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STUDIES IN THE VEGETATION OF SOUTHWESTERN TEXAS

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INTRODUCTION

The Grassland Formation of North America for many years has been a center for ecological study. Numerous extensive and intensive investigations have been made, but the area is so vast that for some sections there is even no reconnaissance work. The present investigation deals with the grasslands of southwestern Texas, especially in their relation to grazing. A study has been made of the structure of the vegetation. The recovery of the vegetation from the harmful effects of overgrazing has been investigated by means of chart and clipped quadrats both inside and outside of exclosures. A portion of the Trans-Pecos region, just north of the Rio Grande, and centering about

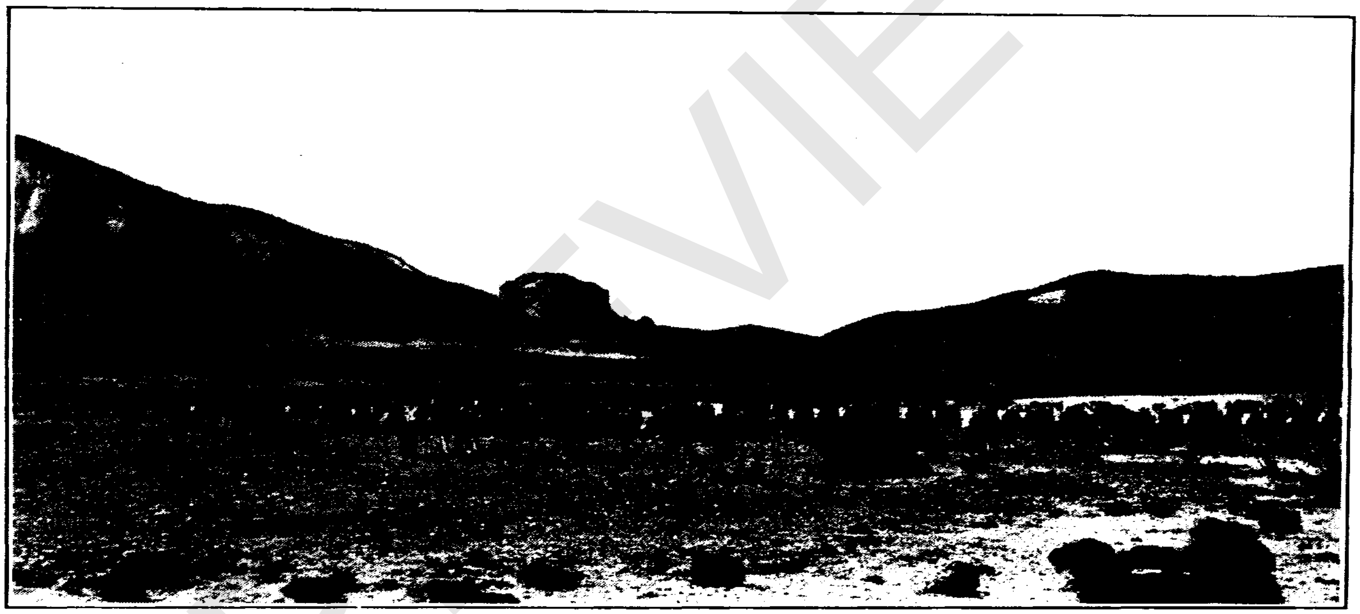

FIG. 1. A flat valley between low mountain ranges. The cover of grama-grass (*Bouteloua gracilis*) is much overgrazed because of its proximity to a water hole. The slopes are covered with an open growth of cedar (*Juniperus monosperma*) and oak (*Quercus grisea*).

Alpine, 225 miles southeast of El Paso and 100 miles north of the Mexican border is the area studied. This area is but little known geologically, geographically, and botanically (Bowman, '11; Bray, '01, '05). Bray ('06) in his "Distribution and Adaptation of the Vegetation of Texas" discusses it

