3.12) Red Fir Plots (Pitcher Plots)

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INTRODUCTION

Ecological relationships and long-term stand dynamics of red fir forest have been poorly studied in the Sierra Nevada. Most studies have been descriptive, concentrating on composition, structure, and very basic biology (Oosting and Billings 1943; Pitcher 1981; Barbour and Woodward 1985; Laake et al. 1996). Similarly, fire effects information is sparse and poorly understood for this forest type in the Sierra, although the first prescribed burn of over a few acres in the western United States was carried out and studied in a red fir forest in Kings Canyon National Park (Kilgore 1971). Within Sequoia and Kings Canyon National Parks red fir forests comprise approximately 26,511 ha or about 13.2% of the parks' vegetation (based on parks' GIS vegetation maps). Within this forest type a range of burn severities and potential fire effects appears to exist, from understory burns with minor impacts on stand structure to severe burns that are stand replacing events (Pitcher 1981; Taylor 1993; Carl Skinner personal communication). The spatial scale of these events also appears to vary within stands. Sequoia and Kings Canyon National Parks have been carrying out an expanding burn program which has included a substantial amount of prescribed burning in this forest type with even greater acreage planned for the future. This has led to the realization that a better understand of both the long-term role and specific ecological effects of fire in this ecosystem are important.

In the late 1970s Donald Pitcher (graduate student at UC Berkeley) established three permanent plots near Mineral King to study forest structure and composition (what species are present and how they are arranged in a forest), and fuel dynamics (fuels available to forest fire) (Pitcher 1981). Because little long-term data from red fir forest exist, these plots will provide information to park managers on changes in forest structure and composition, and fuel loads over a 20 year period. Postburn sampling will provide detailed information on forest changes and fire effects. When combined with the detailed spatial data (tree locations, fuel loads, crown dimensions) this data will provide an excellent opportunity to examine changes over time and fire effects at a degree of sophistication not usually available. Our understanding and interpretation of fire effects and longer-term postfire vegetation responses will be improved by having the 20 years of background information.

STUDY AREA

The three plots established by Pitcher (1981) were located in red fir forest along the Tar Gap Trail (**Fig. 3.12-2**). They were established in roughly three forest "age types" on a north aspect: plot #1 in

