4.15) Fire History

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INTRODUCTION

Over the last three decades the Sequoia and Kings Canyon National Park's fire management program has evolved to where it is now attempting to restore fire at landscape scales. However, burning at such scales has raised a variety of new management and resource questions. Among these are questions about our understanding of pre-Euroamerican fire regimes at such large ecosystem scales. Unfortunately, written records or accurate descriptions of pre-Euroamerican settlement fire regimes do not exist from the southern Sierra Nevada. However, we can, at least temporarily, obtain fairly reliable information about past fire regimes from a proxy record based on fire scarred trees found in most of our forested plant communities. This record documents the minimal role of fire within the land units sampled. Dendroecological analyses of these samples provides a powerful additional tool to characterize attributes of past fire regimes, to examine their variability and to understand how they have shaped landscapes over time. This record about the past provides reference information that can supply guidance for ecologically sound fire management practices today and assist in understanding potential future changes in park ecosystems.

While fire history research has been carried out in Sequoia and Kings Canyon National Parks for many years (Kilgore and Taylor 1979; Pitcher 1987; Swetnam et al. 1992; Swetnam 1993; Caprio and Swetnam 1995; Swetnam et al. 1998) a considerable number of gaps remain in our knowledge and understanding at many levels (Caprio and Lineback 1997). Acquiring this information would be of great value to managers when planning and reintroducing fire in park ecosystems, in evaluating the success of the Park's burn program (Caprio and Graber 2000) and to ecologists interested in understanding dynamics of pre-Euroamerican plant and wildlife communities.

A growing body of empirical evidence indicates considerable variation in pre-EuroAmerican fire regimes, both temporally and spatially, across the landscape. However, because reconstructing past fire regimes is difficult, requiring considerable effort and experience, our current knowledge about this variation is sparse. For example, we have little information about past fire regimes at a scale that encompasses 1000+ hectares and includes varying slope, aspect, vegetation type, and elevation. This also includes a lack of knowledge about past fire regimes from several common vegetation types.

The fire history information being developed in this study will have both a direct impact on fire management decision making and a less direct but equally important impact on park management over the long term. For example, fire history data forms the foundation on which fire management planning using GIS fire return interval departure (FRID) analysis is based (Caprio et al. in press). Using fire return interval information that is of poor quality, in some cases simply an estimate, may result undesired management consequences (Caprio and Lineback in press). A significant unknown is how past fire regimes varied spatially across differing aspects. Recently, Miller (1998) developed computer models that look at surface fire regimes and forest patterns across elevation gradients in the southern Sierra Nevada. The models examined connectivity and spatial extent of fire over elevational gradients. The output suggests that differences in burn patterns/frequencies exist by aspect and these differ most notable between south and north slopes (Carol Miller personal communication). Structural and landscape differences in vegetation by aspect have also been suggested from the preliminary results of the Landscape Analysis Project (Kurt Menning personal communication) which may be related to differing fire regimes on the north versus south aspects. However, other than the preliminary results from the current fire history collections in the East Fork, little data exists on pre-European settlement fire history for north aspect forests in the southern Sierra Nevada. Thus the information collected in the East Fork will be critical in verifying these models and as input for more rigorous parameterization to improve their predictive ability.

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

I - EAST FORK WATERSHED FIRE HISTORY COLLECTIONS

OBJECTIVES

The goal of this data collection effort is to: 1) obtain information on the spatial extent of pre-Euroamerican fire on a watershed scale (fire size, spread patterns, and frequency variation), 2) acquire data on pre-Euroamerican fire regimes from the wide array of vegetation types within a watershed, and 3) integrate this information with the Parks' fire management program. Specifically, these data will provide improved information on fire frequency regimes from a range of vegetation associations that are being used as input into fire/GIS analyses to reconstruct past fire frequency regimes throughout the parks (Caprio and Lineback in press). Additionally, reconstructing the large scale spatial pattern fire in the East Fork will assist managers in determining whether they are meeting management objectives in restoring fire as an ecosystem process (Caprio and Graber 2000)

DATA COLLECTION and ANALYSIS

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

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

Specimens are being dendrochronologically crossdated to determine precise calender years in which past fires occurred (Stokes 1980). Crossdated fire chronologies provide results with precise temporal information that allows consistent comparison of fire dates among sites separated spatially across the landscape. Additionally, intra-annual position (or approximate season) of fire dates are also being determined when scar quality makes this possible (Ahlstrand 1980; Caprio and Swetnam 1995). Sample preparation and crossdating are most advanced from sites collected from 1995 though 1999.

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

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

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

Area burned within a given year by pre-Euroamerican fires is being reconstructed using Thiesson polygons (Davis 1986). Each irregular polygon represents the area around a point (representing a single sample site), in a field of scattered points, determined by Euclidean distance, that is closer to that point than any other point. The resulting field of polygons represents the most compact division of area, given the specific arrangement of points. This approach is commonly utilized for rainfall gauging networks when stations are not uniformly distributed and strong precipitation gradients occur (Dunne and Leopold 1978), both characteristics of the network of fire history sites sampled in the East Fork. Its use provides a valuable tool for quantifying and portraying spatial patterns of over a landscape. For the fire history sampling sites, polygons were constructed around the center point of each site using ArcView 3.2 Spatial Analyst (ESRI 1999) and area of each polygon determined. This allowed maps of annual burn area to be created for the watershed. While not computed for this report, future iterations of polygon calculation will use aspect as a constraint on polygon boundary delineation.

