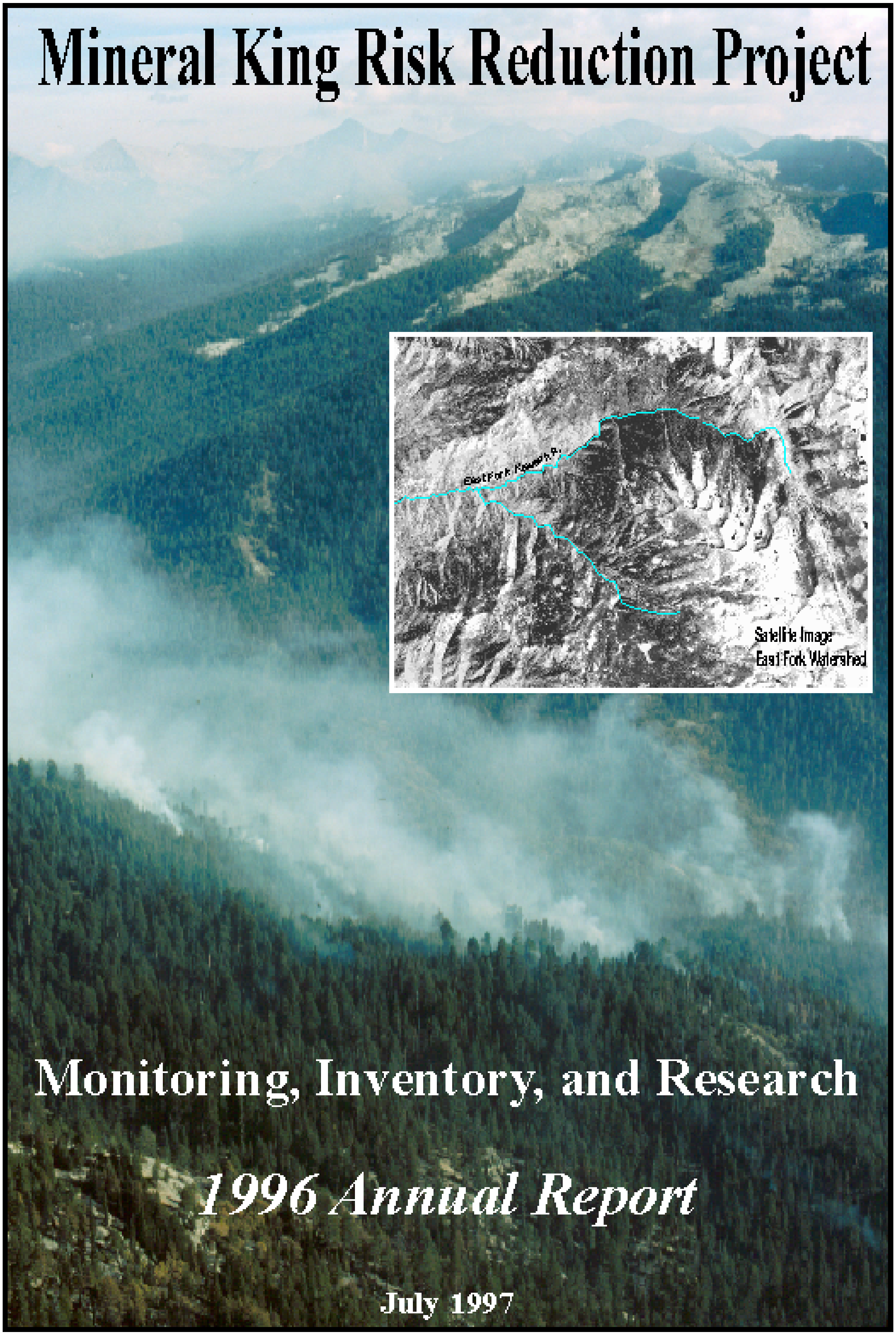
# Mineral King Risk Reduction Project




## Monitoring, Inventory, and Research

## *1996 Annual Report*

**July 1997**

# Annual Report 1996
# Research, Inventory, and Monitoring
## Mineral King Risk Reduction Project

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# Contents

# 1996 Annual Report - 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 [partially funded by the MKRRP and the Biological Resources Division of the USGS]; and the University of Virginia). 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 (USGS).

Several noteworthy observations or findings were made by the monitoring/research projects during 1995/1996. 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: 0% red fir forest, 35% sequoia forest (no mortality of overstory sequoias was noted), and 82% in ponderosa pine forest. These plots also showed total fuel reductions of 67% (ponderosa pine forest) to 94% (red fir forest). 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 Sierran watersheds.

No burning was carried out in the watershed in 1996 (2,100 ac were burned during 1995) due to the severity of the fire season (over 11,000 ac were burned in Sequoia and Kings Canyon National Parks and six millions acres in the western United states during 1996) and the scarcity of resources for carrying out the burning at this scale. Burn plans for 1996 will carry over into 1997.

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

# I) Project Year Synopsis

**Accomplishments for 1996 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 16 fire effects plots have been set up in the East Fork since 1995. These include seven forest plots (five in segment #3, one 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 postburn rechecks completed during 1996. The rechecks showed overstory tree mortality varied by vegetation type: 0% red fir forest, 35% sequoia-mixed conifer forest (no mortality of overstory sequoias was noted), and 82% in ponderosa pine forest. Total fuel reductions of 67% 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.

- **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.

- **Wildlife Monitoring -** Three permanent small mammal live-trapping plots have been established and sampled during 1995 and 1996. 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), and in ponderosa pine/black oak transition forest (Camp Conifer). The mid-elevation sequoia plot, located in segment #3, burned during November 1995 and was resampled in 1996. Initial results indicate a doubling of small mammal biomass in the one year since the burn. 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 (graduate student at UC Davis) is 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 recovered from segments #2, #3, #4, and #10 during 1995 and 1996. 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. 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. This information will provide input into the FARSITE fire spread computer 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 and two permanent "Miller" fuel plots established. 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.

! **Resampling of the 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 40% increase in fuel loads (tons per acre) 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. Initial field sampling was carried out this past summer in segment #4 and #10 (portions originally planned for burning during 1996). 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.

- **Bark-Foraging Bird Species -** Todd Dennis' (graduate student University of Virginia) research focuses on understanding several 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. 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. He plans to obtain additional funding to return to the area to extend his sampling and obtain more postburn observations as more areas are burned as part of the MKRRP.

- **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. There are three phases to this study: 1) initial image processing and remote vegetation classification, 2) ground verification of the initial classification scheme and the collection of forest stand data including fuel load, 3) the integration of the data from the first two phases into a procedure that accurately predicts vegetation and fuels. During 1996 phase one was completed and ground verification begun in the East Fork.

# II) Overview of Project

# 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. 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 consistant with the study objectives.

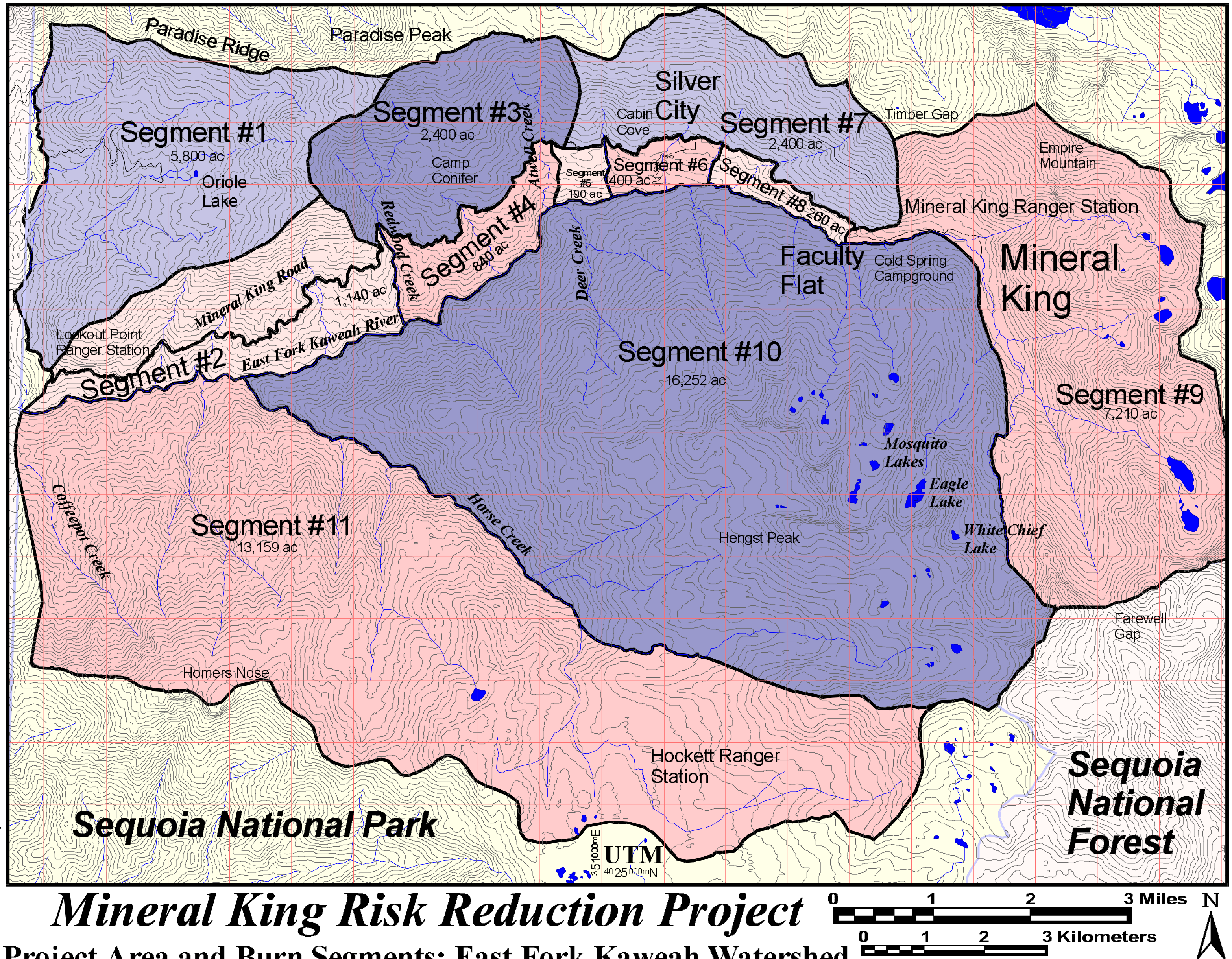



Figure 1.

# Mineral King Risk Reduction Project

**Project Area and Burn Segments: East Fork Kaweah Watershed**

# Description - East Fork Project Area

The East Fork watershed 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).

Eleven burn segments have been outlined within the watershed by fire management staff (**Table 1** and **Fig. 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.

**Table 1.** Segment number and area.

| Segment | Hectares | (Acres) |
|---|---|---|
| 1 | 2352 | (5811) |
| 2 | 439 | (1084) |
| 3 | 962 | (2377) |
| 4 | 289 | (716) |
| 5 | 121 | (300) |
| 6 | 135 | (335) |
| 7 | 989 | (2445) |
| 8 | 121 | (299) |
| 9 | 2917 | (7210) |
| 10 | 6577 | (16252) |
| 11 | 5325 | (13159) |

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

| Vegetation Classification | Hectares | (Acres) |
|---|---|---|
| Foothills Chaparral | 1119 | (2764) |
| Foothills Hardwoods & Grassland | 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.** Vegetation type classification for the East Fork watershed and the area occupied by each class.

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

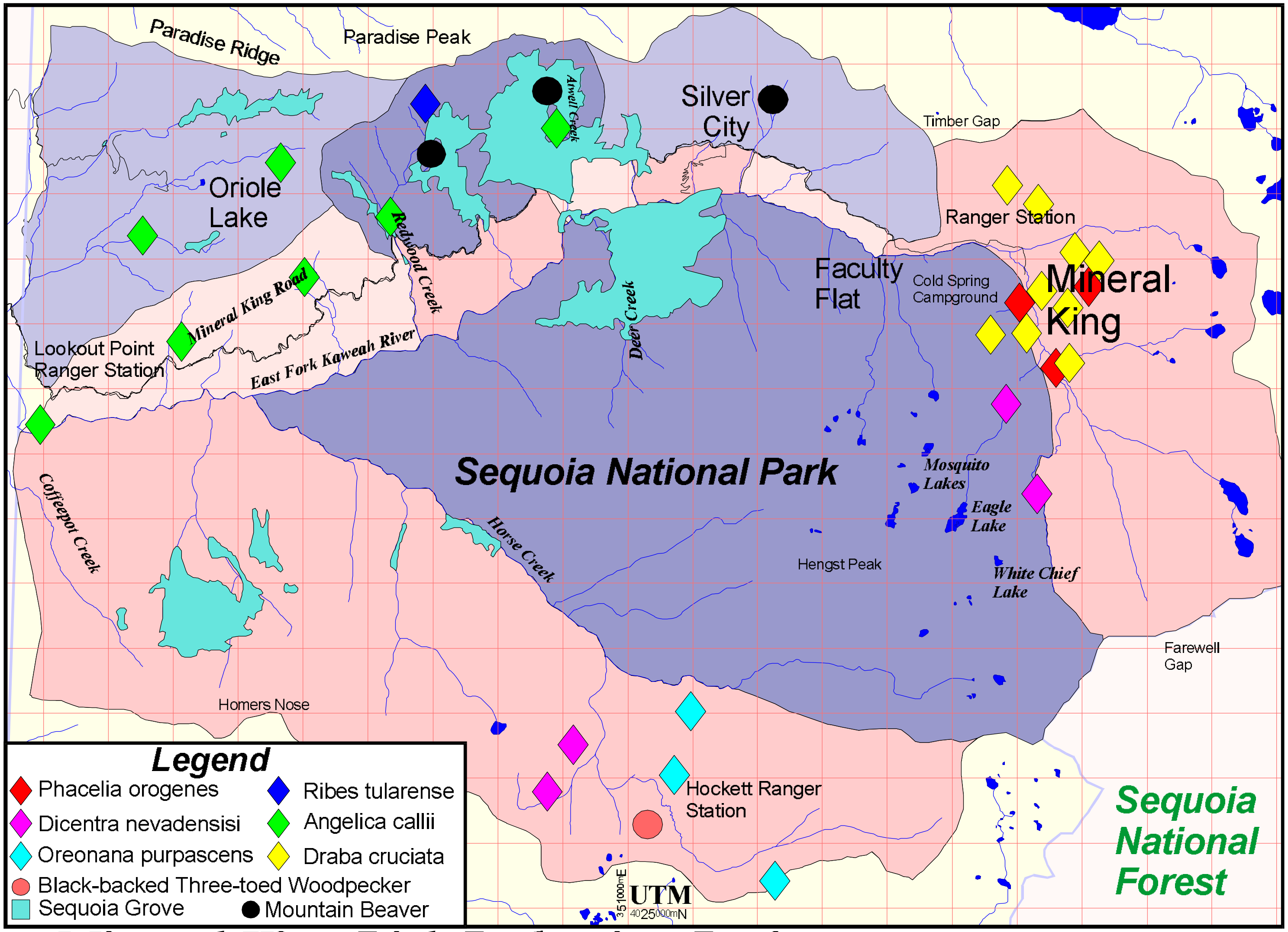



Figure 2.

# Mineral King Risk Reduction Project

**Sensitive Plant & Animal Species - Locations Approximate**

0 1 2 3 Miles

0 1 2 3 Kilometers

N

**Historic Fires (1920-1996) - East Fork Project Area**: No large watershed-scale fires have occurred within the NPS administered portion of the East Fork drainage over at least the last 70 years (**Table 3 and Fig. 3**). The largest burns during this time period occurred in the lower elevation chaparral and evergreen-oak woodlands during the 1920s and 1930s (NPS SEKI fire records database). The largest burn in forested conifer areas (other than the burning of Segment #3 as part of the MKRRP) was the 292 ha (720 ac) Deer Creek Burn (prescribed natural fire) within the East Fork Grove in 1991.

**Table 3**. Updated table (expanded from the 1995 MKRRP Annual Report) on the major fires ($1 acre) from about 1920 (early records are incomplete, 1927 missing) through 1996 that occurred wholly or partially within the East Fork watershed (three fires are off the map to the west {†}several fires named on the map are outside the East Fork {*}). Based on current information from SEKI fire records (NPS 1996) and SEKI GIS, a total of 69 fires ($1 acre) and 17,131 hectares (42,313 acres) burned since 1920.

| Fire Name | Year | Hectares | (Acres) |
|---|---|---|---|
| unknown | 1922 | 141.7 | (350) |
| unknown | 1924 | 16.2 | (40) |
| unknown | 1925 | 149.8 | (370) |
| unknown | 1925 | 18.2 | (45) |
| unknown | 1926 | 24.3 | (60) |
| unknown | 1928 | 9,595.1 | (23,700) |
| Red Hill † | 1930 | 101.2 | (250) |
| South Fork | 1930 | 809.7 | (2,000) |
| unknown | 1933 | 6.1 | (15) |
| Traugers #1 | 1934 | 24.3 | (60) |
| Traugers #2 | 1934 | 97.2 | (240) |
| Eden Grove | 1934 | 3.2 | (8) |
| Case Mountain | 1934 | 809.7 | (2,000) |
| South Fork | 1934 | 161.9 | (400) |
| Grunigen Creek #3 | 1935 | 0.4 | (1) |
| Oriole #2 | 1935 | 1.2 | (3) |
| unknown | 1938 | 121.5 | (300) |
| Lake Canyon | 1939 | 16.2 | (40) |
| Red Hill | 1939 | 728.7 | (1800) |
| Cain Flat | 1939 | 226.7 | (560) |
| unknown | 1939 | 12.2 | (30) |
| unknown | 1939 | 16.2 | (40) |
| Tar Gap Ridge | 1942 | 1.6 | (4) |
| Paradise Peak Lookout | 1945 | 0.4 | (1) |
| Paradise | 1945 | 0.4 | (1) |
| Atwell Mill | 1946 | 43.3 | (107) |
| Castle Grove* | 1947 | 151.8 | (375) |
| Hockett Ridge | 1950 | 0.8 | (2) |
| unknown | 1951 | 14.2 | (35) |
| Homer's Nose | 1952 | 6.9 | (17) |
| Mineral King | 1952 | 18.2 | (45) |
| Paradise | 1952 | 0.8 | (2) |
| Conifer Tract | 1955 | 11.3 | (28) |
| Paradise Peak #1 | 1957 | 0.4 | (1) |
| unknown | 1969 | ? | (?) |
| Homer's Nose | 1969 | 5.3 | (13) |
| Horse Creek | 1969 | 0.8 | (2) |
| Atwell Mill #2 | 1970 | 0.4 | (1) |
| Lookout Point | 1970 | 89.9 | (222) |
| Atwell Mill | 1971 | 1.6 | (4) |
| Jet Plane | 1971 | 1.2 | (3) |
| Clough Cave* | 1971 | 12.2 | (30) |
| Horse Creek | 1973 | 0.8 | (2) |
| unknown | 1974 | 13.8 | (34) |
| Lookout | 1974 | 16.2 | (40) |
| Whitman Creek | 1976 | 3.6 | (9) |
| Whitman | 1978 | 0.4 | (1) |
| Eden Grove | 1978 | 6.9 | (17) |
| Eagle Lake | 1979 | 0.4 | (1) |
| Dome Fire | 1980 | 202.4 | (500) |
| Salt Creek † | 1984 | 18.2 | (45) |
| Garfield* | 1985 | 113.4 | (280) |
| Camp Creek* | 1986 | 206.5 | (510) |
| Coffeepot #1 | 1987 | 0.8 | (2) |
| Coffeepot #2 | 1987 | 0.4 | (1) |
| Coffee | 1987 | 97.2 | (240) |
| Silver | 1987 | 0.8 | (2) |
| Case | 1987 | 2024.3 | (5,000) |
| Kaweah † | 1987 | 64.8 | (160) |
| Lost | 1987 | 0.8 | (2) |
| Hockett | 1988 | 8.1 | (20) |
| Hockett | 1988 | 20.2 | (50) |
| Purple Haze | 1988 | 0.4 | (1) |
| Paradise | 1988 | 2.8 | (7) |
| Deer Creek | 1988 | 5.7 | (14) |
| Deer Creek | 1991 | 291.5 | (720) |
| Paradise | 1994 | 30.4 | (75) |
| Horse Creek | 1994 | 0.8 | (2) |
| Milk Ranch* | 1994 | 20.2 | (50) |
| Empire | 1994 | 47.9 | (118) |
| Hockett | 1994 | 23.1 | (57) |
| Spring | 1994 | 1.2 | (3) |
| Segment #3 | 1995 | 850.2 | (2,100) |
| **TOTALS** | **68 fires** | **17,315 ha** | **42,768 ac** |

* Outside the East Fork watershed but shown for reference purposes.

† Not shown on map (located in lower portion of the Eastr Fork drainage).

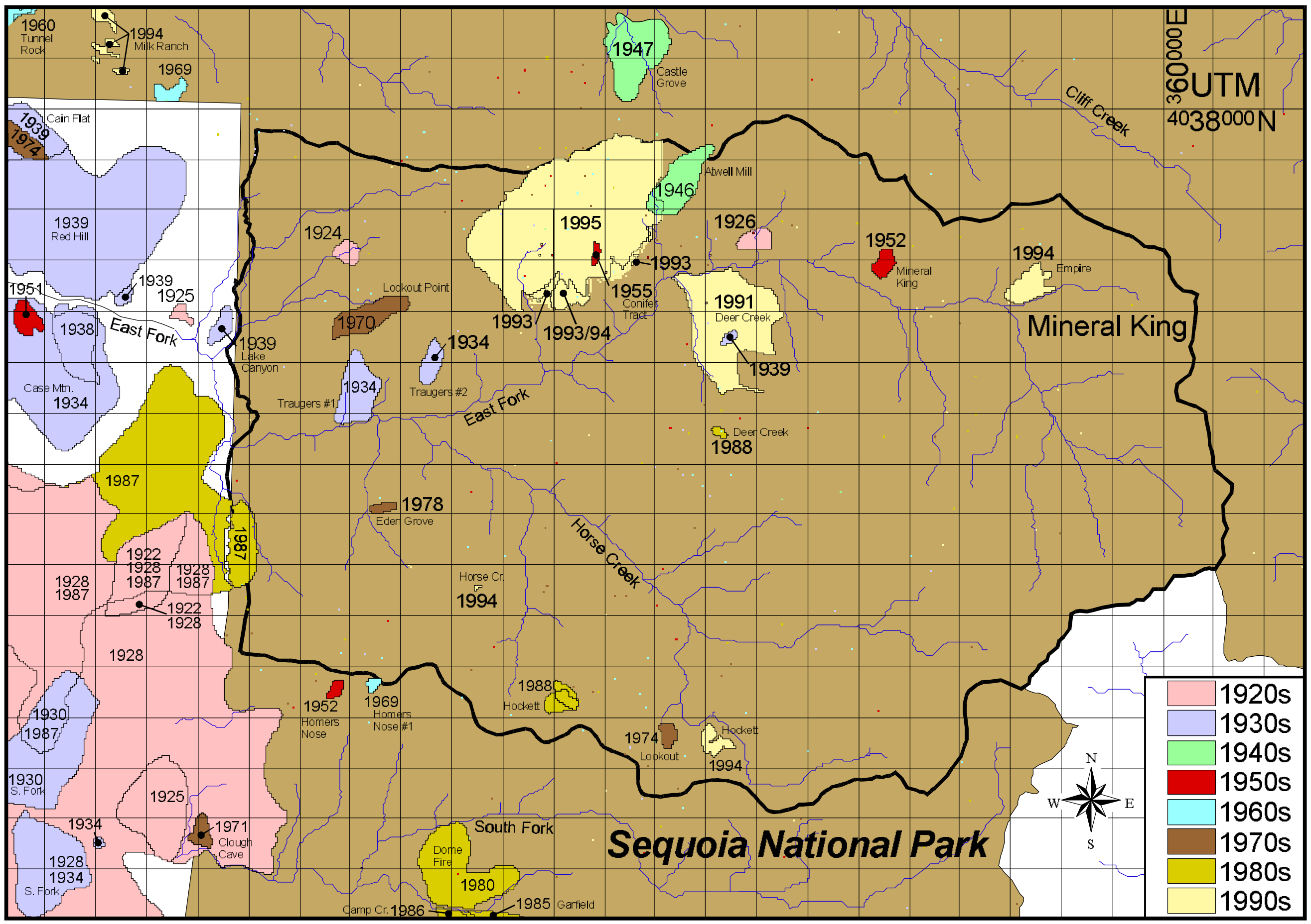



Figure 3.

