Water Intake as Affected by Soil and Vegetation on Certain Western South Dakota Rangelands[1]

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The capacity of rangeland soils to absorb rainfall is of major importance in the production of forage and in the control of runoff and erosion on watersheds. Characteristics of the soil and past and present grazing use as they affect plant cover are some of the important factors determining water-intake. These and factors associated with climate govern the amount of precipitation that can be absorbed and stored by the soil. Improvements in water-intake are of extreme importance in range and watershed improvement programs.

Dyksterhuis and Schmutz (1947), in a comprehensive review of the literature, noted that with few exceptions mulches were a primary factor in determining total annual infiltration of rain water on ranges. Duley and Domingo (1949) found that when grass was clipped and mulch removed, water-intake rates were reduced because of loss of surface protection. The role of range cover in preventing splash erosion and surface sealing was quantified by Osborn (1954).

During the past several years, water-intake studies have been conducted on rangelands of the northern and central plains with a mobile infiltrometer (Figure 1). These tests were conducted over a seven-state area on different kinds of rangelands. Data were obtained by sampling contrasts in the condition of range plant covers along fence lines where soils were homogeneous. In general, these data reveal that the rate of water-intake increases appreciably with an increase in amount of standing vegetation and mulch (Rauzi and Zingg, 1956). Quantitative results, from three areas in the northern plains, emphasized the importance of vegetation and mulch material in increasing the amount of rainfall absorbed by range soils (Rauzi, 1960).

Questions remain on the degree to which results from the infiltrometer apparatus represent the infiltration and runoff to be expected from small watersheds under natural conditions. The purpose of this paper is to report on certain preliminary phases of broader studies designed to answer such questions.

In September 1956, a reconnaissance survey to locate suitable small watersheds was conducted in the general land area adjacent to the corners of Montana, the two Dakotas and Wyoming. Personnel of the Agricultural Research Service and the Soil Conservation Service selected a group of stockponds where useful hydrologic studies could be made and from which results could have wide application in surrounding areas.

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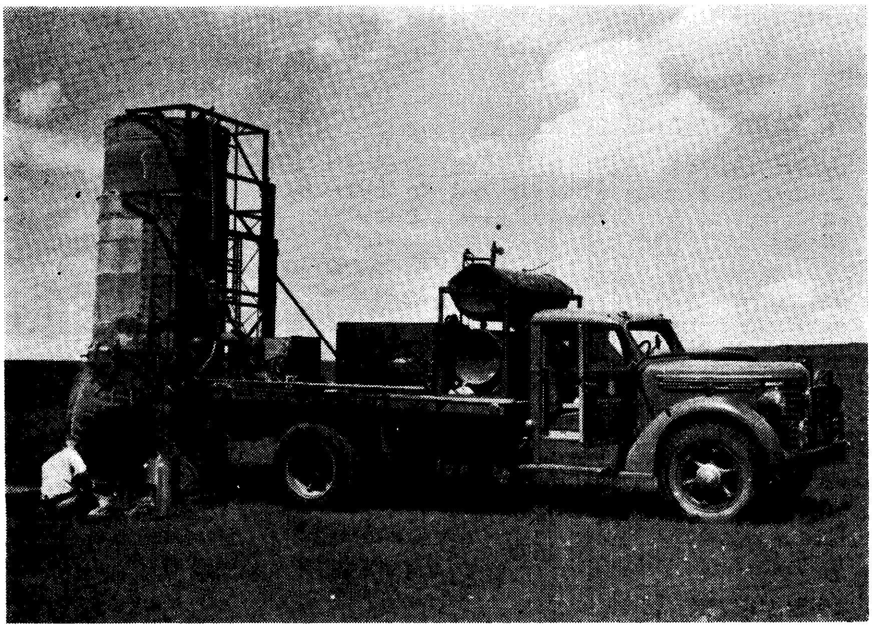

FIGURE 1. Mobile raindrop applicator used to determine water-intake rates on small rangeland watersheds.

Sixteen stockponds with drainage areas of 30 to 13,000 acres in size were selected (Figure 2). Most were in Butte County, South Dakota. One-half of the small stockpond watersheds were located in areas underlain by interbedded Fox Hills and Hell Creek rock formations and the other half were located in areas underlain by Pierre shales. The extensive Bainville-Rhoades association of range soils prevails in the Fox Hills-Hell Creek areas while the extensive Lismas-Pierre range soil association is represented in the Pierre shale area. The watersheds are generally in the 10- to 14-inch belt of average annual precipitation.