Based on GIS analysis and topographic features the watershed landscape has been categorized by elevation and aspect (see **Fig. 4.16-2** Caprio 2000). North and south aspects were defined as: south has slopes facing from 106° to 285° and north facing >285° to <106° with level topography classes as south and high and low elevation conifer forest was separated at 2286 m elevation.

RESULTS and DISCUSSION - Preliminary Analysis

Forty-seven specimens (logs, stumps, snags, or trees) were collected from 8 sites during 2000. This supplements samples from 128 sites previously collected (Caprio 1997, 1998, 2000a, 2000b). The large number of sample sites are required to provide adequately replicated data sets from across vegetation type, elevation, and aspect. The data set is providing baseline information on how past fire regimes operated and varied throughout a watershed with complex topography and vegetation communities. Since 1995 samples from the drainage have been obtained from 10 of the 11 major vegetation classes currently designated in the Parks (**Table 4.15-1**). This includes sites from both north and south aspects and over a range of elevations (**Table 4.15-2**). These collections greatly expand on previous work carried out in the watershed (Pitcher 1987; Swetnam et al.1992). Additionally, the collections are a source of new fire regime information for vegetation types not previously or little sampled in the Parks. These include Jeffery pine, lodgepole pine, foxtail, western juniper, and oak woodland while others,

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

Elevation (m)	Total	South	North
<1000	0	0	0
1000-1250	0	0	0
1250-1500	1	1	0
1500-1750	12	8	4
1750-2000	28	20	8
2000-2250	28	19	9
2250-2500	19	11	6
2500-2750	33	12	21
>2750	14	8	6
Total	131	79	52

