4.21) Evaluation of Cambium and Soil Heating and Other Fire Effects During Prescribed Fire in Giant Sequoia/Mixed Conifer Stands

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INTRODUCTION

The use of prescribed fire in the Sequoia Kings Canyon National Park is well established. The natural occurrence of fire is accepted in this ecotype and the park's prescribed burning program has demonstrated national leadership in the use of prescribed fire. Our involvement began at the request of park managers in response to the Christensen Report, to study the extent of soil and cambium heating in Giant Sequoia/mixed conifer stands during SMA project burns in the Giant Forest area. Our first involvement was in 1988 with the measurement of soil and cambium temperatures of two SMA burns, the sampling of before and after ammonium- and nitrate-nitrogen changes, and the development of a fuel loading prediction equation. This information is contained in Haase and Sackett 1998. Subsequent burns of which we were a part are defined in Table1.

PROJECT OBJECTIVES

The initial objectives of the study have been 1) to determine soil temperatures at six different depths below the soil/duff interface during normal prescribed fires, 2) determine cambium temperatures in sequoia and sugar pine trees during prescribed fires, and 3) determine pre- and post-burn concentrations of the available forms of nitrogen (NH_4-N and NO_3-N) in the upper soil stratum. These objectives were initially applied to first entry prescribed burn projects and they have since been applied to the Nichols' Folly and the Tharp's II re-burn areas. This study will be officially amended to also cover the fuel mitigation work being conducted. The primary objective for this portion is to 1) determine cambium temperatures during prescribed fire of trees that have had the forest floor fuels removed a defined distance from their root collar, and 2) determine slope effects on cambium heating.

SUMMARY OF METHODS

Temperature Measurements

Soil and cambium temperatures are measured by inserting chromel-alumel thermocouples into the cambium of giant sequoia and sugar pine trees, and at six depths for each soil temperature site. The data is collected using Campbell Scientific data loggers and recorded on tapes that are later translated and analyzed. For initial entry burn projects, a representative sugar pine and giant sequoia tree are selected and thermocouples are inserted just beneath the cambium at six points around the tree. Soil temperatures are measured at six set depths starting at the soil/duff interface and going as deep as 20 inches. Three individual sites are selected that extend from the base of the selected tree to its dripline. A hole is dug and thermocouples are inserted horizontally in the soil profile so that the fuels directly above the thermocouples that produce the heat, are not disturbed in the set-up process. The temperatures are measured during and after the burn time in 10-15 minute intervals until they begin to cool. The time interval is then lengthened to cover the full length of the heating and cooling process. This can be for a week or more if fuels are extreme.

Cambium temperatures are measured by inserting the thermocouple between the outer bark and cambium. Originally, a small patch of bark was removed above the point being measured and the 18-inch thermocouple

was pushed downward. The bark patch was returned, edges packed with glass insulation, and then a large heat protective patch made of a fire tent and glass insulation was secured over the thermocouple site. The method has now been modified on the sugar pine trees so that a slit the width of a chainsaw chain is used to slide the thermocouple down and on the giant sequoia the thermocouple is simply pushed at an angle so that the point of measurement is midway within the forest floor depth at that point. The patch marks the depth of the forest floor material and measurements are taken after the fire to limit the amount of disturbance to the fuels, which ultimately affects the fire behavior at that location. The dataloggers reading the cambium temperatures are set for the same time intervals as the soil temperatures.

Mitigation Temperature Measurements

The six points measured on the selected trees will correspond with the different slope effects being questioned, primarily uphill and down hill locations. Paired trees were located in the Bear Hill project burn in 1999, that were of the same size class and in close proximity to each other so that they would experience similar fire behavior. One of the pair was randomly selected to have the forest floor material removed using a garden spade to cut the forest floor material and then a leaf blower to do the final removal of material down to mineral soil. Forest floor depth was marked with aluminum nails prior to the removal of the forest floor material so that an estimate of fuel loading could be made for the individual tree. The depth of the remaining forest floor material at the "cut face" was also recorded to estimate the fuel loading that would be radiating heat to the bark surface. The non-mitigated trees also had aluminum nails placed at the top of the forest floor material so that the fuel loading could be estimated after the prescribed burn.

Soil Nutrients

Soil nutrients have been sampled for each of the areas where temperatures have been measured for a total of nine initial entry burns and two reentry burns. They are measured pre- and post-burn and then annually from then on with the exception of the Grant Grove burn where the sampling area was later determined to be a water treatment spray area. Ten samples are taken around each of the selected trees and each is a composite of 7 one-inch soil core samples. The sample cores are broken down into two depths (0-5 cm and 5-15cm). The samples are process in the field and then the KCl extract is sent to a soils laboratory to be analyzed for ammonium-nitrogen and nitrate-nitrogen.

WORK ACCOMPLISHED IN 2000

Soil nutrients were sampled July 8-11, 2000 for the ten sites and the control. Samples were processed in the field and kept on ice until they were sent to the soils laboratory. The same laboratory was used as the previous year for analysis (USDA-FS-Rocky Mountain Forest and Range Experiment Station, Flagstaff, AZ). A second sample was sent to an additional laboratory for comparison (Northern Arizona University – Bilby Research Center). The two analyses were comparable. The previous years (1999) samples are being evaluated further to see if they can be included in the database. Park personnel selected pairs of trees, mapped, and mitigated fuel around the base of the selected trees in 1999 after they received training. A training session was held July 20, 2000, to instruct new park personnel on the mitigation process for that summer. The paired trees were "refreshed" by blowing out the forest floor material that had accumulated in the cleaned out area during the winter. Nehalem Breiter, NPS, updated depth and condition information during the summer and entered the data into the data set for the mitigation study. She also standardized the field data sheet that will be used for any new mitigation studies.

