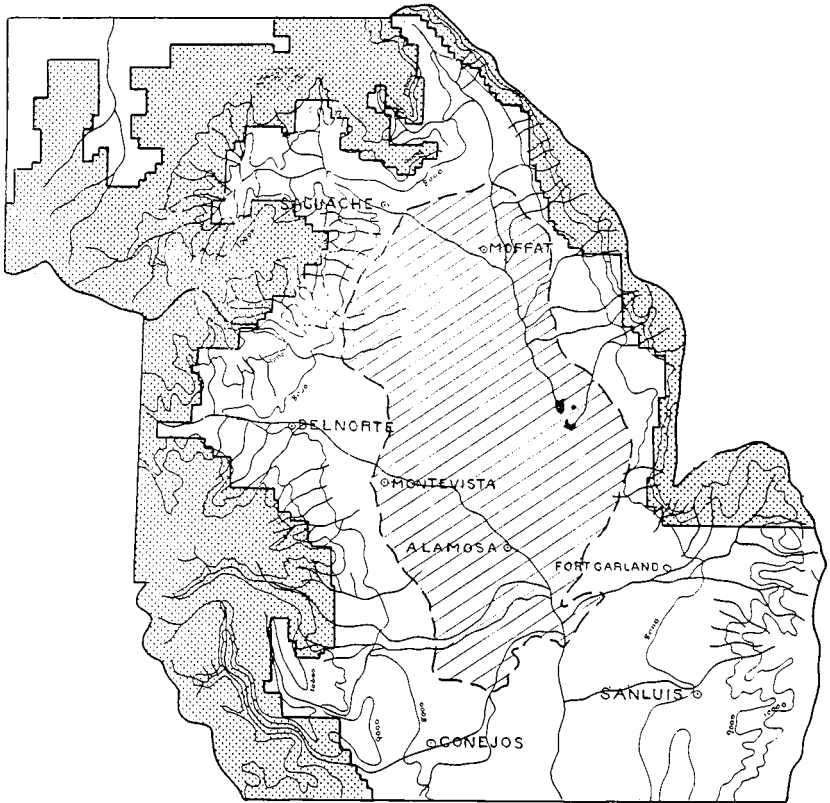


# RANGE RESOURCES OF THE SAN LUIS VALLEY

By HERBERT C. HANSON



**Figure 1.**—Map of the five counties in which the San Luis Valley lies. The heavy black line marks boundary of National Forests. The hatched area is the region of flowing wells which coincides very closely with the area occupied by greasewood.

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# RANGE RESOURCES OF THE SAN LUIS VALLEY

By HERBERT C. HANSON

The range resources of the San Luis Valley according to historical record were formerly much better than at present for the vegetation has changed due to overgrazing and changes in the soil-water content. The condition of the range in early days is mentioned by several early explorers. The greasewood type was much smaller in area than at present (see page 18). Pike, in 1807, found that "the great and lofty mountains covered with eternal snow, seemed to surround the luxuriant vale crowned with perennial flowers, like a terrestrial paradise, shut out from the view of man."<sup>15</sup> Gunnison, who visited the Culebra section of the valley in 1853 found, "a perfect sea of verdure, several thousand acres in extent, on which were numerous herds of cattle and horses."<sup>14</sup>

Joe Bowles moved into the San Luis Valley in the sixties. He had unlimited range and prospered. By 1876 the sheepmen had come in and pasture for cattle became scarce so he moved out of the valley with his herd of 1400 head.<sup>19</sup> Ingersoll, in a book written in 1885,<sup>11</sup> quotes government reports describing the fine grazing conditions. He also wrote: "It (Conejos) is the headquarters of the sheep and cattle men of the San Luis Park. In sheep, I learn that altho about 250,000 are sold out of the park annually, fully 500,000 are left. .... Cattle is less an industry here, because the sheep are so numerous as to consume most of the pasturage. Something like 10,000 head, however, are able to exist in the park and adjacent foothills."<sup>11</sup>

The grazing capacity of this large area is capable of improvement, however, if the relation of the range grasses and other plants to their changed environment is properly understood. The purpose of this bulletin is to present a description of the vegetation of the San Luis Valley in relation to these environmental conditions and to suggest methods that will lead to increased forage.

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The writer wishes especially to express his appreciation to L. W. Durrell, head of the Department of Botany, Colorado Agricultural College, for assistance during the progress of the work and in preparation of this bulletin.

This information is important because the plants growing in this area form the basis of the grazing industry and to know these plants in relation to the growing conditions is essential to proper husbanding of the range resources. Moreover, it indicates the way for range improvement and forms a basis for intensive grazing studies. The answers to such questions as: "Will reseeding to tame grasses pay?" and "How much improvement in forage may be expected by eradication of rodents, by deferred and rotation grazing, or by regulation of the public domain?" are found in the nature of the vegetation and such controlling factors as soil moisture and the length of the growing season.

The viewpoint of this bulletin is ecological, or that of the relation of the plant to its environment. The environment of range vegetation, however, is very complex because in addition to the influence of soil and climate, there are numerous grazing factors such as methods of regulating grazing, class of stock and rodent control. It has therefore, been found necessary to consider a number of factors in order to show the present resources and to indicate methods of range improvement. An attempt is made to assemble and correlate from many sources data on climate, soils, land classification, as well as vegetation, and to focus this knowledge on the improvement of the range.

The term "San Luis Valley," as here used, designates the portions of five counties, Alamosa, Conejos, Costilla, Rio Grande and Saguache, forming a large intermountain plain at a general elevation of 7500 to 8000 feet (see map). The statistics given in the section, "The Range Industry," are based upon the total area of each of the five counties. This is unavoidable because statistics are not available for only the portions of the counties in the valley proper.

### GEOGRAPHY AND SOILS

Before considering the vegetation of the San Luis Valley a brief description of the geography as well as the geology, the soil and the water supply is necessary to explain more clearly the conditions under which the different types of vegetation are found growing.

LOCATION AND AREA.—The San Luis Valley is situated in the south-central part of Colorado, lying at a general elevation of 7500 to 8000 feet. It extends north and south for about 100 miles in Colorado and the southern, narrow end projects a few miles into New Mexico. Its greatest width is about 50 miles and the total area of the valley proper is approximately 4,990 square miles or about the size of Connecticut. This includes most of five counties: Saguache, Rio Grande, Alamosa, Conejos and Costilla.

Mountain ranges completely surround the San Luis Valley. The Sangre de Cristo Range, generally 11,000 to 12,000 feet in altitude,

lies to the east and northeast. Several peaks in this range are among the highest in Colorado, rising to over 14,000 feet. The Cochetopa and La Garita hills, 10,000 to 11,000 feet, form the boundary on the north and northwest and the San Juan mountains, 11,000 to 12,000 feet, on the west and southwest.

TOPOGRAPHY AND GEOLOGY.—The valley is extremely flat. Before the glacial period, in the late Pliocene or early Pleistocene, a large fresh-water lake covered most of this area.<sup>18</sup> The materials deposited in the quiet waters of this lake were alternating layers of blue clay and sand, classified as the Alamosa formation. When flood waters had eroded an outlet to this lake thru the San Luis Hills to the south, the waters drained off leaving a flat lake bottom. Streams entering the valley from the surrounding mountains deposited gravel and sand in the form of alluvial fans at the base of the mountains and often far out on the old lake bottom (Figures 2, 3, 15, 17 and 18). Where the streams were close together these fans joined into a large spreading fan (Figures 2 and 3). The fan formed by the Rio Grande is the largest of them all, occupying one-fourth or more of the valley bottom. It filled in the lower course of San Luis Creek, cutting off its drainage into the Rio Grande, resulting in the formation of the San Luis Lakes and probably making possible the invasion of greasewood into the valley. Another effect of the Rio Grande alluvial fan was to cause the lowest part or trough of the valley, north of the San Luis Hills, to be east of the middle of the valley, close to the base of the Sangre de Cristo Range. The alluvial fans ascend abruptly to these mountains on the east (Figure 2). On the west, however, the slope is much more gradual, ascending only 3 to 6 feet to the mile at first (Figure 7).

The southern part of the valley is divided into two parts by the San Luis Hills. These flat-topped mountains, capped with basalt and rising 1000 to 2000 feet, extend northeast from Antonito toward Fort Garland.

SOILS.—The upper parts of the alluvial fans on the mountain slopes consist largely of coarse gravel intermixed with rock, into which the water sinks rapidly (Figure 24). Descending the fans, the soil gradually becomes finer, the rocks disappearing rapidly (Figures 16 and 17), so that at the outer edges of the fans and over extensive portions in the lower parts of the valley fine silt loams and clayey soils occur (Figures 7 and 8). In many places, as west and north of Alamosa, sand is found on the surface, often forming incipient dunes. (Figures 5 and 12). At the base of the Sangre de Cristo Mountains, between Medano and Sand Creeks, east of Hooper, well-developed sand dunes cover an area of over 40 square miles.

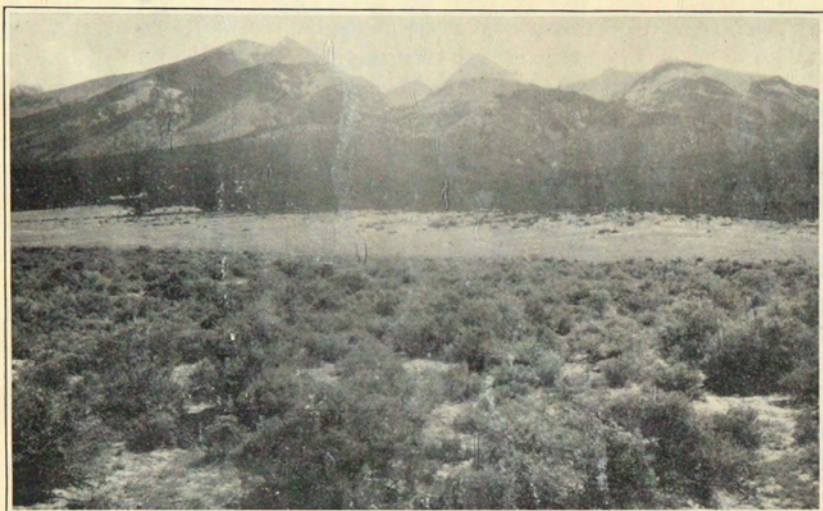


Figure 2.—Zones of vegetation on the east side of the San Luis Valley. Sangre de Cristo Range northeast of Alamosa. Tall rabbitbrush-greasewood zone in the foreground, then the low rabbitbrush-snakeweed-gramagrass, pinyon-juniper, burned-over spruce-fir and alpine zones. Yellow pines in the pinyons and junipers at right. Lower portions of two alluvial fans have coalesced.

**DRAINAGE AND ARTESIAN BASIN.**—The Rio Grande is the main stream in the valley. It enters at the west, flows southeastward toward the San Luis Hills, thru which it has formed a gorge. A number of tributary streams drain the southern part of the valley. The largest of these is the Conejos River. San Luis Creek with its tributary, Saguache Creek, drains the northern part. San Luis Creek becomes very sluggish in its lower course, ending in the San Luis Lakes. There is no outlet to these lakes.

Many creeks flow down the mountain sides upon the alluvial slopes. Here the water is lost by rapid seepage into the gravelly soil. This water and other seepage water lost by rivers, especially the Rio Grande, and water that sinks into drainage basins higher in the mountains, flow into the sand layers in the old lake bed underlying the valley. The larger part of the San Luis Valley (see map) has been considered an almost ideal example of an artesian basin largely because of the inclined sand layers to receive and transmit water from higher elevations and because of the presence of impervious clays which confine the water to the sand layers (Figure 2). In 1891, it was estimated that there were 2,000 artesian wells in the valley, in 1904, about 3,200<sup>18</sup>. The average flow of the two- and three-inch wells has been estimated at 40 gallons per minute. These wells furnish water chiefly for irrigation, stock and household purposes.

**ALKALI AND SHALLOW WATER-TABLE.**—Due to the sub-surface method of irrigation, called "sub-irrigation," and the lack of drainage in many places, the water-table has been brought close to the surface over most of the valley. This system of irrigation greatly favors the accumulation of alkali. The abundance of greasewood, salt grass and alkali sacaton on the valley floor is due to the shallow water-table, seepage areas and alkali.

**RELATIONS OF GEOGRAPHY AND SOILS TO THE VEGETATION.**—The effects of the rather high elevation, 7500 to 8000 feet, are chiefly to shorten the growing season, increase radiation thus causing rapid changes in temperature, and to increase evaporation. These climatic factors are discussed in the next section.



Figure 3.—Zonation of vegetation on the Sangre de Cristo Range in the northern part of the San Luis Valley, near Villa Grove. Low rabbitbrush-snake-weed-gramagrass zone in the foreground and on the lower parts of the alluvial fans. Oak brush forms the gray-colored zone extending irregularly into the former. The spruce-fir zone, intermingled with aspen, shows black in color below the alpine zone above timberline. Vegetation in foreground is much overgrazed.

The poor, natural drainage of most of the valley, caused by the extreme flatness, the damming of San Luis Creek by alluvial fans and layers of impervious blue clay in the subsoil, aided by methods of irrigation have raised the water-table close to the surface. The saturated condition of the soil at or near the surface has resulted in the accumulation of alkali salts in many places. These two conditions



explain the presence of the greasewood type of vegetation. The most characteristic plants in this type such as greasewood, salt grass and alkali sacaton, can grow in soil with a high moisture-content and rich in alkali.

The gravelly to rocky nature of the soil in most of the alluvial fans causes excellent drainage. This, coupled with the low rainfall, results in dry soils free from alkali. There is sufficient moisture in the more rocky upper portions of the fans to permit the growth of pinyons but on the finer, more clayey soil in the lower portions, gramagrass is the chief plant.

### CLIMATE

The climate of a region is made up of a number of closely related factors as precipitation, temperature, humidity, wind, etc. All of these factors, as well as soil conditions, influence in varying degree the growth of plants. The length of the growing season, the total yearly precipitation as well as its distribution thruout the year, the intensity of the wind and the evaporating power of the air affect the distribution of plants and the amount of forage produced. A study of the climate, then, aids in understanding the range conditions of the San Luis Valley.