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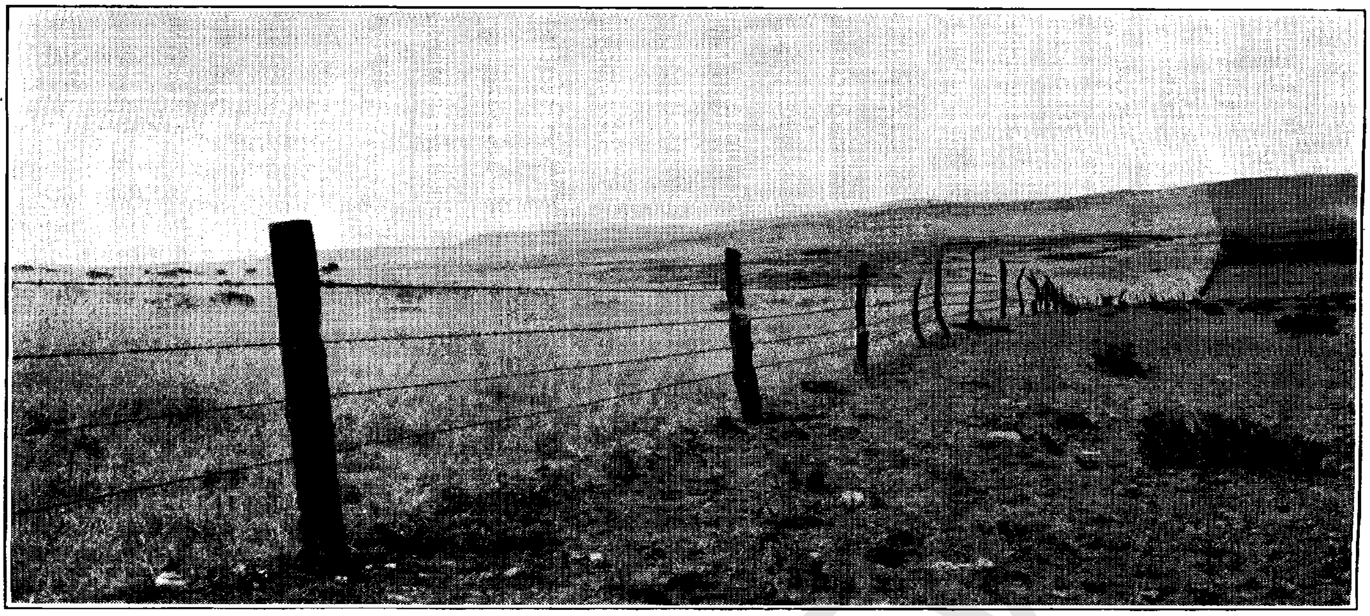

FIG. 2. General view of rolling topography with mountains in the background. The grama grasses on the left of the fence have been only lightly grazed and flower stalks are abundant.