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

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

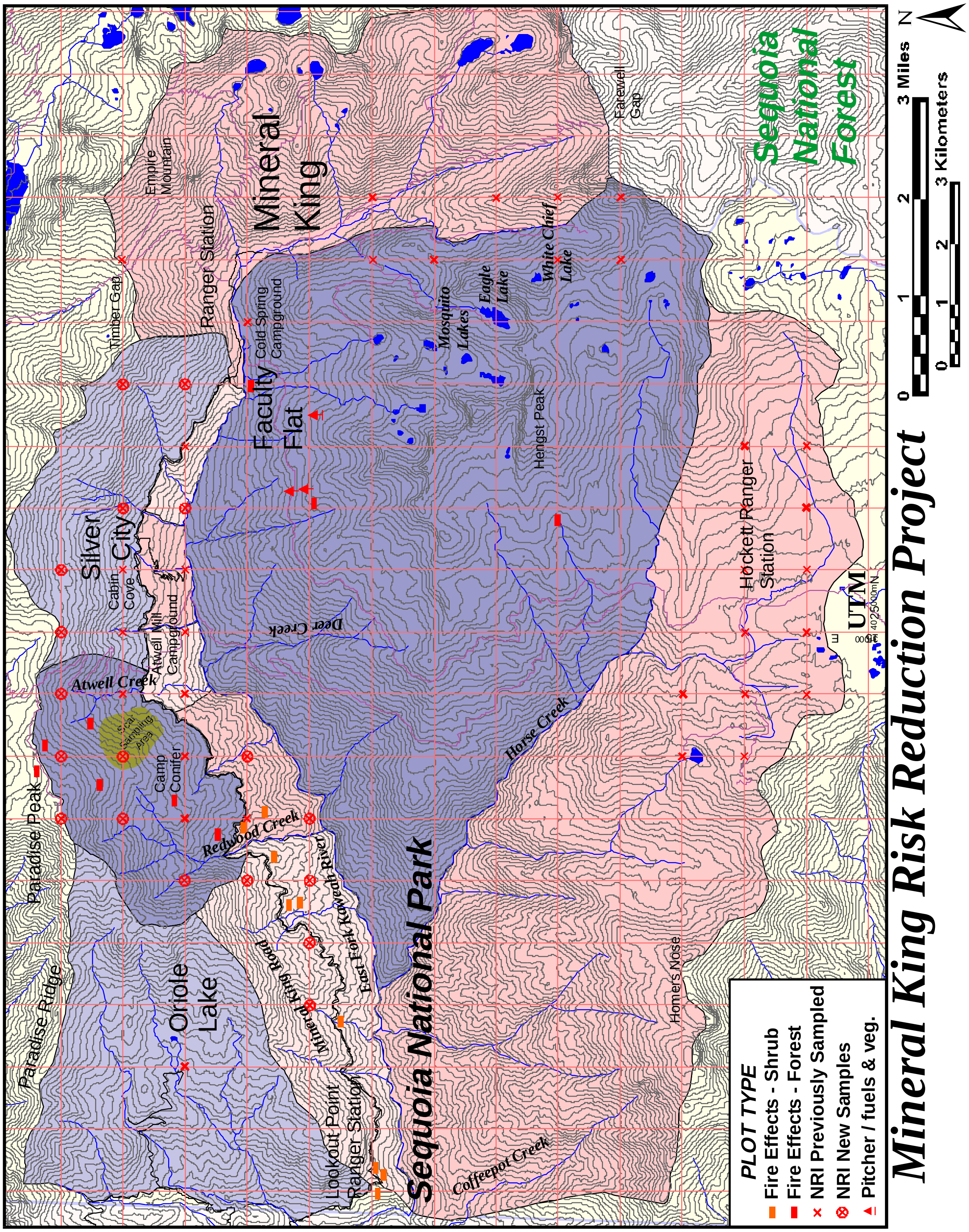

Figure 3.12-2. Plot locations for vegetation sampling projects.

Table 3.12-1. UTM locations and elevation of the NE corner of each plot.

Plot	UTM North	UTM East	Elevation	Plot Size
Plot #1	4033980 N	353328 E	2545 m (8400 ft)	80 x 80 m
Plot #2	4034150 N	353273 E	2485 m (8200 ft)	50 x 50 m
Plot #3	4033910 N	354464 E	2612 m (8620 ft)	50 x 50 m