**Burns in the East Fork Drainage (1920-1995)***

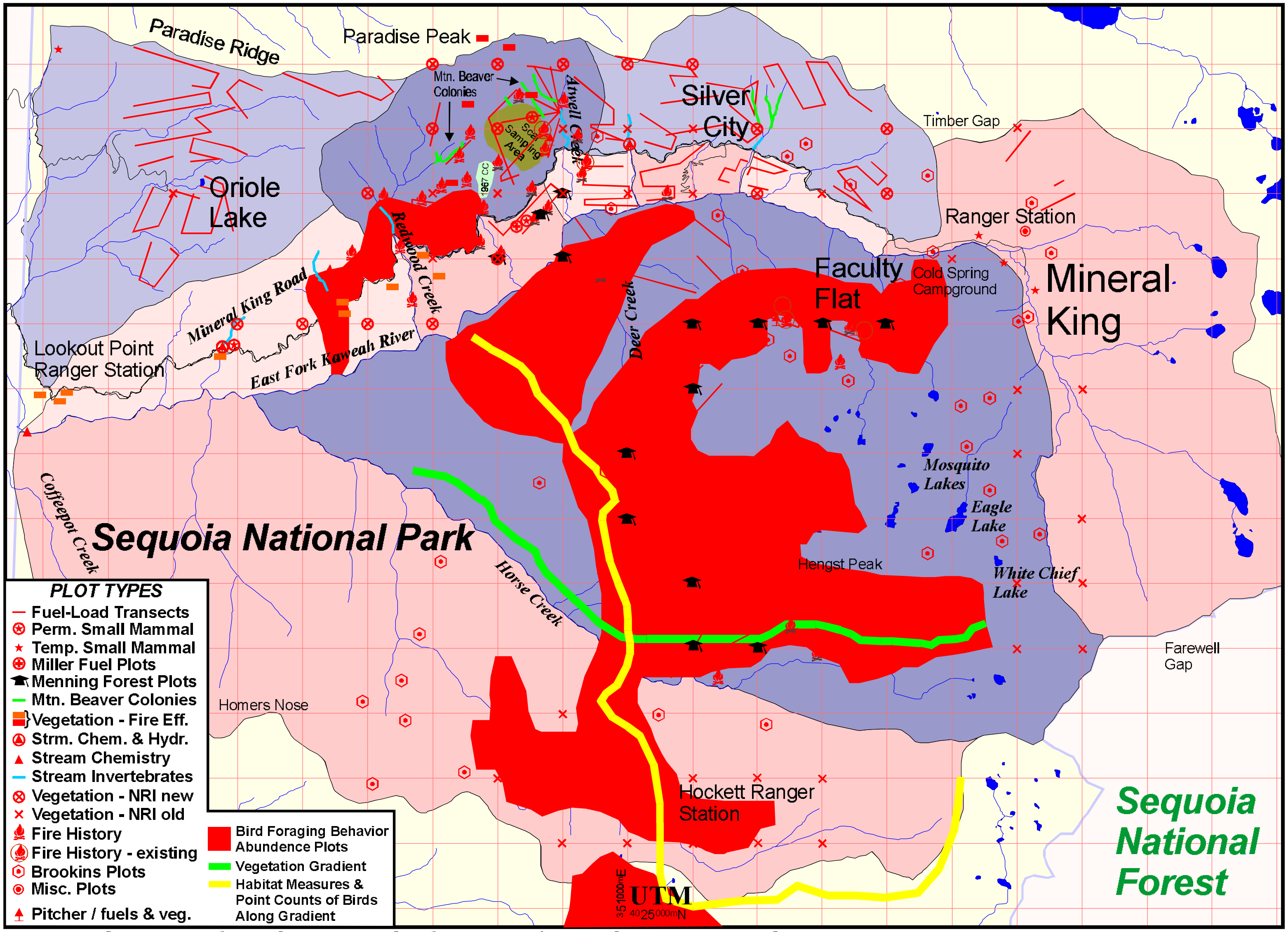
Mineral King Risk Reduction Project area is shown by heavy outline. * Data is incomplete for some years.

# III) Project Year 1996

The Mineral King Risk Reduction Project was initialized during March 1995 with field work and limited burning beginning during 1995 (2,100 ac/850 ha in segment #3, **Fig. 1**). Burn plans developed by the Fire Management Office during the spring of 1996 called for burning portions of segments #10, #4, and #2 during the summer/fall. Ignitions in segment #10 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 burning during 1996 was segment #4 located between the East Fork and the lower portion on segment #3 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. Burning in chaparral and oak woodland in this unit and in segment #2 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. However, due to the extent of resource demands during the summer of 1996 (more acres burned in the western USA than any year since 1920) burning was not initiated in segment #10. Additional burning in segments #4 and #2 was curtailed when early and heavy rains fell during October soaking lower elevation chaparral/oak fuels. At this time, burn plans for 1997 essentially carry forward the plans developed during 1996.

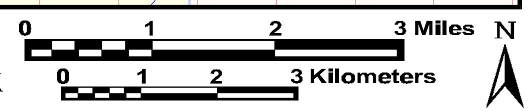
Field work involved with monitoring, inventory, and research during 1996 concentrated on the upper portions of segment #10 and in segments #2 and #4 on the south facing slopes of the East Fork watershed (**Fig. 4**). The projects included studies begun during 1995 and several new investigations. The 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 D. Pitcher; (10) The latter include: (1) remote sensing of fuels and vegetation; (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). A significant amount of information was collected from throughout the East Fork during summer of 1996. While field work was rushed during the early portion of he 1996 season to collect data and establish sampling plots, the lack of burning in the East Fork during the summer created a little breathing room for the investigators. The delay has essentially provided a one field season lead for planning and implementing projects.

Figure 4.




# Mineral King Risk Reduction Project

## Project Area and Monitoring/Research Locations: East Fork



# Vegetation Sampling

## 1) Fire Effects Plots - Science and Natural Resources Management, SEKI

Lead: M. Keifer; field-crew supervisor: G. Dempsey; field crew: D. Haskamp, G. Indinoli, P. Mulligan, and A. Peterson.

**Summary prepared by M. Keifer**

***Work Completed in 1996:*** During the 1996 field season, 5 forest plots that burned in segment #3 of the Mineral King burn unit were remeasured one-year postfire and 1 forest plot located outside the segment (unburned) was also revisited (**Fig. 6**). Segments 2 and 4 were not burned as planned, therefore, none of the 9 chaparral plots (3 chamise and 6 mixed) were revisited. One new plot was installed in segment 10 in the Red fir forest type. UTM coordinates for all plots were determined (**Table 4**).

***Results to Date:*** Results are presented for plots that burned in segment #3 in three forest monitoring types. The results include dead and down fuel load, overstory tree (>1.37 m in height) density, and 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 apply only to the plot areas measured due to the small sample sizes (at most, 2 plots per monitoring type).

***Ponderosa pine-mixed conifer forest*** **(PIPO) -** Only one PIPO plot has been established and burned in the East Fork watershed. This plot was located adjacent to a 2-3 acre hot spot (100% overstory mortality) above Redwood Creek (visible from road when driving up the Mineral King Road). The location resulted in fire effects that were severe relative to effects normally observed in PIPO plots elsewhere in SEKI. Additional plots are being established within the watershed.

In this PIPO plot, **67% of the total fuel load was consumed** by the fire, from 98.3 tons/acre prefire to 33.0 tons/acre immediately postfire (**Fig. 5**). The duff was completely consumed (100%) and woody fuels were reduced by 51%.

Total overstory tree density was 1170 trees/ha prefire and 210 trees/ha one-year postfire, indicating 82% overstory mortality in the plot following the fire (**Fig. 7**). Prefire composition was dominated by incense cedar (85% of all trees), most of which

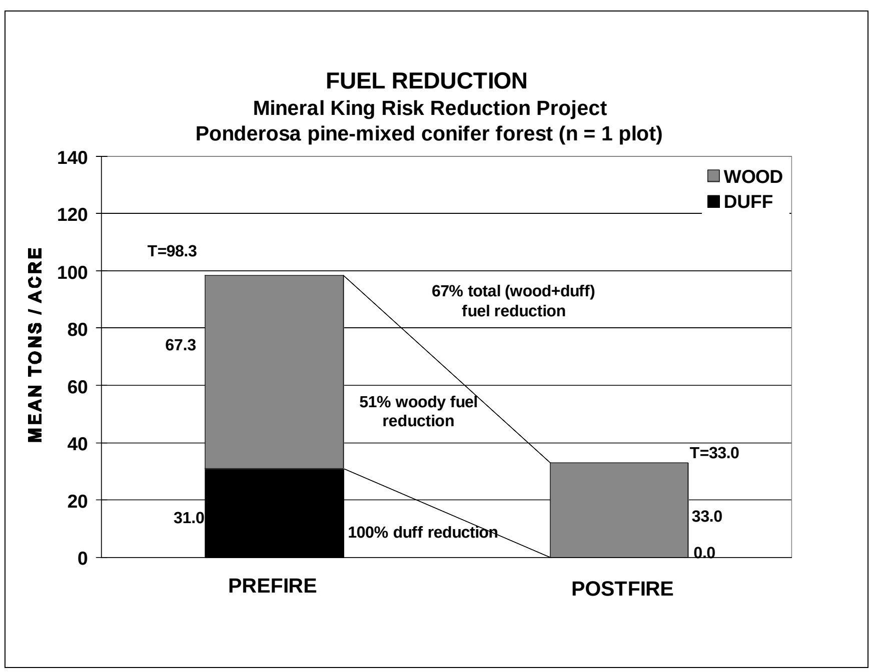



**Figure 5**. Fuel load change in ponderosa pine-mixed conifer forest, preburn to one-year postburn.

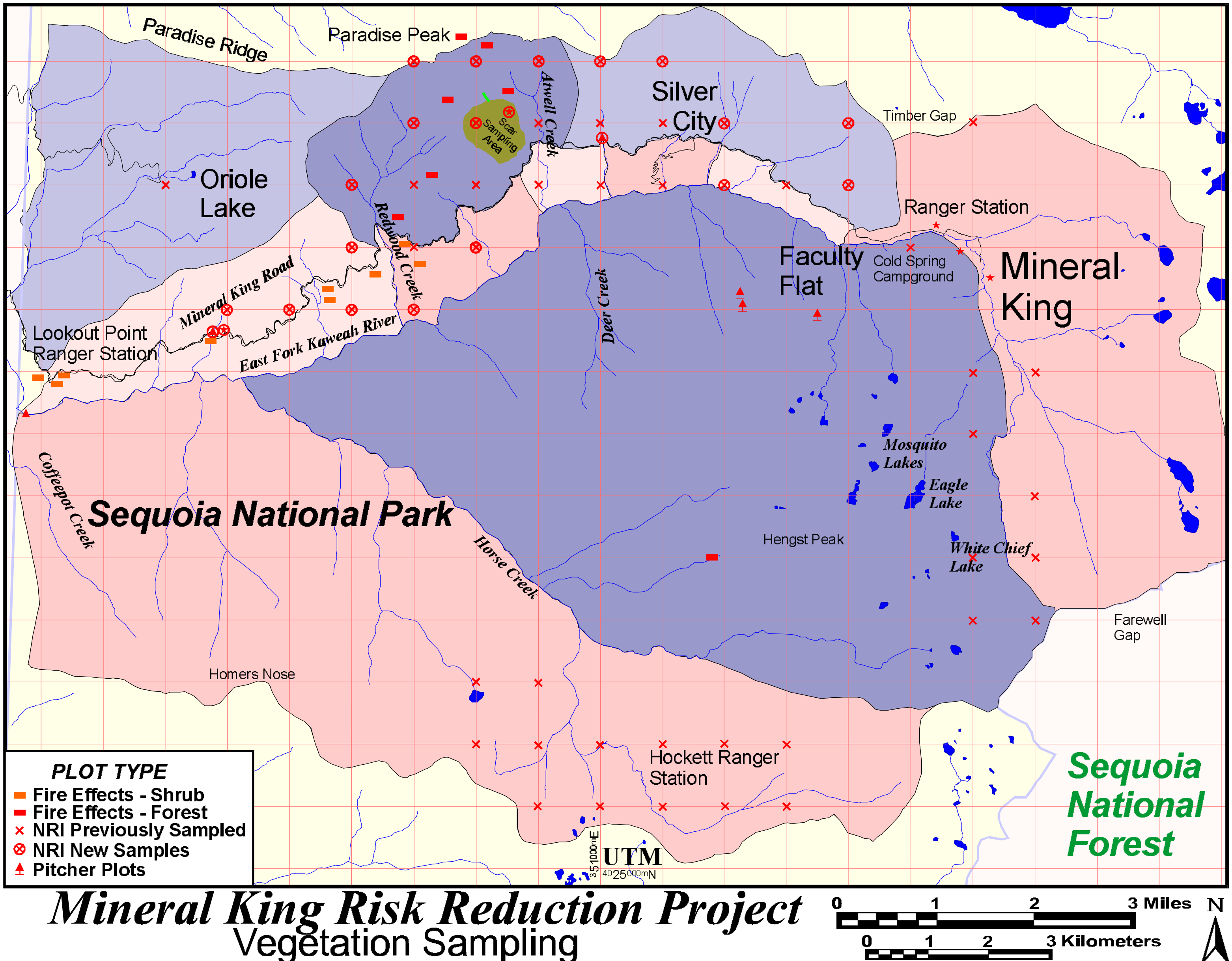


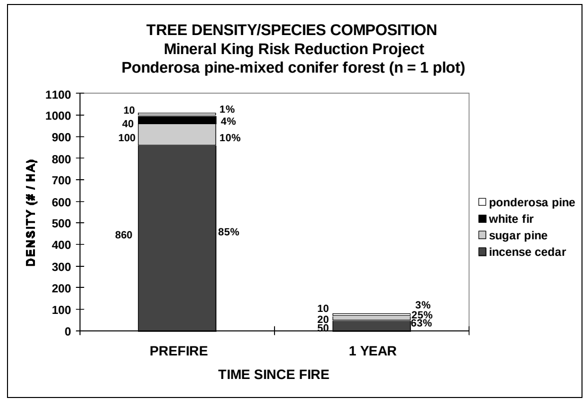

Figure 6.

# Mineral King Risk Reduction Project

## Vegetation Sampling

NRI Plots, Fire Effects Plots, Sequoia Fire Scar Study, and Pitcher Plots were less than 40 cm in diameter at breast height (DBH). Incense cedar was reduced from 860 trees/ha prefire to 50 trees/ha one-year postfire (94% mortality). While incense cedar remains dominant, relative species composition changed from prefire conditions to one-year postfire. Incense cedar decreased (from 85% to 63%) and white fir decreased (from 4% to 0%), while ponderosa pine and sugar pine relative densities increased (from 1% to 3% and from 10% to 25% respectively) (**Fig. 7**).

**Figure 7**. Change in tree species density and composition.




Total seedling density increased by 216% from 16.4 x $10^3$ seedlings/ha prefire to 51.8 x $10^3$ seedlings/ha 1-year postfire (Table 2). Most of this increase was due to the prolific establishment of incense cedar seedlings (from 1.8 x $10^3$ prefire to 51.2 x $10^3$ seedlings/ha one-year postfire).

***Giant sequoia-mixed conifer forest*** **(SEGI) - Total fuel load was reduced by 89%** in one SEGI plot, from 142.5 tons/acre prefire to 16.1 tons/acre immediately postfire (**Fig. 8**). 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.

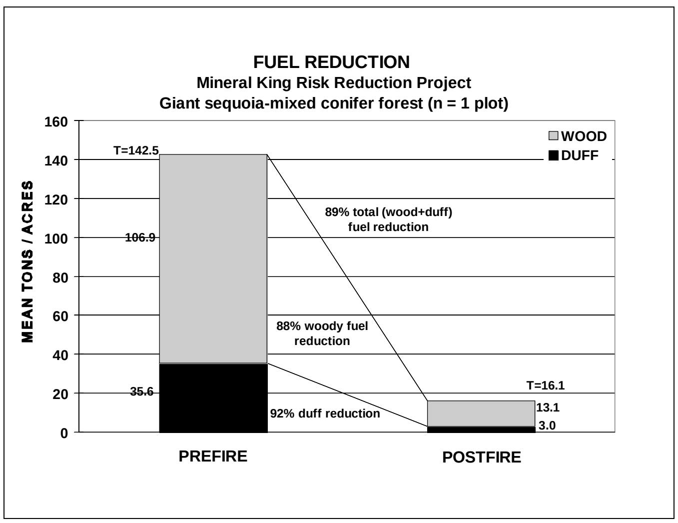



**Figure 8**. Fuel load change in sequoia mixed-conifer forest, preburn to one-year postburn.

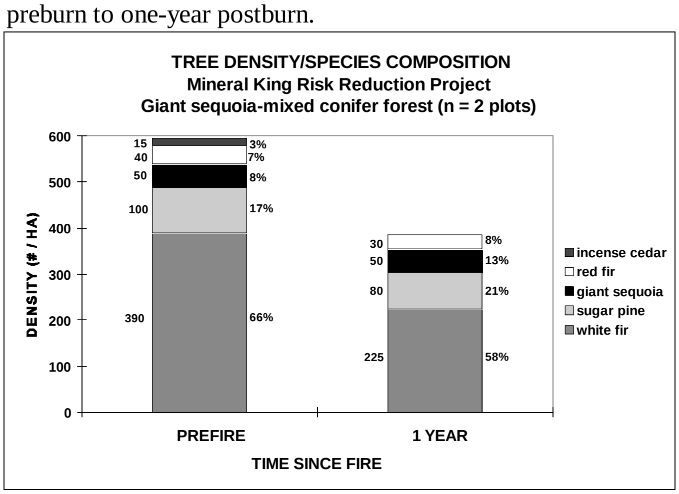



**Figure 9**. Change in tree density and species composition.

In two SEGI plots, mean total overstory tree density was reduced by 35%, from 595 trees/ha (± 215) prefire to 385 trees/ha (± 135) one-year postfire (Figure 4). White fir dominated prefire density (66%) and most mortality occurred in the smaller diameter white fir (less than 40 cm). Relative density changed slightly from prefire conditions to one-year postfire. Incense cedar and white fir decreased (from 3% to 0% and from 66% to 58%, respectively) and relative increases occurred in sugar pine (from 17% to 21%) and giant sequoia (from 8% to 13%) (**Fig. 9**). No mortality of any giant sequoia trees occurred in either plot.

Mean total seedling density for two SEGI plots was 17.6 x $10^3$ seedlings/ha (± 10.4 x $10^3$) prefire and increased by 419% to 91.3 x $10^3$ seedlings/ha (± 85.7 x $10^3$) one-year postfire (**Table 2**). This increase was due to the postfire establishment of giant sequoia seedlings (from 0 prefire to a mean of 88.3 x $10^3$ seedlings/ha one-year postfire); all other species seedling density decreased one-year postfire. This result corroborates previous studies that show that fire greatly increases the establishment of giant sequoia seedlings.

***Red fir forest* (ABMA)** - In two ABMA plots, mean total fuel load was 116.7 tons/acre (± 6.5) prefire and 6.8 tons/acre (± 2.0) one-year postfire, which indicates **94% total fuel reduction** (**Fig. 10**). The plots were not revisited immediately postfire due to the late season burn. A small amount of 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.

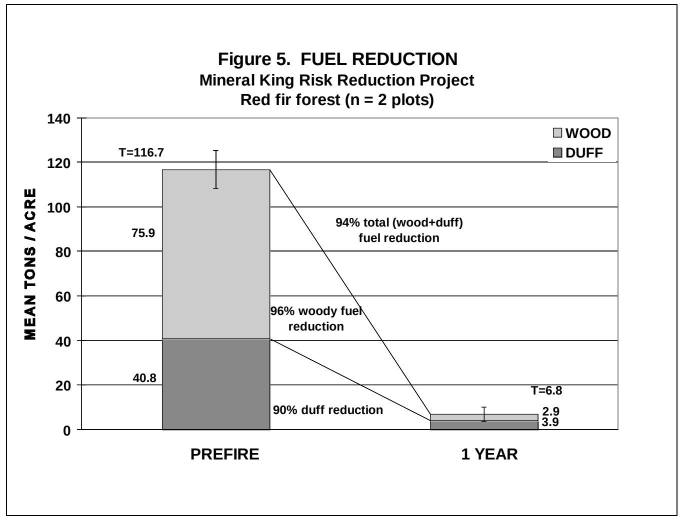



**Figure 10**. Fuel load change in red fir forest, preburn to one-year postburn.

Mean red fir overstory tree density for two plots was 205.0 trees/ha (± 95.0) both prefire and one-year postfire. No overstory red fir mortality occurred in either of the ABMA plots following the fire.

Mean red fir seedling density for two plots was reduced by over 99%, from 86.9 x $10^3$ seedlings/ha (± 19.5 x $10^3$) prefire to 300 seedlings/ha (± 300) one-year postfire (**Table 5**).

**Table 4. Plot locations** (an asterisk in the UTM-East column indicates the plot was georeferenced using a global positioning system with an accuracy of ± 3-30 meters).

| Plot ID | Monitoring Type | Burn Segment | UTM East | UTM North |
|---|---|---|---|---|
| FPIPO1T09 094 | Ponderosa pine-mixed conifer forest | #3 | 347570 | 4035590 |
| FSEGI1T08 093 | Giant sequoia-mixed conifer forest | #3 | 348280 | 4036200 |
| FSEGI1T08 095 | Giant sequoia-mixed conifer forest | #3 | 349200 | 4037510 |
| FABMA1T08 096 | Red fir forest | #3 | 349100 | 4038310 |
| FABMA1T08 097 | Red fir forest | #3 | 348430 | 4037610 |
| FABMA1T08 098 | Red fir forest | unburned | 348680 | 4038320 |
| FABMA1T08 100 | Red fir forest | #10 | 352809* | 4030052 |
| BADFA1D04 012 | Chamise chaparral | #2 | 342251* | 4032915 |
| BADFA1D04 013 | Chamise chaparral | #2 | 342214* | 4032867 |
| BADFA1D04 014 | Chamise chaparral | #2 | 342233* | 4032845 |
| BARME1D04 007 | Mixed chaparral | #2 | 347391* | 4034592 |
| BARME1D04 008 | Mixed chaparral | #2 | 346596* | 4034345 |
| BARME1D04 009 | Mixed chaparral | #2 | 346568* | 4034144 |
| BARME1D04 015 | Mixed chaparral | #2 | 344635* | 4033573 |
| BARME1D04 010 | Mixed chaparral | #4 | 348001* | 4035021 |
| BARME1D04 011 | Mixed chaparral | #4 | 348112* | 4034811 |

**Table 5. Seedling Density**.

| Monitoring Type | Species | PREFIRE Seedling Density # / ha ± 1 SE (x $10^3$) | 1-YR POSTFIRE Seedling Density # / ha ± 1 SE (x $10^3$ ) |
|---|---|---|---|
| Ponderosa pine-mixed conifer forest (PIPO) | Total (all species) | 16.4 | 51.8 |
| | Incense cedar | 1.8 | 51.2 |
| | Sugar pine | 0.8 | 0.4 |
| | Black oak | 8.2 | 0 |
| Giant sequoia-mixed conifer forest (SEGI) | Total (all species) | 17.6 ± 10.4 | 91.3 ± 85.7 |
| | Giant sequoia | 0 | 88.3 ± 88.3 |
| | White fir | 16.1 ± 10.5 | 0.6 ± 0.2 |
| | Incense cedar | 0.5 ± 0.5 | 0 |
| | Ponderosa pine | 0.7 ± 0.7 | 0 |
| Red fir forest (ABMA) | Red fir | 86.9 ± 19.5 | 0.3 ± 0.3 |

***Plans for 1997:*** All forest plots in segment #3 will be remeasured in 1997, two-years postfire. If scheduling allows, the 9 chaparral plots (installed late in 1995) will be remeasured early in the season in order to get more up-to-date preburn information prior to burns scheduled again this year. Also, 5 new plots are scheduled to be installed in segment #10, including 3 plots in the Red fir forest type and 2 plots in the ponderosa pine-mixed conifer forest type.

# 2) Giant Sequoia Fire Scars and Fuel Loading -

Science and Natural Resources Management, Sequoia & Kings Canyon National Parks.

Lead: M. Keifer; field-crew supervisor: G. Dempsey; field crew: D. Haskamp, G. Indinoli, P. Mulligan, and A. Peterson.

***Objectives:*** This study was planned to assess the relationship between the amount of fuel accumulation surrounding giant sequoias prior to burning and the resulting fire effects (Keifer 1995a and 1995b, see Appendix 1 in 1995 MKRRP Annual Report). 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 specific 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 SEKI’s 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.

***Work Completed in 1996:*** All 60 trees in the giant sequoia fuel and fire effects study located in segment #3 were revisited one-year postfire. Fuels, bark char, crown scorch, and mortality information was collected for all trees. Fire scar information was collected where possible, however, some scars could not be remeasured due to permanent marker movement after field equipment overwintered. All new scars (areas where the bark was removed by fires and scars will likely form) were recorded and measured. Detailed results for the giant sequoia fuel and fire effects study are not yet available, however, data collection revealed that no mortality occurred in any of the 60 study trees within one year following the fire.

***Plans for 1997:*** The giant sequoia fuel and fire effects study trees will be revisited to record any mortality, and if time allows, assess any changes in new scars.

# 3) Natural Resource Inventory Plots (NRI) - Biological Resources Division of the USGS, Sequoia & Kings Canyon Field Station

D. M. Graber (P.I.), S. A. Haultain, B. Johnson, and P. Whitmarsh

**Summary prepared by S. Haultain**

***Objectives:*** The general purpose of the broader park-wide Natural Resource Inventory is to provide a systematic, plot-based inventory for detecting and describing the distribution of vascular plants, vertebrate animals, and soils throughout the Parks (Graber et al. 1993). The inventory was initiated in 1985, with 628 plots sampled by the end of 1996. The sampling scheme is designed to be compatible with the Parks' geographic information system (GIS), and to assist in the field validation of remote sensing. All new NRI plots within the MKRRP were permanently marked. Data recorded include cover for all vascular plant species present in a plot, tree DBH, vegetation type, fuels, soils, litter/duff depth, rock type, and evidence of fire or other disturbance.

In the East Fork of the Kaweah, NRI plots were established to document the pre-burn floristic composition and forest structure of the areas included in the MKRRP segments, with an emphasis on those within the Atwell Grove (segment #3).

**Figure 11.** Plant identification for NRI project.

***Fieldwork:*** Fieldwork during 1996 was conducted during the period between 3 June and 21 August in order to capture herbaceous species during peak flowering period at a range of elevations. The emphasis this year was on re-reading previously established NRI plots in the Atwell Grove (segment #3), the segment burned during fall of 1995, and establishing new plots in segments #2, #4, #7 and #8 (**Fig. 6**).

***Data Collected:*** Seven plots within segment #3 were relocated successfully (**Table 6**) and re-read; an additional plot was attempted but not relocated. Of the 7 plots revisited, 5 showed evidence of having burned during the previous fall. Average scorch height and area of plot burned was estimated for each plot, in addition to the standard measurements taken. These data have yet to be analyzed.

