Kilgore 1981). Furthermore, patch dynamic models have experienced limited success since models have frequently imposed artificial boundaries to multiple species systems which tend to follow gradients between patches rather than clearly demarcated borders. The red fir forest are dominated by one species (95-99 %) and the intense clumping of smaller-sized trees reduces these two errors and thus lends itself to testing many of the theoretical ideas of patch dynamics.

Applied applications for the study results will also have benefits for forest management being carried on outside the park. On non-park lands, timber harvesting has been treated as a surrogate for fire in creating canopy gaps. The proposed study will determine the natural range of gap sizes and help to determine optimal cutting units for harvesting operations on these lands. This is important since regeneration was delayed by more than a decade in clearcuts, presumably due to high moisture stress on seedlings in open areas (Gordon 1970).

RESEARCH OBJECTIVES

The initial two sections of the proposed research develop the basis for the application of a patch dynamics model. Subsequently, fire effects will be determined on small trees to evaluate the persistence of patches after fire.

I. Spatial patterning of red fir regeneration

- Determine patterns in the distribution of small trees (seedlings/saplings) and find the scale of regeneration patches.
- Compare the relative abundance of small trees in patches (clumps) versus non-patch areas (in remaining plot area).
- Overlay small tree distributions with canopy gap distribution to determine if relationships exist between patches of small trees and canopy gaps..

II. Gap size and regeneration patch size

- Calculate the threshold of the gap diameter and/or minimum gap size required before regeneration patches establish.

III. Fire effects on red fir regeneration

- Determine whether the fine fuel and duff amounts are lower within regeneration patches versus non-patch areas, presumably because there are fewer canopy trees near patches which can contribute to fuel buildup.
- Ascertain whether the incidence of duff measurements which strike rotten logs in patches is higher than non-patch areas to indicate that the patches (or gaps) had been previously colonized by canopy trees.
- Determine the relative mortality rate of small trees in patch versus non-patch areas.
- Determine whether a dominant agent (fuels, weather, topography, etc.) exists which causes increased red fir mortality within patches.

METHODS

Study Site

The study is being conducted at Sequoia National Park in the Mineral King watershed. This study takes advantage of the concurrent Mineral King Risk Reduction Project (MKRRP) with its associated ecological research relating to fire history, fire behavior modeling, fire effects monitoring of vegetation, and fuel load. MKRRP is one of the first landscape-scale prescribed burn projects within Park Service units and has outlined a plan to burn 10,000 to 20,000 ha over the next five years.

Experimental Design

Sampling units (1 ha area) were randomly selected in red fir forests along a north-facing aspect. In an attempt to find more homogenous, continuous forested areas, the following criteria were imposed for the sampling units: 1) >50 meters from talus slopes and riparian corridors; 2) rock cover <20%; and 3) high canopy cover with red fir dominance. Five plots were established during 1997 (**Fig. 3.11-6** and **Table 3.15-1**)

In order to delineate boundaries of clumped red fir regeneration within the one hectare area, plots were established when there was 10 or more trees within a 5 x 5 m area which satisfied the following size class distribution: 1) 2/3 or more of the trees must have a dbh <10 cm and 2) 3/4 or more of the trees must have a dbh <15cm. (Note: Trees were only counted if they were taller than 30 cm). Any area with

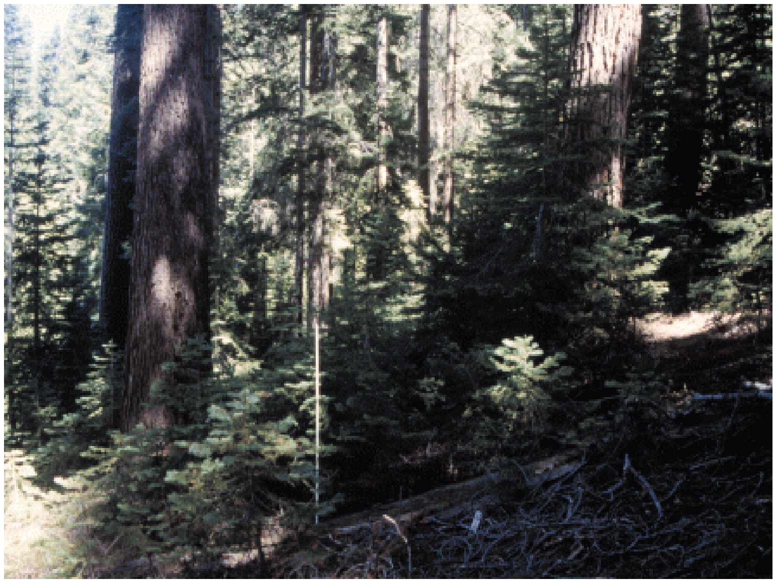


Figure 3.15-1. Preburn view of red fir plot 3.

Figure 3.15-2. Postburn view of plot 3 (view is not a photo pair with Fig. 3.15-1).

an aggregation was mapped in 5 x 5 m grid cells referenced to the hectare coordinate system. The xy coordinate system for the hectare was structured such that the top right and bottom left corners were assigned coordinates (0,0) and (100,100), respectively. While the aggregation must have a center of 10 or more trees, the aggregation is expanded in a contagion manner into neighboring grid cells that have at least 3 or more trees and satisfy the two rules stated above. In the patch areas, all seedlings and saplings were tallied by dbh and species within each grid cell. In low density areas that failed to satisfy the criteria for patches, all trees <10 cm dbh were measured by dbh and species but were not spatially referenced to a grid cell. In other words, a distinction is made between plots which represented clumps of regeneration and the remaining area of more sparsely distributed understory trees.

In order to measure regeneration patch area, the patch area of the entire aggregation was traced using the crown edge of the small trees (<20 cm dbh) within the grid cells which satisfy the criteria for plot establishment. Additionally, trees (<20cm dbh) which have their crown within 3 meters from any tree within the established grid cells are also included within the patch area. Estimates of canopy gap size will be made after crowns were mapped for all canopy trees (> 20 cm dbh) within a 15 m buffer of any patch. The dbh, species, and XY position was recorded for each tree. Crown areas will be estimated from the dbh using a regression equation. Regeneration patch area was correlated to canopy gap area to determine the minimum gap size required before regeneration patches establish.

Fine-scale variations in fuel load will be correlated to the mortality of red fir regeneration. Fuel transects were sampled in each 5 x 5 m grid cell considered a patch area. The transects were orientated horizontally and vertically which extends 5 meters in each direction and cross the grid cell center. Fuel size classes follow the Brown's transect guidelines: 0-¼", ¼-1", 1-3", and 3+". Additionally, five evenly-spaced duff/litter measurements were made for each grid cell. Random fuel plots (four 10 m x 10 m plots per hectare) were measured to characterize average fuel conditions for the hectare in non-patch areas.

Prescribed fire management plans are based on forest type, fuel load, and weather conditions to facilitate fire control, prescription objectives, and to mimic the historical fire regime. Thus, burning is usually performed in the late summer/early fall and ignitions will be located at least 50 meters from any sampling units to reduce the bias attributed to human-initiated fires. Subsequent to all fire events, recensus of all canopy and understory trees for survival rates will occur in addition to measuring several indices of fire intensity, including scar and char height.

Several other data sources were also made available by the Sequoia National Park, Resources Management Division and the USGS/National Biological Service. The Global Change Vegetation Monitoring project has four one-hectare red fir plots, located in Yosemite and Sequoia National Parks, which have stem maps for all trees taller than breast height. Several mapped plots of red fir surveyed in 1978 within the Mineral King study area will provide information on fire history and help to calculate a dbh versus crown area regression curve (Pitcher 1987).

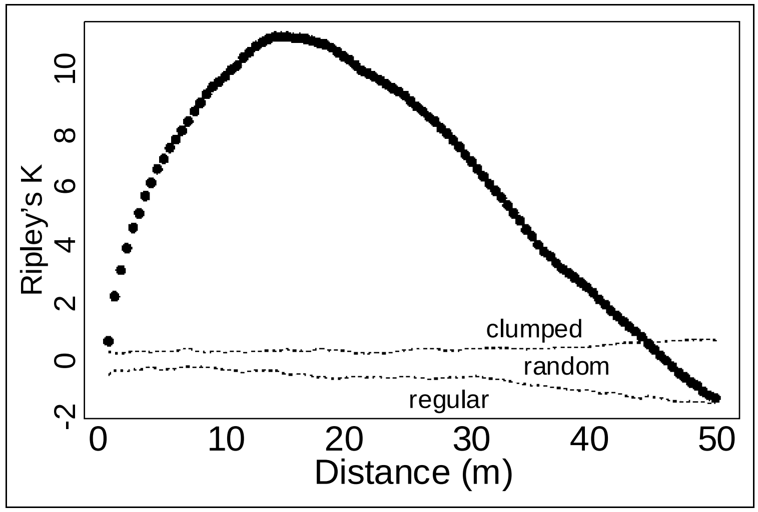


Figure 3.15-3. Clumping pattern at 10-40 m scale from Ripley's K statistic which tests observed data (red fir saplings) for deviation from complete spatial randomness.

PROPOSED ANALYSIS

I. Global Change plots

- Use point pattern analysis by Ripley's K statistic to find clumping patterns for small trees and the size of clumps.
- Plot the positions of small trees (0-10 cm dbh) and overlay crowns of canopy trees (>20 cm dbh). Determine whether the number of small trees not underneath canopy crowns is greater than would be expected from a random distribution, confirming that small trees are positively associated with gaps.

II. Pre-fire analysis of field plots

- Displaying the outline of regeneration patch perimeters and overlay for crowns of canopy trees (>20 cm dbh). Determine the degree of asymmetry of patches toward the southern edge of the gap. Asymmetric distribution of regeneration may indicate that light/water requirements are more significant than nutrients.
- Form buffer strips along the border of the regeneration patch and calculate the proportion of canopy crown area ineach buffer strip. Determine the relationship between proportion of canopy

Plot	UTM East	UTM North
1	352500	4033700
2	351700	4032900
3	350600	4032500
4	351300	4032800
5	353300	4033700

Table 3.15-1. UTM coordinates of plots.

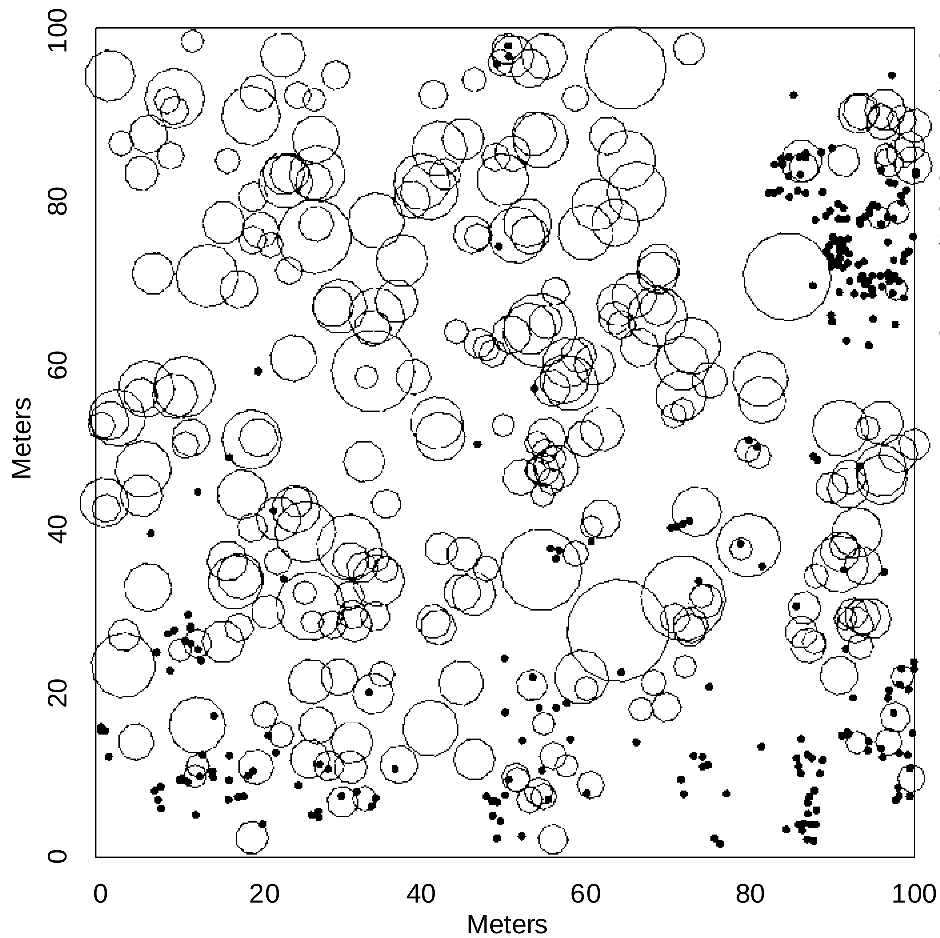


Figure 3.15-4. Spatial clumping of red fir seedlings at Panther Gap. Open circles show locations of the canopies of large overstory trees and small solid dots show locations of saplings (data from BRD global change plot).

closure and distance t patch edge in order to find the threshold distance of gap diameter before regeneration establishes.

III. Post fire analysis of field plots

- Determine mortality rates for smaller-sized trees by size class (seedlings, 0-5 cm, 5-10 cm, 10-15 cm, and 15-20 cm) in both patch and non-patch areas. Apply multivariate regression to correlate understory mortality rate with several factors influencing fire behavior including fuels, weather, and site conditions.

EXTREMELY PRELIMINARY RESULTS

Spatial clumped patterning were detected in smaller-sized (0-10 cm dbh) red fir trees using Ripley's K statistic ($p< 10^{-6}$)(**Fig. 3.15-3**). The size of red fir regeneration patches was 10 m to 40 m, roughly the size of one to several canopy tree crowns. The distribution of smaller-sized (0-10 cm) trees appears to be associated with canopy openings, but quantitative measures have not been applied to date (**Fig. 3.15-4**).

Fuel measurements between patch (gap) areas and random fuel plots in non-patch (understory) areas differed significantly (**Fig. 3.15-5**). The amount of fine fuels in non-patch fuel transects (0-1/4", ¼-1", and 1-3" size classes) are roughly doubled when compared to patch fuel transects. Heavy fuel levels in the sound category are approximately 50% greater in non-patch areas whereas rotten heavy fuels are roughly even under both conditions. Furthermore, average duff depth was 60% greater in non-patch areas versus patch areas.

Moisture levels were compared for both branchlets and duff samples (**Table 3.15-2**). The six

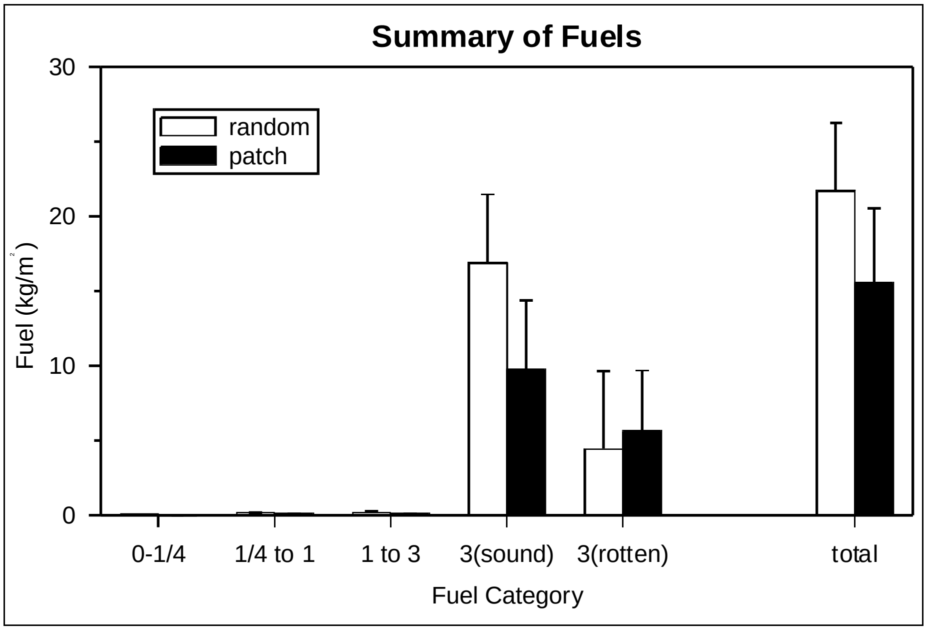


Figure 3.15-5. Comparison of fuel loads between patch areas (areas with high sapling densities) and random non-patch areas.

treatments include the combinations of size (seedling vs. sapling) and density (very sparse, sparse, dense).

While differences between some treatments were statistically significant (t-test), the slight variation in moisture levels probably do not have large implications for higher survival rates of regenerating trees in different size classes or density.

DISCUSSION

Detailed understanding of the role regeneration patches in red fir forest dynamics requires the results from post-fire analysis. Nevertheless, the preliminary results have been promising by demonstrating that the majority of red fir regeneration is found in patches associated with canopy gaps. The patch areas have lower fuel conditions since canopy gaps containing patches have fewer canopy trees contributing to fuel buildup. Post-fire analysis will show whether lower fuel conditions in patches can contribute to their increased survival rates after fire events and may indicate their relative importance in forming later successional seres.

Table 3.15-2. Moisture content of red fir branchlets and ground surface duff during August 1997 at three density levels and two height levels.

Density	Dense		Sparse		Understory	
Size	Sap	Seed	Sap	Seed	Sap	Seed
Branchlets						
Moisture %	61.3	62.2	60.0	64.7	61.3	61.7
S.D.	3.2	5.1	1.9	1.9	2.1	1.6
Duff						
Moisture %	11.5	9.4	9.1	9.0	10.7	9.4
S.D.	1.8	1.9	1.7	2.1	1.8	1.7

3.16) Fuel Inventory and Monitoring

- Science and Natural Resources Management, SEKI

Lead: C. Conover, Crew Leader: D. Yemm, Crew: J. Sevier, R. Parsons, M. Buhler, C. Barclay

INTRODUCTION

Recent advances in computerized technologies have given resource managers more tools for making 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 vegetation maps developed in the 1960s and 1970s.

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, with elevations ranging from 874 m (2,884 ft.) to 3,767 m (12,432 ft.). The watershed, 21,202 ha (52,369 ac) in size, is bounded by Paradise Ridge to the north, the Great Western Divide to the east, and Salt Creek Ridge to the south. 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 3,049-3,354 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 the lower elevations <1,982m (<6,500 ft). The mid-elevations 1,982-2,439m (6,500-8,000 ft) are dominated by the white fir mixed-conifer community including sequoia groves. Red fir forest forest dominates the higher elevations at 2,440-3,049m (8,001-10,000 ft).

METHODS

Information on fuel loading, overstory tree height, canopy cover, basal area, and height to live crown base were collected in the forested areas of the East Fork of the Kaweah drainage over the past three years (1995-1997). The mixed conifer forest was divided into sequoia, fir, and pine forest types depending on which species dominated the area. The data was collected at sampling points along transects that covered the full elevation range of the forest type (**Fig. 3.16-1**). The sampling points were located approximately 100 meters (5 chains) apart along the transects. Data was collected at each sampling point unless one or more of the following rejection criteria were encountered: 1) 30% or more exposed rock, 2) a wet drainage (intermittent stream with fuel crossing was ***not*** rejected), 3) a man made object (trails, roads, structures etc.).

The fuel loading information was obtained using the "Photo Series for Quantifying Natural Forest Residues: Southern Cascades, Northern Sierra Nevada" (Blonski & Schramel, 1981). Three measurements of litter and duff estimates were taken at each sampling point and added to the photo series woody fuel loading information to obtain an estimate of total fuel load. Litter and duff measurements were taken at two meters along the transect azimuth and 45 ° to either side (representing the field of view from the photo series). If the sample point was obviously unrepresentative (fuel depth & % coverage) of the area and then the measurements were offset two meters to the right.