**PRECIPITATION.**—The mean monthly and annual precipitation for 8 localities in the San Luis Valley is given in Table 1. The annual precipitation is very low, the annual mean ranging from 6.21 inches at Garnett to 13.07 at San Luis. As little as 2.64 inches per year have fallen at Manassa and 2.88 at Saguache. The greatest amount in one year is 18.85 inches, occurring at San Luis. At Monte Vista the annual variation for a period of 9 years has been low, ranging from 5.01 to 9.62 inches.

The monthly distribution is shown in Figure 4. The upper curve is the average of the records from two points, Fort Garland and San Luis, in the sagebrush zone in the southeastern part of the valley. The lower curve is the average of the records from four points, Garnett, Monte Vista, Manassa and Saguache, in the greasewood zone. Usually more than one-third of the total annual precipitation comes in 2 months, July and August. The least, only one-fifth to one-fourth of the total, occurs in the period November to March inclusive. A small but striking depression occurs in June. Resemblance to the distribution of precipitation characteristic of southwestern United States is seen in the short rainy period in July and August preceded by a dry June and May<sup>9</sup>. On the plains east of the Sangre de Cristo Range the precipitation rises rapidly in April and remains high thru the spring and summer months.

Table 1.—Mean Precipitation in Inches at Various Points in the San Luis Valley

Town	Length of record years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Annual variation
Garnett, Alamosa County, 7576 feet.	32	0.14	0.22	0.28	0.56	0.66	0.70	1.24	1.14	0.76	0.54	0.27	0.23	6.21	3.54-10.37
Monte Vista, Rio Grande County, 7665 feet.	9	0.24	0.50	0.31	0.82	0.84	0.34	1.48	1.28	0.66	0.47	0.20	0.30	7.44	5.01- 9.62
Manassa, Conejos County, 7700 feet.	17	0.12	0.25	0.37	0.76	0.55	0.51	1.26	1.37	0.57	0.80	0.25	0.28	7.09	2.64-11.57
LaJara, Conejos County, 7909 feet.	4	0.11	0.91	0.13	0.15	0.80	0.23	1.28	1.34	0.67	0.69	0.30	0.32	6.93	
Saguache, Saguache County, 7740 feet.	29	0.24	0.41	0.31	0.37	0.81	0.97	1.77	1.51	0.78	0.73	0.31	0.32	8.53	2.88-14.01
Blanca, Costilla County, 7865 feet.	7	0.10	0.24	0.20	1.26	0.53	0.67	2.23	2.08	0.78	0.73	0.12	0.09	9.03	
Fort Garland, Costilla County, 7996 feet.	28	0.38	0.64	0.49	0.70	0.84	0.72	1.68	1.64	1.09	0.49	0.83	0.64	10.14	5.00-14.66
San Luis, Costilla County, 7794 feet.	31	0.42	0.50	0.66	0.95	1.12	0.75	2.23	1.50	1.05	1.02	0.42	0.61	13.07	6.98-18.85

in.

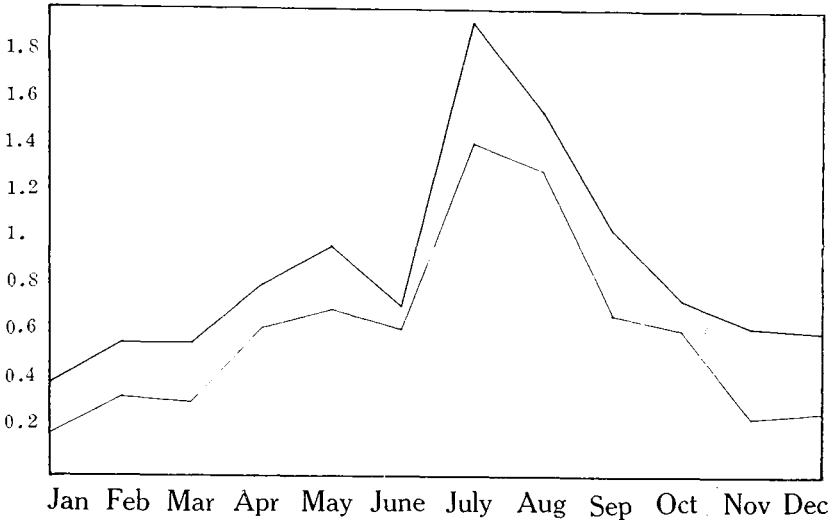


Figure 4.—Average monthly precipitation in the San Luis Valley. Upper curve shows the average of the monthly means of Fort Garland and San Luis (in the sagebrush type), lower curve of Garnett, Monte Vista, Manassa and Sagnache (in the greasewood type).

The precipitation in the two towns in the sagebrush zone averages 11.60 inches per year, in the four towns in the greasewood zone 7.32 inches, a difference of 4.28 inches. The graph and the tables bring out other differences as 24 percent of the annual rainfall in the sagebrush zone occurs during the winter months, November to March, but in the greasewood zone only 18 percent occurs then. During July and August, 30 percent of the yearly precipitation occurs in the former and 38 percent in the latter, so the sagebrush zone is characterized by higher winter and lower summer precipitation as compared with the greasewood zone. The difference in elevation is from 100 to 300 feet, the sagebrush being higher.

The total annual snowfall and its distribution thruout the year are shown in Table 2. Snow may fall every month in the year except July and August. The greatest amount falls in San Luis in the sagebrush zone in the southeastern part of the valley.

The precipitation increases rapidly as the mountains are ascended. The annual mean at La Veta Pass in the Sangre de Cristo Range, at an elevation of 9,242 feet, is 20.69 inches. Hermit Lake at 10,000 feet in the same mountains averages 41.30 inches.

TEMPERATURE.—In Tables 3 and 4 is given the annual distribution of temperature for the valley. These include the mean, the mean maximum, the mean minimum, the highest and the lowest temperatures for five towns. There is very little difference between the records for these towns. The annual mean varies from only 41.2° F. to

F., lowest recorded temperatures vary from  $-26^{\circ}\text{F}$  to  $36^{\circ}\text{F}$ , the highest from  $90^{\circ}\text{F}$  to  $102^{\circ}\text{F}$ . July and August are the warmest months, June and September ranking next. The mean maximum, however, rarely goes over  $80^{\circ}\text{F}$ . The coolest months are December and January, the mean minimum averaging about  $4^{\circ}\text{F}$ . The records show that frost has occurred every month in the year except July and August at Blanca and in August in San Luis. The reason these localities, especially Blanca, have less frost during the summer than the other towns is because their location near the foothills is favorable for cold air drainage, (Figure 2). The colder, and hence heavier, air flows down the slopes to the lower parts of the valley in this way the valley floor may frequently have lower temperatures than the surrounding slopes.

Table 2—Snowfall in Inches for Five Places in the San Luis Valley

Length of record in years	Length of record in inches												Annual
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
27	23	30	24	24	12	T	0	T	0.2	1.8	3.3	3.6	20.2
16	18	3.6	2.0	2.8	0.2	T	0	0	0.2	2.6	2.2	3.2	18.6
27	4.7	4.3	2.8	3.1	0.6	1	0	0	T	2.0	3.1	4.5	25.1
7	1.7	4.6	2.3	6.1	0.4	0	0	0	1	0.3	1.3	1.7	18.4
30	4.6	4.9	1.4	5.5	2.0	0.1	0	0	0.2	2.6	4.1	5.9	34.3

In Table 5 are given the average and latest dates of the last killing frost in spring, the average and earliest dates of the first killing frosts in the autumn, and the average length of the frostless season. The last killing spring frost usually occurs the first week in June, the first fall frost in the third week in September. The length of the frostless season averages from 97 to 119 days in the different

Table 5—Average and Extreme Data on the Length of the Frostless Season

Years	Length of record	Ave date of last killing frost in spring	Ave date of first killing frost in fall	Latest date of killing frost in spring	Earliest date of killing frost in fall	Average length of frostless season in days
24	24	June 4	Sept 14	July 7	Aug 13	102
16	16	June 7	Sept 12	June 20	Aug 2	97
25	25	May 27	Sept 24	June 18	Aug 28	119
7	7	June 6	Sept 19	June 23	Sept 12	104
29	29	June 4	Sept 20	July 6	Sept 5	107

Table 3—Monthly and Annual Mean Maximum and Mean Minimum Temperatures in the San Luis Valley

Town		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Annual
		F °	F °	F °	F °	F °	F °	F °	F °	F °	F °	F °	F °
Garnett	max	35.0	41.5	49.8	58.5	67.8	77.6	80.5	79.1	73.8	62.7	48.8	59.2
	mean	17.2	23.8	32.8	41.2	49.2	58.6	62.0	61.2	54.5	43.1	30.7	41.2
	min	0.6	6.1	15.7	23.9	30.7	39.5	44.6	43.4	35.2	23.5	12.6	23.3
Manitou	max	37.4	42.4	50.2	57.2	65.8	76.4	79.5	77.6	72.6	61.7	50.4	59.1
	mean	20.9	25.7	34.5	41.0	49.4	59.0	62.8	61.2	54.7	43.8	32.0	42.2
	min	4.4	9.0	18.8	24.9	32.9	41.0	46.2	44.7	36.8	25.8	14.9	4.1
Saguache	max	37.7	43.1	51.6	60.7	69.5	78.6	82.2	80.2	74.8	64.7	51.5	61.0
	mean	21.5	27.0	35.4	44.3	52.0	60.8	65.5	63.9	57.0	46.8	34.8	44.2
	min	5.3	10.9	19.3	27.9	34.5	43.0	48.8	47.6	39.2	28.9	18.1	7.0
Blanca	max	36.6	40.7	50.1	57.8	65.8	75.8	79.2	77.1	71.4	58.9	49.6	57.9
	mean	22.2	25.6	34.2	41.4	49.3	58.3	63.4	61.2	54.8	43.0	32.8	42.1
	min	7.9	10.4	18.4	26.9	32.8	40.8	47.6	45.4	38.1	27.0	15.9	4.5
San Luis	max	38.3	42.1	49.6	57.8	66.6	76.0	79.7	78.5	73.0	63.0	51.1	59.7
	mean	21.0	25.8	34.2	41.7	49.3	57.8	62.4	61.4	54.8	44.4	33.2	42.4
	min	3.7	9.5	18.7	25.6	32.0	39.6	45.2	44.2	36.7	25.9	15.3	4.6

Table 4—Highest and Lowest Recorded Temperatures for Each Month and the Year

Town		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
		F °	F °	F °	F °	F °	F °	F °	F °	F °	F °	F °	F °	F °
Garnett	highest	60	61	72	82	84	90	91	92	87	81	69	59	92
	lowest	-35	-43	-19	0	10	20	29	30	16	-12	-16	-36	-36
Manitou	highest	60	61	69	78	84	88	92	90	88	80	72	61	92
	lowest	-32	-23	-11	0	10	20	31	27	13	-8	-17	-31	-32
Saguache	highest	72	78	92	88	92	101	102	98	96	90	78	75	102
	lowest	-23	-21	-10	-1	16	27	31	28	18	5	-10	-26	-26
Blanca	highest	60	67	71	74	82	88	90	86	84	80	67	78	90
	lowest	-30	-17	-5	-2	15	27	33	35	23	8	-6	-27	-30
San Luis	highest	57	65	74	80	90	97	95	98	92	80	72	61	98
	lowest	-34	-34	-27	-14	12	17	30	32	17	-9	-19	-32	-34

**OTHER CLIMATIC FACTORS**—The prevailing southwest wind is important because of its effect in carrying sand and in increasing evaporation from plants and from the soil (Figures 5 and 12). The high altitude, coupled with a high percentage of possible sunshine and low humidity, makes the radiation high. This also tends to increase evaporation from soil and plants. It also causes rapid cooling of soil and air at night and shade temperatures are usually much lower than those in the sun.

**RELATIONS OF CLIMATIC FACTORS TO VEGETATION**—The small annual precipitation in most of the valley is counteracted in the greasewood zone by the high water table. The causes for the high water table are given on page 18. The effect of the light precipitation is accentuated on most of the alluvial fans and other sloping parts of the valley by the gravelly nature of the soil causing rapid percolation, and the slope causing more or less run off. The resulting low soil moisture for the comparatively short season, July and August (see Figure 5), when most of the precipitation comes, is directly in correlation with the type of vegetation found. This is the type in which gramagrass is the chief plant. This grass is noteworthy for its drought resistance as well as its ability to mature in a short period of time. In the sagebrush and pinyon jumper types the precipitation is somewhat greater than in the lower types and the soil

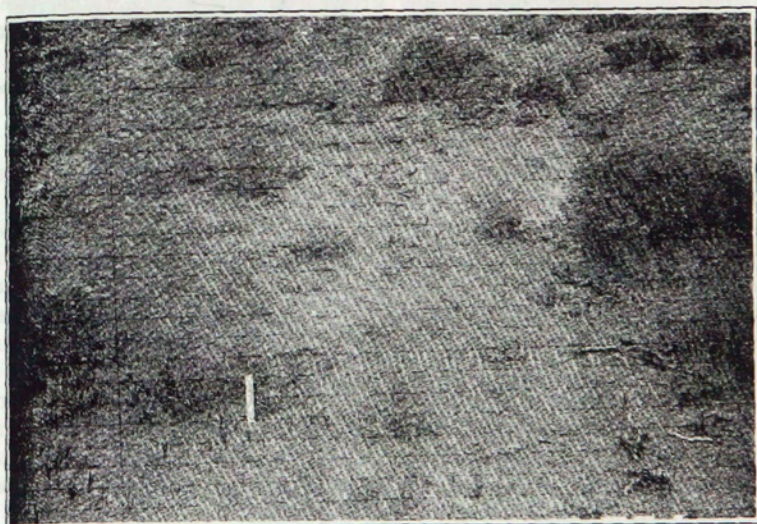


Figure 5.—Vegetation on sandy soil in the tall rabbitbrush greasewood type north east of Alamosa. Sat grass spreading by rhizomes is common especially in lower left. Blowout grass in tufts (especially behind white 6 inch rule Indian millet infrequent dark shrubs are rabbitbrush tall groundsel (at left of rule) infrequent)

retains the moisture better, at least in the subsoil, than in the low rabbitbrush snakeweed gramagrass type

The temperature is important in that the length of the growing season is a factor in limiting the amount of forage that can be produced. The length of the growing season as well as the duration of freezing weather in the winter prevent the growth of some species, as the cane cactus and New Mexico porcupine grass, that might otherwise grow here. High evaporating power of the air tends to cause rapid loss of water from plants. Only such plants as can resist or endure this loss can grow. This is an important factor in explaining the presence of many plants in the valley, especially those in the low rabbitbrush snakeweed gramagrass type.