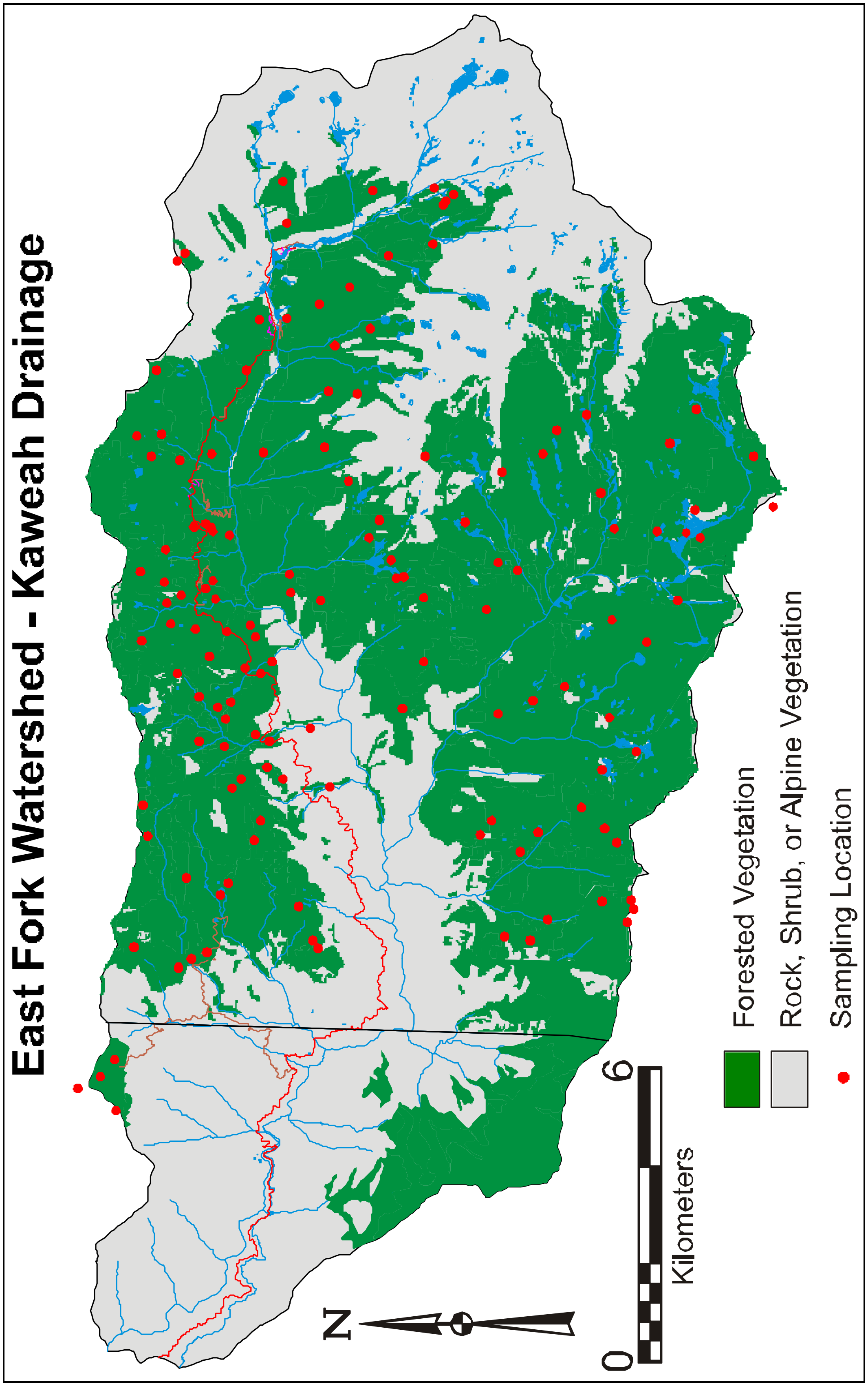

Figure 4.15-1. Fire history collection sites in the East Fork of the Kaweah Watershed.

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

Currently 136 sites have been collected [two of these were previously collection in the Atwell giant sequoia grove by Swetnam et al. (1992)] with 587 individual trees sampled (primarily logs and snags). The sites are located throughout the 12,887 ha watershed (**Fig. 4.15-1**) so that 82 % are within 1000 m of any other site. Mean number of samples collected at individual sites is 4.3 (SD=2.4). Fire dates have been determined from ~108 sites and form the basis for the current fire return interval estimates and annual area burned reconstruction. A total of 255 dated samples were used in this analysis with over 2722 individual fire scar dates. A total of 304 fire event years (years in which a fire event was recorded somewhere in drainage) are recorded between AD 1400 and AD 1995 although fire dates extend back to 284 BC at the sequoia sites (Swetnam et al. 1992). For the primary period of analysis, 1700-1899, 151 fire event years are recorded within the drainage. The last fire of significant size occurred in 1889 (recorded at 5 sites) with 1994 the most recent fire date recorded (sampling in recent burns has been avoided or not possible because most fire history material at these locations has been destroyed by the fires).

Annual Area Burned

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

A chronosequence of annual burn patterns back into the early 18th century will be developed for the watershed. The sequences will provide rough estimates of area burned and spatial pattern of burns. An example the annual burn area for the East Fork is shown for the years from 1839 to 1849 (**Fig.4.15-2**). Apparent are a range of year types, with years when extensive fires occurred to years without fire to years when no fires were recorded. The temporal variation in annual area burned is examined in the following section “Frequency-Area Relationships”. This chronosequence of burn maps will complement and extend the GIS fire records database back in time.

Fire-Return Intervals

Fire-return interval analysis looks at point estimates based on individual site data and is the typical method of looking at past fire history data (**Fig. 4.16-3**). Within the East Fork watershed considerable variation in fire-return intervals have been found among sites with obvious patterns apparent from individual site fire chronologies. For example, fire chronologies show (1) both differences in mean fire-return intervals (FRI) among the sites related to elevational differences, as described by Caprio and Swetnam (1995), and (2) occurrence of common fire years among sites--years such as 1848 and 1875. Further analyses are possible when these results are summarized into composite fire chronologies for each site.

Initial comparisons of FRI between north and south aspects for a subset of sites at low-to-mid elevations (1800-2200 m) have provided the most interesting results to date. These data suggest that