PRELIMINARY FINDINGS AND PERTINENT DISCUSSION

The following is a summary of last year's (2000) soil nutrient information (see also **Table 4.21-1**). The values are very similar to and follow the same trends as the previous years. A complete evaluation is planned for this next year that will review all the previous sample periods. Sites with the larger Standard Deviations (SD) often include a single sample. One would be inclined to exclude these but they do show up regularly and indicate the extreme variability of soil nutrient levels that can be found following prescribed burns and in controls. The level of ammonium-nitrogen is still remaining at levels around the control or as in the latest burn, above the control level. The complete analysis will allow us to determine if there is any relationship between sites, fuel loading, and duration over time. The missing data for the giant sequoia entry for Tharp's II is due to the tree being re-sampled for the re-entry burn. The corresponding sugar pine for the initial burn of Tharp's II was not included in the second burn perimeter and a different sugar pine had to be selected that was included in the burn area.

The nitrate levels are similar to what we have seen in the past. This element is very dependant on the time and soil conditions when the soil microbes begin to convert the ammonium into nitrate. Therefore we may have missed the peak activity time this last year. Again, seldom is the SD smaller than the mean, which indicates there is most likely only one sample out of the ten taken that actually measured a nitrate-nitrogen level. But again, this is commonly found when sampling these soils.

PROBLEMS ENCOUNTERED

The only problem encountered this last year was the delay of burning the Bear Hill unit for the second time. Currently we may be evaluating the longevity of the mitigation treatment and the effect of simply removing the forest floor material around individual trees. Whether or not the simple removal of material will affect the health of the trees may need to be evaluated by doing several fresh mitigation treatments just prior to the burn. The removal of material may affect the moisture content beneath the bark so that the insulating properties may differ between newly mitigated trees and trees mitigated previously. We may be able to detect differences if we probe some newly mitigated trees at the time of the burn.

PLANS FOR THE COMING YEAR

We are planning to sample the eleven sites for soil ammonium-nitrogen and nitrate-nitrogen as we have in the past. This will give us a sample comparison for the evaluation of the laboratory we are now using for the analysis of samples. We have modified our temperature systems so that will be able to measure more trees than previously planned for on the Bear Hill project burn. We will have enough equipment to measure at least 21 trees, which we will distribute between old mitigated, newly mitigated and non-mitigated trees. We will also want to install several soil sites just to verify soil heating is similar to our other findings for the park. We are also planning on completing a second manuscript t of our soil temperature findings. This same data was used to produce the statistical process paper Preisler, H.K. et al. 2000. The soil temperature/risk model will be put on the web for easy access for managers of giant sequoia/mixed conifer stands.

Table . 4.21–1 Summary of the annually sampled soil nutrients, ammonium-nitrogen and nitrate-nitrogen, from all initial entry burn SMA's in the Giant Forest area. Dates of the initial or re-entry burns are included in the ( )'s following the name of the project.

		Ammonium-Nitrogen (NH_4-N)				Nitrate-Nitrogen (NO_3-N)			
		0-5 cm		5-15 cm		0-5 cm		5-15 cm	
		µg/gm soil	SD	µg/gm soil	SD	µg/gm soil	SD	µg/gm soil	SD
Giant Sequoia	**Initial Entry Burns**								
	Tharp's II (7/88)								
	Congress Trail (9/88)	.688	.154	.508	.105	.000	.000	.000	.000
	Tharp's Creek (7/89)	.637	.148	.636	.316	.000	.000	.000	.000
	Highway I (9/89)	.875	.218	.661	.067	.004	.009	.001	.004
	Highway II (9/90)	.899	.379	.499	.123	.003	.007	.000	.000
	Cloister (8/93)	.698	.157	.523	.115	.002	.004	.000	.000
	Upper Sherman (8/95)	2.049	3.290	.480	.112	.208	.356	.016	.019
	Pinewood (7/97)	1.892	1.172	.675	.182	.071	.103	.019	.009
	Re-entry Burns								
	Tharp's II (9/96)	.894	.228	.797	.187	.000	.000	.000	.000
	Nichols' Folly (9/96)	.547	.120	.513	.174	.000	.000	.000	.000
	Control*	1.825	1.182	.586	.163	.000	.000	.005	.014
Sugar Pine	**Initial Entry Burns**								
	Tharp's II (7/88)	.875	.324	.578	.127	.007	.022	.000	.000
	Congress Trail (9/88)	.578	.293	.383	.100	.002	.007	.000	.000
	Tharp's Creek (7/89)	.898	.229	.472	.269	.007	.023	.000	.000
	Highway I (9/89)	.743	.174	.560	.102	.005	.007	.003	.006
	Highway II (9/90)	.957	.390	.551	.123	.037	.115	.000	.000
	Cloister (8/93)	.573	.161	.310	.053	.006	.009	.001	.003
	Upper Sherman (8/95)	.711	.244	.485	.179	.015	.013	.010	.009
	Pinewood (7/97)	1.951	.949	.457	.067	.207	.272	.017	.010
	Re-entry Burns								
	Tharp's II (9/96)	1.028	.350	.614	.147	.000	.000	.000	.000
	Nichols' Folly (9/96)	.720	.332	.464	.104	.001	.004	.000	.000
	Control*	.934	.281	.493	.182	.000	.000	.000	.000

REFERENCES

Haase, Sally M. and Stephen S. Sackett. 1998. Effects of prescribed fire in giant sequoia-mixed conifer stands in Sequoia and Kings Canyon National Parks. Pages 236-243 *in* Teresa L. Pruden and Leonard A. Brennan (eds.). Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, FL.

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