Relative Infiltration Rates of Burned and Unburned Upland Soils

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Abstract—To increase the value of range land densely covered by brush, a number of management practices are being employed. One practice, clearing by the use of fire, has raised the question as to its effect on the infiltration capacity of the soil. Application of single-ring infiltrometers for determining relative infiltration rates of upland soils is discussed. Values of the relative infiltration rates for burned and unburned areas are presented. In all cases the burned soils had substantially higher rates following a fire. One year later the results were similar with one exception.

Introduction—Much of the ten million acres of brush-covered range land in California is so densely covered by vegetation that it has little or no value, particularly from the standpoint of livestock or agronomic production. In an attempt to increase the value of this land, certain range-management practices are being employed. The more important ones are grazing, burning, and mechanical manipulation of the vegetative cover. In some cases these practices have a profound influence on the hydrologic factors of runoff, erosion, infiltration, interception, and others. For any general conditions of a watershed it is rather difficult, and in some cases impossible, to distinguish or isolate the effect of one or another of these factors on the water regimen of the watershed. Their relationships are closely interrelated. Nevertheless tests and measurements involving a variety of methods and analyses are being developed and used by hydrologists to evaluate the quantitative relationships of these factors.

Literature review—One range-management practice which has provoked considerable speculation, observation, and research is that of burning and its effect on the infiltration capacity of the watershed. Results and conclusions reached vary as to its effect. *Rowe* [1941] in a study on small plots reported that changes produced by burning resulted in a reduction of 90 to 95 pct in the infiltration capacity of the soil. *Veihmeyer* and *Johnston* [1944] state that the infiltration capacity of the soil on burned plots was not impaired. *Burgy* and *Scott* [1952] performed a number of tests on several upland soils and found that no decrease in infiltration occurred.

There is considerable evidence presented by a number of workers [*Brown* and *Montgomery*, 1913; *Kamoshita*, 1937; *Kelly*, *Dore*, and *Brown*, 1931; *Puri* and *Asghar*, 1940; *Steenkamp*, 1928] that heating to high temperatures tends to destroy the colloidal properties of soil. This change may contribute to higher infiltration rates. From studies on the effect of sterilization on soil properties it is reported that changes in soil structure, largely increases in aggregation, have occurred when soil has been heated [*Martin* and *Aldrich*, 1952; *Screenivisan* and *Aurangabadkar*, 1940]. *Scott* and *Burgy* [in press] present data based on a laboratory study which indicates changes in aggregation occur when certain upland soils are heated to temperatures which would be reached during the burning of brush.

Procedure—In order to compare the relative infiltration rates of certain upland soils on which burning of brush has occurred, a study was made employing single-ring infiltrometers. It is recognized that the use and results obtained by these devices have certain definite limitations particularly from the standpoint of interpreting results and applying them to the water regimen of an entire watershed. Nevertheless, their use offers the solution to a number of problems involved in making relative infiltration measurements on range-land watersheds. These problems include rolling to rough and steep topography; inaccessible areas; dense vegetative cover, which is so thick that movement of personnel or equipment is virtually impossible; and limited water supply. Single-ring infiltrometers have been used very satisfactorily on cultivated agricultural soils to determine differences in soil structure and surface treatments [*Doneen* and *Henderson*, 1953]. Modification in the application of single-ring infiltrometers to upland soils is required as conditions encountered are different than those for the valley agricultural soils. The upland soils have much higher relative infiltration rates, have had no cultivation, have few surface cracks, and it is not feasible to wet or prime the soil prior to making an infiltration study.

The infiltrometers used in this study were single cylindrical metal shells, approximately six inches in diameter and 20 inches high. The procedure followed was to drive the infiltrometer into the