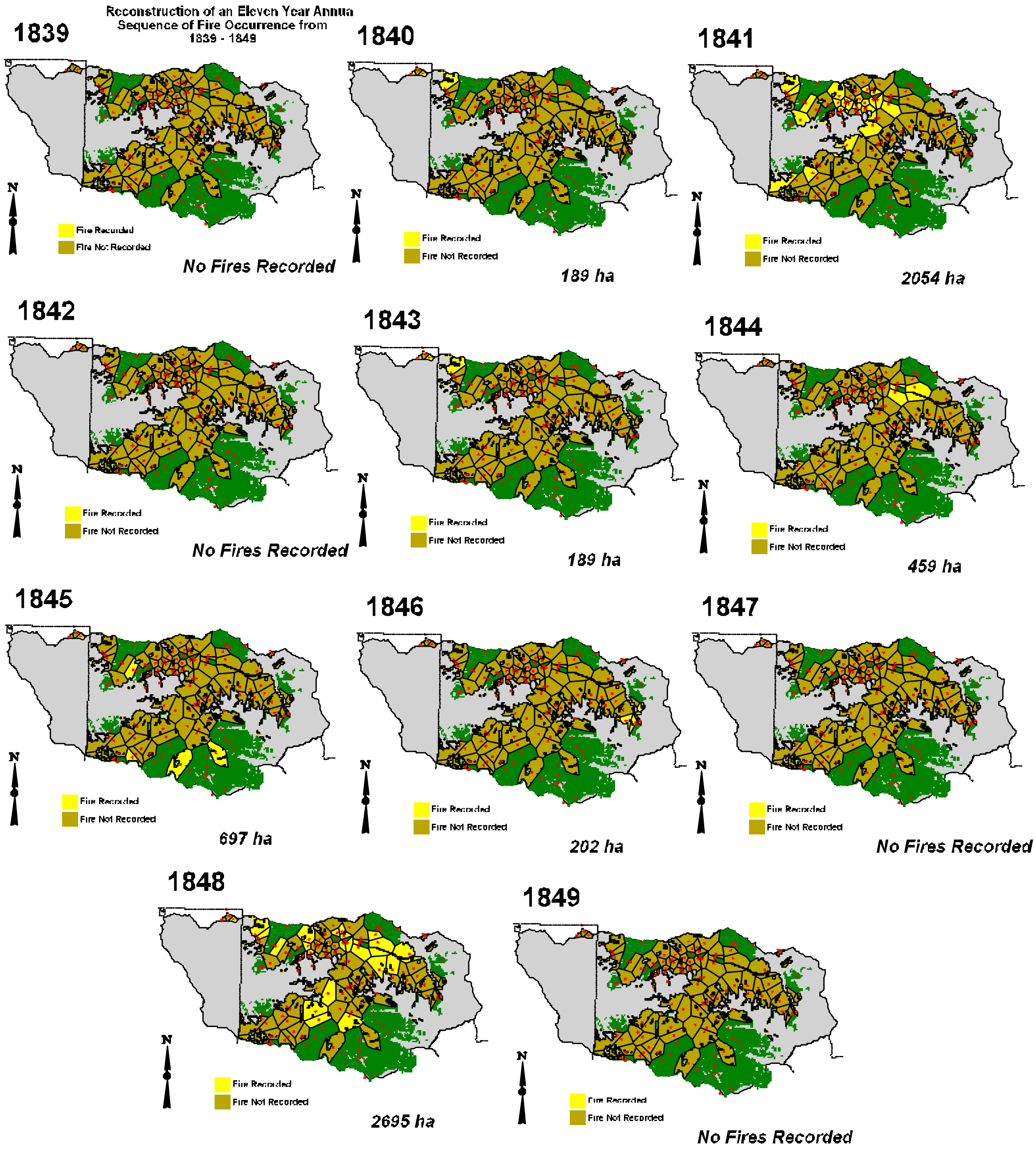

Figure 4.15-2. Chronosequence of reconstructed annual area burned between 1839 and 1849 showing variation in burn patterns across the landscape.

