3.16) Fuel Inventory and Monitoring

- Science and Natural Resources Management, SEKI

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

INTRODUCTION

Recent advances in computerized technologies have given resource managers more tools for making critical resource management decisions. The development of a Geographic Information System (GIS) based fire spread model called *FARSITE* is an example of one of these new tools. The *FARSITE* model, like most models requires quality-input data in order to produce reliable output. The fuels model and canopy characteristic data are the most important inputs to any fire growth model. Currently, the fuel model map for Sequoia and Kings Canyon National Parks is based on vegetation maps developed in the 1960s and 1970s.

The purpose of this study is to improve the parks GIS fuels theme and collect data on forest canopy characteristics. The canopy characteristics data will be used to develop tree height and height to live crown base GIS themes that are used within *FARSITE* to model crown fire activity (torching, spotting, and crowning).

DESCRIPTION OF THE STUDY AREA

The study is being conducted in the East Fork of the Kaweah watershed. Terrain in the watershed is rugged, with elevations ranging from 874 m (2,884 ft.) to 3,767 m (12,432 ft.). The watershed, 21,202 ha (52,369 ac) in size, is bounded by Paradise Ridge to the north, the Great Western Divide to the east, and Salt Creek Ridge to the south. The Parks administrative boundary to the west defines the study area's western extent. The vegetation of the area is diverse, varying from foothills chaparral and hardwood forest at lower elevations to alpine vegetation at elevations between 3,049-3,354 m (10-11,000 feet). The study is being conducted in the mixed conifer belt and red fir forest. Ponderosa pine mixed conifer communities occur at the lower elevations <1,982m (<6,500 ft). The mid-elevations 1,982-2,439m (6,500-8,000 ft) are dominated by the white fir mixed-conifer community including sequoia groves. Red fir forest forest dominates the higher elevations at 2,440-3,049m (8,001-10,000 ft).