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

METHODS

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

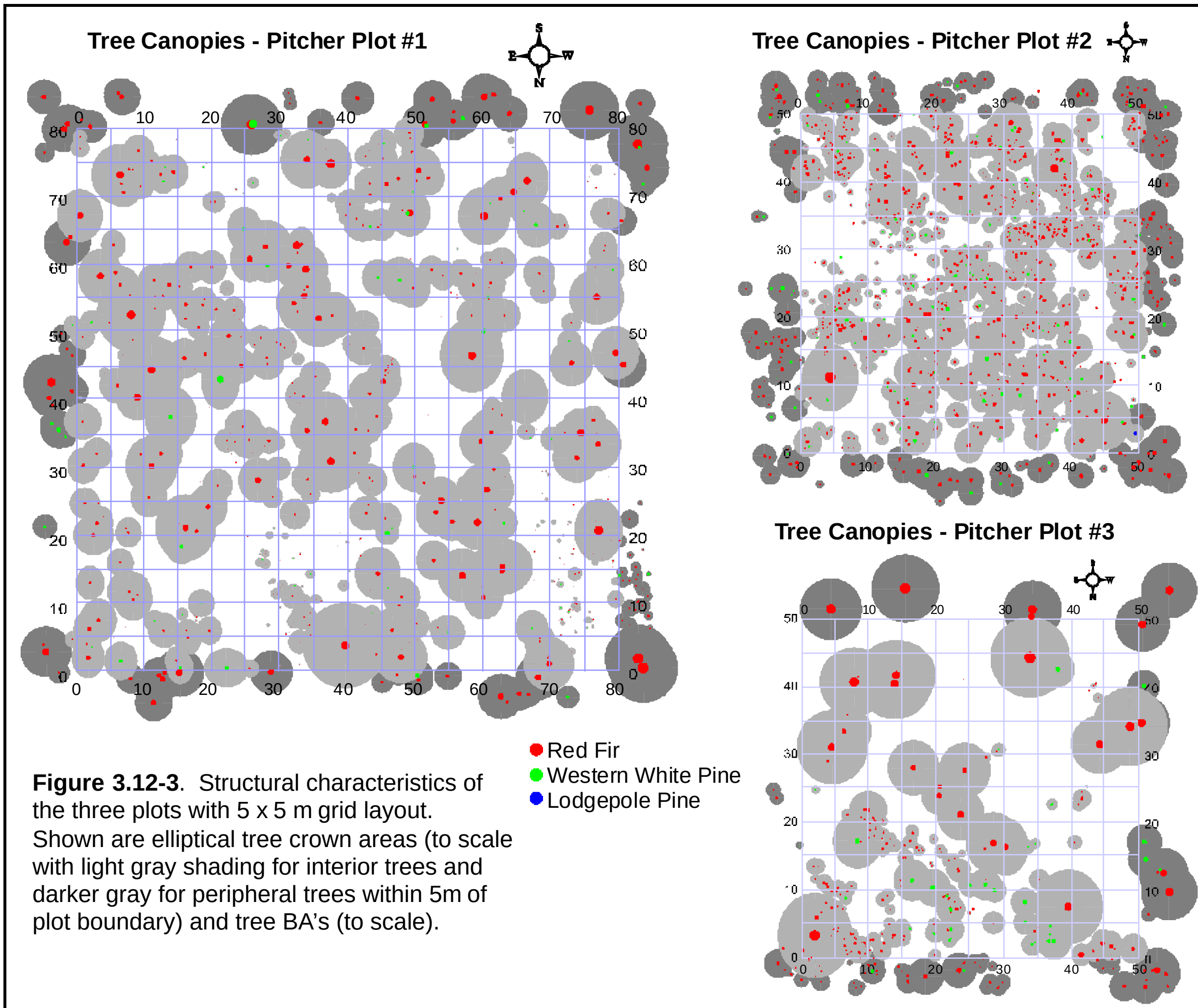

Figure 3.12-3. Structural characteristics of the three plots with 5 x 5 m grid layout. Shown are elliptical tree crown areas (to scale with light gray shading for interior trees and darker gray for peripheral trees within 5m of plot boundary) and tree BA's (to scale).

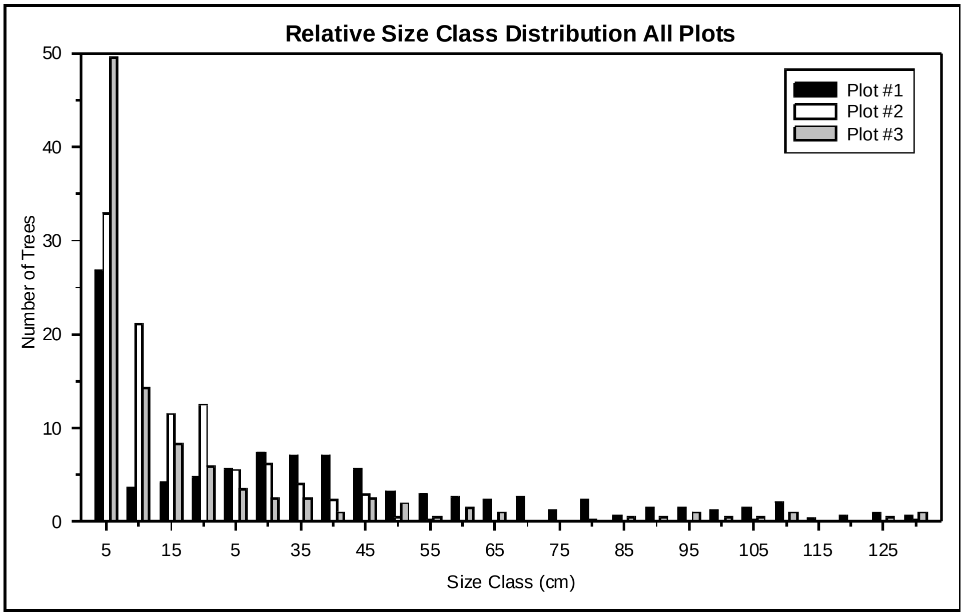

Figure 3.12-4. Comparison of relative size class distribution of trees between plots.