### THE VEGETATION

The foregoing sections describe the chief physical conditions which control the growth of range plants in this region. Due to variations in these physical conditions the plant cover varies with changes in location. Changes in the moisture content of the soil may occur within a few feet and this usually causes a striking change in the kind of plants growing on the area. There are many factors that may vary, some of which are soil texture, salt content or alkali, air and soil temperature, humidity and precipitation. Plants vary greatly in their habits and in their adaptability to these different conditions. Sagebrush cannot grow well where the water table is shallow but greasewood can often thrive in such places. Some plants, as salt grass and inland cord grass, are especially well adapted to invade sandy soil because of their method of propagating by rootstocks as shown in Figures 5 and 12.

The natural distribution of plants is often greatly changed by grazing, especially by over grazing. The highly palatable plants tend to disappear, the unpalatable ones to increase.

When the natural cover of an area has been destroyed by over grazing, plowing, flooding or by some other cause will the original cover return, if given a chance? The time required for this to take place and the stages of vegetation that will be passed thru depend upon soil conditions largely and also upon the habits of the invading plants.

Since the native plants in a region furnish the basis for the grazing industry, it is important to know what these plants are, their forage value, habits, abundance, relation to environmental factors and how they are grouped. Plants that have similar requirements usually grow together under similar conditions, forming types of vegetation. Salt grass, alkali sacaton, greasewood and others grow together under similar conditions. Since greasewood is the most conspicuous plant in this grouping, it is called the greasewood type.

The vegetation of the San Luis Valley may be classified into a number of such types. Most of the floor of the valley, except cultivated and hay land, is occupied by the greasewood type (see map, Figure 1). On the edges of this type greasewood becomes much less abundant and tall rabbitbrush more abundant so this zone may be called the tall rabbitbrush greasewood type. The next zone or belt of vegetation, occurring on the lower portion of the alluvial slopes that rise fairly rapidly out of the valley floor (Figure 2), is the low rabbitbrush snakeweed gramagrass type. Above this usually occur the mountain zones, first the pinyon juniper type with oak brush in places and above this the forest zones characterized by spruces, firs and aspens chiefly. There is considerable area above timberline belonging to the alpine type.

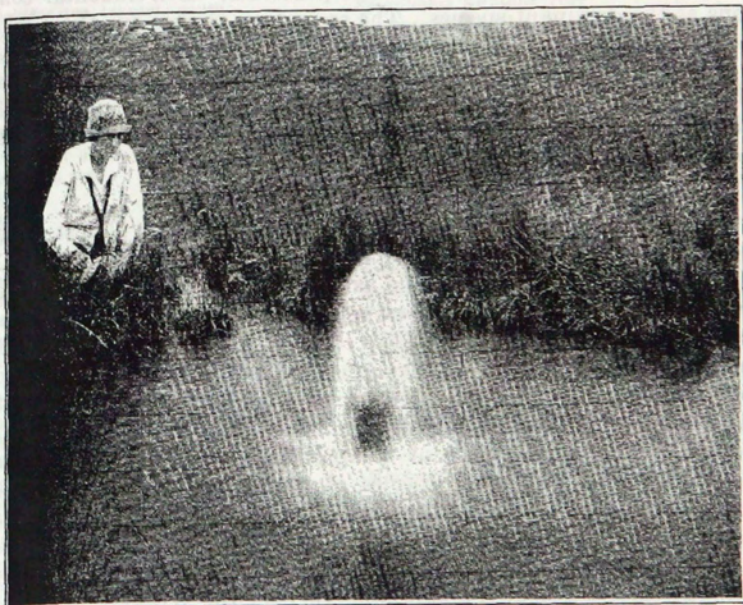


Figure 6 A flowing artesian well used for irrigating the hay meadow in the background. About 12 miles south of Saguache.

In the southeastern part of the valley an extensive area is covered with the sagebrush type. A smaller area occurs in the northern tip of the valley. These areas are found just below the pinyon juniper or oak brush type. The types above the pinyon juniper zone are not treated in this bulletin because they are in the National Forests, and the Forest Service has gathered considerable data on them. Each of these types of vegetation is characterized by certain species of



plants and these plants tell a story about soil and other environmental conditions. *From a knowledge of these conditions as indicated by the plants, the condition of the range can be told and methods of improvement advised.*

In the following descriptions of these vegetative types or zones the plants are listed in three groups. Dominant, primary and secondary species. The dominant species are those which are usually the most abundant in the type and on account of their growth habits, are usually best adapted to the particular environmental conditions of the type. In this way they dominate the vegetation making it difficult or impossible for species of other growth habits to grow in competition with them under those conditions. The primary species are fairly abundant in the type but they are not as abundant, widespread nor as a rule as well adapted to the particular environmental conditions as the dominant species. The secondary species are those which occur infrequently or rarely. They vary in abundance with the seasons and cannot endure the competition of the dominant and primary species. They grow best on disturbed areas such as prairie dog holes, roadways or in other places where soil conditions differ somewhat from the usual conditions.

#### GREASEWOOD TYPE

The boundaries of the area covered by this type are almost exactly the same as those for the area of flowing wells (see map Figure 1). This coincidence in distribution is particularly significant because greasewood can grow better than most shrubs in soil that has a shallow water table and a high alkali content. There appears to be a definite relationship between the area of flowing wells and that covered with greasewood. The flowing wells and the sub surface method of irrigation and lack of drainage have raised the water table and increased the concentration of alkali in many places. This, it appears has killed out other species of plants as rabbitbrush, snake weed, gramagrass etc, and enabled greasewood, salt grass alkali sacaton and other plants tolerant of alkali and a shallow water table to cover the land. Aldous and Shantz<sup>110</sup> state that "greasewood is limited to sub irrigated alkali lands thruout the West."

Since the settlement of the valley the area occupied by greasewood has increased. At present it occupies a region about 60 miles long by a usual width of 25 to 30 miles. According to Hayden the area occupied by it in 1869 was only one fifth, or less as great as today. He wrote "This northern portion, above the bow of the Rio Grande, is about 60 miles in length, and has an average width of 15 to 20 miles. About the center of this park is a singular depression, about 10 miles wide and 30 miles long, it looks like one vast thicket of greasewood, *Sarcobatus vermiculatus* and other chenopodiaceous

shrubs Into it flow some 12 or 15 good sized streams and yet there is no known outlet, neither is there any large body of water visible It seems to be one vast swamp or bog, with a few small lakes " 10 176

Near the margins where the wells are fewer, as near Mirage and 8 to 15 miles east of Alamosa and Mosca, tall rabbitbrush is often more abundant than greasewood The greasewood type occupies most of the valley floor On the north, west and south the boundary follows the 7650 foot contour line rather closely but on the east the agreement with contours is much less close, the boundary varying from 7550 to 7800 feet

## DOMINANT SPECIES

Greasewood ( Chico )	<i>Sarcobatus vermiculatus</i> (Hook ) Torr
Salt grass	<i>Distichlis spicata</i> (L.) Greene
Alkali sacaton tussock grass	<i>Sporobolus airoides</i> Torr
Western wheat grass bluestem	<i>Agropyron Smithii</i> Rydb
Rabbitbrush	<i>Chrysothamnus pulcherrimus</i> A Nels
Rabbitbrush	<i>C Bigelovii</i> (Gray) Greene
Shadscale	<i>Atriplex canescens</i> (Pursh) Nutt

## PRIMARY SPECIES

Muhlenbergia	<i>Muhlenbergia Richardsonsii</i> (Trin) Rydb
Purple hair grass blowout grass	<i>M pungens</i> Thurb
Sand drop seed	<i>Sporobolus cryptandrus</i> (Torr) Gray
Sedge	<i>Carex stenophylla</i> Wahl
Rush	<i>Juncus ater</i> Rydb
Spurge	<i>Euphorbia serpyllifolia</i> Peis

## SECONDARY SPECIES

Pepperwied	<i>Lepidium Jonesii</i> Rydb
Dock	<i>Rumex mexicanus</i> Moiss
Lambs quarters	<i>Chenopodium Watsonii</i> A Nels
Lambs quarters	<i>Chenopodium leptophyllum</i> Nutt
Evening primrose	<i>Anogon coronopifolia</i> (T & G) Brit
White evening primrose	<i>Anogon pallida</i> (Lind) Brit
Sand hll	<i>Nuttallia densa</i> Greene
Russian thistle	<i>Salsola pestifer</i> A Nels
Tall groundsel	<i>Senecio spartioides</i> T & G
Aster	<i>Aster Kunzei</i> Fries
Tansy aster	<i>Machaeranthera parviflora</i> Gray
Bahia	<i>Bahia oppositifolia</i> Nutt
Pingue	<i>Hymenocys floribunda</i> (Gray) Ckil
Green sage	<i>Artemisia aromatica</i> A Nels
Indian milk	<i>Erivoma cuspidata</i> Nutt
Inland cord grass	<i>Spartina gracilis</i> Trin
Dwarf muhlenbergia	<i>Muhlenbergia squarrosa</i> (Trin) Rydb
Slender wheat grass	<i>Agropyron tenerum</i> Vasey
Western couch grass	<i>Agropyron pseudorepens</i> S & S
Sitanon	<i>Sitanon brevifolium</i> J G Smith
Sitanon	<i>Sitanon longifolium</i> J G Smith
Sitanon	<i>Sitanon hystrix</i> (Nutt) Smith

The appearance of the greasewood type varies considerably due to the variation in the depth to the water table and in the salt concentration of the soil In places greasewood forms almost pure stands growing densely to a height of 3 to 5 feet (Figure 7) In places the stand is much more open (Figure 8) Tall rabbitbrush, shadscale, salt grass, alkali sacaton, western wheat grass and muhlenbergias

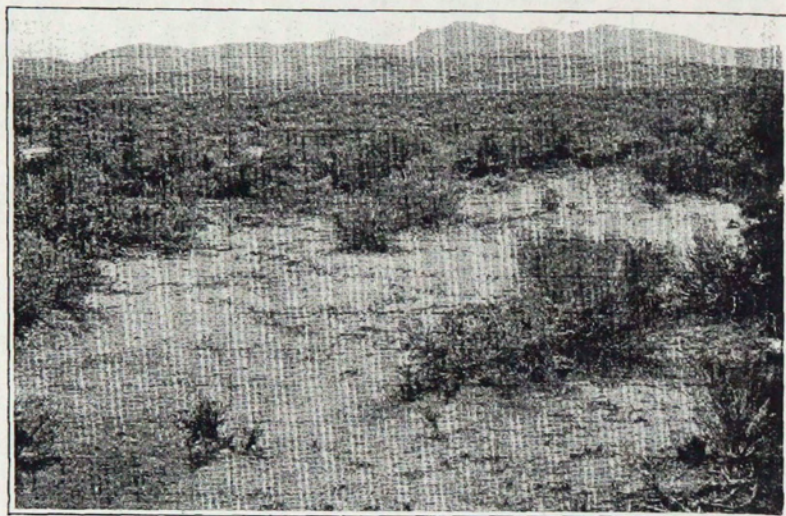


Figure 7.—The greasewood type about 5 miles south of Saguache. Saguache Hills in the background. Shrubs are chiefly greasewood and tall rabbitbrush. Soil is eroding in foreground due to lack of cover.

are the chief plants associated with greasewood. Others, given in the list above are usually less numerous. In other places greasewood is being replaced by salt grass (Figure 9) probably due to excessive soil moisture, and western wheat grass may form almost pure stands



Figure 8.—The greasewood type of vegetation near Alamosa. The shrubs are chiefly greasewood with some tall rabbitbrush. The large grass clump in the foreground is alkali sacaton. Salt grass and western wheat grass form the grassy spot in the center covered with snow.

in slight depressions surrounded by greasewood (Figure 10). Extensive native-hay meadows are common in this type (Figures 6 and 11). These are treated in detail later.

Greasewood is characterized by its woody, light-colored, scraggly and spiny branches and pale green, slender, fleshy leaves about 1 inch long. The leaves are salty to the taste. The stamens and pistils are produced in separate flowers. The staminate flowers, arranged in spikes at the tips of the stems, form a very characteristic shape. The species name, *vermiculatus*, meaning "marked with tortuous impressions as if worm-eaten" refers to these flower clusters. Wind is important in the dispersal of the fruit because winged margins up to one-half inch long are attached to it.



Figure 9.—In the greasewood type east of Alamosa. Salt grass forms most of the vegetation here, greasewood is dead or dying.

Greasewood usually indicates an excess of salts in the soil as well as a permanent source of moisture within reach of its roots. Kearney et al. <sup>12:403</sup> state that, "in its ability to endure the presence of alkali it is surpassed by few other flowering plants." At Grand Junction, Colorado, seedlings were found growing in soil with a salt concentration as high as 2.5 percent. When the soil is moist to the surface thruout the growing season the plants are not so thrifty as where the surface foot is fairly dry (Figure 9). Large plants, associated with rabbitbrush, occur on the incipient sand dunes, especially northeast of Alamosa. The presence of shadscale and rabbitbrush, in mix-

ture with greasewood, indicates drier soil and less alkalinity than where greasewood grows alone or is mixed with grasses as salt grass and alkali sacaton.

The young branches of greasewood are grazed by sheep and cattle, especially during the winter. They form in places an important part of the winter forage for sheep, but in general their palatability is very low. Under certain conditions sheep have been poisoned by eating them. Poisoning occurs only when large amounts of the plant, at least 1.5 pounds per hundredweight of the animal, are eaten in a short time. If eaten slowly or eaten with other feed there are no injurious results.