METHODS

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

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

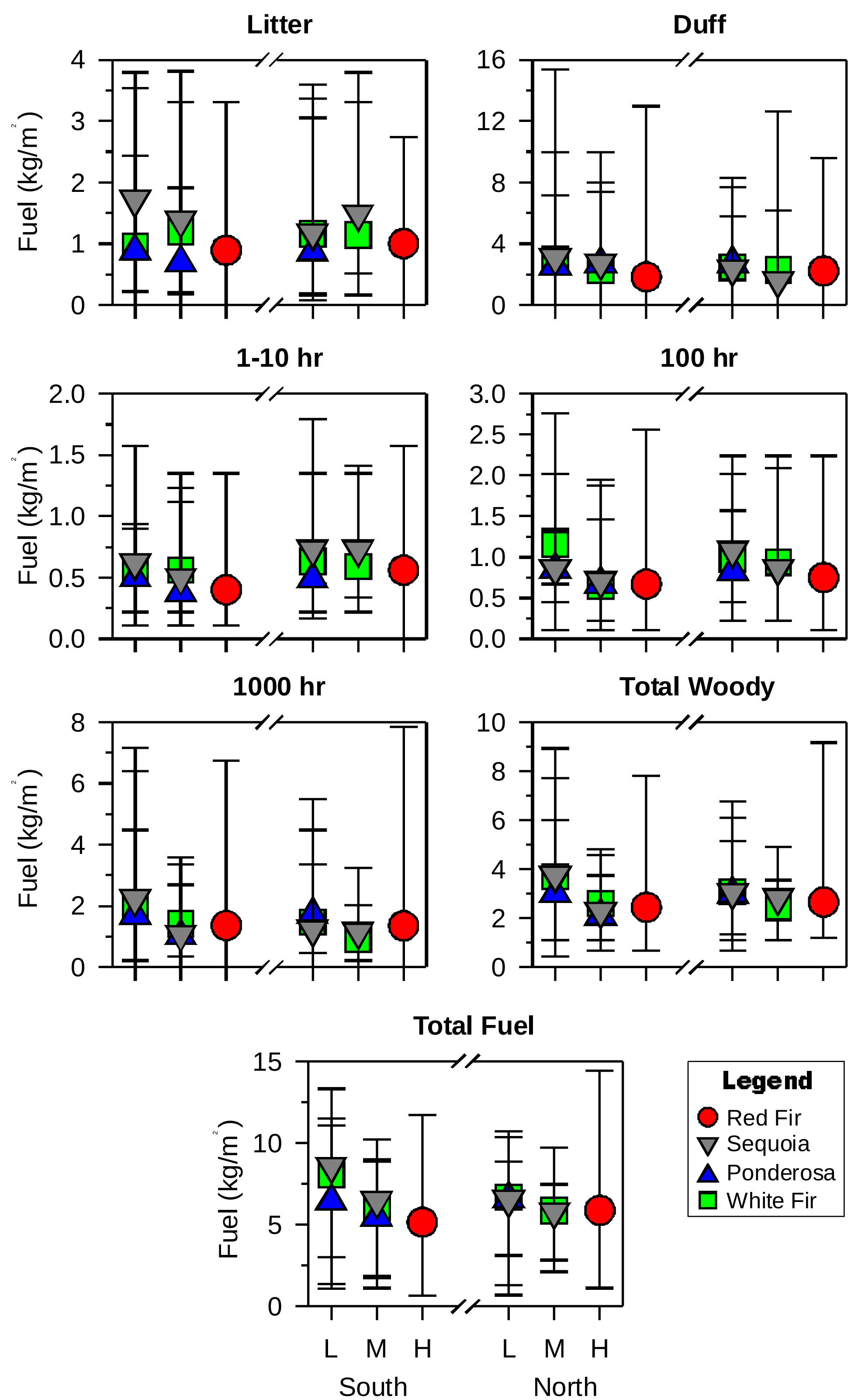
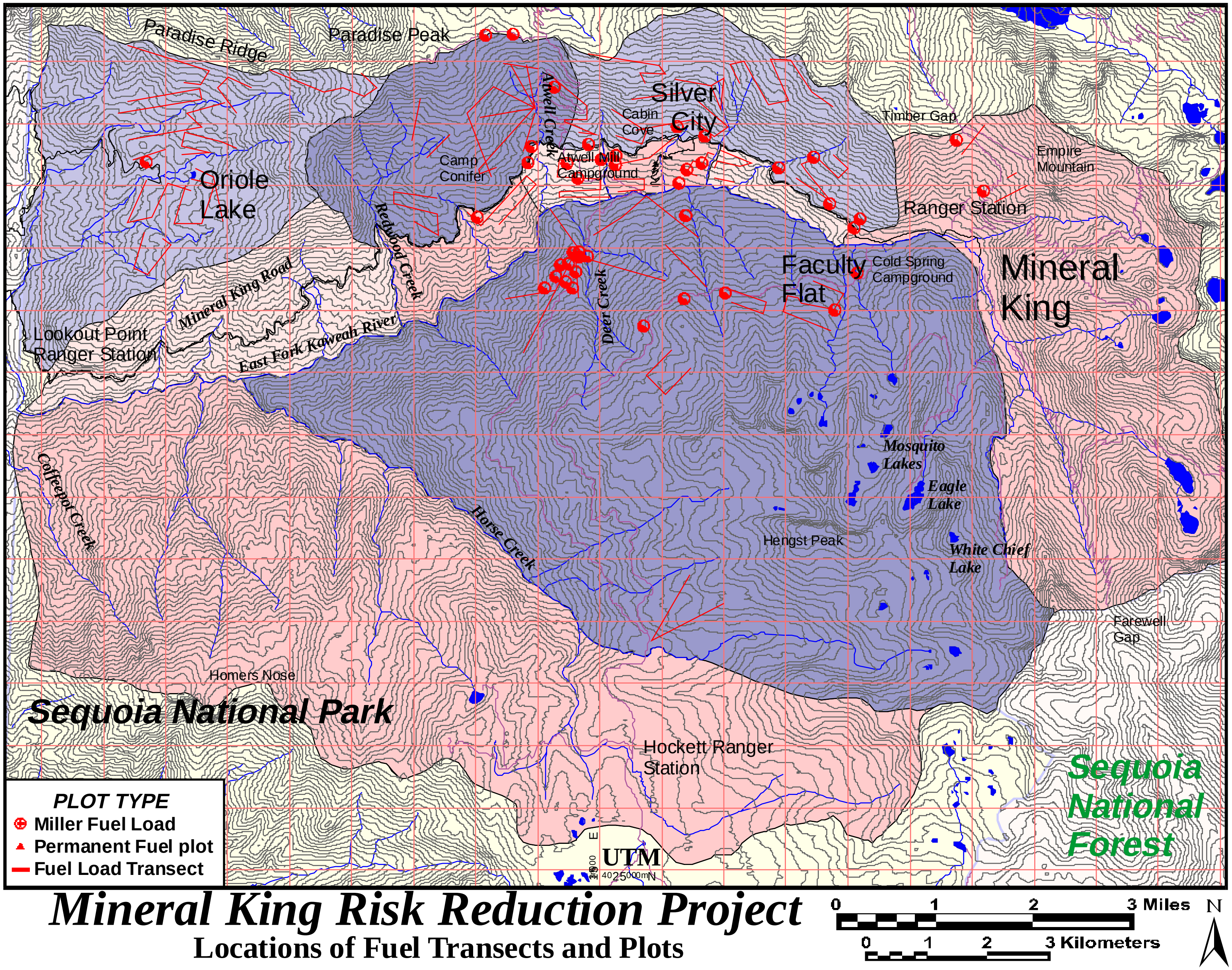


Figure 3.16-2. Fuel data from 1995 and 1996 (from transects) for four vegetation classes at low (L), moderate (M), and high (H) elevations on north and south aspects.