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

Resampling of all three plots has nearly been completed. Data recollected on the plots included: DBH, mortality checks, tree height of individuals <1.4 m tall, fuels, and canopy cover. Additional data (location, species, and DBH) were also collected on peripheral trees, those trees > 1.4 m high that have stems within 5 meters a the plot boundary, since these trees would influence trees in the outer subplots of each plot (see **Fig. 3.12-3**). For example, canopies of these peripheral trees overhang the outer subplots and mortality or fire effects in these subplots may be related to stand characteristics in adjacent areas (for instance tree density or size classes). Canopies of these trees were estimated using the relationship between BA and canopy cover of the internal plot trees..

RESULTS AND DISCUSSION

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

Stand Structure

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

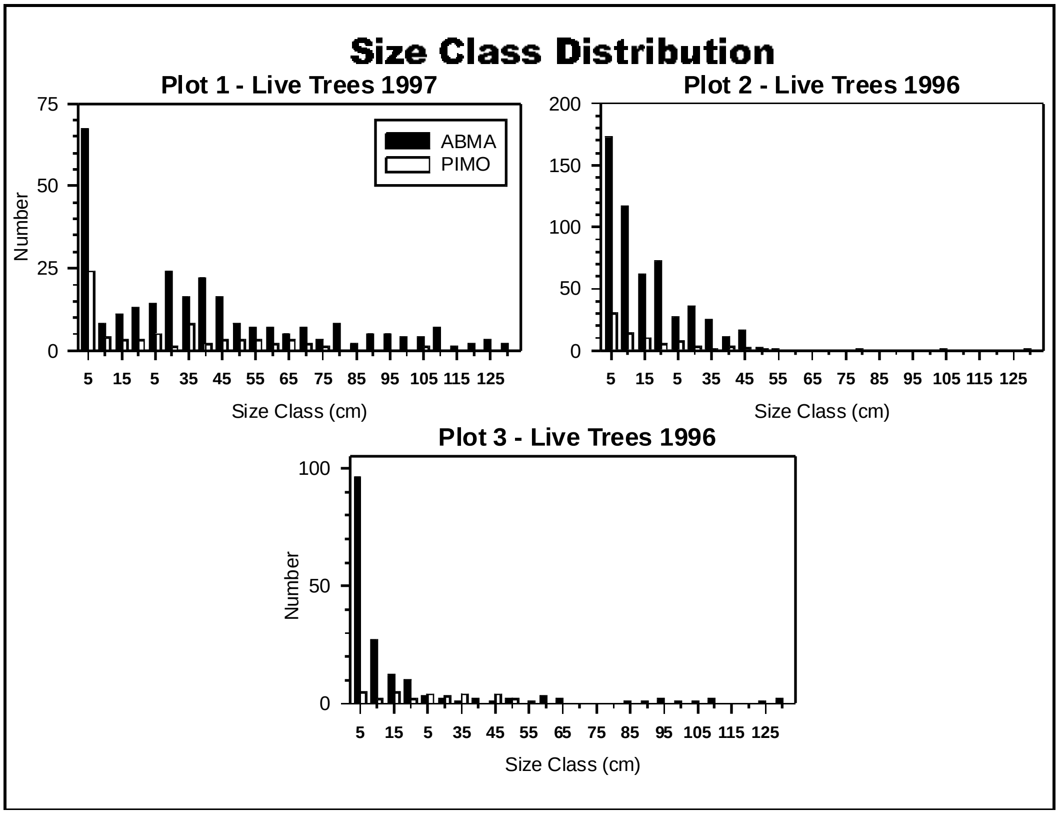

Figure 3.12-5. Size class distribution by plot and species showing differences in size class structure.

