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

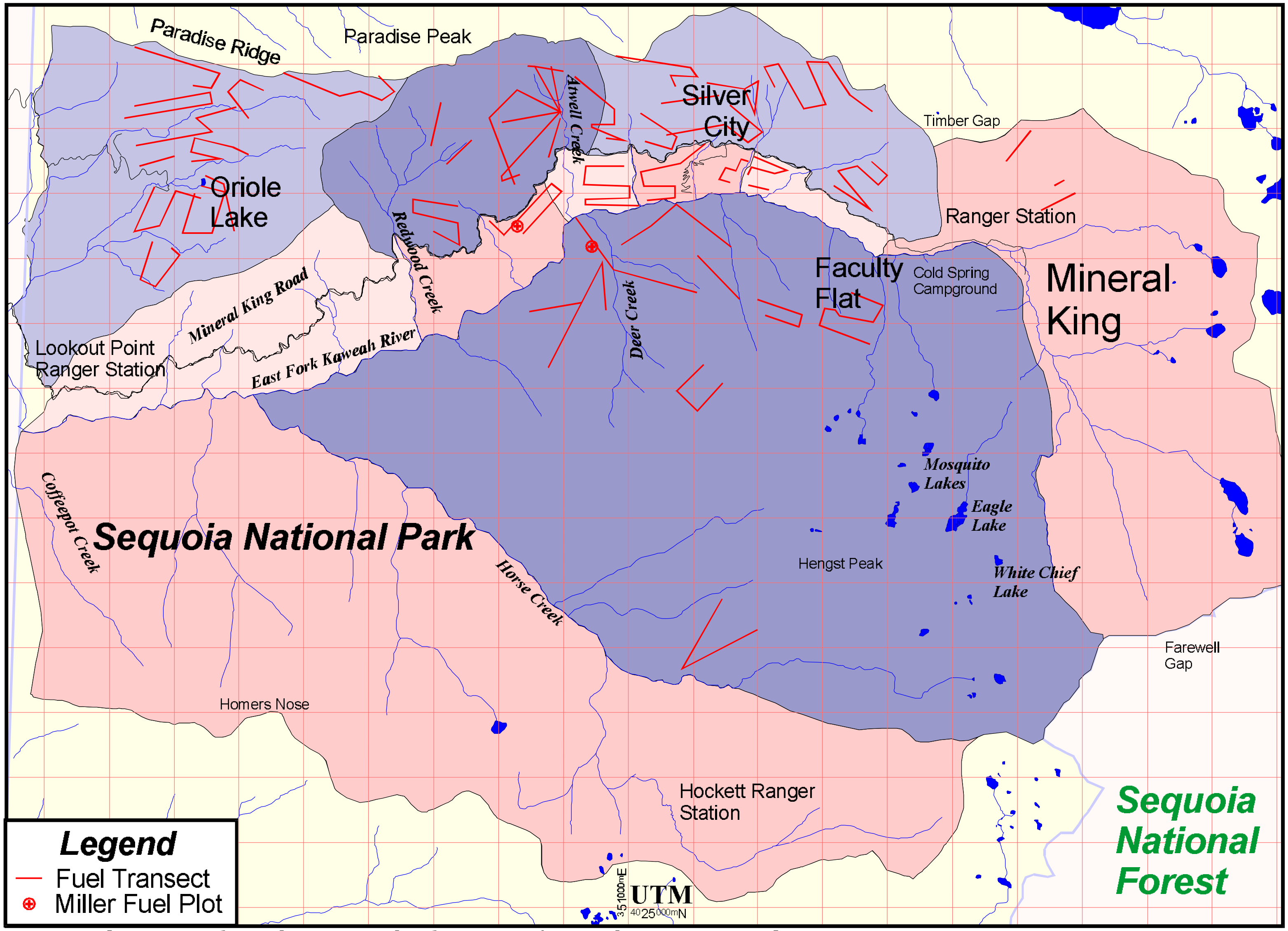

Figure 32.

Mineral King Risk Reduction Project

Fuel Load Sampling

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 (m^2/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 (m^2/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 (m^2/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 (m^2/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 (m^2/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 (m^2/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 (m^2/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;