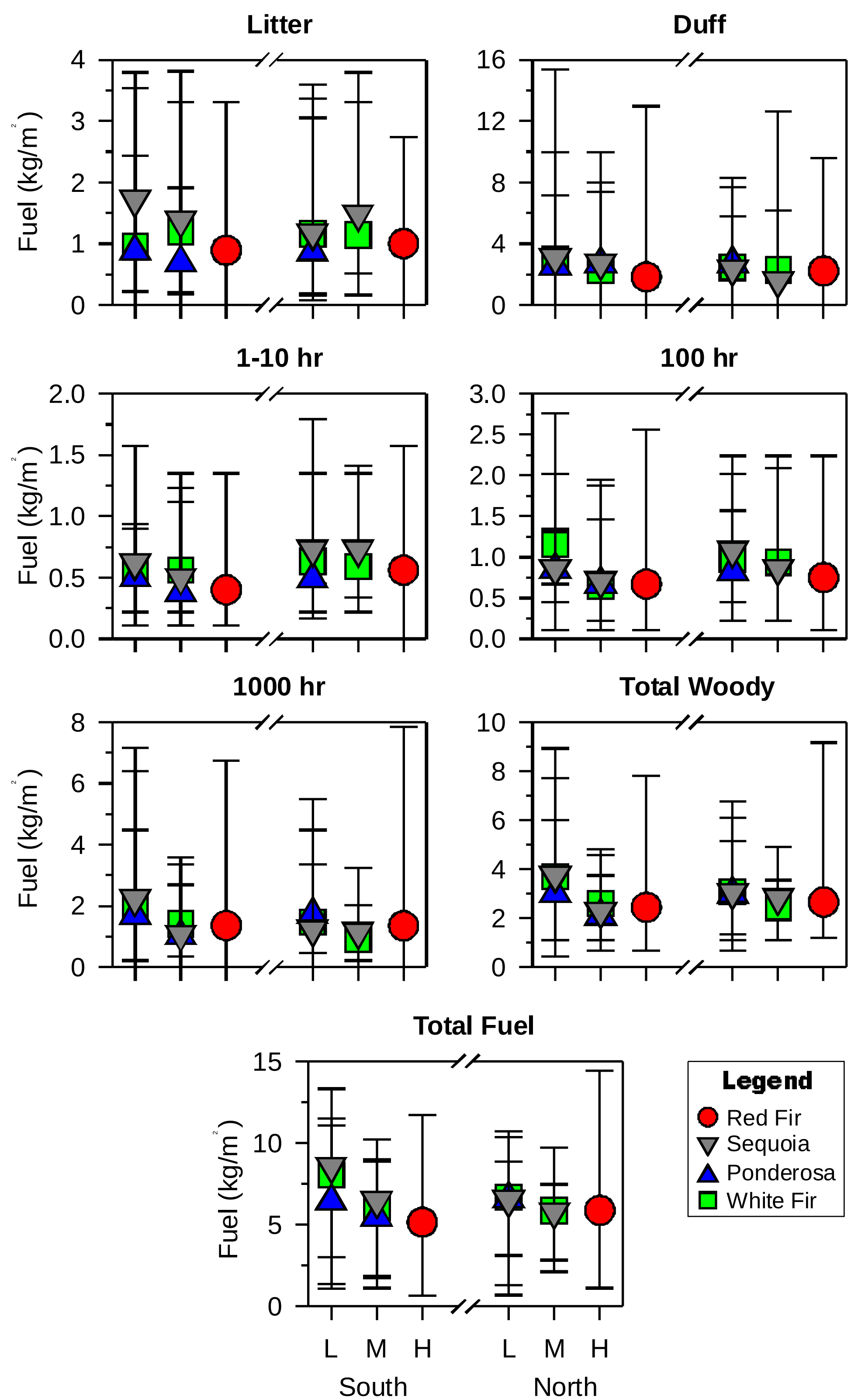


Figure 3.16-2. Fuel data from 1995 and 1996 (from transects) for four vegetation classes at low (L), moderate (M), and high (H) elevations on north and south aspects.

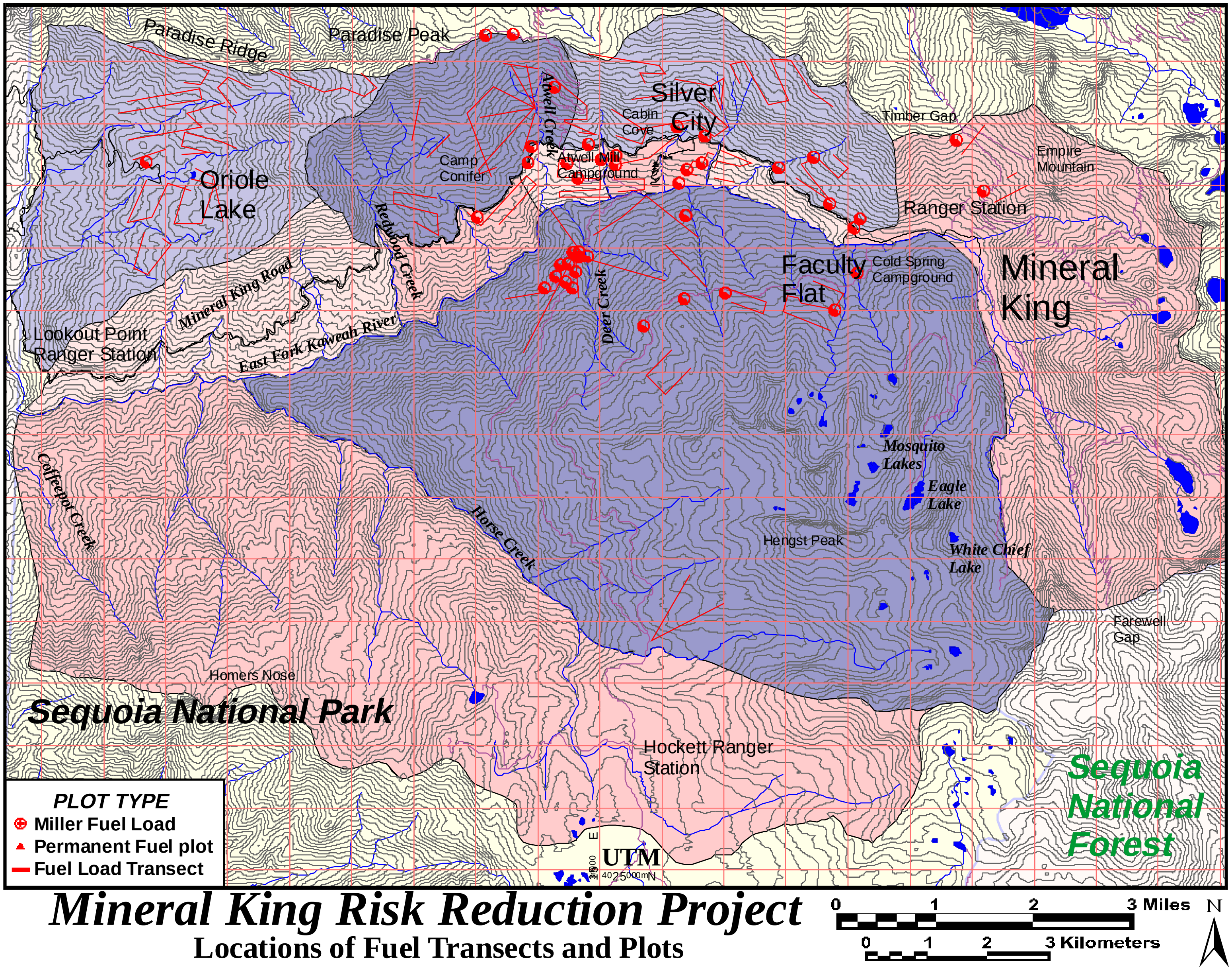


Figure 3.16-1. Fuel data collection sites in East Fork.

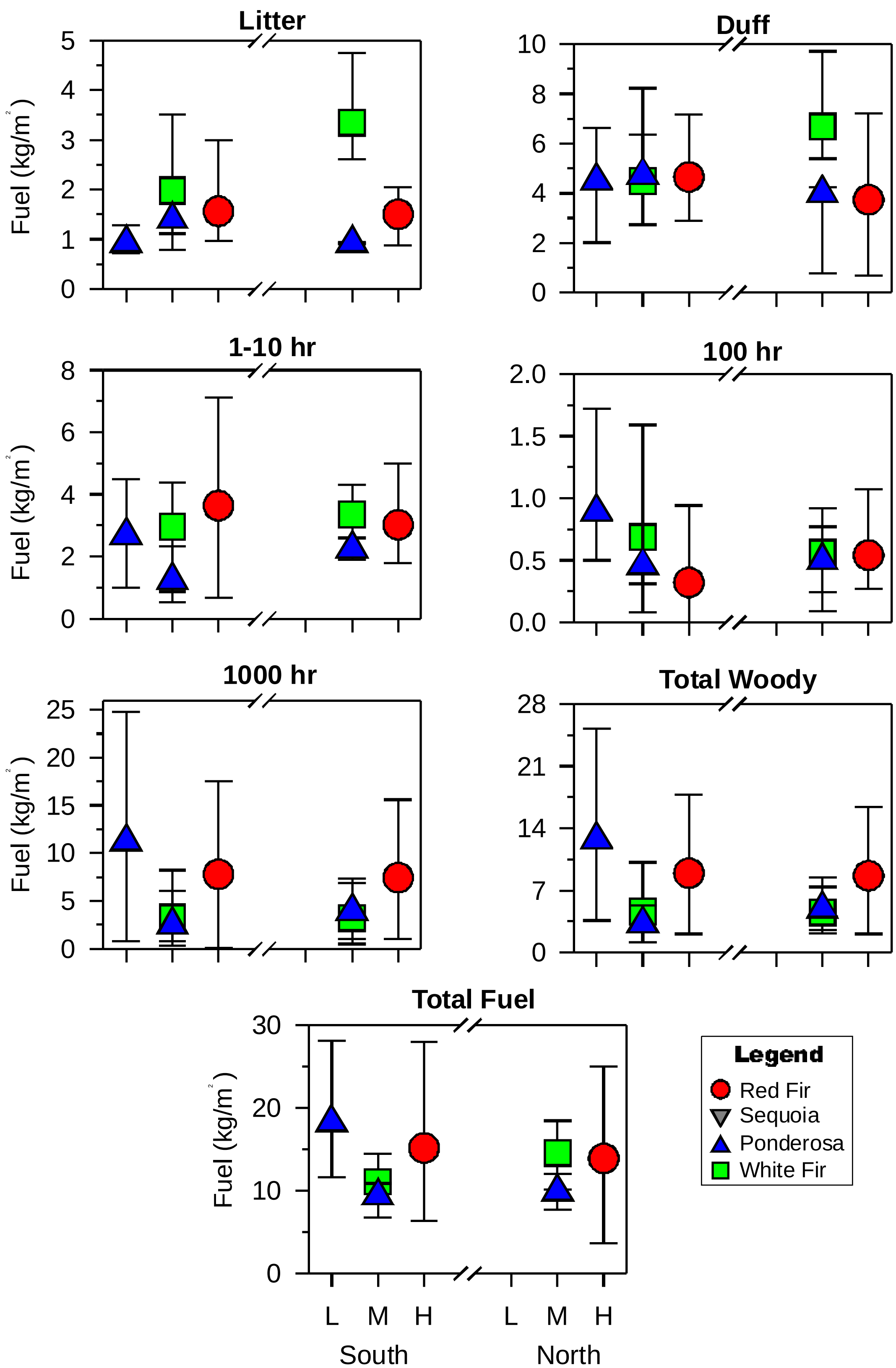


Figure 3.16-3. Fuel data from 1997 (permanent plots) for four vegetation classes at low (L), moderate (M), and high (H) elevations on north and south aspects.

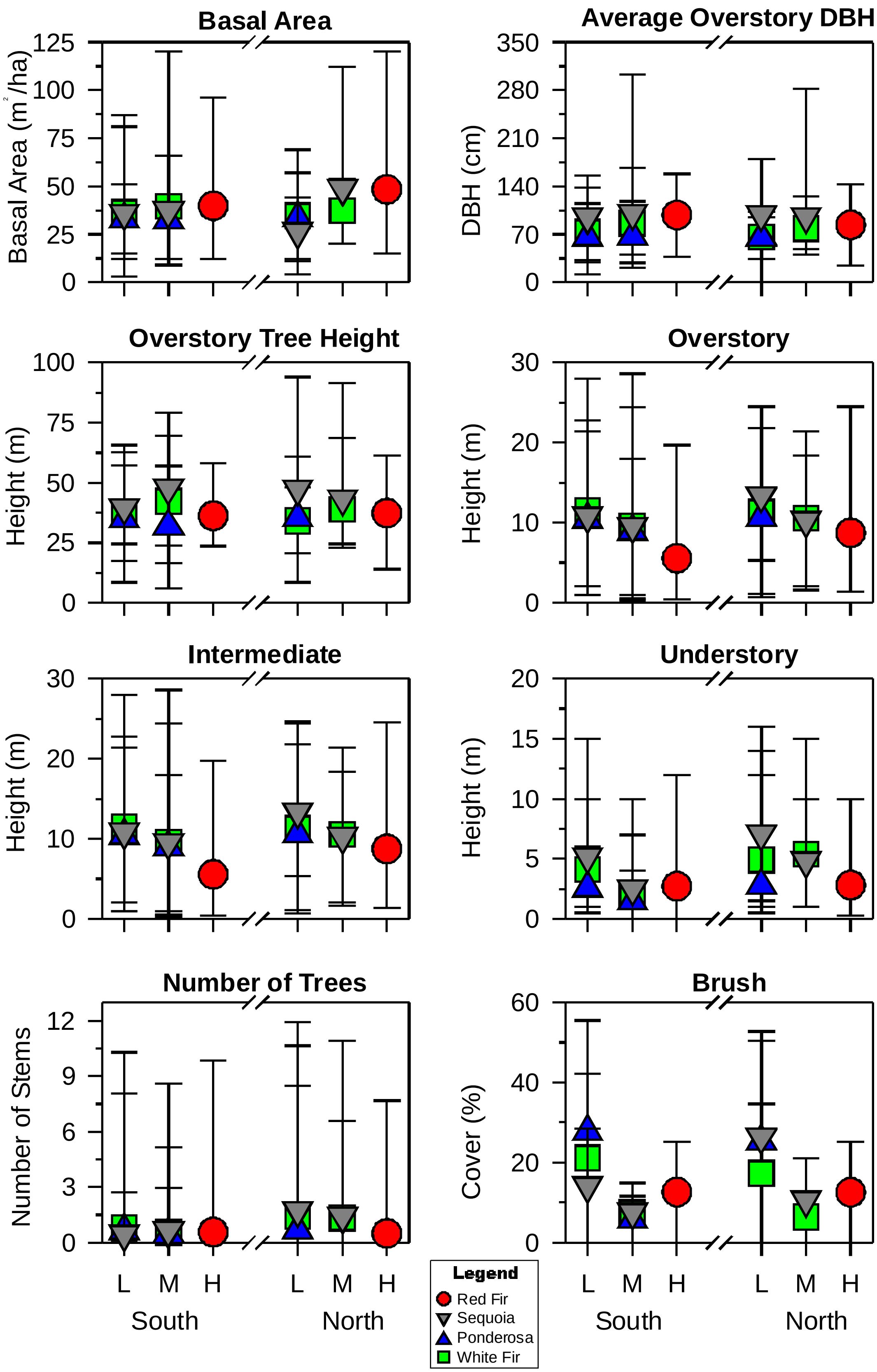


Figure 3.16-4. Stand data from 1995 and 1996 (from transects) for four vegetation classes at low (L), moderate (M), and high (H) elevations on north and south aspects.

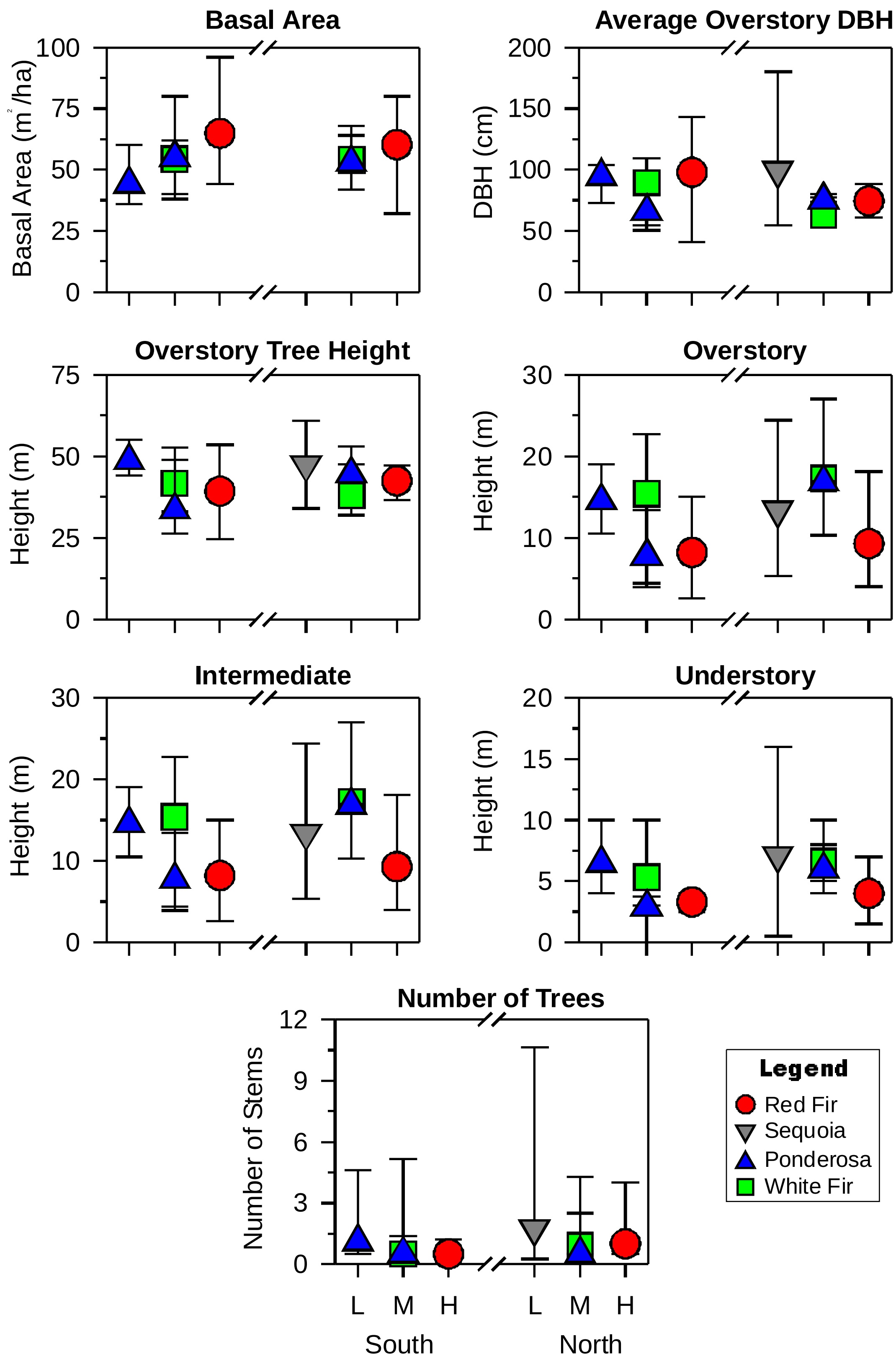


Figure 3.16-5. Stand data from 1997 (from permanent plots) for four vegetation classes at low (L), moderate (M), and high (H) elevations on north and south aspects.

The litter and duff fuel loading estimates were obtained using previously determined depth to weight relationships (Agee, Biswell & Wakimoto, 1977; Van Wagtendonk, unpublished data).

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

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

Beginning in 1997 permanent fuel loading plots were established in order to track fuel accumulation over time. Plots were established in a variety of vegetation types throughout the East Fork watershed (**Fig. 3.16-1**). The planar intercept method (Brown, 1974) was used to sample fuels. Each plot 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. Based on the two previous years data, the permanent plots were located in the short needle – this included sequoias – and long needle conifer forest types in the following elevation classes: low <1,982m (<6,500 feet), mid 1,982-2,439m (6,500-8,000 feet) and high > 2,440m (>8,000 feet).

RESULTS AND DISCUSSION

A total of 663 fuel plots have been sampled in the East Fork watershed. We collected both fuels and stand data in each plot which were located in a variety vegetation classes. These data have been summarized (**Appendix 3.16-1** through **3.16-4**). The sampling included both 621 transect plots collected during 1995 and 1996, and 42 permanent plots established during 1997. Data from both collections have been summarized by aspect (north or south), elevation (high, mid, or low), and by vegetation type (ponderosa pine- PIPO, white fir- ABCO, giant sequoia- SEGI, red fir- ABMA) **(Fig. 3.16-2** through **Fig. 3.16-5)**.

When we sampled pine stands we found that on north aspects there were few stands that could be considered pure pine or pine dominated at low-to-mid elevations, resulting in a small number of replicates for this vegetation type (**Figs. 3.16-6**). Because of the infrequent occurrence of pine stands on this aspect, no additional pine plots will be established on this aspect within the east Fork watershed.