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

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

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

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

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

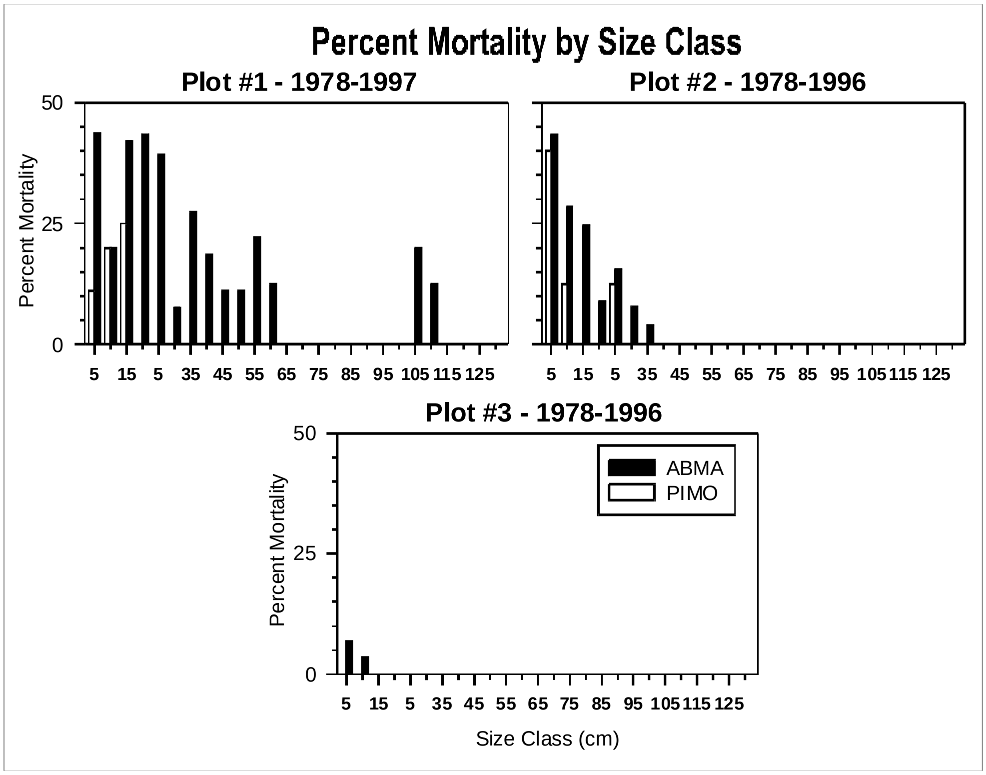

Figure 3.12-6. Percent mortality by species for size classes in the three plots from 1978 to 1997.

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

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

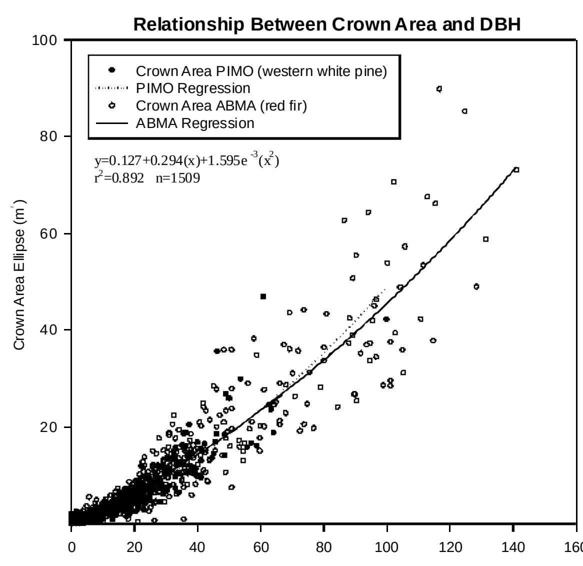

Figure 3.12-7. Relationship elliptical crown area and DBH of ABMA and PIMO (based on 1978 Pitcher data set) used to estimate crown area of peripheral trees. The final equation used combined data from both species.