Mineral King Risk Reduction Project
Locations of Fuel Transects and Plots

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

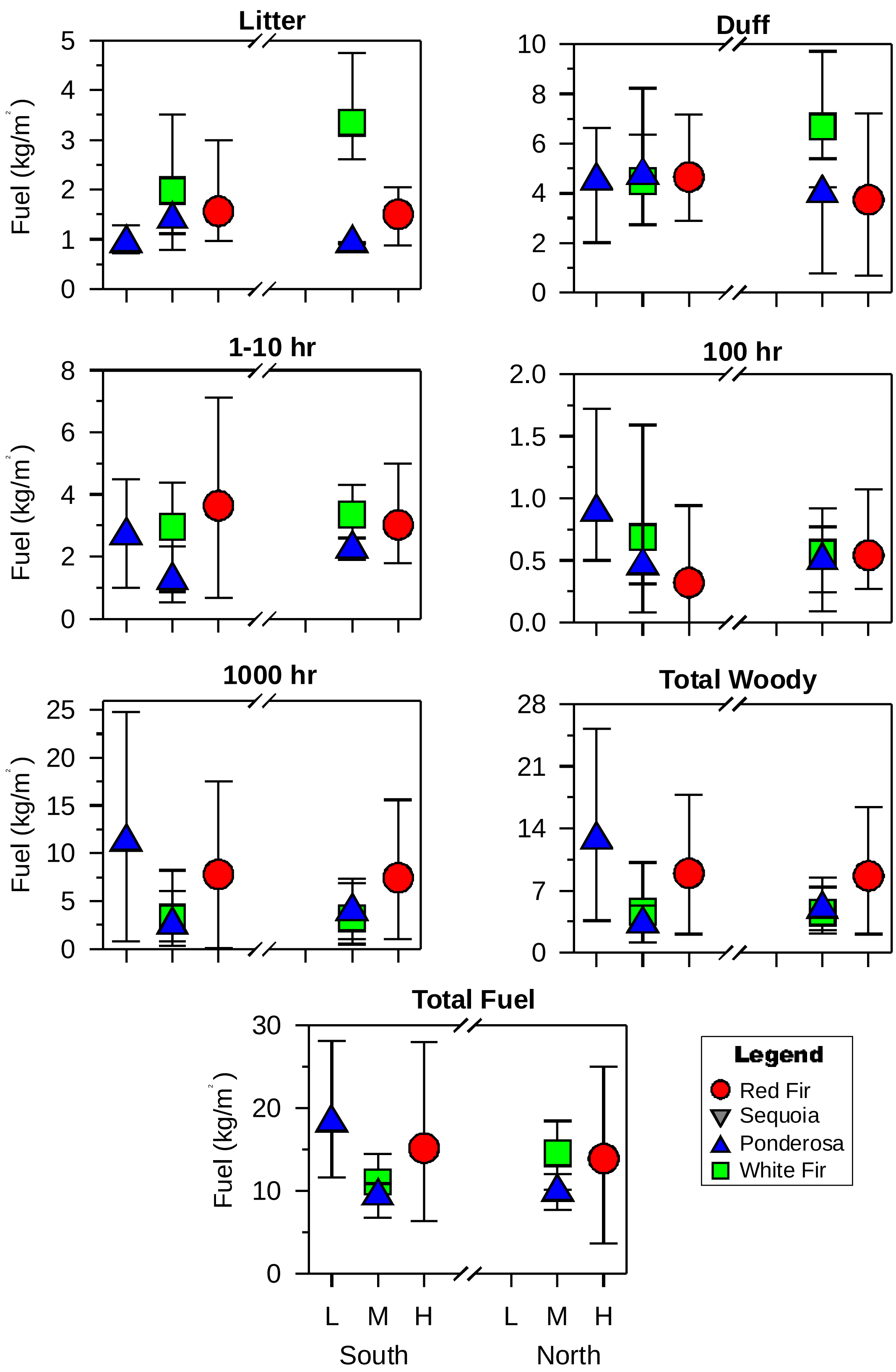


Figure 3.16-3. Fuel data from 1997 (permanent plots) for four vegetation classes at low (L), moderate (M), and high (H) elevations on north and south aspects.