**Table 6**. NRI plots re-visited/segment 3 (n=7) with UTM intersection points sampled.

| Plot Number | utme/utmn | Vegetation Types | Burned 1995 |
|---|---|---|---|
| 173 | 350/4037 | Montane Chaparral | N |
| 601 | 347/4036 | Sierran Mixed Coniferous Forest | Y |
| 604 | 349/4037 | Sierran White Fir Forest | Y |
| 605 | 348/4037 | Big Tree Forest | Y |
| 606 | 350/4038 | Big Tree Forest | N |
| 607 | 348/4038 | Red Fir Forest/Montane Chaparral | Y |
| 608 | 349/4038 | Red Fir Forest/Cliffs and Barren Rock Outcrops | Y |

Ten new plots (**Table 7**) were established within segments #2, #4, #7 and #8; three of these contained chaparral, a type which is traditionally under sampled in the drainage due to problems with accessibility. The total number of NRI plots within the project area is now 53.

**Future plans for NRI Involvement: 1997 field season:** We anticipate having a field crew of two biological technicians (B. Johnson and P. Whitmarsh) re-read the plots within the Atwell Grove (segment #3) in order to collect post-burn data two years following the fire. It is unlikely that we will be establishing any new NRI plots within the drainage this year. We will, however, be surveying for introduced vascular plant species in targeted areas within the East Fork drainage, and will continue to survey for the two sensitive species, ***Angelica callii*** and ***Ribes tularense***, serendipitiously.

**Table 7.** NRI plots established (n=10) with UTM intersection points sampled.

| Plot Number | utme/utmn | Segment | Vegetation Types |
|---|---|---|---|
| 619 | 345/4034 | 2 | Northern Mixed Chaparral/Canyon Live Oak Woodland |
| 620 | 346/4034 | 2 | Northern Mixed Chaparral/Canyon Live Oak Woodland |
| 621 | 348/4034 | 4 | Canyon Live Oak Woodland |
| 622 | 347/4034 | 2 | Northern Mixed Chaparral |
| 623 | 353/4036 | 8 | Cottonwood Riparian Woodland |
| 624 | 352/4038 | 7 | Montane Meadow |
| 625 | 353/4037 | 7 | Sierran White Fir Forest |
| 626 | 351/4038 | 7 | Red Fir Forest |
| 627 | 355/4036 | 7 | Montane Chaparral |
| 628 | 355/4037 | 7 | Dry Alpine Talus and Scree |

# 4) Landscape Assessment - Fire and Forest Structure - University of California, Berkeley

Lead: K. Menning (UC Berkeley) with N. Stephenson (BRD - USGS), J. Battles, and T. Benning (UC Berkeley)

**Summary prepared by K. Menning.**

***Objectives and background:*** The Mineral King Risk Reduction Project (MKRRP) provides an ideal laboratory to test an approach to forest restoration. A team of managers and scientists from the National Park Service, U. S. Geological Survey—Biological Resources Division, and National

Interagency Fire Center (NIFC) have chosen this watershed to test the practicality of introducing prescribed fire at a large scale (Menning 1996).

A century or more of fire suppression and climate change have combined to alter forest structure and pattern in Mineral King and in many places in the American West. It is thought that these changes in the return interval, extent and intensity of fire have resulted in increases in forest density, fuel loads, and fire risk. These changes have effects on wildlife habitat and understory biodiversity; forest structure, composition, and regeneration; ecosystem functioning; fire behavior, including susceptibility to catastrophic fire; and risk of epidemic loss to insects and disease due to a more homogeneous forest structure.

**Figure 12**. Sampling in mixed-conifer forest.

People advocating restoration of forests to recover to historic conditions while minimizing risks are divided into two different camps. *Structural restorationists* would alter forest structure to historic conditions by 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 fundamentally during the period of suppression. *Process restorationists* would restore native processes—fire—directly, without first 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 condition 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.

Little information exists to address this debate, however, particularly from the process-restoration point of view. Because this light-handed restoration approach is generally compatible with National Park Service philosophy and might be implemented on a broader scale its ecological consequences need to be evaluated. In order to perform such an assessment we need to have better information on both the current and post-fire conditions of forests.

The Mineral King Landscape Assessment (MKLA) research seeks to provide some answers to this forest restoration debate by examining landscape-level effects of fire (**Fig. 12**). The research can be divided into several questions. First, what is the historic structure and pattern of the mixed conifer forest in this area? Second, does prescribed fire result in a more structurally diverse and complex forest? Third, can prescribed fire be used to restore forest condition to the state or range of variability described in the first question? The general 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 relatively small 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. To answer these question a suite of metrics needs to be identified which can be applied to a descriptive geometry and texture of forest condition, which indicate significant changes, and which have, to the highest degree possible, relevance to biological function.

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

**Figure 13**. Data collection: Landscape Analysis Project.

***<u>Methods</u>:*** Data collection for the Mineral King Landscape Assessment involves several kinds of information. Pictures of continuous landscapes are critical to any landscape analysis. The National Interagency Fire Center and the Fire Management Office combined to supply very specialized and high quality air photos in 1996. On September 18, 1996, high resolution remote photos were collected with the use of an airborne imaging system, the ADAR 5500 instrument. The instrument, which takes four simultaneous pictures in different bands of light—blue, green, red, and near infrared—digitally records the time, flight conditions and position of each photograph. These images, with a resolution of one meter, cover much of the watershed and over 450 individual photos were taken. The September flight had been delayed for several months due to smoke from fires burning to the north in and around Sequoia National Park.

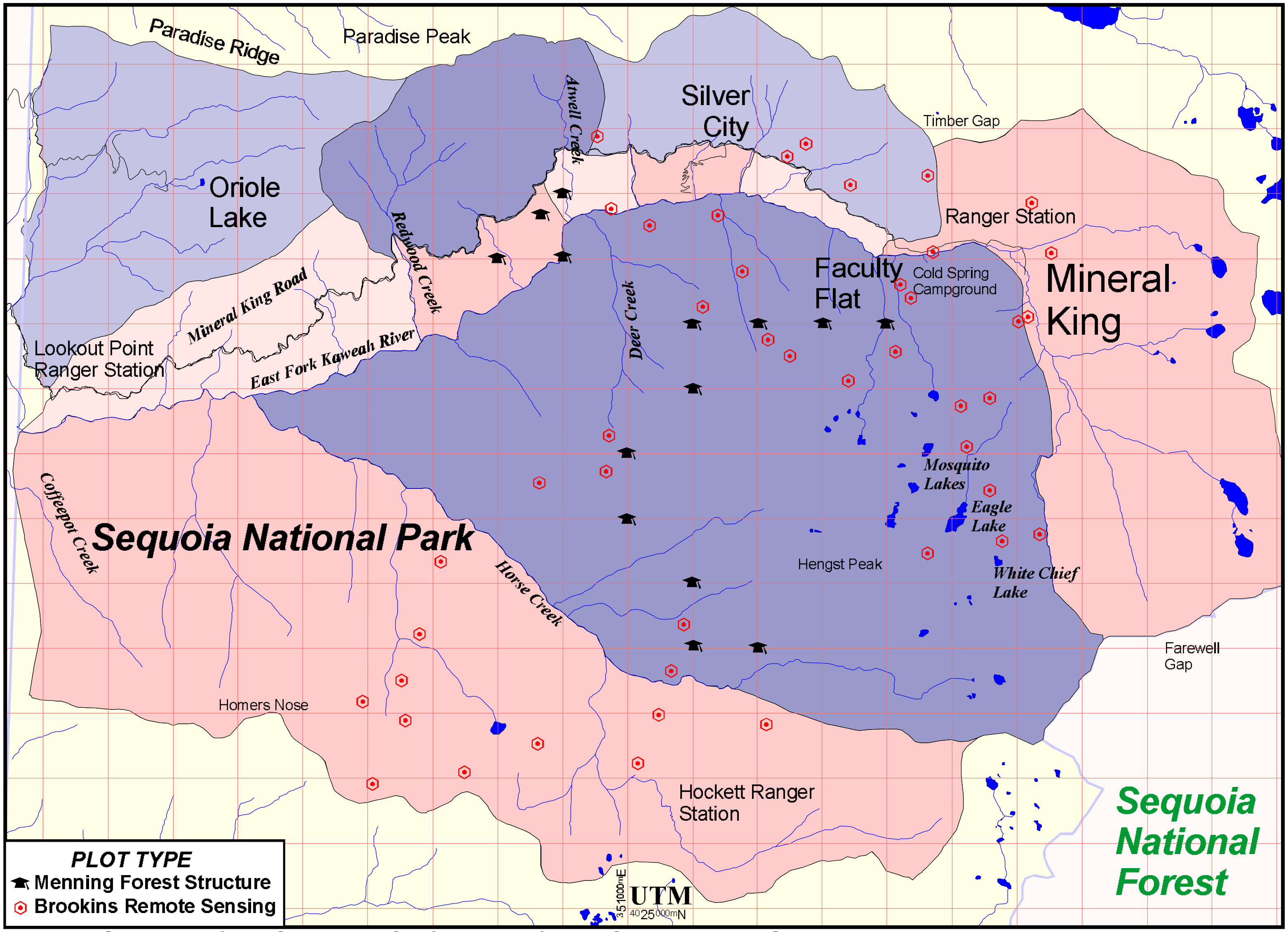
More data are collected in the field to "ground truth" the remote imagery (test its accuracy and assist with corrections) and provide information not available from above. Collection of this information involves a scattered set of field plots (**Fig. 14**). In each plot trees are identified, measured and mapped, fuel conditions are recorded, brush and plant cover are noted, slope and aspect are recorded, and light penetrating through the forest canopy is measured (**Fig. 13**).

***<u>Work Completed</u>:***

***Field data*** - Beginning in July, thirteen volunteers and employees from the former National Biological Service, National Park Service, Student Conservation Association, the University of California—Berkeley, and other institutions contributed 336 hours of time to the project, in addition to lead researcher Kurt Menning's time. Thank you to Dr. John Battles, Adrian Das, Athena Demetry, John Garvey, Jolie Garvey, Martin Hartmann, Jen Lucas, Becky Miller, Linda Mutch, Ronni Pile, Corinna Schalk, Dr. Nate Stephenson, and John Yurish.

Following a trial period of research method development and equipment testing permanent forest plots were established. In total, 45 circular forest plots were created (**Table 8** and **Fig. 14**), each 10 meters (32.8 feet) in radius. These were arranged in clusters around UTM intersections (1 km apart). The locations for the first plots were chosen based upon the likelihood of an area being burned during the summer/fall of 1996. Because fire management burn segments #4 and #10 were scheduled to be burned in 1996, plots were first established in these segments. Over the course of the summer, methods and equipment were significantly improved and the rate of plot establishment escalated.

***Remote imagery*** - As described above, high resolution digital, multispectral pictures of the watershed were taken in September 1996. The images require significant processing, including corrections for the seasonal variation of the amount of light striking the earth's surface, atmospheric distortion, and distortion caused by differences in topography. In addition, the individual photos need to be correctly referenced to their true position on the ground and linked to each other in a process called orthorectification. This process has been delayed due to a gap which appeared between two flight lines and a lack of processing time due to the doctoral qualification exams




# Mineral King Risk Reduction Project

## Landscape Analysis and Remote Sensing

Sampled Areas and Plot Locations

0 1 2 3 Miles
0 1 2 3 Kilometers
N

Figure 13.

**Table 8.** Plot locations in East Fork drainage.

| Segment | Plots established | Plots considered & rejected due to lack of trees or location outside segment | Total plots evaluated |
|---|---|---|---|
| 4 | 9 | 13 | 22 |
| 10 | 36 | 4 | 40 |
| **Total** | **45** | **17** | **62** |

required of the lead researcher. These images are currently being processed and analyzed. Supplemental imagery will be reflow over the watershed during June 1997 to correct a gap in the original imagery.

**Current Status: Development of Cases Studies:** Currently, efforts are underway to process and analyze field data and air photos from 1996. In order to test the methods laid out in the Mineral King Landscape Assessment two case studies are being performed. First, a landscape-level assessment of fire intensity in the Redwood Creek fire (segment #3 prescribed fire, Fall 1995) will attempt to use the remote air photos to delineate different intensities of fire which burned in the area. Second, a more local analysis in segment #4 will be conducted to examine the linkages between the high resolution, digital photos and the field data which were collected in a number of forest plots.

These two case studies will allow corrections to be made to the process before data from the entire mixed conifer belt of Mineral King are analyzed.

***Plans for 1997:*** In the summer of 1997 Kurt Menning will be accompanied in the field by undergraduate help from UC and a USGS biological technician. More field plots will be established throughout the mixed conifer belt of the watershed, pushing the total to about 200. The actual location of the plots to be established will be prioritized by the location and timing of areas to burn. No new remote imagery will be acquired until 1998, however, since there has been no burning inside the study area since the last air photos were collected.

# 5) Remote Sensing - Analysis of Red Fir Forest Using High Resolution Digital Images - University of California, Berkeley

Lead: David Newburn (graduate student at UC Berkeley)

A new project will be initialized for a master thesis during the summer of 1997 to investigate various components of red fir forest structure using portions of the digital imagery that has been collected for the "Landscape Analysis" project. Specific study objects are currently being developed but will involve field data collection for ground truthing and may use portions of the data being collected in the Pitcher plots and the fire effects monitoring plots.

# Wildlife Sampling

## 1) Wildlife Monitoring - Science and Natural Resources Management, SEKI

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

***Objectives:*** Wildlife monitoring efforts were initiated to evaluate fire effects from the MKRRP on selected mammal fauna. Primary effort was placed on small mammals because 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 (Werner 1996, see **Appendix 2** in (Caprio 1996) 1995 MKRRP Annual Report). Small mammal populations were sampled using two methods; 1) long-term monitoring of permanently marked areas, and 2) serendipity surveys of interesting and unique habitats. Long-term monitoring was designed to document changes in small mammal populations following fire under known specific conditions within the predominant vegetation types. Serendipity trapping was conducted to inventory species and their relative abundances as a means to make a large-scale assessment of fire effects.

***Long-Term Plots:*** Small mammal censusing during 1996 concentrated on two permanent plots, one established in 1995 near Atwell and the second a new plot in ponderosa/black-oak vegetation (**Fig. 15**). The new plot was located adjacent to the transition zone between conifer forest vegetation and chaparral/evergreen-oak vegetation.

The Atwell sequoia-mixed conifer plot, established prior to the burning of segment 3, was recensused (June 4 - July 19, 1996) and postburn vegetation resampled. Results show a substantially greater small mammal density in the postburn burn plot relative to the same plot preburn. Average postburn population density was 36 individuals (48 maximum) compared to an average of 15 individuals caught during preburn censusing. The predominant species present in the plot was ***Peromyscus maniculaus*** (deer mouse). One species caught during preburn trapping, ***Microtus longicaudus*** (long-tailed meadow vole), was not

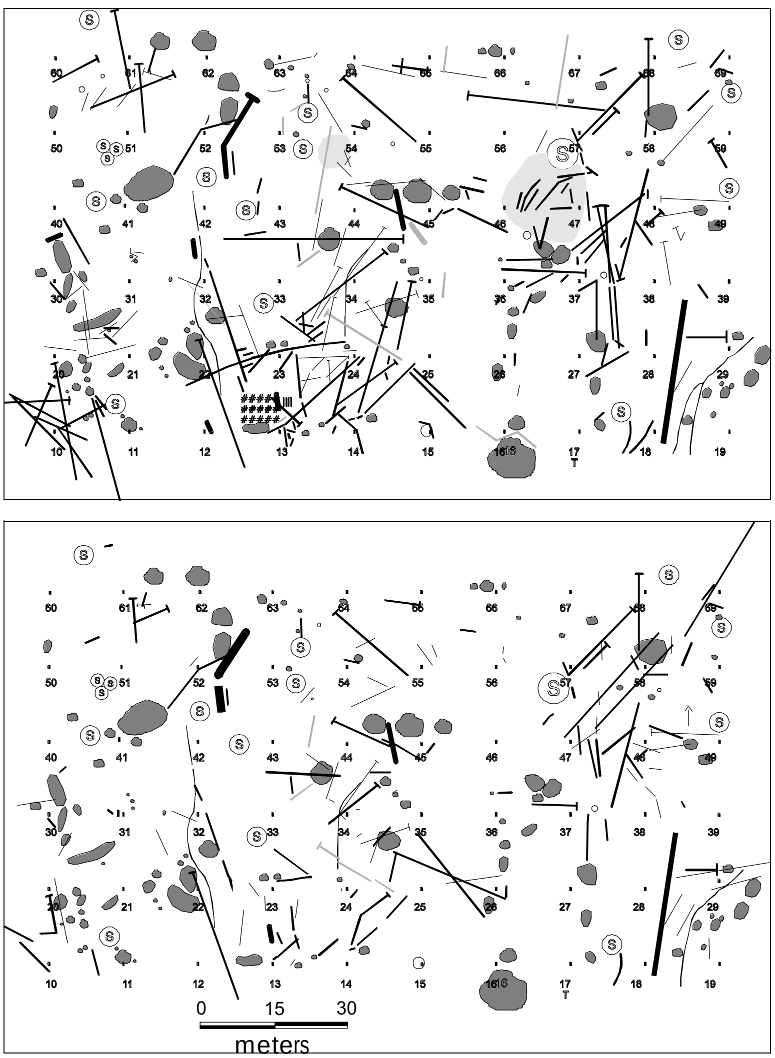



**Figure 16.** Maps of Atwell giant sequoia-mixed conifer small mammal plot pre (top) and postburn (bottom). Maps show trees (sequoia shown as circled S), rocks (dark shaded gray), litter (light shaded gray), logs, streams, and an old sequoia stake crypt.

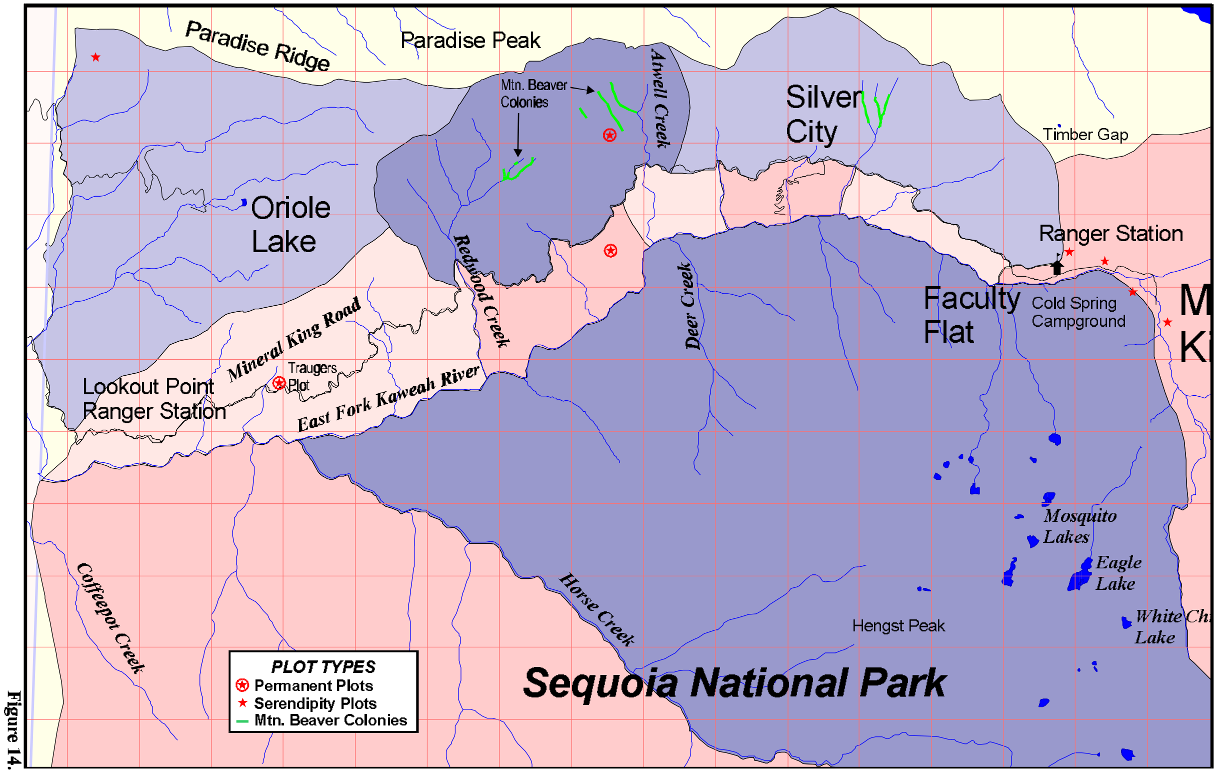



Figure 14.

# *Mineral King Risk Reduction Project*

## Wildlife Monitoring

Permanent Plots, Serendipity Plots, and Mtn. Beaver Colonies

0 1 2 3 Kilometers

0 1 2 3 Miles

N

caught postburn and one species, ***Peromyscus boylii*** (brush mouse), not caught preburn was caught during 1996. Mapping of log distributions showed much of the preburn log biomass to have been consumed but was being replaced by new material as trees fell following the burning (**Fig. 16**).

The new one hectare plot with 60 live trapping stations was located in westside ponderosa-pine forest with a mix of ponderosa pine (***Pinus ponderosa***), black oak (***Quercus kelloggii***), incense cedar (***Calocedrus decurrens***), sugar pine (***Pinus lambertiana***), white fir (***Abies concolor***), and canyon live oak (***Q. chrysolepis***). Understory vegetation was dominated by mountain misery (***Chamaebatia foliolosa***) and manzanita (***Arctostaphylos mewukki***). UTM coordinates for the plot center are 4035466 N and 349415 E. Average small mammal population density found during censusing (July 26 - Sept. 27, 1996) was 28 individuals (maximum 52). The predominant species present in the plot were ***Peromyscus maniculaus*** and ***Peromyscus boylii***. ***P. maniculaus*** preferred open areas dominated by bear clover (***Chamaebatia foliolosa***) while ***P. boylii*** was trapped more frequently in mesic areas with dense overstory canopies. Black bears were a major problem during trapping, disturbing and damaging the live traps.

***Serendipity Trapping:*** Trapping was carried out at several locations and in a variety of habitat types (**Fig. 15**). These included yucca scrub located north of Oriole Lake at between 1,600-1,800 m elevation(375 trap nights), xeric pine forest on the south aspect of Mineral King Valley above Faculty Flat at 2,310-2,380 m elevation (130 trap nights), subalpine meadow at about 2,390 m elevation (70 trap nights), and postburn trapping in chamise chaparral and blue oak woodland along the Sheppard Saddle Road following the Kaweah Fire (269 trap nights). Results of the trapping can be found in Werner (1996 - **Appendix 1**).

There was also some trapping (151 trap nights) carried out for medium sized mammals. This was primarily carried out in montane forest, but also included some subalpine and foothill vegetation.

***Mountain Beaver:*** The mountain beaver (***Aplodontia rufa***) colony on the east fork of Redwood Creek was revisited once and showed signs of postfire activity (Ray, pers. comm.). Similar postfire observations were made of the colony in the Atwell Creek portion of the grove during January 1996 (Caprio, pers. obs.). An additional new colony was also located above Silver City (**Fig. 15**) during 1996 and several new colonies were also found at other locations within the parks (Dorst Cr. and Grant Grove) since field crews were now experienced in what kind of features along creeks indicate mountain beaver presence (tunneling, hay-piles, cut branches on conifer/broadleaf saplings).

***Plans for 1997:***

1) Conduct postburn survey of the Atwell plot burned in November 1995.
2) Establish one more long-term monitoring plot. It will go into a lower subalpine environment (red fir forest, Jeffrey pine forest, green-leaf manzanita chaparral, or sagebrush scrub). If either the Trauger's chaparral plot or the ponderosa plot are burned they will be sampled in lieu of this.
3) Continue serendipity surveys in habitats not surveyed with long-term plots, in alpine/subalpine areas.
4) Revisit ***Aplodontia rufa*** colonies and record observations that may be fire related.
5) Continue development of a guide to wildlife environments.
6) Continue postburn sampling of the Kaweah Burn (chamise chaparral) if time permits.

# 2) **Bark-Foraging Bird Species** - University of Virginia

Lead: Todd Dennis; Advisors: T.M. Smith and H.H. Shugart

***Objectives:*** This research focuses on understanding several possible mechanisms that may limit bird species distributions and abundance (emphasis in this study is on the bark-foraging guild - some 14 species of woodpeckers, nuthatches, etc. that inhabit the west slope of the Sierra Nevada). Understanding the underlying function of these mechanisms is important for conserving species and determining locations of biological preserves. The study is being carried out by examining the population density distributions of the bark-foraging guild over an elevational gradient in temperate forest (Dennis 1996). Todd has collected measurements of abundance, foraging behavior, and habitat use to allow comparison of commonly proposed mechanisms of distributional limitation: environmental gradients, vegetation-zone ecotones, and interspecfic competition. Additionally, the interaction among these mechanisms will be examined to determine how autoecological and synecological factors effect distributional limits. Elevational transects run from slightly above treeline down to California oak-woodland vegetation. The bark-foraging guild was chosen for study because these species are good experimental candidates since their habitat requirements are amenable for quantification, they have stereotyped foraging behavior requiring smaller sample sizes, many species are sexually dimorphic permitting intergender evaluation of habitat differences, and the guild is poorly studied.

This project has been an unexpected bonus for research associated with the MKRRP. The park has been able to provide a relatively undisturbed setting for Todds to establish study transects across elevational gradients, something that he was unable to find in other areas of the Sierra Nevada due to considerable habitat fragmentation and disturbance. In turn this research is providing the parks with substantial information about bird species abundance, habitat information, and some preliminary data on how these relate to fire.