Fifteen of the 16 stockponds have been instrumented with water stage recorders and permanent staff gauges. The other pond is equipped with a permanent staff gauge. Automatic recording rain gauges have been located on each of the watersheds. Detailed sedimentation and water capacity surveys have been completed on all the ponds.

The instrumentation of the 16 rangeland watersheds has provided an opportunity for carrying out infiltrometer studies where, eventually, there will be sufficient data from natural precipitation for comparing with the infiltrometer results. The infiltrometer work reported here, therefore, was planned around the watersheds' studies with the long-term objective of testing the validity of the infiltrometer results against watershed data.

Methods

Simulated rainfall was applied to a circular area of approximately 13 square feet on selected sites in the watersheds by use of a mobile infiltrometer. The test plot for water measurements was 2 feet square and located in the center of the area receiving rainfall. With this arrangement, the test plot was relatively free from the influence of lateral water movement. Water-intake rate was measured as the difference between the rate of applied rainfall and the rate of measured runoff. Surface detention, retention absorption, and interception by vegetation and mulch material were included in the measured intake but usually were negligible after the first 15 to 30 minutes of the test.

Intensity of rainfall on the test plots varied from 2.00 to 3.00 inches per hour. Rainfall was applied to 134 plots, each for a 1-hour period. The amount of runoff was determined at 15-minute intervals. This permitted evaluation of water-intake by 15-, 30-, 45-, or 60-minute periods. Rate of water-intake during the second 30-minute period was found to be more stable than during earlier periods.

All standing vegetation in the plot, including the previous years' growth, was clipped at ground level one or two days after the test. This material was air-dried and weighed and yield computed. All mulch material on

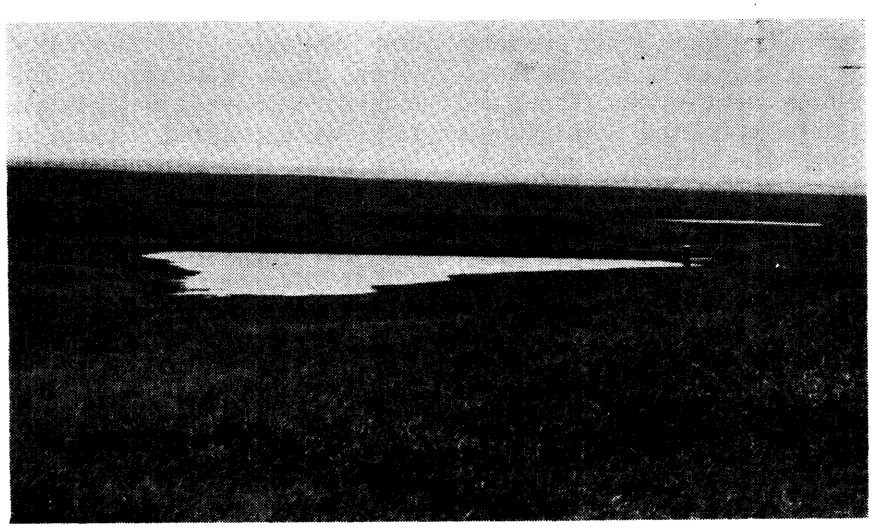

FIGURE 2. A typical small stockpond watershed that has been instrumented to record runoff. Note housing for waterstage recorder at right of photo.

Table I. Water-Intake Rates, Standing Vegetation and Mulch for Four Locations in Butte and Meade Counties, South Dakota, 1957 and 1958.

Stockpond No.	No. of Plots	Drainage Area	Range site	Average Air-Dry Forage	Average Air-Dry Mulch	Water-Intake 1st 15-Min.	Water-Intake 2nd 30-Min.	Water-Intake 4th 15-Min.	Water-Intake Average Total Intake for the 1-Hour Period
		(Acres)		Pounds/Acre		(inches/hr.)			
* P- 5	24	50	Sandy	1,422	1,810	1.96	1.69	1.52	1.69
P- 6	24	30	Panspots	896	294	1.52	0.51	0.36	0.80
P-12	26	90	Dense Clay	1,491	349	1.96	0.57	0.40	0.99
* P-13	60	160	Clayey	1,105	608	2.04	1.41	1.26	1.55

* Water-intake studies conducted in 1957.

the test plot was collected and yield determined in the same manner.

