Effect of Slash Burning on Some Physical Soil Properties

BY
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THOUSANDS OF ACRES of logging slash are burned annually in the Douglas-fir region as a fire-protection measure. Whether or not such burning changes physical soil properties has not been thoroughly explored.

A series of studies has been conducted by the Pacific Northwest Forest and Range Experiment Station to determine the effect of slash burning on soil properties. The present study was made during 1954 to learn whether slash burning actually changes physical soil properties and how any changes might be influenced by the severity of burning. Several related phases have been reported previously (Tarrant, 1953, 1954a, and 1954b; Tarrant and Wright, 1955).

Methods

Two different soils were studied. One, from the upper Wind River Valley of southern Washington, was a pumicy sandy loam with a weakly developed mor humus layer. The other, from the H. J. Andrews Experimental Forest in the Cascade Range of Oregon, was a sandy clay loam with a mull humus layer. At both locations, plots were established in 1954 on areas that had been clearcut and subsequently burned in October 1953.

On each clearcut area, 33 undisturbed soil cores were collected from each of the following surface conditions:

Unburned	No evidence of disturbance during logging and no visible effect of fire.
Light burn	Where fire charred the surface of the forest floor but did not remove all litter from the soil.
Severe burn	Where fire removed all organic litter from the surface and in addition left the mineral soil highly colored.

Undisturbed soil cores were collected in steel cylinders of 350 cc. capacity and 3-inch depth. In the laboratory, percolation[1] tests were made on all cores after saturation. The cores were then subjected to a tension of 60 centimeters to determine macroscopic and microscopic pore space. Bulk density was calculated after oven drying. Cores were analyzed in random

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[1] *Percolation* refers to the passage of water through the soil profile, whereas *infiltration* refers to the entry of water into the surface half inch of soil. Since the effect of severe burning usually extends below the half-inch depth, the term *percolation* is considered to be applicable.

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TABLE 1. Differences between treatment means compared with differences required for significance at the 95-percent level of fiducial probability.

Soil property and unit of measure	Differences between treatment means[1]		
	Unburned and light burn	Unburned and severe burn	Light burn and severe burn
		Pumicy Sandy Loam	
Percolation rate	22.15	16.87	39.02
(cu. in./hr.)	(10.63)	(10.63)	(11.20)
Macroscopic pore space	5.46	15.93	10.47
(percent by volume)	(3.07)	(3.24)	(3.07)
Microscopic pore space	11.33	11.06	0.27
(percent by volume)	(3.78)	(3.59)	(3.59)
Total pore volume	5.88	4.86	10.74
(percent by volume)	(2.95)	(2.95)	(3.11)
Bulk density	0.10	0.07	0.17
(gm./cc.)	(.06)	(.06)	(.06)
		Sandy Clay Loam	
Percolation rate	2.49	43.96	46.45
(cu. in./hr.)	(18.70)	(18.70)	(19.70)
Macroscopic pore space	14.15	18.22	4.07
(percent by volume)	(2.46)	(2.59)	(2.46)
Microscopic pore space	18.89	18.78	0.11
(percent by volume)	(2.37)	(2.25)	(2.25)
Total pore space	4.74	0.56	4.18
(percent by volume)	(3.18)	(3.01)	(3.01)
Bulk density	0.06	0.05	0.12
(gm./cc.)	(.05)	(.05)	(.06)

[1]Figures in parentheses are differences required for significance at the 95-percent level of fiducial probability.

order to avoid the possibility of concentrating any technique error within any one treatment. All analyses followed procedures suggested by the Forest Soils Committee of the Douglas-fir Region (1953).

Effects of Severe Burning

Baver (1940) stated: "Permeability of the soil for water is unquestionably a function of the amount of the larger pores." In this study, severe burning was clearly found to reduce[2] macroscopic pore space and percolation rate below levels for the same properties in unburned condition (Figs. 1 and 2). Microscopic pore space and bulk density, in contrast, were both increased by severe burning (Figs. 1 and 3). Direction of the change was the same in both soils; and the magnitude of change, when expressed as a percent of unburned soil (Table 2), was remarkably consistent. Macroscopic pore space was reduced to about 25 percent of its volume in unburned soil, and percolation rate to about 30 percent.

Total pore space was reduced as a result of severe burning in the pumicy sandy loam, but unchanged in the sandy clay loam.

The practical effect of a reduction in percolation rate is an increase in surface

[2]All references to reductions or increases in soil property measurements imply significance at the 95-percent level of fiducial probability. See Table 1 for statistical comparisons.

TABLE 2. Change in physical soil properties after light and severe burning (expressed as percent of same value for unburned soil).

Physical soil property	Light burn: Pumicy sandy loam	Light burn: Sandy clay loam	Severe burn: Pumicy sandy loam	Severe burn: Sandy clay loam
Percolation rate	+93	+ 4	−71	−72
Macroscopic pore space	−26	+58	−77	−74
Microscopic pore space	+32	+55	+31	+54
Total pore space	+10	+ 8	− 9	+ 1
Bulk density	−11	− 8	+ 8	+ 7

runoff of water during wet periods, causing soil erosion and a reduction in the amount of water taken into the soil . Only beneath the heaviest concentrations of large fuels, however, do slash fires generate enough heat to burn organic matter within the mineral soil. Thus, severe burning occurs only in small and discontinuous patches. A study of some 75 field plots in the Douglas-fir region showed that less than 5 percent of the total surface of a logged and slash-burned area was severely burned. A similar figure on the proportion of severely burned soil surface after slash burning was reported from California (Vlamis et al., 1955).