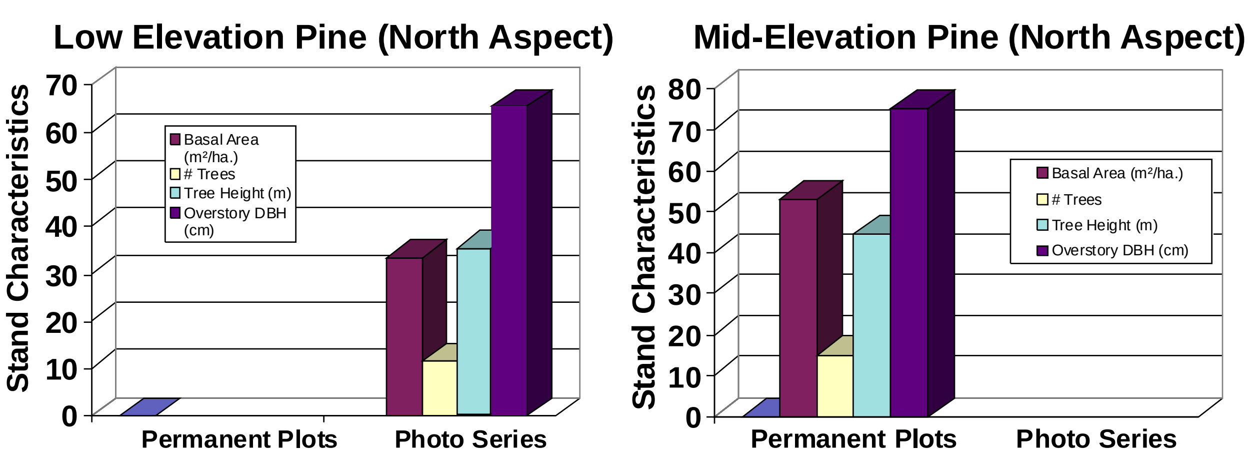


Figure 3.16-6

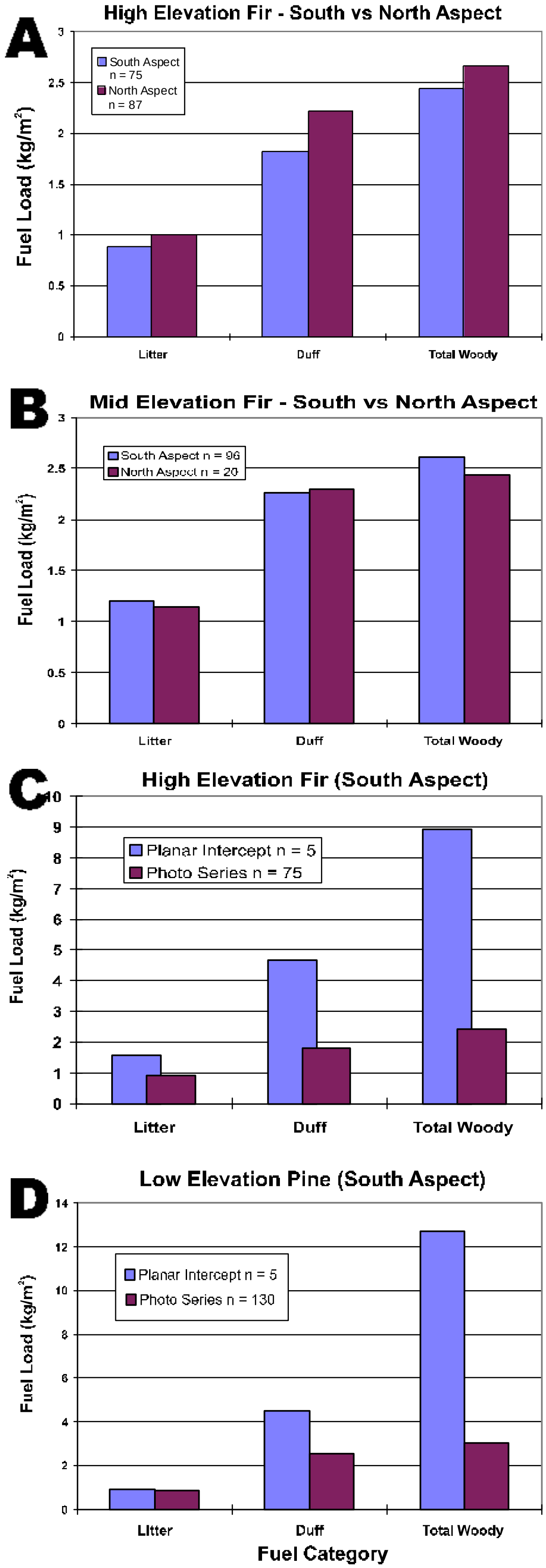


Figure 3.16-7

Stand characteristics generally did not differ greatly among the different forest types across the three elevational zones. The most striking exception was the greater brush cover in the understory of pine dominated stands at lower elevation stands (**Fig. 3.16-.4**). There was also a slight trend for decreasing overstory and intermediate canopy height with increasing elevation, with the lowest average heights recorded in red fir forest (**Fig. 3.16-4**)

Difference in fuel loading between north and south aspects appeared to vary by elevation and vegetation type. High elevation red fir forest had a higher fuel loading on north aspects (**Fig. 3.16-7a**), while mid elevation fir forest had slightly higher fuel loading on the south aspect (**Fig. 3.16-7b**). When we examined basal area of mid and high elevation fir stands, greater total basal areas appeared to be associated with higher fuel loads. The slightly greater basal areas seemed to correspond to slightly higher fuel loading on south aspects in mid elevation fir stands (**Fig. 3.16-8b** and **Fig. 3.16-7b**). In high elevation fir stands, the greater basal area on the north aspects seemed to correspond to higher fuel loading (**Fig. 3.16-.8a** and **Fig. 3.16-7a**). We feel some of this inconsistency was due to differences in past fire regimes between the north and south aspects.

One reason for establishing permanent plots type during 1997 was to examine differences in fuel load estimates derived from two differing sampling methods: photo series used for the transect plots and planar intercept for permanent plots. The two different methods yielded strongly different results with the planar intercept method consistently resulting in higher fuel load estimates (**Fig. 3.16-7c** and **Fig. 3.16-7d**). The planar intercept provides a more accurate fuel estimate and is the method on which the photo series is based (Blonski & Schramel, 1981). The photo series may be problematic for our use because it was developed for the northern Sierra Nevada and may produce biased

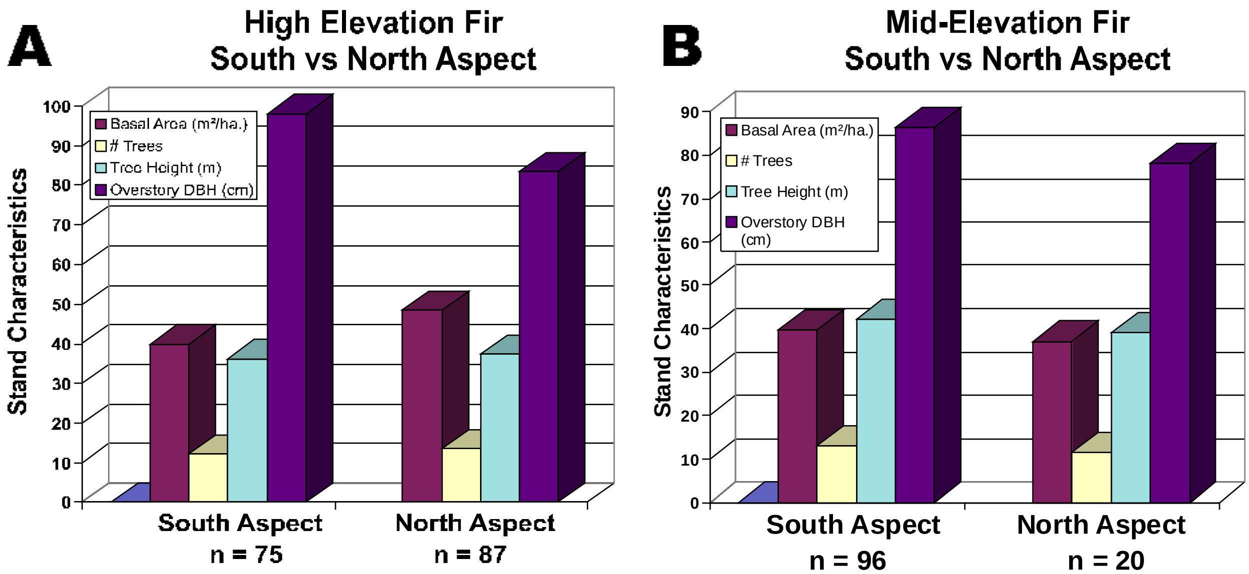


Figure 3.16-8

results when applied to our region with somewhat differing vegetation communities and fuel types.

In contrast, the forest stand charateristic information on the permanent plots appeared to be similar to the photo series plots (**Fig. 3.16-9**). The methodology used to collect the forest stand information was the same, so the results were expected. Any differences in the forest stand information between the permanent plots and the photo series plots was probably due to differences in the number of sample points (n = 5 versus n = 75, n =5 versus n = 130).

SUMMARY

Because of apparent underestimates of fuel load by the photo series we began establishing permanent fuel plots that used the Brown's line intercept method in 1997. Our initial results strongly suggested that the photo series seriously underestimated fuels in the range of vegetation communities we sampled. However, stand data collected while sampling fuels using the photo series and the permanent fuel plots were similar indicating similar stands were sampled using the two methods.

During 1998 we will install additional permanent fuel loading plots in the East Fork drainage. Our goal will be to increase the number of replicated sample points so that the percent error

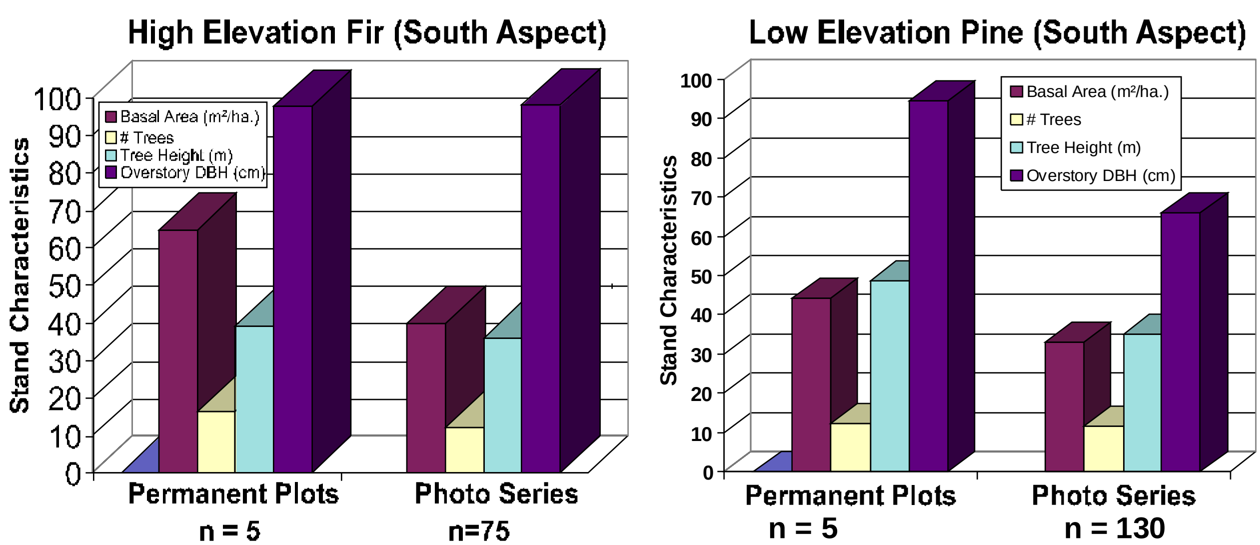


Figure 3.16-9

[[% error=(standard error/mean) x 100] of our total fuel loading estimates are less than twenty percent. When installing future permanent fuel plots, we will also make photo series estimates at the same location. We will also revisit the permanent fuel plots installed in 1997 to take photo series estimates at those locations. Using these two estimates we will attempt to determine if a correlation exists between the two methodologies. If a significant correlation does exist we can derive a correction factor for the photo series. Use of this correction factor 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.

We observed an apparent inconsistency in fuel loadings when comparing north and south aspects which may be a result of differences in fire regimes between the aspects. We will attempt to resolve the problem by looking at the relationship between fuel loading, basal area and fire history. We also hope to improve the correlation of fuel loading and basal area by including the time since the sample area last burned. As we collect more data from the additional permanent plots we will update the custom fuel models that were developed from the 1995-96 data.

Appendix 3.16.1. Summarized fuels data for fuel transect plots.

	Litter kg/m^2 (t/ac)	Duff kg/m^2	1&10 Hr. kg/m^2	100 Hr. kg/m	1000 Hr. kg/m^2	Total Woody kg/m^2	Total Fuels kg/m^2
High elevation > 2440m (8000 feet) Red Fir Forest South Aspect (105-285°) n= 75							
Average	0.89 (3.96)	1.82 (8.12)	0.40 (1.8)	0.67 (3.00)	1.36 (6.09)	2.44 (10.88)	5.15 (22.95)
S.D.	0.64	2.13	0.26	0.41	1.18	1.69	3.65
Maximum	3.30	12.96	1.35	2.56	6.73	8.97	22.42
Minimum	0.00	0.00	0.11	0.11	0.00	0.67	0.67
High elevation > 2440m (8000 feet) Red Fir Forest North Aspect (286-104°) n= 87							
Average	1.00 (4.48)	2.21 (9.87)	0.56 (2.51)	0.75 (3.32)	1.35 (6.00)	2.66 (11.89)	5.87 (26.18)
S.D.	0.57	2.13	0.32	0.42	1.21	1.74	3.37
Maximum	2.74	9.55	1.57	2.24	7.85	11.21	18.00
Minimum	0.00	0.00	0.00	0.11	0.00	1.21	1.12
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest South Aspect (105-285°) n= 96.							
Average	1.20 (5.37)	2.27 (10.14)	0.56 (2.48)	0.65 (2.91)	1.41 (6.29)	2.61 (11.65)	6.09 (27.17)
S.D.	0.71	1.49	0.23	0.28	0.72	1.10	2.26
Maximum	3.81	7.40	1.23	1.46	3.36	5.38	12.09
Minimum	0.00	0.00	0.22	0.22	0.00	1.12	1.12
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest North Aspect (286-104°) n= 20							
Average	1.14 (5.08)	2.30 (10.24)	0.59 (2.65)	0.94 (4.18)	0.91 (4.08)	2.44 (10.90)	5.87 (26.17)
S.D.	0.84	3.03	0.32	0.48	0.50	0.88	3.66
Maximum	3.30	12.60	1.35	2.24	2.02	4.04	17.58
Minimum	0.16	0.00	0.22	0.22	0.00	1.12	2.83
Mid elevation 1982-2439m (6500-8000 ft) Pine, South Aspect (105-285°) n= 27							
Average	0.69 (3.08)	2.68 (11.95)	0.38 (1.69)	0.67 (2.98)	1.04 (4.64)	2.09 (9.31)	5.46 (24.34)
S.D.	0.47	2.18	0.25	0.48	0.58	1.26	2.97
Maximum	1.91	9.98	1.12	1.95	2.69	5.61	15.54
Minimum	0.20	0.29	0.11	0.11	0.34	0.67	1.88
Mid elevation 1982-2439m (6500-8000 ft) Sequoia, South Aspect (105-285°) n= 69							
Average	1.38 (6.14)	2.73 (12.19)	0.50 (2.22)	0.71 (3.16)	1.07 (4.76)	2.28 (10.16)	6.47 (28.85)
S.D.	0.81	1.90	0.26	0.36	0.68	1.18	2.86
Maximum	3.30	7.96	1.35	1.88	3.59	6.05	16.08
Minimum	0.17	0.00	0.11	0.11	0.00	1.12	1.77
Mid elevation 1982-2439m (6500-8000 ft) Sequoia, North Aspect (286-104°) n= 18							
Average	1.48 (6.58)	1.57 (7.00)	0.73 (3.26	0.86 (3.86)	1.16 (5.19)	2.83 (12.64)	5.79 (25.84)
S.D.	0.77	1.94	0.30	0.52	0.77	1.31	3.40
Maximum	3.79	6.14	1.41	2.09	3.23	6.73	12.62
Minimum	0.52	0.00	0.34	0.22	0.22	1.12	2.11
Low elevation < 1982m (6500 ft) Fir Forest, South Aspect (105-285°) n= 16							
Average	0.95 (4.20)	2.98 (13.30)	0.57 (2.60)	1.16 (5.20)	1.95 (8.70)	3.70 (16.50)	8.04 (35.80)
S.D.	0.90	2.75	0.18	0.36	1.77	1.97	4.30
Maximum	3.54	9.96	0.90	2.02	7.17	8.97	14.78
Minimum	0.22	0.00	0.22	0.67	0.00	1.12	1.35
Low elevation < 1982m (6500 ft) Fir Forest, North Aspect (286-104°) n = 27							
Average	1.16 (5.20)	2.45 (10.90)	0.63 (2.80)	0.98 (4.40)	1.48 (6.60)	3.08 (13.70)	6.69 (29.8)
S.D.	0.89	1.65	0.36	0.56	1.15	1.38	3.06
Maximum	3.05	7.69	1.35	2.24	4.48	6.73	15.31
Minimum	0.18	0.00	0.22	0.22	0.00	1.12	1.30
Low elevation < 1982m (6500 ft) Pine Forest, South Aspect (105-285°) n= 130							
Average	0.88 (3.92)	2.55 (11.39)	0.50 (2.24)	0.85 (3.81)	1.70 (7.60)	3.01 (13.41)	6.45 (28.76)
S.D.	0.73	2.19	0.33	0.57	1.08	1.68	3.23
Maximum	3.79	15.34	1.57	2.76	6.39	8.07	21.82
Minimum	0.00	0.00	0.11	0.11	0.22	0.45	1.08
Low elevation < 1982m (6500 ft) Pine Forest, North Aspect (286-104)°) n= 39							
Average	0.87 (3.88)	2.69 (11.98)	0.49 (2.21)	0.83 (3.68)	1.72 (7.68)	3.00 (13.39)	6.57 (29.29)
S.D.	0.74	2.15	0.32	0.53	1.10	1.64	3.13
Maximum	3.59	8.25	1.79	1.57	5.49	7.17	13.30
Minimum	0.07	0.00	0.17	0.22	0.00	0.67	0.70
Low elevation < 1982m (6500 ft) Sequoia Forest, South Aspect (105-285°) n= 6							
Average	1.72 (7.68)	3.08 (13.75)	0.62 (2.78)	0.86 (3.85)	2.23 (9.93)	3.75 (16.73)	8.56 (38.17)
S.D.	0.54	2.55	0.19	0.40	1.73	1.91	4.71
Maximum	2.44	7.15	0.94	1.35	4.48	6.28	15.87
Minimum	1.05	0.00	0.45	0.45	0.22	1.12	3.00
Low elevation < 1982m (6500 ft) Sequoia Forest, North Aspect (286-104)°) n= 11							
Average	1.17 (5.20)	2.33 (10.39)	0.73 (3.27)	1.08 (4.82)	1.24 (5.55)	3.04 (13.55)	6.53 (29.14)
S.D.	0.92	2.15	0.43	0.50	0.94	1.34	3.22
Maximum	3.36	5.78	1.79	2.02	3.36	5.38	11.19
Minimum	0.16	0.09	0.45	0.45	0.45	1.35	3.12

Appendix 3.16.2. Summarized forest stand information for fuel transect plots.

	Overstory Information						Height to Live Crown Base			
	BAF	# Trees	Basal Area (m ²/ha)	Canopy Code	Avg. Overstory DBH (cm)	Overstory Tree Ht. (m)	Overstory (m)	Intermediate (m)	Understory (m)	Brush %
High elevation > 2440m (8000 feet) Red Fir Forest South Aspect (105-285°) n= 75										
Avg	3.33	12.24	39.83	3.13	98.17	36.16	5.55	2.71	0.56	12.60
S.	0.47	5.79	17.45	0.93	24.51	7.99	3.48	2.63	0.85	19.44
Max	4.00	32.00	96.00	4.00	158.00	58.00	19.70	12.00	4.00	80.00
Min	3.00	3.00	12	1.00	37.10	23.6	0.40	0.00	0.00	0.00
High elevation > 2440m (8000 feet) Red Fir Forest North Aspect (286-104°) n= 87										
Avg	3.53	13.66	48.38	2.91	83.63	37.26	8.73	2.81	0.49	12.53
S.	0.50	5.42	20.80	0.94	24.13	8.98	5.04	1.73	0.47	24.46
Max	4.00	30.00	120.00	4.00	142.50	61.20	24.50	10.00	3.00	90.00
Min	3.00	4.00	15.00	1.00	24.40	14.00	1.40	0.30	0.00	0.00
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest South Aspect (105-285°) n= 96.										
Avg	3.00	13.22	39.66	3.57	86.29	42.18	9.58	1.95	0.54	7.40
S.	0.00	5.77	17.30	0.58	24.83	10.44	5.33	1.62	0.62	12.07
Max	3.00	40.00	120.00	4.00	166.50	69.60	25.40	10.00	5.00	60.00
Min	3.00	3.00	9.00	2.00	28.40	16.30	0.35	0.00	0.00	0.00
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest North Aspect (286-104°) n= 20										
Avg	3.30	11.55	37.25	3.70	78.27	38.92	10.54	5.40	1.32	6.35
S.D.	0.47	3.38	9.69	0.47	23.47	9.22	5.19	3.32	1.25	9.10
Max	4.00	18.00	54.00	4.00	125.8	54.90	21.40	15.00	5.00	30.00
Min	3.00	5.00	20.00	3.00	40.10	24.40	2.10	1.00	0.00	0.00
Mid elevation 1982-2439m (6500-8000 ft) Pine, South Aspect (105-285°) n= 27										
Avg	3.00	10.78	32.33	3.33	67.23	31.86	8.93	1.50	0.44	5.77
S.D.	0.00	4.31	12.93	0.55	21.21	11.21	5.64	0.94	0.42	10.65
Max	3.00	22.00	66.00	4.00	118.2	57.00	28.60	4.00	1.00	40.00
Min	3.00	3.00	9.00	2.00	21.2	6.00	1.00	0.00	0.00	0.00
Mid elevation 1982-2439m (6500-8000 ft) Sequoia, South Aspect (105-285°) n= 69										
Avg	3.03	12.43	37.43	3.39	100.92	47.88	9.52	2.49	0.65	7.55
S.D.	0.24	4.14	12.60	0.55	40.46	12.60	6.71	1.49	0.54	9.55
Max	4.00	22.00	66.00	4.00	303.1	79.00	32.10	7.00	3.00	30.00
Min	2.00	4.00	12.00	2.00	39.9	23.7	0.5	0.00	0.00	0.00
Mid elevation 1982-2439m (6500-8000 ft) Sequoia, North Aspect (286-104°) n= 18										
Avg	3.44	13.83	48.83	3.61	96.04	43.24	10.29	4.83	1.42	10.56
S.D.	0.70	5.02	23.16	0.61	53.50	15.57	4.44	2.61	0.79	25.83
Max	4.00	28.00	112.00	4.00	282.00	91.30	18.4	10.00	2.50	100.0
Min	2.00	7.00	20.00	2.00	48.9	22.90	1.6	1.00	0.00	0.00
Low elevation < 1982m (6500 ft) Fir Forest, South Aspect (105-285°) n= 16										
Avg	3.20	11.80	36.40	3.60	72.80	37.60	11.50	4.10	0.80	21.10
S.D.	0.40	5.80	16.80	0.60	24.30	11.00	7.10	1.40	0.80	20.90
Max	4.00	27.00	81.00	4.00	115.10	62.60	21.40	6.00	3.00	60.00
Min	3.00	3.00	12.00	2.00	29.00	17.40	2.10	1.00	0.00	0.00
Low elevation < 1982m (6500 ft) Fir Forest, North Aspect (286-104°) n = 27										
Avg	3.20	11.40	34.70	3.70	66.20	34.10	11.30	4.90	1.40	17.30
S.D.	0.40	5.10	15.50	0.60	15.20	7.10	5.50	2.90	2.00	20.40
Max	4.00	23.00	69.00	4.00	94.50	48.00	21.80	12.00	8.00	70.00
Min	3.00	3.00	11.00	2.00	34.30	20.50	0.70	1.50	0.00	0.00
Low elevation < 1982m (6500 ft) Pine Forest, South Aspect (105-285°) n= 130										
Avg	2.91	11.46	33.05	3.48	65.99	34.90	10.43	2.56	0.64	27.71
S.D.	0.42	4.80	14.67	0.63	22.62	12.19	5.51	1.40	0.57	33.53
Max	3.00	29.00	87.00	4.00	138.00	65.60	28.00	10.00	3.00	100.0
Min	1.00	1.00	3.00	1.00	11.60	8.40	0.95	0.50	0.00	0.00
Low elevation < 1982m (6500 ft) Pine Forest, North Aspect (286-104)°) n= 39										
Avg		11.52	33.54	3.52	65.23	35.31	10.61	2.76	0.68	25.23
S.D.	0.37	4.57	13.95	0.61	22.45	13.10	5.58	1.86	0.64	31.87
Max	3.00	19.00	57.00	4.00	103.00	94.00	24.60	14.00	4.00	85.00
Min	3.00	4.00	12.00	2.00	14.40	8.40	1.10	1.00	0.00	0.00
Low elevation < 1982m (6500 ft) Sequoia Forest, South Aspect (105-285°) n= 6										
Avg	3.00	12.00	36.00	3.50	95.12	39.47	10.85	5.17	0.46	14.17
S.D.	0.00	5.02	15.06	0.84	48.06	12.63	9.65	5.96	0.29	24.58
Max	3.00	17.00	51.00	4.00	155.8	57.1	22.80	15.00	1.00	60.00
Min	3.00	5.00	15.00	2.00	32.8	24.5	1.00	0.50	0.25	0.00
Low elevation < 1982m (6500 ft) Sequoia Forest, North Aspect (286-104)°) n= 11										
Avg	3.55	7.82	26.45	3.73	99.27	47.41	13.36	7.09	1.73	26.36
S.D.	0.52	2.71	11.78	0.47	40.21	8.67	6.25	4.98	1.37	33.02
Max	4.00	12.00	44.00	4.00	180.00	60.90	24.40	16.00	4.00	85.00
Min	3.00	4.00	4.00	3.00	54.2	34.00	5.30	0.50	0.25	0.00

Appendix 3.16.3. Summarized fuels data for permanent forest plots.