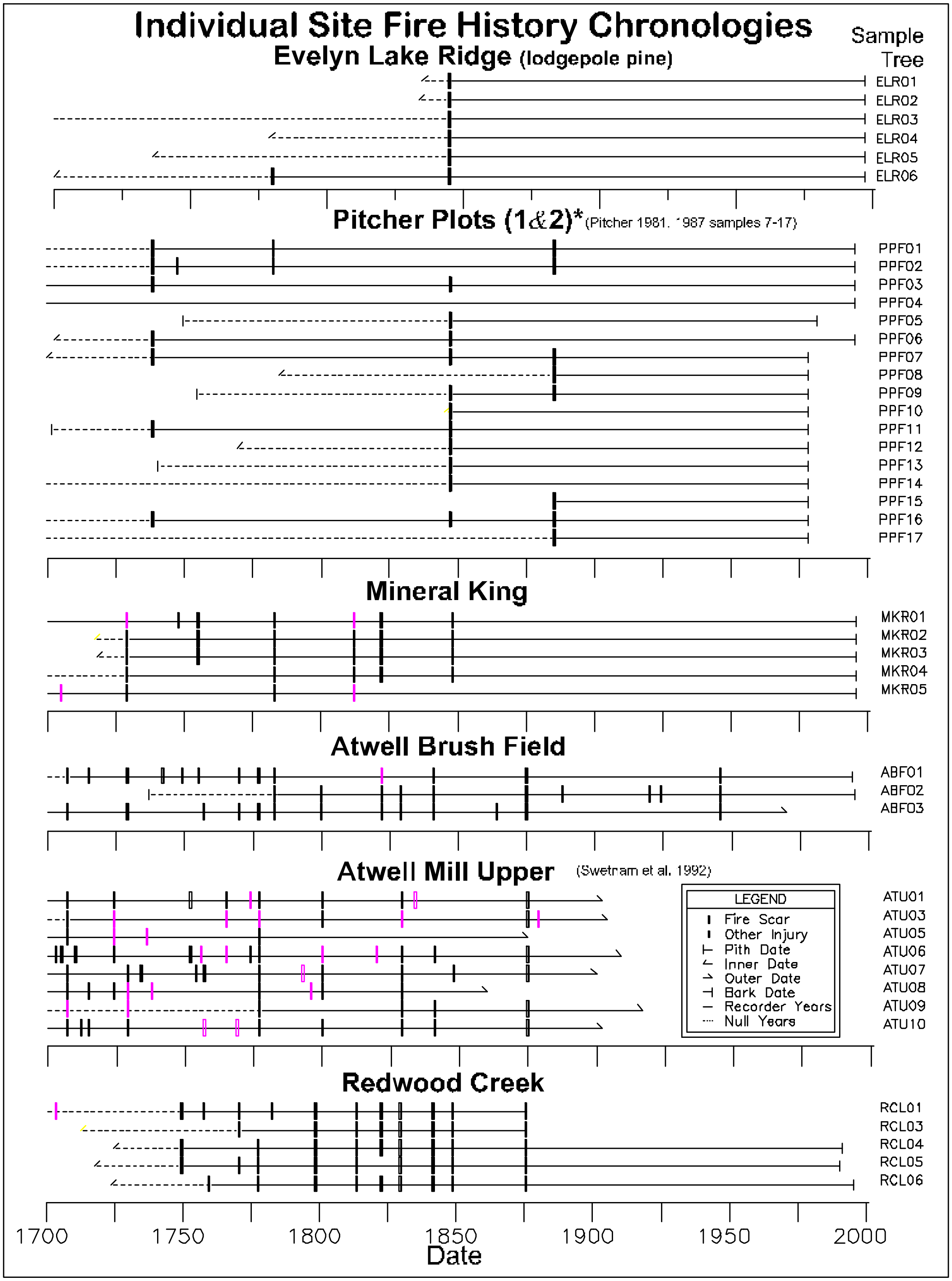

Figure 4.15-3. Examples of reconstructed fire history data from five sites in the East Fork drainage for the period from 1700 to the present. Sites illustrate varying pre-Euroamerican fire regimes from differing vegetation types and aspects in the watershed. Horizontal lines represent a particular sample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

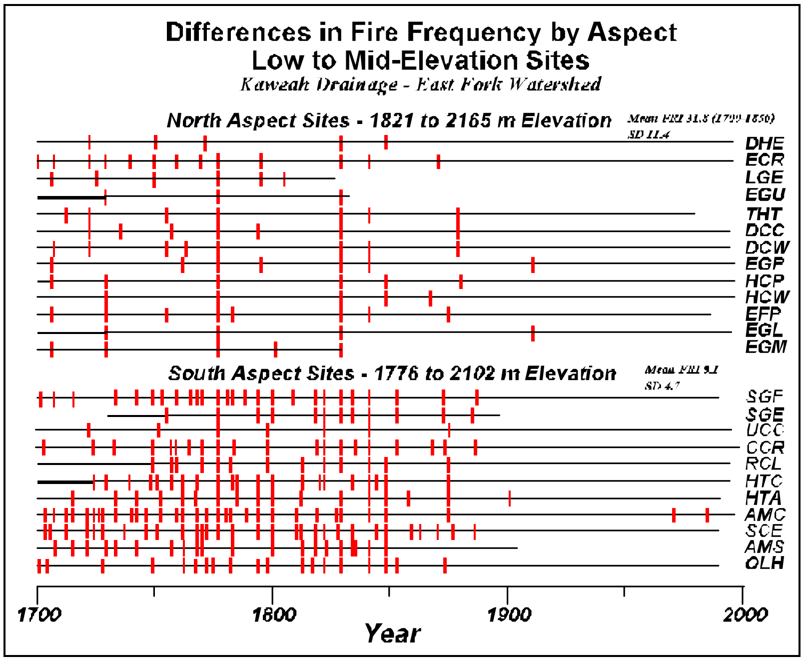

Figure 4.15-4. Differences in fire frequency by aspect for low-to-moderate elevation sites in the East Fork drainage. Each horizontal line represents a composite site chronology with verticle red lines indicating fire dates.

there were considerable differences in FRI between north and south aspects in this elevational range. FRI averaged about three-times greater on the south aspect relative to the north aspect (~9 years versus ~31 years) (**Fig. 4.15-4**). Sampling during 1999 and 2000 has been partially directed at obtaining collections from north/south aspects in other drainages to determine whether such aspect differences can be generalized to larger areas of the Parks. If consistent, such differences in fire return intervals by aspect will have important implications for fire managers in terms of burn planning, on anticipating potential fire effects on these sites, and understanding mechanisms responsible for initiating or maintaining attributes of past forest structure.

Additionally, comparison of point fire frequency estimates, for the period from 1700 to 1899, across the elevational gradient in the drainage, for the sites on the south aspect versus the north aspect show dramatic differences. A strong inverse relationship between number of fires and elevation was observed on the south aspect which corresponded very well with the results from previous sampling along an elevational gradient in the Giant Forest area (Caprio and Swetnam 1995). However, the relationship between elevation and aspect on the north facing slopes was much weaker suggesting that fire occurrence across the elevational gradient on this aspect was comparatively uniform relative to the south aspect (see **Fig. 4.16-16** Caprio 2000).

Frequency-Area Relationships

Reconstructing annual area burned within the watershed permits us to view patterns and variation in area burned through time and in many ways provides a more realistic feel for past fire occurrence at a landscape level. A plot of reconstructed area burned (based on polygons) for the whole watershed shows considerable year-to-year variation. Extensive area burned is apparent in a few years (1777, 1829 and 1848) with many years when a small-to-intermediate amount of area burned. Average area burned annually within the watershed was 320 ha (this value will probably increase as sampling and sample analysis for all area within the watershed are completed) or about 2.4% of the coniferous forest area. The distribution of reconstructed area burned annually within the watershed from 1700 to 1899 shows an inverse J shaped distribution (**Fig. 4.16-5**). Most fires were small with a few years when extensive fire occurred.

