Storing Rainfall at the Grass Roots

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THE conservation and use of rainfall is a major concern of ranchmen throughout the West. On most native ranges, moisture is the principal growth factor limiting forage production, upon which the whole range economy is based. Water stored where it falls on grasslands, and held in the grass roots zone of the soil, is put to work producing feed for livestock. That which escapes as surface runoff creates problems of soil erosion, downstream flooding, and siltation.

That range vegetation itself can contribute to the intake and storage of rainfall has been documented in reports of a number of watershed investigations in the West and by numerous experiment station studies. Range cover evaluations conducted by the Operations and Research branches of the Soil Conservation Service in the Western Gulf Region add further insight into the relation of water conservation to range conditions and grazing management.

In a two-year field survey a mobile raindrop applicator was used (Osborn, 1951) to test the effectiveness of range cover in protecting the soil from the damaging effects of raindrop impact—i.e., splash erosion and related phenomena. Information on the influence of surface cover and soil conditions upon water intake during rains was also obtained. This paper reports results pertaining to the water-intake phase of the study.

Equipment and Methods

The evaluations included 216 examples of different cover conditions on 14 range sites representing major soil units in central and western Texas and Oklahoma. On each site, a series of 8 to 24 plots was selected to represent cover conditions from the best to the worst, including examples of each range condition class and degree of current use.

The raindrop applicator (Fig. 1) applied controlled amounts of water as falling drops of uniform size and velocity of impact on each plot. The soil detached and the water lost were measured. These results indicated the relative effectiveness of the cover in protecting the soil and preventing runoff.

Plots were 12 by 18 inches in size (Fig. 2). Water was applied at a standard rate—2 inches in 20 minutes, or 6 inches per hour. Such a rain in Texas may be expected once in 35 years at Fort Worth, once in 50 years at San Angelo, and once in 100 years at Pecos (Yarnell, 1935). In each case, the combined amount of water collected from the plot as splash and runoff was considered as water lost. This was expressed as a percentage of the amount applied.

Some Typical Results

Wide variations in the proportions of the applied water lost and held during the standardized tests on different plots of the same site showed that changes in the amounts of cover and condition of the soil in response to range use or abuse profoundly affect the disposition of rainfall.

Comparisons of selected plots from the same site which had maximum and minimum water losses reveal the degree to which the infiltration and water storage capacities of a soil may vary with changing range conditions.

Results from contrasting conditions of cover on the Trans-Pecos clay loam flats site, a deep, fine-textured, slowly permeable soil, illustrate this point. With a dense cover of tobosa grass (*Hilaria mutica*) unused during the current season

FIGURE 1. Raindrop applicator in operation on range land.

(Fig. 3*L*), this soil absorbed 97 percent of the applied water. The same soil, in poor range condition, with only a few annual weeds for cover (Fig. 3*R*) lost 90 percent of the water as runoff.

Similar results were obtained on nearly every range site tested. Except on two very shallow soils, on every site where good or excellent range conditions were found, one to several plots absorbed 90 percent or more of the applied water. In some cases, fair condition plots with an abundance of cover did just as well.

On the other hand, the least favorable plot on each site lost more than 60 percent, and in several cases 90 percent, of the water applied in the standard test.

On A Heavy Tight Soil

Tests on deep heavy upland range of the Edwards Plateau following a flood-producing storm at San Angelo, Texas, demonstrated the potential capacity of this site, when in optimum condition, to

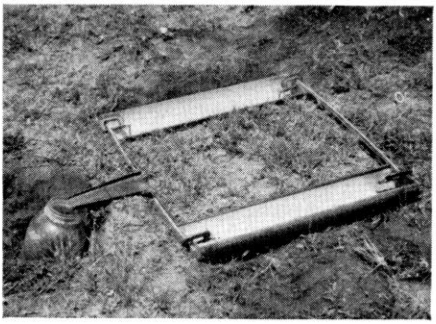

FIGURE 2. Plot with splash collection troughs and runoff jar ready for test.

absorb hard rains without producing runoff.

The rain there on March 20, 1949, amounted to 1 to 3.2 inches. Intensities were of 10 to 25 year frequency. Runoff from closely grazed range lands flooded cultivated fields and damaged terraces and diversions.

Barren areas in pastures were wet to a depth of 6 to 8 inches. Beneath the best grass cover the water soaked to a depth of 24 inches. These differences in soil conditions were reflected in results of tests with the raindrop applicator the following day.