	Litter kg/m² (tons/acre)	Duff kg/m²	1 Hr. kg/m²	10 Hr. kg/m²	100 Hr. kg/m²	1000 Hr. kg/m²	Total Woody kg/m²	Total Fuels kg/m²
Low elevation < 1982m (6500 ft) Pine Forest, South Aspect (105-285°) n= 5								
Avg	0.92 (4.10)	4.51 (20.10)	0.18 (0.79)	0.42 (1.89)	0.89 (3.96)	11.22 (50.03)	12.71 (56.67)	18.24 (81.34)
Max	1.27	6.62	0.41	0.64	1.72	24.82	25.26	28.07
Min	0.72	2.01	0.02	0.14	0.50	0.77	3.61	11.61
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest, South Aspect (105-285°) n= 6								
Avg	1.98 (8.83)	4.48 (19.97)	0.17 (0.76)	0.50 (2.23)	0.69 (3.06)	3.27 (14.57)	4.62 (20.61)	11.08 (49.41)
Max	3.50	8.22	0.39	0.80	1.59	8.23	10.17	14.49
Min	1.11	2.73	0.07	0.10	0.31	0.29	1.11	8.76
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest, North Aspect (286-104°) n= 5								
Avg	3.35 (14.95)	6.68 (29.79)	0.22 (0.98)	0.53 (2.37)	0.56 (2.48)	3.23 (14.42)	4.54 (20.25)	14.57 (64.99)
Max	4.74	9.71	0.36	0.69	0.77	7.34	8.48	18.45
Min	2.60	5.39	0.12	0.35	0.24	0.50	2.16	10.14
Mid elevation 1982-2439m (6500-8000 ft) Pine Forest, South Aspect (105-285°) n= 4								
Avg	1.40 (6.25)	4.73 (21.10)	0.03 (0.12)	0.25 (1.12)	0.46 (2.06)	2.50 (11.18)	3.24 (14.47)	9.37 (41.79)
Max	1.71	6.35	0.10	0.42	0.78	6.06	5.29	10.88
Min	.79	3.97	0.00	0.12	0.08	0.77	1.19	6.80
Mid elevation 1982-2439m (6500-8000 ft) Pine Forest, North Aspect (286-104°) n= 2								
Avg	0.92 (4.12)	4.0 (17.86)	0.28 (1.25)	0.22 (1.00)	0.50 (2.25)	3.94 (17.57)	4.95 (22.08)	9.88 (44.05)
Max	0.93	4.24	0.37	0.24	0.92	6.89	7.38	12.06
Min	0.91	3.77	0.19	0.21	0.09	1.00	2.52	7.69
High elevation >2440m (8000 ft) Fir Forest, South Aspect (105-285°) n= 5								
Avg	1.56 (6.95)	4.65 (20.75)	0.19 (0.83)	0.63 (2.81)	0.32 (1.44)	7.8 (34.77)	8.94 (39.86)	15.15 (67.59)
Max	2.99	7.16	0.37	1.35	0.94	17.51	17.81	27.97
Min	0.97	2.88	0.07	0.08	0.00	0.08	2.08	6.39
High elevation >2440m (8000 ft) Fir Forest, North Aspect (286-104°) n= 5								
Avg	1.50 (6.71)	3.73 (16.63)	0.27 (1.19)	0.41 (1.83)	0.54 (2.40)	7.43 (33.12)	8.64 (38.53)	13.87 (61.87)
Max	2.04	7.20	0.43	0.68	1.07	15.61	16.35	25.02
Min	0.88	0.68	0.10	0.30	0.27	1.05	2.08	3.64

Appendix 3.16.4. Summarized forest stand information for permanent forest plots.

	Overstory Information					Height to Live Crown Base			
	BAF	# Trees	Basal Area (m^2/ha)	Canopy Code	Avg. Overstory DBH (cm)	Overstory Tree Ht. (m)	Overstory (m)	Intermediate (m)	Understory (m)
Low elevation < 1982m (6500 ft) Pine Forest, South Aspect (105-285°) n= 5									
Avg.	3.60	12.4	44.20	3.20	94.68	48.60	14.54	6.50	1.10
Max.	4.00	15.00	60.00	4.00	103.70	55.00	19.00	10.00	3.00
Min.	3.00	9.00	36.00	3.00	72.80	44.00	10.5	4.00	0.50
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest, South Aspect (105-285°) n= 6									
Avg.	4.00	13.58	54.33	3.67	89.32	41.63	15.40	5.33	0.50
Max.	4.00	15.50	62.00	4.00	109.00	52.50	22.70	10.00	1.00
Min.	4.00	10.00	40.00	3.00	50.40	32.90	4.40	3.00	0.00
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest, North Aspect (286-104°) n= 5									
Avg.	3.40	16.00	54.00	4.00	62.90	37.94	17.24	6.60	.90
Max.	4.00	19.00	68.00	4.00	80.00	47.50	27.00	10.00	1.50
Min.	3.00	13.00	42.00	4.00	55.30	31.90	10.30	5.00	0.50
Mid elevation 1982-2439m (6500-8000 ft) Pine Forest, South Aspect (105-285°) n= 4									
Avg.	4.00	13.75	55.00	3.25	65.78	33.58	7.73	2.88	0.50
Max.	4.00	20.00	80.00	4.00	80.30	48.80	13.40	4.00	0.50
Min.	4.00	9.00	38.00	3.00	54.50	26.20	3.90	2.00	0.50
Mid elevation 1982-2439m (6500-8000 ft) Pine Forest, North Aspect (286-104°) n= 2									
Avg.	3.50	15.00	53.00	3.50	75.25	44.55	16.85	6.00	0.50
Max.	4.00	16.00	64.00	4.00	77.20	53.00	16.90	8.00	0.50
Min.	3.00	14.00	42.00	3.00	73.30	36.10	16.80	4.00	0.50
High elevation >2440m (8000 ft) Fir Forest, South Aspect (105-285°) n= 5									
Avg.	4.00	16.20	64.80	2.80	97.82	39.22	8.18	3.30	0.50
Max.	4.00	24.00	96.00	4.00	143.0	53.50	15.00	4.00	0.50
Min.	4.00	11.00	44.00	1.00	40.70	24.50	2.60	2.50	0.50
High elevation >2440m (8000 ft) Fir Forest, North Aspect (286-104°) n= 5									
Avg.	3.60	15.20	60.20	3.00	74.40	42.38	9.26	4.00	1.00
Max.	4.00	20.00	80.00	4.00	88.50	47.20	18.10	7.00	2.00
Min.	3.00	8.00	32.00	2.00	60.80	36.40	4.00	1.50	0.50

3.17) Fire History

- Anthony Caprio, Science and Natural Resources Management, SEKI

Lead: A.C. Caprio, field help by A. Das, C. Dickard, V. Pile, G. Dempsey, K. Menning, and B. Sullivan

OBJECTIVES

Over the last three decades the parks' fire management program has evolved to where it now includes restoration of fire at a landscape scale. However, burning at such scales has raised a variety of new management and resource questions. These include an understanding pre-Euroamerican fire regimes at such large ecosystem scales. While fairly extensive fire history research, based on fire scars recorded in trees (**Fig. 3.17-1**), has been carried out in Sequoia and Kings Canyon National Parks (Kilgore and Taylor 1979; Pitcher 1987; Swetnam et al. 1992; Swetnam 1993; Caprio and Swetnam 1995) considerable gaps still remain in our knowledge and understanding at some levels (Caprio and Lineback in prep). For instance, we have limited information about past fire regimes at a scale that encompasses tens of thousands of acres and includes varying slope, aspect, vegetation type, and elevation. Local knowledge about past fire regimes from several common vegetation types is lacking. Acquiring this information would be of great value to managers when planning and reintroducing fire in park ecosystems and to ecologists interested in understanding dynamics of pre-Euroamerican plant and wildlife communities.

Figure 3.17-1. Example of dated fire scars from a giant sequoia snag-- intervals between fires generally varied from 15 to 30 years.

The goal of this data collection effort is to: 1) obtain information on the spatial extent of pre-Euroamerican fires on a watershed scale (fire size, spread patterns, and frequency variation), and 2) to acquire data on pre-Euroamerican fire regimes from the wide array of vegetation types within a watershed. This work will begin to reconstruct the spatial scale and pattern of pre-European settlement fire events from throughout the East Fork watershed and to provide information on past fire occurrence, frequencies, and size in a variety of habitats, vegetation types, and aspects in the drainage. These data will also provide additional and improved data on fire frequency regimes from a range of vegetation classes that are being used as input into fire/GIS analyses that are reconstructing past fire frequency regimes throughout the parks (Caprio and Lineback in prep). Reconstructing the large scale spatial pattern fire in the East Fork will help managers determine whether they are meeting management objectives in restoring fire as an ecosystem process and to develop improved burn plans.

Recently, computer models that look at surface fire regimes and forest patterns across elevation gradients in the southern Sierra Nevada have been developed (Miller 1998). They examine connectivity and spatial extent of fire over elevational gradients. The models also suggest differences in burn patterns/frequencies by aspect with these differences most notable between south and north slopes (Carol Miller personal communication). However, at this time little data exists 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 and as input for more rigorous parameterization to improve their predictive ability.

FIELD WORK AND DATA COLLECTION

Sampling during 1997 concentrated on burn segments scheduled to for ignition during 1997 and 1998 (Tar Gap [segment #10], Redwood [#4], and Lookout [#1]). Additional sites were also located in the Oriole Lake (#1), Atwell (#3), and Eden Grove (#11) segments in addition to the Milk Ranch area– an area outside the MKRRP boundaries but within the East Fork drainage (**Fig. 3.17-2**). Emphasis was placed on collecting sites in higher elevation conifer forest and on aspects, or vegetation types for which we have little information. Specimens are being dendrochronologically crossdated to determine precise calender years (**Fig. 3.17-3**) in which past fires occurred (Stokes 1980). Intra-annual position (or approximate season) of fire dates is also being determined when possible. Sample preparation and crossdating have been begun on samples from many sites with this work most advanced from sites collected during 1995 and 1996 on south aspects.

RESULTS and DISCUSSION - PRELIMINARY ANALYSIS

Over 160 specimens (logs, stumps, snags, or trees) were collected from 31 sites which supplements some 35 sites previously collected (Caprio 1997b). These collections have supplemented and added to previous work that was carried out in the watershed (Pitcher 1987; Swetnam et al.1992). Some vegetation types represented in these collections have not previously been sampled in the parks for fire history and will be a useful source for new information. These include Jeffery pine, lodgepole pine, and oak woodland while others such as red fir have only been sparsely sampled.

Patterns of past fire occurrence are beginning to emerge as more sites are collected and crossdated from a broad array of areas in the watershed. Dating of samples is most advanced for the area extending from the Redwood Creek to Atwell Creek areas on the north side of the drainage. Preliminary mapping of a few fire years supports the proposal that patterns of past fires over the landscape can be reconstructed to a certain degree (**Fig. 3.17-4** and **Fig. 3.17-5**). For example, the current map of the 1777 fire date shows a burn (or possibly more than one burn) with a fairly well defined burn area, based on those areas from which fire dates have been collected and dated. This preliminary mapping suggests the burn was primarily centered on the north side of the drainage in an area from Redwood Creek to above Atwell. However, the 1777 date was also recorded from the one site dated in the Oriole Lake drainage, suggesting the fire may have been more widespread than the current map indicates. Other fire dates showed different patterns. The current information for an1829 burn(s) shows that it occurred in both the main East Fork drainage and the Horse Creek drainage. Of interest were maps of the extent 1873 and 1875 burns (**Fig. 3.17-5**). The area of the 1873 burn that has currently been mapped shows that it burned in the central portion of the Atwell Grove while the map for the 1875 burn showed it burned predominantly to the east and west of this area. The maps show burns that appear to be somewhat mutually exclusive. Two potential hypothesis may explain this pattern. One is that fuels may have been sparse enough at two years postfire that a send burn was not able to carry through the area. The second, that the burn carried through the area but due to sparse fuel the burn was not hot enough to scar many trees. There is also an interesting historical footnote for the 1875 burn. While traveling through the Atwell area in 1875 John Muir made natural history observations about a fire that appears to be this 1875 burn (Muir 1878). He observed the fire burning intensely up-canyon through chaparral vegetation but with decreasing intensity once it entered the sequoia grove where fuel levels were low and consisted primarily of conifer needles.

The number of sites on the north aspect was increased substantially during 1997 during an eight

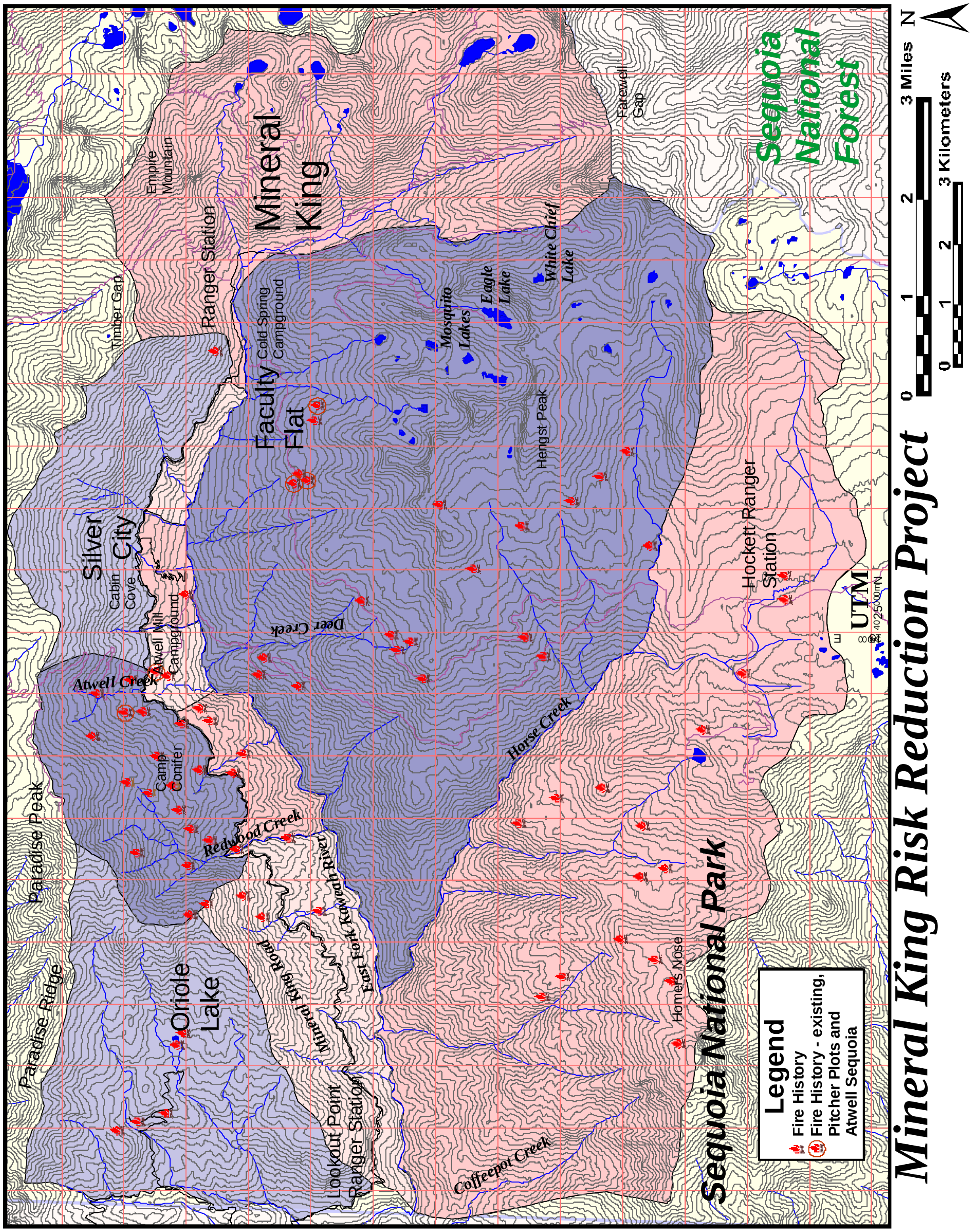


Figure 3.17-2. Fire history collection sites in the East Fork.