In the region where the characteristic vegetation is the greasewood type, abandoned fields are at first covered with annual weeds, as Russian thistle and lamb's quarters, as well as seedling greasewoods. In a short time greasewood becomes dominant. Robbins<sup>17:44</sup> states that greasewood has been widening its limits in the valley and that "seeped" land "invariably runs to an almost pure stand of greasewood within 20 to 25 years." Aldous and Shantz<sup>11:10</sup> say, "under the proper system of irrigation land of this type will produce good crops, but unless drainage is supplied it is likely to develop excessive quantities of alkali." Summers and Smith in the bulletin, "An Agricultural Program for the San Luis Valley of Colorado,"<sup>20:19</sup> show the advisability of changing the system of sub-irrigation to the flood and row method, of throttling down or shutting off artesian wells when they are not needed and of improving drainage systems. All of these measures would tend to improve the forage because the lowering of the water-table and the decreasing of the alkalinity would enable more valuable forage species, as gramagrass, to grow where greasewood now is dominant.

Salt grass (Figure 9), a common species growing in the greasewood type, is a perennial grass spreading by means of rather shallow, vigorous rootstocks or rhizomes. The harsh, salty leaves rarely grow over 8 inches tall. The pistils and stamens are borne in separate flowers on different plants. Salt grass covers a considerable area in western United States, especially in the Great Basin. It is one of the most alkali-enduring of the grasses, usually growing on soil with a shallow water-table. This grass is also very drought-resistant. It usually indicates even more strongly than greasewood, that the land on which it is growing must have the water-table lowered and the alkali leached out before it can be cropped. Salt grass when young is palatable to cattle and horses. As it grows older, however, it becomes tough and wiry. It will endure very close grazing. It is advisable to graze it closely because if the stock, cattle or horses, eat it before it dries out, they will eat the new growth as it is pro-

duced. Under close grazing it tends to form a dense sod. In pure stands it has a grazing capacity during the summer of 5 to 15 acres per head but in mixture with greasewood where it may be much less dense, 20 to 65 acres per head are required.

Alkali sacaton or tussock grass (Figure 8) another prominent species in the greasewood type, is a coarse perennial bunch grass forming mats or tussocks a foot and more in diameter at the base. It grows to a height of 3 feet with a finely branched, widely spreading flower cluster or inflorescence, often purplish in color. It is widely distributed in southwestern United States, forming an important element in the forage especially in New Mexico and Arizona. It is very tolerant of alkali but less tolerant of a shallow water-table than salt grass. It grows especially well on alkali soil that receives some flood water. When young and green it is readily grazed by horses and cattle. It should be fairly closely grazed so that new shoots continue to grow out. If the shoots become old and dry it is coarse and woody. In places, when closely grazed, it tends to form a sod instead of bunches. It is very resistant to close grazing and trampling but since it is one of the most important range grasses on areas where it grows it should not be grazed so closely that its vigor is impaired. The grazing capacity of good stands of this grass varies from about 6 to 15 acres per head during the summer, but when it is mixed with greasewood and there is considerable bare soil, the grazing capacity is much less.

Western wheat grass or bluestem (Figures 10 and 21), another important forage plant in the greasewood type, is a long-lived peren-



Figure 10.—A slight depression in the greasewood zone, northeast of Alamosa, occupied chiefly by western wheat grass (tall), Richardson's muhlenbergia and sedges (low). Such areas yield considerable forage.

nial, spreading by means of vigorous rootstocks. It forms rather open stands composed of uniformly scattered single stalks. It grows on a great variety of soils but is most common on those that are clayey, deep and fairly moist. It endures drought and alkali very well, growing in soil containing as much as 2 percent white alkali. In the San Luis Valley, however, it usually indicates less alkali and a deeper water-table than alkali sacaton and salt grass.

Wheat grass grows usually to a height of 1 to 2 feet, but under especially favorable conditions, to over 3 feet. The leaves are fairly rigid and thick, but not coarse. It is highly nutritious and palatable to both cattle and sheep, being surpassed by few other range grasses. It remains green for a long time, the seed maturing rather late. The herbage cures well on the ground and forms excellent winter feed. Sheep are especially fond of the heads. The amount of forage produced is closely dependent upon soil moisture. In dry seasons the production of seed and herbage is greatly decreased. The grazing capacity varies with density of stand, moisture, alkali and other conditions, ranging from 10 or 12 to over 50 acres per head of cattle during the season. In many places hay of good quality has been cut from this grass. Overgrazing reduces the stand rapidly and, in time, kills it out. The first effects are reduction in number and size of fruiting heads or spikes and in the density of the stand. It responds rapidly to proper grazing methods by spreading vigorously, thus checking the growth of undesirable plants, increasing in density and height; all of these resulting in increasing the grazing capacity.

The other plants growing in this type of vegetation are less abundant but in the aggregate they form a large amount of forage. Some of the more important of these are sand drop-seed, sedges, rushes and Russian thistle. Others as Indian millet, slender wheat grass and western couch-grass, while being highly palatable are usually too scarce to be very important as forage. Weeds, such as lamb's quarters, dock, Russian thistle, evening primrose, pepper weeds and asters are important forage plants for sheep. On abandoned fields these are often very abundant. Later, however, greasewood and the grasses gradually replace most of the weeds. The species of *Sitanion*, sometimes called squirrel-tail, are eaten to some extent early in the season before the seeds become ripe. The awns attached to the grain are troublesome to stock because they work into the gums and tongues causing inflammation or ulcers. After the time of seed maturity these grasses are usually of little value because of the harshness of the leaves.

Every plant has a story to tell about the environment, especially soil conditions, under which it is growing<sup>1, 6, 12</sup>. This story or indicator significance, is of great help in interpreting conditions

over an area as well as in utilizing the land to its fullest extent. The indicator significance of the plants in the greasewood type is particularly important. A high concentration of salts in the surface soil, as well as a very shallow water table, are indicated by greasewood, salt grass and alkali sacaton (Figure 8). Western wheat grass indicates less alkali and, in good stands, a deep, clayey moist soil (Figure 10). Rabbitbrush and shadscale indicate a deeper water table and usually less alkali than greasewood. The sedge, *Carex stenophylla*, indicates a rather dry, often gravelly, soil. Indicators of sandy soil are sand drop seed, purple hair grass, inland cord grass and Indian millet (Figures 5 and 12). Weeds especially Russian thistle, evening primroses and lamb's quarters, indicate disturbance of natural soil conditions such as plowing, rodent activity, etc.

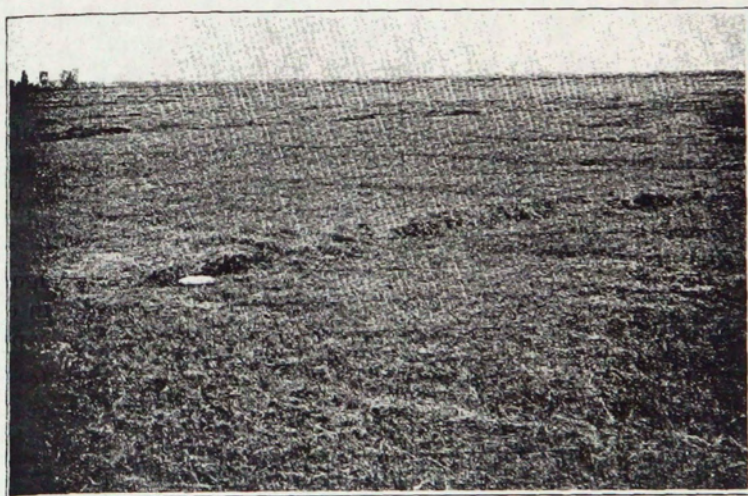


Figure 11—A hay meadow southeast of Alamosa in the greasewood type. The chief grasses in the meadows are redtop, timothy, western wheat grass, tufted annual dropseed, squirrel tail grass and a rush.

**HAY MEADOWS**—Hay meadows composed chiefly of native plants are numerous and often large in the valley. They are irrigated by means of flowing wells (Figure 6) or from streams (Figure 11) and support a large number of species. Many of these plants are given in the following list, arranged according to abundance.

COMMON AND ABUNDANT

Redtop	<i>Agrostis alba</i> L.
Western wheat grass	<i>Agropyron Smithii</i> Rydb.
Timothy	<i>Phleum pratense</i> L.
Tufted annual drop seed	<i>Sporobolus confusus</i> (Fourn.) Vasey
Squirrel tail grass	<i>Hordeum jubatum</i> L.
Rush	<i>Juncus longistylis</i> Torr.



## FREQUENT

Alkali sacaton	<i>Agropyron violaceum</i> (Hornem) Lange
Slough grass	<i>Muhlenbergia Richardsonii</i> (Trin) Rydb
Violet wheat grass	<i>Sporobolus airoides</i> Torr
Muhlenbergia	<i>Beckmannia erucaeformis</i> (L) Host
Winter red top	<i>Agrostis hiemalis</i> (Walt) B S P
Rush	<i>Juncus nodosus</i> L
Spike rush	<i>Eleocharis ovata</i> (Roth) R & S
Blue flag	<i>Iris missouriensis</i> Nutt
Water parsnip	<i>Sium cicutaefolium</i> (Gmelin)
Wild lettuce	<i>Lactuca pulchella</i> (Pursh) DC
False dandelion	<i>Troximon arizonicum</i> Greene
Wild clover	<i>Trifolium oxylon</i> Greene
Wild buckwheat	<i>Polygonum montanum</i> (Small) Greene
Wild aster	<i>Aster ascendens</i> Lindl

## INFREQUENT TO RARE

Kentucky blue grass	<i>Poa pratensis</i> L
Manna grass	<i>Panicularia grandis</i> (S Wats) Nash
Gramagrass	<i>Bouteloua gracilis</i> (H B K) Lag
Rush	<i>Juncus alii</i> Rydb
Hedge nettle	<i>Stachys palustris</i> L
Wild hennip	<i>Glucyrrhiza lepidota</i> Pursh
Willow herb	<i>Epilobium adenocaulon</i> Haussk
Dogbane Indian hemp	<i>Ipocimium hypericifolium</i> Jacq
Wild aster	<i>Aster armeriaefolius</i> Greene
Plantain	<i>Plantago nitrophila</i> A Nels
Milk vetch	<i>Astragalus hypoglottis</i> L
Locoweed	<i>Agallus difleris</i> (DC) Heller
Vetch	<i>Vicia angustifolia</i> (L) Reich
Cinquefoil	<i>Potentilla propinqua</i> Rydb
Cinquefoil	<i>Potentilla monspeliensis</i> L
Sidalcea	<i>Sidalcea neo-mexicana</i> Gray
Orthocarpus	<i>Orthocarpus hirtus</i> Nutt
Fleabane	<i>Erigeron lonchophyllus</i> Hook
Hawksbeard	<i>Crepis sp</i>
Golden dock	<i>Rumex persicarioides</i> L
Cress	<i>Roripa curvipes</i> Greene
Golden Pea	<i>Thermopsis montana</i> Nutt
Yarrow	<i>Achillea millefolium</i> L
Black eyed Susan	<i>Rudbeckia flavo</i> Moore
Agoseris	<i>Agoseris pauciflora</i> (Nutt) Dietr
Gentian	<i>Gentiana strictiflora</i> (Rydb) A Nels

The kind of plants found in the meadows varies with the moisture supply, salt concentration and other factors. The large number of broad leaved plants that may be found is striking. Not very many species of grasses and grass like plants are found. The most common are redtop, timothy and western wheat grass. Clovers are not abundant. The rushes and sedges usually are valuable because their seeds are very nutritious and fattening. The broad leaved herbs as false dandelion, asters, plantains, agoseris, etc., are very palatable if well cured. Many of these plants are native to the slopes surrounding the valley. The seeds have been carried into the meadows usually with the irrigation water.

**TALL RABBITBRUSH GREASEWOOD TYPE**—This type of vegetation is found usually along the margin of the greasewood (Figure 2), or it may occur on the valley floor itself if the water table is somewhat

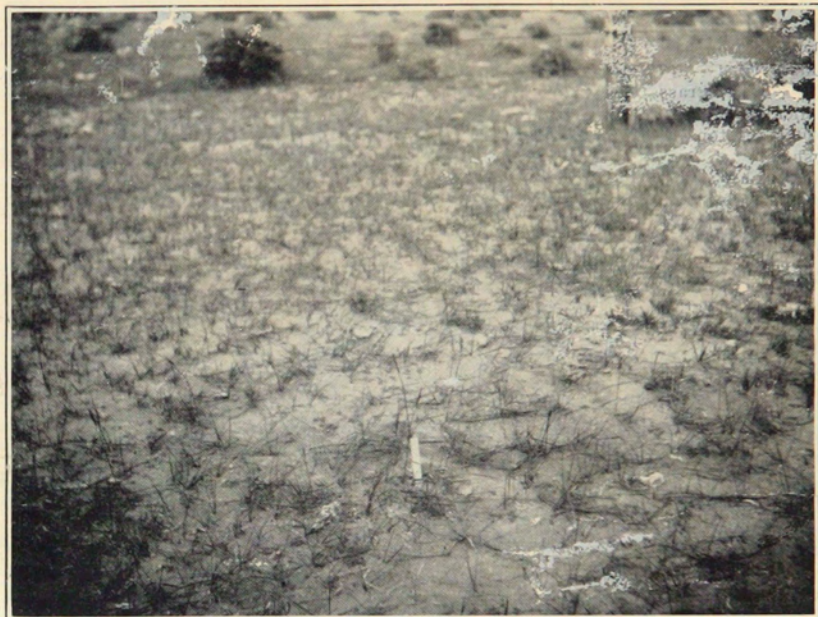


Figure 12.—A sandy area northeast of Alamosa, in the rabbitbrush-greasewood zone occupied chiefly by inland cord grass. This grass, spreading by rootstocks, is well adapted to this soil.

deeper and the alkali concentration somewhat lower. It varies greatly in composition, in density and in height. In places greasewood is as abundant as the other shrubs; in other places it is almost lacking (Figure 14). Grasses may occupy considerable areas; salt grass on the more alkaline spots; sand drop-seed, blow-out grass, Indian millet and Indian cord grass on the sandy soil (Figure 12), western wheat grass on more clayey soil; and gramagrass, ring muhlenbergia, three-awn grass and false buffalo grass on dry, usually somewhat gravelly soil (Figure 13). Russian thistle and prickly pear may also be abundant on dry areas.

This great variation, due chiefly to soil conditions, is explained by the position of this type, usually between the greasewood and the low rabbitbrush-snakeweed-gramagrass type. The latter type, characterized by dry soil and good drainage, is discussed in detail below. The composition, then, of the tall rabbitbrush-greasewood type varies from the greasewood to the low rabbitbrush-snakeweed-gramagrass zone. Nearly all of the plants occurring in these latter two types may be found somewhere in the tall rabbitbrush-greasewood. The following list, therefore, gives only some of the most important and characteristic species in this type.



