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EFFECT OF HEAT ON SOIL COLOR AND pH OF TWO FOREST SOILS

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Intensity of a slash burn is often judged by the change in soil color. Reddened or yellowed areas of soil and charred patches of organic litter are found on most burned areas, but such color changes are difficult to interpret. A study was therefore made to explore two questions:

(1) At what temperature does the color of mineral soil change to the reddish or yellowish hues found on severely burned spots?

(2) How do high temperatures of varying duration affect soil reaction (pH)?

Method

Samples of two soils which occur over large areas in the Douglas-fir region were collected for laboratory study. The soil types are:

(1) Olympic loam, a residual soil derived from basalt.

(2) Astoria clay loam, a residual soil derived from marine sedimentary material.

Two samples of each soil were taken from the first inch of mineral soil where the organic matter content is about 5 percent. They were air dried before testing.

Duplicate samples were heated in electric muffle furnaces at temperatures of 600°, 900°, and 1200° F. for 15-, 45-, and 90-minute periods. When the samples had cooled, their color was recorded and determinations of pH were made by the glass electrode method, according to the procedure adopted by the Forest Soils Committee of the Douglas-fir Region.[1/]

Results

The recorded color changes (table 1) are not subject to statistical analysis, but some general observations can be made. Altering soil color to the point where no further change occurred requires a temperature of 900° F. This figure is not exact for Olympic loam, but the difference between the light yellowish-brown and the light brown that holds constant at higher temperatures is very slight. For Astoria clay loam, the effect of heating on color is more pronounced, but the colors are different from those of Olympic loam at similar temperatures.

Statistical analysis of the soil reaction data (table 1) disclosed that for both soil types:

(1) The pH of soils heated at 900° and 1200° F. is significantly greater than the pH of soils heated at 600° F.

(2) There is no significant difference in pH between soils heated at 900° and 1200° F. A plateau of pH change is apparently reached with temperatures above 900° F.

(3) At temperatures of 600° F., pH increases as the length of exposure is increased.

(4) At the temperatures of 900° and 1200° F., length of exposure has no effect on pH.

When Astoria clay loam is held at 600° F. for 90 minutes, the pH almost equals that of samples held at 900° and 1200° F. In the case of Olympic loam, however, the pH of samples held at 600° F. for 90 minutes is significantly lower than that of samples heated at 900° and 1200° F.

1/ Forest Soils Committee of the Douglas-fir Region. Sampling procedures and methods of analysis for forest soils. Seattle, Wash., College of Forestry, Univ. of Wash. 38 pp. Processed. March 1953.

Table 1.--Effects of heat on soil color and reaction (pH)

Temperature	Duration	Color [1]	Soil reaction [2]
Degrees F.	Minutes		(pH)
		OLYMPIC LOAM	
Unheated	--	Light brownish-gray	5.50
600	15	Light brownish-gray	6.92
600	45	Light brownish-gray	7.05
600	90	Light brownish-gray	7.57
900	15	Light yellowish-brown	8.50
900	45	Light yellowish-brown	8.50
900	90	Light yellowish-brown	8.55
1200	15	Light brown	8.83
1200	45	Light brown	8.02
1200	90	Light brown	8.51
		ASTORIA CLAY LOAM	
Unheated	--	Weak brown	4.50
600	15	Brownish-black	4.60
600	45	Brownish-black	4.87
600	90	Brownish-black	5.31
900	15	Moderate yellowish-brown	5.47
900	45	Strong brown	5.37
900	90	Dark orange	5.37
1200	15	Dark orange	5.50
1200	45	Dark orange	5.30
1200	90	Dark orange	5.32

1/ Color standards from "Preliminary Color Standards and Color Names for Soils." U.S.D.A. Misc. Publication No. 425. In all cases, colors of duplicate samples were identical.

2/ Logarithmic average of two samples.

The results may be summarized:

(1) A temperature of about 900° F. is required to alter the color of mineral soil to a point of no further change. Because of differences in the amount and type of clay minerals in soils, the color after burning cannot accurately be used to indicate severity of fire.

(2) The greatest change in pH took place at temperatures below 900° F. At temperatures below 900° F., duration of exposure to heat was likewise a factor in determining the amount of pH change. At temperatures above 900° F., duration of exposure did not influence pH change.

Conclusions

Although soil color may indicate very roughly the intensity of a slash fire, it cannot be used as a precise measure of fire severity. Olympic loam, for example, turns an inconspicuous light brown at 1200° F., but Astoria clay loam turns a striking dark orange at the same temperature. Differences in properties of the clay minerals in the two soils are largely responsible for the differences in color change. A series of tests on various soil types might provide the basis for a color chart to measure burn intensity, but the probable usefulness of the chart is not believed to warrant the intensive study that would be required.

The greatest change in pH takes place at temperatures below 900° F. It is also at temperatures below 900° F. that duration of exposure to heat exerts an effect on the increase in soil reaction. To minimize the change in soil reaction during slash burning, a fire should move rapidly through a light concentration of fuel. Under these conditions, less heat will be developed, and the duration of maximum temperatures will likewise be reduced to as short a period as possible.

Isaac and Hopkins[2/] found that at a depth of 1 inch below the forest floor (about the same depth as the soil used in this study), the heat generated under a heavy pile of Douglas-fir slash was 608° F. The current study shows that this temperature would be sufficient to make a significant change in soil reaction. The findings of Isaac and Hopkins lend additional strength to the recommendation that slash fires should move rapidly through light concentrations of fuel to avoid undue changes in soil reaction.

2/ Isaac, Leo A., and Hopkins, Howard G. The forest soil of the Douglas-fir region and changes wrought upon it by logging and slash burning. Ecology 18: 264-279. 1937.

The change in hydrogen-ion concentration (of which pH is a measure) is geometric. There are 9 units of acidity between pH 6 and 7, 90 units between pH 5 and 6, 900 units between pH 4 and 5, etc. Because the reaction of the soil is determined by the proportion of acidic and basic ions, much more basic material must be released to increase the pH of Astoria clay loam, with a normal pH of 4.5, than for Olympic loam with a normal pH of 5.5. The figures in table 1 suggest that highly acid soils can withstand the chemical effects of burning better than those which are only moderately or slightly acid.