3.16) Fuels Inventory and Monitoring

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INTRODUCTION

Recent advances in computerized technologies have given resource managers more tools to help make 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 1970's vegetation maps.

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).

Figure 3.16-1. Typical fuel load in a white fir-mixed conifer stand.

DESCRIPTION OF THE STUDY AREA

The study is being conducted in the East Fork of the Kaweah watershed. Terrain in the watershed is rugged, elevations range 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 lower elevations < 1,982m (6,500 ft). The middle elevations 1,982-2,439m (6,500-8,000 ft) are dominated by the White Fir mixed conifer community including the sequoia groves. The Red Fir Forest community dominates the higher elevations 2,440-3,049m (8,001-10,000 ft).

METHODS

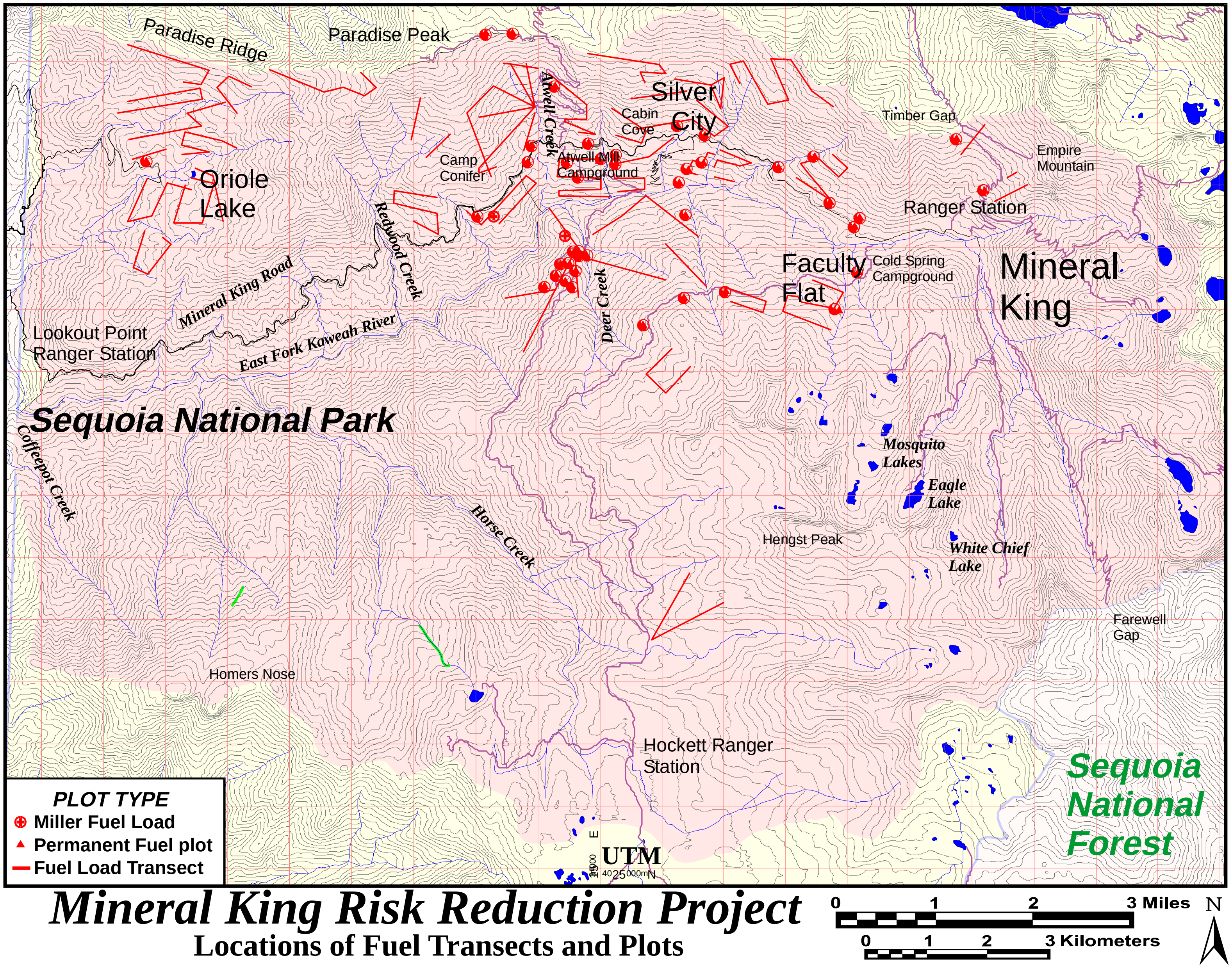
Permanent fuel plots were established in order to track fuel accumulation over time. The permanent fuel plots were established using the planar intercept method (Brown, 1974). The plots consisted of four fifty foot transects running north, south, east and west from the center point. Ten litter and duff measurements were taken along each of the 50 foot transects. These plots will be re-read about every 5 years to track fuel accumulation. Based on the previous years data the permanent plots were located in the short needle (includes 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 (8,001+ feet).