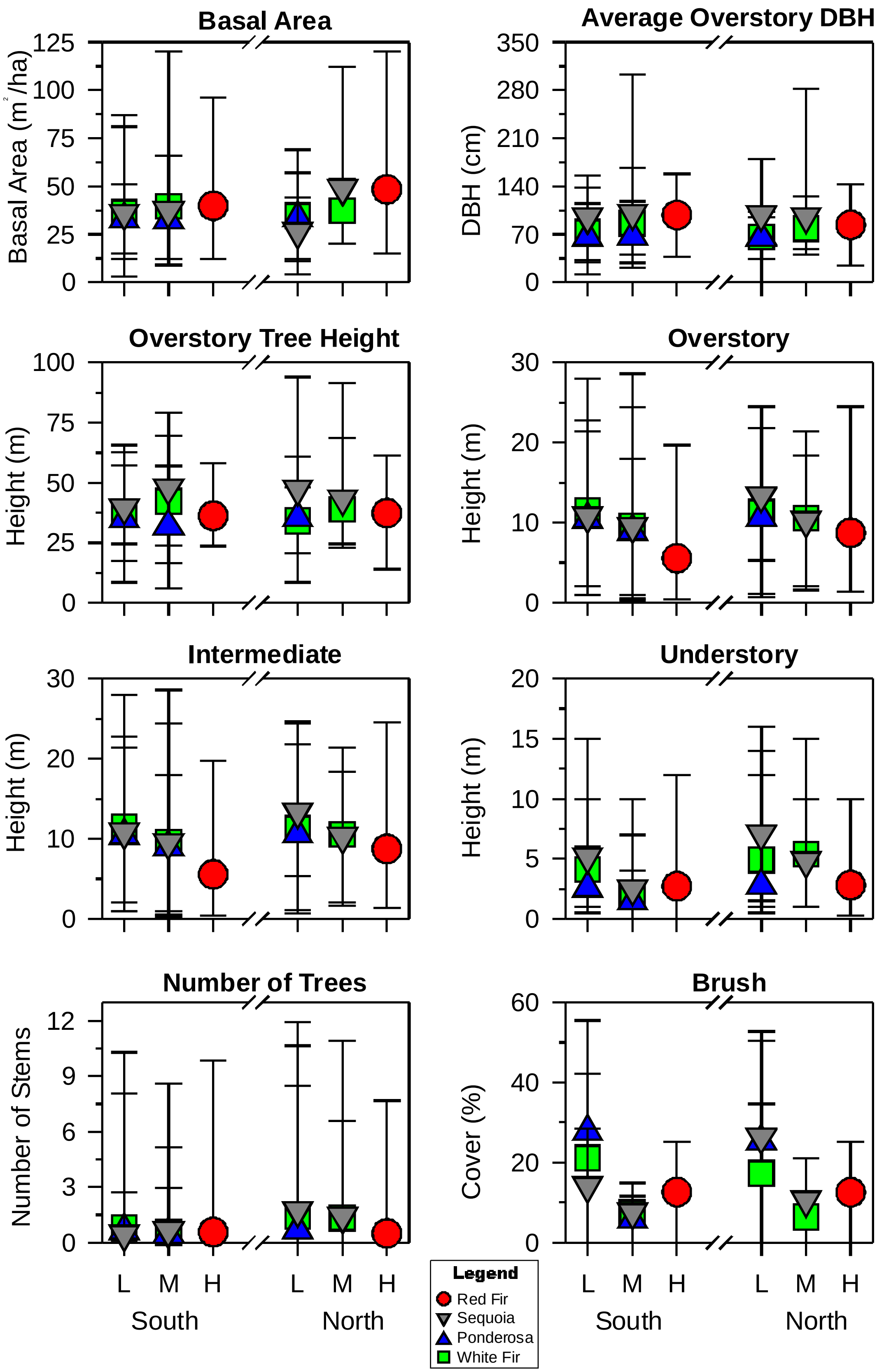


Figure 3.16-4. Stand data from 1995 and 1996 (from transects) for four vegetation classes at low (L), moderate (M), and high (H) elevations on north and south aspects.

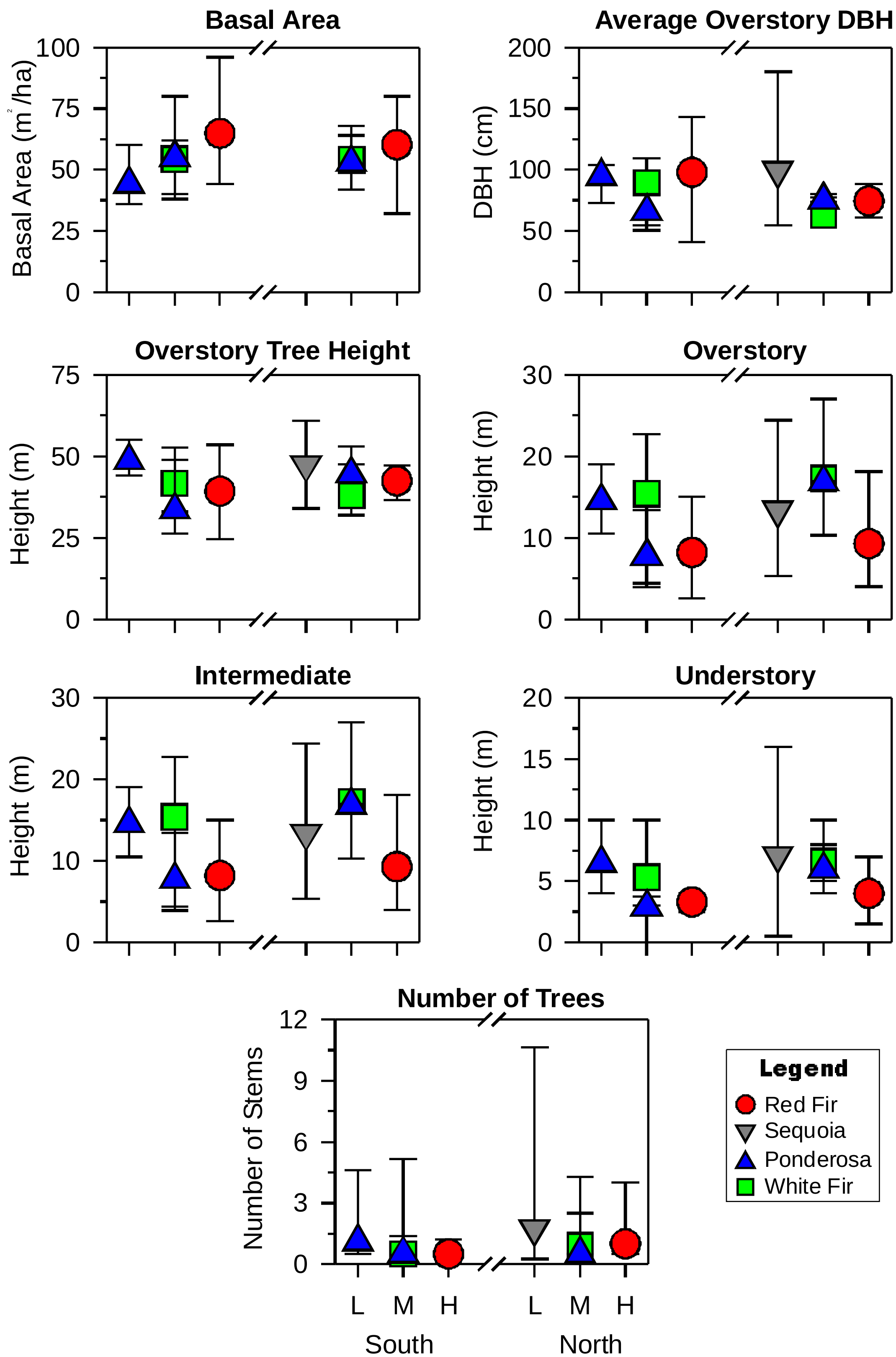


Figure 3.16-5. Stand data from 1997 (from permanent plots) for four vegetation classes at low (L), moderate (M), and high (H) elevations on north and south aspects.