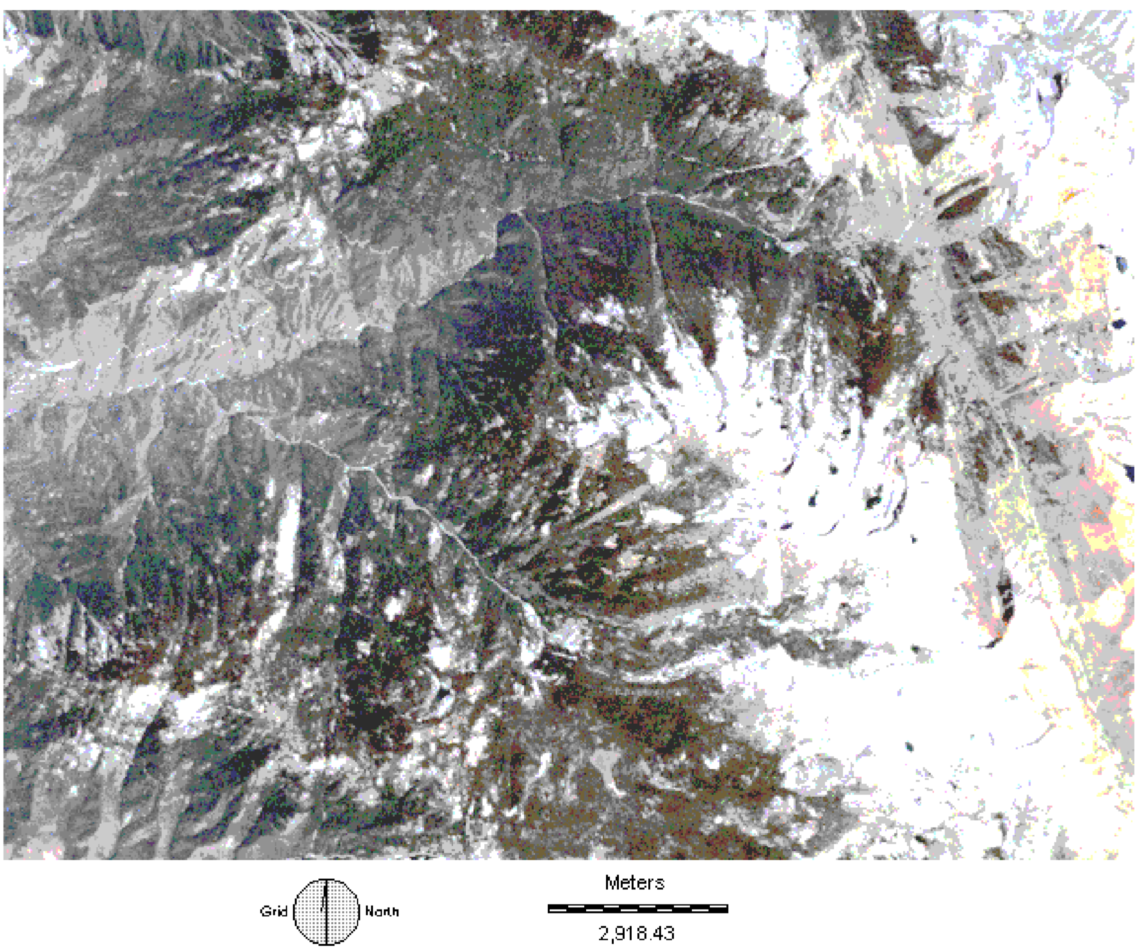

Figure 34. Color composite of the Mineral King study area using July 1992 Landsat TM bands 1,2,&3.