Figure 13.—Tall rabbitbrush-greasewood type of vegetation, west of Blanca. Shrubs are chiefly rabbitbrush. Ring muhlenbergia, gramagrass, false buffalo grass and three-awn grass are the chief grasses. Prickly-pear cactus is abundant in background between the shrubs.

#### DOMINANT SPECIES

Rabbitbrush	<i>Chrysothamnus Bigelovii</i> (Gray) Greene
Rabbitbrush	<i>Chrysothamnus pulcherrimus</i> A. Nels.
Shadscale, Chamisa	<i>Atriplex canescens</i> (Pursh.) Nutt.
Greasewood	<i>Sarcobatus vermiculatus</i> (Hook.) Torr.

#### PRIMARY SPECIES

Western wheat grass	<i>Agropyron Smithii</i> Rydb.
Muhlenbergia	<i>Muhlenbergia Richardsonis</i> (Trin.) Rydb.
Ring muhlenbergia	<i>Muhlenbergia gracillima</i> Torr.
Blow-out grass	<i>Muhlenbergia pungens</i> Thurb.
Sand drop-seed	<i>Sporobolus cryptandrus</i> (Torr.) Gray
Sedge	<i>Carex stenophylla</i> Whal.
Rush	<i>Juncus ater</i> Rydb.
Gramagrass	<i>Bouteloua gracilis</i> (H. B. K.) Lag.
Three-awn grass	<i>Aristida Fendleriana</i> Steud.

#### SECONDARY SPECIES

Indian millet	<i>Eriocoma cuspidata</i> Nutt.
Inland cord grass	<i>Spartina gracilis</i> Trin.
Evening primrose	<i>Anogra pallida</i> (Lind.) Brit.
False buffalo grass	<i>Munroa squarrosa</i> (Nutt.) Torr.
Alkali sacaton	<i>Sporobolus airoides</i> Torr.
Tall groundsel	<i>Senecio spartioides</i> T. & G.
Prickly pear	<i>Opuntia polyacantha</i> Haw.
Russian thistle	<i>Salsola pestifer</i> A. Nels.

The two species of rabbitbrush, *Chrysothamnus Bigelovii* and *C. pulcherrimus* and shadscale or chamisa, are the most characteristic plants in this type. These, with greasewood, grow to a height of 2 to 5 feet (Figure 14). The most valuable for grazing is chamisa.



Figure 14.—Tall rabbitbrush-greasewood type northeast of Alamosa. The dense growth of the shrubs, chiefly rabbitbrush with some greasewood, prevents a good stand of gramagrass which does occur in the openings. Many cattle are grazing in the grassy valley in the background.

It is browsed rather extensively by both cattle and sheep. The various species of rabbitbrush, as a rule, are but little palatable. The grazing value of this type depends chiefly upon the kind of grasses that occur. As stated above, these vary considerably depending upon soil conditions. The most valuable grasses are western wheat grass and gramagrass.

The indicator significance of the plants in this type is very important, because of the great variation that occurs, from a highly alkaline soil with a shallow water-table to dry gravelly soil with little or no alkali. Tall rabbitbrush and chamisa usually indicate excessive alkali but the abundance of greasewood is one of the best indicators for alkali and the depth to the water-table. Where it is very scarce soil conditions are much better as a rule than where it is abundant. The grasses in this type are very important indicators. Gramagrass, especially, is important because it indicates no, or extremely little, alkali. The indicator values of the various species are discussed in more detail under the preceding and following types.

**LOW RABBITBRUSH-SNAKEWEED-GRAMAGRASS TYPE.**—This is the most valuable grazing type in the valley. It forms a zone, varying considerably in width, at the base of the mountains, between the tall rabbitbrush-greasewood zone below and the pinyon-juniper or sagebrush zones above. As shown in Figures 2 and 3, it occupies the lower parts of the alluvial fans as they rise above the area of flowing wells (see map, Figure 1). A large portion of the southern part of the valley, outside the limits of the flowing wells, is also covered with



Figure 15.—The border zone between the low rabbitbrush-snakeweed-gramagrass and the pinyon-juniper types near Mirage P. O. The abundance of grama-grass and the scattered low rabbitbrush in the foreground forms excellent range vegetation.

this type. The type as a whole indicates a soil that is well-drained, rather gravelly (Figures 15, 16, 17), free from alkali and with limited soil moisture. The following list classifies the plants according to abundance and importance.

#### DOMINANT SPECIES

Rabbitbrush	<i>Chrysothamnus Parryi</i> (Gray) Greene
Rabbitbrush	<i>Chrysothamnus Vaseyi</i> (Gray) Greene
Rabbitbrush	<i>Chrysothamnus filifolius</i> Rydb.
Rabbitbrush	<i>Chrysothamnus elegans</i> Greene
Rabbitbrush	<i>Chrysothamnus Bigelovii</i> (Gray) Greene
Snakeweed	<i>Gutierrezia diversifolia</i> Greene
Gramagrass	<i>Bouteloua gracilis</i> (H.B.K.) Lag.
Ring muhlenbergia	<i>Muhlenbergia gracillima</i> Torr.
Winter fat, white sage	<i>Eurotia lanata</i> (Pursh.) Moq.
Shadscale	<i>Atriplex canescens</i> (Pursh.) Nutt.
Apache plume	<i>Fallugia paradoxa</i> (Don.) Endl.

#### PRIMARY SPECIES

Three-awn grass, wire grass	<i>Aristida Fendleriana</i> Steud.
Western wheat grass	<i>Agropyron Smithii</i> Rydb.
Drop-seed	<i>Sporobolus Wolfii</i> Vasey
Sand drop-seed	<i>Sporobolus cryptandrus</i> (Torr.) Gray
Drop-seed	<i>Sporobolus strictus</i> (Scrib.) Merr.
Richardson's muhlenbergia	<i>Muhlenbergia Richardsonis</i> (Trin.) Rydb.
Prickly pear	<i>Opuntia polyacantha</i> Haw.
Scarlet mallow	<i>Malvastrum coccineum</i> (Pursh.) Gray.
Porcupine grass	<i>Stipa comata</i> (Trin.) Rupr.
Sand lily	<i>Nuttallia densa</i> Greene.

## SECONDARY SPECIES

Wild buckwheat	<i>Eriogonum effusum</i> Nutt.
Wild buckwheat	<i>Eriogonum Jamesii</i> Benth.
Golden pea	<i>Thermopsis arenosa</i> A. Nels.
False buffalo grass	<i>Munroa squarrosa</i> (Nutt.) Torr.
False sunflower	<i>Ximenesia exauriculata</i> (R. & G.) Rydb.
Lamb's quarters	<i>Chenopodium incanum</i> (S. Wats.) Heller
Indian millet	<i>Ericcoma cuspidata</i> Nutt.
Tall groundsel	<i>Senecio spartioides</i> T. & G.
Evening primrose	<i>Anogra pallida</i> (Lindl.) Britt.
Gilia	<i>Gilia laxiflora</i> (Coul.) Osterh.
Six-week's grass	<i>Bouteloua prostrata</i> Lag.
Slender-stemmed muhlenbergia	<i>Muhlenbergia filiculmis</i> Vasey
False oats	<i>Trisetum montanum</i> Vasey.
Russian thistle	<i>Salsola pestifer</i> A. Nels.
Pingue	<i>Hymenoxys floribunda</i> (Gray) Ckll.
Mountain sage	<i>Artemisia frigida</i> Willd.

At a distance this zone appears to be composed of grasses alone, (Figures 1 and 2), but this is rarely the case. The most common grouping is a scattered stand of low bushes, rabbitbrush and snake-weed, with short grasses, usually gramagrass, between (see Figures 13 and 14). In places the stand may be much denser (Figure 15); in others it may be almost pure gramagrass (Figures 16 and 17).

At least 5 species of rabbitbrush occur in this zone. All of these are low, only 6 inches to 2 feet tall, except one, *Chrysothamnus Bigelovii*, which is often 3 to 4 feet tall. The plants usually have numerous greenish or gray branches and form a more or less rounded shape. The leaves are narrow and usually rather viscid or sticky. The yellow flower heads do not have ray flowers and may be dis-



Figure 16.—Badly depleted range south of Monte Vista, in the low rabbitbrush-snakeweed-gramagrass type. Shrubs are chiefly low rabbitbrush and snakeweed. Ring muhlenbergia and gramagrass form small raised clumps. Jack rabbits and prairie dogs eat most of the grass.

tinguished readily from snakeweed which has such flowers. The palatability of most species of rabbitbrush is very low.

Snakeweed forms a rounded, shrubby tuft a foot or less high (Figure 16). The leaves are short and narrow. The yellow flower heads are abundant and have conspicuous rays. It is not palatable. Snakeweed is characteristic especially on gravelly soil. Under overgrazing it tends to increase in number.

Apache plume is an evergreen shrub, 3 to 6 feet high with many slender white branches. The small divided leaves are borne in small clusters. Many large white flowers cover the plant during the blooming season. Long feathery hairs, tinged with red, are attached to the fruit giving the plant a striking appearance when the fruit is ripe. It is a valuable browse plant for both cattle and sheep. It is found most abundantly along stream courses.

Perhaps the most valuable range grass in the valley is grama-grass, *Bouteloua gracilis* (Figures 19, 20, 22). In New Mexico, it has been claimed to be the most valuable forage plant in the state. It is a vigorous grass, spreading by means of strong rootstocks as well as by seed. Usually it grows in the form of tufts but may form a sod under more favorable conditions. The height of the plant varies considerably due to soil moisture. In favorable seasons the stems



Figure 17.—A dense stand in the low rabbitbrush-snakeweed-gramagrass type of vegetation near Crestone. Gramagrass is abundant and thrifty, rabbitbrush and prickly-pear cactus are abundant. Pinyon-juniper zone and Sangre de Cristo Mountains in the background.

may be over 18 inches tall, in dry seasons only 6 inches. Flower-stalk production is much less in dry seasons than in moist ones. The leaves are usually abundant and in places have been cut for hay in very favorable years. When soil moisture is low the leaves may be much curled and lie close to the soil. This grass is highly palatable and nutritious. It withstands close grazing and trampling unusually well. It is one of the most drouth-resistant plants and can mature seed in about 60 days from the beginning of growth in the spring. Exceptionally nutritious winter forage is formed by this plant because it cures well on the ground. This forage is highly relished by stock. The grazing capacity of gramagrass ranges from 16 to 32 acres per head of cattle during the growing season.

Ring muhlenbergia (Figure 16), is one of the short grasses, usually associated with gramagrass. It is perennial, spreading by means of rootstocks, and forms small dense tufts. As it spreads radially the center may die so that rings up to 2 feet in diameter are formed. The leaves, varying from 1 to 4 inches in length, are rather stiff and rolled inward. The flower stalk is up to 10 inches tall, bearing a widely spreading flower cluster. This grass is better adapted to dry thin soil than gramagrass. It can grow in soil where the hardpan layer is so close to the surface that gramagrass is either absent or grows very poorly. It is of very little value for grazing because the leaves are usually too short and because it is pulled out of the soil readily. Under overgrazing it tends to replace gramagrass to some extent.

Richardson's muhlenbergia is less abundant than ring muhlenbergia. It is of minor importance for grazing because it usually is very short, producing little forage.

Three-awn grass is a perennial forming small bunches up to a foot in height. It grows especially on sandy or gravelly soils. The numerous basal leaves are 2 inches or less in length, narrow and rolled inwards. The grain bears a very characteristic three-branched awn. This awn often causes considerable injury to stock as it forces the sharply pointed grain into the gums and tongues as well as thru the skin of sheep. This grass should be particularly avoided in bedding grounds for sheep. Before the seeds are ripe the grass is often grazed rather closely. It may also be eaten somewhat after the fruit has been shed.

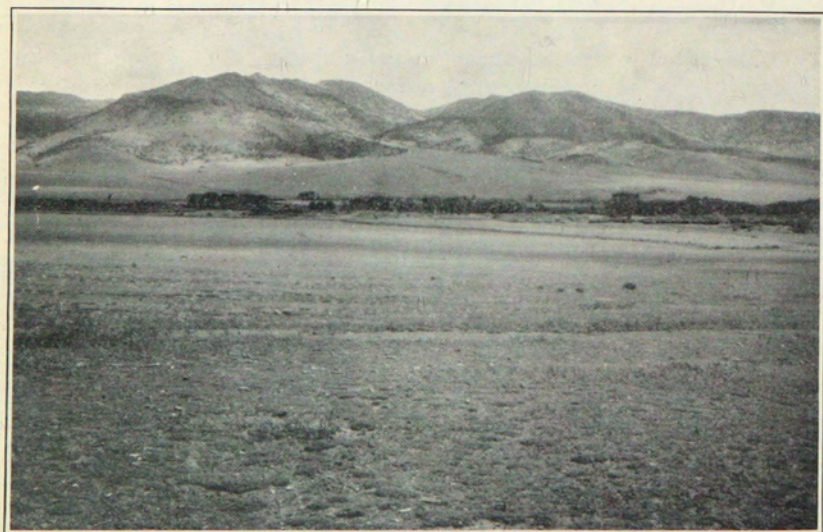
Porcupine grass is a very valuable range plant. It is an erect, fairly stout perennial growing in bunches up to about 3 feet tall. This grass requires more moisture than the grasses discussed above. It is one of the first grasses to turn green in the spring and remains green later in the fall than most grasses. Many leaves up to a foot in length are produced. Attached to the grain is a long twisted and curled awn, 5 inches or more long. This awn unwinds and twists



again with variations in moisture forcing the very sharply pointed seed into the soil or thru the membranes and skin of animals. It is particularly injurious to sheep. Before the grain is ripe porcupine grass is usually closely grazed. It is grazed again after the grain has been shed. It is usually the first grass to disappear under close grazing so that on most ranges where it can grow it is much less abundant than formerly.

Most of the other plants growing in this zone have very little grazing value. Usually they are not grazed unless the forage is very scant. Lamb's quarter, evening primrose, Russian thistle and the wild buckwheats, however, are fairly good, especially for sheep. The grasses—six-week's grama, false buffalo grass and slender-stemmed muhlenbergia—are too short and pull out of the ground too easily to be of much importance. Indian millet and false oats are of more value since they are well-rooted bunch grasses but usually they are very scattered.