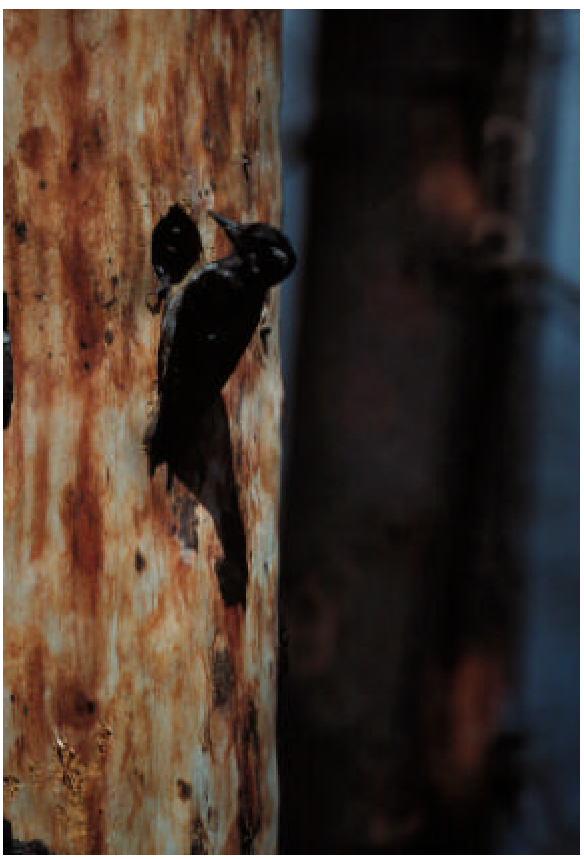


**Figure 18**. Black-backed three-toed woodpecker on burned lodgepole pine (photo taken in Yellowstone National Park - Tony Caprio).

***Field Work:*** Sampling during 1996 concentrated on elevational transects located in segment #10 (**Fig. 17**) although lower elevation oak-woodland species and vegetation was sampled in the vicinity of Ash Mountain and along the North Fork of the Kaweah. Foraging behavior of 14 species of scansorial birds were made with habitat observations were made in oak woodland, lower montane, upper montane, and sub-alpine habitats. Over 1000 foraging behavior plots were sampled along with some 570 descriptive vegetation/habitat plots. Estimates of relative abundance of the bark-foraging guild were made along eight elevational transects. Exploratory data analysis is currently being carried out. Field sampling during 1996 also included the examination of species within a number of recent burns in the drainage. A number of bark-foraging species were found that preferred these recently burned areas: northern flicker, white-headed woodpecker, hairy woodpecker, Williamson’s sapsucker, and black-backed woodpecker (**Fig. 18**), relative to unburned areas. The latter

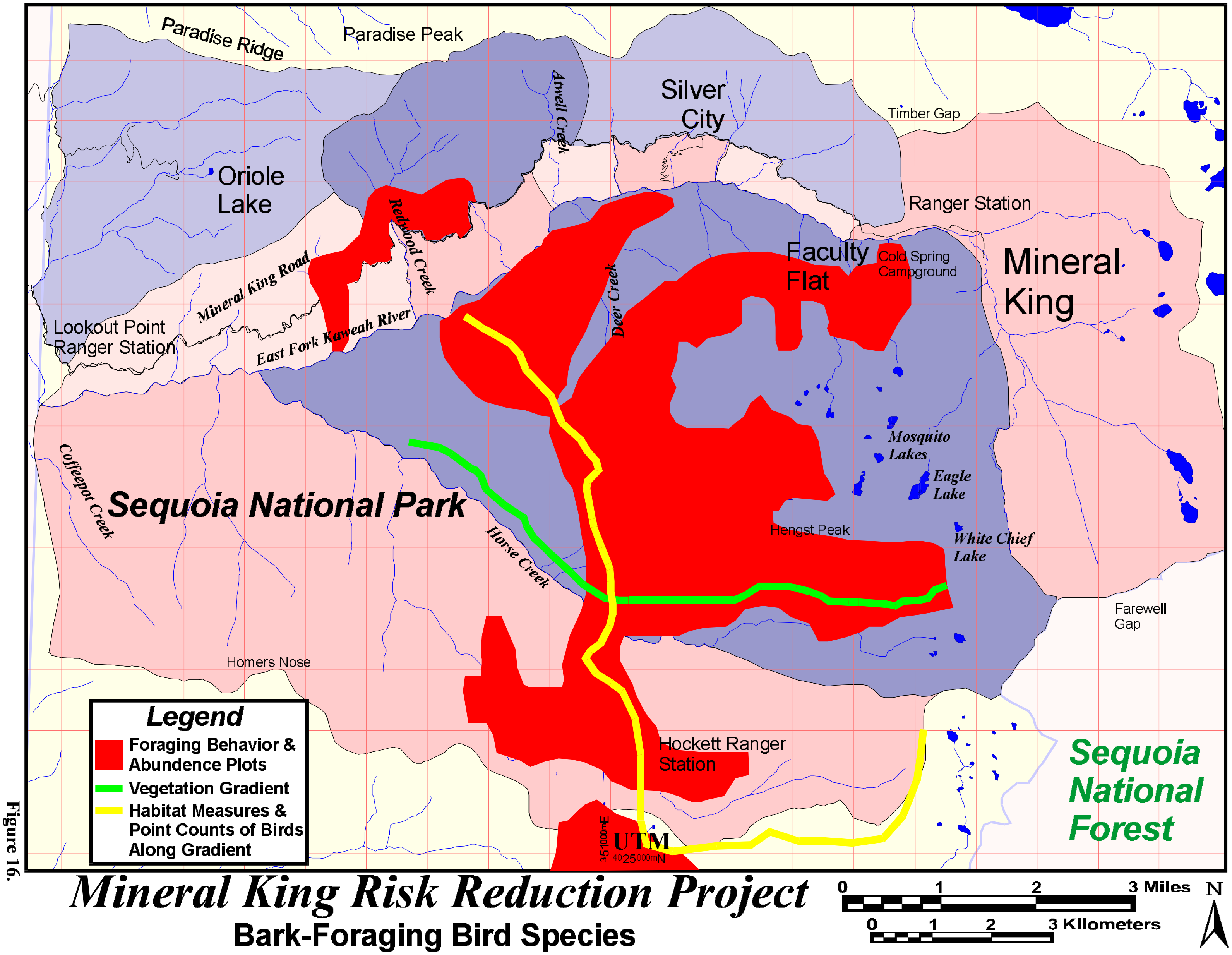



Figure 16.

# Mineral King Risk Reduction Project

## Bark-Foraging Bird Species

species (black-backed woodpecker) was only observed in recent burns which appear to be critical habitat for its presence. His data suggest that fire creates more habitat diversity, allowing better foraging opportunities and nesting locations.

***Plans for 1997:*** Additional field work will be carried out during a three week period in June. Direct gradient analysis of avian abundance and habitat structure and floristics will be begun. Todd would like to return to his study transects following burning of the area to examine the response bird populations to fire-induced habitat changes if funding is available.

# Watershed Sampling

## 1) Watershed: Stream Chemistry and Stream Hydrology - National Biological Service, SEKI Field Station

Lead: D. M. Graber, field-crew supervisor: C. Moore & L. H. Hammett (through June 1996), field-crew: J. Yurish, B. Johnson, A. Das, and V. Pile.

**Summary prepared by C. Moore.**

***East Fork Drainage:*** The East Fork study area is a large watershed that encompasses an elevation gradient extending from chaparral (1230 m) to alpine (>2770 m). The upper part of the watershed is comprised of seven alpine/subalpine sub-basins that make up 17 percent of the total acreage, but account for 40 percent of the peak runoff in the E. Fork (Black 1994). Although these sub-basins are not part of the study area, they contribute substantially to the hydrology and stream chemistry of the East Fork.

In addition to the East Fork of the Kaweah River, two first and second order tributaries on the north side of the drainage were chosen to study the fire effects on stream flow regime and chemistry (**Fig. 19**). No historic flow or chemistry data exist for these sub-catchments. Trauger's Creek and Deadwood Creek are the primary focus for the stream chemistry and hydrology study. Both tributaries appear to be perennial and partially spring fed. Their riparian areas are distinctly different as they are separated by an elevation difference of approximately 600 meters. Stilling wells, constructed of 10 inch diameter PVC pipe, enclose two pressure transducers and a thermistor at each site (**Fig. 30**). Flow data and temperature are recorded hourly on Omnidata portable data loggers. The data loggers were installed in February 1996. Weekly grab samples have been collected since May 1995 for chemical analyses. Additional sampling will occur during precipitation events. The macro-invertebrate study includes the primary streams, as well as four additional streams in the East Fork drainage (Slapjack, Redwood, Atwell and Silver City). Stream chemistry and flow data are collected for these secondary stream sites on a rotational basis. Weekly grab samples are also collected from the East Fork below Lookout Point.

**Primary Site Descriptions**

***Trauger's Creek*** is a low elevation (1400 m) with mixed chaparral/oak- woodland in a transition zone between the lower mixed conifer zone and the upper chamise chaparral zone. Vegetation includes 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 at Lookout Point, 2 miles west of the study site, with a Belfort Recording Rain Gauge operated by the National Park Service.

***Deadwood Creek*** is a mixed conifer forest (2000 m) environment characterized by white fir (***Abies concolor***), red fir (***Abies magnifica***), giant sequoia (***Sequoiadendron giganteum***), and incense cedar (***Calocedrus decurrens***). Precipitation measurements for this site are recorded at the Atwell Mill stables, approximately one mile west, by the Army Corps of Engineers. The Corps operates a remote access rain/snow gauge.

***Stream Hydrology:*** Data loggers went online at Deadwood and Trauger's Creeks in February 1996. We now have almost a complete year's worth of pressure transducer and


Figure 18.

# *Mineral King Risk Reduction Project*

## Watershed Studies

Stream Flow, Stream Chemistry, and Macro Invertabrates

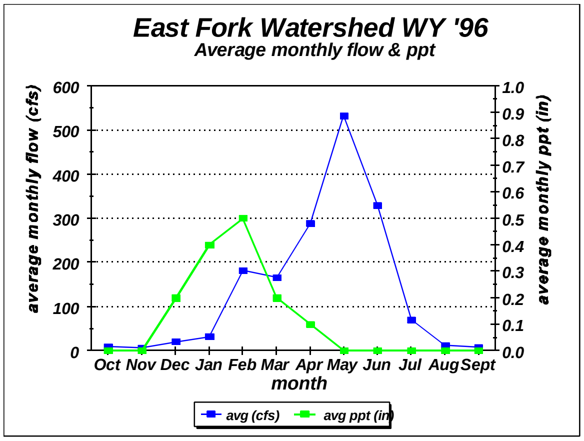



**Figure 20**. Average monthly precipitation (in) compared to average flow (cfs) in the East Fork Kaweah River. Flow data provided by Southern California Edison. Precipitation data provided by U.S. Army Corp of Engineers.

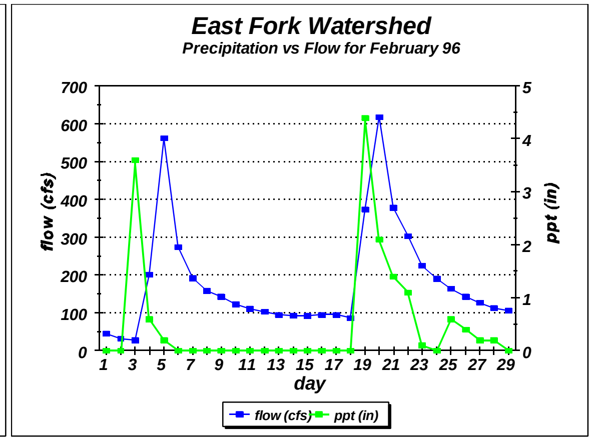



**Figure 21.** Daily flow (cfs) response to precipitation in East Fork Kaweah River for February 1996.

temperature data for both streams. While there were some equipment problems throughout the year, the data set is fairly complete. Presently, the Data Storage Modules (DSPs) are changed and downloaded weekly, which enables us to identify problems with sensors or the program. Jim Sickman, from UCSB, was instrumental in helping our research staff to troubleshoot both equipment and software problems.

The constant injection salt dilution method is being used to determine flow in the six East Fork streams in the study area. This method uses changes in conductivity to determine flow rates. The primary focus is on Trauger's and Deadwood Creeks, where the data loggers are located. Seven dilutions were completed on Trauger's, three summer flow and four winter flow. Five dilutions were completed at Deadwood, two summer flow and three winter flow. Additional salt dilutions will be conducted this winter ('97) and this information will be used to develop stage discharge curves for these streams and to develop daily flow records based on the data set from the data logger. Salt dilutions are being conducted on the other four streams in the study area as time allows to develop a rough estimate of flow. If there is good correlation between the priority watersheds and the secondary watersheds, flow estimates for the secondary watersheds will be more accurate.

Most of the precipitation falls as snow above 1850 m and is stored in the snow pack until temperatures warm up in the spring producing spring runoff, which peaks in early summer. While precipitation peaked in February (**Fig. 20**), with an average of 0.5 in. and a total of 15.1 in. (data provided by the U.S. Army Corp of Engineers from the Atwell precipitation site), peak runoff did not occur until May. Average flow varies greatly throughout the year with averages ranging from 10 cfs in the fall to >500 cfs during peak runoff. The river also responds to precipitation with local spikes in flow (**Fig. 21**) where daily flow is graphed with daily precipitation for February '96. There is a one to two day delay in flow response after a precipitation event, and then the flow returns to baseline levels.

**Table 9.** Precipitation totals in inches and centimeters for Mineral King stations in Sequoia National Park for WY 1995 and WY 1996.

| | Water Year 1995 | | Water Year 1996 | | Avg 1983-1995 |
|---|---|---|---|---|---|
| **Sites** | **inches** | **cm** | **inches** | **cm** | **inches** |
| Atwell | 61.0 | 154.9 | 44.8 | 113.8 | Not available |
| Lookout Point | Not available | ------------ | 30.9 | 78.4 | Not available |

Precipitation for Atwell and Lookout Point for WY 95 and WY 96 were summarized (**Table 9**). Atwell had a total of 44.80 in (U.S. Army Corp of Engineers). This was slightly above the long term average (period of record from 1966 to 1984) of 41 inches for Atwell. WY 96 was also the first year that precipitation data were available from Lookout Point. These data was collected from a Belfort gauge maintained by NPS staff. The first quarter of WY 96 was unseasonably dry, with no appreciable rainfall until December. Consistent winter and spring rains account for near normal totals.

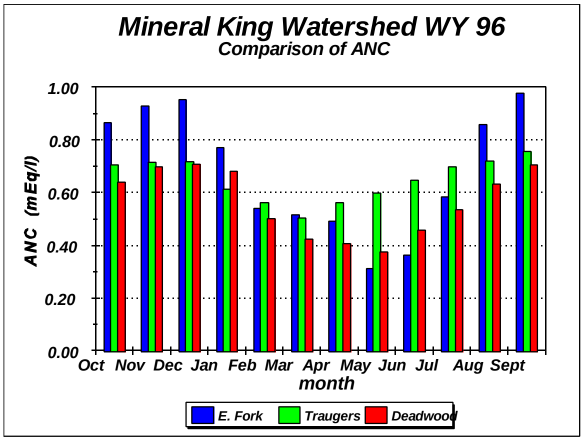



**Figure 22.** Comparison of ANC concentrations in E. Fork, Trauger's Cr. and Deadwood Cr.

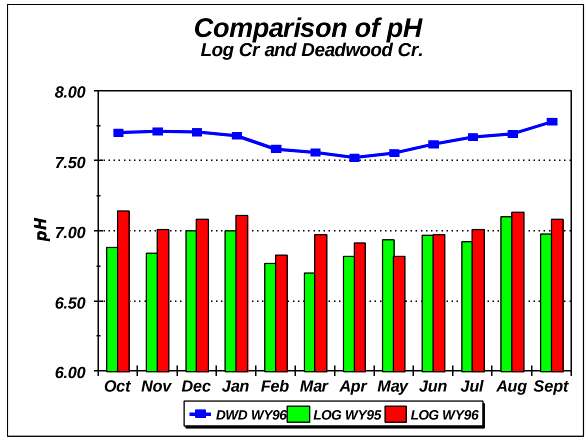



**Figure 23**. Comparison of Log Cr. (Control watershed) pH with Deadwood Cr.

***Stream Chemistry***: Acid neutralizing capacity (ANC) or alkalinity for the East Fork and the primary tributaries shows that the East Fork and Deadwood Creek have similar patterns in alkalinity concentrations in response to flow **(Fig. 22)**. Increased runoff in the summer months from snow melt results in a drop in summer ANC. In the winter months, the East Fork maintains the highest ANC, however in early spring there is a shift and Trauger's Creek ANC is greater. All three sites show a seasonal drop in ANC in February with increased flow, but Trauger's ANC recovered within a month, whereas the E. Fork and Deadwood didn't reach their low ANC until May, which was the peak month of runoff for the E. Fork this year. The quick recovery of Trauger's Cr. ANC is likely due to its low elevation and early meltout in the watershed. Trauger's Cr had the most consistent ANC concentrations ranging from 0.4 mEq/l to 0.72 mEq/l. E. Fork showed the greatest flux in ANC from 0.31 mEq/l to 0.97 mEq/l. Deadwood ANC flux fell in the middle with a range of 0.38 mEq/l to 0.71 mEq/l.

A comparison of pH reveals that the East Fork is better buffered than the Middle Fork areas that have been studied for many years (**Fig. 23**). Although there has been an overall increase in Log

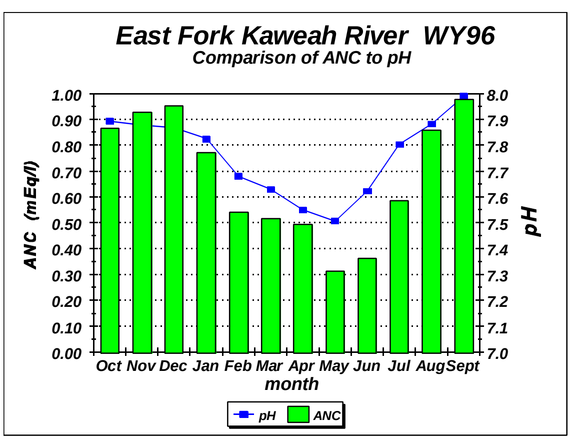



**Figure 24**. Comparison of alkalinity and pH in the East Fork.

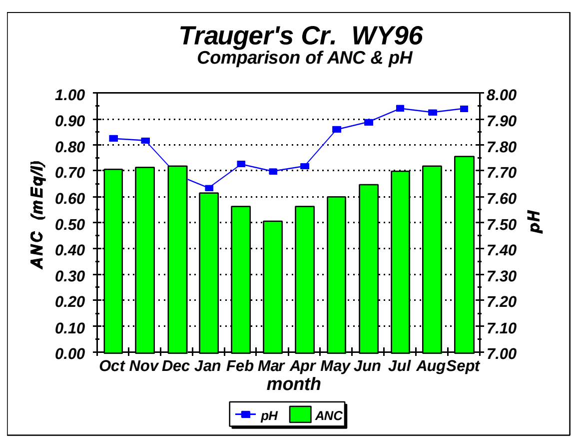



**Figure 25**. Comparison of alkalinity and pH in Trauger's Cr.

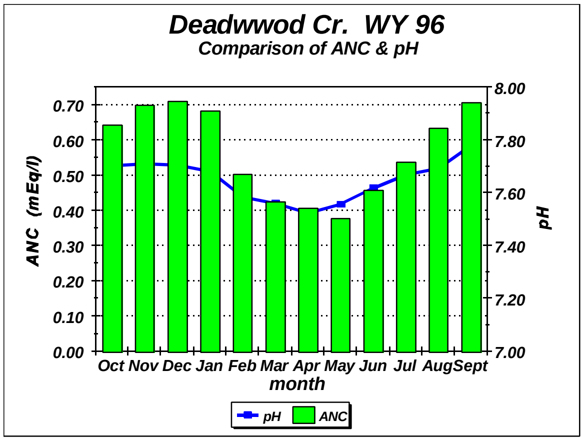



**Figure 26.** Comparison of alkalinity and pH in Deadwood Cr.

Cr pH in the last 10 years, Deadwood Cr. pH was consistently >7.5, while Log Cr. averaged <7.0. These data are based on 4 samples/month from Deadwood Cr., monthly samples (WY '96), and bi-weekly samples(WY '95) from Log Cr. pH values generally ranged from 7.5 during peak runoff to 7.8 during late summer flow. pH was consistently higher in Trauger's, which corresponds to the higher and more consistent ANC concentrations (**Fig. 24-26**).

The Southern Sierra Research Center Water Laboratory conducted chemistry analyses for ammonium ($NH_4^+$), phosphate ($PO_4^{2-}$), and silicate ($SiO_2$). Preliminary ion data ($Ca_2^+$, $Mg_2^+$, $K^+$, $Na^+$, $NO_3^-$, $SO_4^{2-}$, $Cl^{-,}$ $F^-$) analyzed at Ft Collins by Dr Stottlemeyer are available for Oct-Apr only. Dissolved Organic Carbon (DOC) analysis was added to the chemistry regime this year in an attempt to better understand the imbalance between anions and cations. This procedure is conducted at Michigan Technological University by the Toczydlowski lab.

$NH_4^+$ and $PO_4^{2-}$ concentrations differed by an order of magnitude in all three sample sites (**Fig. 27-29**). Phosphate was consistently present throughout the year with the highest concentration averages found in Deadwood Cr. (>0.5 mg/l) and the lowest in E. Fork (<0.1 mg/l). Ammonium concentrations were only present during the winter months, with concentrations ranging from 0.0003 mg/l in the E. Fork to 0.003 mg/l in Deadwood. Phosphate and ammonium showed little seasonal trend.

Ion analyses showed an imbalance of anions and cations. Cations exceeded anions for reasons that are not clearly understood. However, this is a phenomenon that exits in other Sierran watersheds (Stottlemeyer personal comm. 11/96). Calcium and sodium dominated the cation balance and were present in concentrations significantly greater that other

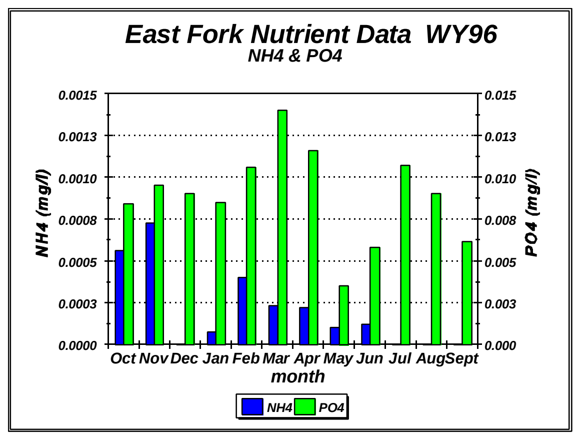



**Figure 27.** Comparison of NH4 and PO4 in East Fork.

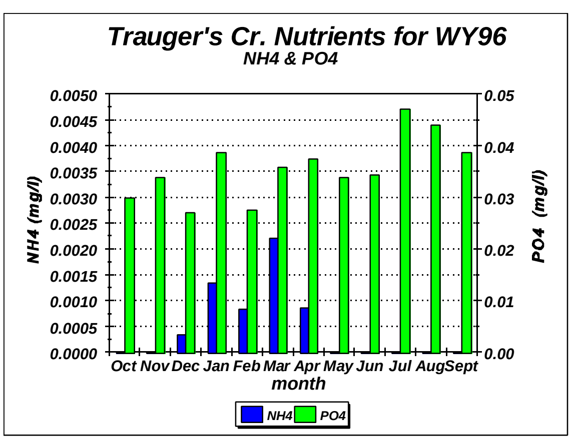



**Figure 28**. Comparison of NH4 and PO4 in Trauger's Cr

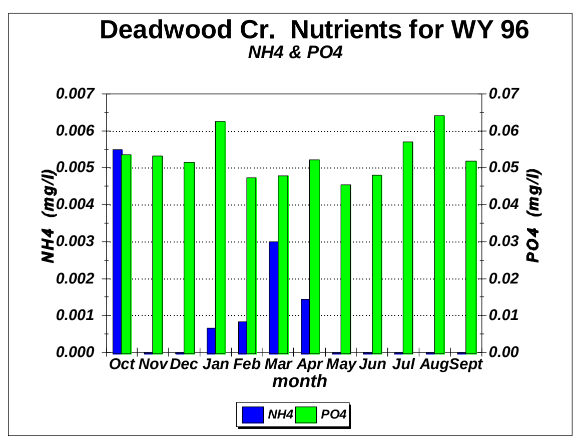



**Figure 29**. Comparison of NH4 and PO4 in Deadwood Cr.

**Figure 30**. Stilling well and staff gauge at Deadwood Creek, Atwell.

cation or anion constituents. While DOC does made up a significant portion of the anion balance, it did not account for the total discrepancy between anions and cations.

This year ended the first complete water year of chemistry data for the East Fork watershed. Since little work has been done in this area previously, additional data collection is needed to better understand the preliminary trends that were revealed from this year's data collection and analyses. These initial results showed similar responses to shifts in flow, pH and ANC when compared with other Sierran watersheds (Melack and Sickman 1995, Black 1994).

***Plans for 1997:*** Weekly sampling will continue, with the major focus on Trauger's and Deadwood Creeks and the East Fork sites. Rotational sampling will continue on the secondary watershed sites as time permits. Stage discharge curves will be developed for Trauger's and Deadwood and logger data will be converted into flow measurements. This will enable us to monitor how the creeks respond to precipitation events. More in-depth stream chemistry analyses will be completed to determine wet and dry season ranges in ionic solutes, and comparisons will be made with the Log Meadow prescribe fire watershed project.

Presently, we are planning a sediment project, which would be a cooperative project with UC Davis, and a nitrogen budget project, which would be a cooperative project with the Desert Research Institute in Reno, NV. These projects would start in late summer or early fall.

# 2) Watershed: Macro-Invertebrate Study - University of California, Davis

Lead: Ian Chan, Graduate Research Assistant, Department of Wildlife, Fish, and Conservation Biology at UC Davis under the study of Dr Don C. Erman and Dr. Nancy A. Erman: Co-Principal Investigators.

**Summary prepared by C. Moore.**

***Objectives:*** Biological monitoring of headwater ecosystems is an important component of understanding the dynamic linkages between hillslope and instream processes. As such, it represents an indispensable tool for watershed management. We are studying aquatic macro-invertebrate communities of tributaries of the East Fork Kaweah in the Mineral King area as part of larger-scale watershed monitoring efforts to assess the impacts of prescribed fire on park resources. Our research complements more traditional methods of physical water quality monitoring with information on the status of invertebrate assemblages. Such information is valuable as basic biological inventory. Other objectives of our work are to determine potential variation in biological communities resulting from fire management practices and to establish baseline information for use in future research applications. We are developing and testing quantitative and repeatable sampling methodology appropriate for small stream habitats in this area. These methods can be incorporated into long-term monitoring programs.