The forty-two permanent fuel plots that were established during the 1997 field season were re-read during the 1998 field season (**Fig. 3.16-2**). The plots were re-inventoried in an attempt to eliminate the bias of collecting all of the small diameter woody fuels near the plot origin. The transects were read from the far end back towards the plot origin, which meant that the small diameter fuels were all read from distinctly different areas.

Tree basal area was measured at each permanent plot using Basal Area Factor (BAF) prisms. The 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

Table 3.16-1: Current fuel model parameters.

Fuel Model Description	Model #	Fuel Loads					Surface to Volume Ratios (S/V)			Depth	Heat	Moist. Ext.
		1 Hr	10 Hr	100 Hr	Herb	Woody	1 Hr.	Herb.	Woody			
Low Elev. Short Needle Conifer	14	3.7	2	2.2	0	6.15	2000	190	1500	0.6	8000	30
Low Elev. Long Needle Pine	15	3.1	1	2.3	0.2	7.37	3000	3000	1500	0.9	9000	25
Mid Elev. Short Needle Conifer	16	3.32	1.2	3.37	0	3	2000	190	1500	0.5	8000	30
High Elev. Short Needle Conifer	18	2.4	1.7	3.1	0	3.32	2000	190	1500	0.25	8000	30



average diameter "in tree" and **Figure 3.16-2.** Fuel data collection sites in the East Fork.

Table 3.16-2: Quantitative stand information by vegetation type broken into aspect and elevation. Where field data did not exist, sample size (n) was listed as a zero and the numbers were based on expert opinion.

Vegetation Description	Aspect	N	Veg. Code	Tree Height (m)	Height to Live Crown Base (m)
Ponderosa Mixed Conifer		274	1	31.2	0.7
White Fir Mixed Conifer < 1,818 m	N	27	2	35.4	1.2
White Fir Mixed Conifer >= 1,818 m	N	139	2	40.2	0.7
White Fir Mixed Conifer < 1,982 m	S	44	2	35.4	1.2
White Fir Mixed Conifer >= 1,982 m	S	159	2	40.2	0.7
Red Fir Mixed Conifer	S	157	3	34.7	0.5
Red Fir Mixed Conifer North	N	95	3	34.7	0.8
Lodgepole Pine		132	4	10.2	0.5
Xeric Conifer Forest		27	5	30.0	1.0
Sub Alpine Conifer		819	6	14.4	1.0
Foothill Hardwoods & Grass		0	7	15.0	2.5
Foothill Chaparral		N/A	8	0	0
Mid Elevation Hardwoods		0	9	20.0	1.5
Montane Chaparral		N/A	10	0	0
Meadow		N/A	11	0	0
Barren Rock/Rock & Sparse Veg.		N/A	12	0	0
Water			13	0	0
Sequoia North Aspect < 1,818 m	N	11	14	46.0	1.7
Sequoia North Aspect >= 1,818 m	N	18	14	46.7	0.8

their diameter at breast height (DBH) was measured and recorded. An average value was be calculated from the three trees measured and used to represent the trees at that sampling point.