Pingue, or Colorado rubber plant, is injurious to sheep (Figures 21 and 22). It usually grows in dry gravelly soil. It is a perennial herb growing to a height of 4 to 12 inches. The numerous leafy branches form a rounded, often flat-topped, clump, and in the blooming season are covered with a profusion of golden-yellow flowers. Pingue belongs to the composite or aster family. Marsh<sup>13:30</sup> states



**Figure 18.**—Alluvial fans from the Saguache Hills covered with almost a pure stand of gramagrass, in the low rabbitbrush-snakeweed-gramagrass type. Thin stand of trees on southerly slopes of hills are pinyons and junipers. In the valley of Saguache Creek are hay meadows and other crop land. The trees are chiefly cottonwoods, willows and alders.

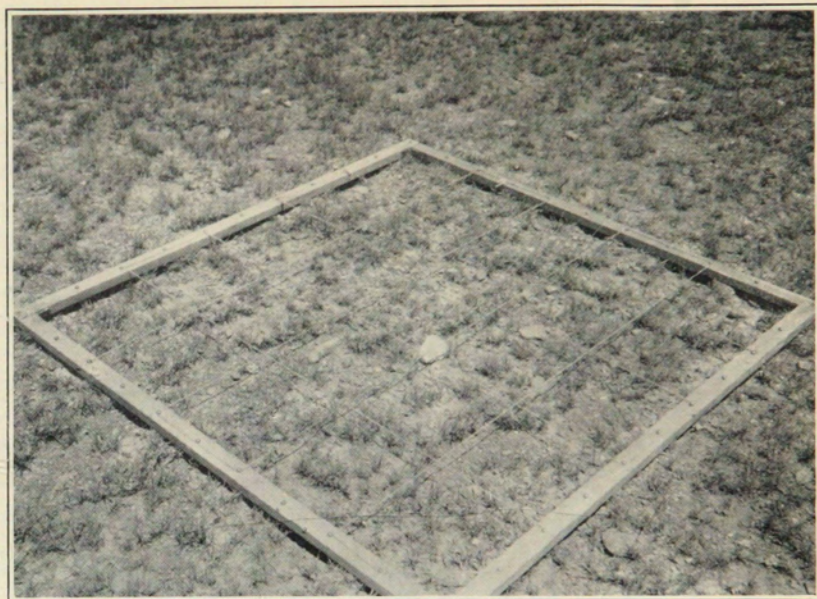


Figure 19.—A quadrat (one meter square) showing detail of vegetation on an alluvial fan shown in Figure 18. A thin stand of almost pure gramagrass on a gentle south slope west of Saguache.



Figure 20.—Range land west of Saguache badly infested with prickly-pear cactus. Such infestations are usually due to over-grazing. Gramagrass is the chief plant between the cactus clumps. Destruction of the cactus would increase the stand of grass. Low rabbitbrush-snakeweed-gramagrass type of vegetation.

that sheep do not graze it readily and "it is doubtful whether there would be any loss from this plant if bands were properly fed."

The indicator significance of plants in the low rabbitbrush-snakeweed-gramagrass type is very important because soil and grazing conditions vary considerably. An abundance of shrubs usually indicates a fairly deep soil (Figure 17). Tall rabbitbrush, shadscale and Apache plume indicate more moisture than low rabbitbrush. A fairly deep soil with good moisture conditions most of the summer can be expected where porcupine grass and western wheat grass are fairly abundant (Figure 21). Gramagrass indicates a soil that may be compact, fairly shallow and in which moisture is available for growth only in the forepart of the growing season (Figures 18 and 19). Thin dry soils usually underlie ring, Richardson's and slender-stemmed muhlenbergia, as well as six-week's grass (Figure 16). False buffalo grass is found usually on disturbed soil around prairie-dog holes but occurs also on dry thin soils (Figure 16). Indicators of sandy soils are sand drop-seed, sand lily and especially Indian millet. Snakeweed and three-awn grass often characterize gravelly soils not too scarce in moisture.

Some plants, when they are abundant or are increasing over an area, are very good indicators of overgrazing. The best in this type are prickly pear cactus (Figures 17 and 20), snakeweed, three-awn grass and rabbitbrush. An increase in other unpalatable weeds

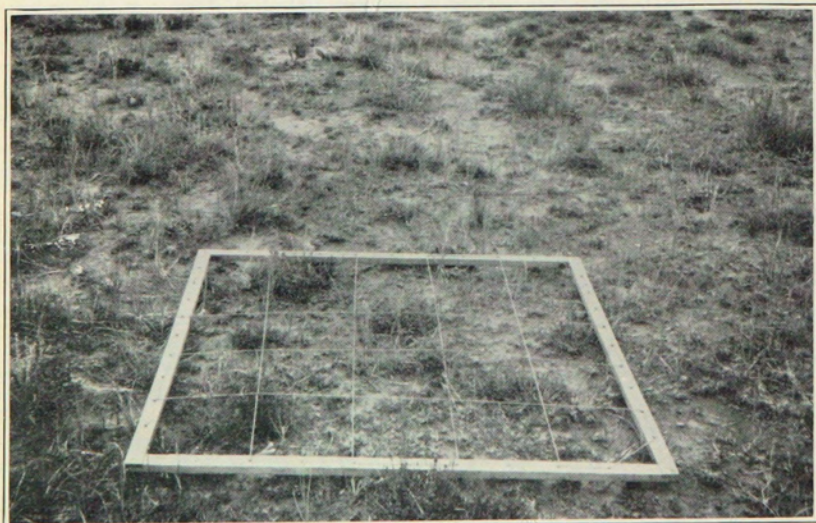


Figure 21.—A quadrat showing detail of forage in the low rabbitbrush-snakeweed-gramagrass type in the north end of the valley near Villa Grove. The tall grass is western wheat grass and the low one gramagrass. The bushy plants are chiefly pingue (dark-colored) and mountain sage (light-colored). The two grasses are excellent forage plants.

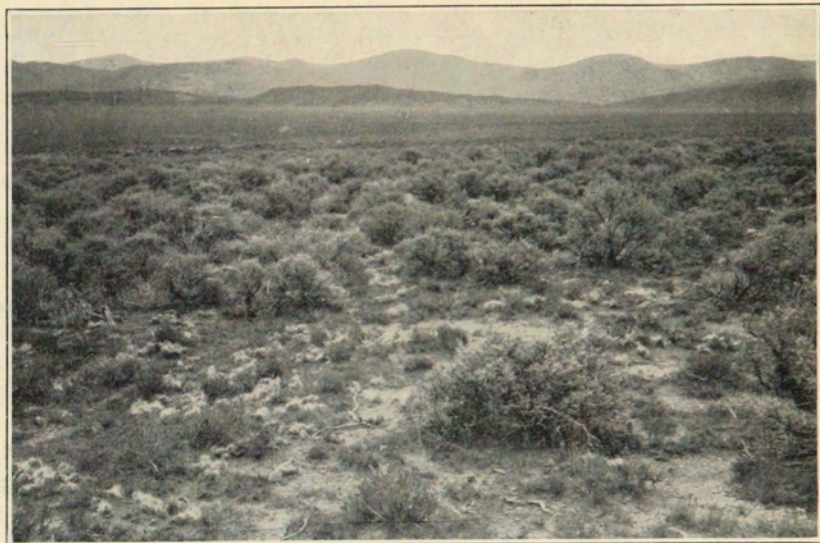


Figure 22.—Sagebrush type near San Luis. The chief plants in this type of vegetation are sagebrush with gramagrass, prickly-pear cactus, snakeweed and pingue in the openings. Destruction of the sagebrush leads to an increased growth of grass.

and shrubs, as well as a decrease in the amount of porcupine grass, winter fat and western wheat grass tell the same story.

SAGEBRUSH TYPE.—This type is best developed and most exten-

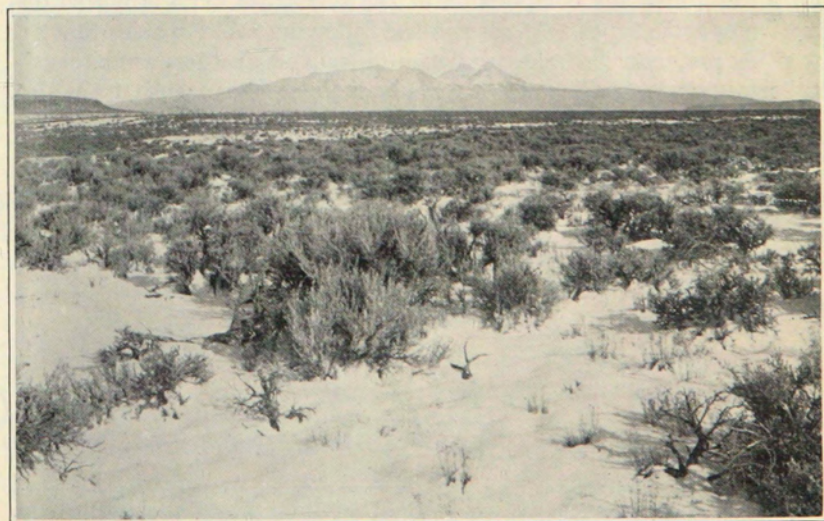


Figure 23.—Sagebrush range near San Luis. Old Baldy and Mt. Blanca in the background. Such range in winter may furnish much forage when other more palatable plants are covered with snow.

sive in the southeastern part of the San Luis Valley, extending southward from Fort Garland. It is especially well developed in the vicinity of San Luis (Figures 22 and 23). Sagebrush is found also to a limited extent in the extreme northern end of the valley, north of the town of Alder. Typically, it consists of a scattered stand of sagebrush 2 to 5 feet tall. The bushes are sometimes so close together that branches of neighboring plants may touch each other but usually the openings between the plants or groups of plants are several feet in diameter. In these openings grasses, half shrubs, cacti and forbs\* grow rather sparsely. Other tall shrubs as rabbitbrush and shadscale are rare.

Toward the center of the valley this type is bordered by the low rabbitbrush-snakeweed-gramagrass type. Frequently toward the lower limits large patches of gramagrass may occur between clumps of sagebrush. On the outer higher margin its contact in the southeastern part of the valley is with the pinyon-juniper type. In the north end it usually meets oak scrub. Usually the line separating sagebrush from woodland is not abrupt but one type gradually replaces the other. The pinyons are often very scattered and most of the openings are covered with sagebrush. At the elevation increases the pinyons gradually become denser and the sagebrush less abundant until the latter disappears entirely:

On account of this overlapping in distribution with the higher and lower zones, the composition of the sagebrush type is not so distinctive as some types. As seen in the following table, species that are more characteristic of the pinyon-juniper and the low rabbitbrush-snakeweed-gramagrass zones are common in the sagebrush type also.

## DOMINANT SPECIES

Sagebrush	<i>Artemisia tridentata</i> Nutt.
Rabbitbrush	<i>Chrysothamnus lanceolatus</i> Nutt.
Rabbitbrush	<i>Chrysothamnus Parryi</i> (Gray) Greene
Rabbitbrush	<i>Chrysothamnus filifolius</i> Rydb.
Shadscale	<i>Atriplex canescens</i> (Pursh.) Nutt.

## PRIMARY SPECIES

Gramagrass	<i>Bouteloua gracilis</i> (H. B. K.) Lag.
Mountain muhlenbergia	<i>Muhlenbergia gracilis</i> Trin.
June grass	<i>Koeleria cristata</i> (L.) Pers.
Sitanion	<i>Sitanion montanum</i> J. G. Smith
Sandwort	<i>Arenaria Fendleri</i> A. Gray.
Western wheat grass	<i>Agropyron Smithii</i> Rydb.
Androsace	<i>Androsace filiformis</i> Retz.
Pingue, Colorado rubber plant	<i>Hymenoxys floribunda</i> (Gray) Ckll.

\*Forbs is a term that has been coined by Dr. F. E. Clements to designate flowering plants other than grasses and grasslike plants as sedges and rushes. The Forest Service uses the word "weeds" in a similar sense. Forbs is used in this bulletin because some such term is needed and there are too many objections to the use of "weeds" in this connection.

Lupine	<i>Lupinus argophyllus</i> (Gray) Ckll.
Mountain sage, "Estafiata"	<i>Artemisia frigida</i> Willd.
Indian tobacco	<i>Antennaria aprica</i> Greene.
Sub-alpine porcupine grass	<i>Stipa minor</i> (Vasey) Scribn.
	SECONDARY SPECIES
Wild buckwheat	<i>Eriogonum subalpinum</i> Greene
Toad-flax	<i>Comandra pallida</i> A. DC.
Cinquefoil	<i>Potentilla propinqua</i> Rydb.
Milk vetch	<i>Astragalus hypoglottis</i> L.
Locoweed, "Rattleweed"	<i>Aragallus Lambertii</i> (Pursh.) Greene
Painted cup	<i>Castilleja linariaefolia</i> Benth.
Beard-tongue	<i>Pentstemon pseudohumilis</i> Rydb.
Orthocarpus	<i>Orthocarpus luteus</i> Nutt.
Fleabane	<i>Erigeron flagellaris</i> Gray.
Fleabane	<i>Erigeron consobrinus</i> Greene
Tetranneuris	<i>Tetranneuris simplex</i> A. Nels.
Groundsel, squaw-weed	<i>Senecio ob lanceolatus</i> Rydb.
Indian millet	<i>Eriocoma cuspidata</i> Nutt.

Sagebrush (Figure 22), sometimes called black sagebrush, is a much-branched shrub with grayish white to dark brown or black stems. The small gray leaves are usually three-toothed at the tip. The rather inconspicuous yellow flowers appear late in the summer. The "sage" odor of leaves and stems is very characteristic. Tall dense sagebrush usually grows on deep fertile soil free from alkali. Soil moisture is available for growth at least in the deeper layers thruout the summer. Perhaps the limited distribution in the valley may be explained by these soil relations. The soil may be too shallow and may dry out too rapidly to support sagebrush on the lower edges of the pinyon-juniper zone in most parts of the valley as around Del Norte, Saguache, etc. It is not very palatable to stock. It is grazed more in winter than in the summer by cattle and sheep. The chief value of the plant is as a filler. When the low palatable plants are covered with snow in the winter, sheep often depend considerably upon sagebrush.