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

<u>Image Processing</u>

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,

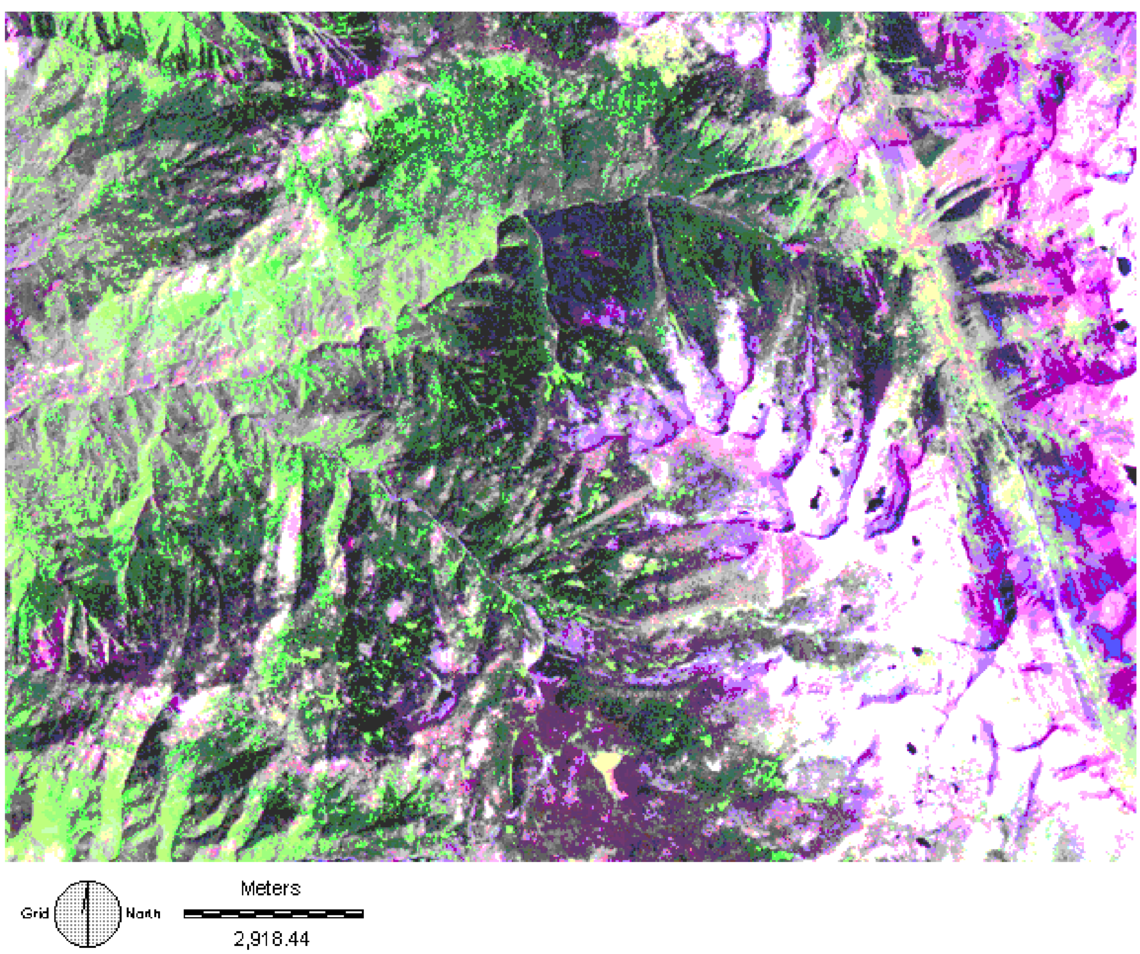

Figure 35. Pseudo color infrared composite image (TM bands 3, 4, and 5) of the Mineral King study area, Sequoia National Park

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.

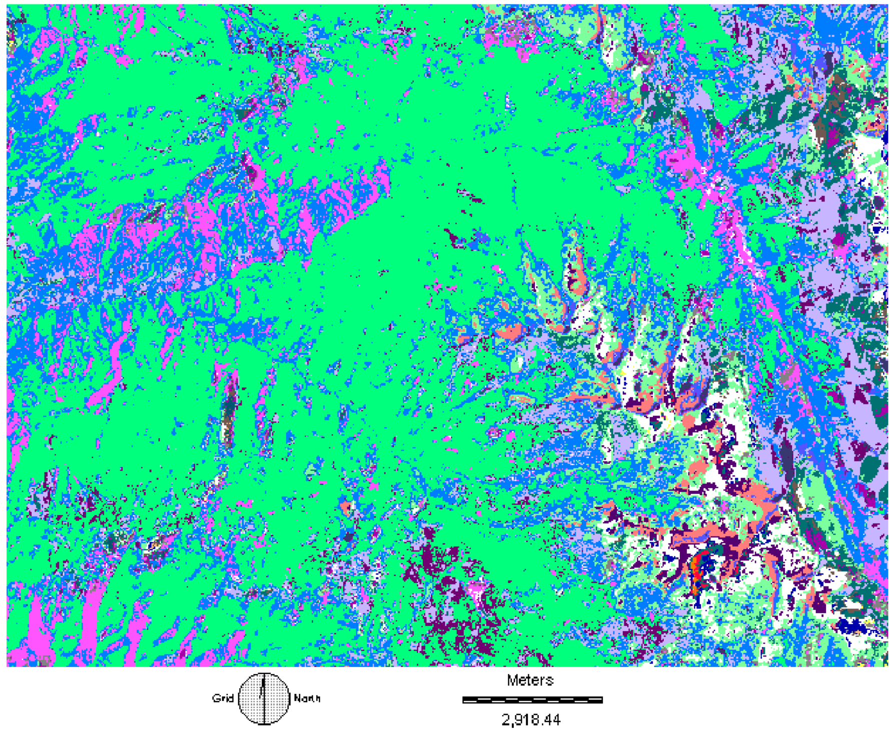

Figure 36. Composite image from principal component analysis using PCA images 1, 2, and 3 for the Mineral King study area, Sequoia National Park.