***Background*:** Macro-invertebrate collection began in September 1995. Six streams in Mineral King area (with completed or planned fire prescriptions) have been sampled intensively: Trauger's, Slapjack, Redwood, Atwell, Deadwood, and Silver City Creeks (**Fig. 19**). Four additional streams in the Giant Forest/Eagle View area were originally included as reference streams: Big Fern Creek, Log Creek, and Panther Creek Tributaries III and IV. However, three of these streams were subsequently dropped from sampling when the Park Service changed its burn schedule after we began the study. We decided to concentrate intensively on before-after sampling in the East Fork Project area. We have continued to sample only Log Creek outside of Mineral King. All streams are small first to third order, high-gradient tributaries with channels largely dominated by bedrock (granite) outcrops. Streams are typically sequences of cascades, plunge pools, short tailout riffles, and slickrock slides. Where substrate is not bedrock, sediments are fine granitic gravels and sands. All streams are relatively well shaded by a canopy of mixed conifers (mostly firs, pines and sequoias) or mixed oak/chaparral (at lower elevations) and a variety of riparian vegetation along the stream corridor.

**Figure 31**. Mayfly larvae (photo courtesy of UC Santa Barbara)

***Methods:*** Invertebrate methods require complementary benthic (larval) and emergent (adult) sampling (**Fig. 31**). Differences in timing and spatial distribution of larval and adult stages of aquatic insects necessitate benthic and emergence-trap sampling over different seasons in order to collect adequate representatives of the various taxa present at a particular site and to make species-level determinations. The small, steep, bedrock-dominated character of these streams posed a methodological challenge for quantitative sampling. Established methods and equipment were inappropriate for use in these habitats and had to be modified or replaced.

Benthic macro-invertebrates are collected through a combination of sampling methods in three microhabitat types: riffles, pools, and slickrock glides. Invertebrates are collected from small riffle areas using a modified (200 $cm^2$) Surber sampler. Pool areas are sampled by grab-sampling volumes of litter with a Nitex mesh dip net. Areas of slickrock habitats are scraped into a catch net to dislodge and retain clinging invertebrates. All samples are preserved in the field in 80% ethanol. Prior to laboratory sorting, samples are counter-stained with rose bengal to facilitate separation of invertebrate tissues from collected debris. Identification is made to the lowest practical taxonomic level (usually genus).

Adult stages are collected using one meter pyramidal emergence traps that have been used successfully in several other studies of small streams (**Fig. 32**). Traps are maintained throughout the year (conditions permitting). Collection usually proceeds on a weekly to biweekly basis.

Physical channel characteristics and surroundings are measured and described at each stream location. Temperature, pH, alkalinity, conductivity, and discharge are monitored as part of chemical water quality investigations (by BRD/USGS staff). Surveys of instream large woody debris, average insolation, and sediment substrates are also conducted.

Data analysis will follow conventional summary statistics of means and variance. Similarity of before-after and treatment-reference sites will be examined in this manner. Test hypotheses should accommodate comparisons between streams, habitat types, and fire treatments.

***<u>Progress</u>:*** In 1996 we changed our study design in response to several postponements by the Park in the burn schedule. Park decisions not to burn areas in our study drainages this year allowed us to sample streams in this target area more intensively. We have, therefore, focused our sampling on the six streams in Mineral King rather than using a previously considered extensive approach. Individual sites will now be directly compared before and after fire. Data collected up until the time of burning will serve to strengthen baseline information and help validate long-term monitoring efforts. Sites which have already experienced fire can be compared to adjacent, unburned sites (e.g., Atwell vs. Deadwood).

**Figure 32**. Pyramidal trap used to capture adult macro-invertebrates (photo by C. Moore).

We increased sampling intensity in 1996 to achieve improved statistical power. We used a stratified random design in which invertebrate assemblages from different habitat types are represented by a set of three random samples per stream. Additionally, each individual sample was collected as a composite of four subsamples. For example, four pool litter subsamples made up an individual pool habitat sample, and these were collected from three randomly-chosen pools in each stream. This benthic sampling effort was repeated for riffle and slickrock habitats. Benthic sampling was repeated once in spring/early summer and once in late summer/early fall. From each of the six Mineral King streams, nine samples (three from each habitat type) were collected in June and again during another round of sampling in late September. Log Creek in Giant Forest was also sampled with equivalent effort over the same period. Emergence trap sampling has proceeded continuously since April 1996 and will continue year-round as conditions permit.

Field surveys of physical channel characteristics were also based on a random design. Sediment cores were collected from three randomly chosen pool sites in each Mineral King stream in October. At the tail of each pool, three 5 centimeter deep cores (each 10 cm in diameter) were excavated by hand and retained for analysis. This was repeated at three pool sites per stream. Bed surface sediments were sampled using the pebble count method in a randomly chosen pool and riffle in each stream. Fine sediments appeared more frequently in Redwood and Atwell Creeks which were burned in Fall, 1995.

Solar radiation was measured at three randomly spaced points along each stream using a Solar Pathfinder. Average insolation values were calculated on a monthly and yearly basis.

Large woody debris was surveyed in all six Mineral King streams this November. All pieces of at least 10 centimeters diameter and 1 meter length within the bankfull channel were measured for volume. The length of channel surveyed was determined by the distance required to count 50 pieces. In addition, orientation and origin (where possible) were recorded for each piece.

***<u>Plans for 1997</u>:*** Collection of aquatic insects will continue through fall 1997. Sorting and identification of invertebrate samples is proceeding currently. Processing of benthic samples should be completed by spring, 1997. Compilation and interpretation of this and other data represents the bulk of work for the remainder of 1997. An important part of this process will be supported by cooperation with USGS staff incorporating physical and biological data with existing geographic information on watersheds in the study area. He will finish up his field season this summer and begin writing his thesis in the fall. His study will describe the pre-burn aquatic macro-invertebrate populations at each of the six watersheds. Presently, there are no plans to continue the project to include a post-fire evaluation. However, this project will be pursued as it will add valuable data to the watershed project.

# Fuels Inventory and Monitoring - Resources Management, SEKI

Lead: C. C. Conover, field-crew supervisor: D. Yemm; field crew: M. Buhler, L. McNeilus, T. Schwend, and J. Sevier

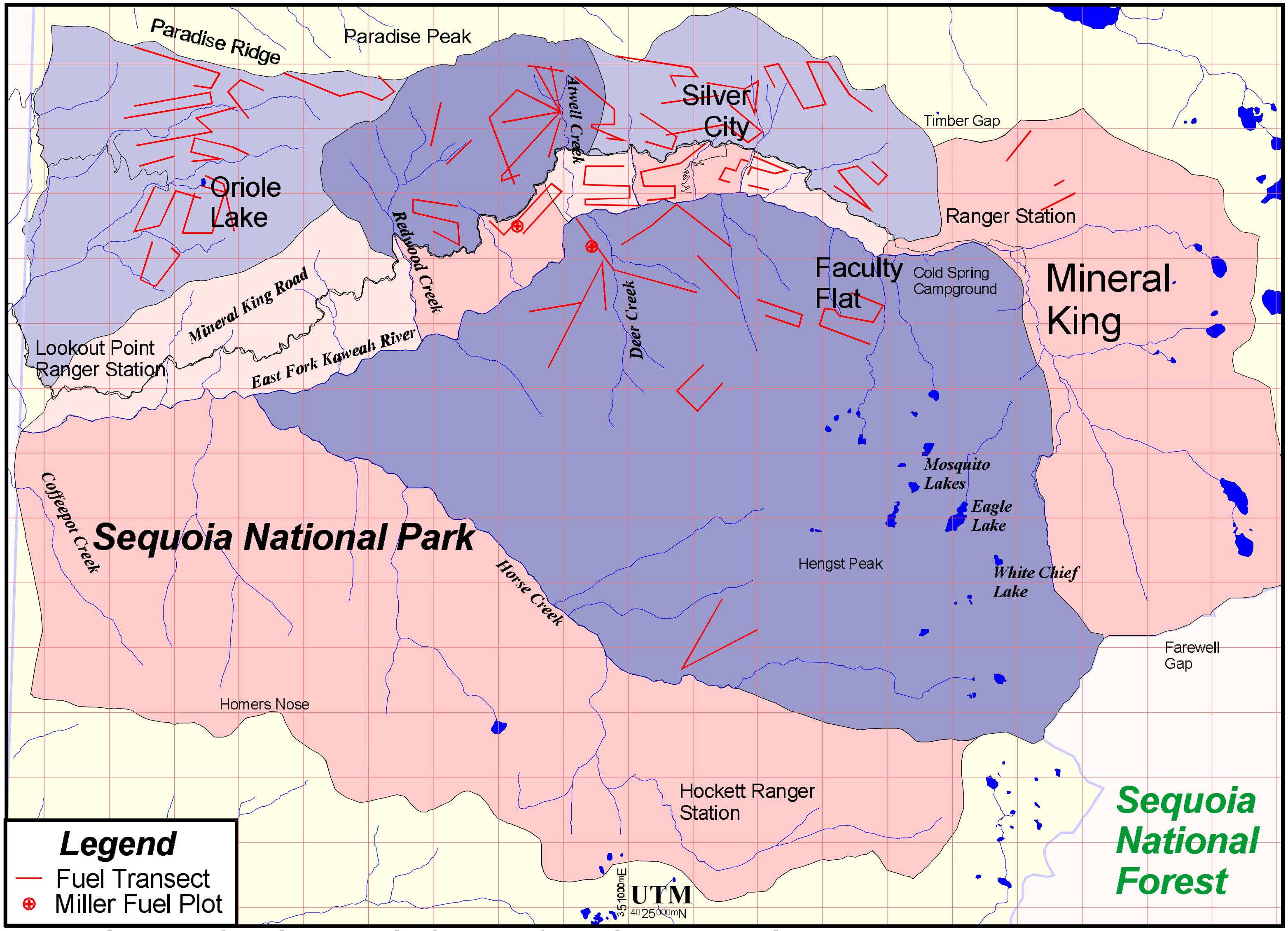
***Objectives:*** The objectives of the inventory is to improve our GIS fuel maps which are critical to providing more accurate fuels data for use in the FARSITE, a program for modeling fire behavior and spread. This program will in turn be used to model fire events in the watershed and to assess the cost of the prescribed burn project versus potential wildfire suppression costs. Because FARSITE relies on GIS fuels data for its modeling, it is essential that a more accurate fuel theme for the East Fork be developed. Additional attribute data that is being collected for the modeling effort includes tree height, height to live crown base, and basal area.

***Summary Fuel Loadings & Forest Stand Data:*** The following information is summarizes data collected during the summers of 1995-96. The information was collected from the forested areas on the north side of the East Fork of the Kaweah during 1995 and the upper portions of the drainage on the south side in 1996 (segment #10).

In 1995 a four person crew was hired specifically to collect the fuel loading and forest stand data. In 1996 there was one position hired from Mineral King Risk Reduction Project funds to collect fuels information, with this person assigned to the parks' prescribed fire monitoring crew. The crew worked as a group collecting fuels data in the East Fork watershed when they were not assigned to monitoring fires. Because the 1996 fire season was very busy with a considerable number of wildfires and prescribed natural fires the crew was required to be away from Mineral King for much of the summer. However, even with the busy fire season, the prescribed fire monitoring crew collected data from 113 sample points (**Fig. 33**). The crew also collected data from two permanent fuel plots (Miller Plots) in the drainage (**Fig. 33**), one located in a south aspect ponderosa pine forest (UTM 4035660 N, 349310 E, elevation 1850 m) and the other in a north aspect pine forest (UTM 4035200 N, 350540 E, elevation 1760 m). The fuels and forest stand data collected the last two years has been summarized (**Table 13 and 14,** Note: The maximum and minimum data are by individual fuel category for all sample points in each table (so the total is the highest/lowest total fuel loading found and not the summation of that row) and used to create five new custom fuel models (**Table 10 and 11**) for he East Fork that will be used for future fire spread modeling with FARSITE. Data are presented by forest type and elevation range (**Table 12**). The elevation ranges were broken into three categories: low, mid and high. The elevation categories are vegetation-based with a 1000-foot adjustment between south and north aspect to account for aspect differences (fuels on south aspects are more typical of fuels 1000 feet lower on north slopes). Elevation classes are as follows; low elevation #6500 Feet (south aspect) or #5500 feet (north aspect), mid elevation >6500 to #8000 feet (south aspect) or >5500 to #7000 feet (north aspect), and high elevation >8000 feet (south aspect) or >7000 feet (north aspect). The forest types used were pine, fir and sequoia. The fir type occurred in all three elevation ranges with red fir only in the higher range. The pine and sequoia types only occurred in the low and mid elevation ranges. There are three optional GIS layers supported by the latest version of FARSITE: tree heights, height to live crown base, and crown bulk density. These layers all relate to crown fire activity (torching, spotting, and crowning). The data collected from the Mineral King Risk Reduction Project could be

**Table 10**. Custom fuel models.

| Model # | Description |
|---|---|
| 14 | Low elevation short needle conifer |
| 15 | Low elevation pine |
| 16 | Mid elevation short needle conifer |
| 17 | Mid elevation pine |
| 18 | High elevation fir |




# Mineral King Risk Reduction Project

## Fuel Load Sampling

Figure 32.

**Table 11.** Summary of five new custom fuel models developed for FARSITE modeling.

| Category | Value | | | | | Units |
|---|---|---|---|---|---|---|
| **Fuel Model Number** | **14** | **15** | **16** | **17** | **18** | **Integer** |
| 1 Hour | 2.84 | 2.91 | 3.32 | 2.26 | 2.19 | Tons/acre |
| 10 Hour | 1.10 | 0.27 | 1.20 | 0.20 | 0.77 | Tons/acre |
| 100 Hour | 4.70 | 3.68 | 3.37 | 2.98 | 5.91 | Tons/acre |
| Live Herbaceous | 0.00 | 0..20 | 0.00 | 0.00 | 0.00 | Tons/acre |
| Live Woody | 6.15 | 7.37 | 2.78 | 4.35 | 3.32 | Tons/acre |
| 1 Hour | 2000 | 3000 | 2000 | 2750 | 2000 | Surface/Volume Ratio |
| Live Herbaceous | 190 | 3000 | 0 | 0 | 0 | Surface/Volume Ratio |
| Live Woody | 1500 | 1500 | 1500 | 1500 | 1500 | Surface/Volume Ratio |
| Fuel Bed Depth | 0.5 | 0.7 | 0.3 | 0.5 | 0.2 | Feet |
| Heat Content | 8000 | 9000 | 8000 | 9000 | 8000 | BTU/LB |
| Moisture of Extinction | 30 | 25 | 30 | 25 | 30 | Percent (%) |

used to create a first draft of the tree heights and height to live crown base GIS layers. This would entail reclassifying the new fuels layer with the average values from these three options for each fuel model, or the data could be looked at spatially and compared to the existing vegetation layer, and reclassified on a polygon by polygon basis.

***Plans for 1997:*** The one fuels position that is funded from the Mineral King Risk Reduction Project will again be attached to the prescribed fire monitoring crew. When not assigned to fires, the main objective for the crew will be the collection of fuels and forest stand data on the south side of the East Fork of the Kaweah as part of the Mineral King Risk Reduction Project. The initial emphasis will be to complete the work begun in 1996 in segment #10. Additionally, during the 1997 field season the crew will also begin establishing permanent fuel loading sampling points. The purpose of these sampling points is to track changes in fuel loadings and fuel characteristics over time. A minimum of ten permanent sampling points will be established in each distinctive fuel type for each of the three elevation ranges described above (low, mid and high).

**Table 12**. Average tree heights and height to live crown base for main vegetation types (Note: The height to live crown base takes into account ladder fuels so the heights given above are heights to the lowest layer, not to the crown base of the over story).

| Vegetation Description | Tree Heights (m) | Height to Live Crown Base (m) |
|---|---|---|
| Low Elevation Fir | 35.4 | 1.2 |
| Low Elevation Pine | 35.5 | 0.7 |
| Low Elevation Sequoia | 46.1 | 1.7 |
| Mid Elevation Fir | 41.6 | 0.7 |
| Mid Elevation Pine | 41.7 | 0.7 |
| Mid Elevation Sequoia | 46.7 | 0.8 |
| High Elevation Fir | 36.5 | 0.5 |

Table 13. Summary of fuel load data (tons/acre) for the main vegetation types by elevation.

**High Elevation Fir (ABMA):**

| N=120 | 1 hr. | 10 hr. | 100 hr. | 1000 hr. | Litter | Duff | Total |
|---|---|---|---|---|---|---|---|
| Avg. | 1.2 | 0.8 | 2.9 | 5.5 | 4.2 | 8.6 | 23.5 |
| Max. | 4.2 | 2.8 | 11.4 | 30.0 | 14.7 | 57.8 | 100.0 |
| Min. | 0.4 | 0.3 | 0.5 | 0.0 | 0.0 | 0.5 | 3.0 |

**Mid Elevation Fir (ABCO & ABMA):**

| N=115 | 1 hr. | 10 hr. | 100 hr. | 1000 hr. | Litter | Duff | Total |
|---|---|---|---|---|---|---|---|
| Avg. | 1.5 | 1.0 | 3.1 | 5.9 | 5.3 | 10.2 | 27.7 |
| Max. | 3.6 | 2.4 | 10.0 | 15.0 | 17.0 | 56.2 | 78.4 |
| Min. | 0.6 | 0.4 | 1.0 | 0.0 | 0.0 | 0.0 | 5.0 |

**Low Elevation Fir (ABCO):**

| N=42 | 1 hr. | 10 hr. | 100 hr. | 1000 hr. | Litter | Duff | Total |
|---|---|---|---|---|---|---|---|
| Avg. | 1.6 | 1.1 | 4.7 | 7.4 | 4.8 | 11.8 | 32.1 |
| Max. | 3.6 | 2.4 | 10.0 | 32.0 | 15.8 | 44.4 | 68.3 |
| Min. | 0.6 | 0.4 | 1.0 | 0.0 | 0.8 | 0.0 | 5.8 |

**Mid Elevation Pine (PIPO & PIJE):**

| N=27 | 1 hr. | 10 hr. | 100 hr. | 1000 hr. | Litter | Duff | Total |
|---|---|---|---|---|---|---|---|
| Avg. | 1.5 | 0.2 | 3.0 | 4.6 | 3.1 | 11.9 | 24.3 |
| Max. | 4.3 | 0.6 | 8.7 | 12.0 | 8.5 | 44.5 | 69.3 |
| Min. | 0.4 | 0.1 | 0.5 | 1.5 | 0.9 | 1.3 | 8.4 |

**Low Elevation Pine (PIPO):**

| N=168 | 1 hr. | 10 hr. | 100 hr. | 1000 hr. | Litter | Duff | Total |
|---|---|---|---|---|---|---|---|
| Avg. | 1.9 | 0.3 | 3.7 | 7.7 | 3.9 | 11.9 | 29.3 |
| Max. | 8.0 | 1.1 | 12.3 | 28.5 | 16.9 | 68.4 | 97.3 |
| Min. | 0.4 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 3.1 |

**Mid Elevation Sequoia (SEGI):**

| N=94 | 1 hr. | 10 hr. | 100 hr. | 1000 hr. | Litter | Duff | Total |
|---|---|---|---|---|---|---|---|
| Avg. | 1.5 | 1.0 | 3.4 | 5.0 | 6.3 | 11.2 | 28.2 |
| Max. | 4.8 | 3.2 | 9.3 | 16.0 | 16.9 | 35.5 | 71.7 |
| Min. | 0.3 | 0.2 | 0.5 | 0.0 | 0.8 | 0.0 | 4.6 |

**Low Elevation Sequoia (SEGI):**

| N=10 | 1 hr. | 10 hr. | 100 hr. | 1000 hr. | Litter | Duff | Total |
|---|---|---|---|---|---|---|---|
| Avg. | 1.6 | 1.1 | 4.6 | 7.6 | 4.9 | 11.6 | 31.2 |
| Max. | 3.0 | 2.0 | 9.0 | 20.0 | 10.9 | 31.9 | 70.8 |
| Min. | 1.2 | 0.8 | 2.0 | 2.0 | 0.7 | 0.4 | 14.1 |

**Table 14.** Summary of stand information by vegetation type and elevation.

**High Elevation Fir (ABMA) Stand Info.:**

| N=120 | BA (m²/ha) | Overstory DBH.(cm) | Overstory Ht.(m) | Ht. to Overstory (m) |
|---|---|---|---|---|
| Avg. | 39.8 | 94.9 | 36.5 | 7.1 |
| Max. | 96.0 | 158.0 | 58.0 | 24.5 |
| Min. | 12.0 | 29.2 | 23.6 | 0.4 |

**Mid Elevation Fir (ABCO & ABMA) Stand Info.:**

| N=115 | BA (m²/ha) | Overstory DBH(cm) | Overstory Ht.(m) | Ht. to Overstory (m) |
|---|---|---|---|---|
| Avg. | 39.1 | 84.9 | 41.6 | 9.7 |
| Max. | 120.0 | 166.5 | 69.6 | 25.4 |
| Min. | 9.0 | 28.4 | 16.3 | 0.3 |

**Low Elevation Fir (ABCO) Stand Info.:**

| N=42 | BA (m²/ha) | Overstory DBH.(cm) | Overstory Ht.(m) | Ht. to Overstory (m) |
|---|---|---|---|---|
| Avg. | 35.3 | 68.7 | 35.4 | 11.4 |
| Max. | 81.0 | 115.1 | 62.6 | 21.8 |
| Min. | 11.0 | 29.0 | 17.4 | 0.7 |

**Mid Elevation Pine (PIPO & PIJE) Stand Info.:**

| N=27 | BA (m²/ha) | Overstory DBH(cm) | Overstory Ht.(m) | Ht. to Overstory (m) |
|---|---|---|---|---|
| Avg. | 32.3 | 67.2 | 31.9 | 8.9 |
| Max. | 66.0 | 118.2 | 57.0 | 28.6 |
| Min. | 9.0 | 21.2 | 12.6 | 1.0 |

**Low Elevation Pine (PIPO & PIJE) Stand Info.:**

| N=168 | BA (m²/ha) | Overstory DBH (cm) | Overstory Ht.(m) | Ht. to Overstory (m) |
|---|---|---|---|---|
| Avg. | 33.5 | 65.2 | 35.3 | 10.6 |
| Max. | 87.0 | 138.0 | 94.0 | 28.0 |
| Min. | 3.0 | 11.6 | 8.4 | 0.9 |

**Mid Elevation Sequoia (SEGI) Stand Info.:**

| N=94 | BA (m²/ha) | Overstory DBH (cm) | Overstory Ht.(m) | Ht. to Overstory (m) |
|---|---|---|---|---|
| Avg. | 39.1 | 98.1 | 46.6 | 9.6 |
| Max. | 112.0 | 303.1 | 91.3 | 32.1 |
| Min. | 12.0 | 32.8 | 22.9 | 0.5 |

**Low Elevation Sequoia (SEGI) Stand Info.:**

| N=10 | BA (m²/ha) | Overstory DBH (cm) | Overstory Ht.(m) | Ht. to Overstory (m) |
|---|---|---|---|---|
| Avg. | 29.1 | 114.0 | 46.1 | 15.3 |
| Max. | 45.0 | 180.0 | 60.9 | 24.4 |
| Min. | 4.0 | 54.2 | 31.8 | 6.9 |

# Remote Sensing: Fuel Loading and Vegetation Classification - Arizona State University

Lead: M. Brookins and W. Miller

**Summary of the report prepared by W.H. Miller and M. Brookins**

***Objectives:*** The need for more efficient methods of resource monitoring is universal throughout various resource management fields. One method used for this type of monitoring is remote sensing techniques. The purpose of this study in the East Fork drainage was to demonstrate the versatility of remote sensing technology for the collection of fuels data for use in fire management planning, and to aid in the development of a comprehensive vegetation classification for the Mineral King region of Sequoia & Kings Canyon National Parks (Miller 1996; Miller and Brookins 1997). In order to accomplish these goals the following objectives were established.

1. The development of a vegetation classification scheme for the Mineral King region of SEKI using Landsat thematic mapped (TM) data.
2. Development of a fuel loading classification by vegetation class for the Mineral King region of SEKI using a combination of remote sensing data and ground truth data.