Fuels Data

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

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

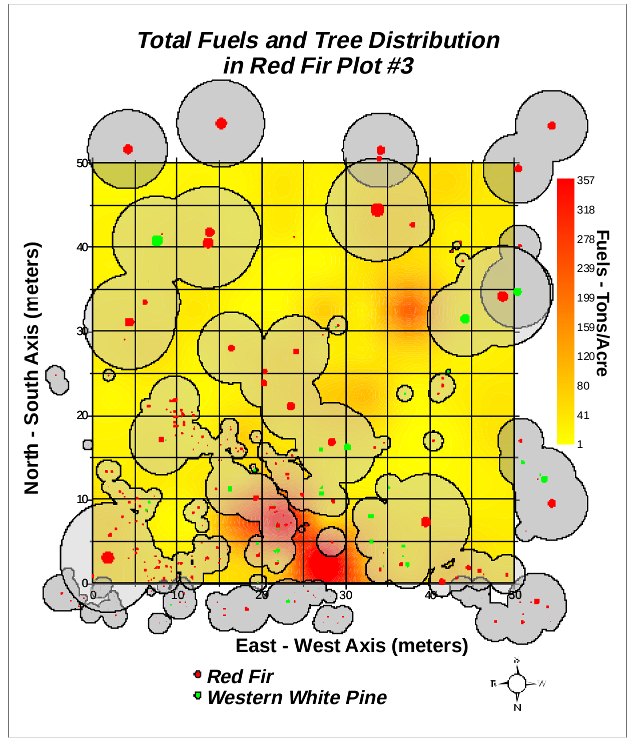

Figure 3.12-8. Spatial distribution of total fuels and tree crowns and DBH across plot #3. Total fuels tended to be heavier in areas where tree mortality has occurred, often areas with a low canopy density (see Fig. 3.12-10).

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

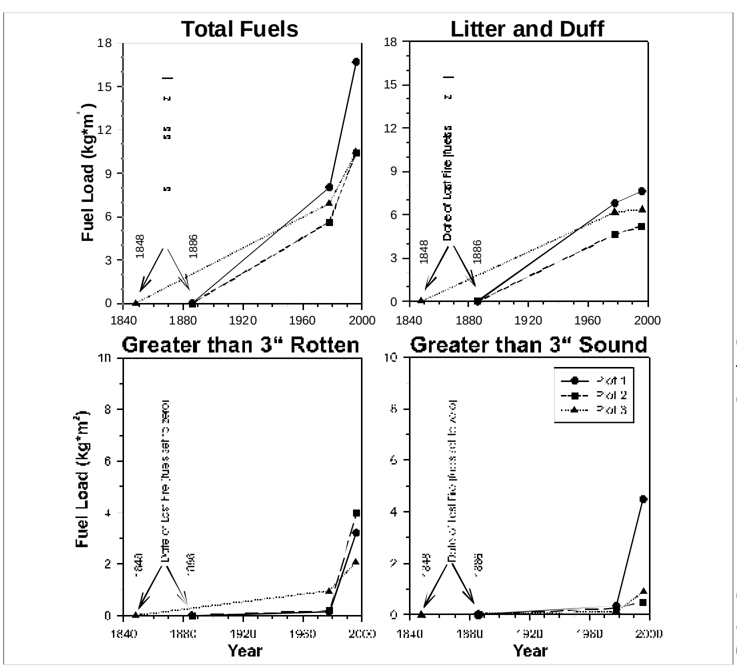

Figure 3.12-9. Preliminary estimates of fuel load changes in the three plots for four fuel categories. Initial zero value is based on the last recorded fire that burned through the plots (see Fire History). Estimates from 1978 and 1996 are based on modified Brown's inventory techniques (Brown 1974).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