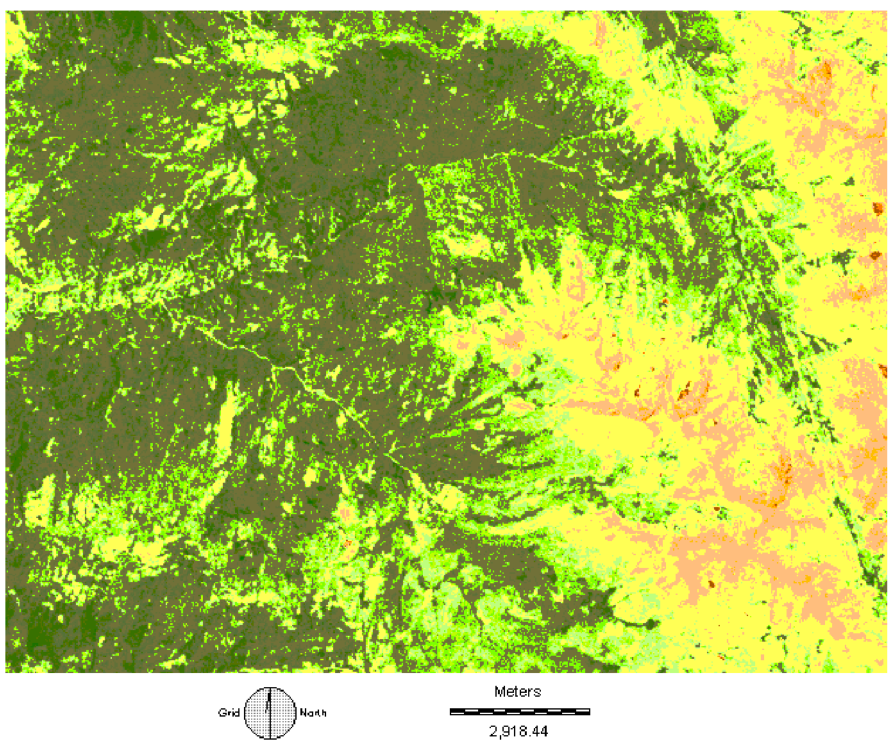

Figure 37. Normalized difference vegetation index for the Mineral King study area, Sequoia National Park.

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.

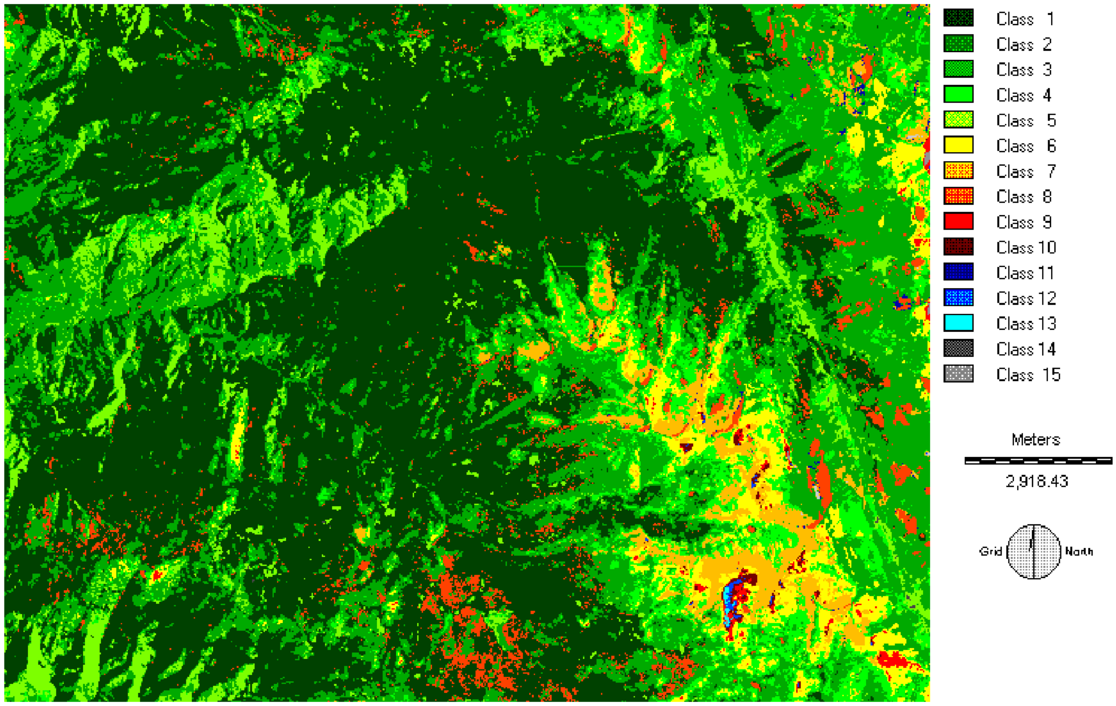

Figure 38. Unsupervised classification using the composite PCA image for the Mineral King study area, Sequoia National Park.

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).