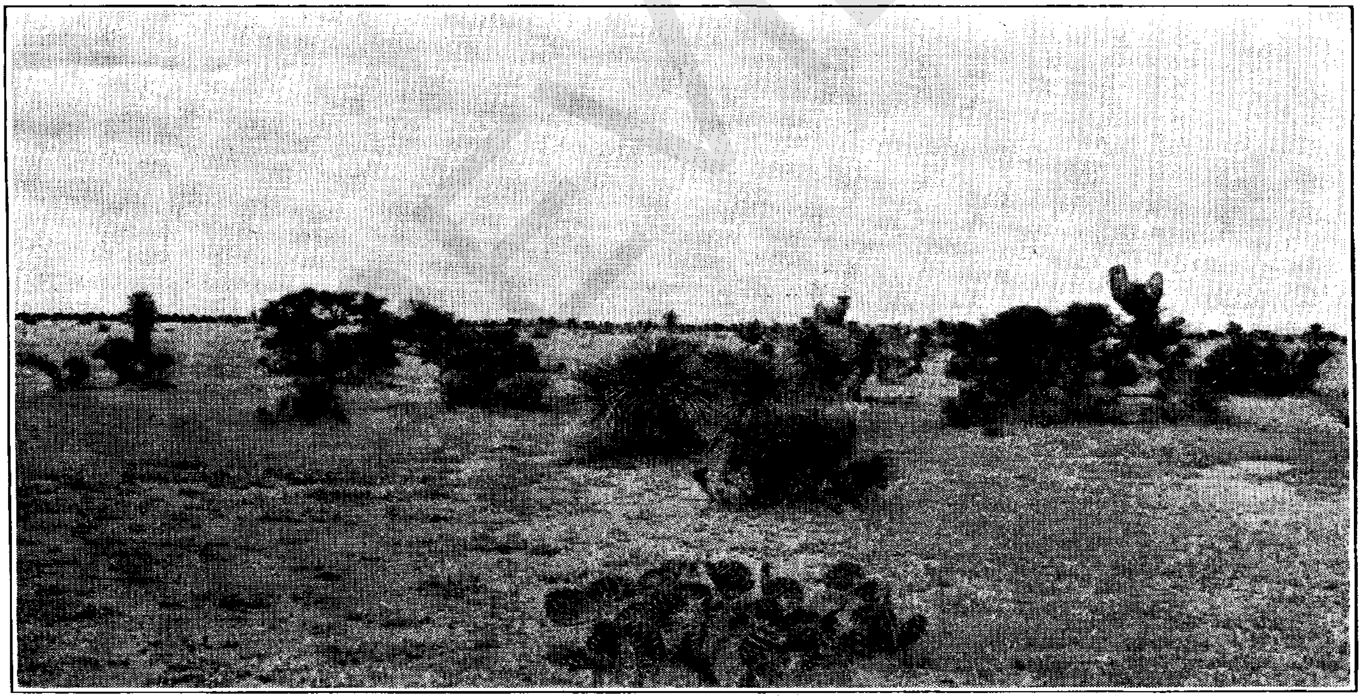

FIG. 3. Representative area of grama grass on Mitchell flat showing the abundance of *Yucca, Koeberlinia,* and *Opuntia.*

only in a general way, and the recent work of Tharp ('26) is confined to the vegetation of Texas east of the 98th meridian. The area is greatly diversified and affords a rich and virgin field for ecological study. It is probably the

FIG. 4. A society of cat's claw (*Acacia* sp.) on a flat at the Mitchell station. *Bouteloua gracilis* is dominant and well developed.

largest remaining area of native grassland in the United States. It has been continuously grazed since the bison were displaced by white men's herds of cattle (Havard, '85; Smith, '99).

FIG. 5. Red cedar (*Juniperus monosperma*) in the grama-grass sod on thin soil of uplands at the McIntyre station. Note the eroded area in the foreground.

The land is one of high mesas or flats and of broad valleys bordered by outlying buttes and mountains (Figs. 1 and 2). Although the annual rainfall is only about 14.5 inches, the relatively high altitude favorably modifies the high temperature and evaporation of this latitude. This, combined with a soil of good water retaining power, greatly increases the efficiency of the precipitation and permits the development of a short-grass type of vegetation. As a result of continuous grazing in summer and winter, however, the short grasses are now reduced to a very open cover. On the rougher lands and on porous soils, where grazing injury has been especially severe, other xeric types of vegetation occur. Among these are piñon-juniper woodland, yucca, mes-

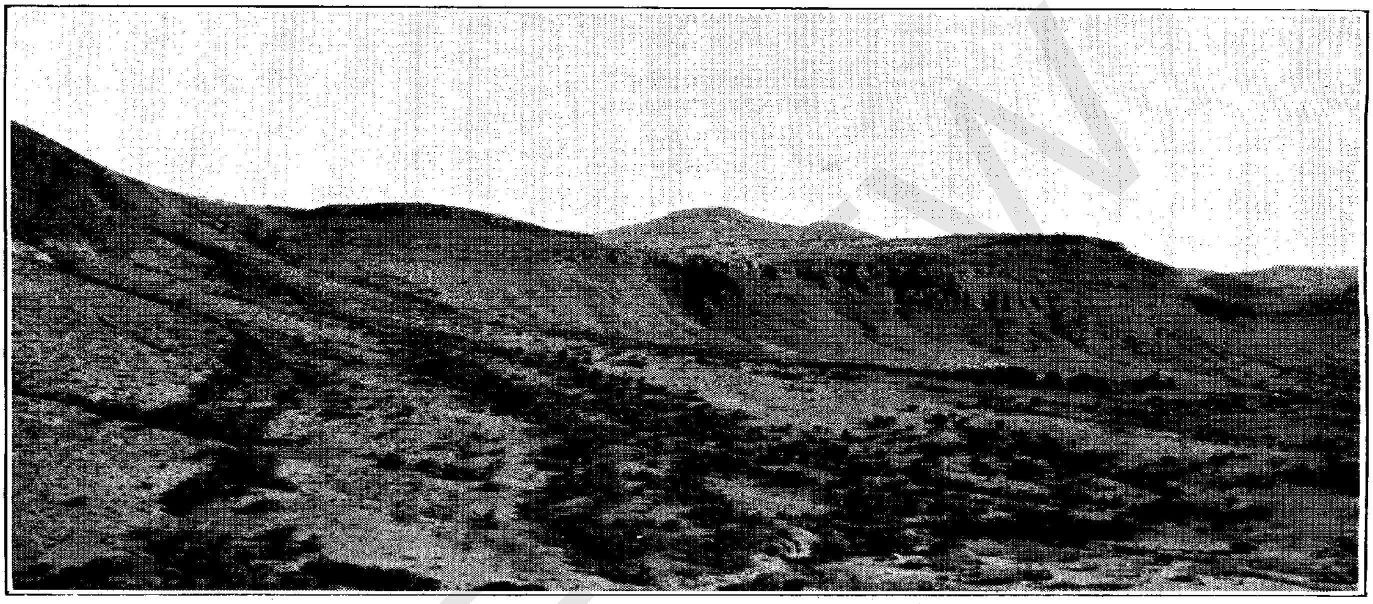

FIG. 6. An open postclimax woodland, mostly *Quercus grisea,* distributed along drainage courses.