The following measurements were also taken at each permanent plot with a clinometer and recorded: overstory tree height, 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%.

RESULTS

The ponderosa pine forest had fuel loads of 0.69 kg/m^2 (litter), 4.23 kg/m^2 (duff), 12.47 kg/m^2 (woody) for the south aspects (105-285°) and 0.80 kg/m^2 (litter), 6.87 kg/m^2 (duff), and 10.21 kg/m^2 (woody) on the north aspects (286-104°, aspect determination based on analysis by Caprio and Lineback [in review]) (**Table 3.16-1**). The basal area for the south aspects was 36.8 m^2/hectare compared to 38.8 m^2/hectare on the north aspects. The overstory tree heights were similar for the south (44.9 m) and the north (44.3 m) aspects (**Table 3.16-2**). The diameter at breast height (dbh) was similar for the south (83.4 cm) and the north (85.5 cm) aspects. The heights to live crown base of the understory were higher for the south (1 m) than for the north (0.5 m) aspects.

The low elevation short needle forest had fuel loads of 1.85 kg/m ^{2} (litter), 10.14 kg/m ^{2} (duff) and 5.04 kg/m ^{2} (woody) for the south aspects (105-285°). There were no plots installed in this elevation range on the north aspects. The basal area was 54.5 m^2/hectare. The overstory tree heights averaged 36.45 meters while the dbh averaged 52.85 cm for these plots. The height to the live crown base of the understory was 1.0 meter.

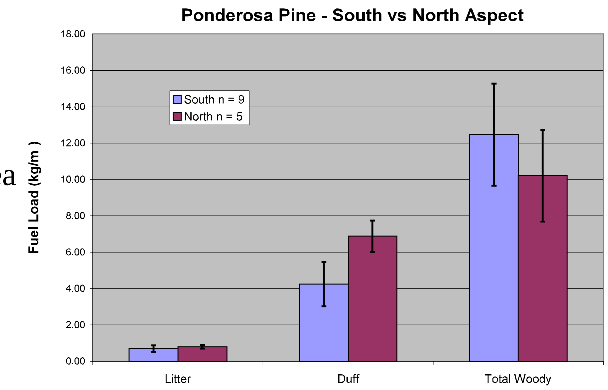


Figure 3.16-3. Fuel load, Ponderosa Pine North vs. South.

As stated in last years report, there are very few mid elevation pine dominated forests on the north aspects, so plots were only installed on the south aspects for the mid elevation pine type. The middle elevation pine forest had fuel loads of 0.72 kg/m^2 (litter), 5.30 kg/m^2 (duff), and 3.74 kg/m^2 (woody). The basal area was 50.0 m^2/hectare. The overstory tree heights averaged 38.93 meters while the dbh averaged 73.71 cm for these plots. The height to the live crown base of the understory was 0.6 meters.

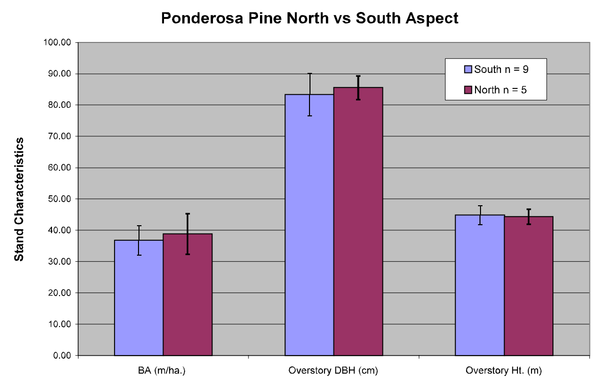


Figure 3.16-4. Stand Characteristics, Ponderosa Pine North vs. South.

