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Seasonal Variation of Infiltration Capacities of Soils in Western Oregon

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Abstract

Infiltration capacities were 50 percent greater during fall than during summer for forest soils of western Oregon. These results contrast with those measured in other studies. In forested areas, investigators should be aware of potentially large seasonal changes in infiltration capacities. Such seasonal changes may exceed effects due to applied treatments (logging, slash disposal, burning, etc.) and can confound study results.

KEYWORDS: Infiltration capacity (soil) , seasonal variations, Oregon (Cascade Range).

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Introduction

Infiltration capacity is the rate at which rain or melted snow enters a thoroughly wetted soil surface. Infiltration capacity is not usually constant throughout a year and appears to vary with season. Beutner et al. (1940), Borst et al. (1945), and Horner and Lloyd (1940) studied infiltration of desert and agricultural soils in southern Arizona, central Ohio, and southwest Illinois, respectively. They found that infiltration capacities were higher during summer than during the cooler seasons of the year. Bertoni et al. (1958) found that infiltration capacity of farm soils in southwest Iowa appeared to increase gradually from March to mid-June, then increase sharply until late July, and decrease from August to mid-October. Satterlund (1972) reported that infiltration capacity usually reaches a maximum in late summer and a minimum in late winter. Reichman (1954) and Gifford (1972) both observed that infiltration capacity of grassland and range soils in central Montana and southeast Idaho declined from late spring to fall.

In conjunction with an investigation of the effects of forest harvesting activities on infiltration (Johnson and Beschta 1980), we also observed a seasonal fluctuation in the infiltration capacity of forest soils at two locations in the Cascade Range in Oregon. This change, however, was in direct contrast to findings in all of the cited studies. We found infiltration capacity was 50 percent higher during fall than during summer.

Study Areas

Infiltration measurements were made at two locations: (1) the Coyote Creek watersheds, located on the South Umpqua Experimental Forest approximately 65 km southeast of Roseburg, Oregon, and (2) the Hi-15 watersheds, located on the H. J. Andrews Experimental Forest about 72 km east of Eugene, Oregon (fig. 1). Elevations range from 730 to 1 065 m above mean sea level at the Coyote Creek watersheds and from 855 to 1 050 m at the Hi-15 watersheds. Both areas have relatively dry, warm summers and wet, mild winters. The mean annual precipitation is 123 cm at the Coyote Creek and 234 cm at the Hi-15 watersheds. Over 80 percent of the annual precipitation normally occurs from October to April. Mean temperatures in January and July average approximately 1°C and 17°C, respectively. The Coyote Creek watersheds contain a mixture of soils derived from basalt and red and green breccias, agglomerates, and tuffs. Scattered rhyolitic breccia and agglomerate soils are also present. The Hi-15 watersheds have andesite-derived soils. Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) dominates the overstory vegetation of undisturbed sites at both areas.

