Runoff in Relation to Range Condition in the Big Bend-Davis Mountain Section of Texas

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The conservation program in the Big Bend — Davis Mountain section of Texas since 1940 has been geared to the conservation of water as well as the conservation of the soil resources.

Grass management practices are being applied with the goal of restoring the original vegetative cover of ranges which have a condition class rating less than excellent. This is being done by a natural ecological process of plant succession, so that the soils will be tied down and a minimum of moisture will be lost by runoff and from other causes. Studies on ranges on the Alamito and Terlingua creek drainages have been directed toward an answer to the question: "How much can we reduce our water loss by improving the condition of our ranges?". These drainages lie adjacent and are similar as to soils, topography and climate.

This report will present the data collected on: (1) The rate of moisture absorption by the soils on the gravelly loam site in excellent, good, fair and poor condition; (2) the difference in moisture penetration after high intensity rainstorms on range sites that supported range in good and poor condition; (3) the rate of moisture loss from the surface foot and one-half of soil under different range condition and use; (4) the measurable flow from Alamito and Terlingua creeks, where there was a difference between the condition of the range on the two watersheds due to past management.

Description of Watersheds

The Terlingua and Alamito watersheds are each slightly over 1,000 square miles in area. Both drain to the south. Elevations range from approximately 2,200 feet where they empty into the Rio Grande to about 5,500 feet elevation on the headwaters. They are approximately 80 miles in length, with an average gradient of about 40 feet to the mile (Figure 1).

The topography of the Alamito Creek watershed is characterized by gently to moderately rolling hills adjacent to the valley floor. These valleys are large, broad flats of loam soils generally over four feet deep. Tobosa grass *(Hilaria mutica)*, blue grama *(Bouteloua gracilis)*, sideoats grama *(Bouteloua curtipendula)*, and cane bluestem *(Adropogon barbinodis)* were