quite, and various other desert shrubs. The broken grass cover affords an excellent opportunity for these greatly to increase their territory (Figs. 3, 4, and 5). Along drainage courses where more water is available, narrow bands of postclimax woodland contrast strikingly with the surrounding grassland and desert types (Fig. 6). Oaks, ash, and walnut are among the chief woody species. On intermediate areas the shrubby vegetation (*Prosopis,* etc.) is more mesic than is the desert scrub of the uplands.

Residence in Alpine, in connection with botanical work at the Sul Ross State Teachers College, during 1926–1929, gave excellent opportunity to engage in field work.

Location and Extent of the Area

The area lies between the Guadalupe Mountains on the northeast and the Rio Grande on the southwest in that portion of the Trans-Pecos country locally known as the Big Bend Region. Latitude 30° N. and longitude 104°

W. approximately pass through the center of the region. Altitudinally the area varies from a height of about 4,000 feet on the flats which lie between the more or less detached ranges of buttes and mountains, to about 7,000 feet on the general mountain mass.

An area of 900 square miles lying in Brewster and Presidio counties was most intensively studied, but extensive reconnaissance was made into adjoining areas. As a result of this survey it clearly seems that much of the surrounding territory, including perhaps 10,000 square miles, has a cover of vegetation which, in general, is very similar to that about Alpine.

Topography

The whole region during the Tertiary age consisted of a high mesa or series of mesas. Throughout long periods of time erosion has molded the surface so that in general two types of topography prevail. One consists of level flats, often many miles in extent, lying between detached mountain chains and isolated mountain masses, and the other of the mountains proper which are the hard cores of the former mesas that more successfully resisted the forces of erosion (Hill, '00). In some cases the original mesas have not