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

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

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

Beginning in 1997 permanent fuel loading plots were established in order to track fuel accumulation over time. Plots were established in a variety of vegetation types throughout the East Fork watershed (**Fig. 3.16-1**). The planar intercept method (Brown, 1974) was used to sample fuels. Each plot consisted of four fifty foot transects running north, south, east and west from the center point. Ten litter and duff measurements were taken along each of the 50 foot transects. Based on the two previous years data, the permanent plots were located in the short needle – this included sequoias – and long needle conifer forest types in the following elevation classes: low <1,982m (<6,500 feet), mid 1,982-2,439m (6,500-8,000 feet) and high > 2,440m (>8,000 feet).

RESULTS AND DISCUSSION

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

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

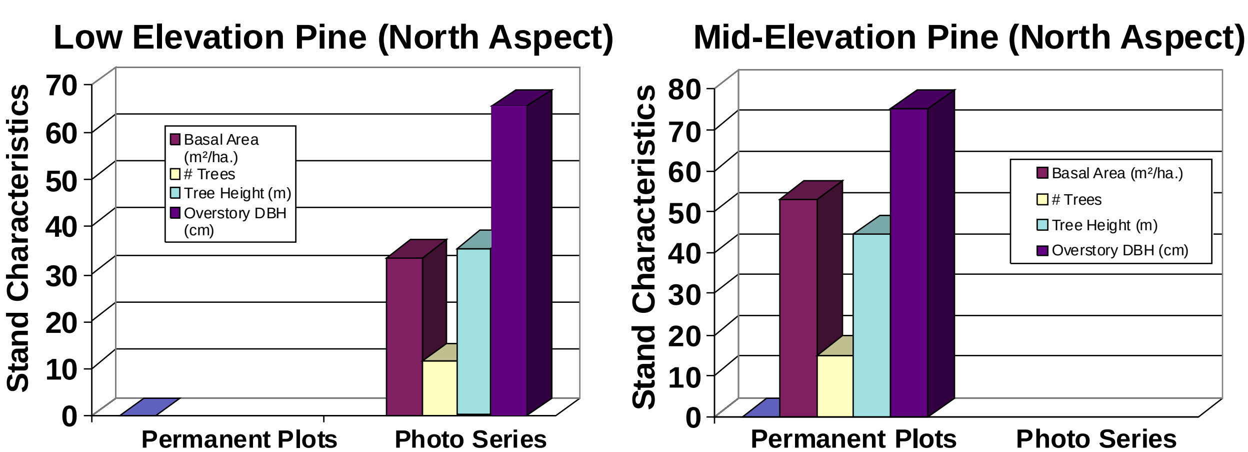


Figure 3.16-6

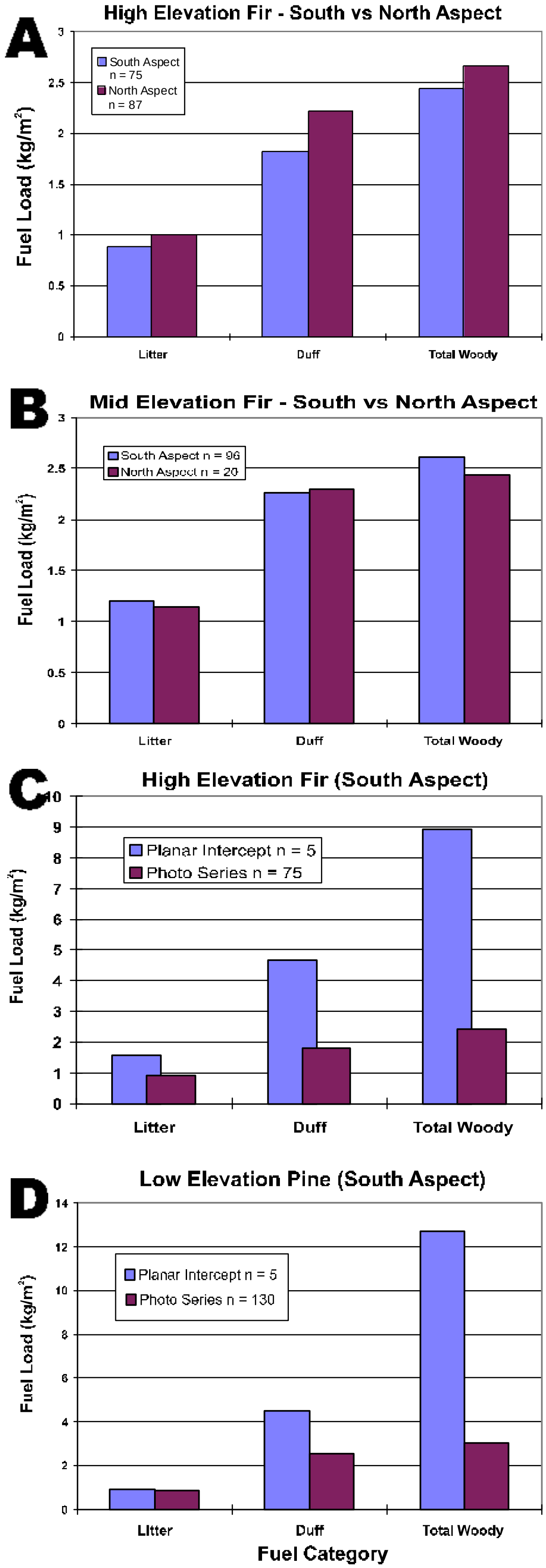


Figure 3.16-7