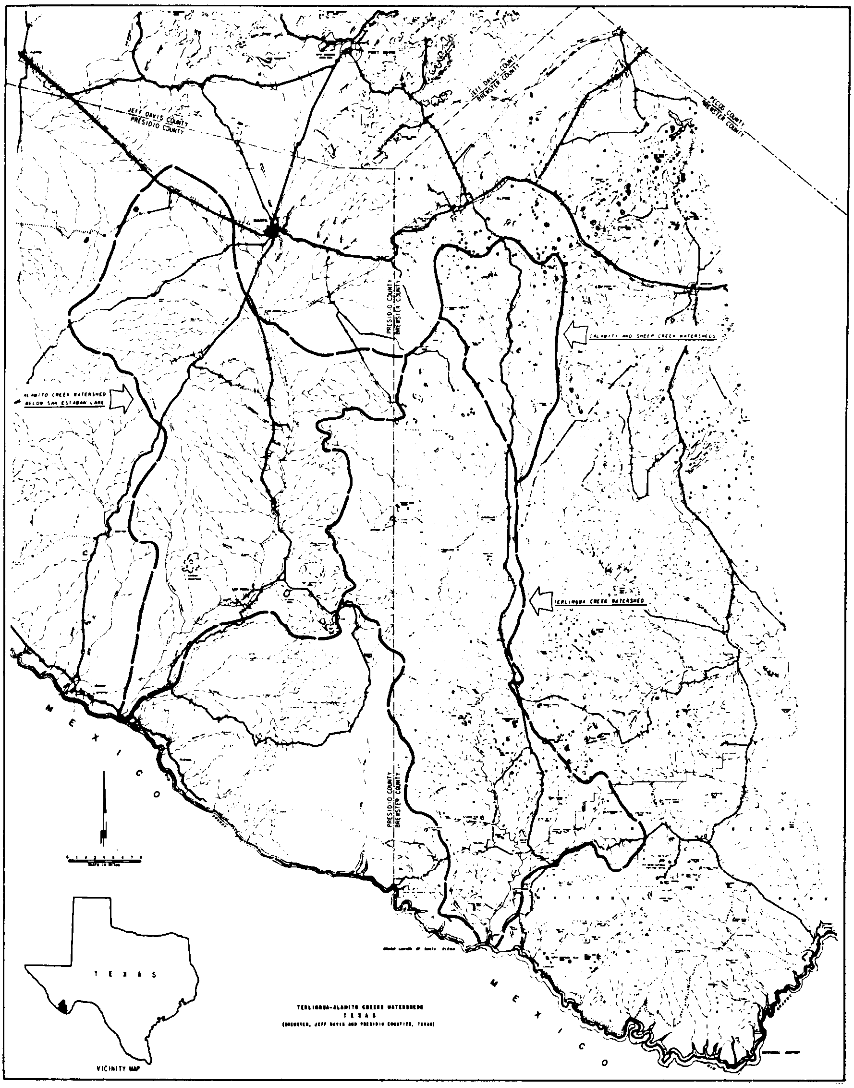

FIGURE 1. Location map of the Terlingua Creek and Alamito Creek watersheds in Brewster, Jeff Davis, and Presidio Counties, Texas.

the climax grasses in these overflow draws and clay loam flat sites.

The soils on the hills to the west of Alamito Creek are gravelly loams, 10 to 20 inches deep, over cemented gravels and caliche, with slopes averaging 20 to 25 percent. The dominant climax grasses on these soils are sideoats grama, hairy grama *(Bouteloua hirsuta)*, cane bluestem, and black grama *(Bouteloua eriopoda)*.

The area east of Alamito Creek has predominantly stony loam soils, 10 to 15 inches deep on the average, over basalt. It originally supported black grama, hairy grama, and sideoats grama grasses.

North of the Rio Grande and west of Alamito Creek are some dissected outwash gravelly loam soils. Although these soils originally supported black grama; bush muhly *(Muhlenbergia porteri)*, Chino grama *(Bouteloua breviseta)*, and Neally grama *(Bouteloua uniflora)*, they are eroded to desert pavement in many places, and they are now dominated by creosote bush *(Larrea tridentata)*, and mariola *(Parthenium incanum)*.

A rock escarpment divides the two watersheds. It varies in height from 100 to 600 feet.

The headwaters of Terlingua Creek originate in numerous canyons with mesas between. The soils are loams with varying amounts of stone throughout the profile, 10 to 20 inches deep, over fractured basalt rock. The dominant vegetation on the mountain soils is composed of hairy grama, blue grama, sideoats grama and cane bluestem. Slopes are variable. The canyons have slopes over 60 percent while the mesas and ridges between may average around 15 to 20 percent.

The O2 Flat, which makes up about one-fourth of the watershed next to the escarpment on the west and northwest, is about 40 miles long. It covers the middle portion of the area. The average slope on the flat is about five percent. Soils are loams and clay loams over five feet deep. This flat at one time supported a good stand of tobosa grass and blue grama, with smaller colonies of sideoats grama and cane bluestem. In the main drainage ways giant sacaton *(Sporobolus giganteus)* could be found.

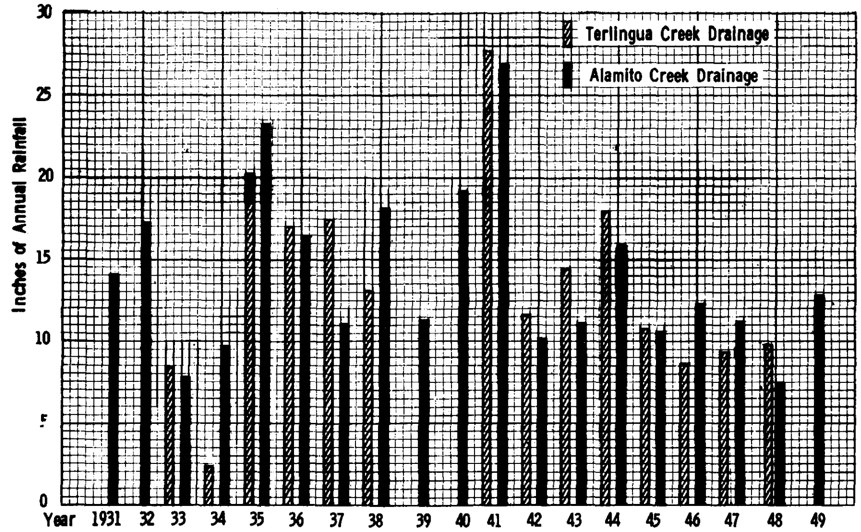

FIGURE 2. Mean annual rainfall over the Alamito and Terlingua watersheds during a 19-year period.