The middle elevation fir forest had fuel loads of 1.7 kg/m^2 (litter), 6.5 kg/m^2 (duff), 6.1 kg/m^2 (woody) for the south aspects (105-285°) and 1.5kg/m^2 (litter) 5.3 kg/m^2 (duff) and 5.1kg/m^2 (woody) on the north aspects (286-104°). The basal area for the south aspects was 55.13 m^2/hectare compared to 42 m^2/hectare on the north aspects. The overstory tree heights were higher for the south (40.0 m) than for the north (34.3 m) aspects. The diameter at breast height (dbh) was larger for the south (83.48 cm) than for the north (74.3 cm) aspects. The heights to live crown base of the understory were higher for the south (0.6 m) than for the north (0.5 m) aspects.

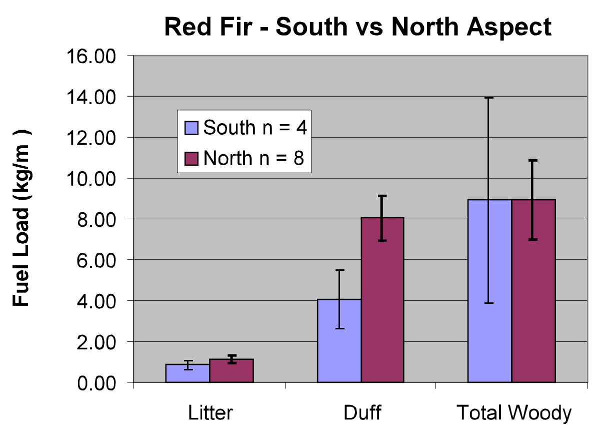


Figure 3.16-5. Fuel load, red fir north vs south aspect.

The high elevation fir forest had fuel loads of 0.9 kg/m^2 (litter), 4.0 kg/m^2 (duff), 8.9 kg/m^2 (woody) for the south aspects (105-285°) and 1.1kg/m^2 (litter) 8.1 kg/m^2 (duff) and 8.9 kg/m^2 (woody) on the north aspects (286-104°). The basal area for the south aspects was 67 m^2/hectare compared to 62.4 m^2/hectare on the north aspects. The overstory tree heights were higher for the south (40.4 m) than for the north (38.5 m) aspects. The diameter at breast height (dbh) was larger for the south (92.7 cm) than for the north (78.7 cm) aspects. The heights to live crown base of the understory were lower for the south (0.5 m) than for the north (0.9 m) aspects.

In the summary of last year's report it was stated that the custom fuel models would be updated with any changes from the new data. The custom model that was created for the middle elevation pine forest (custom model 17) was eliminated due to being too similar to the standard fuel models (NFFL models 8, 9).

In the introduction section above it was mentioned that one of the objectives of this study was to develop new GIS themes for overstory tree height and height to live crown base. During this past winter I acquired tree height data from the following sources: White Pine Blister Rust Survey (Duriscoe, unpublished data), Yellow Pine Ozone Injury Study (Duriscoe, unpublished data), the Clover Creek Fir Project (Duriscoe/Stephenson, unpublished data) and the Natural Resources Inventory project [NRI] (Graber et al. 1993). All data were arrived at by direct measurement except for the NRI data where the data was put into size classes. The NRI data was only used for the Lodgepole Pine Vegetation Type where we previously had no data. The White Pine Blister Rust data also gave us data for the Sub-Alpine Vegetation type where we previously had no data. The Yellow Pine Ozone Injury study increased our sample size by 34%. The Clover Creek fir Project increased our sample size by 50% for White Fir and 67% for Red Fir Vegetation types. **Table 3.16-1** includes data from all the sources listed above, the sample size (n) is listed with the Vegetation Description. If the sample size (n) listed ia a zero, the numbers are a subject matter expert guess.