Although severe burning definitely damages physical soil properties, it affects only a very small portion of the total area logged and slash burned. Therefore, it is concluded that severe burning exerts a minor influence under current slash-burning practice. Increased utilization of low-grade logs and small size stems will tend further to reduce the volume of heavy fuels left after logging, thus minimizing the extent of severe burns and soil damage during slash disposal.

Effects of Light Burning

Although the effects of severe burning are clearly defined, an anomaly is apparent when the results of light burning are studied. In the pumicy sandy loam, percolation rate (Fig. 2) on lightly burned areas was greater than that of the unburned

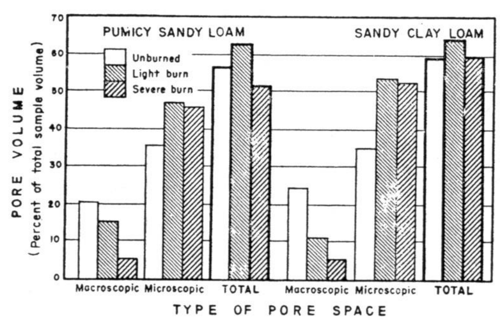

FIGURE 1. *Relation between soil porosity and surface condition after slash burning.*

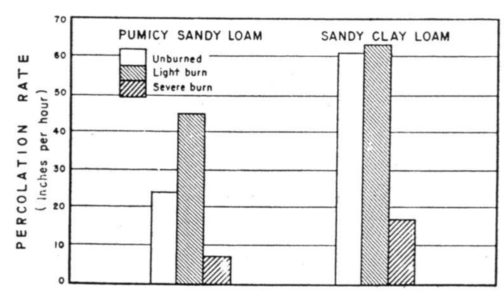

FIGURE 2. *Relation between percolation rate and surface condition after slash burning.*

condition, although macroscopic pore space (Fig. 1) was less. In the sandy clay loam, there was no difference between percolation rates in unburned and lightly burned soils, although again, macroscopic pore space was less. Microscopic pore space and total pore space were greater in both lightly burned soils than in their unburned counterparts. Bulk density of both lightly burned soils was less than that of the unburned soils (Fig. 3).

There is no ready explanation for the failure of percolation rate and macroscopic pore space to follow the usual relationship. Since the sequence of soil samples in laboratory tests was determined by random selection, there is no reason to suspect a concentration of analytical technique error in the lightly burned soils. Moreover, the changes in total pore space and bulk density in the two soils were highly consistent in both direction and amount (Table 2), although these soils were distinctly different in texture and were collected from cutting areas more than 100 miles apart. The inconsistencies in percolation rate and macroscopic pore space after light burning may be due in part to the highly aggregated character of the surface soils. Low values for bulk density (even after severe burning) are typical of Douglas-fir region soils, as evidenced by some 1,200 measurements now available for comparison.

Discussion

Some interesting associations are evident when changes in soil properties after both light and severe burning are expressed as a percent of the same value for unburned soil (Table 2). In both soils, the decrease in percolation rate after severe burning is very nearly balanced by the decrease in macroscopic pore space. For each soil, the increase in microscopic pore space following both light and severe burns is almost identical. Change in bulk density, except for severely burned sandy clay loam, is matched almost exactly by a change in total pore space in the opposite direction. Only

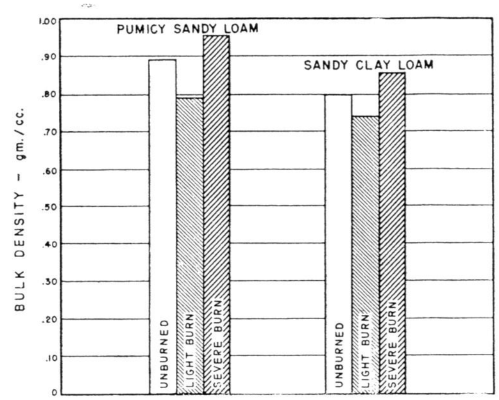

FIGURE 3. *Relation between soil bulk density and surface condition after slash burning.*

the relationship between percolation rate and macroscopic pore space in lightly burned soils fails to conform to established principles of soil water movement.

Conclusions

Severe burning seriously lowered the rate of moisture movement in the two soils studied. Light burning did not hamper the movement of water within the surface 3 inches of soil, although macroscopic pore space was reduced.

Severe burn occurred only in small, scattered patches that, combined, amounted to only a very small portion of the total surface of the slash-burned areas. For this reason, it is concluded that the over-all influence of slash burning on the moisture properties of the soils studied was of minor consequence. These findings are applicable only to intentional slash burning and should not be applied to areas in which repeated wild fires have occurred.

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