***Methods and Data Collection:*** The study being undertaken involves three parts: initial image processing and remote vegetation classification; ground verification of the classification output of the initial image processing, ie. the collection of habitat information including fuel loading;

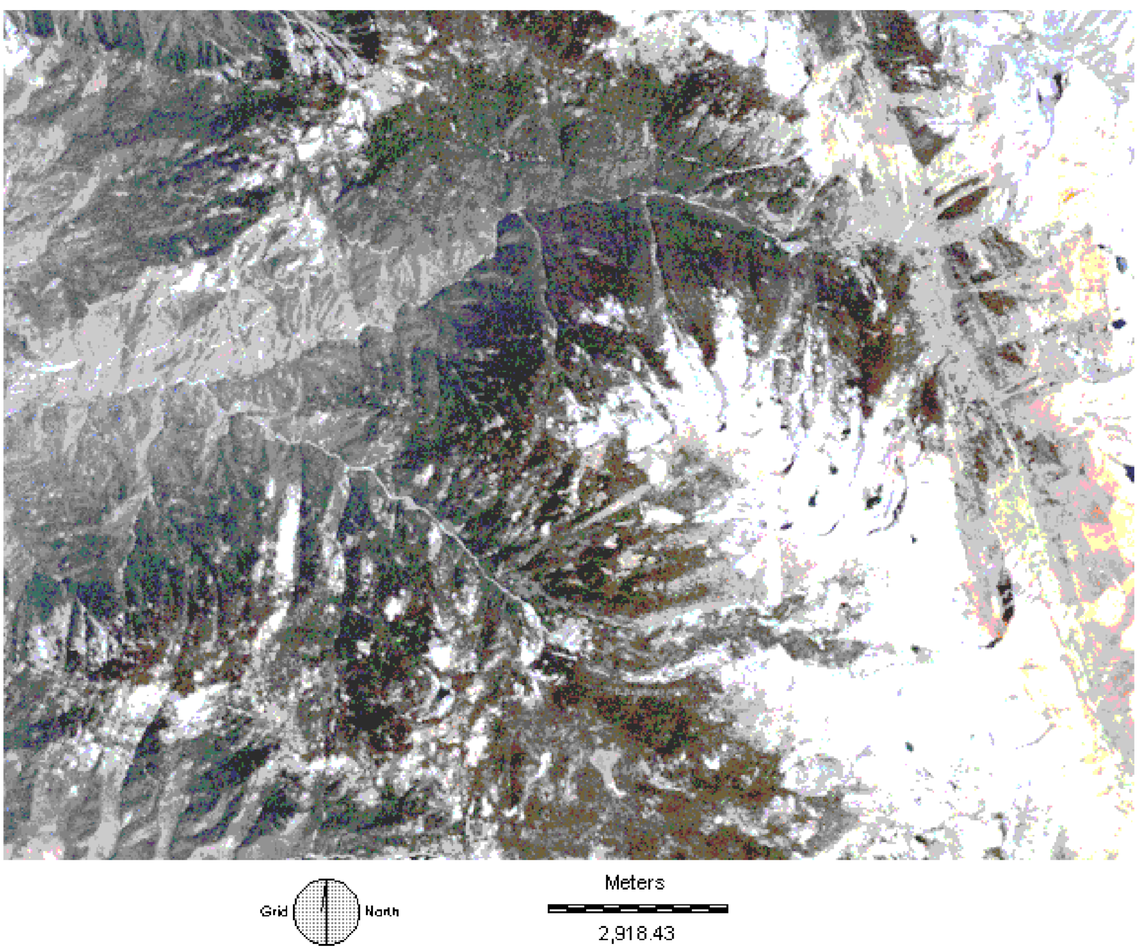



**Figure 34.** Color composite of the Mineral King study area using July 1992 Landsat TM bands 1,2,&3.

and third, the integration of these data into a procedure for producing a fuel loading classification by vegetation class.

**Image Processing**

Digital image processing of Land Sat thematic mapped data (satellite TM scene from July 29, 1992) provided by SEKI was carried out to develop an unsupervised classification of the Mineral King region of the SEKI. Feature extraction was performed using principal component analysis (PCA), with those bands having >95% of their spectral properties present in a higher band discarded. For the purpose of unsupervised classification, a series of images were produced which would be used for evaluating a potential classification scheme of the study area. These images included: color composite (Bands 1,2, and 3) (**Fig. 34**), a n-IR color composite (Bands 2, 3 and 4), pseudo IR composite (Bands 3, 4, and 5)(**Fig. 35**), a PCA composite (PCA1, PCA2, and PCA3)(**Fig. 36**), and a normalized difference vegetation index (NDVI, [Band 4-Band 3/Band 4 + Band 3])(**Fig. 37**). The correlation matrix of the PCA analysis used in producing the pseudo IR composite (Bands 3,4,5) carried >95% of the spectral information contained in the data set. As a result of this PCA procedure a new composite image was produced (PCA composite) which accounted for 99.7% of he spectral data in he individual bands. The unsupervised classification procedure used allowed for a broad classification of the spectral image. The resulting images were evaluated and reclassified to account for possible aspect influences on spectral characteristics.

Output of the unsupervised classification of the color composite, pseudo color infrared, and the NDVI images failed to produce an adequate number of classes to represent the possible variation in vegetation types present in the Mineral King study area. The PCA composite, on the other hand,

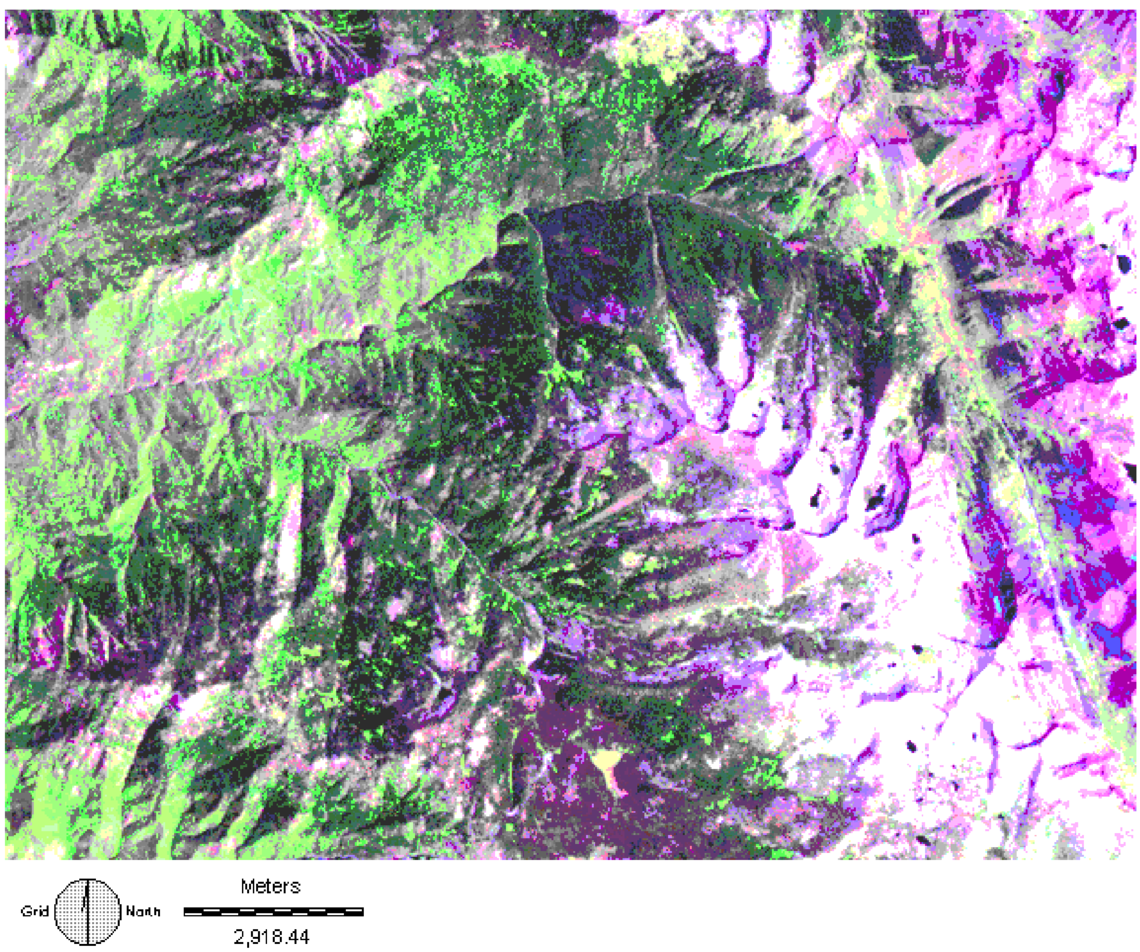



**Figure 35**. Pseudo color infrared composite image (TM bands 3, 4, and 5) of the Mineral King study area, Sequoia National Park

produced 15 different classes within the study area (**Fig. 38**). Analysis of the relative amount of area accounted for by the resulting classification indicated that classes 9-15 accounted for approximately 173 ha. (0.7%) of the total 26,080 ha. analyzed. Further examination of the image indicated that all eight of these classes were found at high elevation, and were most likely associated with bare rock. The exact classification of the first eight classes is unknown, and will require ground verification for accurate identification.

However, some preliminary observations on the characteristics of the unsupervised classification are possible. It is our general impression that classes 1-4 constitute the coniferous vegetation types, with class 1 being those area with the highest density, and class 4 with the lowest density. Classes 5 and 6 are most likely associated with the chaparral/shrub communities within the Mineral King area, and classes 7 and 8 represent the more herbaceous communities.

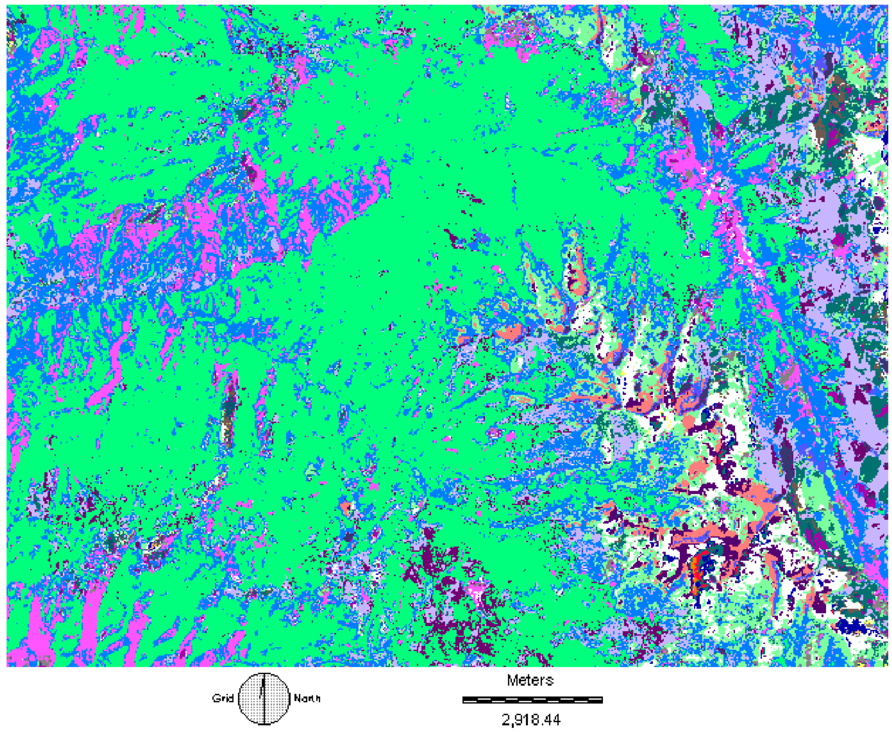



**Figure 36**. Composite image from principal component analysis using PCA images 1, 2, and 3 for the Mineral King study area, Sequoia National Park.

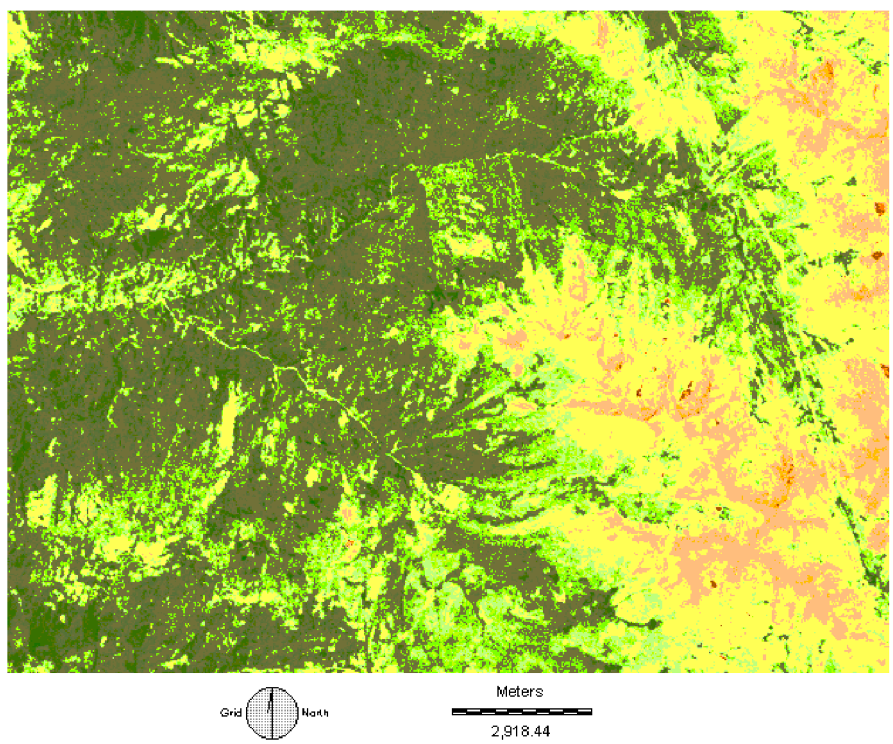



**Figure 37**. Normalized difference vegetation index for the Mineral King study area, Sequoia National Park.

## Ground Data Collection

Following the development of an acceptable unsupervised classification, a stratification procedure was used to select 200 randomized plot locations within the designated study area. The number of plots in each potential vegetation type was proportional to the relative amount of each class. Each plot was located using a GPS. Data on the general characteristic of each plot was collected at the center of the plot. This data included:

percent slope (inclinometer), aspect, elevation (from topographic map), relative position on slope, vegetation type, and canopy cover (densiometer).

Vegetative data collected were divided by canopy layer. Overstory and shrub story density were recorded by species using a 0.025 hectare (25m X 10m) plot macro-plot. The direction of the macro-plot was randomly chosen using the second hand of a watch. Overstory density data were recorded by growth stage (mature, > 25 cm DBH; pole, < 25 cm > 2.5 cm DBH; and seedlings < 2.5 cm DBH. Shrub data recorded in the macro-plot was total density by species. Additionally, tree data were individually collected and included: species, diameter at breast height (DBH), total height, crown position, and live or dead. Shrub cover was measured using a 25 m line intercept located along the midline of the macro-plot. When a shrub species was encountered along this line, additional measurements taken included: height, and width along two axes of each shrub. Herbaceous data was collected using four 20 cm X 50 cm micro-plots located at 5, 10, 15, and 20 m along the midline of the macro-plot. Data in each micro-plot was recorded by species and included: density, cover, and mean height.

Fine fuels data were collected using a modification of the NPS system, with four 50 foot transects oriented at random directions starting at 5, 10, 15, and 20 m along the midline of the macro-plot. Data collected along each transect included the number of hits on fuels (1-0.25 in, 0.25-1 in, 1-3 in, > 3 in solid, > 3 in rotten), and litter and duff depth at 5 foot intervals along the transects. Upon completion of each plot a photograph was taken along the length of the macro-plot.

Not all ground truthing plots were sampled during the summer of 1996 because of the extreme terrain in the study area, and the complexity of the data collection procedure. The maximum number of plots that could be collected per day was two or three. This severely limited the amount of data that could be collected, and required that sampling be concentrated in a small area of the study area during 1996 (**Fig. 14**).

## Data Integration

This portion of the research will involve the statistical analysis of the ground data collection, and correlation of the results with the imagery processing in step one. One of the primary methods to be used in this phase will be cluster analysis to determine if there are any natural groupings of data. The resulting clusters will be further correlated with the imagery data to determine potential for wildfire risk evaluation. Much of the procedures to be used in this phase are currently under review, and the exact procedures to be used will be dictated by the nature of the data produced and collected in the image processing and field data collection portions of the study.

Principal component analysis was performed on bands 1-5, bands 6 and 7 were not used because of errors in the data upon import. The correlation matrix from PCA indicated that bands 3, 4, and 5 carried > 95% of the spectral information contained in the data set (**Table 15)**. Based on this analysis a composite image of bands 3, 4, and 5 was created and included as a potential image in the unsupervised classification of the study area.

As a result of the PCA procedure a series of new images were produced. These images are based on the output of the PCA eigenvectors and are designed to account for the amount of variability found in the spectral data. In this case PCA image 1 accounted for 90.48% of the spectral variation, with PCA images 2 and 3 accounting for 5.72 % and 3.52 % respectively. By combining these three images a PCA composite accounted for 99.72 % of the spectral data found in the

| Landsat Spectral Bands | Landsat Spectral Bands | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 1.00 | 0.99 | 0.98 | 0.63 | 0.86 |
| 2 | 0.99 | 1.00 | 0.99 | 0.65 | 0.90 |
| 3 | 0.98 | 0.99 | 1.00 | 0.62 | 0.91 |

**Table 15**. Correlation matrix from principal component analysis of five bands of thermatic data from the July 1992 landsat coverage.

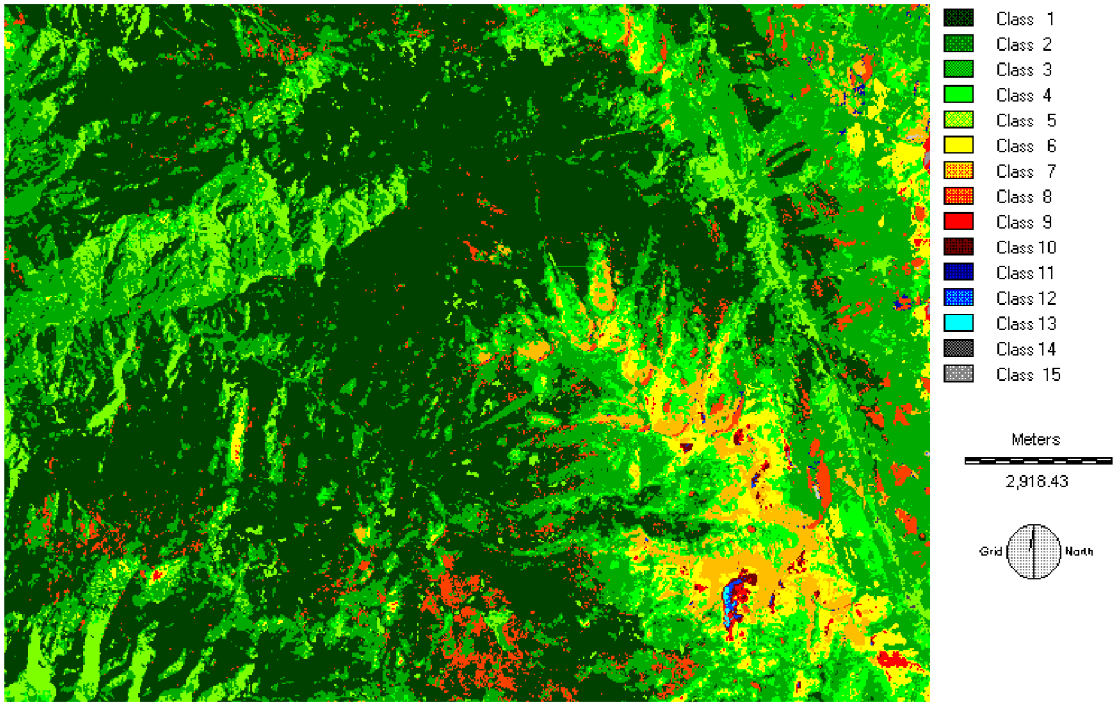



**Figure 38**. Unsupervised classification using the composite PCA image for the Mineral King study area, Sequoia National Park.

individual bands. The resulting composite PCA image (**Fig. 38**) was then used as one of the images evaluated for use in the unsupervised classification procedure.

***Implications and Plans for 1997:*** The preliminary results of vegetation classification based on this first years effort appear very promising. Field work to collect additional data from ground truthing plots will continue during the summer of 1997 with field work beginning in mid-June. An earlier start for field sampling (sampling began in mid-July during 1996) should greatly increase the number of plots sampled during 1997.

# Fire History - Science and Natural Resources Management, SEKI and Biological Resources Division of the USGS, SEKI Field Station

Lead: A.C. Caprio, field help by M. Buhler, A. Das, A. Peterson,, and J. Sevier

***Objectives*:** The goal of this data collection effort is to obtain information on the spatial extent of pre-Euroamerican fires on a watershed scale (fire size, spread patterns, and frequency variation) and to acquire data on pre-Euroamerican fire regimes from the wide array of vegetation types withing the watershed. Little or no information currently exists for the Sierra Nevada on fire at a scale that encompasses tens of thousands of acres of varying slope, aspect, vegetation type, and elevation. Sampling will begin 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. 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 in addition to providing baseline data on past fire frequency and size in the East Fork Watershed. Additionally, 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 eventually be important in verifying these models.

***Field Work and Data Collection*:** Sampling during 1996 concentrated on burn segments in the East Fork in which burning was planned during 1996 (segments 2,4, & 10). Within these segments emphasis was placed on three general sampling locations: lower and higher elevation conifer sites, and sites on north aspects. Lower sites either bordered chaparral/evergreen oak vegetation or where isolated pockets of (islands) pine forest or stringers of pine forest along drainages (see Dieterich and Hibbert(1990) for similar study in Arizona chaparral). Throughout the summer and fall 108 specimens (logs, stumps, snags, or trees) were collected from segments #2, #4, #5, and #10 (**Fig. 40**). All specimens are being dendrochronologically crossdated to determine precise calender years (**Fig. 39**) in which past fires occurred (Stokes 1980).  Sample preparation and preliminary crossdating have been started on samples from most sites.

Additional fire history samples from the area of the three Pitcher plots, originally sampled in 1979 by Pitcher (1981, 1887), were collected during 1996.  These new samples permitted the fire history for the area to be extended back into the late 1400s at plots #1 and #2 and late 1500s at plot #3 (**Fig. 41**). This will provide better estimates of fire return intervals in red fir forest located on a north aspect, a vegetation type for which little pre-Euroamerican settlement fire history information exists. These data have already been utilized in the initial stages of developing a GIS/fire planning model for the parks (Lineback et al. 1997).

These collections have supplemented and added to previous work that was previously carried out in the watershed (Swetnam et al.1992; Caprio and Swetnam 1995).  Data from some of these new collections have

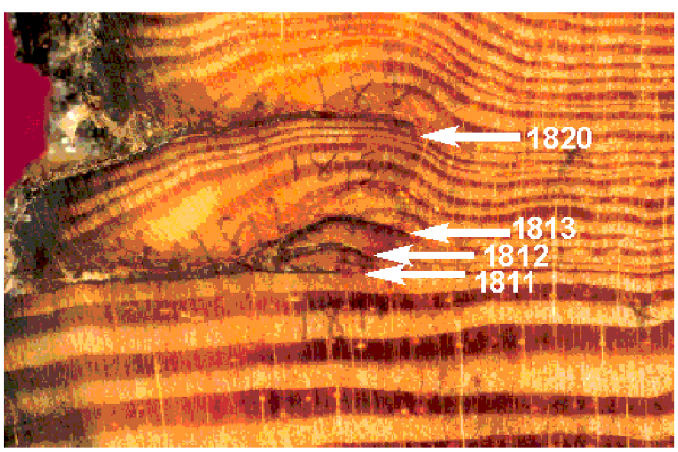
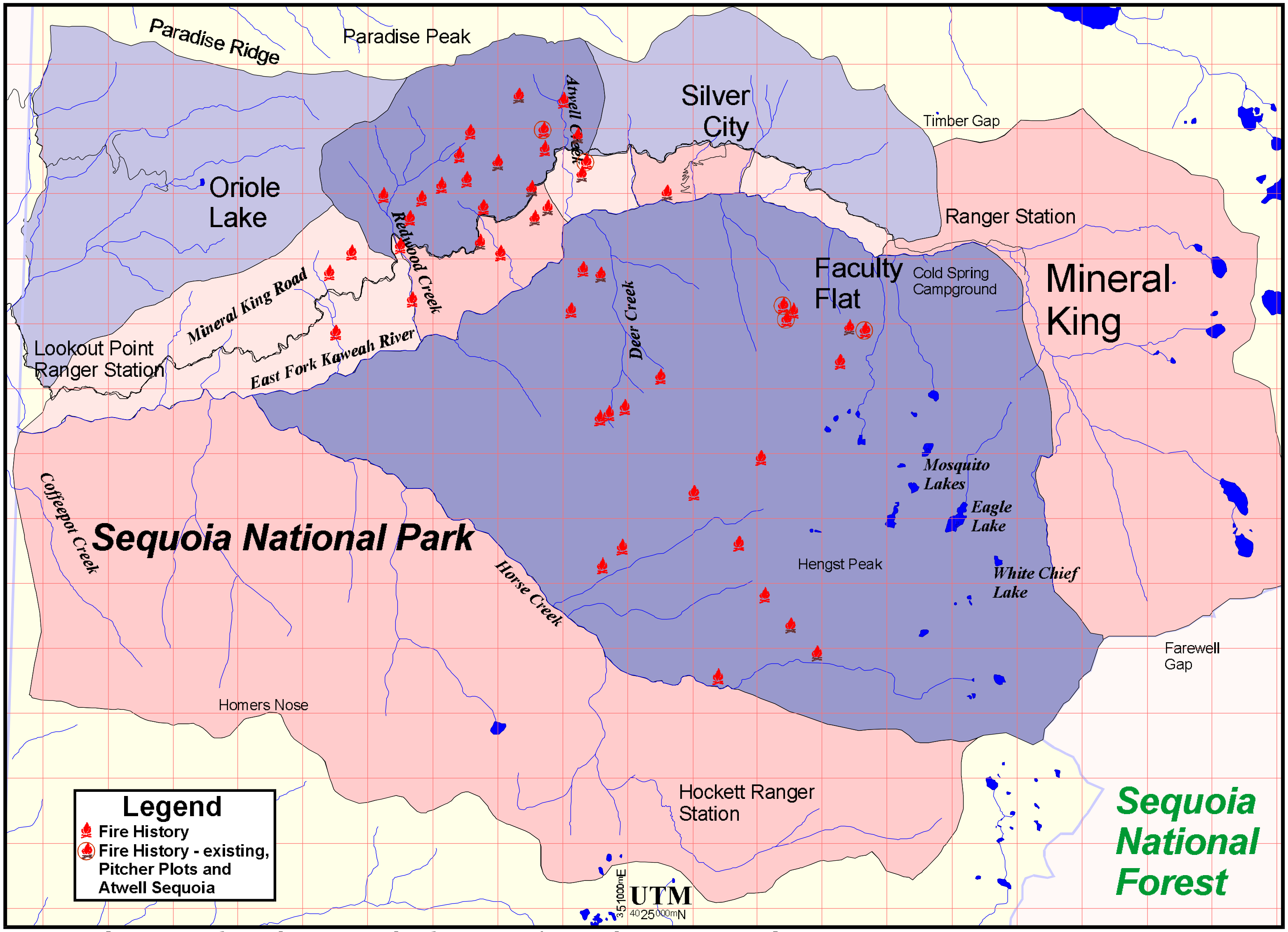



**Figure 39**. Example of fire scars from a ponderosa pine. The sample is unusual in having several consectuative year dates (all dates were confirmed by other nearby trees).

