Infiltration Rates of Various Vegetative Communities within the Blue Mountains of Oregon

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Abstract

Mean infiltration rates differed among several natural vegetation communities with ponderosa pine *(Pinus ponderosa)* exhibiting the lowest mean infiltration rate of 6.0 cm/hr and larch *(Larix occidentalis)* demonstrating the highest at 8.8 cm/hr. A trend toward increasing infiltration rates corresponded to increasingly mesic sites. Alpine, Douglas fir *(Psuedotsuga menziesii)*, mountain meadow, and larch types demonstrated the greatest vegetative cover, occupied the most mesic sites, and exhibited the highest infiltration rates. Infiltration differences within vegetative communities based upon changes in condition and productivity were also noted. The forested sites were more dependent upon condition class than productivity class, with higher infiltration rates being exhibited on pole sites than on timbered sites, apparently in response to higher plant densities associated with the pole thickets. Nonforested sites were responsive to both productivity and condition class with higher infiltration rates being exhibited on these sites with the more productive or better condition classifications.

Water is a primary factor limiting production on many western rangelands. Many of these areas are subject to low annual precipitation and high potential evaporational losses. Activities which disturb the soil surface or vegetative composition and cover have the potential for reducing soil water intake, thereby reducing productivity which in some instances may be minimal at best. A prime concern of land managers is to maintain or enhance those factors within managerial capabilities which affect soil water intake and to identify those areas most susceptible to disturbance. Blackburn and Skau (1974) studied infiltration rates and sediment production fo 29 plant communities and soils in central and eastern Nevada. The highest infiltration rates occurred on sites with well-aggregated surface soils free of vesicular porosity. Williams et al. (1972) used multiple regression analysis to determine relationships between vegetative and soil factors and infiltration rates and erosion from 550 infiltrometer plots at chained pinyon-juniper sites in Utah. Factors found to be most important in predicting infiltration rates were: (1) total porosity in the 0–8 cm layer of soil, (2) percent bare soil surface, (3) soil texture in the 0–8 cm layer of soil, and (4) crown cover.

Raindrop impact on bare soil tends to rapidly close the natural channels of percolation by degrading soil structure. Studies at the Manti County watershed in Utah showed that runoff varied inversely with the total amount of ground cover (Orr 1957). Vegetative cover tends to reduce the energy of rainfall by reducing velocity and by breaking the large drops into a fine spray which can then enter the soil without damage to the soil surface. Gifford (1972) reported that the ability to predict infiltration rates, using cover characteristics alone varies with time, both within a given storm event and on a seasonal basis. He further stated that measured cover characteristics may help explain hydrologic behavior of a site at one time, yet be of little value at another time.

The objective of this study was to determine and compare infiltration rates within and among 10 different ecosystems found in the Oregon Range Evaluation Project Work Area.

Description of Area

The Oregon Range Evaluation Project is located in northeastern Oregon between 44° and 45° north latitude and 118° and 120° west longitude. The area has a climatic range from semiarid to cold, subhumid. Average winter temperature is 2.1° C and mean summer temperature is 19.2° C. Precipitation occurs primarily during the winter and spring months, generally in the form of snow. Although the summer months are relatively dry, significant amounts of precipitation may fall in response to intense convectional storms. Annual precipitation varies between 25 cm at lower elevations to 100 cm at the higher elevations.

The area is located in the John Day Drainage Basin which represents a borderland between the Columbia Plateau Province to the north and the Basin and Range Province to the south. The topography is generally hilly or mountainous and the major streams are deeply entrenched. Three physiographic divisions are considered to be important in the study area. They are: (1) alluvial fans and flood plains comprised of soils varying from deep, well-drained loams to poorly drained alkali, silty, clay loams; (2) middle elevation uplands comprised of moderately deep, clayey soils; those over basalt or tuff are silty, strong soils while those over ash or loess are silty clay loams and deep, ashy, clay loams; (3) high elevation uplands support mixed coniferous vegetation types and are derived from volcanic ash and basalt-andesite (Geist and Ehmer undated).

Methods

The basic ecological land unit for research purposes within the Evaluation Area is defined as the "Resource Unit." Resource units were derived in the Forest-Range Environmental Study (FRES 1972) by categorizing the forest and range land into ecosystems; each ecosystem in turn was further refined into 1 of 4 productivity levels (I-IV) and one of several condition classes (Excellent, Good, Fair, Poor for nonforested sites, and Timber or Pole for forested sites) (USDA 1972). The 10 ecosystems found within the Evaluation Area are: (1) Douglas fir *(Pseudotsuga menziesii)*, (2) Ponderosa pine *(Pinus ponderosa)*, (3) Spruce-Fir *(Picea englemannii-Abies concolor)*, (4) Larch *(Larix occidentalis)*, (8) Mountain Grassland, (9) Meadow, and (10) Alpine.

These ecosystems were refined into resource units by determining wood or forage volume as a measure of productivity and species composition relative to climax as a measure of condition.