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

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

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

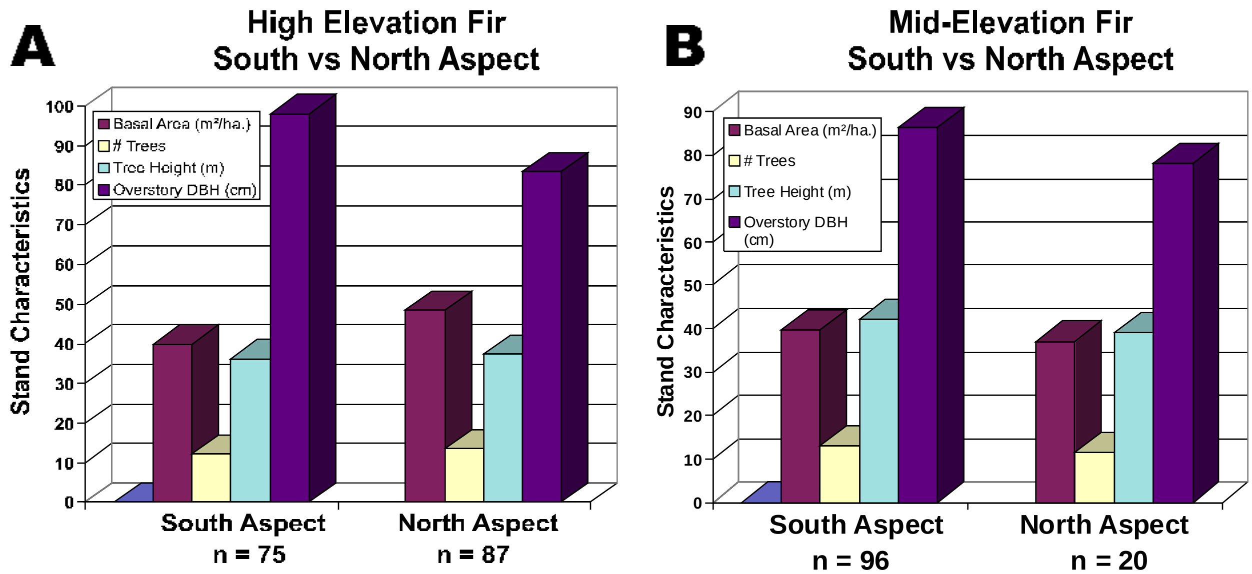


Figure 3.16-8

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

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

SUMMARY

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

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

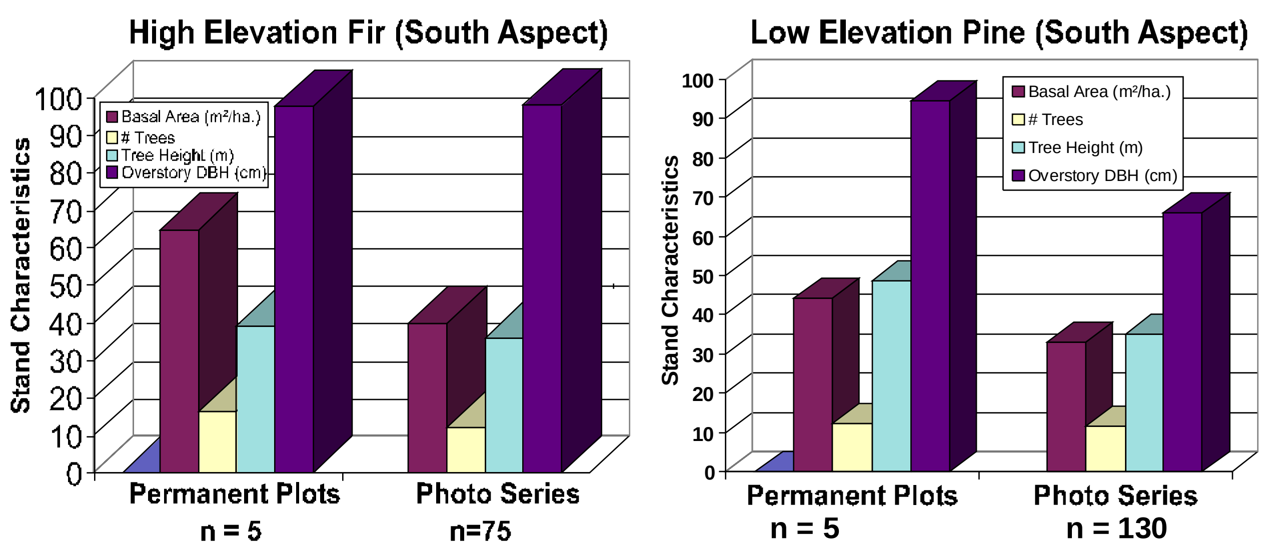


Figure 3.16-9

[[% error=(standard error/mean) x 100] of our total fuel loading estimates are less than twenty percent. When installing future permanent fuel plots, we will also make photo series estimates at the same location. We will also revisit the permanent fuel plots installed in 1997 to take photo series estimates at those locations. Using these two estimates we will attempt to determine if a correlation exists between the two methodologies. If a significant correlation does exist we can derive a correction factor for the photo series. Use of this correction factor to survey future areas because you can collect about five times as many sample points with the photo series when compared to the planar intercept method.