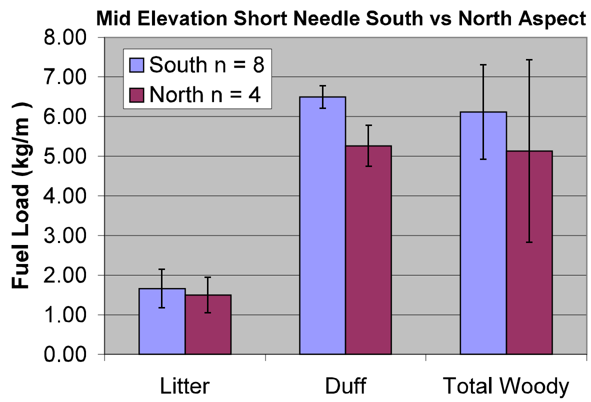


Figure 3.160-6. Fuel load, Mid Elevation Short Needle North vs. South Aspect

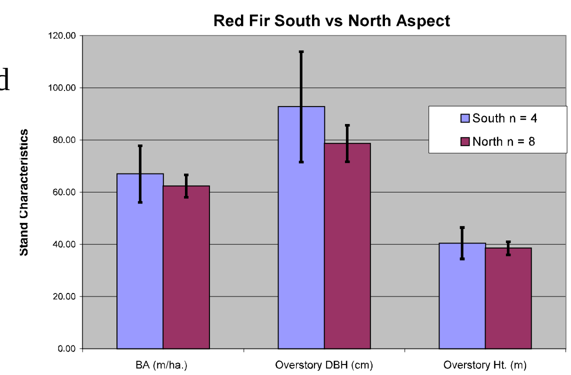


Figure 3.16-7. Stand Characteristics, Red Fir North vs. South Aspect

DISCUSSION

The difference in fuel loading from north to south aspect appears to vary by elevation and vegetation type (results presented in the graphs are mean values ± one standard error). The ponderosa pine forest appears to have higher duff fuel loads on the north aspects and higher woody fuel loads on the south aspects (**Fig. 3.16-3**). The ponderosa pine stand characteristics for basal area, overstory dbh and tree heights appear to be the same for both south and north aspects (**Fig. 3.16-4**). The high elevation red fir forest have higher fuel loading on the north aspect (**Fig. 3.16-5**), while the mid elevation fir forest have higher fuel loading on the south

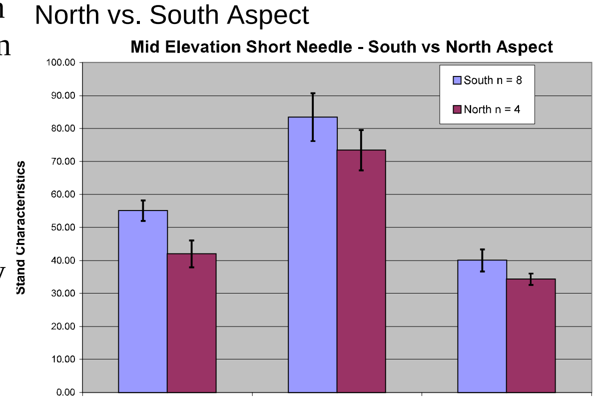


Figure 3.16-8. Stand characteristics, mid-elevation short needle north vs south aspect.

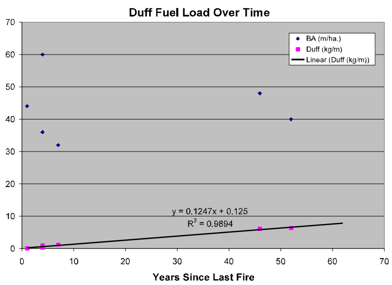


Figure 3.16-9. Duff fuel load and time since last fire.

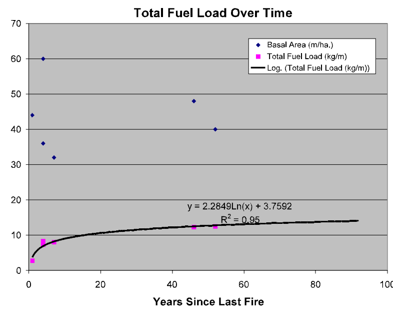


Figure 3.16-10. Total fuel load and time since last fire.