A Rocky Mountain infiltrometer was used to determine infiltration rates of soils of the resource units. This sprinkler-type infiltrometer is particularly well adapted to testing comparative

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conditions associated with natural rainfall (Dortignac 1951). The infiltrometer was calibrated to produce a storm even of approximately 10 cm/hr over a 28-minute storm length. This particular kind of simulated storm was chosen because it approximated a 75-year, convectional storm at this location.

Sites were identified and quantified into resource units by a U.S. Forest Service vegetation team prior to infiltration measurements. Verification of site classification and specific vegetation cover, litter, and pavement estimates were completed by ocular reconnaissance immediately prior to infiltration trials by the authors.

Eighteen observations were made within each resource unit. Plots consisted of 6 randomly selected clusters comprised of 3 subplots per cluster. Cluster sampling provided practical and economical advantages (Steel and Torrie 1960). Duncan multiple comparison tests were made in order to determine differences in infiltration rates among the different resource units.

Results and Discussion

Mean infiltration values were established for 40 resource units representing each of the 10 ecosystems found within the Evaluation Work Area. Twenty-eight of the 40 were distinct resource units.

Douglas Fir

Resource units within the Douglas fir ecosystem had relatively high mean infiltration rates (Figure 1). Mean infiltration rates ranged from 6.6–9.7 cm/hr with an overall mean of 8.2 cm/hr (Table 1). There were statistical differences ($P<.05$) among these resource units, although a trend based on productivity and condition classes taken together could not be established. Taken separately, multiple comparison tests indicated a significant difference in mean infiltration rates based on condition class but not productivity class. This difference was manifested as a decrease in mean infiltration rate as condition class changed from Pole to Timber.

Ponderosa Pine

Three different locations were sampled within the ponderosa pine ecosystem; however, they were all of the same resource unit classification (productivity class IV and Pole condition class). This resource unit reflected the lowest mean infiltration rate of any sampled. The mean value was 6.0 cm/hr.

Spruce-Fir

The spruce-fir resource units, as a whole, reflected relatively low mean infiltration rates. Values ranged from 3.6–9.0 cm/hr with an overall mean of 6.3 cm/hr. Significant differences between these resource units existed. Mean infiltration rates decreased as condition class changed from Pole to Timber.

Larch

Resource units within the larch ecosystem as an average, reflected the highest infiltration rates of all study sites. Mean infiltration rate ranged from 7.7–12.1 cm/hr with an overall mean of 8.8 cm/hr. There was a significant difference between the two resource units sampled. As with the Douglas fir and spruce-fir resource units, mean infiltration rates decreased as condition class changed from Pole to Timber.

Lodgepole Pine

Two locations were sampled within the lodgepole pine ecosys-

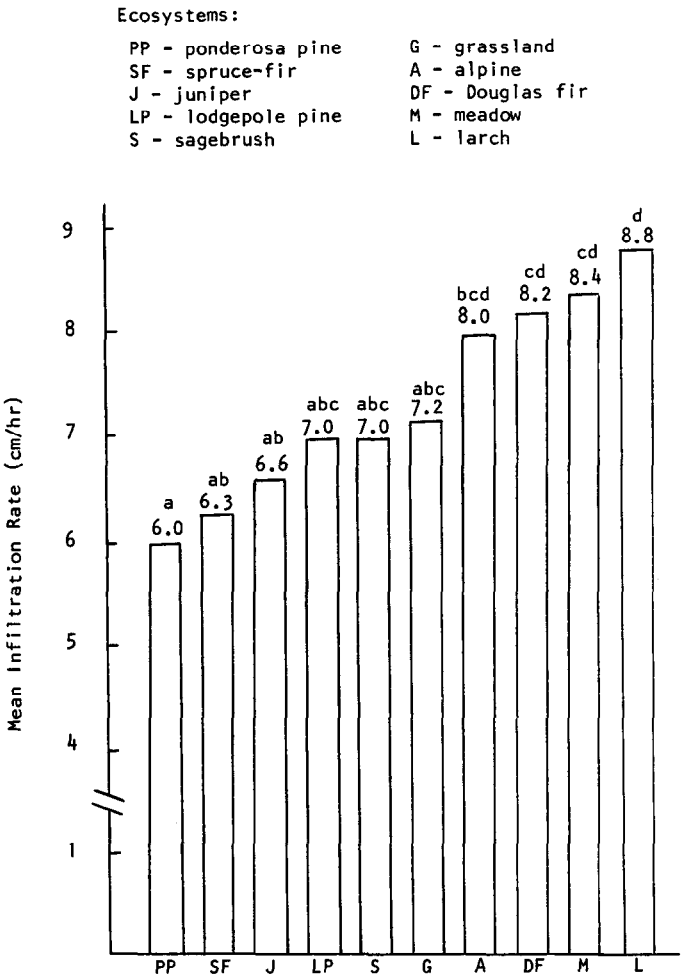

Figure 1. Mean infiltration rates of the 10 FRES ecosystems (different case letters indicate statistical difference P<.10).