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

Appendix 3.16.1. Summarized fuels data for fuel transect plots.

	Litter kg/m² (t/ac)	Duff kg/m²	1&10 Hr. kg/m²	100 Hr. kg/m	1000 Hr. kg/m²	Total Woody kg/m²	Total Fuels kg/m²
High elevation > 2440m (8000 feet) Red Fir Forest South Aspect (105-285°) n= 75							
Average	0.89 (3.96)	1.82 (8.12)	0.40 (1.8)	0.67 (3.00)	1.36 (6.09)	2.44 (10.88)	5.15 (22.95)
S.D.	0.64	2.13	0.26	0.41	1.18	1.69	3.65
Maximum	3.30	12.96	1.35	2.56	6.73	8.97	22.42
Minimum	0.00	0.00	0.11	0.11	0.00	0.67	0.67
High elevation > 2440m (8000 feet) Red Fir Forest North Aspect (286-104°) n= 87							
Average	1.00 (4.48)	2.21 (9.87)	0.56 (2.51)	0.75 (3.32)	1.35 (6.00)	2.66 (11.89)	5.87 (26.18)
S.D.	0.57	2.13	0.32	0.42	1.21	1.74	3.37
Maximum	2.74	9.55	1.57	2.24	7.85	11.21	18.00
Minimum	0.00	0.00	0.00	0.11	0.00	1.21	1.12
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest South Aspect (105-285°) n= 96.							
Average	1.20 (5.37)	2.27 (10.14)	0.56 (2.48)	0.65 (2.91)	1.41 (6.29)	2.61 (11.65)	6.09 (27.17)
S.D.	0.71	1.49	0.23	0.28	0.72	1.10	2.26
Maximum	3.81	7.40	1.23	1.46	3.36	5.38	12.09
Minimum	0.00	0.00	0.22	0.22	0.00	1.12	1.12
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest North Aspect (286-104°) n= 20							
Average	1.14 (5.08)	2.30 (10.24)	0.59 (2.65)	0.94 (4.18)	0.91 (4.08)	2.44 (10.90)	5.87 (26.17)
S.D.	0.84	3.03	0.32	0.48	0.50	0.88	3.66
Maximum	3.30	12.60	1.35	2.24	2.02	4.04	17.58
Minimum	0.16	0.00	0.22	0.22	0.00	1.12	2.83
Mid elevation 1982-2439m (6500-8000 ft) Pine, South Aspect (105-285°) n= 27							
Average	0.69 (3.08)	2.68 (11.95)	0.38 (1.69)	0.67 (2.98)	1.04 (4.64)	2.09 (9.31)	5.46 (24.34)
S.D.	0.47	2.18	0.25	0.48	0.58	1.26	2.97
Maximum	1.91	9.98	1.12	1.95	2.69	5.61	15.54
Minimum	0.20	0.29	0.11	0.11	0.34	0.67	1.88
Mid elevation 1982-2439m (6500-8000 ft) Sequoia, South Aspect (105-285°) n= 69							
Average	1.38 (6.14)	2.73 (12.19)	0.50 (2.22)	0.71 (3.16)	1.07 (4.76)	2.28 (10.16)	6.47 (28.85)
S.D.	0.81	1.90	0.26	0.36	0.68	1.18	2.86
Maximum	3.30	7.96	1.35	1.88	3.59	6.05	16.08
Minimum	0.17	0.00	0.11	0.11	0.00	1.12	1.77
Mid elevation 1982-2439m (6500-8000 ft) Sequoia, North Aspect (286-104°) n= 18							
Average	1.48 (6.58)	1.57 (7.00)	0.73 (3.26	0.86 (3.86)	1.16 (5.19)	2.83 (12.64)	5.79 (25.84)
S.D.	0.77	1.94	0.30	0.52	0.77	1.31	3.40
Maximum	3.79	6.14	1.41	2.09	3.23	6.73	12.62
Minimum	0.52	0.00	0.34	0.22	0.22	1.12	2.11
Low elevation < 1982m (6500 ft) Fir Forest, South Aspect (105-285°) n= 16							
Average	0.95 (4.20)	2.98 (13.30)	0.57 (2.60)	1.16 (5.20)	1.95 (8.70)	3.70 (16.50)	8.04 (35.80)
S.D.	0.90	2.75	0.18	0.36	1.77	1.97	4.30
Maximum	3.54	9.96	0.90	2.02	7.17	8.97	14.78
Minimum	0.22	0.00	0.22	0.67	0.00	1.12	1.35
Low elevation < 1982m (6500 ft) Fir Forest, North Aspect (286-104°) n = 27							
Average	1.16 (5.20)	2.45 (10.90)	0.63 (2.80)	0.98 (4.40)	1.48 (6.60)	3.08 (13.70)	6.69 (29.8)
S.D.	0.89	1.65	0.36	0.56	1.15	1.38	3.06
Maximum	3.05	7.69	1.35	2.24	4.48	6.73	15.31
Minimum	0.18	0.00	0.22	0.22	0.00	1.12	1.30
Low elevation < 1982m (6500 ft) Pine Forest, South Aspect (105-285°) n= 130							
Average	0.88 (3.92)	2.55 (11.39)	0.50 (2.24)	0.85 (3.81)	1.70 (7.60)	3.01 (13.41)	6.45 (28.76)
S.D.	0.73	2.19	0.33	0.57	1.08	1.68	3.23
Maximum	3.79	15.34	1.57	2.76	6.39	8.07	21.82
Minimum	0.00	0.00	0.11	0.11	0.22	0.45	1.08
Low elevation < 1982m (6500 ft) Pine Forest, North Aspect (286-104)°) n= 39							
Average	0.87 (3.88)	2.69 (11.98)	0.49 (2.21)	0.83 (3.68)	1.72 (7.68)	3.00 (13.39)	6.57 (29.29)
S.D.	0.74	2.15	0.32	0.53	1.10	1.64	3.13
Maximum	3.59	8.25	1.79	1.57	5.49	7.17	13.30
Minimum	0.07	0.00	0.17	0.22	0.00	0.67	0.70
Low elevation < 1982m (6500 ft) Sequoia Forest, South Aspect (105-285°) n= 6							
Average	1.72 (7.68)	3.08 (13.75)	0.62 (2.78)	0.86 (3.85)	2.23 (9.93)	3.75 (16.73)	8.56 (38.17)
S.D.	0.54	2.55	0.19	0.40	1.73	1.91	4.71
Maximum	2.44	7.15	0.94	1.35	4.48	6.28	15.87
Minimum	1.05	0.00	0.45	0.45	0.22	1.12	3.00
Low elevation < 1982m (6500 ft) Sequoia Forest, North Aspect (286-104)°) n= 11							
Average	1.17 (5.20)	2.33 (10.39)	0.73 (3.27)	1.08 (4.82)	1.24 (5.55)	3.04 (13.55)	6.53 (29.14)
S.D.	0.92	2.15	0.43	0.50	0.94	1.34	3.22
Maximum	3.36	5.78	1.79	2.02	3.36	5.38	11.19
Minimum	0.16	0.09	0.45	0.45	0.45	1.35	3.12