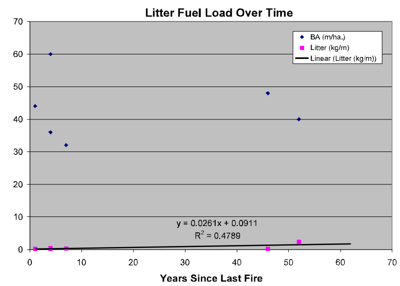


Figure 3.16-11. Litter fuel load and time since last fire.

aspect (**Fig. 3.16-6**). When we looked at the basal area of the high and middle elevation fir stands, the south aspects have higher basal areas and tree sizes (**Fig.s 3.16-7 and 3.16-8**). The difference in fuel loading is probably due to the different fire regimes (frequency and intensity) on each aspect.

When we compared the known fire history with our plot locations we came up with six plots that occurred in areas that we knew the date of the last fire. As stated in last year's report we were going to see if a relationship exists between the number of years since the last fire and the fuel loading. Keeping in mind that our sample size is only six (n=6), there appears to be a strong linear relationship (R^2 = .9894) of duff accumulation with time (**Fig. 3.16-9**). There also appears to be a good logarithmic relationship (R^2 = .95) of total fuel load with time (**Fig. 3.16-10**). The relationship for litter (**Fig. 3.16-11**) and woody (**Fig. 3.16-12**) fuel loads with time appears to be poor. The litter load is probably related to the scorch height post fire and the stand mortality as time passes. The woody fuel load is probably related to stand mortality as time passes and it appears that after the first few years, higher fuel loads are associated with higher basal areas for locations with similar years since disturbance (**Fig. 3.16-13**).

SUMMARY

Last years report indicated that we would take photo series estimates at the same location that we installed the permanent plots, to see if a correlation exits between the two methodologies. The crew took photo series estimates at the permanent plots, but they forgot to record the data! We will take photo series estimates when we revisit the 31 plots to take the digital photos, and we

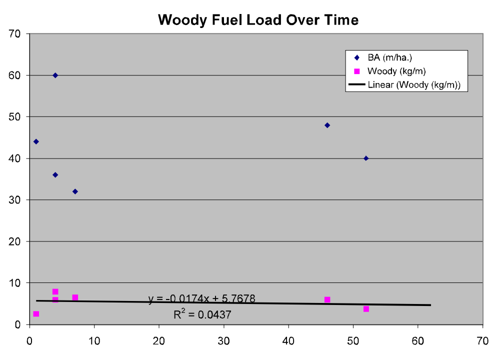


Figure 3.16-12. Woody fuel load and time since last fire.

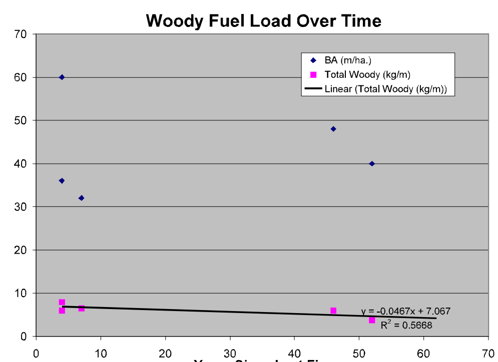


Figure 3.16-13. Woody fuel load and time since last fire starting after 3 years.

will create a space on the data sheet and record the data next season! When installing future permanent fuel plots, we will take photo series estimates at the same location and record the data. We will try to see if a correlation exists between the two methodologies. If a correlation can be established, we will use this correlation 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.

Our goal was to have enough permanent plots by elevation and fuel type so that the percent error of our total fuel loading estimates was less than twenty percent. We will need to install additional plots in the following types: Red Fir South aspect, Middle Elevation Short Needle North aspect, Low Elevation Pine South aspect, Low Elevation Short Needle South, and Low Elevation Short Needle North aspect to lower the percent error of the total fuel loading estimate. It will probably take between 2-5 new plots in each of these fuel types to achieve our goal of less than twenty percent error. When we install these new plots we will try to place them in areas of known previous fires in order to increase our sample size and improve on our correlation between time since last fire and fuel load.

Lastly, we acquired a digital camera in the middle of last season (see cover photo) and have digital pictures for 16 of the 47 permanent fuel loading plots. During the 1999 field season we will revisit the 31 plots that need a digital photo.

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