Mountain muhlenbergia is a very important range grass because of its high palatability, wide distribution and resistance to grazing. It is a perennial, growing in dense tufts up to about 2½ feet tall. Many narrow leaves are borne on each plant. The flower cluster or panicle is narrow and is characterized by many, somewhat curled, short awns. It grows on rocky to sandy soils.

June grass is another very valuable range plant in the sagebrush type. It is a perennial, growing in small tufts, usually 1 to 2 feet tall. There is an abundance of soft leaves attached to the base of the plant. The compact spike-like flower cluster is characteristic. It is fairly drought-resistant. In palatability and nutritiousness it ranks very high among the grasses.

Sub-alpine porcupine grass, *Stipa minor*, is similar in many ways to porcupine grass, *Stipa comata*. It is very palatable and nutritious,

becoming green early and remaining so later than most grasses. It forms dense tufts up to 3 feet tall. The awns are much shorter, about an inch long, and cause but very little damage compared to the long awns of other porcupine grasses.

A number of other palatable plants occur in the sagebrush type. Some of the most important of these are gramagrass, western wheat grass, Indian millet, sandwort, cinquefoil, painted cup, fleabane and groundsel. Several poisonous plants occur: Pingue, lupine and locoweed.

Lupine belongs to the pea family and has typical pea-like flowers arranged in a rather large, conspicuous cluster at the tip of the stems. The leaf is very characteristic, the five or more parts, leaflets, being borne on the apex of the leaf stalk. The most poisonous parts of the plant are the seeds and pods. Lupine is more dangerous after the blooming period. Losses from poisoning are usually confined to sheep, especially in late summer and fall, but horses may also be poisoned if they eat enough of the plant.

Locoweed, *Aragallus Lambertii*, is considered the most destructive of the locoweeds. It belongs to the pea family. It is a stemless perennial, highly resistant to drought, with a very well-developed root system. The leaflets are scattered along the main axis of the leaf similar to the arrangement of the rose or ash leaf. The leaflets are



Figure 24.—Overgrazed range in the pinyon-juniper type west of Saguache. Prickly-pear cactus has largely replaced gramagrass. Tall rabbitbrush in left foreground soapweed in left center. Trees are chiefly pinyons and occasional junipers.

rather narrow and somewhat hairy. The white-to-purple flowers are grouped in conspicuous spikes above the leaves. It is poisonous to horses, cattle, sheep and goats. All parts of the plant are injurious at all times of the year. There is greater danger of poisoning in the spring because it begins growth earlier than many palatable range plants.

**PINYON-JUNIPER TYPE.**—This type of vegetation usually forms a narrow zone, 8000 to 8500 feet in elevation above the low rabbitbrush-snakeweed-gramagrass zone (Figure 2), or the sagebrush type. The transition between the former and the pinyons is abrupt (Figure 15), but sagebrush and pinyons may alternate over rather large areas in the southeastern part of the valley (Figure 22). In the northern part of the valley oak brush may largely replace the pinyons (Figure 3) or alternate with them.

The pinyon-juniper type is composed chiefly of pinyons. The junipers are much less abundant and in many places almost absent. These trees are usually low and wide-spaced, the intervening areas occupied by grasses, especially gramagrass, or by a variety of shrubs, as rabbitbrush, snakeweed, sagebrush and scrub oak. On rocky portions of some of the alluvial fans, tall yellow pines are scattered, standing out prominently above the lower uniform layer of pinyons (Figure 2). Along streams aspens, alders, snowberries, wild gooseberries and many herbaceous plants are abundant, forming dense stands (Figure 25).



Figure 25.—Wild Cherry Creek in the pinyon-juniper zone near Mirage P. O. in the Sangre de Cristo Range. The trees are chiefly aspen and alder. Such vegetation is characteristic along the streams in this type.



Since soil moisture conditions vary from very wet along the streams to very dry on exposed ridges, a large variety of woody and herbaceous plants is found in this zone. Plants that belong typically in higher zones have been carried down into this zone and are found especially along streams. Plants characteristic of the lower types are found in the lower and drier parts of this zone.

	DOMINANT SPECIES
Pinyon	<i>Pinus edulis</i> Engelm.
Juniper	<i>Juniperus monosperma</i> (Engelm.) Sarg.
Scrub oak	<i>Quercus Gunnisonii</i> (Torr.) Rydb.
Narrow-leaved cottonwood	<i>Populus angustifolia</i> James
Yellow pine	<i>Pinus scopulorum</i> (Engelm.) Lemmon
	PRIMARY SPECIES
Rabbitbrush	<i>Chrysothamnus Bigelovii</i> (Gray) Greene
Snakeweed	<i>Gutierrezia diversifolia</i> Greene
Apache plume	<i>Fallugia paradoxa</i> (Don.) Endl.
Mountain mahogany	<i>Cercocarpus parvifolius</i> Nutt.
Alder	<i>Alnus tenuifolia</i> Nutt.
Shadscale	<i>Atriplex canescens</i> (Pursh.) Nutt.
Sagebrush	<i>Artemisia tridentata</i> Nutt.
Squaw currant	<i>Ribes cereum</i> Lindl.
Wild gooseberry	<i>Ribes leptanthum</i> Gray
Prickly pear	<i>Opuntia polyacantha</i> Haw.
Snowberry	<i>Symphoricarpos vaccinioides</i> Rydb.
Gramagrass	<i>Bouteloua gracilis</i> (H. B. K.) Lag.
Muhlenbergia	<i>Muhlenbergia Richardsonii</i> (Trin.) Rydb.
Mountain muhlenbergia	<i>Muhlenbergia gracilis</i> Trin.
Western wheat grass	<i>Agropyron Smithii</i> Rydb.
Indian millet	<i>Eriocoma cuspidata</i> Nutt.
Sand drop-seed	<i>Sporobolus cryptandrus</i> (Torr.) Gray
June grass	<i>Koeleria cristata</i> Pers.
Porcupine grass	<i>Stipa Scribneri</i> Vasey
Three-awn grass, wire grass	<i>Aristida Fendleriana</i> Steud.
Long-awned brome grass	<i>Bromus ciliatus</i> L.
Arizona fescue	<i>Festuca arizonica</i> Vasey
	SECONDARY SPECIES
Milk vetch	<i>Astragalus scopulorum</i> Porter
False sunflower	<i>Ximenisia exauriculata</i> (R. & G.) Rydb.
Winter fat, white sage	<i>Eurotia lanata</i> (Pursh.) Moq.
Four o'clock	<i>Mirabilis multiflora</i> Gray.
Cryptanthe	<i>Cryptanthe Pattersonii</i> (Gray) Greene.
Sitanion	<i>Sitanion molle</i> J. G. Smith.
Sitanion	<i>Sitanion brevifolium</i> J. G. Smith
Solomon's seal	<i>Smilacina stellata</i> (L.) Desf.
Goosefoot	<i>Chenopodium incanum</i> (S. Wats.) Heller.
Fremont's goosefoot	<i>Chenopodium Fremontii</i> S. Wats.
Narrow-leaved goosefoot	<i>Chenopodium leptophyllum</i> Nutt.
Feather geranium	<i>Chenopodium botrys</i> L.
Virgin's bower	<i>Clematis ligusticifolia</i> Nutt.
Western wall-flower	<i>Erysimum Wheeleri</i> Wats.
Thelypodium	<i>Thelypodium linearifolium</i> Wats.
Wild geranium, cranesbill	<i>Geranium viscosissimum</i> F. & M.
Spurge	<i>Euphorbia serpyllifolia</i> Pers.
Dogbane, Indian hemp	<i>Apocynum androsaemifolium</i> L.
Dogbane, Indian hemp	<i>Apocynum hypericifolium</i> Ait.
Skyrocket	<i>Gilia aggregata</i> (Pursh.) Spreng.
False boneset	<i>Kuhnia glutinosa</i> Ell.
Golden aster	<i>Chrysopsis villosa</i> (Pursh.) Nutt.
Iron plant	<i>Sideranthus spinulosus</i> (Pursh.) Sweet

Tetaneuris	<i>Tetaneuris angustifolia</i> Rydb
Wormwood	<i>Artemisia canopolum</i> Rydb
Groundsel	<i>Senecio Fendleri</i> A Gray
Tall groundsel	<i>Senecio spartioides</i> T & G
Fendler's blue grass	<i>Poa Fendleriana</i> (Steud.) Vasey
Blue grass	<i>P. crocata</i> Mich
Porcupine grass	<i>Stipa comata</i> T & R

The shrubs in this zone furnish considerable browse altho most of them are not very palatable to stock. A large number of palatable nutritious grasses are found such as gramagrass, mountain muhlenbergia, wheat grass, June grass, brome grass, blue grasses, porcupine grass fescues, Indian millet and drop seed. The blue grasses, brome grass and porcupine grass grow best in moister soils, Indian millet and drop seed on sandy or gravelly soils. Gramagrass is the most common grass, growing in most places except where there is too much shade. Forbs, or "weeds," with medium to high palatability, especially to sheep, are the goosefoots, winter fat, Solomon's seal, wall flower, wild geranium, false boneset and groundsel.

Poisonous plants are not abundant in this zone. Oak leaves are reported to cause poisoning. This happens when other feed is short or lacking and the oak leaves are eaten exclusively or nearly so. When oak is browsed in mixture with other feed there is no danger. Pinyon, locoweed and probably larkspur grow in places in this zone. Dogbane is also reported to cause poisoning. Due to the presence of awns at the time of seed maturity, a few plants are mechanically injurious. These are three awn grass, porcupine grass and sitanion.

Overgrazing is indicated by an increase in abundance of prickly pear, three awn grass and other unpalatable shrubs and weeds, and by a decrease in abundance of the more palatable plants, especially winter fat, porcupine grass, June grass, wheat grass and brome grass.

#### LAND CLASSIFICATION IN RELATION TO GRAZING

Extended discussion has been given to the vegetation of the San Luis Valley because it forms the basis of the range industry. For the most efficient management of ranges it is necessary to know the plants, their relation to environmental conditions, their food value and their resistance to grazing. By knowing the requirements, habits and life history of the plants, it is possible to manage the range in such a way that desirable plants will increase in abundance and undesirable ones will decrease. How to make the most use of a range or how to improve it, then depends upon the plants that are on it and upon environmental relations. The plants themselves serve as indicators of the surroundings and the conditions under which they live.

Particularly important environmental relations in range management are the length of the growing season of plants, precipitation, evaporation, topography, soil moisture, salt content and texture. The length of the growing period, especially the beginning date, largely determines the grazing period on many ranges. The distribution of precipitation thruout the year influences the kind and growth of forage plants as well as the management of the range. Trampling the ground when it is wet is very injurious. This trampling is more injurious on soils that are clayey in texture than on those that are sandy. Topography often determines the class of stock which can use the range. Much forage may be lost by the lack of water for stock, or the time and length of the grazing season may be determined by water supplies. Much of the outer part of the San Luis Valley has little or no water during the summer due to the rapid drainage thru the gravelly soils of the alluvial fans (Figures 24 and 17).

By knowing the environmental conditions and the plants growing in a region, methods of grazing may be devised that will provide for the requirements of the plants and permit maximum forage production under the particular soil and climatic conditions. But even when these facts are known, range improvement methods may be impossible to apply because various economic usages, as ownership of the land and governmental regulations, may be more potent in determining grazing methods than environmental conditions and plant requirements. Such is the case in the San Luis Valley, so that in discussing the range resources and possibilities of range improvement it is necessary to show the relation of the ownership of the land, Forest Service regulation lack of regulation on the public domain and sources of livestock feed to the vegetation and environment. Only by considering all three aspects—soil and climatic conditions, vegetation and economic usages and necessities—can the range resources and range improvement be adequately treated.

**LAND CLASSIFICATION**—A very important factor in range management in the San Luis Valley is the ownership and control of the land. Whether the land is privately owned, or is under the control of the Forest Service of the United States Department of Agriculture, the Land Office of the United States Department of Interior or under the Board of Land Commissioners of the State of Colorado, makes a great difference in grazing usage.

The following tables, 6 and 7, based upon the Colorado Year Book for 1926, show the classification of the land in the 5 counties in which the San Luis Valley lies. Table 6 gives a classification on the basis of the use made of the land.

Table 6—San Luis Land Classification 1925

County	Total area acres	1 Irrigated land acres	1 Natural hay land irrigated acres	Dry farming land acres	Patented grazing land acres	Forests National acres	2 Other grazing land acres
Alamosa	467 280	26 280	37 300	112 150	31 439	156 049	99 275
Conejos	891 280	86 950	9 920		270 472	151 843	279 018
Costilla	758 400	80 825	5 560	10 000		290 000	368 931
Rio Grande	74 720	72 400	7 500		243 931	124 089	130 170
Sapunche	2 000 120	37 640	49 000		882 673	421 079	606 089
Totals	4 604 800	394 618	100 330	122 150	1 419 515	1 143 060	1 483 483

1 These two columns added together give total acreage under irrigation  
 \* Includes state land unappropriated government land open to homesteaders  
 land unclassified as to ownership and timber land in Costilla County exclusive of mining claims town and city lots and railway rights of way

According to Table 6, the total area of these 5 counties is 4,604,800 acres. Almost six sevenths, the total of the last 3 columns, slight over 4,000,000 acres, of this land are useful primarily for grazing. The other seventh is made up chiefly of irrigated land, irrigated natural hay land and dry farming land. The explanation of such a large proportion of range land is found in the large acreage in National Forests, comprising about one third of the total area of these 5 counties and in the great extent of the land that cannot be irrigated due to topographic and soil conditions.

Grazing management of this large range acreage is dependent upon the ownership of the land. This is brought out in Table 7.