Table 1. Mean infiltration rates (cm/hr) for resource units (RU) within 10 natural ecosystems located in Oregon's Blue Mountains.

	RU	Mean[1]
Douglas fir	20-IV-P[2]	6.6 a
	20-III-T	7.8 ab
	20-IV-T	9.3 b
	20-III-P	9.7 b
Ponderosa pine	21-IV-P	6.0
Fir-Spruce	23-IV-T	3.6 a
	23-IV-P	9.0 b
Larch	25-III-T	7.7 a
	25-III-P	12.1 b
Lodgepole pine	26-IV-P	7.0
Sagebrush	29-IV-G	6.1 a
	29-II-P	6.6 ab
	29-III-G	7.3 ab
	29-II-F	8.0 b
Juniper	35-IV-P	4.2 a
	35-III-P	7.3 b
	35-I-F	7.5 b
Grassland	36-IV-F	4.9 a
	36-IV-P	6.2 ab
	36-III-P	7.2 b
	36-III-F	7.6 b
	36-III-G	9.5 c
Meadow	37-III-P	2.6 a
	37-I-P	8.0 b
	37-III-F	8.1 b
	37-II-F	11.6 c
Alpine	44-III-P	6.1 a
	44-III-F	10.0 b

[1]Different case letters indicate significant difference $p<.05$.
[2]Two-digit number indicates ecosystem; Roman numerals indicate productivity class; letter indicates condition class (P = pole, T = timber, E = excellent, G = good, F = fair, P = poor).

tem. Both were of the same resource unit classification. This resource unit reflected a moderate infiltration rate as compared to other resource units. The mean value was 7.0 cm/hr.

Sagebrush

Sagebrush resource units also reflected moderate infiltration rates. Values ranged from 6.1–8.0 cm/hr with an overall mean of 7.0 cm/hr. Although significant differences existed between resource units associated with condition class and productivity class interactions, there were no significant differences evident when these classes were considered independently.

Juniper

Resource units within the juniper ecosystem reflected relatively low mean infiltration rates. Values ranged from 4.2–7.2 cm/hr with an overall mean of 6.6 cm/hr. Significant differences existed between resource units. Data indicated that mean infiltration rates were better correlated with productivity class than condition class. A significant difference was noted between productivity class I and III versus productivity class IV. There was no difference between productivity classes I and III. Mean infiltration rates decreased as productivity decreased from I and III to IV. A significant difference did not exist between condition classes Poor and Fair.

Mountain Grassland

Grassland resource units were found to have moderate infiltration rates as compared to resource units of other ecosystems. Mean infiltration rates ranged from 4.9–9.5 cm/hr with an overall mean of 7.2 cm/hr. Significant differences existed among resource units. Data indicated that mean infiltration rates were influenced by both productivity class and condition class. There was a significant difference between productivity classes III and IV and condition classes Poor and Fair versus condition class Good. A difference was not shown between condition classes Poor and Fair. Mean infiltration rates increased as productivity increased from IV to III and as condition class changed from Poor and/or Fair to Good.

Meadow

Meadow resource units were found to have some of the highest infiltration values in the study area. Mean infiltration rates ranged from 2.6–11.6 cm/hr with an overall mean of 8.4 cm/hr. A significant difference was found among productivity classes, although a sequential trend could not be established. Data indicated that mean infiltration rates were dependent upon interactions between condition class and productivity class. In general, as productivity increased and condition class changed from Poor to Fair, mean infiltration rates increased.

Alpine

Resource units of the alpine ecosystem reflected moderately high mean infiltration rates. Values ranged from 6.1–10.0 cm/hr with an overall mean of 8.0 cm/hr. There was a significant difference between these resource units. As in other ecosystems, mean infiltration rates increased as condition class changed from Poor t Fair.

Management Implications

Data indicated that condition class was generally more closel related to infiltration than was productivity class in the foreste units. Mean infiltration rates decreased as condition class change from Pole to Timber. We speculate that this is due to density (no biomass) relationships. Apparently as the density of vegetatio decreased (fewer stems per hectare in mature forests than in pol thickets), a hydrologic reflection in terms of infiltration wa manifested.

In nonforested sites, both productivity and condition classes an their interactions were important. A significant decrease in mea infiltration rates of almost 4 cm/hr was noted between alpin resource units as conditions went from Fair to Poor. Infiltratio rates were more dependent upon productivity class than conditio class within the juniper resource units. Mean infiltration rate decreased as productivity decreased from productivity classes and III to IV. Mean infiltration rates were shown to be directl correlated with both productivity class and condition class withi the grassland meadow resource units. This influence was particu larly noticeable when comparing grassland ecosystems of low pro ductivity and Poor condition class to areas of higher productivit and Good condition.

Clearly, the effects of vegetative cover, litter, and pavement ar important within these areas. This study illustrates the need fo maintaining or enhancing adequate ground cover in order t ensure optimal infiltration rates.

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