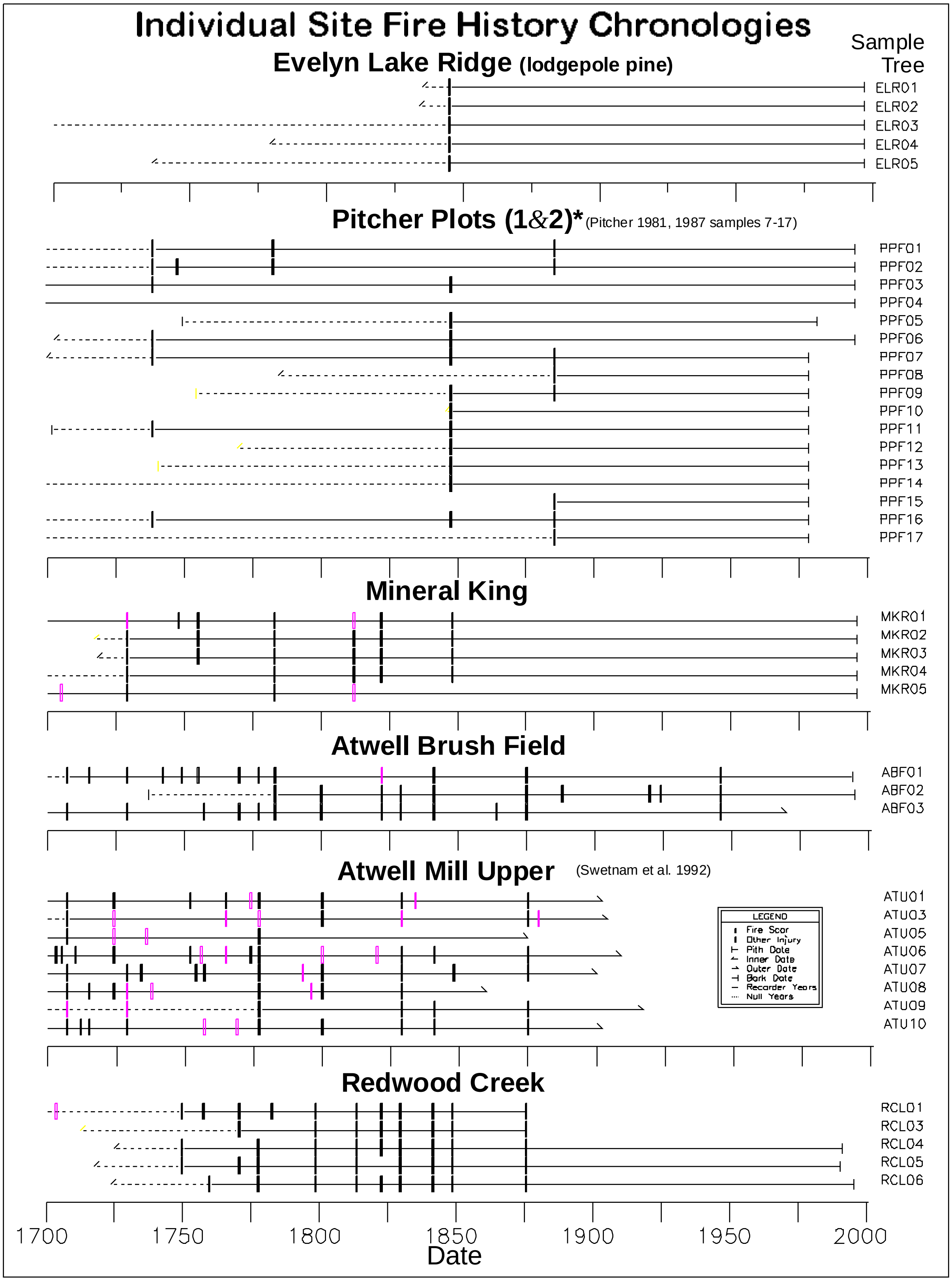
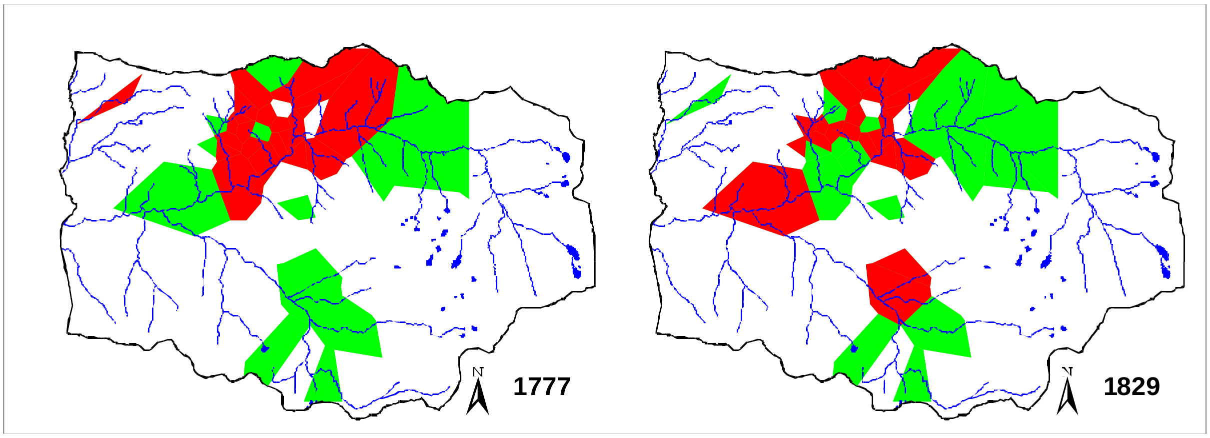


Figure 3.17-3. Examples of reconstructed fire history data from five sites in the East Fork drainage for the period from 1700 to the present. Sites illustrate varying pre-Euroamerican fire regimes from differing vegetation types and aspects in the watershed. Horizontal lines represent a particular sample (one tree) with vertical bars indicating crossdated fire dates.

Figure 3.17-4. Preliminary reconstruction of area burned by fires in 1777 and 1829 in the East Fork. Red color represents areas where samples have been dated with fires observed in the fire scar record during these two years and green color represents areas where samples have been dated and these fire dates have not been observed.



day trip into the Cahoon Meadow and Hockett Meadow areas, carried out in conjunction with sampling by Kurt Menning and his crew. Additional collections are planned for this aspect during 1998, however, because of the remoteness of some of these areas sampling density may be lower.

While the current information is encouraging a considerable number of additional sites are needed to improve the resolution and spatial accuracy of the reconstructed past burn areas. This will be somewhat dependant on available sample material in the field. This appears to vary by vegetation type and to be poorer at lower elevations and on north aspects in mid-to-low elevations (this may be why previous studies have not sampled such areas). However, it is important that fire history information be obtained from these areas to present a more unbiased picture of past fire regimes over the landscape. As the information from these samples is obtained it will greatly improve the resolution and spatial extent of our knowledge about fire from throughout the watershed. Data from some of these new collections have been used as input into a GIS/Fire model being developed for Sequoia and Kings Canyon National Parks (Caprio et al. 1997). As more data on fire dates are added from a larger portion of the watershed, more detailed analyses will be carried out.

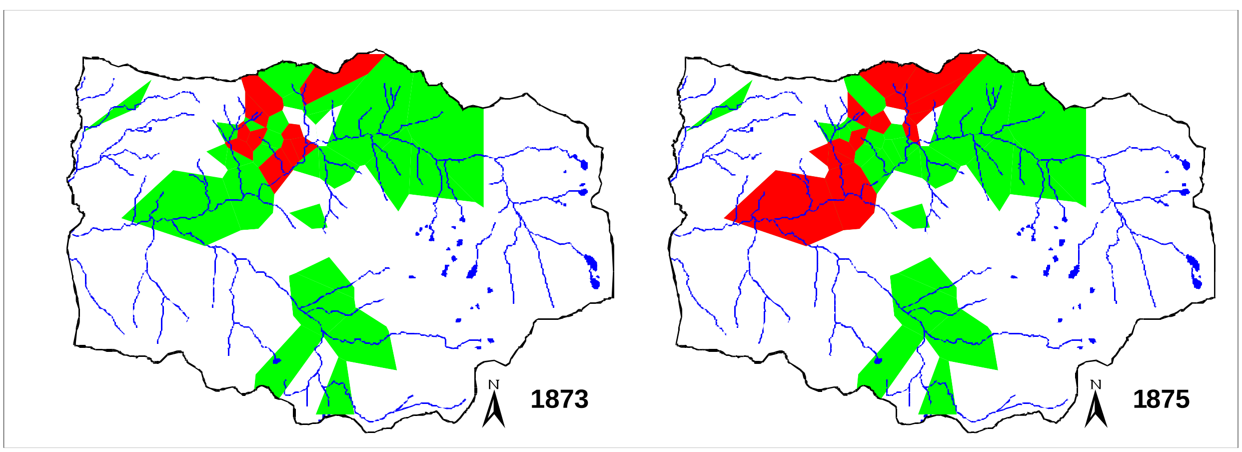


Figure 3.17-5. Preliminary reconstruction of area burned by fires in 1873 and 1875 in the East Fork. Red color represents areas where samples have been dated with fires observed in the fire scar record during these two years and green color represents areas where samples have been dated and these fire dates have not been observed.

PLANS FOR 1998

Sampling will continue during 1998, again concentrating on segments scheduled for burning during 1998 and 1999 and on locations having north aspects. Particular target areas include upper elevation red fir, lodgepole and western white pine forests, where some stand replacing burns may have occurred in the past. Sampling in the Oriole Lake drainage and Milk Ranch area will continue (approximately six additional sites) and should be completed during 1998. Permission from the BLM was obtained for collecting in the Milk Ranch area with the stipulation that they receive copies of the fire history data. This area will provide fire dates for lower portion of the East Fork drainage and is interesting because it is largely surrounded by chaparral vegetation and similarities or differences between fire dates from here and other portions East Fork may provide insights into fire source and spread patterns through what is now chaparral vegetation.

3.2 - Wildlife

3.21) Wildlife Monitoring - Science and Natural Resources Management, SEKI

Lead: H. Werner; field-crew members: T. Keesey, C. Ray, and C. Mustric (volunteer).

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 and their specificity to habitat structure and composition. In 1997, 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 and in Jeffrey pine forest. The 1,260 trapnights at the Atwell Plot produced 319 rodent captures. The deer mouse (***Peromyscus maniculatus***) was the most abundant postburn rodent at the Atwell Plot with an average population estimate of 33 individuals, similar to the first postburn year (36 individuals in 1996) and over twice as high as the preburn population (15 individuals in 1995). Other rodents included a few captures of the brush mouse (***Peromyscus boylii***) and northern flying squirrel (***Glaucomys sabrinus***). The brush mouse was only seen in the postburn sampling and the long-tailed vole (***Microtus longicaudus***) that was present in preburn sampling had disappeared. At the Jeffrey Plot, 1,500 trapnights produced 101 rodent captures with an average population of 19 individuals during the trapping period. Predominate preburn rodents were the deer mouse (***P. maniculatus***; 58% of individuals), brush mouse (***P. boylii***, 20% of individuals), and lodgepole chipmunk (***Tamias speciosus***, 13% of individuals). Other species present included the western flying squirrel (***G. sabrinus***, 7% of individuals), and bushy-tailed woodrat (***Neotoma cinerea***, 2% of individuals).

The Jeffrey Plot habitat was described. The tree density was estimated at 324 trees/ha with Jeffrey pine (***Pinus jeffreyi***) dominating frequency (59%) and basal area (80%). There was a significant presence of white fir (***Abies concolor***), black oak (***Quercus kelloggii***), and western juniper (***Juniperous occidentalis***). The shrub density was estimated at 922 stems/ha with green-leaf manzanita (***Arctostaphylos patula***) dominating the frequency (58%) and basal area (72%). The remainder of the diverse shrub understory was shared among nine species. Shrubs had a clumped distribution. The plot faced southwest at 2,340-2,380 m elevation. Side slopes varied from 21 to 35 degrees. Boulders and litter were common. Down logs were not common, and no surface water was present.

The Ponderosa Plot was photographed and mapped after being burned during the week of November 2, 1997.

Serendipity surveys were conducted at four areas in the East Fork Kaweah River (**Fig. 3.2-1**). In the unburned sequoia forest near Deadwood Creek, the captured species in descending order of capture abundance were the deer mouse (***Peromyscus maniculatus***) and long-tailed vole (***M. longicaudus***). Captures here helped substantiate that rodent population changes at the Atwell Plot were in fact caused by fire. In descending order of capture abundance, the rocky Jeffrey pine forest was inhabited by the deer mouse (***P. maniculatus***), brush mouse (***P. boylii***), and lodgepole chipmunk (***T. speciosus***). This site's fauna resembled the adjacent Jeffrey Plot even though the habitat was structurally different. The red fir forest was inhabited by the deer mouse (***P. maniculatus***), long-tailed vole (***M. longicaudus***) and lodgepole chipmunk (***T. speciosus***). Serendipity trapping in the Monarch area was done in an alpine/subalpine site containing eleven different habitats. The six species of rodents (deer mouse, ***P. maniculatus***; brush mouse, ***P. boylii***; long-tailed vole, ***M. longicaudus***; golden-mantled ground squirrel, ***Spermophilus lateralis***; alpine chipmunk, ***Tamias alpinus***; and bushy-tailed woodrat, ***N. cinerea***)

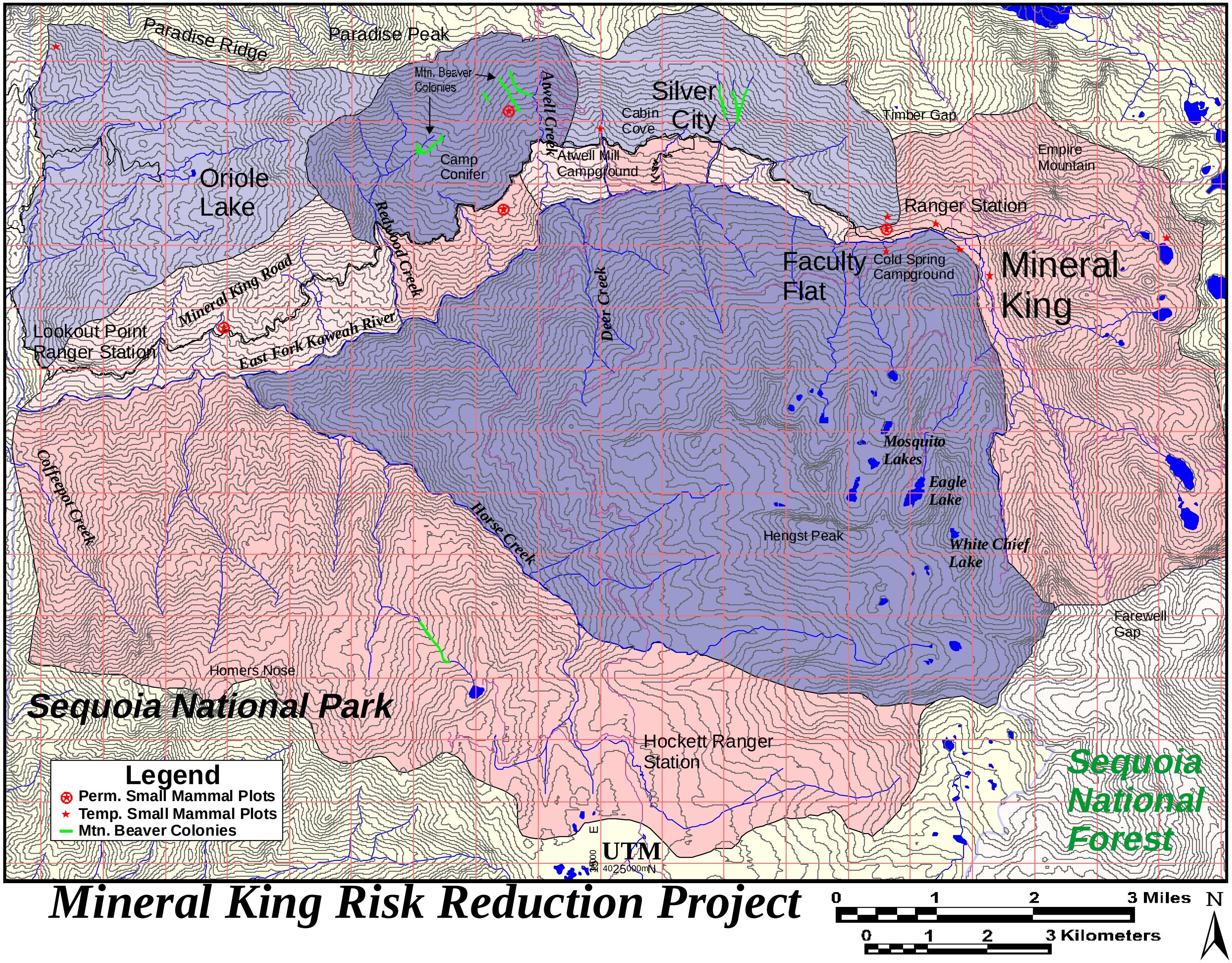


Figure 3.2-1. Location of small mammal live trapping sites and location of mountain beaver colonies.

showed considerable habitat specificity, except for the deer mouse which is a generalist. Two non-rodents captured included pica, ***Ochotona princeps***, and an unidentified shrew, ***Sorex*** sp.

Serendipity trapping of mid-sized mammals found ringtail (***Bassariscus astutus***) and pine martin (***Martes americanus***) in sequoia forest. A yellow-bellied marmot (***Marmota flaviventris***) was captured in red fir forest.

There was one-year-postburn serendipity trapping within the perimeter of the 1996 Kaweah Wildfire. The predominant species in the burned chamise chaparral was the western pocket mouse **(*Chaetodipus californicus***). Other species included deer mouse (***P. maniculatus*)**, brush mouse (***P. boylii***), and pinion mouse (***P. truei***). The California mouse (***P. californicus***) did not appear in the one-year postburn collection even though it was one of the frequent immediate-postburn captures. Likewise, it was not collected in the riparian site and dropped in capture frequency in the blue oak woodland. Chamise areas with the least cover remained the most depauperate. The burned riparian habitat increased in capture activity compared to last year. It was predominately western pocket mouse (***C. californicus***), but also acquired a new postburn species, the western harvest mouse (***Reithrodontomys megalotus***). The burned blue oak woodland had less capture activity than last year, and the dusky-footed woodrat (***Neotoma fuscipes***) was not found in 1997. The western pocket mouse (***C. californicus*)** dominated the sampling. Other species included the brush mouse (***P. boylii***), deer mouse *(**P. maniculatus***), and California mouse (***P. californicus***).

Mountain beaver (***Aplodontia rufa***) continue to occupy the east fork of Redwood Creek following the burn in 1995. Mountain beaver were also found near the Atwell Plot and along streams in the Evelyn Lake area.

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 second 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 ***P. 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) 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 providing methodologies. 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 tools 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 birds and insects. Both of the these groups are represented by large numbers of species, but their documentation requires more observer skill and larger plots for 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.

Two one-hectare permanent long-term monitoring plots were surveyed. The Atwell Plot was located in a mature sequoia forest in Atwell Gr ove with plot center at UTM coordinates 4037.147 northing and 349.506 easting. The Jeffrey Plot was located in Jeffrey pine forest with plot center at UTM coordinates 4035.456 northing and 355.264 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) normally within one meter of each station stake. The traps were normally run four nights per week. The Atwell Plot was run for a total of 21 nights from June 3 through July 19, 1997 (1,260 trapnights). The Jeffrey Plot was run for a total of 25 nights from August 27 through October 17, 1997 (1,500 trapnights). The traps were baited with a dry mixture of rolled oats and peanut butter. A high-low thermometer was located in the Atwell 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 at four sites in the Mineral King drainage: unburned sequoia forest near Deadwood Creek at UTM coordinates 4036.9 northing, 350.9 easting (180 trapnights), a rocky area in a Jeffrey pine forest at UTM coordinates 4035.5 northing, 355.3 easting (150 trapnights), red fir forest (40 trapnights), and at eleven vegetation types within the Monarch Lake area (Table 3.21-1). In addition, serendipity trapping was done at five sites in the Kaweah Fire in the drainage of the main stem of the Kaweah River. These habitats

Table 3.2-1. Location of trapping efforts by habitat in the Monarch area.

Vegetation Type	Approximate Centroid for Trapping		Trap-nights
	UTMN	UTME	
alpine prairie, dry graminoid (HAG)	4035.8	359.5	30
alpine prairie, heather (SAH)	4035.6	359.9	54
alpine prairie, mixed prairie (HMA)	4035.8	359.5	69
alpine prairie, dwarf shrub (SAD)	4035.8	359.1	33
alpine wet meadow, graminoid (HAW)	4035.4	359.6	66
alpine wet meadow, willow (SWS)	4035.4	359.6	27
sparse alpine, fell field (HAF)	4035.4	359.8	70
sparse alpine, rock outcrop (BRS)	4035.6	359.9	53
sparse alpine, scree (BTB)	4035.9	359.3	54
subalpine forest, foxtail, grassy (FFG)	4035.2	359.2	80
subalpine forest, foxtail, sparse (FFB)	4036.0	359.2	88

included chamise burned by a high intensity headfire and little rock (UTM coordinates 4040.6 northing, 333.2 easting; 84 trapnights), chamise burned by high-intensity headfire and much rock (UTM coordinates 4040.7 northing, 333.5 easting; 70 trapnights), chamise burned by medium-intensity fire (UTM coordinates 4040.6 northing, 333.4 easting; 35 trapnights), a riparian area in which all leaves and twigs were consumed by fire (UTM coordinates 4040.6 northing, 333.2 easting; 35 trap-nights), and burned blue oak wood-land (UTM coordinates 4040.2 northing, 334.2 easting; 56 trap-nights). Sherman live traps were scattered loosely through these sites at approximately 15 m intervals (not measured). Serendipity sites were surveyed from July 7 through November 4, 1997 for a total of 994 trapnights in Mineral King drainage and 280 trapnights on the Kaweah Fire. 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. All serendi-pity site coordinates need to be verified with a GPS.

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 through October, 1997. It amounted to 49 trapnights. This trapping included sequoia grove (28 trapnights), mixed conifer forest (3 trapnights), Jeffrey pine (14 trapnights), and red fir forest (4 trapnights).

Vegetation density was determined using T-square procedures as described in Krebs (1989). The station stakes were used for random points making the procedure systematic. The same plots surveyed for density were used to characterize the species composition and size. Trees were measured at breast height and shrubs at ground level. Only living stems >1 cm diameter at point measured were surveyed.

RESULTS and DISCUSSION

Permanent Plots:

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

Twenty-one nights of trapping (1,260 trap nights) produced 319 rodent captures (81 different individuals). The mean population estimate during the survey period was 34 individuals (95% CI = 30-39 individuals). This was twice as high as the preburn sampling and is similar to 1996 postburn population estimates (Werner 1996, 1997). The population estimates for 1997 are almost identical to the previous year (**Fig. 3.2-2**). Ninety-six percent of the individuals (98% of the captures) were ***Peromyscus maniculatus*** (mean plot population = 33 individuals, 95% CI = 28-37 individuals). Two percent of the individuals (2% of the captures) were ***Glaucomys sabrinus***. One ***P. boylii*** was captured (1% of the individuals, 0.3% of the captures). Captures of non-rodents included two ***Sorex trowbridgii***. There were several changes in species captured between the preburn sampling in 1995 and the two years of postburn sampling in 1996 and 1997. ***P. boylii*** was only captured in the postburn sampling, and ***Microtus longicaudus*** was only captured in the preburn sampling.

