Rangeland Watershed Management

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RANGELAND WATERSHED MANAGEMENT deals with the problem of how to use rangelands, not in terms of forage and livestock production alone, but on the basis that forage production and water yield are interdependent and must therefore be considered together. Forage production and water yield form a natural unit and reflect the interactions of soil, geology, climate, and vegetation by providing a common end product—runoff or streamflow—that can be measured and appraised.

Seldom are complete drainage basins or watersheds covered solely by range vegetation—browse, grasses, and forbs. More often such vegetation on a watershed is intermixed with forests, meadowlands, and cultivated croplands, complicating to a considerable degree rangeland watershed management activities.

The objective of this discussion is to point out some of the concepts of rangeland watershed management, the application of which will enable rangelands to contribute their share to the overall management of a watershed. These concepts are built around small plot watershed studies in grasslands only. They have provided information to set the course of rangeland watershed management.

Some of the factors needed to maintain or foster good grassland watershed conditions are (1) a cover of herbaceous vegetation consisting of a high percentage of bunchgrasses, (2) a large amount of litter covering the soil surface, (3) a small percentage of bare or exposed soil, and (4) high noncapillary porosity of surface soils consistent with soil profile characteristics.

A lysimeter study on the Sierra Ancha Experimental Forest in central Arizona shows how heavy grazing can influence the yield of water on rangelands in that area. The lysimeter installation was constructed in 1934 in a grassland area at elevations below the ponderosa pine type. From 1935 until 1942 the three lysimeters received no treatment, and surface flow and subsurface drainage were not significantly different between them. From 1942 until 1948 one lysimeter was left ungrazed, one was grazed heavily each year by sheep, and one was grazed moderately.

Ground-cover density decreased during the treatment period on both grazed lysimeters, the decrease being much more marked in the area grazed heavily. During winter storms, surface runoff was very low on all three lysimeters, and drainage of water through them was substantially the same. Water yield during winter was not affected by grazing treatment. In the course of the summer storm season, however, the quantity of surface flow increased with increasing intensity of grazing. During this season, on the average, the ungrazed lysimeter yielded 1.8 percent of the rain as surface flow; the moderately grazed lysimeter yielded 5.5 percent; and the lysimeter grazed heavily yielded 10.8 percent. Because very little water drained through any of the lysimeters during the summer, the water yield, almost entirely surface runoff, increased with increasing grazing treatment. With this increased surface runoff came increased surface soil erosion.

In this study the cover of vegetation was decreased, the amount of litter reduced and exposed soil surface increased. These factors acting together facilitated surface runoff and erosion from summer storms but had little effect on runoff and erosion from winter storms because the soils had sufficient porosity to absorb the rains that fell.

The influence of grazing upon surface runoff and erosion was also studied on six 1/100-acre hillside bunchgrass plots located on the Manitou Experimental Forest in Colorado. From 1938 to 1941 the plots were undisturbed, and it was found that both runoff and erosion were virtually the same on all of them. Between 1942 and 1948 two of the plots were grazed moderately by cattle each year, two were grazed heavily, and two were ungrazed and hence served as controls. Moderate grazing removed one-third of the perennial grass herbage from the plot annually; heavy grazing removed nearly 60 percent.

Grazing resulted in a pronounced increase in runoff during the rainfall period—June to September, inclusive. Average runoff during this period was 0.11 area-inch on the check plots compared with 0.34 area-inch from the heavily grazed plots. Moderate grazing resulted in an average yield of 0.22 area-inch per season.

Erosion occurred almost exclusively during the months of July and August, a period of high-intensity rainstorms. During calibration, the average amount of erosion in the course of the summer period varied from 111 to 163 pounds per acre. After grazing was started, no significant change occurred as a result of moderate use; but heavy use virtually doubled the normal amount—an increase to 316 pounds per acre.

In this study the replacement of the bunchgrasses by sodgrasses and forbs and a reduction in the amount of litter on the soil surface acting together appeared responsible for the increased runoff and erosion from the treated plots.

Infiltration measurements of bunchgrass ranges on the Manitou Experimental Forest made on paired plots—one inside and one outside 2½-acre cattle exclosures—show how protection from grazing affects infiltration. Infiltrometer plots outside exclosures were located between 25 and 300 ft. from the fence. An isolation strip around the fence was necessary to avoid sampling on the roads and in the area where cattle might concentrate excessively because of the presence of the exclosure itself. Paired comparisons were made in 1947 and 1954 in 12 exclosures.

Infiltrometer tests were also obtained in each exclosure in 1941. Paired infiltration measurements inside and outside exclosures were not made at that time because prior to fencing the exclosures the same grazing treatment had been received.

In 1941, the vegetation in the exclosures was representative of the outside conditions and the difference in infiltration between inside and outside exclosures in subsequent years is the result of protection from grazing. The major recovery of infiltration inside the exclosures occurred between 1941 and 1947 as illustrated below:

[1]Maintained in cooperation with Colorado State University.