Figure 39.




# *Mineral King Risk Reduction Project*

## Fire History Sampling

been used as input into the GIS/Fire model being developed for Sequoia and Kings Canyon National Parks (Lineback et al. 1997). Some of the 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.

Preliminary inspection of the data set has begun. Patterns of past fire occurrence are beginning to emerge within the watershed as more sites are collected and crossdated from a broad

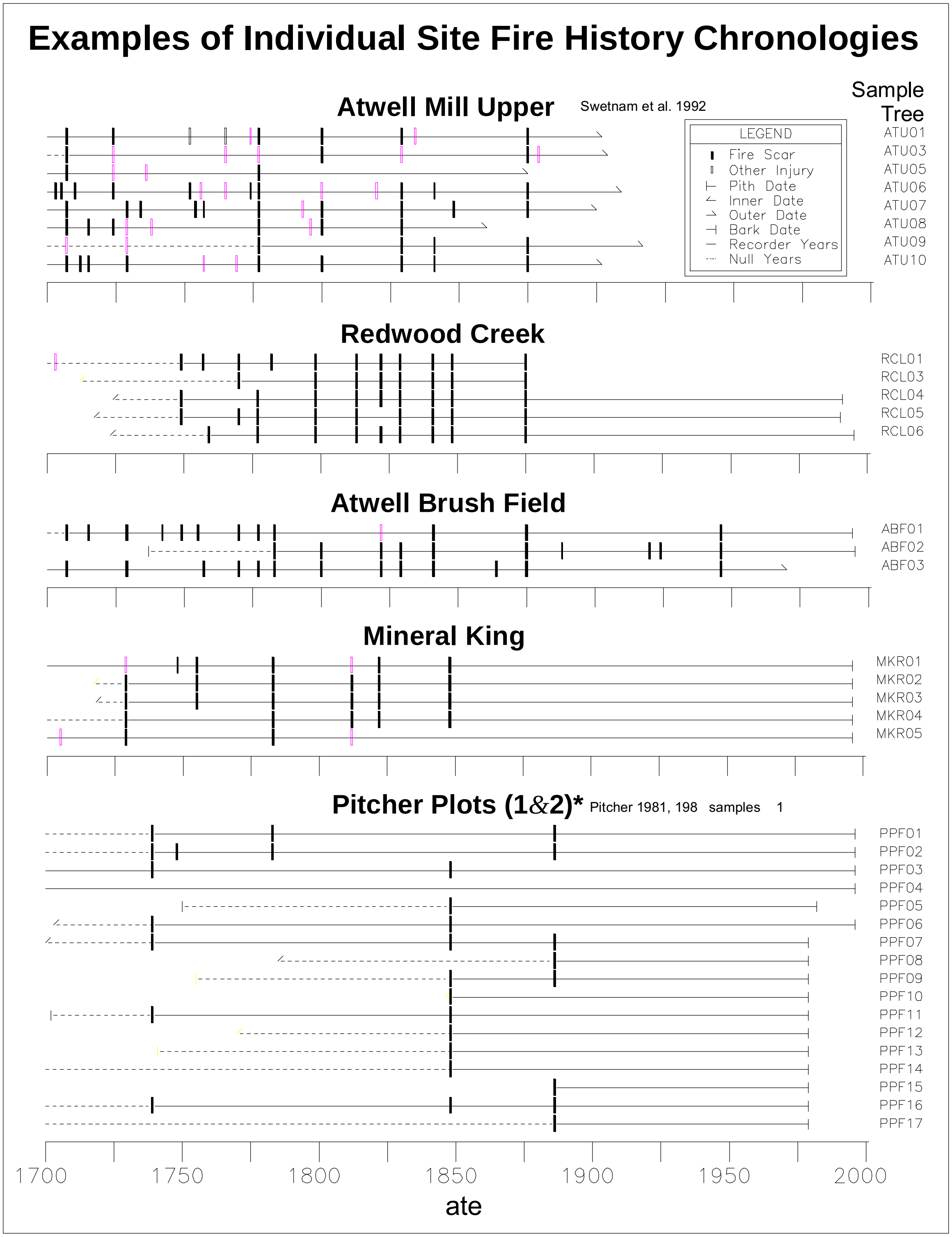



**Figure 41**. Examples of reconstructed fire history data from five sites in the East Fork drainage for the period from 1700 to the present. Sites illustrate varying pre-Euroamerican fire regimes from differing vegetation types and aspects in the watershed. Horizontal lines represent a particular sample (one tree) with vertical bars indicating crossdated fire dates.

array of areas in the watershed are obtained. However, considerable additional collection effort needs to be carried out in some of the more remote areas of the drainage to obtain a clearer picture of fire at the watershed level. Because of the remoteness of some of these areas sampling density may be lower than in areas with easier access.

***Plans for 1997*:** Sampling will continue during 1997 as time permits and resources are available. It will concentrate on segments scheduled for burning during 1997 and 1998 and on locations having a north aspect (no dendrochronologically dated fire history reconstructions exist from the southern Sierra for such sites). Also of interest are upper elevation red fir, lodgepole and western white pine forests where some stand replacing burns may have occurred in the past. A small number of sites will also be sampled in the Oriole Lake drainage to provide information on how fire dates in this subdrainage of the East Fork relate to other portions of the watershed.

# Resampling of the Pitcher Plots - Science and Natural Resources Management, SEKI

Lead: A.C. Caprio, field help by: A. Das, D. Haskamp, G. Indinoli, P. Mulligan, A. Peterson, V. Pile, C. Schalk, and J. Yurish,

***Objectives***: In the late 1970s 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 to forest fire). These plots were relocated in 1995 and are now being resampled prior to the burning of segment #10 (**Fig. 40**). 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. Change in the plots between 1978 and 1996/7 will provide information on the direction of vegetation change the plots were undergoing prior to burning, such as whether they were stable or undergoing transition. This background information will help us understand and interpret immediate fire effects once the plots are burned and long-term effects as we monitor future postfire vegetation changes. Postburn sampling of these plots will also provide detailed information on forest changes and fire effects which have been little studied in this forest type. The detailed spatial data (tree locations, fuel loads) will also provide an excellent opportunity to examine changes over time and fire effects at a degree of sophistication not usually available.

***Field Work and Data Collection*:** The area where the plots are located was scheduled to be burned during 1996 but was delayed due to the severity of the 1996 fire season. Segment #10 is again scheduled to be burned during 1997 although again conditional on the severity of the fire season and final decisions about priorities for burning other segments in the East Fork. Considerable field data were recollected in the plots during 1996, the first sampling since 1978. To facilitate relocation of the plots for future work UTM positions were obtained using a PLGR (**Table 16**).

**Table 16**. 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 |

We were very fortunate to be able to locate Donald Pitcher (who originally sampled the plots in 1978 for his masters thesis at UC Berkeley (Pitcher 1981)) in Anchorage, AK (thanks to the information provided by Dr. Ron Wakimoto at the Univ. of Montana) and contact him about obtaining a copy of his original data for the plots. We were also fortune in that he still possed a printed copy of the data (the original data was on punch cards and could no longer be read) which he sent us. Being able to use this data will greatly facilitate comparisons between the original sampling and the current sampling, since we will have the exact measurementsand locations for trees from the original

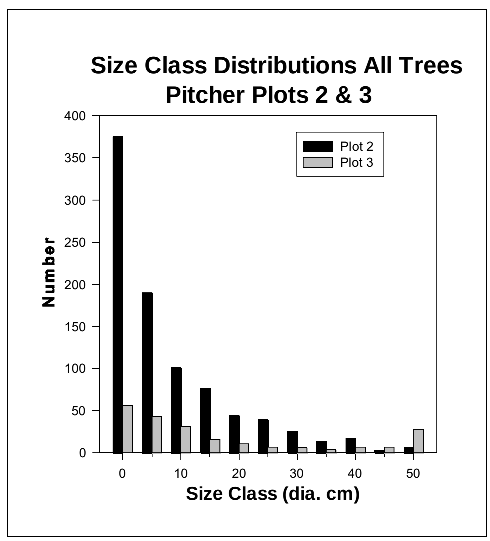



**Figure 42**. Size class distribution of all trees by plot in 1996.

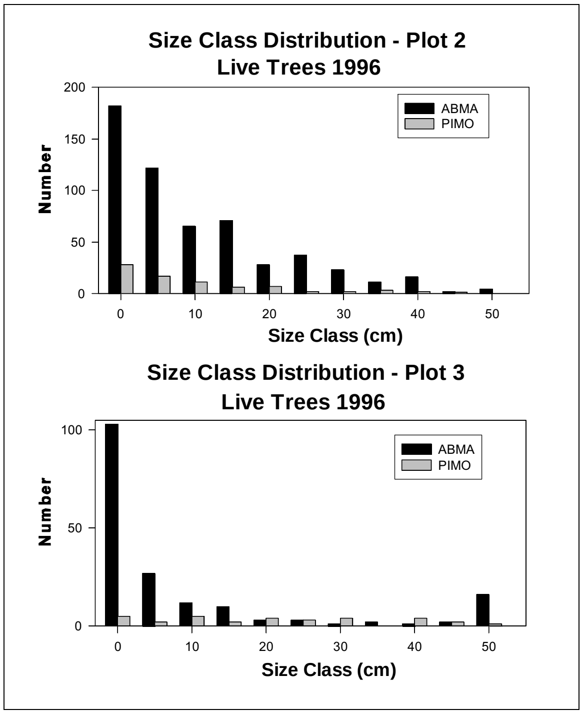



**Figure 43**. Size class distribution by species for diameter of trees in plots #2 and #3.

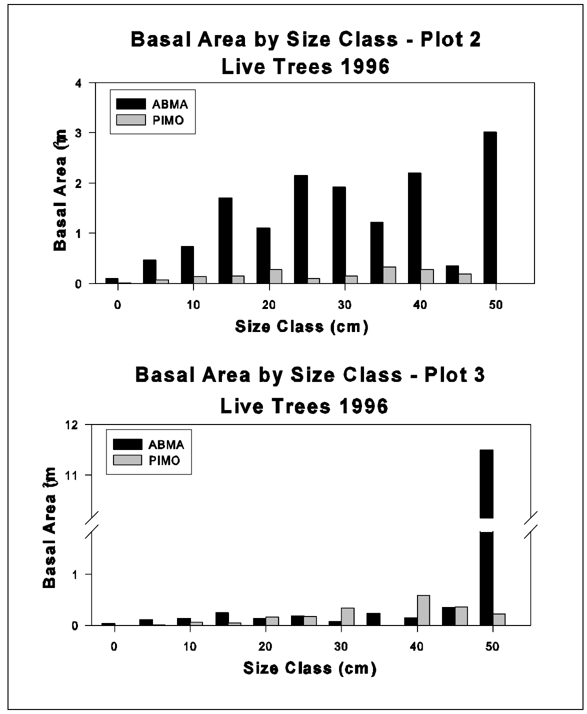



**Figure 44**. Size class distribution by species for basal area of trees in plots #2 and #3.

data. As a result we will be able to describe changes DBH, fuels, and stand structure over the intervening time.

Initial resampling of trees in plots #2 and #3 has been completed (DBH, mortality checks, and height of trees <1.4 m tall) with 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 being made. Size class distribution of trees in plot #2 showed a strong negative exponential distribution with few large (old) trees while plot #3 had a much flatter distribution with a substantial number of large dominant overstory trees, with the exception of the smallest size class (**Fig. 42**). These difference are a result of the stand age and history differences with plot #2 a relatively young stand and plot #3 a much older stand, although having a cohort of young trees in the lower portion of the plot (Pitcher 1981). Plots of size class by species also suggests variation within the red fir stands with the distribution of ***Pinus monticola*** (western white pine) having fewer young trees (particularly in plot #3) (**Fig. 43**) than ***Abies magnifica***. Total basal area and basal area by species (**Table 17**) increased between 1978 and 1996 in the two plots sampled by a relatively constant amount (total increase was 10.58 $m^2 \cdot ha^{-1}$ in plot #2 [19%] and 10.95 $m^2 \cdot ha^{-1}$ in plot #3 [22%]). However, there was considerable difference in BA distribution by size class between the two plots, with ***A. magnifica*** (red fir) having most BA in plot #3 located in the >50cm DBH size class while in plot #2 it was spread across most size classes (**Fig. 44**). This is probably a result of the stand age and history differences between the two plots (Pitcher 1981). In contrast, BA of ***P. monticola*** was spread

**Table 17**. Change in basal area (BA $m^2 \cdot ha^{-1}$) by species at plots #2 and #3 between 1978 and 1996 (ABMA - ***Abies magnifica***, red fir; PIMO - ***Pinus monticola***, western white pine; PICO - ***Pinus contorta***, lodgepole pine).

| **Sample** | **Plot #2 - BA $m^2 \cdot ha^{-1}$** | | | | **Plot #3 - BA $m^2 \cdot ha^{-1}$** | | |
|---|---|---|---|---|---|---|---|
| **Date** | **ABMA** | **PIMO** | **PICO** | **Total** | **ABMA** | **PIMO** | **Total** |
| 1978 | 50.26 | 5.74 | 0.06 | 56.06 | 43.15 | 6.22 | 49.37 |
| 1996 | 59.62 | 6.75 | 0.26 | 66.64 | 52.54 | 7.78 | 60.32 |

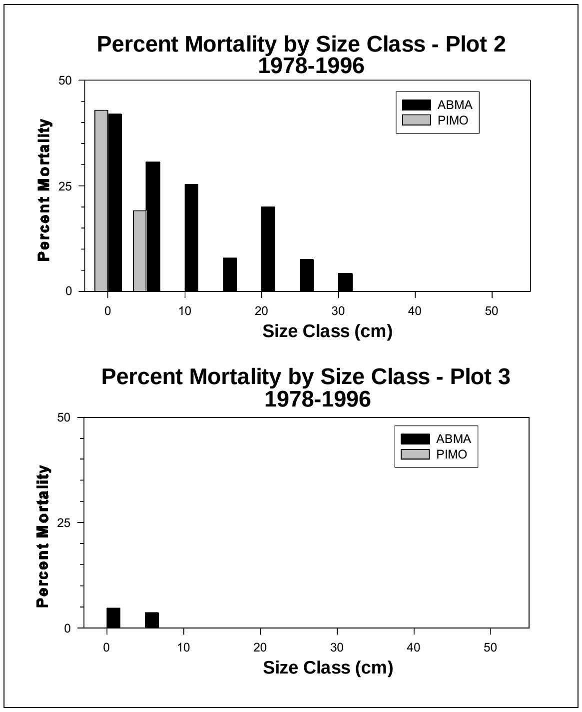



**Figure 45**. Percent mortality by species for size classes in plots #2 and #3.

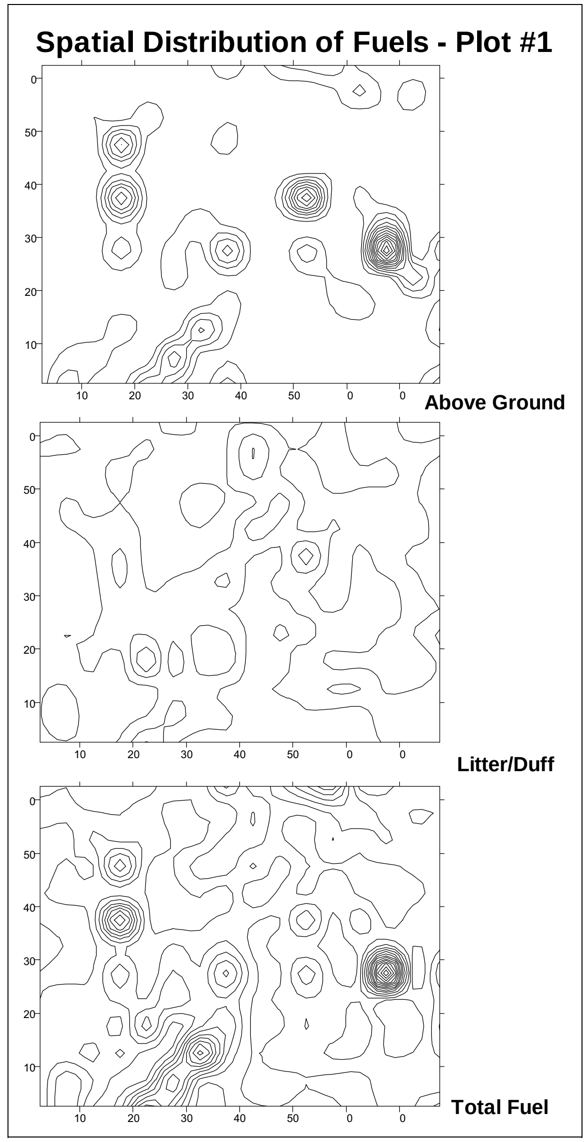



**Figure 46**. Spatial distribution of fuels across plot #1 (top - above ground fuels [i.e. fuels above the litter surface]; middle - litter/duff; bottom - total fuels). Heavy fuel concentrations of above ground fuel are due to the location of stumps or downed logs. Axes are meters.

between many size classes in both plots. Mortality (percent by size class) was concentrated in the denser and younger stand (plot #2) with the greatest mortality between 1978 and 1996 occurring in the small size classes (**Fig. 45**). This appeared to hold across species.

Fuel load resampling has been completed in plots #2 and #3 (a few subplots need to be rechecked), and about 80% completed in plot #1. Sampling methods followed Pitcher's procedures (Pitcher 1981), modified from Brown (1974), which sampled 5x5m subplots within each plot. This is very intensive sampling (912 modified Brown's transects) but will provide extremely detailed spatial information about fuel loads across the plots (**Fig. 46**). This will provide excellent baseline spatial information for the interpretation of any variation in fire effects observed following burning of the area. These data will also be used to make comparisons between visual fuel estimates from using photo series and estimates from Browns fuel transects. These data have also provided information on change in fuel load over the intervening 18 years since the plots were sampled by Pitcher. Fuel load increased in all plots (**Fig. 47**) with the greatest increases in the >3" diameter fuel class. The increase was most pronounced in plot #1 (this may change somewhat since this plot has not been completely resampled yet). The increase may be 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). This breakage appeared to have been most pronounced in moderately aged and density stands (plot1 #1), and not as common in stands with fewer large old trees (plot #3) or smaller younger trees with greater stand density (plot #2).

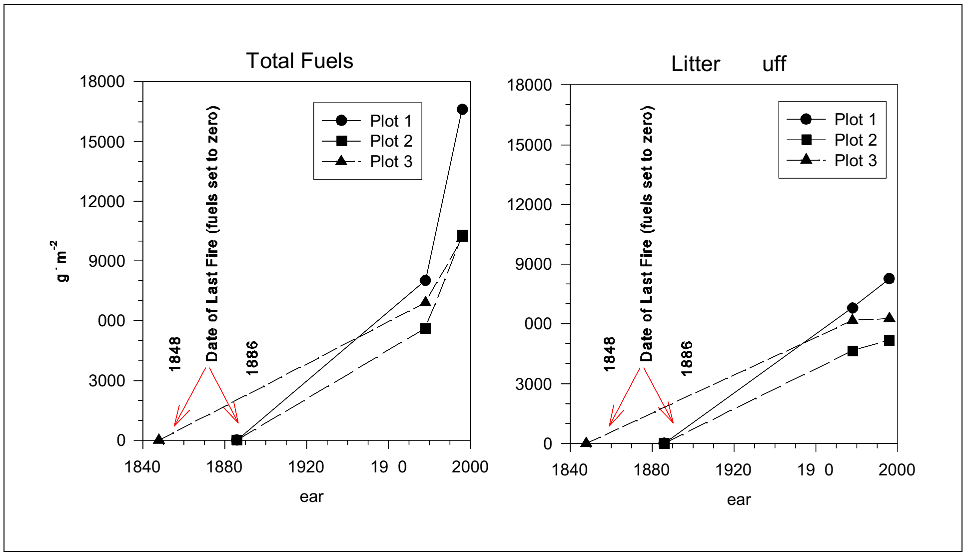



**Figure 47**. Fuel load changes in the three plots (data from plot #3 is incomplete). Initial zero value is based on the last recorded fire that burned through the plots (see Fire History). Estimates from 1978 and 1996 are based on modified Brown's inventory techniques. Formula for conversion of values to tons per acres is: tons/ac = g/m$^2$ * 0.0044613.

Updates of tree position maps within plots are in progress but will require additional field checks and corrections now that measurements can be compared to copies of the original data provided by Donald Pitcher. Having these data will permit more detailed and fine-grained analyses of mortality and growth patterns spatially across the plots in addition to good background data that can be used for understanding postfire fire effects once the plots are burned.

***Plans for 1997:*** Resampling of all plots is planned to be completed during June of 1997 although this will depend on snow conditions in the area and the final burn schedule that is developed.

# 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.

# Data Coordinator - Science and Natural Resources Management, SEKI

Anthony C. Caprio

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. Their projects include:

1) **Remote Sensing -Vegetation & Fuels**: M. Brookins and Dr. W. Miller, Arizona State University. Masters thesis project.
2) **Landscape-Level Effects of Prescribed Fire on Forest Structure and Composition**: K. Menning, UC Berkeley. Ph.D. dissertation project (in cooperation with Biological Resources Division of he USGS (formerly the National Biological Service).
3) **Bark-Foraging Bird Species**: T. Dennis, University of Virginia, Ph.D. dissertation project.

An new graduate student has also begun researching a potential project to be carried out in the watershed beginning in the summer of 1997.

**Remote Sensing - Analysis of Red Fir Forest Using High Resolution Digital Images**: 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, 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 Region 5 Conference on Ecosystem Management; USDA Forest Service Eldorado National Forest meeting on timber and ecosystem management; Society of American Foresters - Northern California Chapter field trip. Presentations have also been given during several local public meetings and for park training sessions. Field trips to the MKRRP area have been given to numerous park staff (interpreters, visiting personnel, and researchers), Forest Service, environmental groups, and representatives of the local timber industry interested in learning about and seeing the MKRRP area. Additionally, Point Reyes National Seashore was visited for the purpose of providing the park with an evaluation of the potential for conducting fire history sampling at the seashore, with a report summarizing the finding and recommendations prepared (Caprio 1996).

Lastly, 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 (Lineback et el. 1997; Caprio and Lineback in prep).

# Acknowledgements

Reviews and suggestions for improvement of this annual report were made by Linda Mutch, Jeff Manley, and Nate Stephenson. The satellite image used on the cover was derived from a TM scene of the East Fork watershed which was processed and produced by William Miller and Mitchal Brookins at Arizona State University as part of their remote sensing project within the watershed. I would also like to thank everyone who contributed individual project sections for this report.

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# Appendix 1

## FIRE EFFECTS MONITORING ON WILDLIFE

## 1996

April 23, 1997
Mineral King Risk Reduction Project

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TABLE OF CONTENTS

# *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 1996, 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 westside ponderosa pine forest east of Redwood Creek. The 1,560 trapnights at the Atwell Plot produced 480 rodent captures. The deer mouse (***Peromyscus maniculatus***) was the most abundant preburn rodent at the Atwell plot with an average population estimate of 36 individuals. 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 Ponderosa Plot, 1,740 trapnights produced 216 rodent captures. Predominate preburn rodents were brush mouse (***P. boylii***) and deer mouse (***P. maniculatus***). Brush mice were captured in the more mesic areas of the plot, and the deer mice were in the more open dry areas. The other species captured was a pocket gopher (***Thomomys*** sp.).

The Ponderosa Plot habitat was described. The tree/shrub density was estimated at 1,456 stems/ha with incense cedar (***Calocedrus decurrens***) dominating frequency and basal area. Other prominant vegetation included canyon oak (***Quercus chrysolepis***), black oak (***Q. kelloggii***), ponderosa pine (***Pinus ponderosa***), and white fir (***Abies concolor***). The plot faced south-southeast at 1,834-1,873 m elvation. Side slopes varied from 8 to 38 degrees. Rocks, logs, and litter were common. No surface water was present.

Serendipity surveys were conducted at three sites in the East Fork Kaweah River. In descending order of capture abudance, the yucca scrub site had brush mouse (***P. boylii***), western pocket mouse (***Chaetodipus californicus***), pinion mouse (***Peromyscus truei***), dusky-footed woodrat ***(Neotoma fuscipes***), and California mouse (***P. californicus***). In descending capture abuundance, the xeric conifer forest dominated by Jeffrey pine (***Pinus jeffreyi***) had lodgepole chipmonk (***Tamias speciosus***), brush mouse (***P. boylii***), deer mouse (***P. maniculatus***), northern flying squirrel (***G. sabrinus***), and bushy-tailed woodrat (***Neotoma cinerea***). The subalpine meadow had equal capture abundance of long-tailed vole (***M. longicaudus***) and deer mouse (***P. maniculatus***).

Serendipity trapping of mid-sized mammals found ringtail (***Bassariscus astutus***) in westside ponderosa pine forest, pine martin (***Martes americanus***) in sequoia forest and subalpine conifer forest, spotted skunk (***Spilogale gracilis***) in mixed conifer forest and westside ponderosa pine forest, and yellow-bellied marmot (***Marmota flaviventris***) in sagebrush scrub. A visit to the mountain beaver (***Aplodontia rufa***) colony on the east fork of Redwood Creek found evidence of postburn activity.