The southern portion of the watershed is an area of eroded clay loam hills with large areas covered with broken lava rocks. The major species of vegetation on this site are Chino grama, Neally grama, hairy grama, sideoats grama, lechuguilla *(Agave lechuguilla)* and several other shrubs.

The outwash plains along the Chisos Mountains make up a small percentage of the area. The climax vegetation is principally the same as on the outwash plains in the Alamito Creek watershed.

Rainfall Characteristics

The Big Bend is known for its erratic rainfall, and any rancher there may tell you he would be in "tip top shape" if he had just one more rain.

Most of the yearly rainfall comes during the growing season from June through October. The yearly mean average rainfall over the entire watershed is about 14 inches. From 1931 through 1950 the yearly high was 32.38 inches on the Alamito Creek watershed, the low 6.95 inches. On the Terlingua Creek watershed the yearly high was 27.25 inches and the low 2.32 inches. Figure 2 shows the mean annual rainfall over both watersheds from the best rainfall records available from the U. S. Weather Bureau, International Water and Boundary Commission, Soil Conservation Service, and local rancher records.

The mean annual rainfall was computed from the records of ten stations on the Alamito Creek drainage and six stations on the Terlingua Creek drainage. These stations were selected because of the uniformity of coverage in percent of the total watersheds.

Storms are of two general types: (1) thunder storms and (2) coastal storms that move in from the Gulf of Mexico. Thunder storms occur mostly in the afternoon and between midnight and sun-up. The afternoon storms were found to be of higher intensities than the storms at night. Recording rain gages have measured several storms with intensities of 1 to

Table 1. Water intake rates and production of forage by range condition class on the Gravelly Loam Site, Highland Soil Conservation District, 1950.

	Range Condition			
	Excellent	Good	Fair	Poor
Water intake—inches per hour	9.5	5.8	4.25	2.75
Pounds of forage per acre	1065	666	511	341

1.25 inches per hour. The local thunder storms seldom cover a large area, but often yield 2 to 3 inches of rain during one storm.

These local thunder storms fit the expression so often used, "Someone knocked a hole in the bottom of the bucket." A large amount of water falls in a very short period of time and yields a large volume of runoff locally, which can cause severe erosion, especially on ranges in poor condition (Figure 3).

The storms that move in from the Gulf of Mexico generally cover an area that greatly exceeds the size of the two watersheds. These storms are of much lower intensity and of a longer duration. These storms often last for two and sometimes three days. For the period covered by this report there have been on the average two to three of these coastal storms over the area each year, and they yield, on the average, ½ to 2 inches of moisture.

Infiltration Studies

Infiltration rings were used to determine the correlation between range condition and rate of water absorption by the soil (Leithead, H. L. 1950. Field methods used to demonstrate range condition. Jour. Range Mangt. 3:95-99.). This study was made on the gravelly loam and overflow sites. Data are presented on the gravelly loam site because it was one range site where all four range condition classes could be found. The same correlation was found to exist between range condition and rate of water absorption on the good, fair, and poor conditions on the overflow site, even though the rate of absorption was correspondingly slower.

Water was absorbed at the rates shown in Table 1 on the four range condition classes on the gravelly loam site using infiltration rings. Production of these same ranges was measured by plot clippings on ungrazed pastures.

Field observations were made after many storms to check the depth of moisture penetration on the various range sites that supported range in different condition classes. A spade was used to check the depth of penetration. When it was possible, sites were selected where a fence separated range in two different condition classes. This was to eliminate the possibility of comparing moisture penetration under different intensities and amounts of rain.

After one general rainstorm moisture penetrated to 30 inches on a loamy upland site in good condition. Across the fence, where the range was in a low fair condition, the same rain only soaked into the soil to a depth of 5 inches.

On an overflow site where runoff water was diverted onto rangeland from an arroyo, moisture penetrated to over 5 feet on good condition range. On range in poor condition moisture did not penetrate more than a foot. These measurements were taken after water flowed over the soil for approximately 20 hours.