Average f_c infiltration

	Inside	Outside
	Inches per hour	
1941	1.77	1.97[1]
1947	2.59	1.38
1954	2.82	1.63

[1]Average of grazed plots outside exclosures—not paired.

The 15 years of protection from cattle grazing allowed the vegetation to change to a high percentage of desirable bunchgrasses, litter to accumulate on the soil surface, bare spots to be occupied by plants, and the noncapillary porosity of the surface soils to increase. These factors collectively resulted in an increase in infiltration rate and a consequent reduction in surface runoff and erosion.

Another study carried out in the bunchgrass ranges of the Front Range in Colorado dealt with the relation between range condition and infiltration and erosion. Range condition was scored for each 2½-sq. ft. infiltrometer plot by considering (1) density of perennial grasses and sedges, (2) plant composition as related to stages of plant succession, and (3) plant vigor or thriftiness of growth. Scoring on the basis of range condition also provided an index to the air-dry herbage production of perennial grasses and sedges.

In a grassland type on soils derived from a mixture of granite and schist, the infiltration rate increased with changes from very poor to good range condition classes. The erosion rate—pounds per acre per inch of surface runoff—was found to be related to the percent of bare area, the rate increasing with increases in percent bare area. Most of the 2½-sq. ft. infiltrometer plots had less than 30 percent bare area and within this range the differences in erosion rate observed were about proportional to the differences in percent bare area.

Both herbage production and percent area bare were found to be related to range condition. On the average herbage production by plants of good forage value was greatest for plots in good condition and least for poor condition. Plots in very poor condition produced more herbage than the plots in poor condition due to the abundance of herbage of low forage value. The percent area bare was least on good condition and greatest on poor and very poor conditions. On the area studied the average amount of bare area was 4.7 percent on good condition plots compared with 20.8 percent for very poor condition.

Because of these relations the water infiltrated and erosion rate were correlated with the condition of the range from the point of view of forage production. This is called forage condition. How they vary is shown in Figure 1.

The infiltration rate during the last 20 minutes of a 50-minute period on plots in good forage condition, for example, was 108 percent greater than on plots in very poor condition, 97 percent greater than plots in poor condition, and 35 percent greater than plots in fair condition. Likewise, the rate of erosion from plots in good condition was less than one-fourth that from plots in very poor condition and about half that from plots in fair condition. It can therefore be concluded that forage conditions and watershed conditions on the grassland type on granite—schist derived soil are related. A desirable range condition from the standpoint of forage production also gives good watershed protection.

A different relation between forage condition and infiltration and erosion rates occurred in a grassland type on soils derived solely from biotite schist. Here both the infiltration and erosion rates tended to decrease with improved condition class. These relations are shown in Figure 2.

Under most grassland conditions the higher condition classes have better infiltration capacities than the lower. The above contradiction to the general observation is not unusual and has been observed in other studies of grasslands in the Front Range of Colorado.

In this study two sites were in-

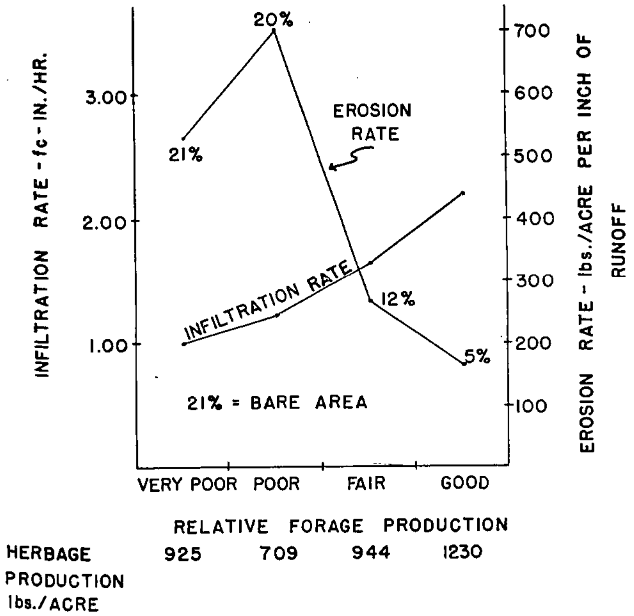

FIG. 1.—Infiltration and erosion rates as influenced by relative forage production of grazed grasslands occurring on soils derived from a mixture of granite and schist.