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

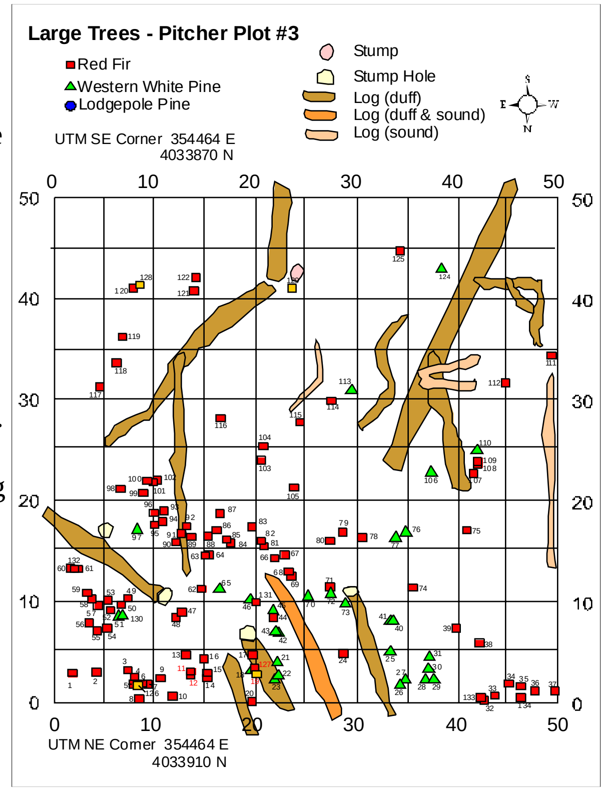

Figure 3.12-10. Location of downed logs and stumps in plot #3. Decay state of logs was also noted.

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

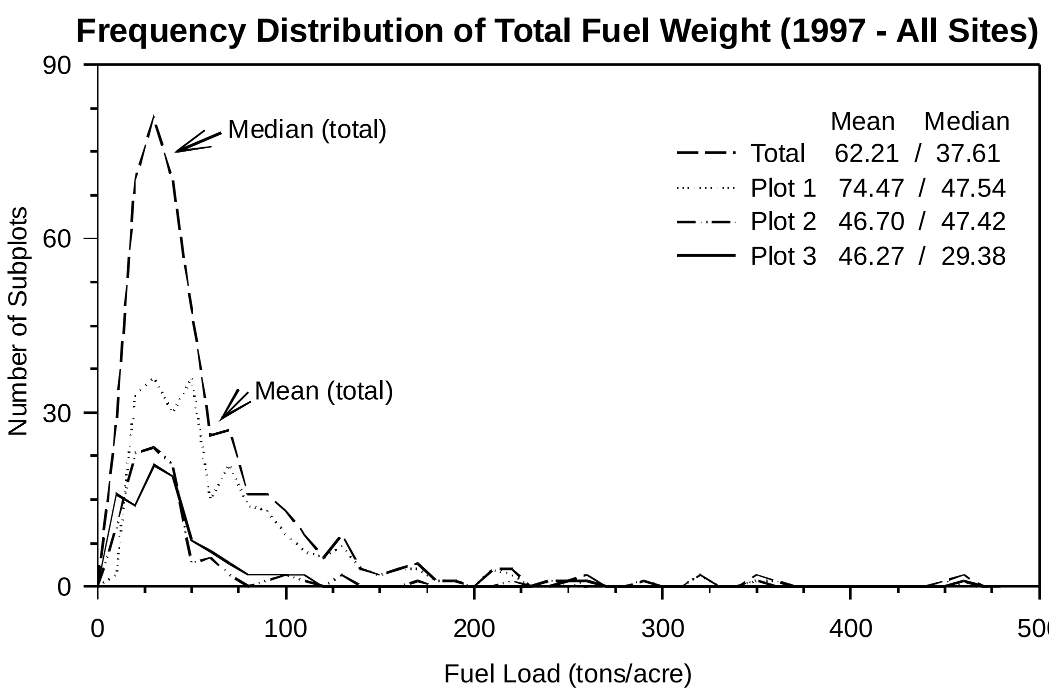

Figure 3.12-11. Frequency distribution of total fuel weights for subplots for 1997 data. Graph shows that very high fuel loads were uncommon and that the median fuel value was a better estimator of the central tendency of the distribution.