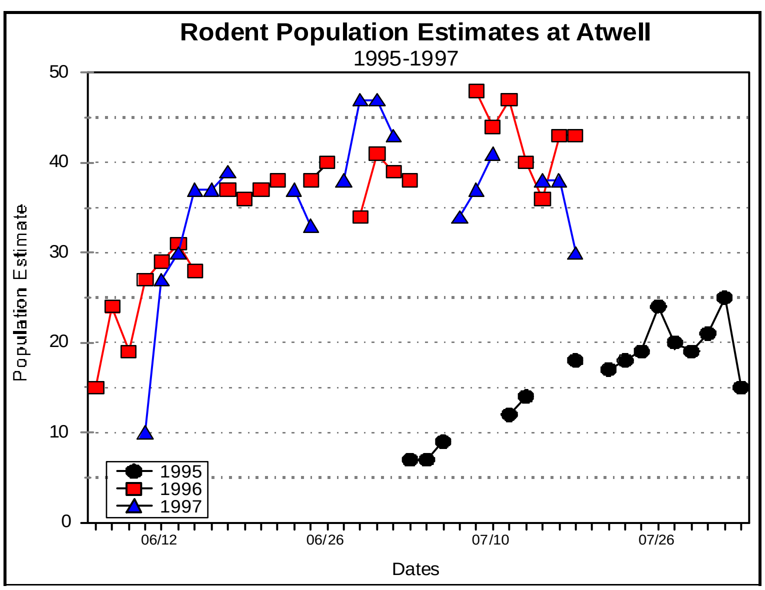


Figure 3.2-2. Comparison of population estimates at the Atwell Plot before the burn and during two postburn years.

Both of these species were relatively scarce. ***M. longicaudus*** was usually associated with wetland vegetation, which was limited to a small perennial seep near the center of the plot. After the burn, wetland vegetation seemed smaller and more isolated.

Catch rates for the three rodent species were 0.248, 0.005, and 0.0007 cap-tures/ trapnight for ***P. maniculatus***, ***G. sabrinus***, and ***P. boylii***, respectively. Like the mean population size, the catch rate for ***P. maniculatus*** doubled during the postburn sampling from 0.133 captures/trapnight preburn to 0.248 captures/trapnight postburn.

The sex ratios for the sampled population of ***P. maniculatus*** were about equal for the individuals sampled (♀ = 53%, ♂ = 47%, n=78) and for total captures (♀ = 51%, ♂ = 49%, n=312). The ***P. boylii*** captured was male, and the two ***G. sabrinus*** were both female.

Eighty-two percent of the ***P. maniculatus*** captured were adults (88% in 1996). Only adults were captured for the other species. Overall, the estimated population, catch rates, sex ratios, and age are very similar to the first postburn year.

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 density of trees was estimated at 324 trees/ha (95% CI = 270-408 trees/ha). While ***Pinus jeffreyi*** dominated the site both numerically and in basal area, ***Abies concolor, Quercus kelloggii***, and ***Juniperus occidentalis*** were common. By descending order of dominance,

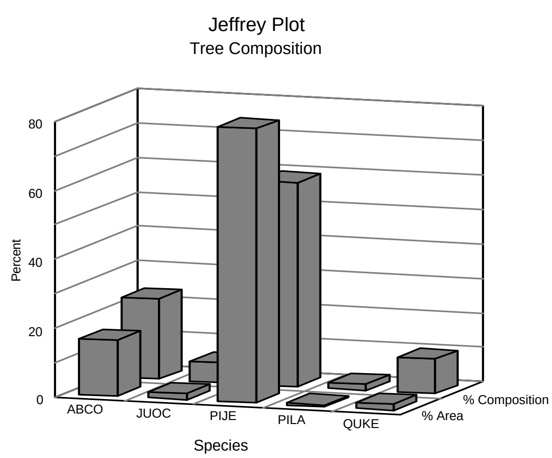


Figure 3.2-3. Tree composition at the Jeffrey Plot in 1997.

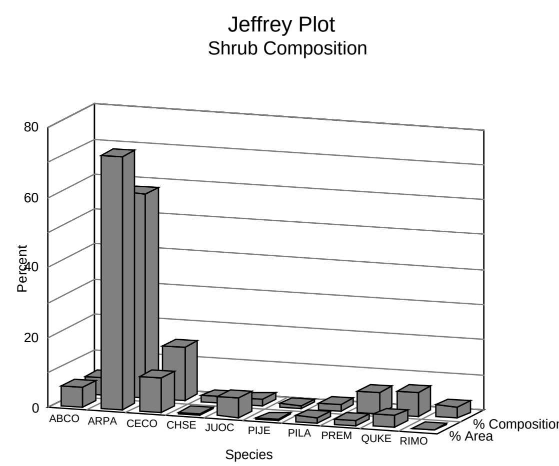


Figure 3.2-4. Shrub composition at the Jeffrey Plot during 1997.

the trees were predominately ***P. jeffreyi*** (59.2% composition, 79.7% area), ***A. concolor*** (23.3% composition, 16.2% area), ***Q. kelloggii*** (10.0% composition, 1.8% area), ***J. occidentalis*** (5.8% composition, 1.8% area), and ***P. lambertiana*** (1.7% composition, 0.5% area; **Fig. 3.2-3**). The density of shrubs in the understory was estimated at 922 stems/ha (95% CI = 522-3,912 stems/ha). Over half of the shrub understory was ***Arctostaphylos patula*** (58.3% composition, 72.3% basal area). In descending order of frequency, other species included ***Ceanothus cordulatus*** (15.0% composition, 9.8% basal area), ***Q. kelloggii*** (6.7% composition, 3.4% basal area), ***Prunus emarginata*** (5.8% composition, 1.2% basal area), *Abies concolor* (5.0% composition., 5.6% basal area), ***Ribes montigenum*** (3.3% composition., 0.3% basal area), ***J. occidentalis*** (1.7% composition, 5.6% basal area), ***P. lambertiana*** (1.7% composition, 1.5% area), ***Chrysolepis sempervirens*** (1.7% composition., 0.4% basal area), and ***P. jeffreyi*** (0.8% composition, 0.1% basal area; **Fig. 3.2-4**). The distribution of understory shrubs was aggregated (Hines' Test: H(T) = 7.881, P<0.001).

The plot faced southwest at 2,340-2,380 m elevation. Side slopes varied from 21 to 35 degrees (mean = 27^{o}). The plot was dissected by several gullies that might occasionally serve as ephemeral drainages under unusually wet conditions (**Fig. 3.2-5**). While large boulders are scattered throughout the plot, there are only a few major rock outcrops. Fine fuels form a thick mat over the soil in most areas, but large logs are sparse compared to other plots in this study. Grasses and other herbaceous vegetation were largely inconspicuous. There was no evidence of recent fire though there was ample fuel. The presence of junipers, a fire-intolerant species, suggests that it has not burned for a while. Empirically, the site appears to be a homogeneous stand of ***P. jeffreyi*** being invaded by ***J. occidentalis*** and ***A. concolor.***

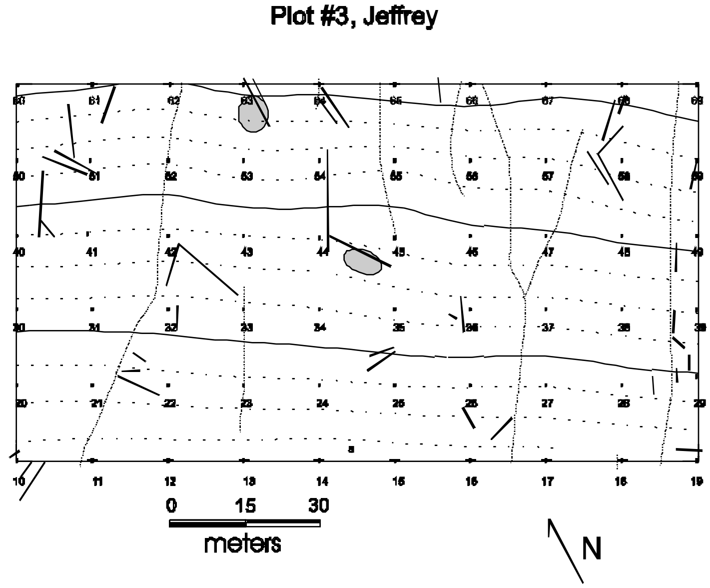


Figure 3.2-5. Jeffrey Plot. Horizontal lines represent contour intervals. The circular areas are major rock outcrops. Vertical lines are drainages or gullies.

Twenty-five nights of trapping (1,500 trapnights) produced 101 rodent captures (45 individuals). The mean population estimate during the survey period was 19 individuals (95% CI = 17-22 individuals; **Fig. 3.2-6**). ***Peromyscus maniculatus*** dominated the sampled rodent population with 58 percent of the individuals (67% of the captures). Of intermediate capture abundance were ***P. boylii*** (20% of individuals, 15% of captures) and ***Tamias speciosus*** (13% of individuals, 12% of captures). The least frequently encountered were ***G. sabrinus*** (7% of the individuals, 5% of the captures) and ***Neotoma cinerea*** (2% of the individuals, 1% of the captures). Captures of non-rodents included three *Sorex* sp.

Catch rates for the five species of rodents were 0.045 captures/trapnight for ***P. maniculatus***, 0.010 captures/trapnight for ***P. boylii***, 0.008 captures/trapnight for ***T. speciosus***, and 0.003 captures/trapnight for ***G. sabrinus***, and 0.0007 captures/trapnight for ***N. cinerea***. Catch rates were considerably less than reported the previous year (Werner 1997) doing serendipity trapping in the same forest type. This site differed from the 1996 site in having a denser and more homogeneous canopy, and there was a conspicuous lack of grasses and other herbaceous vegetation that could provide seeds or other food. Few cones were observed either in the trees or on the ground. Trap disturbance by ***Ursus americanus*** (and possibly other animals) also hindered trapping efficacy.

The sex ratios for the sampled population were predominately male. Seventy-three percent (n=24) of the ***P. maniculatus*** were male (71% of captures, n=66), and all of the *T. speciosus* were male (6 individuals, 10 captures). Two of the three ***G. sabrinus*** were male, and the single capture of a *N. cinerea* was male. Only ***P. boylii*** showed any balance with 56% of the individuals (n=9) being female (64% of captures, n=14).

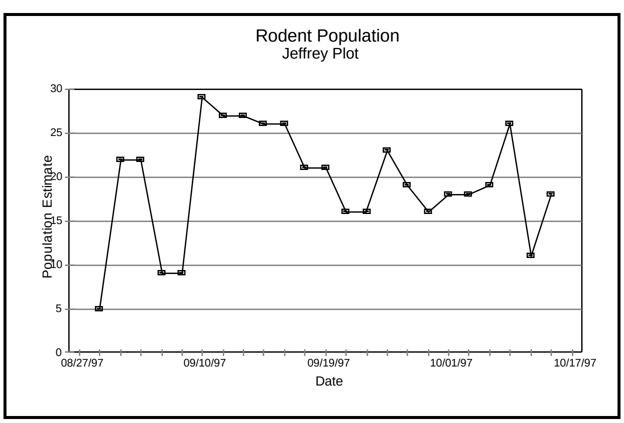


Figure 3.2-6. Population estimates for all rodent species at the Jeffrey Plot during surveys, August 27 through October 17, 1997.

Most of the rodents captured were adults. This includes 94% of the *P. maniculatus* and all of the ***T. speciosus, G. sabrinus***, and ***N. cinerea***. Only ***P. boylii***, the species with a balanced sex ratio, had a large percentage of subadults, 29% (n = 14).

Ponderosa Plot: The Ponderosa plot burned during the week of November 2, 1997. It was too late in the year for postburn trapping due to cold, moist conditions; but downed logs were mapped and postburn photographs were taken. In general, the plot burned very hot. Most trees were either leafless or scorched to the top. The understory had become very open. The ridge in the center of the plot was one of the few areas

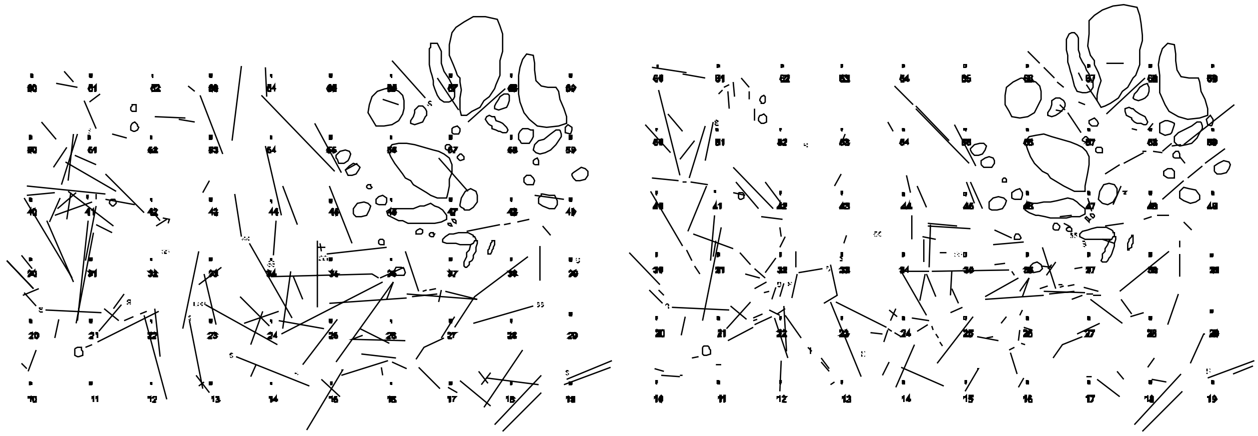


Figure 3.2-7. Down logs in the Ponderosa Plot prior to burning (left side; 1996) and postburn (right side; 1997). Circular images are large rocks.

where green tree tops were visible. It was the only place where any of the surface fuels remained unburned. The unburned fuels were estimated at about a square dekameter of ***Chamaebatia foliolosa*** that was not consumed because of an anthropogenic firebreak caused by an old abandoned trail that crossed the north side of the plot. Of the 60 trap stations within the plot, 56 (93%) were completely consumed, 3 (5%) were partially consumed due to sparse fuel, and one (2%) was in the unburned area described above. Unlike other combustible components of the landscape, heavy logs showed little loss, and they seemed to be almost as abundant after the burn as during the preburn trapping (**Fig. 3.2-7**). Most stumps seemed to burn well with consumption extending underground along the large roots.

Serendipity Surveys:

Deadwood Creek: This site was in unburned sequoia forest. The site was selected to compare trap success in an unburned sequoia forest with the existing burned sequoia forest at the Atwell Plot. The site was at about 2,000 m elevation and west of Deadwood Creek. In descending order of capture abundance, the site produced *P. maniculatus* (0.061captures/trapnight), ***Microtus longicaudus*** (0.051 captures/trapnight), and one non-rodent, ***Sorex*** sp. These results resembled the preburn condition in the Atwell plot in that ***M. longicaudus*** was present and trap success was low compared to the postburn Atwell trap success (0.248 captures/trapnight for ***P. maniculatus***). The catch rate for ***P. maniculatus*** at Deadwood Creek was less than half the preburn catch rate for ***P. maniculatus*** (0.133 captures/trapnight) at the Atwell Plot. ***M. longicaudus*** had a higher catch rate at Deadwood Creek than in the preburn condition at the Atwell plot (0.010 captures/trapnight). This was probably due to the Deadwood site being near more riparian habitat than in the Atwell area. While the sites were not completely comparable, the captures at Deadwood Creek support the proposition that the population increase at the Atwell plot was a consequence of the last burn there.

The cause of the increased postburn catch rates at Atwell remains a mystery, but I propose several theories for further exploration: 1) Increased productivity from enhanced food supply, either more of it or better quality; 2) Decreased predation, either less predators present or less efficient predation; 3) Physiological reproductive response triggered by fire; 4) Increased immigration to trap bait in plot due to lack of food outside plot; or 5) Coincidental event caused by influences unrelated to fire. This serendipity site provides some evidence by which to dismiss the last theory. The second seems unlikely since fire tends to reduce availability of cover for prey. However this can work both ways since fire also reduces ambush cover for some predators. Some combination of the remaining three (theories 1, 3, and 4) seems most likely.

Monarch: The Monarch trapping was done in a diverse area in which eleven vegetation types were sampled. Elevations ranged from about 3,100 to 3,200 m, and side slopes were generally steep (estimated 20^{o}-30^{o}). The drainage faced west.

Table 3.2-2. Summary of rodents captured in the Monarch serendipity trapping area in 1997.

Vegetation Type	Species Captures/Trapnight						
	MILO*	**NECI***	**PEBO***	**PEMA***	**SPLA***	**TAAL***	**ALL**
alpine prairie, dry graminoid	0.067			0.267			0.333
alpine prairie, heather				0.074		0.056	0.130
alpine prairie, mixed prairie	0.087	0.029		0.087	0.087		0.290
alpine prairie, dwarf shrub				0.303		0.061	0.364
alpine wet meadow, graminoid	0.242						0.242
alpine wet meadow, willow	0.222						0.222
sparse alpine, fell field				0.186			0.186
sparse alpine, rock outcrop				0.226		0.019	0.245
sparse alpine, scree				0.111			0.111
subalpine forest, foxtail, grassy			0.013	0.063	0.013	0.200	0.288
subalpine forest, foxtail, sparse				0.011		0.011	0.023

* MILO = ***Microtus longicaudus***, NECI = ***Neotoma cinerea***, PEBO = ***Peromyscus boylii***, PEMA = ***Peromyscus maniculatus***, SOLA = ***Spermophilus lateralis***, TAAL = ***Tamias alpinus***

The rodents in the Monarch (**Table 3.2-2**) area showed considerable vegetation type specificity, with the exception *P. maniculatus*, a generalist, which was found in all vegetation types except for the wet meadows. Capture rates were relatively high compared to other trapping done in this drainage. Biodiversity was also good. Three of the habitats had four species of small rodents. One of the most interesting sites was foxtail pine. Without grass in the understory, foxtail pine was depauperate and had the lowest catch rate in the Monarch area. With grass, foxtail was one of the most diverse sites in the Monarch area with over twelve times the catch rate of sites without grass. Only the grassy site had sufficient fuel to carry a fire. Fifty-five percent of the captures in the Monarch area were recaptures. Non-rodent captures included four ***Ochotona princeps*** (0.074 captures/trapnight) and two unidentified (to date) ***Sorex*** spp. (0.037 captures/trapnight).

Jeffrey Rock: This site was established to compare the rodent species of a very open, rocky area to the rodent fauna of the Jeffrey Plot. The site was mostly exposed and fissured granite with little vegetation and steep side slopes (estimated about 30º) facing southwest. The elevation was about 2,400 m. The predominate species captured were ***P. maniculatus*** (0.073 captures/trapnight), ***P. boylii*** (0.033 captures/trapnight), and ***T. speciosus*** (0.020 captures/trapnight). These capture rates were significantly higher (P=0.047) than for the same species in the Jeffrey Plot. Forty-two percent of the individuals (n=12) and 53% of the captures (n=19) were rodents from the adjacent Jeffrey Plot. The ***Peromyscus*** found at both places only occurred on the northern (adjacent) edge of the Jeffrey Plot suggesting home ranges that spanned both areas. Two of the three ***Tamias*** found in the Jeffrey Rock Site were captured in the southern part of the Jeffrey Plot. Thirty-seven percent of the captures at the Jeffrey Rock Site (n=19) were recaptures (Note: First captures of marked Jeffrey Plot rodents at the Jeffrey Rock Site were not counted as recaptures at the Jeffrey Rock Site.). The incombustible rocky areas appear to support fauna “similar to” (in species composition - not necessarily similar numerically) and partially “shared with” the combustible portions of the Jeffrey pine forest.

Red Fir: The site was on a heavily forested north aspect estimated at about 2,300 m elevation and about 20º slope. The vegetation was predominately ***Abies grandiflora*** and appeared homogeneous. A small stream was present. Nineteen captures representing four species of small rodents were found at the Red Fir Site from only 40 trapnights. The captures were predominately ***P. maniculatus*** (0.250 captures/trapnight), but also included ***M. longicaudus*** (0.075 captures/trapnight), ***G. sabrinus*** (0.075 captures/trapnight), and ***T. speciosus*** (0.075 captures/trapnight). As part of a separate trapping effort using larger traps, one ***Marmota flaviventris*** (0.250 captures/trapnight, n=4) was captured. Only four (21%) of the captures were recaptures. The preliminary data suggested that the site was rich numerically and in biodiversity.

Mid-sized Mammals: Twenty-eight trapnights produced five ***Bassariscus astutus*** (0.179 captures/ trapnight) and one ***Martes americana*** (0.036 captures/trapnight) in sequoia forest. Three trapnights in mixed conifer forest and fourteen trapnights in Jeffrey pine forest produced no captures. Four trapnights in red fir forest produced one ***M. flaviventris*** discussed above.

Table 3.2-3. Summary of rodent capture success following the Kaweah Fire. Within each box, the first number describes results form trapping in 1996, immediately postburn. The second value is capture data for 1997.

Site Description	Species Capture Rate (captures/trapnight)						
	CHCA	**NEFU**	**PEBO**	**PECA**	**PEMA**	**PETR**	**REME**
chamise, complete consumption, few rocks (1996 TN* = 94; 1997 TN = 84)	0.021 0.036				0 0.036		
chamise, complete consumption, very rocky (1996 TN = 63; 1997 TN = 70)	0.175 0.271		0.032 0.114	0.079 0		0 0.014	
chamise, poor consumption of stems (1996 TN = 38; 1997 TN = 35)	0.132 0.200			0.026 0	0.053 0.057	0.026 0	
foothill riparian, high consumption (1996 TN* = 38; 1997 TN = 35)	0.026 0.314			0.026 0			0 0.057
blue oak woodland, consumption good (1996 TN* = 36; 1997 TN = 56)	0.083 0.196	0.028 0	0.194 0.036	0.111 0.018	0.056 0.036		

* TN = trap nights

Kaweah Fire: One-year-postburn data on the Kaweah Fire is summarized in **Table 3.2-3.** The table provides for a comparison with trap results immediately following the fire. The most conspicuous change was the increase in ***Chaetodipus californicus*** at all sites, and the addition of ***Reithrodontomys megalotus*** in the burned riparian area. ***Neotoma fuscipes*** was captured in blue oak woodland immediately after the fire but not captured anywhere in 1997. After a year, ***Peromyscus californicus*** were captured at fewer locations and at lower capture rates than immediately after the burn. During the year, ***P. boylii*** captures decreased dramatically in the blue oak woodland, but increased greatly in the rocky area of chamise burned by high intensity fire.