Results

Rate of water-intake as determined by the mobile infiltrometer on the watersheds varied with soil type, amount of standing vegetation and mulch cover. Table I shows water-intake rates on a per-hour basis for the first 15-minute period, the second 30-minute period, the fourth 15-minute period, and for the 1-hour interval. To illustrate the variations in water-intake rates that are associated with different types of range sites, kinds of cover and amounts of mulch, data from four small representative watersheds are presented. For convenience of discussion, the stockpond watersheds are identified by number. The range sites and range condition classes were determined by methods, and are referred to by terminology, standardized by the Soil Conservation Service, as described by Dyksterhuis (1949, '58). Mr. Ralph Cole, Range Conservationist, Soil Conservation Service, and the junior author mapped the sites and conditions.

Stockpond Watershed (P-5)

Stockpond watershed designated P-5 is located approximately 45 miles northeast of Newell, South Dakota. The drainage area is approximately 50 acres. Data were obtained from the area mapped as a Sandy range site, a fine sandy loam probably in the Vebar series, with vegetation in the Good range condition class. Vegetation consisted chiefly of blue grama *(Bouteloua gracilis)*, needleandthread *(Stipa comata)*, prairie sandreed *(Calamovilfa longifolia)*, western wheatgrass *(Agropyron smithii)*, and sedge *(Carex* spp.). Both cattle and sheep graze this area, and use was considered light. Average amount of standing vegetation present on the test plots was 1,422 pounds per acre and mulch material averaged 1,810 pounds per acre.

Average rate of water-intake (Table I) during the first 15-minute period of the 1-hour test was 1.96 inches per hour and 1.52 inches per hour during the fourth 15-minute period of the 1-hour test. The average total water-intake during the 1-hour test was 1.69 inches.

Stockpond Watershed (P-6)

This stockpond watershed is located approximately 50 miles northeast of Newell, South Dakota, and has a drainage area of approximately 30 acres. Soil surface textures at plots included sandy loams, sandy clay loams, and clay loams. However, the dense B horizon of solodized solonetz characterized the entire area. Data were obtained from the area mapped Panspots range site, with vegetation in the Good range condition class. Shallow depressions with B horizon exposed occupied approximately one-third of the area. Accordingly, 32 percent of the plots were located on the "panspots" and 68 percent were located on the inter-areas.

Vegetation was dominantly blue grama, western wheatgrass, needleandthread, and sandberg bluegrass *(Poa secunda)*. There was an average of 896 pounds of standing vegetation per acre and 294 pounds of mulch per acre on the test plots. Only cattle graze this area.

Water-intake rates during the first 15-minute period averaged 1.52 inches per hour and 0.36 inch per hour during the fourth 15-minute period of the 1-hour test. Total water-intake for this location averaged 0.80 inch per hour for the 1-hour test. During the first 15-minute period, the water-intake rate was relatively high, but it declined sharply as the test progressed. Since these averages apply to a mappable unit where one-third of the surface was occupied by "panspots", it may safely be assumed that average intake would be less with greater percentage of "panspots" and vice versa.

Stockpond Watershed (P-12)

This stockpond watershed is located approximately 12 miles east of Newell, South Dakota. The drainage area is approximately 90 acres in size. Soils include heavy clays probably in the Pierre-Lismas complex. Surface soil textures include clays, clay loam, silty clay loam, and silt loams. The data were obtained from the areas mapped Dense Clay range site and Shallow C. The latter designates a thin clay over shale. They showed no significant difference in infiltration rates. The vegetation on both types of rangeland was dominantly western wheatgrass with a small percentage of other grasses and forbs, and both were mapped in the Good range condition class. However, the

Shallow C site had greater relief and more bare ground. The area was grazed by sheep. There was an average of 1,491 pounds of standing vegetation and 349 pounds of mulch per acre on the test plots. The average water-intake rate during the first 15-minute period of the 1-hour test was 1.96 inches per hour and 0.40 inch for the fourth 15-minute period. The average water-intake during the 1-hour test was 0.99 inch. At the time of the tests, the soils were dry and severe cracking on the surface was observed. The surface fissures may help to explain the high rate of water-intake experienced during the first 15-minute period.

Stockpond Watershed (P-13)

Stockpond watershed P-13 is located in Meade County, approximately 33 miles east of Newell, South Dakota. The drainage area for this watershed is approximately 160 acres in size. Surface textures on the test plots included clays, clay loams, and silty clay loams. Data were obtained from the Clayey range site (clay but not heavy clay, probably in the Pierre series) with vegetation in the Fair to mostly Good range condition class.

Vegetation consisted chiefly of western wheatgrass and buffalograss *(Bouteloua dactyloides)*. The watershed is characterized by western wheatgrass colonies of various sizes. These almost pure stands are surrounded by buffalograss. It was estimated that the colonies of western wheatgrass occupied 40 percent of the area on the watershed. Equal numbers of tests were conducted on areas of western wheatgrass and areas of buffalograss sod in order to evaluate individually the two kinds of cover.