During the winter of 1950 the author made a study on a ranch that had an overflow site near a rain gage. A fence separated two range condition classes that had been grazed at different intensities. There were 2.18 inches of moisture that fell in a five-week period at such a gentle rate that none ran off, and all was absorbed by the soil where it fell (Table 2). Moisture penetrated the clay loam soil under both good and poor range conditions to a depth of 18 inches. Soil samples were taken once a week to the depth which moisture penetrated. The samples were oven-dried to determine the percent of moisture.

The soil supporting poor condition range that was closely grazed continued to lose moisture after it was first moistened, even though light showers continued to fall (Table 3). The area

FIGURE 3. Water concentrating in an arroyo after a 3-inch rain that fell in 12 hours near Valentine, Texas, June 25, 1938. When rains like this fall on poor condition range they cause a lot of damage. Soil and water losses are great from the area covered by the storm.

Table 2. Amount and distribution of rainfall on infiltration study area during the period January 19-February 23, 1950.

Date		Inches of Precipitation
January	19	.78
	22	.44
	23	.08
	24	.10
	29	.23
February	1	.23
	13	.18
	23	.01
Total precipitation		2 18

supporting good condition range that had been properly grazed maintained its soil moisture supply for a long time.

The soil that supported heavily used, poor-condition range lost on the average one-fourth inch of moisture per week. This loss was attributed primarily to evaporation from the soil surface. There were light winds every few days, and for the most part the atmosphere was dry. The maximum daily temperatures were less than 70 degrees, which is too cold for active plant growth of warm season species such as blue grama, sideoats grama, and cane bluestem. These were the major species on the site in good condition. Fluffgrass *(Tridens pulchellus)*, burrograss *(Scleropogon brevifolius)*, and annual three-awn were the major species on the poor-condition range.

In a 2½-month period prior to active plant growth the range in poor condition lost approximately 74 percent of the moisture that had entered the soil. The range in good condition that had been properly grazed lost about 42 percent. The wilting coefficient of these soils is about 4.5 percent.

Runoff and Condition

The International Boundary and Water Commission had maintained water stage recorders since January 1931, at the mouth of Alamito and Terlingua creeks. Therefore, it was decided to analyze this flow data to determine if a correlation existed between range condition and runoff from these two watersheds that were each over 1,000 square miles in area.

It should be brought out here that all dates showing any measurable amount of runoff above normal were checked against the rainfall records. The records showed that 9 out of 10 storms that were of such magnitude to produce a measurable amount of runoff were from coastal storms that covered both watersheds and yielded, on the average, more than .75 inch of moisture.

When storms covered less than one-third or one-fourth of either watershed, measured discharge from runoff was quite small. Coastal storms have usually contributed less than one-fourth of the annual rainfall.

The recorded annual discharge in acre-feet per square mile of drainage on the Alamito and Terlingua Creek watersheds was computed from data taken from International Boundary and Water Commission Bulletins Nos. 2 through 21, 1933-1951, and is expressed in Figure 4. Low flows were based on meter measurements, and medium and high flows were a continuous record of gage heights and rating curve, the higher points of which were determined by meter measurement, computations by shifting channel methods. In analyzing this figure it should be kept in mind that a diversion dam was constructed across Calamity Creek and Chalk Draw into the Maravillas drainage. This reduced the drainage area of Terlingua Creek by 219 square

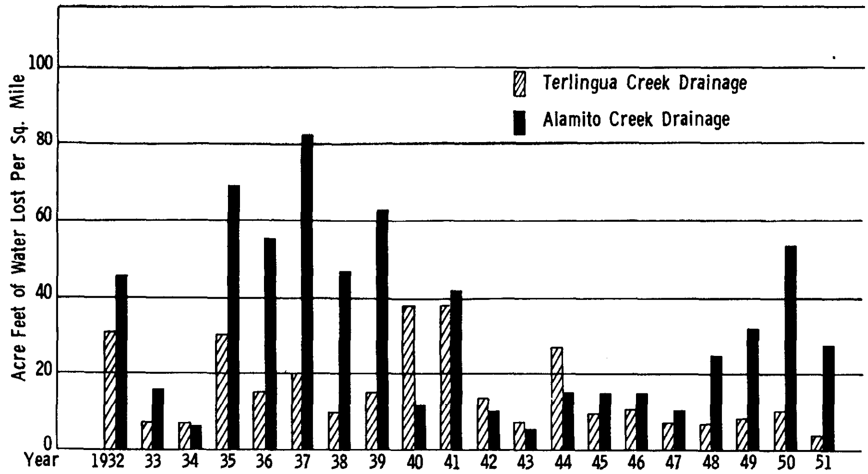

FIGURE 4. Acre-feet of water lost per square mile of drainage during a 20-year period on the Alamito and Terlingua drainages.