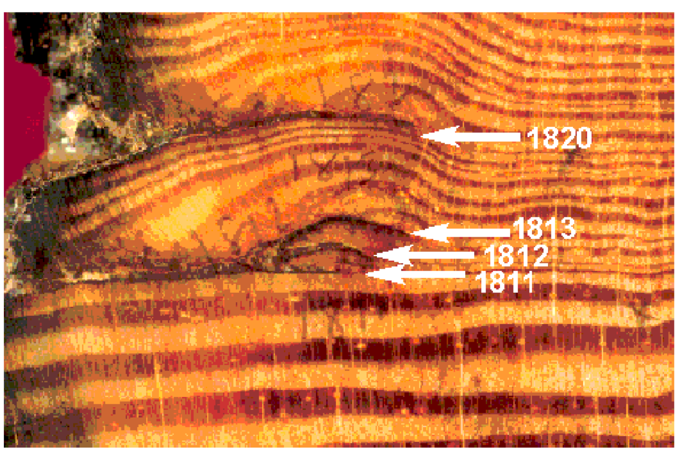

Figure 39. Example of fire scars from a ponderosa pine. The sample is unusual in having several consectuative year dates (all dates were confirmed by other nearby trees).

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

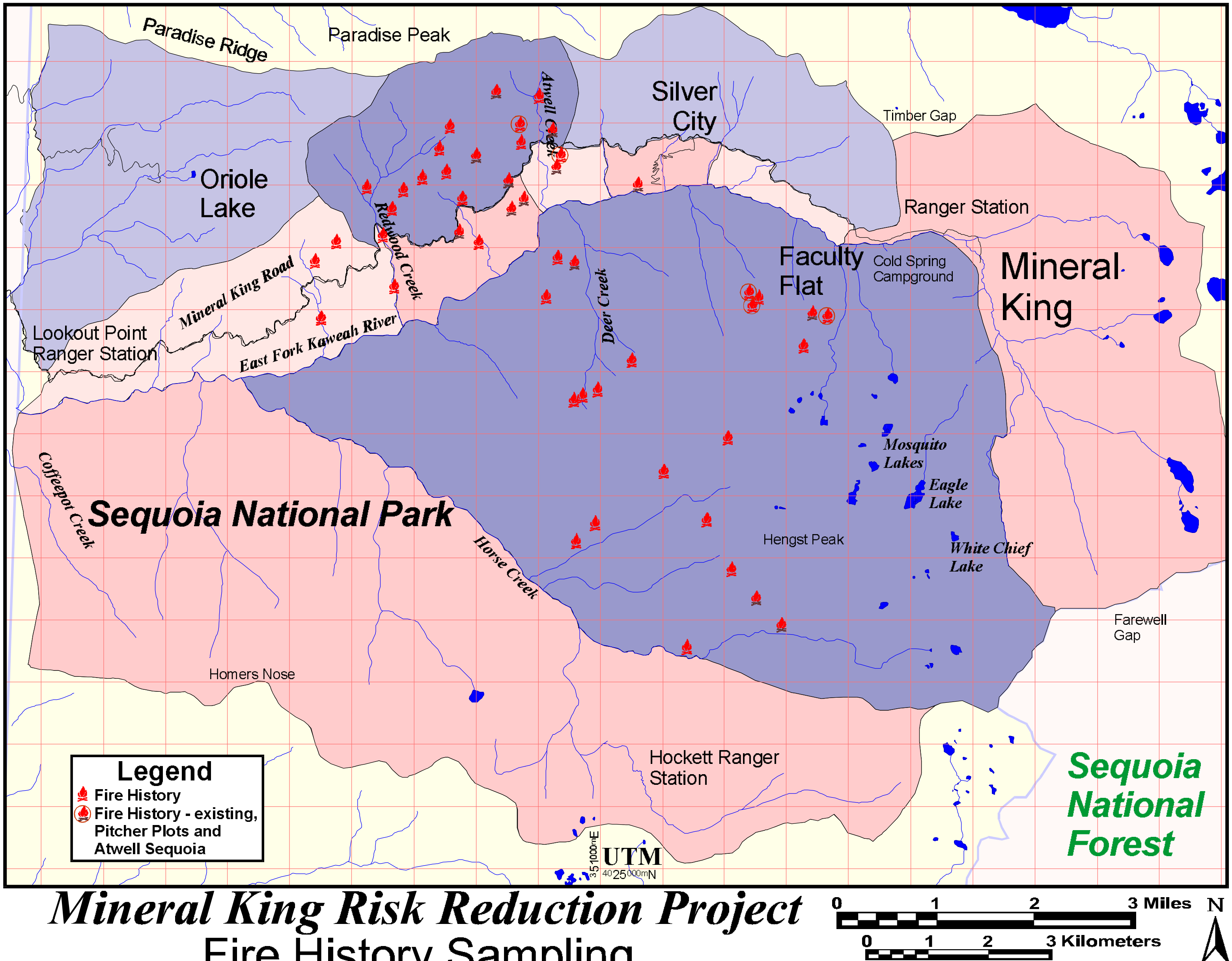

Figure 39.