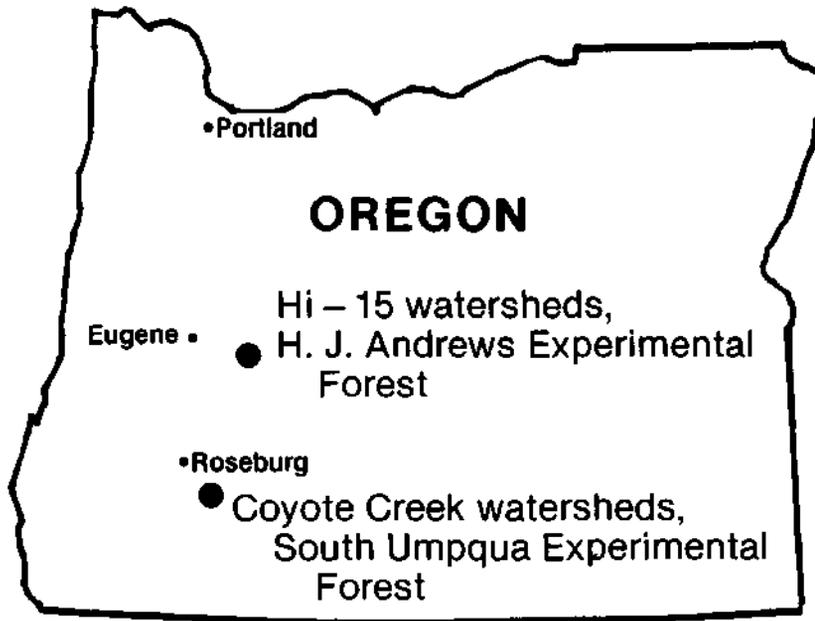


Figure 1.--Location of the study areas in western Oregon.

Methods

In 1977, when summer soil temperatures were high and soil moisture levels low and late fall soil temperatures were moderate to cool and soil moisture levels at or near capacity, Johnson (1978) determined infiltration capacities at both study areas. He used an infiltrometer similar to that used by Meeuwig (1971). This instrument is a rainfall simulator which uniformly applies water at controlled rates to about 0.3 m² of soil surface. To determine infiltration capacity, Johnson followed these procedures: Prior to the start of each measurement, he pre-wet the plots with 7.6 liters of water. He then applied simulated rainfall with the infiltrometer, collected runoff at the downhill edge of the application area, and determined the infiltration capacity by subtracting the volume of runoff from the volume of water applied. During both summer and fall seasons, he measured infiltration this way on the same plots at both study areas.

Summer and fall infiltration capacities were evaluated with paired t-tests at the 0.05 and 0.1 levels of probability. Because infiltration capacities were similar for soils disturbed by logging activities and undisturbed soils, we combined the data at each study location for the t-test comparisons. We also utilized regression analysis to further illustrate changes in seasonal infiltration capacities.

Results and Discussion

Infiltration capacities for the Coyote Creek and Hi-15 watersheds averaged about 50 percent higher in the fall than during the summer (table 1). All data on infiltration capacity appeared to be normally distributed. Even though the number of samples were relatively small, differences between summer and fall means were highly significant ($\alpha = 0.01$). The pattern of greater infiltration in fall, compared with summer, was found in both disturbed and undisturbed soils at both study areas. Linear regression analysis of the data from both study areas further demonstrates that infiltration capacities were greater in fall than in summer (fig. 2).

Table 1—Infiltration capacities for forest soils at study sites in western Oregon, 1977

Location	<u>Mean infiltration capacity</u>		Number samples	of Significant ^{1/}
	Summer	Fall		
- - Centimeters per hour - -				
Coyote Creek watersheds, South Umpqua Experimental Forest	8.42 (2.82) ^{2/}	12.33 (4.28)	17	**
Hi-15 watersheds, H. J. Andrews Experimental Forest	6.89 (1.43)	12.11 (4.35)	6	**
Average, all watersheds	8.02 (2.59)	12.27 (4.20)	23	**

^{1/}Significance of differences in paired t-tests (** = significant at 0.01 level of probability).

^{2/}Values in parentheses are standard deviations.