Considerable more detail was apparent when data were separated by elevation and aspect (**Fig. 4.16-6**). The analysis showed dramatic differences in area burned annually by aspect and elevation with patterns that were similar to the fire-return interval analysis described above. Differences were greatest between lower elevation north/south aspects (~ three-times) and decreased as elevation increased (~ two-times).

Low elevation south aspect with high frequency of small to fairly large fires in contrast to low elevation north aspect where fire frequency was moderate-to-low but punctuated by very large fires at intermittent intervals. Between 1700 and 1899 two large fires occurred in 1777 and 1829 (based on tree-ring analysis these appear to have been dry to very dry years). On both the north and south aspect at higher elevation frequencies were low (lowest on north high). North high with similar freq to south low although was not punctuated by large fires.

SUMMARY

The current sample set greatly improves the resolution and spatial accuracy for reconstructing past burn history within the East Fork watershed. It is important that fire history information be obtained from a large set of areas to present a clear picture of past fire regimes over the landscape with less bias than previous sampling that centered on specific vegetation types, aspects, or elevations. As data from the current sample set are developed it will provide information about attributes of past fire regimes from throughout the watershed. Data will also be used as input into the GIS/Fire model (FRID) being developed for Sequoia and Kings Canyon National Parks (Caprio et al. 1997, Caprio and Graber 2000).

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

Main Findings

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

• ***Estimates of past fire size*** - The results suggest that past

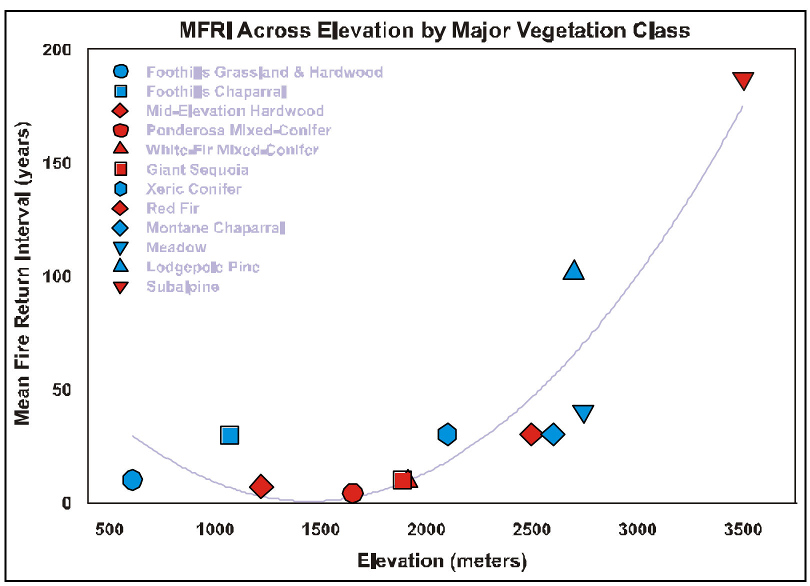

Figure 4.15-5. Relationship between mean fire return interval and elevation for the 12 major vegetation classes within Sequoia and Kings Canyon National Park (from Caprio and Lineback 1997).