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

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

Appendix 3.16.3. Summarized fuels data for permanent forest plots.

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

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

	Overstory Information					Height to Live Crown Base			
	BAF	# Trees	Basal Area (m²/ha)	Canopy Code	Avg. Overstory DBH (cm)	Overstory Tree Ht. (m)	Overstory (m)	Intermediate (m)	Understory (m)
Low elevation < 1982m (6500 ft) Pine Forest, South Aspect (105-285°) n= 5									
Avg.	3.60	12.4	44.20	3.20	94.68	48.60	14.54	6.50	1.10
Max.	4.00	15.00	60.00	4.00	103.70	55.00	19.00	10.00	3.00
Min.	3.00	9.00	36.00	3.00	72.80	44.00	10.5	4.00	0.50
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest, South Aspect (105-285°) n= 6									
Avg.	4.00	13.58	54.33	3.67	89.32	41.63	15.40	5.33	0.50
Max.	4.00	15.50	62.00	4.00	109.00	52.50	22.70	10.00	1.00
Min.	4.00	10.00	40.00	3.00	50.40	32.90	4.40	3.00	0.00
Mid elevation 1982-2439m (6500-8000 ft) Fir Forest, North Aspect (286-104°) n= 5									
Avg.	3.40	16.00	54.00	4.00	62.90	37.94	17.24	6.60	.90
Max.	4.00	19.00	68.00	4.00	80.00	47.50	27.00	10.00	1.50
Min.	3.00	13.00	42.00	4.00	55.30	31.90	10.30	5.00	0.50
Mid elevation 1982-2439m (6500-8000 ft) Pine Forest, South Aspect (105-285°) n= 4									
Avg.	4.00	13.75	55.00	3.25	65.78	33.58	7.73	2.88	0.50
Max.	4.00	20.00	80.00	4.00	80.30	48.80	13.40	4.00	0.50
Min.	4.00	9.00	38.00	3.00	54.50	26.20	3.90	2.00	0.50
Mid elevation 1982-2439m (6500-8000 ft) Pine Forest, North Aspect (286-104°) n= 2									
Avg.	3.50	15.00	53.00	3.50	75.25	44.55	16.85	6.00	0.50
Max.	4.00	16.00	64.00	4.00	77.20	53.00	16.90	8.00	0.50
Min.	3.00	14.00	42.00	3.00	73.30	36.10	16.80	4.00	0.50
High elevation >2440m (8000 ft) Fir Forest, South Aspect (105-285°) n= 5									
Avg.	4.00	16.20	64.80	2.80	97.82	39.22	8.18	3.30	0.50
Max.	4.00	24.00	96.00	4.00	143.0	53.50	15.00	4.00	0.50
Min.	4.00	11.00	44.00	1.00	40.70	24.50	2.60	2.50	0.50
High elevation >2440m (8000 ft) Fir Forest, North Aspect (286-104°) n= 5									
Avg.	3.60	15.20	60.20	3.00	74.40	42.38	9.26	4.00	1.00
Max.	4.00	20.00	80.00	4.00	88.50	47.20	18.10	7.00	2.00
Min.	3.00	8.00	32.00	2.00	60.80	36.40	4.00	1.50	0.50