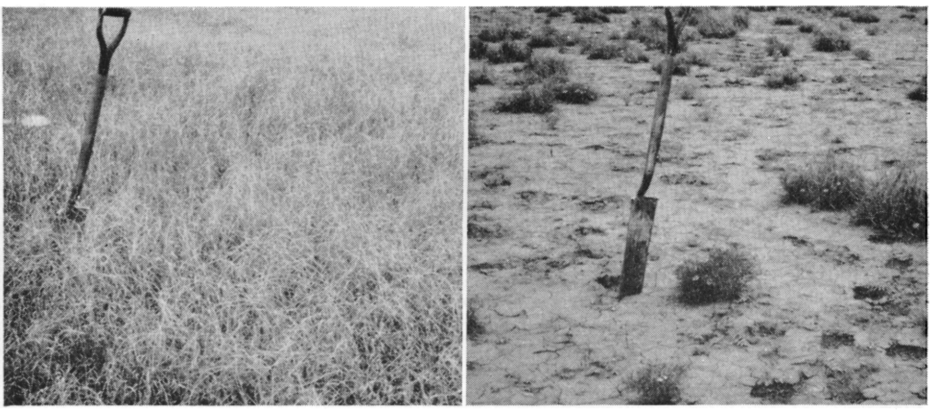

FIGURE 3. TRANS-PECOS CLAY LOAM FLAT SITES. *L.* Tobosa cover, with 10,860 pounds per acre, lost 3 percent of applied water. *R.* Annual weed cover, with 627 pounds per acre, lost 90 percent of applied water.

The first plot was in a lightly grazed poor condition range area dominated by red grama (*Bouteloua trifida*). The cover was equivalent to 755 pounds per acre, of which 243 pounds was litter. The exposed soil was already beginning to dry in the sun. A topsoil sample contained 23 percent moisture, compared to a field capacity of 35 percent. Runoff started in 2.5 minutes, and 69 percent of the applied water was lost.

The second plot was in a good condition area with a dense cover of tobosa, curly-mesquite (*Hilaria belangeri*), and buffalograss (*Buchloe dactyloides*), and lesser amounts of sideoats grama (*Bouteloua curtipendula*) and Texas wintergrass (*Stipa leucotricha*). A plot of tobosa was selected as an example of maximum cover with 3,482 pounds of forage and 4,896 pounds of litter, a total of 8,378 pounds per acre. The soil was wet to field capacity, with 36 percent moisture. Nevertheless, this plot absorbed the test application of water without loss by splash or runoff.

Another plot in the poor condition area was covered by annual weeds amounting to 454 pounds per acre. The soil had dried to a moisture content of 17 percent, just half its field capacity. Here runoff started in 3.5 minutes and 71 percent of the water was lost.

The three plots were on the same soil that comprised most of the farmland which had been flooded the day before; the same that predominated in the range lands which had contributed most of the damaging runoff. Yet this fine textured soil, when possessing a favorable physical condition and adequately covered with grass and litter, and though still wet to field capacity, was capable of absorbing even a larger and more intensive rain than the one which had caused the flood damage.

On a Deep Sand

An equally striking example of different water intake under different cover conditions was found on a deep sandy soil representing the other extreme in texture and natural permeability.

On the Rolling Red Plains deep sand, plot 196, in excellent condition and with 11,386 pounds per acre of little bluestem (*Andropogon scoparius*) cover, lost only 8 percent of the water applied. Across a pasture fence, not a hundred yards away, a bare ground plot in a poor condition area lost 79 percent of the applied water.

Here again, differences in soil conditions were reflected in organic matter content and volume-weight of the surface soil. Plot 196 contained 1.43 percent organic matter, and had a volume-weight of 1.33, while the bare plot had .99 percent organic matter and a volume-weight of 1.58.

It is apparent that the force of the drops beating on a coarse sand seals and compacts the surface to prevent the entry of water just as effectively as on a fine-textured soil.

Summary of Results

The foregoing examples are typical of findings on most of the range sites tested. They show how different cover and soil conditions on the same soil can influence water intake during rains.

The importance of the intake capacity of a site during the first few minutes of a rain should not be under-estimated. Most of the rains in the range areas are of less than 2 inches. Many of them are of high intensities, and most of them fall on dry soil. The ability of the land to absorb this water and use it to produce forage is as important to the ranchman as the control of runoff during major storms. These tests gave convincing testimony to the importance of cover in holding and utilizing these small but vital rains in the range country.