Mountain Beaver:

The mountain beaver (***Aplodontia rufa)*** colony on the east fork of Redwood Creek continued to show evidence of an active population. Additional activity was observed near the Atwell Plot along the creek that is east of the plot (Ray and Keesey, pers. comm.) ***Aplodontia rufa*** evidence was seen along a creek that drains Evelyn Lake (Caprio and Ray, pers. comm.). This is the most southern known population in the Park.

PLANS FOR 1998

1. Conduct post-burn survey of the Atwell Plot and Ponderosa Plots.
2. Conduct serendipity surveys in Oriole Lake and/or Hockett areas.
3. Visit burned ***Aplodontia rufa*** colonies and record observations that may be fire related.
4. Continue development of guide to wildlife fire environments.
5. Continue postburn sampling of the Kaweah Fire if time permits.
6. Examine literature regarding fire and predation.

ACKNOWLEDGMENTS

This work was possible because of funding from the National Interagency Fire Center. Catherine Ray and Timothy Keesey did the majority of the trapping. The project got strong support from two volunteers. Crystal Mustric frequently assisted with the trapping, and Lori Werner transcribed most of the data sheets to the computer.

3.3 - Watershed Studies

Several watershed related studies are ongoing in the East Fork drainage. In 1995 the Sequoia-Kings Canyon Field Station (USGS-BRD) began an evaluation of the effects of prescribed fire on stream chemistry, and hydrology. An additional study was also initiate by UC Davis to identify macro-invertebrate populations and assemblages in selected streams. The East Fork and six tributaries, located on the north side of the East Fork and Mineral King Road, were chosen to study the effects of fire on stream chemistry, hydrology and aquatic biota (**Fig. 3.3-1**).

MANAGEMENT IMPLICATION OF WATERSHED STUDIES

The report for the Sierra Nevada Ecosystem Project (SNEP 1996) states that "aquatic/riparian systems are the most altered and impaired habitats of the Sierra". According to the report, 64% of the aquatic habitat throughout the Sierra Nevada is declining in quality and abundance. Small streams and springs are more affected by adjacent land use and receive lower standards of protection than do larger streams. These streams are particularly vulnerable to impacts from grazing and other permanent land disturbance such as development and road construction, which lead to increased sediment delivery to these streams. They are also affected by both the presence or absence of fire.

Sequoia and Kings Canyon National Parks with a high level of land protection is not threatened by many of these factors. As a result, small watersheds in these parks can serve as a laboratory for learning about the dynamics and functioning of fragile systems in a largely natural settings. This information will be important in understanding our watersheds and for other land management agencies that are interested in restoring small watersheds.

However, many Sierran ecosystems have been severely altered by a century of reduced fire frequency (Kilgore and Taylor 1979; Pitcher 1987; Swetnam et al. 1992; Caprio and Swetnam 1995; SNEP 1996). This has resulted in unnaturally heavy fuel buildups and more homogeneous forests, which have almost certainly altered the riparian stream corridors that drain those forests. These changes have severely impacted many ecosystems within Sequoia and Kings Canyon National Parks. While it is not

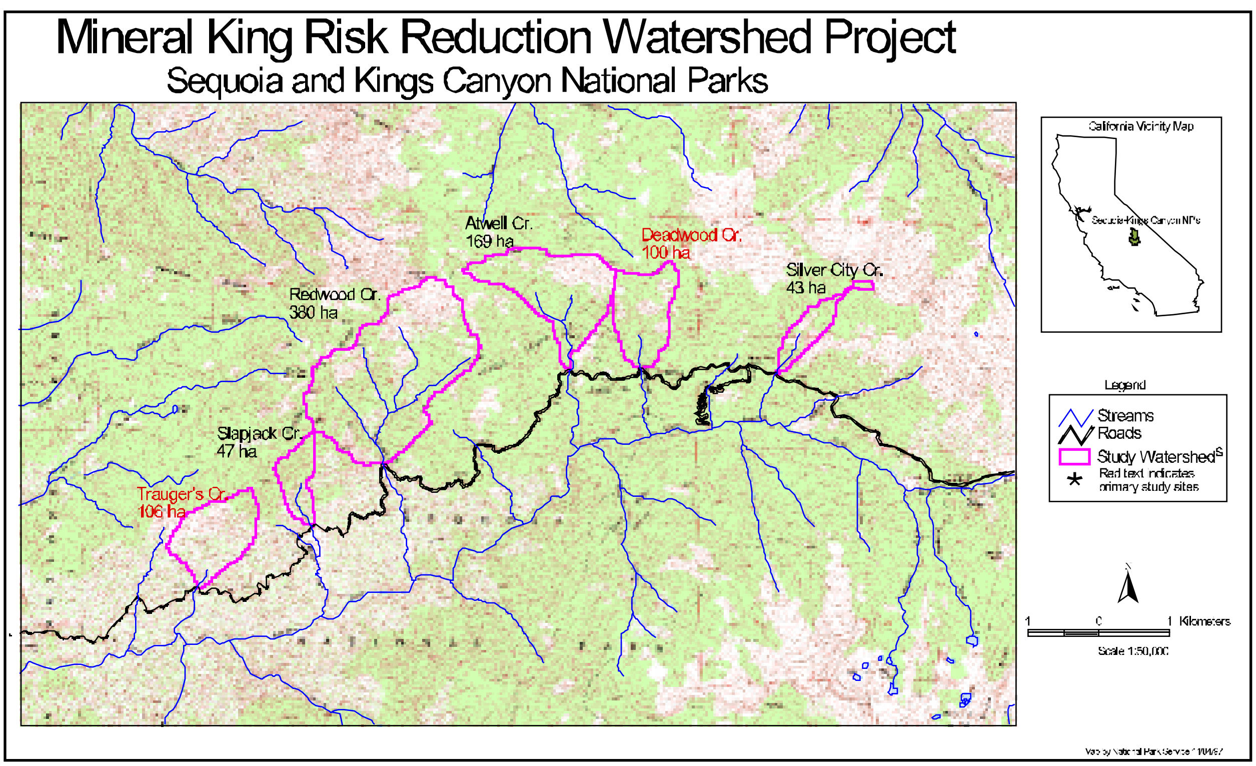


Figure 3.3-1. Tributaries of the East Fork used in the watershed studies.

possible to know what the stream chemistry and hydrology patterns were like 100 years ago, changes in the riparian corridor such as an increase in large woody debris in streams, a reduction in sediment pulses due to fire suppression, changes in snowmelt and evapotranspiration patterns, and the shading of the streams, have resulted in changes in stream dynamics over the last century. This study will also provide insight on how fire suppression influenced these watersheds. Preburn hydrochemsitry and hydrology results will provide a benchmark with which to measure the fluctuation of stream chemistry and discharge in postfire conditions.

Aquatic invertebrates, a key component of aquatic ecosystems, can be used to monitor the impacts of change in watersheds when spatial and temporal are also considered (Erman 1996). The aquatic macro-invertebrate research along the East Fork of the Kaweah River near Mineral King will determine the spacial and temporal distribution of aquatic species and assemblages. The results of this study will provide information on inter- and intra-stream variability in species diversity and abundance in undisturbed small order streams in the Sierra. Additionally, the results will enhance our understanding of the impacts of prescribed fire on the structure of macro-invertebrate communities in the Sierra once the drainages are burned. While prefire surveys of aquatic invertebrate communities provide a baseline for monitoring and developing a catalog of information on the parks' biological resources, post-fire long-term research will track the response and recovery time of communities to prescribed fire while supplementing biological inventory.

3.31) Watershed: Stream Chemistry and Hydrology

- Claudette Moore, Biological Resources Division of the USGS

Lead: C. Moore, A. Esperanza, D. Graber (NPS), Crew: A. Huber

As part of the MKRRP, the Sequoia-Kings Canyon Field Station (USGS-BRD) initiated a watershed study in 1995 to evaluate the effects of prescribed fire on stream chemistry, hydrology and aquatic macro-invertebrate communities. We are monitored ten 1st and 2nd order streams on the north side of the East Fork Kaweah River as a pilot study during the summer of 1995. Two primary streams and four secondary streams were then selected for long-term monitoring, which includes discharge measurements, solute analyses.

OBJECTIVES

One objective of the East Fork Watershed project are to evaluate the effects of prescribed fire on the hydrology, hydrochemistry and sediment transport of first order streams. Specifically, the study will quantify solute inputs for each watershed using wet deposition data from the NADP and CARB collection sites. Solute exports will be quantified using stream discharge and periodic chemical samples.

A second objective is to evaluate the effects of fire on the East Fork watershed as a whole. Solute exports will be determined from East Fork stream samples collected at Lookout Point and discharge measurements collected by Southern California Edison below Lookout Point. Solute inputs will be determined using wet deposition data from the NADP and CARB collection sites. The Mineral King burn project provides the opportunity to evaluate fire effects on watersheds at two scales - large (ca. 21,000 ha) and small (ca. 100 ha). Previous research has mainly focused on small (<100 ha) watersheds.

The third objective is to compare the effects of fire in the Deadwood watershed with the observations made from the Log Meadow prescribe fire project– located in Giant Forest, Sequoia National Park– in which paired watersheds (Log and Tharp's) were monitored. Geomorphology and stream characteristics in the East Fork watershed are different from those in the Log Meadow watershed. These differences will allow us to generalize our characterization of response to fire and compare responses in watersheds with different landscape features. Preliminary stream studies in Yellowstone (Minshall and Robinson, 1992) show that slope and stream order affect how fire affects streams. Continued monitoring in the East Fork will allow us to make a comparatively evaluation of recovery rates of parameters such as nitrogen and sulfur constituents, pH, and alkalinity.

EAST FORK SITE DESCRIPTIONS

Trauger's Creek and Deadwood Creek are the primary focus for the stream chemistry and hydrology study. Both tributaries are first order perennial streams. Their riparian areas are distinctly different as they are separated by an elevation difference of approximately 600 meters.

1. **Trauger's Creek** is a low elevation (1400 m) watershed (106 ha) with mixed chaparral/oak-woodland in a transition zone between the lower mixed-conifer zone and the upper chamise-chaparral zone. Dominant species include California live oak (***Quercus*** spp.), incense cedar (***Calocedrus decurrens***), maple (***Acer macrophyllum***), California laurel (***Umbellularia californica***), spicebush (***Calycanthus occidentalis***), and willow (***Salix*** spp.). Precipitation is measured by a tipping bucket at Lookout Point, two miles west of the study and is operated by the National Park Service.

2. **Deadwood Creek** is a mixed-conifer forest (2000 m) watershed (100 ha) characterized by white fir (***Abies concolor***), red fir (***Abies magnifica***), giant sequoia (***Sequoiadendron giganteum***), and incense cedar (***C. decurrens***). Precipitation measurements for this site are recorded at the Atwell Mill stables, approximately one mile west, by the Army Corps of Engineers.

Both streams are equipped with stilling wells, constructed of 10 inch diameter PVC pipe, that enclose two pressure transducers and a thermistor at each site. Stage and temperature data are recorded every five minutes on Omnidata portable data loggers. The data loggers were installed in February 1996. Weekly chemical samples are collected from each stream. Stream sampling commenced in May 1995. Weekly grab samples are also collected from the East Fork at Lookout Point and discharge data are collected by Southern California Edison below Lookout Point.

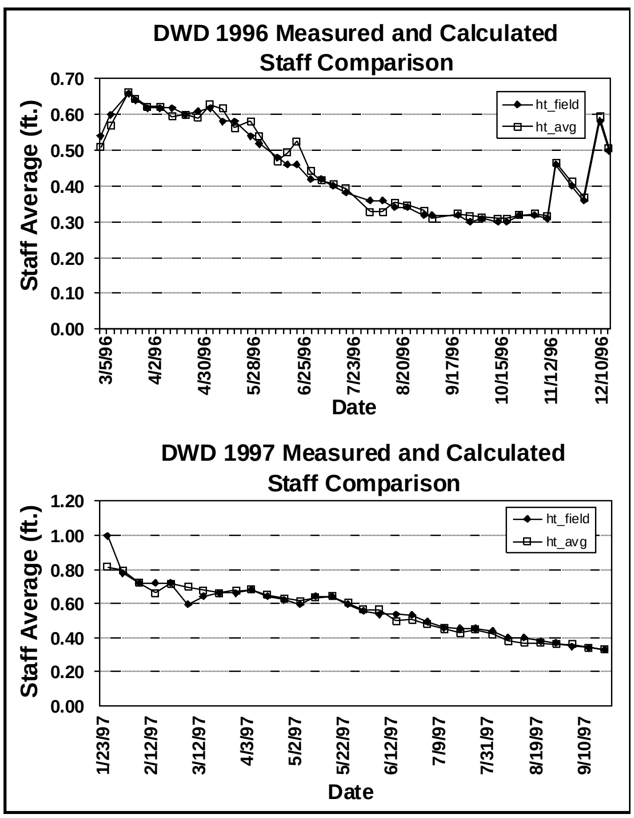


Figure 3.31-2a. Comparison of measured and calculated staff values at Deadwood Creek for WY 96 and WY 97.

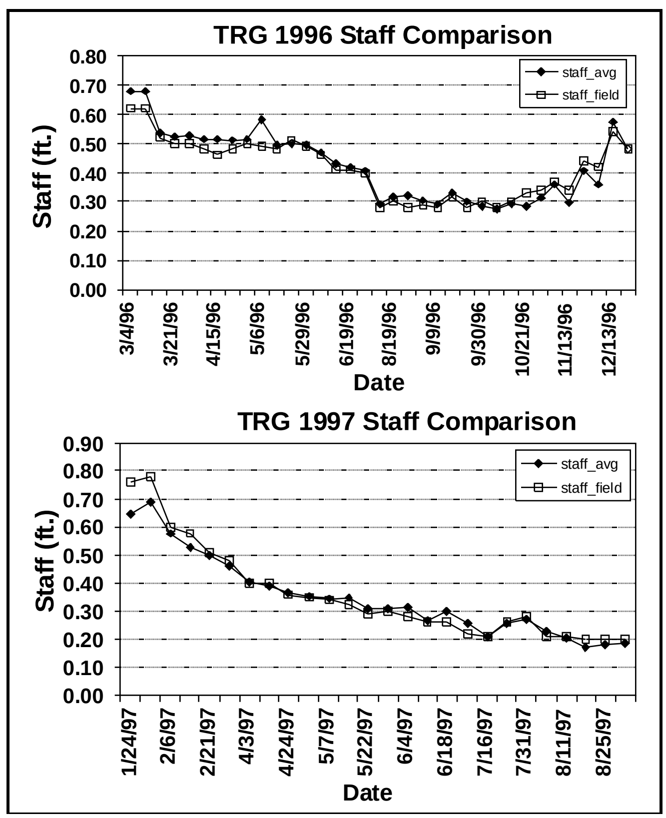


Figure 3.31-2b. Comparison of measured and calculated staff values at Trauger's Creek for WY 96 and WY 97.

Stream chemistry and discharge data were also collected from four secondary stream sites (Slapjack, Redwood, Atwell and Silver City) used in the macro-invertebrate study (see section 3.32) on a rotational basis. Sampling ended at these streams in October, 1997.

CURRENT STATUS

Preliminary data analysis was initiated for pre-burn hydrochemistry and discharge data from the Trauger's and Deadwood watersheds. The discussion below is based on data from wateryear 1996.

Hydrology

Discharge data were calculated from salt dilution and pressure transducer data. Two regression equations were required to make these calculations. First, a regression was derived using the pressure transducer data and corresponding measured staff heights. This equation produced a very good fit, r^2 of 0.93 and 0.91 for Deadwood (DWD) and Trauger's (TRG), respectively. Transducer data were converted to staff data, and a comparison of measured staff values and calculated staff values was made for each creek for 1996 and 1997 (**Fig. 3.31-2a** and **Fig. 3.31-2b**). The average calculated values were derived from an average of transducer 1 and 2. There was better correlation in 1997 between the measured and calculated staff heights because we had fewer problems with the data loggers, however both years showed good correlation. The measured staff heights were recorded weekly in most instances.

The second part of the discharge calculation involved developing a regression equation from the salt dilution (SD) data. The DWD stream rating curve was based on 12 salt dilution measurements ranging from staff heights of 0.35' to 0.65'. The TRG rating curve was based on 16 readings with staff heights ranging from 0.20' to 1.32'. These rating curves produced r^2 values of 0.78 and 0.89, respectively. These were preliminary rating curves, as more salt dilution data are needed during high flow periods.

The discharge measurements from TRG and DWD were used to determine runoff coefficients (the ratio of runoff to precipitation) for water year 1996 (**Fig. 3.31-3**). The DWD ratio of 0.90 was an overestimated. Generally, coefficients were in the range of 60-70 percent for small forested watersheds (Williams 1997, Melack et. al., 1998). The ratio for Trauger's Creek was 0.62. For comparison, the Log Creek runoff coefficient for water year 1996 is included. This is the control watershed in the Log Meadow study area.

More salt dilution data points and improved technique will enable us to produce more refined and accurate stream rating curves for these streams. Additional calculations using the culverts at each site will also be used to determine discharge, and will be correlated with the salt dilution results to refine the regression equation.

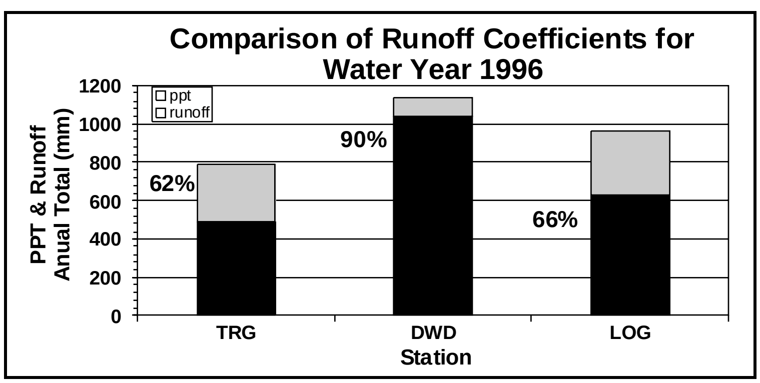


Figure 3.31-3. Runoff coefficients for Trauger's, Deadwood and Log Creeks for Water Year 1996.

Hydrochemistry

Solute data were summarized by watershed for Trauger's and Deadwood for water year 1996 (**Table 3.31-3**). More years of data are needed to fully describe the variability and range of solute concentrations in these watersheds. Vegetation and elevation differences were likely contributing factors to the differences in stream chemistry between these sites. The watersheds showed similar temporal responses to shifts in flow, pH and ANC when compared with other Sierran watersheds (Black 1994; Melack and Sickman 1995).

Table 3.31-3. Summary of Trauger's and Deadwood Creeks solute outputs in kg/ha/yr for Water Year 1996.

Site	H^+	NH_4^+	Na^+	K^+	Ca^{2+}	Mg^{2+}	ANC	SiO_2	PO_4^{3-}	NO_3^-	SO_4^{2-}	Cl^-
TRG	0.00	0.00	46.55	6.43	26.77	4.24	182.32	59.24	0.10	0.00	2.32	5.27
DWD	0.00	0.00	49.32	12.32	59.68	11.54	86.30	84.96	0.05	0.01	3.56	3.81

Stream temperature values were reviewed for the available data for water year 1996 for Deadwood and Trauger's Creeks, along with the highest recorded temperatures (**Fig. 3.31-4a** and **Fig. 3.31-4b**). There were some gaps in the Trauger's data set due to equipment failure in the summer of 1996, however, the trend is evident. Winter and fall temperatures were less variable and range between 5°C to 8°C in Deadwood, and 6°C to 14°C in Trauger's Creek. Stream temperature peaked in June at Deadwood, with an average of 13.5°C and a max of 16°C. While the fall and winter stream temperatures varied by >1°C, summer temperatures varied more than 4°C. Monthly stream temperatures in August at Trauger's Creek also varied more than 7°C and had 6 days with temperatures exceeding 20°C.

These baseline stream temperatures will be important in assessing postfire impacts on these streams. Since many aquatic biota have upper stream temperature limits, additional information on insolation collected as part of the macro-invertebrate study (Erman et al. 1996), will provide additional insight for determining how changes in canopy cover along the stream corridor affect stream temperature.