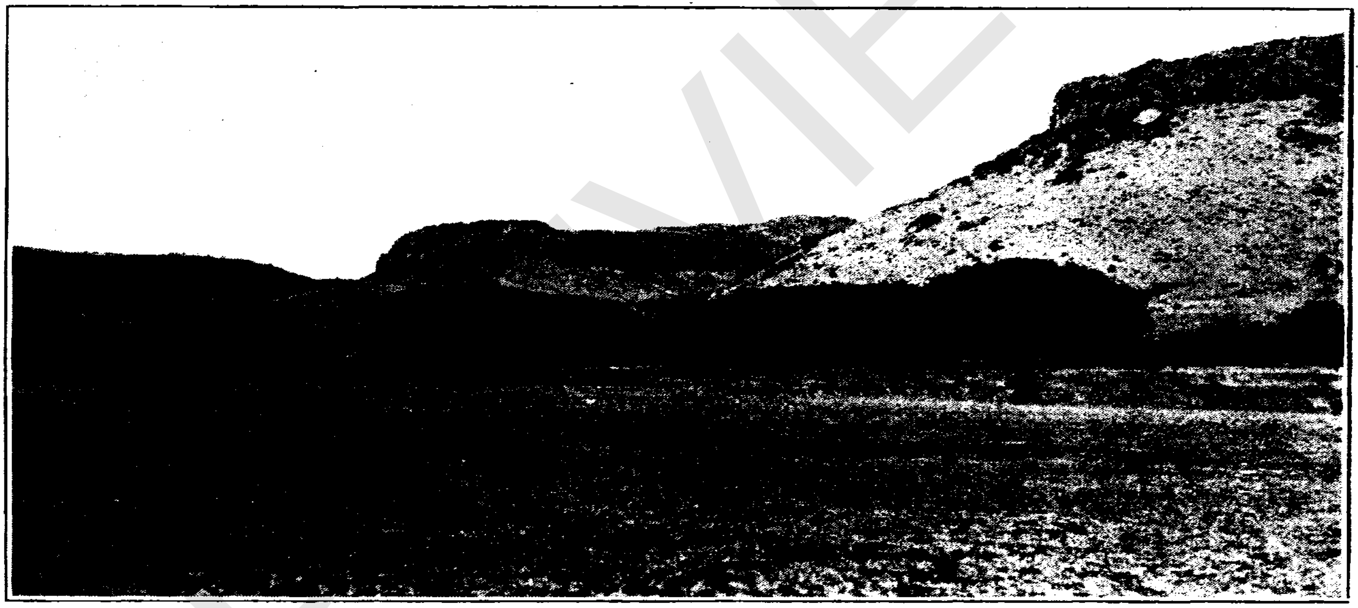

Fig. 7. Flat-topped mountain with vertical walls of igneous rock and steep talus slopes bordering an extensive flat on the Kokernott ranch. Walnut (*Juglans rupestris*) borders the water course which is usually dry.

been entirely removed, and limited areas, sometimes a few square miles in extent, are found above the eroded mountain sides, i.e., above the so-called rim rock (Fig. 7).

The flats or plains between the mountains appear to have been degradation

plains which have later been built up by the outwash from the surrounding mountains. Soil profiles reveal rounded, water-worn boulders at great depths (15–20 feet) with gradual diminution of size of rocks as the surface soil is approached. The surface 1 to 3 feet is often free from rock and consists of well formed soil with a protecting cover of grasses (Fig. 8). Where this cover has been greatly broken by continued overgrazing and trampling, degradation has again begun. In many places arroyos cut deeply and spread widely through the land, the slope being sufficient to afford great momentum to the onrushing water resulting from torrential rains.

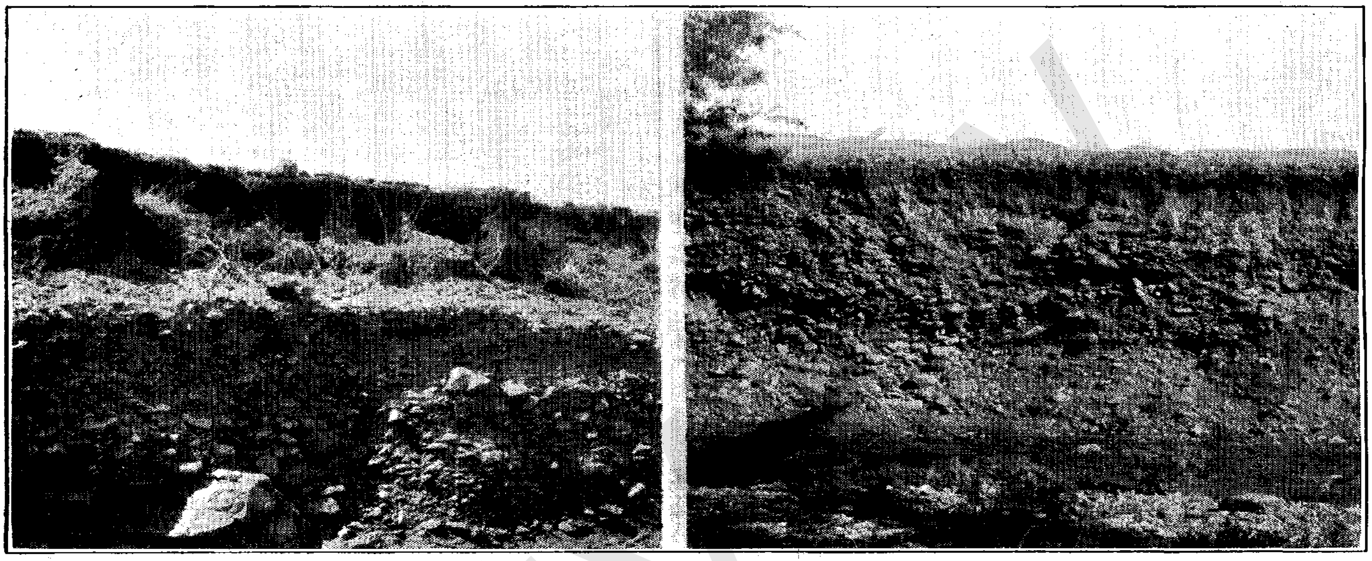

FIG. 8. Soil profiles from the vertical sides of arroyos showing water-worn boulders overlaid by two or three feet of silt-loam soil intermixed with gravel. The one on the right is from Kokernott Springs station.

The mountains lack continuity and exhibit many irregularities and eccentric forms of relief. They often extend two or three thousand feet above the valley flats, and heights of 6,000 to 7,000 feet are frequently attained. The Davis Mountains in the vicinity of Alpine, for example, consist of an extensive group of igneous rocks with the mesas of adjacent, dissected, volcanic plateaus.