When water losses were averaged by range site and condition, it was found that on each site, average losses generally increased materially with each lower range condition class (Table 1). Almost without exception, highest water losses were from poor condition or bare ground plots.

There were consistently greater differences between average results from different range conditions on the same site than between averages of all conditions on different sites.

An extremely wide range of water losses occurred on all sites, usually ranging from nearly nothing on the plots of best condition, to nearly all the water applied on one or more poor condition or bare ground plots. The only exceptions to this were the two very shallow sites, where water losses were high from all range conditions.

Thus it appears that initial water losses during rains are affected more by the condition of the range than by the permanent characteristics of the site, except where impervious layers near the surface limit storage and disposal capacities to less than the amount of rainfall. Since range condition is classified by the ecological stage of development or deterioration of the vegetation, as indicated by composition of the present cover in comparison to the climax (Dyksterhuis, 1949), the condition classes naturally summarize both cover and soil conditions. Water intake and runoff consequently are likely to be more closely related to general range condition than to any one feature of cover or soil.

Individual Factors

Individual factors which vary with range condition and influence the proportions of the rainfall absorbed and lost from the land include characteristics of both the cover and the soil.

In general, the amount of water absorbed on the plots was proportional to the amounts of surface cover on each site, but results of individual tests were extremely variable in relation to this factor. On some sites, no well-defined relationship between water loss and amount of cover was apparent. When water losses from all sites and conditions were plotted against weight of cover on the plots, a poorly defined trend within very broad limits of variation was evident.

TABLE 1

Average water losses by range condition classes on each site, in percentages of applied amounts (Approximately 2 inches in 20 minutes)

SITE (PROBLEM AREA AND SOIL UNIT)	NO. PLOTS	EXCELLENT	GOOD	FAIR	POOR	BARE	MINIMUM	MAXIMUM	ALL CONDITIONS
		Percent							
Deep Fine-Textured:									
Blackland 2[a]	29	17[b]	46[c]		56[d]	63	0	94	41
Grand Prairie 2	22	15	35	17	28		0	61	23
Edwards Plateau 2	18		30	48	65	46	0	75	49
Trans-Pecos 2	5			33	84	79	3	84	52
Trans-Pecos 2x	12			3	59	81	3	100	58
Rolling Red Plains 2	5		44	88		88			62
Deep Medium-Textured:									
Rolling Red Plains 5	12			53	70	78	21	78	63
Cross Timbers 6	24			34[e]	45[f]	53	2	65	43
Rio Grande Plain 7	9			40	59	53	30	65	54
Trans-Pecos 7	8			60	80	71	22	100	68
High Plains 7x	23		26	80	70	72	5	95	63
Deep Coarse-Textured:									
Rolling Red Plains 12	8	8	54	66	62	79	8	80	56
Shallow Soils:									
Rolling Red Plains 24	17	74	76	81	75	73	29	97	62
Cross Timbers 19	24	50	56	66	69	67	20	98	62

[a] Numbers refer to soil mapping units in conservation surveys, [b] Native meadow, [c] Reestablished meadow, [d] Farm pastures, [e] Wooded pastures, [f] Old field pastures.

Amount of cover on range land is related in general to range condition, the average amount declining with each lower range condition class. However, the actual amount of forage and litter on the ground at any particular time and place is greatly affected by seasonal conditions and the accidents of recent use and treatment.

When percent of water loss from all plots was plotted against the effectiveness of the cover in intercepting raindrop impact, it was found that high water losses occurred whenever the cover was of low effectiveness, and soil splash correspondingly active. In general, water losses exceeded 50 percent of the applied amount whenever the cover was less than 50 percent effective in controlling splash. However, control of the splash did not necessarily prevent loss of water. High water losses as well as low ones occurred when the cover was 95 to 100 percent effective in controlling splash.

It is apparent, therefore, that other factors than the cover influence infiltration and runoff under field conditions on range land. These must, no doubt, be sought in the soil itself.

Soil Conditions

Within the same site, amounts of water loss were clearly related to soil conditions, such as organic matter content, volume-weight, and observable structure, which are associated in a general way with the stage of ecological development or deterioration of the cover.