TABLE 1 – *Relative infiltration rates of burned and unburned upland soils*

County	Date	Fifteen minutes		One hour	
		Control	Burned	Control	Burned
		in/hr	in/hr	in/hr	in/hr
Napa	52	1.85 ± 0.37	2.34 ± 0.53	1.16 ± 0.21	1.47 ± 0.24
	53	5.28 ± 0.66	3.98 ± 1.10	3.95 ± 0.52	2.02 ± 0.49
Madera	52	14.71 ± 1.31	18.06 ± 1.45	7.18 ± 0.40	7.67 ± 0.65
	53	17.65 ± 0.84	19.36 ± 1.34	9.67 ± 0.30	8.79 ± 0.46
Mariposa	52	4.84 ± 0.94	13.73 ± 1.69	2.79 ± 0.43	4.86 ± 0.55
	53	14.35 ± 1.84	17.50 ± 1.66	6.34 ± 0.65	8.37 ± 0.60
Nevada	52	5.37 ± 0.72	14.06 ± 1.66	3.41 ± 0.32	6.69 ± 0.32
	53	6.66 ± 0.70	8.30 ± 0.82	4.59 ± 0.43	5.67 ± 0.43
Nevada	52	7.33 ± 0.57	24.06 ± 1.36	5.27 ± 0.31	9.34 ± 1.12
	53	6.51 ± 0.79	15.33 ± 0.58	4.80 ± 0.43	9.06 ± 0.30
Shasta	52	7.57 ± 0.96	9.26 ± 1.01	5.50 ± 0.56	5.96 ± 0.59
Madera	53	19.45 ± 1.11	21.01 ± 1.29	...	...

ground approximately one to two inches, and fill it with water. A portable disk inserted into the cylinder during the filling operation protected the soil surface and, in the case of the burned areas, the ash on the soil surface from being disturbed. The drop in the water surface was recorded by means of a hook gage and the relative infiltration rate computed.

The usual procedure was to test an area before a control burn then retest soon after the burn. In a few cases several days had elapsed before the burned area was tested. In other cases similar adjacent burned and unburned areas were tested simultaneously. In all cases the areas tested were selected without bias after careful examination indicated no detectable underlying differences and that conditions were considered the same.

Six areas were tested during the summer of 1952. Five of these areas were retested in 1953 and one new area was included. These areas were in five California counties; namely, Shasta, Nevada, Napa, Mariposa, and Madera. The soils represented six of the typical upland soils found on rangeland watersheds. These were Redding, Aiken, Sierra, Hugo, and Vista. The parent material of these soils include coarse-textured granitic, fine-textured basic igneous, consolidated sedimentary, and mixed alluvium rocks. The vegetative cover varied from almost pure stands to mixtures of chamise, ceanothus, manzanita, oak, and grass. There was also considerable difference in the density of cover. This factor was most influential in determining the intensity of heat during the burn and the amount of ash on the soil surface following the fire.

Rates of infiltration were determined for the first 15 minutes and one hour after water was added to the infiltrometers. In several cases the rates were so high that the infiltrometers would be dry before the end of the hour period. No effort was made to refill them once they were empty. Therefore, the figures used to calculate the rate at the end of the hour period were for only those cylinders which still had water in them at the end of the period.

In each burned and unburned area except one at least 24 infiltrometers were set and filled. Only ten were set in each area in the Shasta County study.

Results and discussion—Values of the relative infiltration rates of the burned and unburned areas for the 15-minute and one hour period are presented in Table 1. In this table the unburned area is denoted as the control. The values of the standard error follow each relative infiltration rate.

It will be noted in every case for the 1952 tests and the one in 1953 (Madera) the relative infiltration rates of the burned soils is higher than that of the unburned. In the two Nevada sites on Aiken and Sierra soils the difference amounts to more than ten inches per hour for the 15-minute rate and three to four inches per hour for the one hour rate. Of the five sites retested in 1953 the rates were higher on the burned areas in all cases for the first 15 minute period except in the Napa County site. The difference between the burned and unburned on the other sites was not as great after one year, yet there appeared to be no apparent decrease in the rates of the burned areas except in the case of the Napa site.

On the basis of the statistical analysis the differences were highly significant at the one per cent level in three of the cases (the two Nevada and Mariposa sites) for the 15-minute rate and in two (the Mariposa and first Nevada site) of the one hour rate for 1952. For the 1953 results one

case (the first Nevada site) showed a highly significant difference at the one per cent level for the 15-minute rate.

Reasons that can be advanced for the increase in the relative infiltration rates may be attributed to physical and to some extent chemical changes in the soil at the surface.

Summary—These data indicate that the effect of burning and the presence of ash did not render the soil of the burned areas impervious to water. In fact the difference between the relative infiltration rates as measured by the single-ring infiltrometers was in favor of the burned areas in all cases immediately following a fire and with only one exception one year later.

The results of study should be applied with caution to large watershed areas subjected to the range management practice of burning. Such questions as the stability of the physical and chemical changes, the effect of raindrop impact, surface-runoff effects, and the loss in vegetative cover and the resulting decrease in interception must be evaluated and integrated in the hydrologic study of watershed management.

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