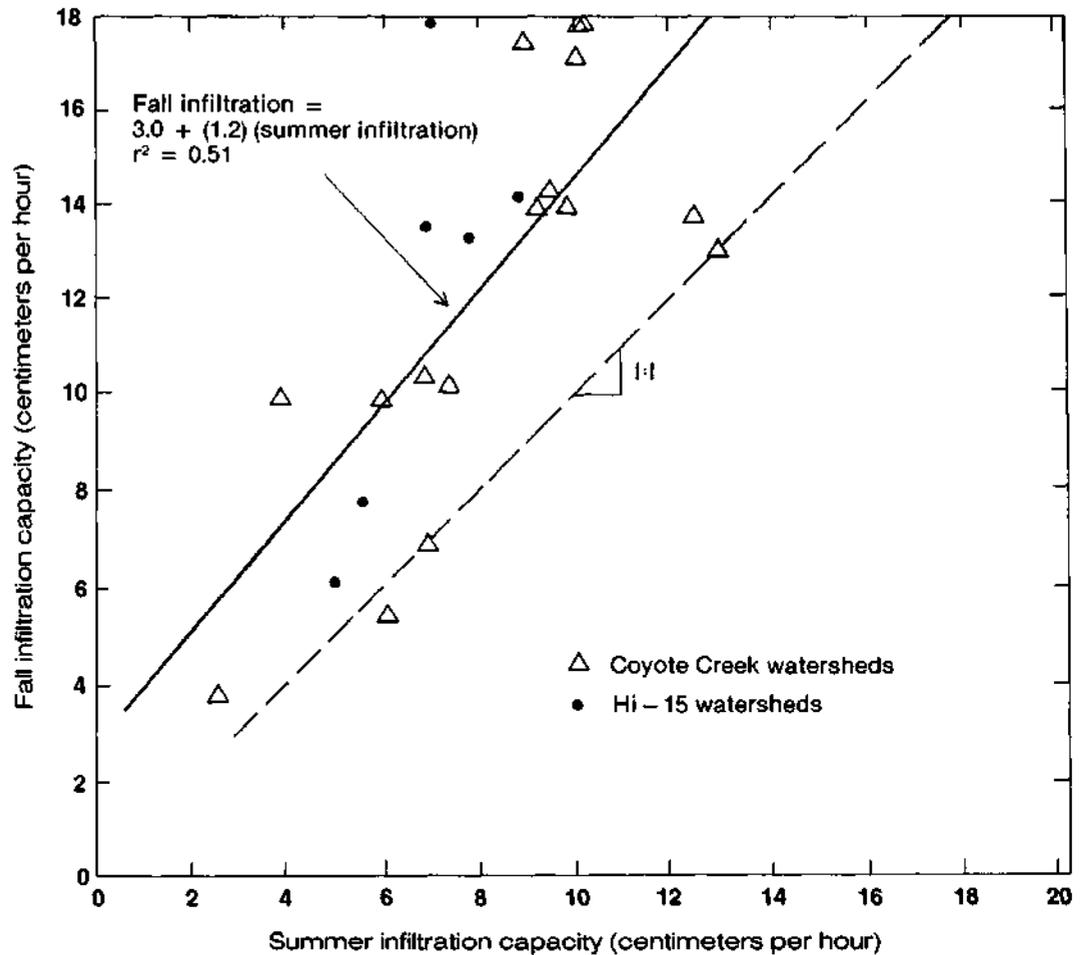


Figure 2.--Seasonal variation in infiltration capacities from summer to fall for the Coyote Creek and Hi-15 watersheds, 1977.

The cause of this seasonal increase in infiltration capacity is not known. Field observations, however, indicate that during the summer months the soil surface presents a non-wettable condition. This condition may result from changes in characteristics of the soil organic matter caused by the hot and dry climate of summer. This surface-limiting condition apparently changes after the first fall rains, and infiltration capacities increase.

In contrast to the results of this study, most other investigators have found fall infiltration capacities 30-80 percent lower than those occurring during summer (fig. 3). Possible explanations for reduced infiltration during summer are: (1) greater vegetal cover which protects the soil surface and prevents sealing, (2) lower surface soil moisture resulting in a greater degree of deep soil cracking, and (3) high soil temperatures which reduce the viscosity of water. Satterlund (1972) hypothesized that seasonal changes in infiltration were caused by the addition and decomposition of organic matter, the growth of plants, the activities of soil organisms, and seasonal climatic patterns. Gifford (1972) indicates that reduced infiltration in fall may be the result of both normal seasonal fluctuations and the influence of land management practices (i.e., grazing).