GOALS FOR 1998

The plans for 1998 are to continue collecting pre-burn hydrochemistry and discharge data at Trauger's and Deadwood Creeks, and in the East Fork. Additional samples are also being collected during storms to capture variability in solute concentrations during high flows. This will increase accuracy in determining annual loads in these watersheds. Additional time will also be spent fine tuning

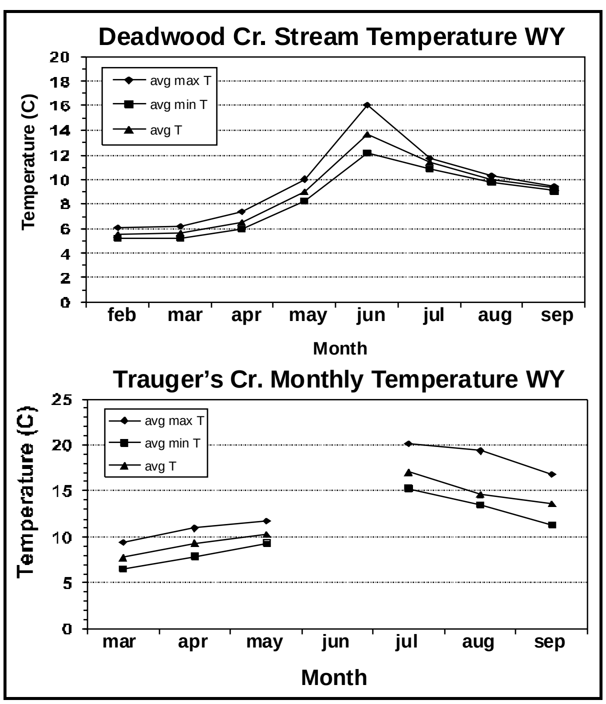


Figure 3.31-4a. Comparison of stream temperatures at Deadwood Creek (top) and Trauger's Creek (bottom) for WY 1996.

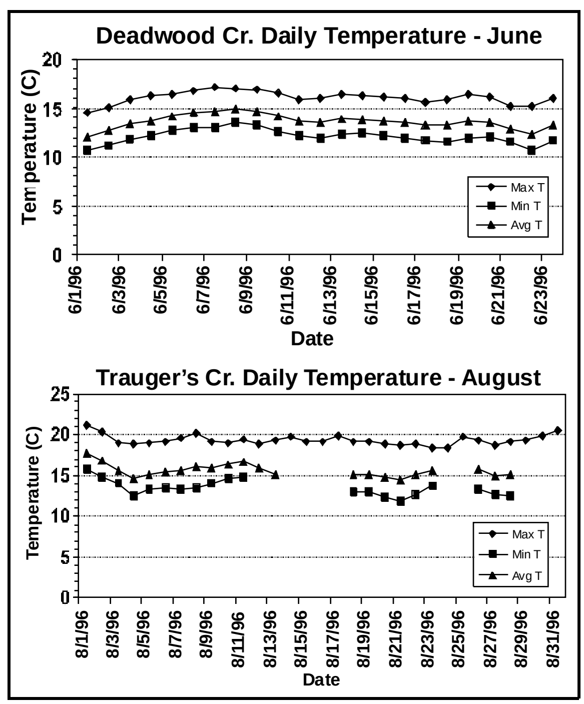


Figure 3.31-4b. Comparison of daily stream temperatures at Deadwood Creek (top) during June 1996 and Trauger's Creek (bottom) during August 1996.

the rating curves for Trauger's and Deadwood Creeks with additional high flow salt dilution measurements. Data analyses will continue and preburn solute ranges during low flow and high periods will be determined.

We are also very interested in conducting a sediment project in conjunction with the on going physical and biological research. We have established contacts to pursue a sediment project and hope to have a proposal and budget for research this year.

3.32) Watershed: Macro-invertebrate Study

- Ian Chan, Graduate Research Assistant, Department of Wildlife, Fish, and Conservation Biology at University of California, Davis under the direction of Dr Don C. Erman and Dr. Nancy A. Erman.

Summarized from 1997 annual report by D. Erman, N. Erman, and I. Chan (Erman et al. 1997)

INTRODUCTION

Watershed monitoring is necessary for ecosystem-scale management, and baseline and reference information are essential to this objective. Understanding the variability in natural systems, and then how management practices affect physical and biological resources, provide knowledge of ecosystem function and improve management choices. Biological monitoring of headwater ecosystems is an important component of understanding linkages between hillslope and instream processes. As such it represents an indispensable tool for watershed management. Information such as population size, species richness, or community diversity provide an better biological picture of the larger ecosystem. This study examines aquatic macro-invertebrate communities of tributaries of the East Fork of the Kaweah River as part of the monitoring efforts to assess the impacts of large scale prescribed burning. Such information allows consideration of the status of aquatic biota in management processes that determine the fate of aquatic habitats.

Aquatic habitats are one of the most altered and threatened biotic communities in California (SNEP 1996) with small freshwater habitats among the most understudied and undervalued aquatic resources. These habitats are often overlooked when considering watercourse protection, in spite of the fact that unique and rare species frequently occur only in these areas (Erman 1996). Headwater and low order streams are transitional zones between terrestrial and aquatic ecosystems (Naiman and Decamps 1990) and biological monitoring is an important part of understanding linkages between hillslope and instream processes within these streams. Gregory et al. (1987) state, "The landscape and biotic communities of terrestrial and aquatic ecosystems are intricately linked, and effective management must acknowledge and incorporate such complexity."

Fire is a integral ingredient of the complexity of aquatic habitats in many locations, affecting physical and biological characteristics (Tiedemann et al. 1979; Schindler et al. 1980; Minshall et al. 1989). Most studies on the impact of fire on these habitats have been from the perspective of wildfire. Wildfire impacts on streams may cause short-term and long-term effects. Short term impacts may include sudden increases in temperature, deposition of wood ash, changes in pH, increases in ionic composition and nutrients, and possibly increased sedimentation if watershed conditions promote erosion (Johnson and Needham 1966; Schindler et al. 1980; Amaranthus et al 1989; Spittler 1989). Long-term changes may include reductions in canopy, loss of large near-stream or instream woody debris, reduction in wood recruitment, and changes in flow (Roby 1989; Amaranthus et al. 1989; Nasseri 1989). Limited research on macroinvertebrate communities has shown the potential for both short and long-term effects (Albin 1979; Roby 1989) with these communities acting as sensitive indicators of the impacts of fire.

This study utilizes the opportunity to make before-after comparisons in combination with treatment-reference comparisons to provide conclusions about aquatic community responses and recovery. The multi-year scope of the prescribed fire operations will allow treatment-reference pairing of adjacent burned and unburned streams within target burn areas. Specific objectives of the study are to:

- Provide biological and physical resource data to compliment the stream hydrology and chemistry data necessary to assess the affects of fire on small streams.

- Begin a basic biological inventory of macroinvertebrates.

- Develop biological and physical sampling methodology for small bedrock streams.

• Determine the degree of natural similarity required between control and impact sites to learn what parameters make streams suitable for treatment-reference pairing in the Sierra.

STUDY AREA

Six first and second order tributaries in the northern portion of the East Fork drainage were studied– Trauger's, Slapjack, Redwood, Atwell, Deadwood, and Silver City Creeks (**Fig. 3.3-1**). Study reaches were located within the Lookout (segment #1), Atwell grove (segment #3), and Purple Haze (segment #7) burn segments. Portions of only the Redwood and Atwell Creek drainages have been burned (fall 1995) to date. All streams were small, high gradient, headwater tributaries with channels largely dominated by bedrock (granite) outcrops. Longitudinal profiles were typically sequences of cascades, plunge pools, and short riffles at pool ends. Where substrate was not bedrock, sediments were fine granite gravels and sands, with abundant allochthonous material in depositional areas. Streams were relatively well-shaded by a canopy of mixed conifers or mixed oak/chaparral and a variety of riparian vegetation along stream corridors.

METHODS

Benthic macroinvertebrates were collected from three habitat types: pools, riffles, and slickrock substrate (**Fig. 3.32-1**). Standard sampling methods, designed for larger freestone rivers, were modified or replaced for these habitats. Data was also collected on channel substrate, solar radiation along each study reach, and large woody debris (≥10 cm and ≥1 m length).

CURRENT STATUS

All field work has been completed and data analysis is in progress for publication. Field work was conducted from September 1995 through November 1997. This knowledge about the distribution and abundance of macro-invertebrates in pre-burn conditions will aid park managers in understanding both real and potential impacts resulting from fire on aquatic communities, an important but poorly studied ecosystem. The information will allow stronger conclusions about the types of responses and recovery can be expected in these habitats. Postfire sampling plans are being developed to continue this project.

Figure 3.32-1. Pyramidal trap used for sampling macroinvertabrates. Trap is placed within stream.

3.4 - Prescribed Fire Cost-Effectiveness Project

- Colorado State University

Lead: P. Omi, and D. Rideout.

Objectives: The overall role of SEKI in this project is to provide a case study location for conducting a problem analysis on a Department of the Interior (DOI) unit using an aggressive hazard fuels and prescribed fire management program. This will facilitate the development of an experimental cost-effectiveness system and simulation process using SEKI information inputs. The role of SEKI resources and research in this process is to provide resource related background information, various types of data, and GIS information, etc. to the analysis. Other operational input information and project documentation will be provided by the Fire Management Office (FMO).

Data: Information provided to the cost-effectiveness project to date has centered on GIS data, ARC/INFO coverages for various attributes of the East Fork watershed, remote sensing and various type of map data, and information databases associated with the area. Additionally, fuels data are being provided to help drive the NPS FARSITE model simulations that will eventually be a product of the prescribed fire cost-effectiveness project.

3.5 - Data Coordinator

- Anthony Caprio, Science and Natural Resources Management, SEKI

The data coordinator has made contacts with and organized meetings with a number of graduate students about possible research locations and topics for graduate research projects. Three graduate students began research projects within the East Fork watershed during 1996. One new graduate student project was initiated in the watershed during the summer of 1997.

Analysis of Red Fir Forest Regeneration and Fire: D. Newburn, UC Berkeley. Masters thesis project.

The data coordinator provided coordination between FMO, PIO, and field crews. Help was also provided to field crews when needed and suggestions on sampling locations or procedures were made. A continuing effort is being made to locate and document past resource or research information, data, or plots sites within the East Fork drainage and obtain or document the location of the data for these sites. Considerable time has been spent in reviewing and analyzing data from various MKRRP projects, summarizing activities of all projects, and producing an annual report. Information and graphics have been developed and provided to the Public Information Office, Superintendents Office, Interpretive Division, and Fire Management Office about resource and research studies or results that are applicable to the MKRRP and public information.

Talks and presentations were given to a number of groups on subjects related to the MKRRP. These include: USDA Forest Service Eldorado National Forest meeting on timber and ecosystem management; Society of American Foresters - Northern California Chapter field trip, presentation to a meeting by Sequoia National Forest and Assistant Regional Foresters on giant sequoia management, and a presentation at the Conference on Fire in California Ecosystem. Joint interpretive walks and evening talks with the Mineral King/Silver City interpretive staff were also given during the summer. These provided information to the public about fire ecology and fire regimes in East Fork ecosystems and how these interrelate with the park's burn program and its fuel and smoke issues. Field trips to the MKRRP area have also been given to numerous park staff (interpreters, visiting personnel, and researchers), the Forest Service, environmental groups, and representatives of the local timber industry interested in learning about the burn project and seeing the MKRRP area.

FIRE/GIS MODEL

Additionally, the data coordinator was involved with input of ideas and data into the GIS/Fire modeling effort were made during the past year. This involved the development of an "ecological needs" model (with MaryBeth Keifer - NPS and Linda Mutch - BRD) to provide a quantitative rating scheme for the need to burn specific vegetation types based on time-since-last burn and pre-Euroamerican fire frequency. Fire history knowledge was summarized from within park locations and non-park areas (data were obtained from the literature and recent sampling within the MKRRP area) for the various park vegetation types. Quality of these data were also rated to provide some measure of reliability. This GIS effort has produced some extremely useful maps for management and resource planning within the Parks (Caprio et el. 1997)

Using the same fire history information a fire regime map for all portions of the parks was also developed and evaluated for quality (Caprio and Lineback in prep). This provided estimates of pre-Euroamerican fire frequencies within the major vegetation classes within the parks based on our current knowledge. The evaluations considered criteria such as the quality of our knowledge from within each of the parks major vegetation classes, by aspects, and by location within the parks. Broad fire frequency regime classes were: very high (<6 yr), high (6-15 yr), moderate (16-25 yr), low (26-100), and very low (>100 yr). These estimates of fire return intervals are being utilized by fire managers to look at and plan burn schedules for locations within the park over long periods. It has provided information on where current and future effort and plans need to be made and where no effort is needed resulting in more efficient resource use.

EAST FORK PLOT BURN CRITERIA DATABASE

To facilitate the burn planning and field operations an information database on known study plots in the East Fork watershed was developed. The database contains "burn criteria" (specifications by principle investigators on desired burn conditions or type for their study plots) for all the plots. The purpose is to make this data available during burn planning and field operations to help alleviate problems in how and when plots are burned. This data was developed within a GIS frame to provide both maps and linked information database. This GIS/database information could be used as an extension to the GIS plot location database that has been developed for the parks by Pat Lineback (SEKI GIS coordinator) and MaryBeth Keifer (SEKI Ecologist).

An ARCVIEW project was developed that displayed all known plots in the East Fork watershed that have precise UTM coordinates and current "burn criteria". When the project is opened it will bring up a map of the watershed showing plots listed in the current database (**Fig. 3.5-1**). It will also show burn segments, roads, trails, and hydrology (optional). Using the "information" tool within ARCVIEW any plot point on the map can be opened and a window listing information about that plot accessed. This information includes study type, investigator, who to contact about the plot, phone number, UTM coordinates, and a summary of the burn criteria (or lack there of). The criteria are given as "preferred burn conditions", "suitable burn conditions", and "undesirable burn conditions". The burn condition criteria are summarized and grouped into four categories which are also color coded on the ARCVIEW map. Red (BURN_KEY=4 in the database) are plots with the most specific criteria, cyan (light blue) (BURN_KEY=3) are plots with limited burn criteria, green (BURN_KEY=2) are plots without burn criteria but disturbance (line construction etc.) needs to be avoided, and dark blue (BURN_KEY=1) are plots without burn criteria and which will not be adversely affected by disturbance.

Criteria Class & Map Color	Criteria
BURN_KEY=1 (dark blue)	- no criteria, sample sites will not be revisited
BURN_KEY=2 (green)	- disturbance of plots should be avoided
BURN_KEY=3 (cyan)	- ***limited*** burn criteria plus disturbance of plots should be avoided
BURN_KEY=4 (red)	- ***specific*** burn criteria plus disturbance of plots should be avoided

There have been some questions about what the differences in specific versus limited criteria? The main difference are that the former are usually plots where intense sampling has been undertaken with the result that only a few plots can be installed or sampled. Thus, the "value" of a plot is greater and there is more concern on how the plot area burns. Adding new plots if one is burned under poor

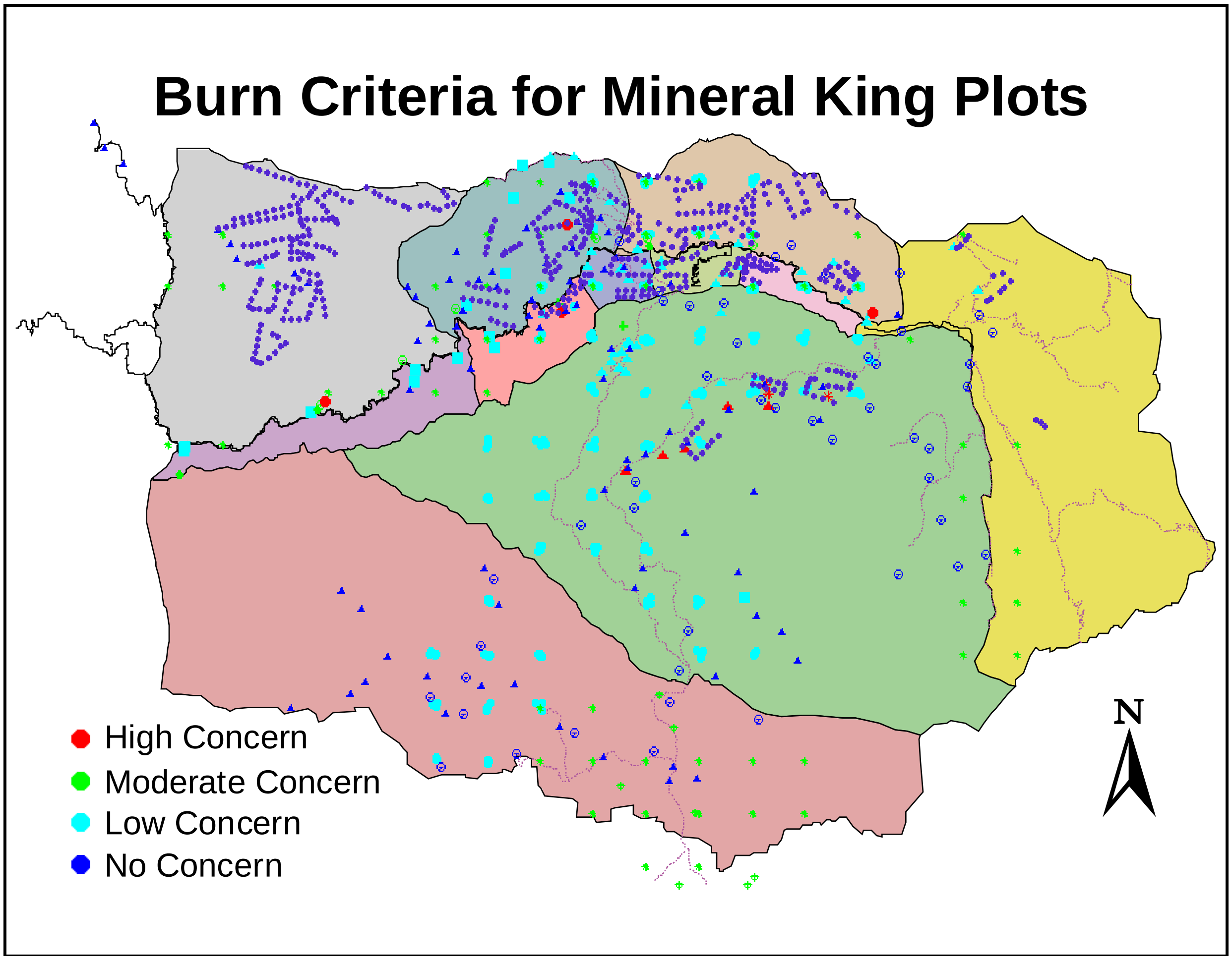


Figure 3.5-1. Map of all plots installed in the East Fork drainage and the burn criteria specified for each plot by the principle investigators. Plots are color coded depending on the degree of concern over how they are burned. Burn segments are shown color coded in the background.

conditions is not an option. These include the small mammal plots, David Newburn's red fir plots, and the Pitcher plots.

Information on plot size, how they are marked (rebar etc.), and if trees are tagged within the plot are also included in the database. This information could be used if a plot needs to be located.

The most common burn criteria specification for the plots is to not be disturbed. The number of plots in the red class (***specific burn criteria***) is actually quite small with 2/3 of these in the Tar Gap Segment (segment #10) above the Tar Gap Trail (Dave Newburn may be adding several more in the area early this summer).

3.6 - Other

- **Natural Resource Inventory -** No Natural Resource Inventory (NRI) plots were sampled during 1997 because no plots were burned during 1996. A few plots may be sampled during 1998 that were burned during 1997 in the Redwood Segment (segment #4). The NRI project has been carried out by staff of the Biological Resources Division of the USGS (formerly NBS). Their objectives have been to establish or revisit permanent inventory plots within the East Fork drainage. The general purpose of the NRI plots is to provide a systematic, plot-based inventory for detecting and describing the distribution of vascular plants, vertebrate animals, and soils throughout the Sequoia and Kings Canyon National Parks. Within the East Fork, the plots document the preburn floristic composition and structure of vegetation. Since 1995, 18 plots have been established as part of the MKRRP (**Fig. 3.12-1**). These supplement 32 plots that already existed in the watershed. Plots that burned during 1995 have been revisited during 1996 (seven of nine were relocated) to assess burn impacts and first year postburn vegetation responses. An effort was made to also sample locations falling within the little known, dense chaparral vegetation of the East Fork.

- **Bark-Foraging Bird Species -** Todd Dennis (graduate student University of Virginia) conducted research that focused on understanding possible mechanisms that may limit bird species distributions (his emphasis is on the bark-foraging guild - some 14 species of woodpeckers, nuthatches, etc. inhabit the west slope of the Sierra Nevada). Over 600 foraging behavior plots were sampled along with some 450 descriptive vegetation plots during 1996 and 1997 (**Fig. 3-1**). Much of his field sampling was undertaken within the East Fork watershed and has included the examination of species within a number of recent burns in the drainage. He found a number of bark-foraging species to prefer these recent burned areas: northern flicker, white-headed woodpecker, hairy woodpecker, Williamson's sapsucker, and black-backed woodpecker. The latter species was only observed in recent burns which appear to be critical habitat for its presence. His data suggests that fire creates more habitat diversity, allowing better foraging opportunities and nesting locations. Sampling through 1997 is described in the 1997 MKRRP Annual Report (Caprio 1997). No further updates on the work carried out in 1997/1998 are available.

- **Remote Sensing and Fuels -** Mitchell Brookins and William Miller (graduate student and professor at Arizona State University) are in the initial phases of developing a fuels inventory based on TM data with field verification. This project will develop a vegetation classification scheme for the watershed based on Landsat thematic mapped (TM) data and a fuel loading classification based on these vegetation classes that can be for fire management planning. During 1996 and 1997 ground verification was carried out in the East Fork drainage (**Fig. 3.11-6** show 1996 plot locations). Sampling and analyses through 1996 are described in the 1997 MKRRP Annual Report (Miller and Brookins 1997). No further update on the work carried out in 1997/1998 is available.

4. Acknowledgments

Reviews and suggestions for improvement of 1997 MKRRP Annual Report were made by Linda Mutch, Jeff Manley, and Bob Meadows. Assistance in the tedious task of printing, compiling, and checking that all sections of the report were included was provided by Bob Meadows. I would also like to thank everyone who contributed individual project sections for this report or helped in some other capacity. The BRD office provided equipment and assistance in printing the color copies.

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