Table 3. Percent of moisture in the first 18 inches of clay loam soil that supported range in different condition and intensities of grazing, 1950.

Date		Percent of moisture in the soil: Good condition range — lightly used	Poor condition range — heavily used
January	19	21.15	21.51
February	2	26.44	18.26
	8	23.75	16.93
	18	23.92	17.26
	24	23.20	13.59
April	7	15.22	5.79

Table 4. Range condition by sites on the Alamito and Terlingua Creek Watershed.

Site	Alamito Creek 667,523 acres				Terlingua Creek 684,800 acres			
	Range Condition (Acres)				Range Condition (Acres)			
	Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor
Overflow Draw		1,024	5,274	50,586				
Clay Loam Flat				1,152			73,308	152,245
Loamy Upland	2,560	22,733	137,062	26,086				7,991
Gravelly Loam Ridges	21,024	41,004	91,904	87,987				
Stony Loam Hills		10,358	17,075	563		13,727	115,657	67,407
Lava Mesa		20,470	76,339	7,910				
Gravelly Outwash				46,412				14,649
Lavas and Clays							92,607	122,418
Calcareous Loam Mts.							24,791	
Total Acres by Range Condition	23,584	95,589	327,654	220,696		13,727	306,363	364,710
Percent of Range in each Condition Class	3.53	14.32	49.09	33.06		2.00	44.74	53.26

miles. In 1948 this diversion dam washed out and the runoff water from these two headwater drainages again flowed into Terlingua Creek.

The average yearly amount of moisture to leave the Alamito Creek watershed by runoff would amount to less than one-fourth inch of the total annual rainfall over the watershed. The Terlingua Creek watershed lost on the average about one-half inch of the annual rainfall by runoff.

In order to have a comparison of the range condition on each watershed, the author carried out a range site and condition survey in 1951, using the method developed by the Soil Conservation Service. A large portion of the Alamito Creek watershed had been surveyed before that time for developing ranch conservation plans. The Terlingua Creek watershed was not in an organized Soil Conservation District until 1948. The range condition on Alamito Creek was checked in 1951. There were indications that the ranges were improving, but few of them had improved as much as one condition class. Range improvement by natural plant succession in this area is, of course, slow.

There were nine major range sites recognized on these watersheds. Table 4 gives an acreage breakdown of range condition by sites on each watershed.

Conclusions

Runoff is increased in the Davis Mountain-Big Bend area as ranges deteriorate in range condition because the soil absorbs moisture slower. A range site in good condition absorbs moisture five to six times faster than the same range site in poor condition.

The loss of moisture by evaporation from the first foot of soil is about three times greater on closely grazed, poor condition range than it is from the same sites in good condition that have been properly grazed. Moisture lost to evaporation can be just as serious as moisture lost by runoff, even though it is less noticeable.

Moisture lost by runoff on Alamito and Terlingua Creek drainages is from general storms that yield more than .75 inches of moisture per storm and cover more than two-thirds of the watershed. Alamito Creek has lost, on the average, over the 25-year period, about one-fourth inch of the annual rainfall. Terlingua Creek lost about one-half inch of rainfall during the same period. However, it is questionable if the difference in runoff from these watersheds can be attributed altogether to the difference in range condition, since comparable range does not occur on each watershed in the same percentage. Although the soils are similar, there is a higher percentage of clay in the soils in three of the range sites found on Terlingua Creek.

Runoff from the local thunder storms does not leave the watershed even though it leaves the area on which the rains fall. This runoff is absorbed in the dry beds of the arroyos, and very seldom reaches the gaging stations at the mouths of these drainages.

A greater percentage of the annual precipitation in this section of Texas can be held where it falls by improving the condition of the range. Local runoff can be reduced and production increased; yet, because of the rainfall pattern it is doubtful that the amount of water that leaves a watershed as large as these drainages can be reduced greatly by improving the condition of the range.