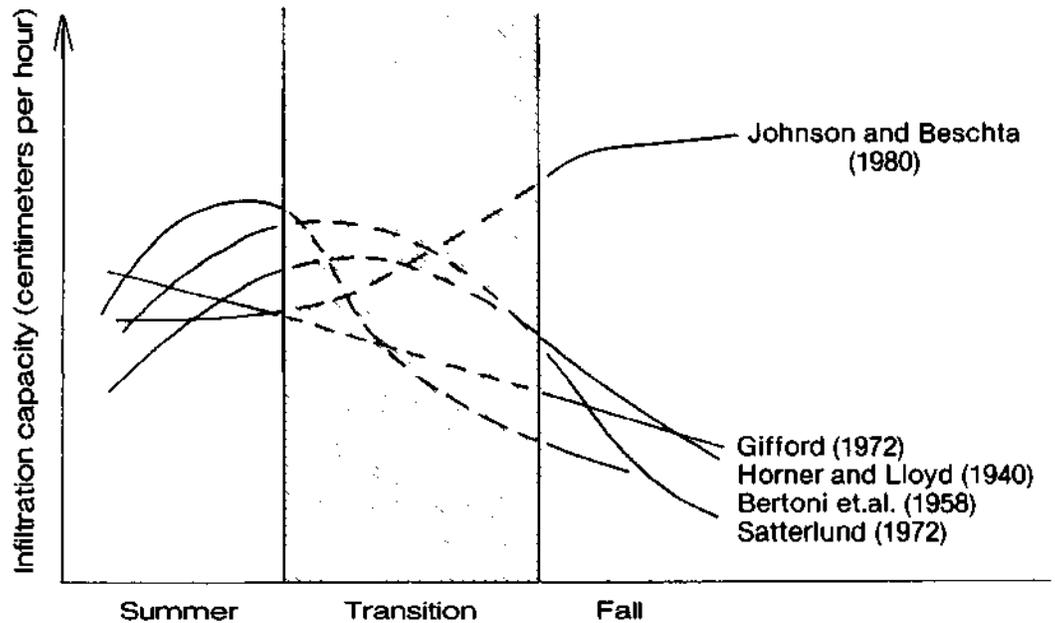


Figure 3.--Variation in infiltration capacity from summer to fall as observed in various studies.

Future Considerations

Many infiltration studies have been performed throughout the United States during the past 40 years. Most of these have been done on agricultural and range lands (Parr and Bertrand 1960, Gifford and Hawkins 1978). Seldom have these studies taken into account the seasonal variations in the infiltration process. Even though most investigations were conducted during the summer, some must have started in the spring or extended into the fall. Future investigators should be aware that temperature or moisture changes during or between seasons can trigger a major change in the infiltration capacity of soil. This seasonal change could exceed the effects of land use or an applied treatment and thus confound results.

In spite of the large number of infiltration studies done in the United States, relatively little information exists about soils associated with forest vegetation types, particularly those in the Pacific Northwest. Yet such information is vital to improving our understanding of runoff processes and ways they are influenced by forest management practices. Results of our study raise several fundamental questions relating to the understanding of and ability to predict infiltration capacity. For example: (1) Is an increase in infiltration in fall found in other forest types in the Pacific Northwest or elsewhere? (2) Does infiltration capacity also change during winter and spring? If so, how? (3) What are the specific causes of variation in infiltration capacity? Are they changes in temperature and moisture or chemical and physical properties of soils? (4) Do infiltration studies provide an accurate measurement of soil's capability to receive and transmit moisture downward in the profile during natural rainfall and/or snowmelt? Until such questions are answered, the ability of soil scientists, hydrologists, and other natural resource specialists to predict the hydrologic effects and impacts of land use on either forest or rangeland (as illustrated by Gifford and Hawkins 1979) will be limited.

Metric Equivalents 1 centimeter (cm) = 0.39 inch
1 Kilometer (km) = 0.54 mile
1 meter (m) = 1.09 yards
1 liter = 1.06 quarts
 $^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$

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