There was an average of 1,105 pounds standing vegetation per acre present on the test plots and 608 pounds of mulch material. The standing vegetation on western wheatgrass colonies average 241 pounds per acre more than that from the plots on the buffalograss sod. Mulch material was only 114 pounds per acre more from the western wheatgrass plots than from the buffalograss plots. The difference in total cover between the western wheatgrass colonies and the buffalograss sod was 355 pounds per acre.

Average water-intake rate for the two plant groups during the first 15-minute period of the 1-hour test was 2.04 inches per hour and 1.26 inches per hour. The average water-intake during the 1-hour test for the two plant groups was 1.55 inches.

On the buffalograss test plots the average water-intake rate during the first 15-minute period was 1.68 inches per hour and 0.80 inch per hour during the fourth 15-minute period of the 1-hour test. On the western wheatgrass plots the average water-intake during the first 15-minute period of the hour test was 2.40 inches per hour and 1.72 inches per hour during the fourth 15-minute period of the 1-hour test.

Discussion

The water-intake studies on the watersheds reported herein represent four distinct range sites that were rated generally in the Good range condition class. The rate of water-intake during the first 15-minute period of the 1-hour test was relatively high on each of the four watersheds, even though many of the soil characteristics were quite different. After the first 15-minute period of the 1-hour test the Panspots and Dense Clay range sites showed greatly reduced intake. This apparently was correlated with dense B horizon of the Panspots range site, and with the dense C horizon of the Shallow C range site.

The Panspots type of range site found on watershed P-6 was derived from weathered clays, shales, and shaly sandstones. The soils are characterized by slick spots where easily dispersed surfaces inhibit the rate of infiltration. The slick spots were in depressions ranging from two to thirty feet in diameter and from two to several inches in depth. Fair to good stands of native vegetation were present on the inter-spot areas. The slick spots supported a sparse growth of vegetation. The rate of water-intake on the inter-spot areas was considerably higher than on the slick spot areas. Rates of intake were averaged.

The soils on watershed P-12 were derived from heavy Cretaceous clay-shales. The surface soils when dry and bare may have a thin crust that is highly dispersed and seals rapidly when wetted. They also are subject to cracking upon drying, thus, influencing the rate of water-intake. The width and depth of the fissures, plus a good root population between fissures, tends to allow more water to enter the soil along the fissured area. Rainwater washes surface organic materials into the fissures and increases the organic content.

It was observed that the root systems of plants were subject to breakage by the wetting, drying, and cracking of these soils. This appears to handicap many species but to favor the dominance of the rhizomatous western wheatgrass.

The Clayey range site characterizing watershed P-13 was developed from heavy clays and clay-shales of Cretaceous age. There was far less bare ground exposed to the beating and sealing action of the raindrops on the Clayey site than on the Dense Clay site. This, as well as the better structure of the B horizon in the Clayey site may account for the greater intake.

The soils of watershed P-5 were derived from soft shales and sandstone and were included in the Sandy range site. The rate of water-intake was found to be only slightly greater than on the well structured clays of watershed P-13, yet these two soils are vastly different in textural characteristics. The similarity in rate of water-intake for these two soils may, in part, be explained by the dry condition and severe soil cracking present on the Clayey range site at the time of test. The rate of water-intake as determined for the Sandy range site is in line with previous studies on soils of sandy texture in this rainfall belt and with vegetation in comparable range condition.

This study has shown that differences in rate of water-intake between soils is not a function of surface texture only. Dense sub-soils as in Panspots range sites and thin surface soils over shale parent materials can inhibit the rate of water-intake, especially after the surface soil becomes saturated as in the second 30 minutes of water application. Surface cracking is important in determing the amount of water absorbed by the soil during the forepart of a runoff-producing storm.

Summary

During the summer months of 1957 and 1958, water-intake studies were conducted on instrumented rangeland watersheds in the 10- 14-inch precipitation belt near Newell, South Dakota.

Data from four range sites on four watersheds showed that water-intake rates were correlated with range sites, as mapped by SCS, where the range condition class was comparable. With Good range condition class, the water-intake during the first 15-minute period of the 1-hour test was high even on thin or fine-textured soils. However, the rate of intake declined much more rapidly on such sites in later periods of the test except on thick well-structured clays which maintained a rate comparable to a sandy loam.

The effects of surface conditions such as texture, cracking, and amount of cover are important factors but during prolonged rainfall subsurface features becomes important in determining the amount of water absorbed during the storm event.

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