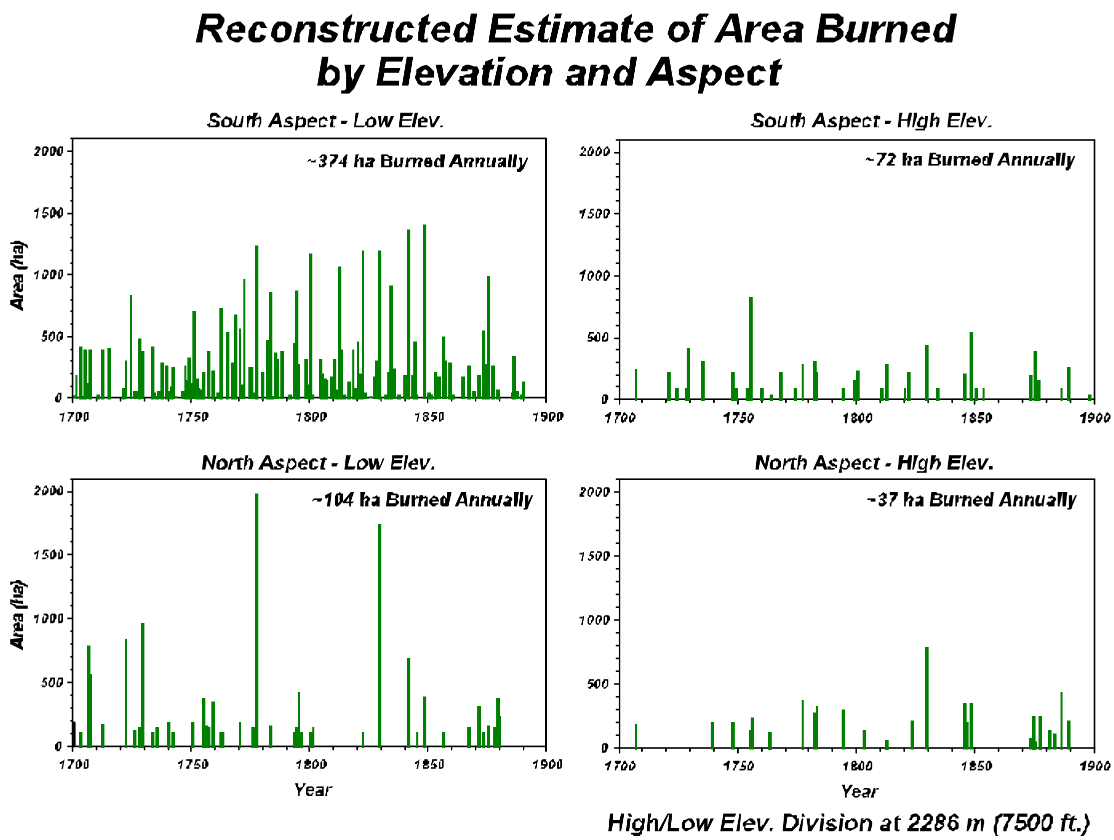

Figure 4.15-6. Reconstructed estimates of area burned annually in the East Fork drainage showing differences by aspect and elevation. The lower south aspect showed the greatest differences relative to the other aspect categories.

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

II - ADDITIONAL SAMPLING

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

The sampling for this validation study is designed to be much less intense than the East Fork with only 4-6 sites collected on each aspect within a drainage. Obtaining this information and understanding potential differences among watersheds will eventually be incorporated into the FRID analysis and into fire management planning. Sampling procedures for individual sites were the same as described for the Mineral King Study above. During the year 2000 aspect sampling was carried out in the Marble Fork of the Kaweah River (**Fig. 4.15-7**) and in Kings Canyon (**Fig. 4.15-8**).

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

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

The specific goal of the Kings Canyon sampling is to provide more detail on past fire frequency and how it varied throughout the valley. The valley contains a ponderosa dominated forest community that is unusual in the Parks. North aspects are more typical ponderosa pine/white fir mixed conifer. Dry sites, particularly on south aspects, that are protected from fire starts or fire spread have mixed piñon pine/evergreen oak (*Pinus monophylla/Quercus chrysolepis*) forest. More mesic mid-elevation sites on this aspect are dominated by Jeffrey pine (*Pinus jeffreyi*). Of note: the only fire history material available in the valley was found in areas that had not been burned over the last 20 years. Fuel loads and condition of fire scarred trees from the pre-settlement period are such that the fire scar record is destroyed by any fires that occur. Thus the current samples will become an important historical record that document some attributes of past fire regime characteristics in the valley that would have been lost otherwise.

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

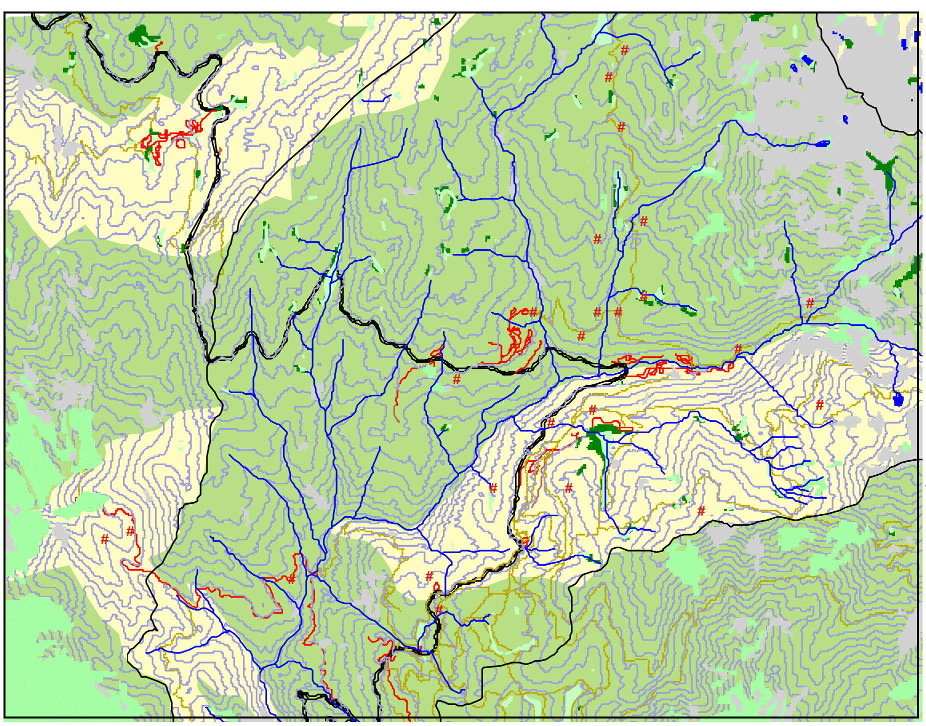

Figure 4.15-7. Sites (red dots) sampled in the Marble Fork of the Kaweah drainage (light green = chaparral, grey = rock, dark green = meadow, yellow = north aspect, medium green = south aspect).