In general, the individual mountains present sharp and rugged outlines. The highest are largely conical peaks rising to an altitude of over 8,000 feet. The mountainous part of the region is very rugged, and the slopes are usually steep. Most of the mountains are flat topped, and the igneous walls of rim rock are frequently exposed in vertical cliffs 100 to 300 feet high. At the bases of these occur extensive talus slopes. Many consist of large boulders, but all gradations occur, some having a coarse soil (Fig. 7). The slope from the foot of the cliff to the valley proper is usually one-half to one mile in length. Water from torrential rains has assorted the materials in such a

manner that while the heavier, coarser detritus has been deposited near the mountains, the finest material has been carried to the foot of the slope or on to the mesa itself.

Soils

In a region of such diversified topography many soil types are encountered. Until extensive surveys are completed no detailed statements can be made. Soils of certain flats consist of clay loam to a depth of 18 inches and are underlaid with a calcareous soil, nearly half of which is calcium carbonate. This is powdery dry and several feet thick.

Quite in contrast are the soils of other apparently similar flats where adobe is found. These may consist of one-third clay and only slightly less silt, with a similar high content of very fine sand. This grayish colored soil may continue rather uniformly to a depth of several feet.

On more rolling flats, the soil is often fairly uniform to a depth of 2 to 4 feet. Although half of the substratum may consist of coarse gravel, a third of the soil is often very fine sand and enough finer soil particles occur to hold the water in the first 2 or 3 feet.

In depressions such as ancient lake beds, a very heavy type of soil is found. It frequently contains more than 50 per cent of clay and although very plastic when wet it is so hard when dry that it can scarcely be removed with a pick. Particles larger than very fine sand make up less than 10 per cent. At a depth of about 3 feet a very calcareous, yellowish subsoil is found.

Soils on the slopes at the foot of the mountains are coarser in texture and show extreme variations. Boulders and coarse gravel may be overlaid with a thin veneer of a fairly well disintegrated rock, but as the mountains are approached surface rocks and boulders become more and more abundant and the soil coarser. Often rock fields support only a vegetation of lichens.

Drainage

The annual rainfall is so low and the climate so arid that the drainage system is immature and no rivers are found. Because of the rugged, mountainous topography, a local torrential rain may result in such a rush of water from the mountain slopes that floods occur several miles away. The rise of water is rapid, drainage channels overflow, and enormous loads of sand and silt are carried by the flood. Arroyos, often having their beginnings in cattle paths or other slight depressions, are the chief lines of drainage, although the rushing waters also cause extensive sheet erosion on the flats. The drainage channels quickly cut through the compact soil, and, once the gravelly and rocky subsoil is reached, the arroyos are widened with alarming rapidity (Fig. 9). But the recession of the flood is almost as sudden as its rise, the water sinking away into the dry soil. Some drainage from mountains to flats also occurs in the coarser subsoil and results in occasional, never failing springs. One of these (Kokernott Springs) has been known since the time of the Spanish

explorers in the sixteenth century. Below the spring is an arroyo over 20 feet in depth and more than a mile in length. The factor of drainage has a marked effect upon the distribution of the water. It is scarcely less important than that of soil type in determining the distribution of the various plant communities.