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

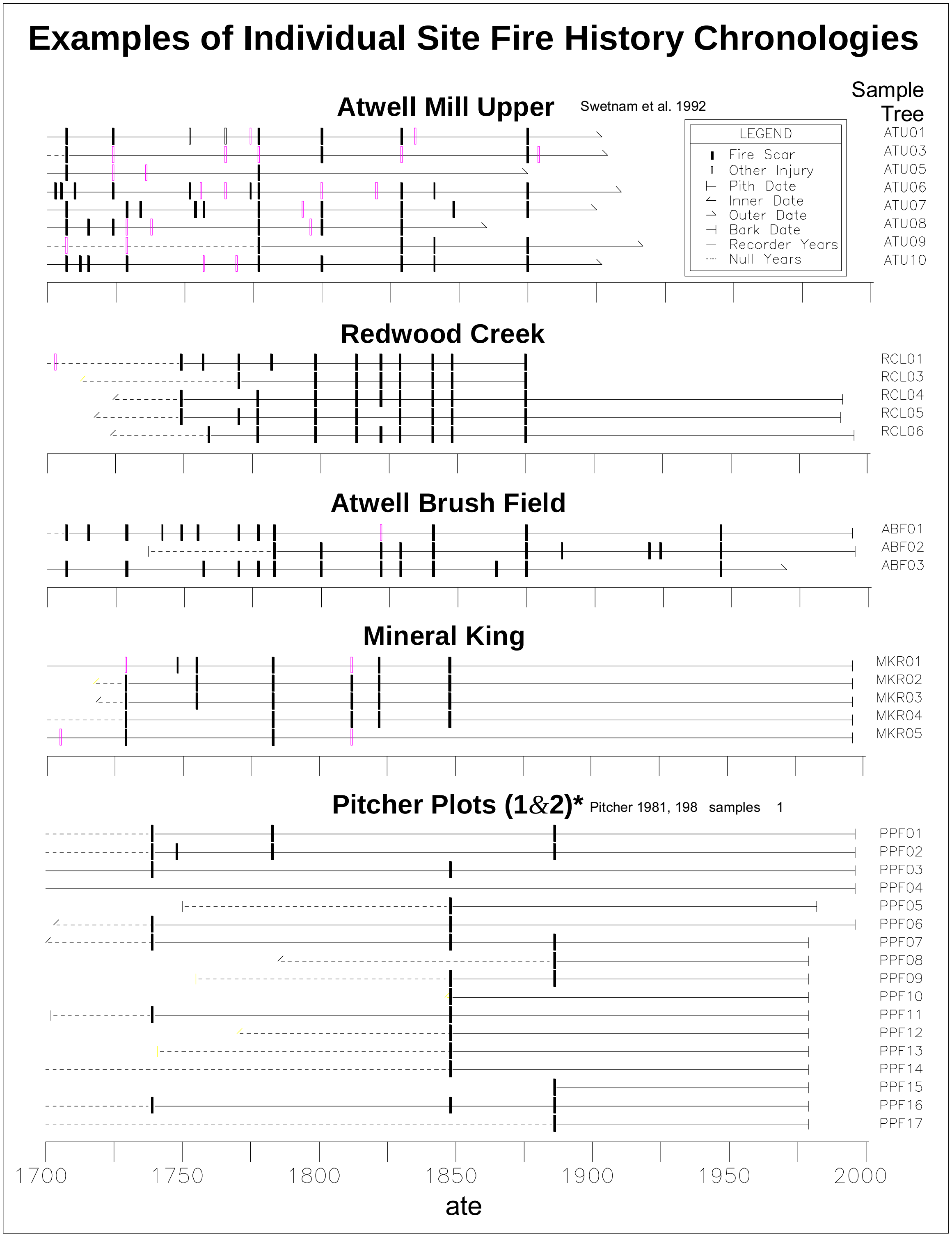

Figure 41. Examples of reconstructed fire history data from five sites in the East Fork drainage for the period from 1700 to the present. Sites illustrate varying pre-Euroamerican fire regimes from differing vegetation types and aspects in the watershed. Horizontal lines represent a particular sample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

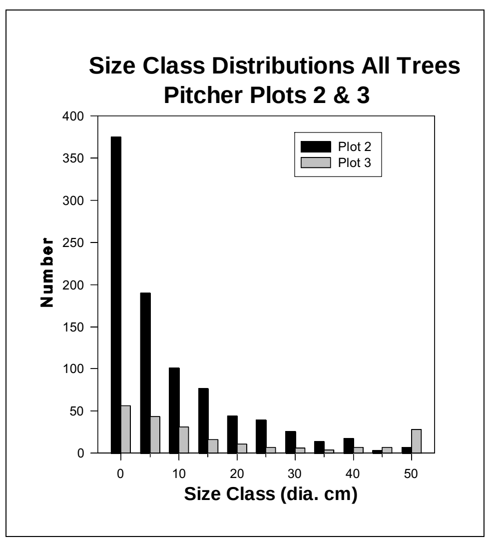

Figure 42. Size class distribution of all trees by plot in 1996.