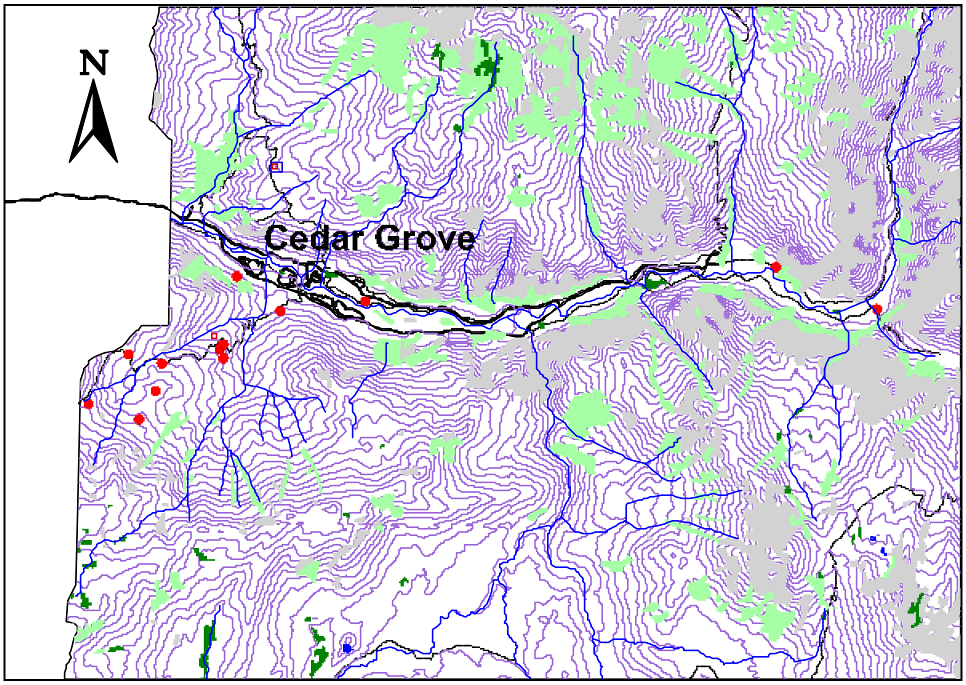

Figure 4.15-8. Sample site locations (red dots) in Cedar Grove, Kings Canyon (light green = chaparral, grey = rock, dark green = meadow).

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

Prior to this sampling only one fire history site had been collected in Kings Canyon. These data collected by Warner (1980) show very short fire intervals, in the order of three-to-four years between fires and are about the shortest recorded in the parks. However, although much of the valley is dominated by ponderosa pine forest there is considerable difference in site productivity within the valley with very strong gradients between these areas. Vegetation and productivity of sites located along lowland river terraces appear much greater than terraced upland locations such as the area known as the Gobi Desert (a large dry flat expanse east of Roads End). Site productivity appears to be associated with moisture availability in the highly permeable glacially deposited soils. Considerable differences in species composition and canopy cover exist by site and appears dependant on site productivity. Upland sites tend to be dominated by ponderosa pine (*Pinus ponderosa*) and lowland sites by white fir (*Abies concolor*) although ponderosa pine may have been more important historically. Because of these differences in site productivity fuel accumulations differ today and probably differed in the past. If fuel accumulation rates governed past fire occurrence (versus ignition source) then the drier upland terrace sites (such as Gobi Desert) should show longer fire return intervals than the lower river terraces.

Sampling in the Kings Canyon area will complement several research projects underway or being planned in the area. These include the USGS Repeat Photo study (Bueno et al. 2000 and this document) and the USGS Cheatgrass study funded by the JFSP which will be initialized during 2001 (see Caprio et al. 2000 and Section 4.6 of this document for details). Baseline information about past fire regimes in the valley will be important in developing management strategies for dealing with the exotic cheatgrass.

The three sites collected were located just south of the housing area, in the Gobi Desert area, and immediately east of the footbridge across the Kings River Creek off the Bubbs Creek Trail.

III- PLANS FOR 2001

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

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

IV - PAPERS OR PRESENTATIONS BASED ON FIRE HISTORY SAMPLING

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

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

Returning Fire to the Mountains: Can We Successfully Restore the Ecological Role of Pre-Euroamerican Fire Regimes to the Sierra Nevada? A.C. Caprio and D.M. Graber. 2000. pp 233-241. In: Cole, David N.; McCool, Stephen F.; Borrie, William T.; O'Loughlin, Jennifer (comps). Proceedings: *Wilderness Science in a Time of Change-- Vol. 5 Wilderness Ecosystems, Threats, and Management*; 1999 May 23-27; Missoula, MT. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-15-VOL-5

Incorporating a GIS Model of Ecological Need into Fire Management Planning. M. Keifer, A.C. Caprio, P. Lineback, and K. Folger. 2000. *Proceedings of the Joint Fire Science Conference and Workshop, Crossing the Millennium: Integrating Spatial Technologies and Ecological Principles for a New Age in Fire Management*, June 14-16, 1999, Boise, ID.

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

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

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

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

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