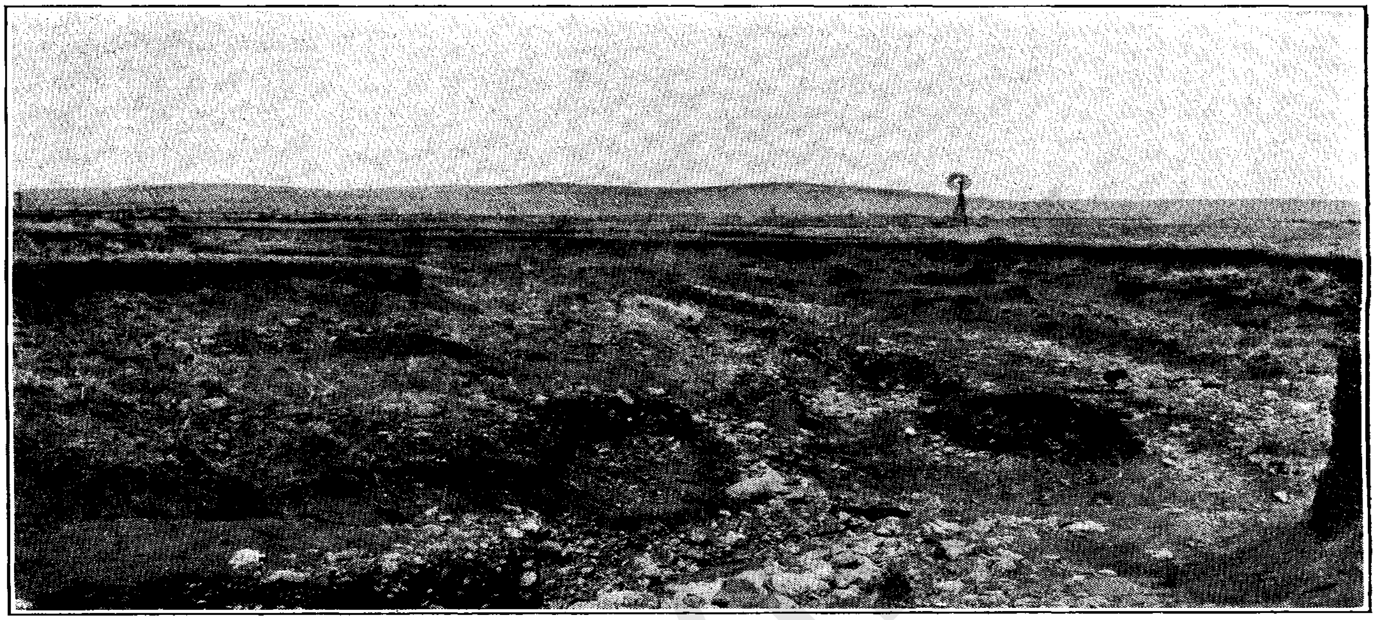

FIG. 9. General view of damage done to range lands by erosion. This arroyo increased in width from 25 to 200 feet in a period of four years.

General Plant-Life Conditions

Water is the major limiting factor to plant growth, consequently the amount and distribution of the precipitation are of great importance. This, of course, must always be studied in connection with the many factors modifying its efficiency, among which is that of run-off. The latter is largely controlled by porosity of soil together with topography. Measurements of rainfall have been made at Alpine and at Green Valley, about 35 miles to the southwest. The precipitation at both stations is of the same sporadic type and very similar in amount.

At Green Valley, the rainfall record for 14 years preceding 1929, gives an annual mean of 14.5 inches. Less than 7 inches fell in 1917 and 25.5 inches in 1920 (Fletcher, '28). Most of the rainfall occurs between June and October (Table I).

TABLE I. *Mean monthly and annual precipitation at Alpine for a period of 7 years and at Green Valley for 14 years*

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
Alpine	0.17	0.38	0.67	0.40	0.85	1.76	2.53	2.35	2.50	1.19	0.70	0.96	14.46
Green Valley	0.63	0.08	0.33	0.28	1.42	1.95	1.23	3.28	1.96	1.56	1.12	0.17	14.02

The showers are nearly always sudden and rather local. Cloudbursts are of frequent occurrence. For example, in August, 1920, nearly 8 inches of rain fell in a few hours over a relatively small area. While this is an extreme case, it emphasizes the great loss of water due to run-off even on rather flat areas and especially on sloping and rolling lands. Such floods remove both soil and vegetation, leaving great gullies and covering other vegetation with unsightly soil deposits. Much moisture is dissipated, moreover, in light showers that do not increase the water content of the soil. Snowfall is light and the snow invariably melts within one or two days, the unfrozen soil readily absorbing the water. Hence a spring favorable for plant growth almost invariably follows a snowfall of any magnitude.

Very little rain falls during March and April when temperatures are favorable for renewed plant growth. This is, moreover, a season of high winds which further desiccate both plants and soil. Throughout the rest of the year, wind movement is so small as to be of little ecological importance.

The sunlight is intense because of the high altitude, cloudless skies, and dry atmosphere. Clear weather is a marked characteristic of the climate.