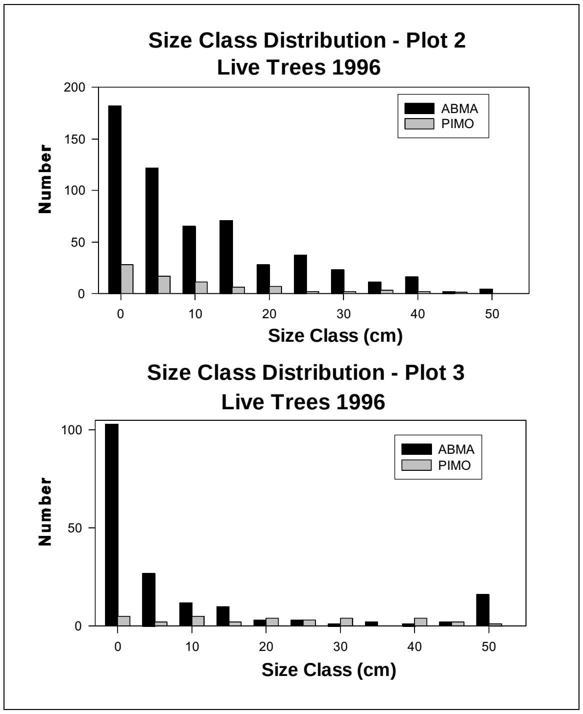

Figure 43. Size class distribution by species for diameter of trees in plots #2 and #3.

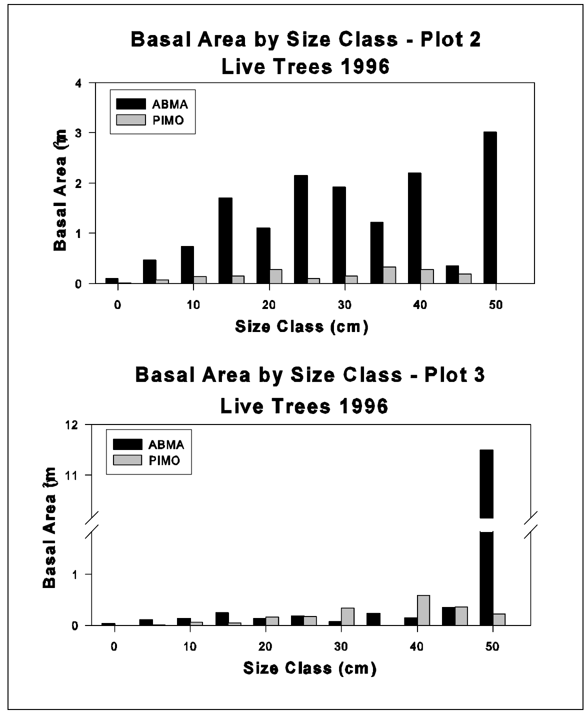

Figure 44. Size class distribution by species for basal area of trees in plots #2 and #3.

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

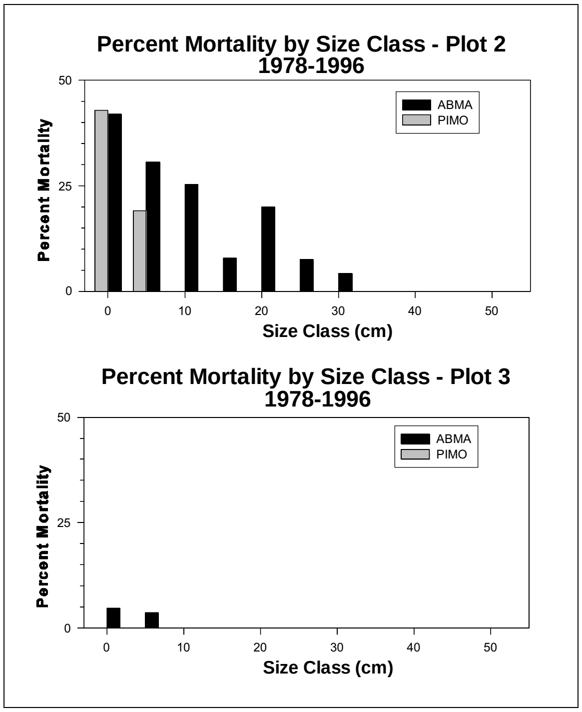

Figure 45. Percent mortality by species for size classes in plots #2 and #3.