There was postburn seredipity trapping within the Kaweah Fire perimeter. The predominant species in the burned chamise chaparral was the western pocket mouse (***C. californicus***). Other species included California mouse (***P. californicus***), deer mouse (***P. maniculatus***), brush mouse (***P. boylii***), and pinion mouse (***P. truei***). Captures in burned chamise chaparral were primarily burrowing species, and most species were captured where there was bostburn cover, primarily from rocks and unburned woody material. Postburn fatalities included dusky-footed woodrat (***N. fuscipes***), mule deer (***Odocoileus hemionus***), and two lagomorphs, probably brush rabbits (***Silvalagus bachmani***). The burned riparian area had few captures. They included one western pocket mouse (***C. californicus***) and one California mouse (***P. californicus***). The burned blue oak woodland had the most species and the highest captue frequency. Those species included brush mouse (***P. boylii***), California mouse (***P. californicus***), western pocket mouse (***C. californicus***), deer mouse (***P. maniculatus***), and dusky-footed woodrat (***N. fuscipes***).

## 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 ***Peromyscus maniculatus*** which occurs in a wide range of habitats and elevations to other species like ***Chaetodipus californicus*** which has much more specificity in its habitat requirements. b) Most rodents consume significant quantities of vegetation, and some are arboreal or otherwise dependent on plants for cover. This links them to floral composition and structure, two things that are normally affected by fire. c) Rodents do not have large home ranges. The species of rats and mice present in the East Fork Kaweah drainage typically have home ranges that are under 0.6 ha (Zeiner *et al.* 1990). Because the individuals do not roam far, rodent populations can be correlated to more descrete 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 measureable 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 Grove with plot center at UTM coordinates 4037.147 northing and 349.506 easting. The Ponderosa Plot was located in westside ponderosa pine forest with plot center at UTM coordinates 4035.466 northing and 349.415 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 26 nights from June 3 through July 19, 1996 (1,560 trapnights). The Ponderosa Plot was run for a total of 29 nights from July 25 through September 27, 1996 (1,740 trapnights). The traps were baited with a dry mixture of rolled oats and peanut butter. A high-low thermometer was located in each plot at a shady location about 1.5 m above the ground, and a rain guage 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 three sites in the Mineral King drainage: yucca scrub at UTM coordinates 4038.2 northing, 342.1 easting (375 trapnights), a xeric conifer forest at UTM coordinates 4035.3 northing, 355.9 easting (130 trapnights), and a subalpine wet meadow at UTM coordinates 4034.4 northing, 355.9 easting (70 trapnights). In addition, seredipity trapping was done at five sites in the Kaweah Fire in the drainage of the main stem of the Kaweah River. These habitats included chamise burned by a high intensity headfire and little rock (UTM coordinates 4040.6 northing, 333.2 easting; 94 trapnights), chamise burned by high-intensity headfire and much rock (UTM coordinates 4040.7 northing, 333.5 easting; 63 trapnights), chamise burned by medium-intensity fire (UTM coordinates 4040.6 northing, 333.4 easting; 38 trapnights), a riparian area in which all leaves and twigs were consumed by fire (UTM coordinates 4040.6 northing, 333.2 easting; 38 trapnights), and burned blue oak woodland (UTM coordinates 4040.2 northing, 334.2 easting; 36 trapnights). These coordinates need to be verified on the ground with a GPS. Sherman live traps were scattered loosely through these sites at approximately 15 m intervals (not measured). These areas were surveyed from September 30 through October 25, 1996, 1997 for a total of 575 trapnights in Mineral King drainage and 269 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.

Serendipity surveys also included some trapping for medium-sized mammals (e.g. forest carnivores) using mid-sized Tomahawk and Havahart traps baited with meat and covered with burlap bags. This sampling was done from July through September, 1997. It amounted to 151 trapnights. This trapping included mixed conifer forest (12 trapnights), subalpine conifer forest (8 trapnights), westside ponderosa pine forest (62 trapnights), sequoia grove (7 trapnights), sagebrush scrub (15 trapnights), mixed chaparral (30 trapnights), chamise chaparral (5 trapnights), blue oak woodland (6 trapnights), and palustrine wetland forest (6 trapnights). The last three sites were part of the sampling following the Kaweah Fire.

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. Basal area was measured at breast height. Only living stems >1 cm diameter at ground level and trees 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). Visually the postburn plot resembled the preburn condition except for the loss of duff and litter, increase in exposed rocks, and widespread ash. While much of the heavy fuel was eliminated by the fire, there was enough tree fall for the postburn condition to resemble the preburn plot (**Fig. 1**).

Twenty-six nights of trapping (1,560 trap nights) produced 480 rodent captures (101 different individuals). The mean population estimate during the survey period was 36 individuals (95% CI = 28-45 individuals). This was twice as high as the preburn sampling (Werner 1996). The postburn sampling did begin earlier in the summer than the preburn sampling, but numbers were higher even where dates overlapped (**Fig. 2**). Ninety-six percent of the individuals (99% of the captures) were ***Peromyscus maniculatus*****.** Three percent of the individuals (1% of the captures) were ***Peromyscus boylii**.* One ***Glaucomys sabrinus*** was captured. Captures of non-rodents included two ***Sorex trowbridgii**.* There were serveral changes in species captured between the preburn sampling in 1995 and the first year of

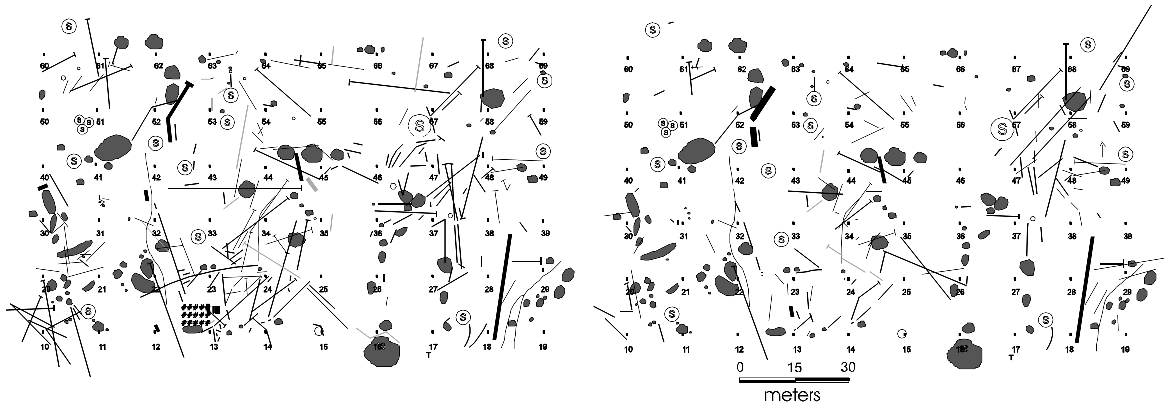


**Figure 1**. Comparison of downed logs in the Atwell Plot between the preburn condition in 1995 (left side) with the postburn condition in 1996 (right side). The circles with an "S" in the middle are mature sequoia trees and the circular objects are rocks. The curved lines are steambeds.

postburn sampling in 1996. ***Peromyscus boylii*** was only captured in the postburn sampling, and ***Microtus longicaudus*** was only captured in the preburn sampling. 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, it seemed smaller and more isolated by the large areas of ash. Catch rates for the three rodent species were 0.304, 0.003, and 0.0006 captures/trapnight for ***P. maniculatus***, ***P. boylii***, and ***G. sabrinus***, respectively. Like the mean population size, the catch rate for ***P. maniculatus*** doubled during the postburn sampling from 0.133 captures/trap-night preburn to 0.304 captures/trapnight postburn.

The sex ratios for the sampled population of ***P. maniculatus*** were about equal, 49% female and 51% male (n=94); but females were captured more frequently than males (**&** = 63% of captures, n=470). Three of the four ***P. boylii*** captures were male.

Eighty-eight percent of the P. maniculatus were adult. Only adults were captured for the other species.

Ponderosa Plot: The Ponderosa Plot (**Fig. 3**) was located in a stand of westside ponderosa pine forest. The density of trees and shrubs was estimated at 1,456/ha (95% CI = 1,092-2,180 trees & shrubs/ha). While ***Pinus ponderosa***, ***Quercus kellogii***, and ***Abies concolor***

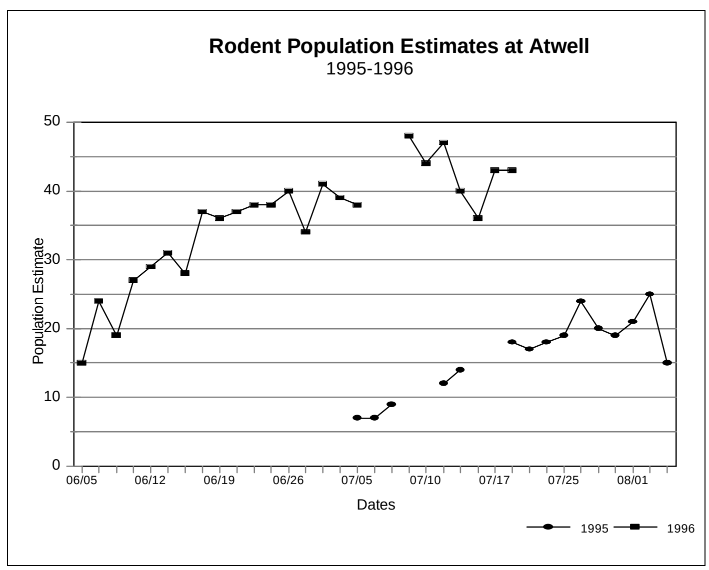


**Figure 2.** Comparision of daily population esti-mates for the Atwell Plot during 1965 (preburn) and 1966 (postburn).

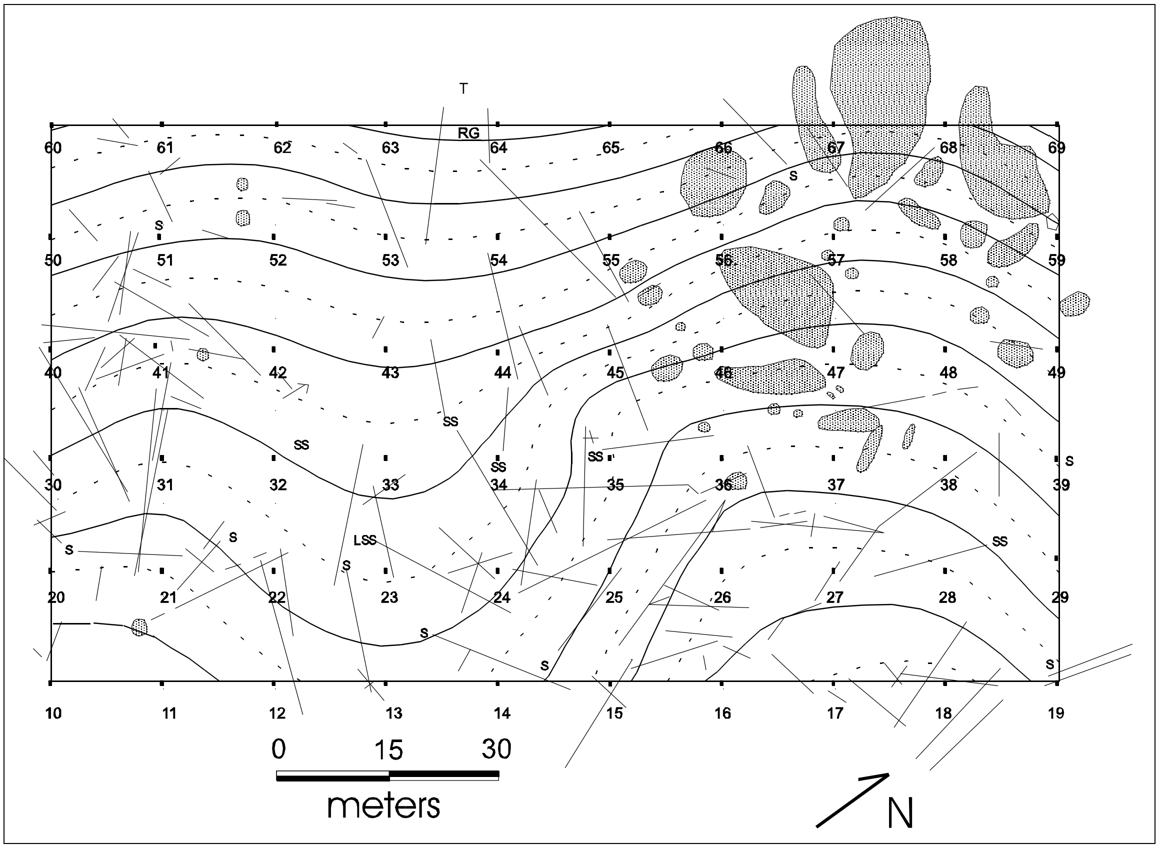


**Figure 3**. Ponderosa Plot. The curved lines represent contours. The straight lines are logs. Rocks are grey. Numbers are trap stations. The "T" and "RG" are the locations for the thermometer and rain guage. The "SS" and "LSS" are large snags.

were the largest and often most conspicuous trees present, ***Calocedrus decurrens*** dominated the plot by frequency and area (**Fig. 4**). By descending order of frequency, the sampled vegetation was dominated by ***C. decurrens*** (54%), ***Quercus chrysolepis*** (9%), ***Q. kelloggii*** (9%), ***A. concolor*** (7%), ***P. ponderosa*** (7%), ***Arctostaphylos mewukka*** (5%), ***Pinus lambertiana*** (5%), ***Quercus garryana*** (2%), ***Umbellularia californicus*** (2%), and ***Torreya californica*** (1%). By area in descending order, the sampled vegetation was dominated by ***C. decurrens*** (55%), ***A. concolor*** (16%), ***Quercus chrysolepis*** (12%), ***Q. kelloggii*** (8%), ***P. ponderosa*** (7%), ***P. lambertiana*** (1%), ***Q. garryana*** (<1%), ***T. californica***(<1%), ***A. mewukka*** (<1%), and ***U. californicus*** (<1%).

The plot faced south-southeast at 1,834-1,873 m elevation, though some sites within the plot faced south and soutwest. Sideslopes varied from 8 to 38 degrees (mean = 18º). The northeast corner of the plot was extremely rocky, and the soil was covered by litter except on south and southwestern exposures where ***Chamaebatia foliolosa*** covered the ground (50% of the trap sites). There was no surface water in the plot, but two drainages were present. Maximum temperatures during the trapping were 15-35ºC (mean = 28ºC) during the day and 6-21ºC (mean = 14ºC) at night. The only evidence of cultural use was an abandoned trail along the north edge of the plot.

The abundance of small trees, the lack of large trees, and the sparse scattering of ***A. mewukka*** suggested that the current vegetation structure may have become an artifact of fire exclusion. I suspect that at the turn of the century, this site had far less trees and that the open areas contained both more grass and larger patches of flamable brush. The site looked like it could continue to evolve toward dense forest, return to a more open condition, or become very "park-like" with large trees and open understory depending on the nature of furture fires in the plot.

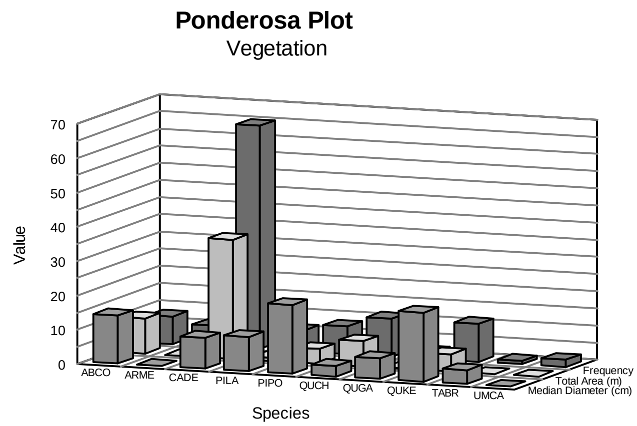


**Figure 4**. Structure of woody vegetation at the Ponderosa Plot. Graph compares species frequency, area, and median diameter of sampled vegetation.

Twenty-nine nights of trapping (1,740 trapnights) produced 216 rodent captures (72 individuals). Two species dominated the rodent population at the Ponderosa Plot, ***P. boylii*** and ***P. maniculatus*** (**Fig. 5**). ***P. boylii*** was the predominate species initially, but abundance was similar for both species during the late summer. In addition, there were two captures of ***Thomomys*** sp. Non-rodents captured included four captures of shrews, ***Sorex*** sp.

The two species of ***Peromyscus*** were captured largely in different portions of the plot. ***Peromyscus boylii*** were captured primarily on southeast facing slopes and near drainage bottoms. These areas were predominately ***Abies concolor***, ***Quercus chrysolepis***, and ***Calocedrus decurrens***. There was little ground cover by live plants. ***Peromyscus maniculatus*** were captured primarily on south and southwestern slopes and on ridge tops. The vegetation was primarily ***Pinus ponderosa***, ***Quercus kelloggii***, and ***C. decurrens*** with ***Chamaebatia foliolosa*** for ground cover. While there was no significant difference in the number of captures for either species on the plot (P=0.270), the capture frequency for each species was significnatly different (P=0.047 for ***P. maniculatus***, P=0.042 for ***P. boylii***) depending on the presence or absence of ***C. foliolosa***, the indicator for each of the two areas (**Table 1**).

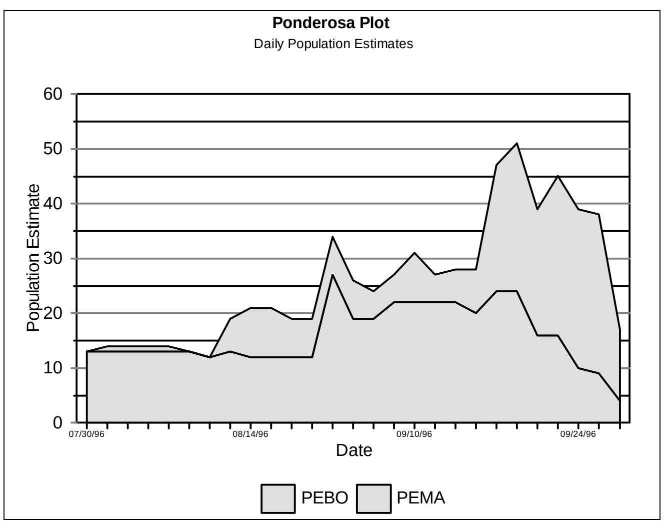


**Figure 5**. Daily population estimates for ***P. boylii*** and ***P. maniculatus*** at the Ponderosa Plot.

Catch rates for the three species of rodents were 0.066 captures/trapnight for ***P. boylii***, 0.057 captures/trapnight for ***P. maniculatus***, and 0.0001 captures/trapnight for ***Thomomys*** sp. The catch rates were probably artificially low due to ***Ursus americancus*** (and possibly other animals) disturbing the traps during at least half of the trapping days. Disturbance often accounted for a third to half of the traps being sprung. One day, 87% of the traps were knocked over. The traps were normally not destroyed, and the effect it had on the trapping depended primarily on whether the traps were disturbed before rodents had an opportunity to be trapped. At least once, the crew had to deal with a bear while they were working in the plot.

The sex ratios for the sampled population was predominately female (58%) for ***P. boylii*** and male (58%) for ***P. maniculatus***.

**Table 1**. Comparison of stations showing where ***P. boylii*** and ***P. maniculatus*** were captured in relation to the presence or absence of ***C. foliolosa***.

| Species Captured | Number of Trap Stations | |
|---|---|---|
| | ***C. foliolosa*** Present | ***C. foliolosa*** Absent |
| PEBO | 6 | 13 |
| PEMA | 10 | 1 |
| Both | 10 | 13 |
| None | 4 | 3 |

Most of the rodents captured were adults. This included 94% of the ***P. maniculatus*** and 96% of the ***P. boylii***.

**Serendipidy Surveys:**

The habitat for the yucca scrub was characterized by steep, open, rocky terraine over a marble substrate. Where soil existed, it was very coarse. Characteristic plants included ***Yucca whipplei***, ***Cercocarpus ledifolius***, and scrubby ***Quercus chrysolepis***. The general appearance resembles a desert. The elevation was about 1,600-1,800 m.

Species captured (n=58) in the yucca scrub in descending order of capture abundance included ***Peromyscus boylii*** (0.064 captures/trapnight), ***Chaetodipus californicus*** (0.048 captures/trapnight), ***P. truei*** (0.035 captures/trapnight), ***Neotoma fuscipes*** (0.005 captures/trapnight), and ***P. californicus*** (0.003 captures/trapnight). About half of the traps were on the east side of a canyon which was very rocky, and the other traps were on the west side that contained considerable soil. Seventy-seven percent of the ***P. truei*** (n=13) were captured on the west side, and 72% of the ***C. californicus*** (n=18) and 58% of the ***P. boylii*** (n=24) were captured on the rocky east side. The east side was the only place ***N. fuscipes*** (n=1) and ***P. californicus*** (n=1) were captured. Forty percent of all captures were recaptures.

The habitat for xeric conifer forest was steep and rocky. ***Pinus jeffreyi*** dominated the overstory. The understory contained large patches of brush, particularly ***Arctostaphylos patula***. The elevation was about 2,310-2,380 m. The species captured (n=56) in the xeric conifer forest included ***Tamias speciosus*** (0.2238 captures/trapnight), ***P. boylii*** (0.100 captures/trapnight), ***P. maniculatus*** (0.077 captures/trapnight), ***Glaucomys sabrinus*** (0.008 captures/trapnight), and ***Neotoma cinerea*** (0.008 captures/trapnight). Thirty-four percent of the captures were recaptures.

The habitat for the subalpine meadow consisted of dense graminoid vegetation growing on moist soil. The land was not flat, but most slopes were gradual. The elevation was about 2,390 m. The species captured in the subalpine wet meadow included four ***Microtus longicaudus*** (0.057 captures/trapnight) and four ***P. maniculatus*** (0.057 captures/trapnight). This was very different from the wet meadow sampled last year where the dominant species was ***Zapus princeps*** (Werner 1996). The 1996 sampling was done after temperatures began to routinely drop below freezing. This may have influenced what species were active in the meadow. Thirty-eight percent of the captures were recaptures.

Serendipity sampling for medium-sized mammals included resulted in ***Spilogale gracilis*** in mixed conifer forest (0.083 captures/trapnight) and in westside ponderosa pine forest (0.016 captures /trapnight), ***Martes americana*** in subalpine conifer forest (0.250 captures/trapnight) and in sequoia forest (0.143 captures/trapnight), ***Bassariscus astutus*** in westside ponderosa pine forest (0.081 captures/trapnight), and ***Marmota flaviventris*** in sagebrush shrub (0.400 captures/trapnight).

The rodent sampling on the Kaweah Fire was more successful. The rodent trapping results are summarized in **Table 2**.

No ***N. fuscipes*** were captured in the areas of burned chamise, and ***P. truei*** were only captured in the area with low consumption. These are the two species that I would have expected to have been common prior to the burn based on surveys in similar vegetation (Werner 1981). Because ***N. fuscipes*** live in stick houses above the ground, they are very susceptable to fire mortality. Several ***N. fuscipes*** carcasses were found after the fire. Two of the dead ***N. fuscipes*** were **not** burned even though they were in the ashes. The physical evidence suggested that they died after the fire passed. I speculated that they escaped the flames in a nearby rock outcrop, but were not able to escape the heat and probably died later from internal heat injuries, particularly to their lungs. There was one observation of a live ***N. fuscipes*** in the burned chamise at night.

While all expected species of ***Peromyscus*** were captured in chamise chaparral, catch rates were not high. ***Peromyscus californicus*** was the most frequently captured, and it was primarily in rocky areas.

***Chaetodipus californicus*** was most abundant rodent in the postburn sampling of chamise. This is a burrowing species that appears to have survived well during the fire. It was the only species captured in the area that was completely denuded of all vegetation and without rock cover.

Postburn cover was probably important. By day, hawks were commonly observed over the burned landscape, and tracks of ***Canis latrans*** were commonly seen in the ashes. The areas of chamise with the most cover, primarily rock and unburned woody material, were also the areas with the most postburn rodent captures.

Another burrowing rodent that was not captured, but which left evidence of postburn activity, was ***Thomomys bottae***. Several fresh soil mounds were observed after the burn, and one live specimen was seen at night.

In addition to the woodrats, several other animal carcasses were found in the burned chamise. These included at least two lagomorphs, probably ***Silvalagus bachmani***, and one male ***Odocoileus hemionus***.

Only two rodents were captued in the burned riparian area. Whether there was high mortality or naturally low use was not apparent without preburn data or previous experience trapping in that habitat. Prior to the fire, the dominat trees were ***Quercus wislizenii***, ***Aesculus californica***, and ***Plantanus***

***racemosa***. I was impressed at how thoroughly the fire consumed vegetation that I normally think of as incombustible.

The most diverse rodent biota and highest capture success was in the burned blue oak. Structurally, this area was least affected by the fire, and it contained a rich diversity of microhabitats.

**Table 2**. Summary of rodent capture success immediately following the Kaweah Fire.

| Site Description | Species Capture Rate (captures/trapnight) | | | | | |
|---|---|---|---|---|---|---|
| | **CHCA** | **NEFU** | **PEBO** | **PECA** | **PEMA** | **PETR** |
| chamise, complete consumption, few rocks | 0.021 | - | - | - | - | - |
| chamise, complete consumption, very rocky | 0.159 | - | 0.032 | 0.079 | - | - |
| chamise, poor consumption (numerous stems) | 0.132 | - | - | 0.026 | 0.053 | 0.026 |
| foothill riparian, high consumption (all leafy vegetation consumed) | 0.026 | - | - | 0.026 | - | - |
| blue oak woodland, surface fuels consumed | 0.083 | 0.028 | 0.194 | 0.111 | 0.056 | - |

**Miscellaneous:**

The Aplodontia colony on the east fork of Redwood Creek was visited once after the burn, and it appeared to be active (Ray, pers. comm.).

## PLANS FOR 1997

1. Conduct post-burn survey of the Atwell Plot.
2. Establish one more long-term monitoring plots. It will go into a lower subalpine environment (red fir forest, Jeffrey pine forest, green-leaf mananita chaparral, or sagebrush scrub).
3. Continue serendipity surveys in habitats not surveyed with long-term plots.
4. Visit burned ***Aplodontia rufa*** colonies and record observations that may be fire related.
5. Continue development of guide to wildlife fire environments.
6. Continue postburn sampling of the Kaweah Fire.

**ACKNOWLEDGMENTS**

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