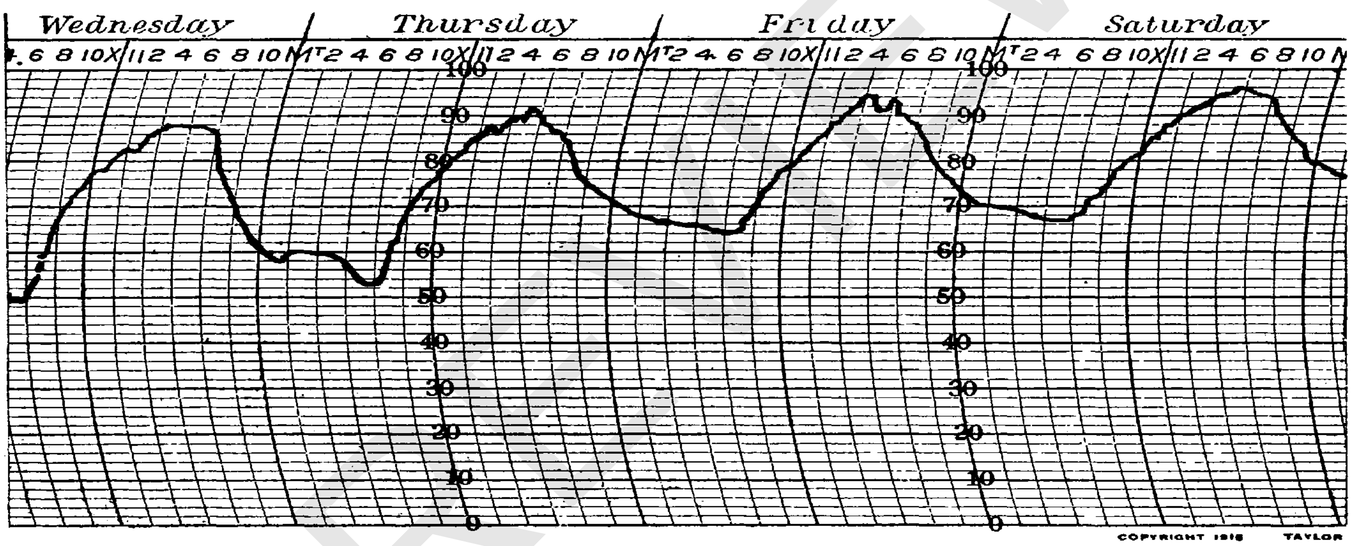

FIG. 10. Portion of a thermograph record during June showing the high temperatures of late afternoon and the relatively low night temperatures.

Approximately 75 per cent of the days are cloudless and only rarely do entirely cloudy days occur.

The frostless season usually extends from March 15 to November 15. The lowest temperature of any day during January and February of both 1928 and 1929, was 12° F., although by noon of these same days the temperature had risen to 60°. The average daily minimum temperature for these months was 31°, and the average daily maximum was 60°. The high variation in temperature from day to night (usually 30° and sometimes 60°)

is a marked feature of the climate. The sparse cover of vegetation, low humidity, and high altitude all contribute to the intense heating of the earth's surface by day and an equally rapid cooling at night. Summer temperatures (in shade) of 90° to 95° are common and sometimes temperatures of 100° to 104° are attained. Figure 10 shows a portion of a typical thermograph record for June. The average daily maximum and minimum temperatures at Alpine during 1927 and 1928 are shown in Table II.

TABLE II. *Average daily maximum and minimum temperatures at Alpine*

1928	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Ave. Maximum	66	57	71	70	81	93	85	79	78	76	76	
Ave. Minimum	32	28	38	43	50	61	61	57	52	46	40	
1929												
Ave. Maximum	59	60	62	79	85	92	86	86	90	78	56	54
Ave. Minimum	31	31	37	49	56	65	63	63	65	48	34	30

Few data are available on humidity. Psychrometer readings were taken in the grassland at Alpine, during two consecutive weeks in August and September (Table III).

TABLE III. *Relative humidity at Alpine, during August and September, 1929*

Time	August				September							
	27	28	30	31	1	2	3	4	5	6	7	8
7 A.M.	69	90	89	74	65	67	49	76	85	76	80	76
10 A.M.			50	46	40	38	41	48				
1 P.M.	56	30	32	30			30	30	30	30	33	38
6 P.M.	35	35	36	31	22	29	24	35	35	44		44
10 P.M.	52	54	55	38	34	40	39	46	46	70	62	60

These figures show that the cold night air (7 A.M.) is fairly moist (49 to 90 per cent humidity), but that of the day, often as late as 10 P.M., is very dry. The day humidity was frequently between 25 and 35 per cent. During periods of drought it is probably lower. This is clearly indicated by losses from atmometers which were frequently 75 to 85 cc. daily.

LOCATION AND DESCRIPTION OF STATIONS

Four stations were selected to study carefully the vegetation and to measure the environmental factors under which it develops. In addition, permanent quadrats and exclosures were made in order to determine the responses of the plant cover to grazing and to protection from grazing.

One station was located on the Mitchell flat, 18 miles west of Alpine, at an altitude of 4,650 feet. This is one of the largest and highest flats in the