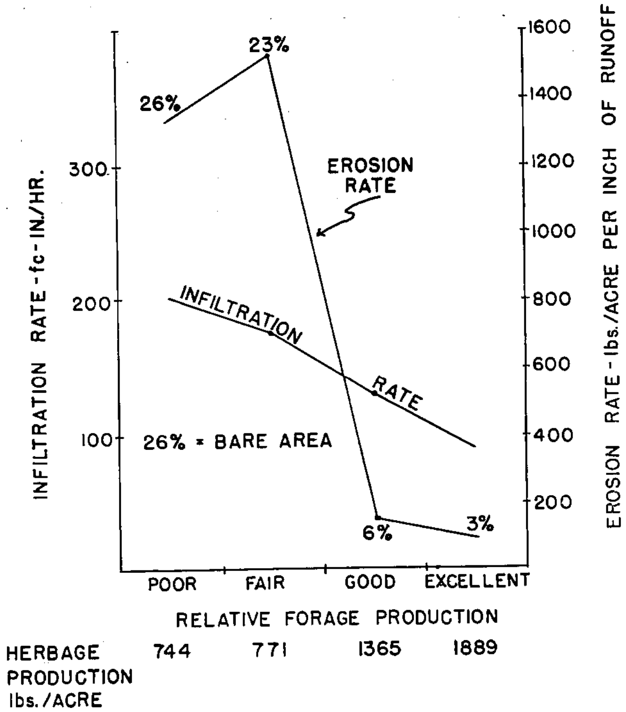

FIG. 2.—Infiltration and erosion rates as influenced by relative forage production of grazed grasslands occurring on soils derived from biotite schist.

volved. The good and excellent conditions occurred on one site and the fair and poor on another. Both sites were grazed by cattle. The sites were about 500 yards apart.

The soils of the good and excellent conditions average 20 inches in depth above the parent material. Other characteristics of the soils are:

	Surface 0-2 inches	Subsurface 7+inches
	Percent	
Gravel	17	27
Fraction less than 2 mm.		
Sand	74	62
Silt	18	19
Clay	8	19
Total porosity	57	32
Noncapillary porosity	23	----

Both the surface and subsurface soils were cemented and were not conducive to the rapid intake of water.

The soils of the fair and poor conditions average 14.5 inches in depth above the parent material. Other characteristics are:

	Surface 0-2 inches	Subsurface 7+inches
	Percent	
Gravel	20	38
Fraction less than 2 mm.		
Sand	80	68
Silt	12	14
Clay	8	18
Total porosity	46	31
Noncapillary porosity	22	----

In most cases the surface and subsurface soils were loose, noncemented, and conducive to the rapid intake of water.

The soils of both sites were considered to be similar so far as their morphology and development were concerned. Certain physical differences did occur that help to explain the reversal of the infiltration rates as related to range condition classes. The good and excellent conditions contained more silt and clay and less gravel in the surface and subsurface soils than did the soils under fair and poor conditions. The surface soil under good and excellent condition contained 10 percent more capillary porosity than the surface soil under fair and poor conditions.

The soils under fair and poor conditions had superior infiltration rates, averaging 1.94 inches per hour than those under good and excellent conditions, which averaged 1.13 inches per hour. The former, however, had a higher erosion rate, averaging 1,412 pounds per acre per inch of runoff compared with 127 pounds per acre per inch of runoff for the latter conditions.

This study illustrates how local soil differences influence infiltration investigations and also how a good grass producing soil may not be the best hydrologically.

One inescapable fact stands out, however. The good and excellent classes provided the best soil stabilization and protection to the site.

The studies cited cover a variety of grasses, soils, elevations, and climates. In most of these studies it was found that increased plant cover reduces surface runoff and curtails erosion. This reduced surface runoff and erosion is more associated with summer rainstorms than with periods of snowmelt. Curtailment of surface runoff and erosion is closely related to the abundance of desirable bunchgrasses, amount of litter on the soil surface, the amount of bare soil, and the percent large pores in the surface soil. Improving range condition from poor to good results in greater water absorption by the soil and less soil washing.

The conditions under which greater water absorption will occur vary with the kind of plant cover present, physical characteristics of the soil, and the kind and amount of precipitation. Severely depleted stands of range vegetation will require a longer time for improvement than those with desirable remnants present. Soils badly eroded or those whose erodibility is high will be slower to recover desirable water absorbing qualities. Where precipitation amounts are low, improvement will be slow.

There is a large body of information leading to the conclusion that heavy grazing has bad hydrologic consequences. It is doubtful that more investigations are needed to emphasize this conclusion. There is need for more quantitative research. For example, grazing intensity must be expressed in terms that can be related to the erosion and runoff of different soils. Methods must be sought to manage grazing so as to provide soil-protecting cover adequate to hold runoff and erosion damage to acceptable levels.

There is some evidence that usable water yield can be increased by managing vegetation on grazed lands. This requires, first, that an adequate soil cover and highly permeable soil condition be maintained, so that the maximum amount of water will enter the soil; second, that the cover be composed of shallow-rooted plants or other plants that do not make large demands upon soil moisture. Such conditions may not be compatible with the most desirable range management because high forage producing plants require adequate soil moisture for their growth and are often deep- rooted.