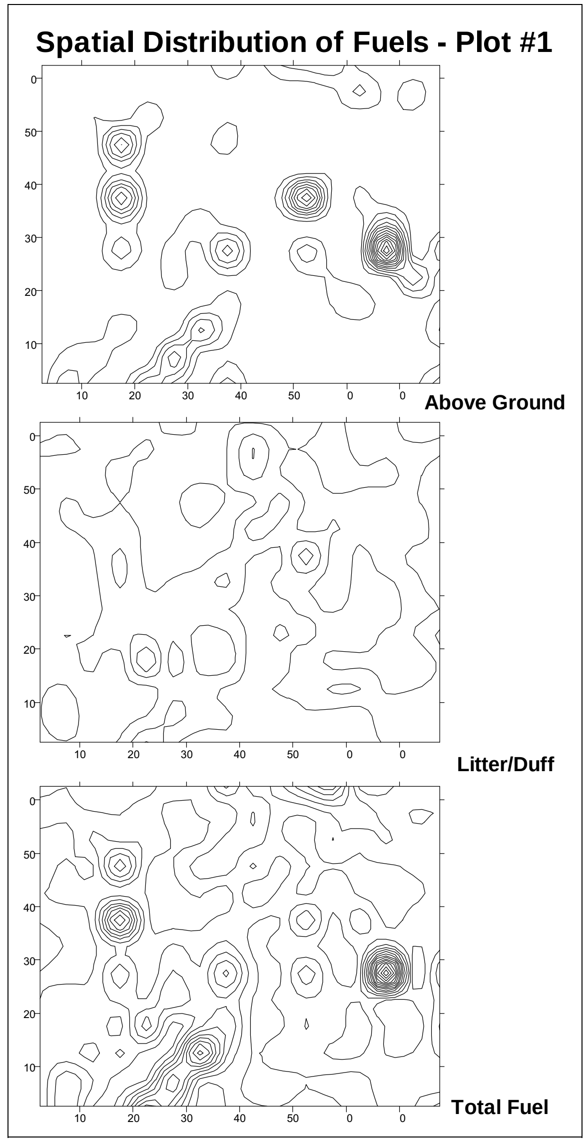

Figure 46. Spatial distribution of fuels across plot #1 (top - above ground fuels [i.e. fuels above the litter surface]; middle - litter/duff; bottom - total fuels). Heavy fuel concentrations of above ground fuel are due to the location of stumps or downed logs. Axes are meters.

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).

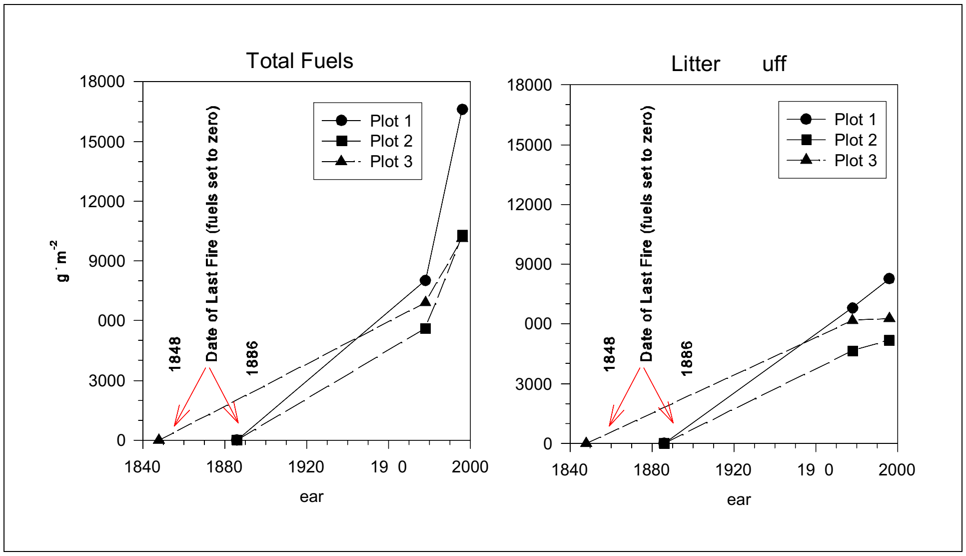

Figure 47. Fuel load changes in the three plots (data from plot #3 is incomplete). Initial zero value is based on the last recorded fire that burned through the plots (see Fire History). Estimates from 1978 and 1996 are based on modified Brown's inventory techniques. Formula for conversion of values 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).