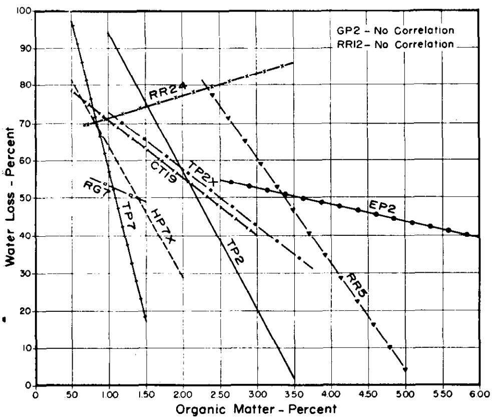

FIGURE 4. Water loss from various sites in relation to organic matter content of surface 2 inches of soil.

A considerable range in organic matter content of the surface 2 inches of soils of the same site in different cover conditions was found. On most sites the average organic matter content declined with each lower range condition class. Water losses tended to increase sharply as organic matter content of the soil decreased (Fig. 4).

Comparative weights of the surface 2 inches of soil were obtained from undisturbed core samples taken from near each plot. The volume-weight of the soil was expressed as the ratio between oven-dry weight of soil and weight of an equal volume of water. Considerable range in volume-weights was found in every site, and water losses increased sharply as the density of the soil increased (Fig. 5). Average volume-weights by condition classes generally increased with each lower class.

Surface crusts were often found on bare soils or those with sparse cover. High water losses were generally associated with these conditions. The degree of crusting was not measured, but was clearly shown in photographs of plots.

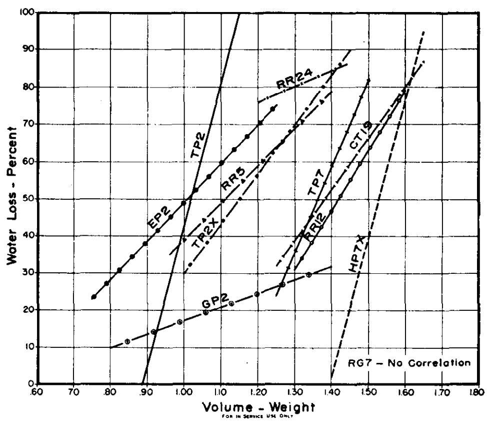

FIGURE 5. Water loss from various sites in relation to volume-weight of surface 2 inches of soil.

Observable structure, insect burrows, and other evidences of animal life in the soil frequently provided logical explanations for water held or lost on the same site, but these factors were not measured. They must be reckoned, however, among soil conditions that influence infiltration and runoff.

CONCLUSIONS

The potential capacity of range lands to absorb and store most ordinary rains is indicated by results of standardized tests on small field plots with a mobile raindrop applicator.

These tests showed that every deep

soil studied, regardless of texture, was capable in its optimum condition of holding with little or no runoff the first 2 inches of water applied, at intensities of up to 50 year frequency.

The conditions of cover and soil which may change on the same site with time, and which are related to range condition classes, greatly influence the ability of the land to absorb the rain as it falls.

For maximum intake of water, two conditions are essential:

1. An adequate surface cover to cushion the impact of the falling raindrops.

2. Favorable soil conditions associated with a relatively advanced stage of ecological succession for the site, typical of one of the higher range condition classes.

At the extremes of conditions possible on the same site we may find almost complete absorption or almost complete loss of the rain from the place where it falls. This is true except for certain shallow profiles which lack storage or disposal capacities to handle the amounts of water involved although the surface may be capable of absorbing it.

These facts suggest remarkable possibilities for moisture conservation in the range country—where moisture is of such vital importance—through the control of cover and soil conditions by grazing management.

To be effective in storing rainfall in the soil, management needs to develop favorable cover and soil conditions uniformly over an entire land area. This goal is likely to be reached only in the highest range condition—that most nearly reaching the climax for the site. At the same time, utilization needs to be regulated to maintain an adequate cover on all the land at all seasons when rains are likely to fall, and to protect the desired conditions of the soil as well as to husband the particular forage plants favored as feed.

This is indeed a challenge to range managers and range users. And, inasmuch as moisture is the primary requirement of forage production, the successful accomplishment of this goal can hardly fail to be profitable. The storage of rainfall at the grass roots places the moisture precisely where it can be most readily converted into grass, and into meat, and into dollars.

LITERATURE CITED

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