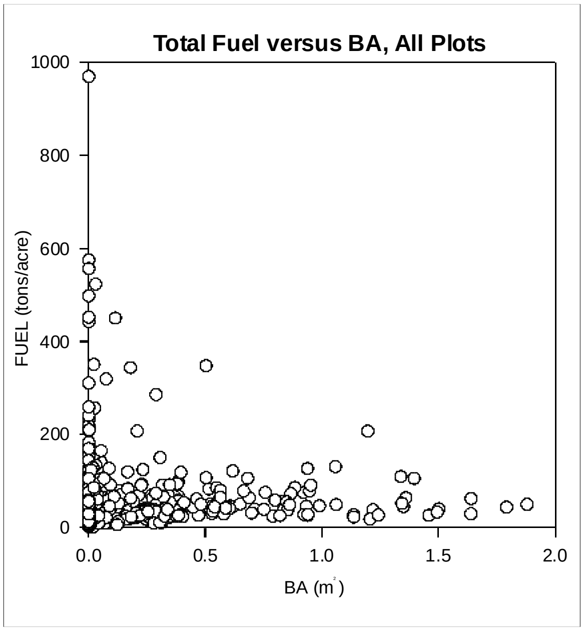

Figure 3.12-12. Relationship between total fuel and BA for each subplot. The greatest fuel loads were found in subplots of low BA.

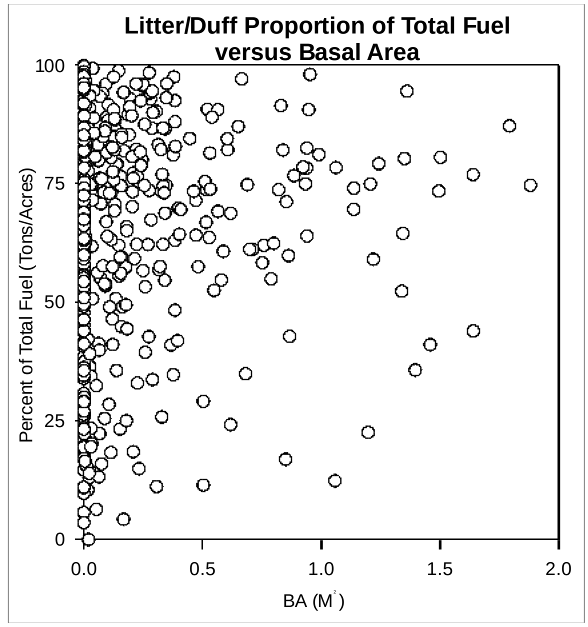

Figure 3.12-13. Relationship between BA and the proportion of litter/duff fuel of total fuel. Subplots with small amounts of litter/duff were generally not observed in areas of high BA.

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

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

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

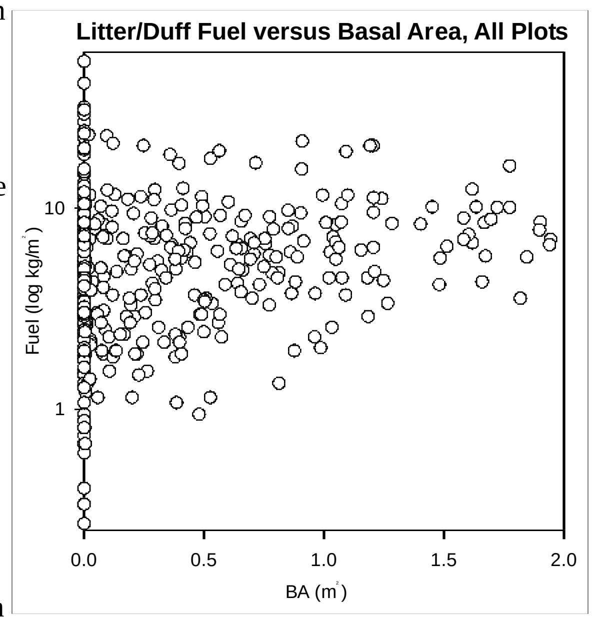

Figure 3.12-14. Relationship between litter/duff fuel (log scale) and BA for each subplot.

PLANS FOR 1998:

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