Table 7—Land Classification as to Ownership 1925

County	Patented acres	Unclassi- fied as to owner- ship acres	Non patented acres	State land unappor- tioned acres	Federal land open to home- steaders acres	National Forests acres
Alamosa	234 566	10 346	120 368	47 443	41 486	31 439
Conejos	251 790	80 614	468 876	62 644	133 760	270 472
Costilla	757 469	931				
Rio Grande	209 619	60 027	305 074	15 607	54 446	234 931
Sapunche	516 358	161 833	1 326 929	100 757	343 499	882 673
Totals	2 069 802	313 751	2 221 247	226 541	575 191	1 419 515

Table 7 shows that somewhat less than half the total acreage of these 5 counties is patented and that about one half is not patented. Of the patented land over one half is classified as grazing land in Table 6. On this land the system of range management that is used

depends upon the individual who owns the land, provided that his land is not surrounded by non patented state land or government land. If surrounded by such land he may not be able to prevent the extension of the grazing usage of that land to his own.

The non patented land is made up chiefly of three classes. Land in the possession of the state, federal land open to homesteaders, and National Forests. The latter comprises about twice as large an acreage as the total of the two former. Grazing on the National Forests is under regulation by the Forest Service. The federal land is under the supervision of the United States Land Office and the state land under the Board of Land Commissioners. The latter rents out the land for grazing purposes on the area basis but otherwise there is no regulation of grazing on these two classes of range land, comprising a total of about 800,000 acres.

This lack of control leads to rapid deterioration of the range because the land may be grazed at any time, even when the forage is very short and the soil wet, and by as many head of stock as one chooses to put on the land. On the federal land any one may graze his stock and usually it is to no one's advantage to improve or conserve the range by using it properly.

It has been emphasized that in order to secure the greatest use of this land, the public domain, regulation is necessary.<sup>20, 7, 23</sup> At present the grazing capacity is very low. The total grazing capacity of the uncontrolled range lying in the San Luis Valley proper has been estimated by the range reconnaissance method\* and is shown in Table 8. The uncontrolled range in this table is the unfenced portion of the valley lying outside of the National Forest boundaries. It includes the state and federal land, land unclassified as to owner.

Table 8—Grazing Capacity of Uncontrolled Range in San Luis Valley

County	Surface acres	Grazing capacity in cow months	Surface acres required to support 1 cow for 1 month
Saguache	577,944	75,660	7.6
Alamosa	82,338	11,169	7.6
Conejos	219,888	27,645	7.9
Rio Grande	130,040	17,005	7.7
Costilla	402,200	28,622	15.7
Totals	1,463,015	160,101	9.0 (average)

\*This estimation was made chiefly by P. B. Lister, range examiner, U. S. Forest Service, with the assistance of Chester Lee, U. S. Forest Service supervisor and rangers and the author.

ship and unfenced patented land, belonging chiefly to the low rabbit brush snakeweed gramagrass type but much of it lying also in the tall rabbitbrush greasewood, greasewood and pinyon juniper types

The total grazing capacity of this million and a half acres is estimated at only 160,000 cow months, averaging about 9 acres per cow per month. For a 6 months period the capacity would be only 26,667 head of cattle and would require about 54 acres per head. This low carrying capacity is due to a number of causes. One is the poor condition of the range caused largely by overgrazing (Figures 19, 20 and 24). The large number of rodents, prairie dogs, rabbits, etc., consume an enormous amount of forage usually preferring the same plants that cattle eat with most relish (Figure 16). It has been estimated that rodents destroy enough forage each year to support 1,500 head of beef cattle.<sup>20 22</sup> The low precipitation and dry conditions generally as discussed on page 10, do not allow a heavy yield of forage. Grazing methods adapted to the requirements of the forage

Table 9—Classification of Farm Land of Five Counties San Luis Valley  
U S Census of Agriculture 1925

County	Total area acres	All land in farms acres	Total crop land acres	Total pasture land* acres	Wood land not used for pasture acres	All other land in farms acres
Alamosa	465 280	298 677	57 535	235 493	2 064	3 585
Conejos	801 240	202 470	79 427	112 096	843	10 104
Costilla	758 400	611 714	38 430	568 363	215	4 697
Rio Grande	574 720	162 772	87 321	67 732	62	7 657
Saguache	2 005 120	404 903	102 187	225 638	18 605	58 473
Totals	4 604 800	1 680 536	304 909	1 209 322	21 789	84 516

\*In Table 10 is given a classification of this pasture land

Table 10—Classification of Pasture Land on Farms in Five Counties  
San Luis Valley U S Census of Agriculture 1925

County	Total pasture land acres	Plowable pasture acres	Woodland pasture acres	Other pasture acres
Alamosa	235 493	6 918	3 737	224 838
Conejos	112 096	15 575	12 560	83 961
Costilla	568 363	7 457	208 508	352 298
Rio Grande	67 732	5 696	4 562	57 474
Saguache	225 638	13 912	7 583	204 143
Totals	1 209 322	49 658	236 950	922 714

plants would increase the grazing capacity of this large portion of the valley

The patented land, or land in farms, makes up slightly over one third of the total acreage of these 5 counties. The classification of this land is given in Tables 9 and 10. According to Table 9 the total area of the land in crops in 1925 which includes land from which hay was cut was 364,909 acres or 22 percent of all the farm land. The total pasture land was 1,209,322 acres or 72 percent of all the farm land.

The plowable pasture, which includes the irrigated pastures, altho comprising only about 4 percent of the total farm pasture land furnished a large amount of feed in proportion to the other grazing land. This feed is estimated at a total of 4,900,000 animal unit days (see Table 13) which is equal to about 22 percent of the total farm or patented pasture and equal to about 13 percent of all the pasture and range land in these 5 counties. The woodland and other pasture totalling 1,160,000 acres has been estimated to provide enough feed for 17,900,000 animal unit days, as given in Table 13. The bulk of this large acreage, making up about one fourth of the total area of the 5 counties, lies in the San Luis Valley proper. The vegetation consists chiefly of greasewood range and moist meadow land that is not cut for hay (Figure 10). Other types as the low rabbitbrush snakeweed gramagrass, sagebrush and pinyon juniper types are represented to some extent.

The large acreage of National Forest range in these counties inevitably influences the grazing industry in the valley. As given in Table 13, this acreage furnishes feed for an estimated total of 8,500,000 animal unit days. This is more than one fifth of the total feed supplied by the pasture and range lands in these 5 counties or about 13 percent, more than one eighth of the livestock feed supplied from all sources in the valley. The total grazing capacities of the 3 National Forests in the San Luis Valley are given in Table 11.<sup>20 22</sup>

Table 11—Grazing Capacities of National Forests in the San Luis Valley

Forest	Number of cattle and horses	Number of sheep and goats
Rio Grande	18 500	130 000
Cochetopa	15 000	40 000
San Isabel	1 300	11 000
Totals	34 500	231 000

The grazing season on these forests is from the opening date which varies from May 1 to June 1 to the closing date, October 31, a

period of 5 to 6 months. The grazing lands in the National Forests are in great demand by ranchers in the valley. Summers and Smith<sup>20</sup> state that about 30 percent of the total number of beef cattle and 65 percent of the total number of sheep in the valley graze on the forest range.

Forest Service officials have found it necessary to limit the number of head of livestock and the grazing season on the Forests to grazing capacities determined by the Forest Service. An important factor in determining the stock that is admitted or excluded from the Forests is commensurability. Applicants for grazing permits who have commensurate and dependent ranch properties are given preference over those who are lacking in these.<sup>25 32</sup> The Forest Service has defined the term "commensurate property" as "property of the kind and amount necessary to furnish feed or forage for the class of

Table 12—Converting Factors Used in Determining Commensurability for Rio Grande Forest

CONVERTING FACTORS	
120 acres natural pasture (foothill type)	1 ton native hay
70 acres natural pasture (valley type)	1 ton native hay
15 acres natural pasture (uncut meadow)	1 ton native hay
90 acres pasture (cutover meadow)	1 ton native hay
180 acres pasture (stubble)	1 ton native hay
075 acres peas (uncut) for sheep	1 ton native hay
15 acres peas (uncut) for cattle	1 ton native hay
200 acres peas (stubble) for cattle	1 ton native hay
150 acres peas (stubble) for sheep	1 ton native hay
075 acres sweet clover (green uncut)	1 ton native hay
075 acres alfalfa hay	1 ton native hay
50 tons straw (all forms)	1 ton native hay
06 tons barley (cut for hay)	1 ton native hay
FEEDING REQUIREMENTS	
Cattle and horses	3000 pounds native hay or equivalent for 6½ months
Sheep and goats	600 pounds native hay or equivalent for 9 months
AMOUNT NECESSARY TO CARRY AN ANIMAL UNIT FOR A YEAR <sup>16 332</sup>	
Concentrated feeds	Tons
Cottonseed or flaxseed meal and peanuts	2 10
Corn barley rye emmer and spelt	2 65
Wheat mixed grains dry beet pulp	2 75
Oats sorghum rice	2 85
Hay and fodder	
Alfalfa annual legumes clover	5 00
Corn fodder and small grain hays	7 00
Timothy wild hay miscellaneous tame hays and sorghum fodder	8 00
Straws and stovers	
Corn and sorghum stover	10 00
Oats and rice straw	11 00
Cottonseed hulls	12 00
Barley straw	13 00
Wheat rye and flax straw	15 00
Silage and roots	
Silage and sweet potatoes	16 00
Potatoes	20 00
Wet beet pulp and roots	32 00



stock in accordance with the custom of the locality during the portion of the year when it is not grazed upon the national forest,"<sup>3 35</sup>

In 1926, R. E. Clark, the supervisor of the Rio Grande National Forest, calculated that the portion of the San Luis Valley using the forest for grazing purposes was commensurate for 30,254 head of cattle and horses and 167,648 head of sheep. The numbers approved for admittance to the forest were 17,425 in the former class and 168,091 in the latter. The numbers applied for were somewhat larger than the numbers approved. These calculations show that this portion of the valley can support from November 1 to May 1 or June 1, nearly twice as many cattle and about the same number of sheep as this forest has capacity for. In Table 12, are given the converting factors and feed requirements which served as a basis for these calculations.

**SOURCES OF LIVESTOCK FEED**—A summary of the number of live stock in the five counties in which the San Luis Valley lies and the sources of the feed required to sustain this livestock are given in Table 13. This table is based upon the best information available. Much of the data, however, are of such nature that it cannot be determined precisely. Moreover, the figures vary from year to year due to changing numbers of livestock, increases or decreases in yields of crops and in grazing capacities of ranges and changes in the administration of the National Forests. The table is valuable, in spite of needing revision every year, in that it shows the relation of the various sources of livestock feed to each other. The form and terminology of the table follow Circular 41, "Feed Resources, Eleven Western States," of the Extension Service of the United States Department of Agriculture.<sup>2</sup> Some explanation of terms is perhaps desirable.

"Animal unit day" is a unit of measurement designating the amount of feed furnished an animal, as a cow or a horse, for a day. In order to place the various kinds of livestock on a comparable basis as to feed requirements, 5 head of swine or 6 head of sheep, are considered equivalent to 1 cow.

The total number of animal unit days was secured, in sections A and B, by multiplying the number of animal units of each class by the number of days that they were fed, as 16,133 horses and mules multiplied by 365, the number of days they were fed in a year, gives almost 5,900,000, the total number of animal unit days.

In Section C "animal unit days per acre per year" means the number of days during the year that one acre of the various types of pasture and range land will support 1 cow, 1 horse, 6 sheep or 5 pigs. The method of securing this figure is "by dividing the length of

the pasture season by the acres required to support a cow. For example, if it takes 40 acres to maintain a cow for 8 months the animal-unit days per acre would be 240 days divided by 40 or 6 days per acre.<sup>16</sup> The last column, "total animal unit days" was obtained then, by multiplying the number of acres of each type of pasture or range by the animal unit days per acre per year.

Table 13—Sources of Livestock Feed in Five Counties San Luis Valley 1925\*  
A Feed Requirements

kind	Number animal units	Days feed required	Total animal unit days
Horses and mules	16 133	365	5 900 000
Dairy cattle	8 903	365	3 200 000
Beef cattle	102 477	365	37 500 000
Swine	1 800	365	650 000
Swine	7 100	120	850 000
Sheep and goats	34 000	365	12 400 000
Sheep and goats	27 000	90	2 500 000
<b>Totals</b>	<b>197 413</b>	<b>2035</b>	<b>63 000 000</b>

B Days Fed Harvested Crops

kind	Number animal units	Days feed required	Total animal unit days
Horses and mules	16 133	240	3 900 000
Dairy cattle	8 903	275	2 500 000
Beef cattle	102 477	120	12 300 000
Swine	1 800	240	400 000
Swine	7 100	120	800 000
Sheep	34 000	150	5 100 000
Sheep	27 000		
<b>Total</b>			<b>25 000 000</b>

C Sources of Pasture and Range Forage

	Acres	Percent of total area	Animal unit days per year per acre	Total animal unit days	Percentage of total animal unit days
Farm plowable	40 658	1	100	4 900 000	13
Other farm pasture	1 160 000	28	15½	17 900 000	47
Non farm National Forest	1 419 515	35	6	8 500 000	22
Other non farm range	1 483 483	36	4½	6 700 000	18
<b>Totals</b>	<b>4 112 656</b>	<b>100</b>		<b>38 000 000</b>	<b>100</b>

\*This table is a compilation of information from many sources. Special acknowledgement is due Eugene Merritt of the Office of Cooperative Extension Work of the United States Department of Agriculture, I. H. Summers, E. D. Smith and other members of the extension service of the Colorado Agricultural College, super visors of National Forests, Chester Lee and many individuals in the San Luis Valley.

Table 13 can be summarized rather briefly. The total amount of feed required, in the year 1925, for 197,413 animal units (16,133 horses and mules, 8,903 dairy cattle, 102,477 beef cattle, 44,500 swine and 366,000 sheep and goats according to statistics for 1925) was 63,000,000 animal unit days. Harvested crops furnished 40 percent

of this or 25,000,000 animal unit days, pastures and ranges furnished 60 percent or 38,000,000 animal unit days. This indicates, then, the importance of pastures and ranges, producing over half of the feed required by livestock in these 5 counties.

Section C, of the table, shows the relative importance of the various kinds of grazing land. The kinds of pasture lands are given in the order of greatest carrying capacities as shown in the third column. According to this column, the forage production per acre on "other farm" pasture is only about one sixth, or 15.5 percent, of that on plowable pasture. This is because much of the plowable pasture consists of irrigated pastures but the "other farm" pasture is largely native range and meadowland belonging to the greasewood type. The National Forests provide only one seventeenth or 6 percent as much forage per acre as the plowable pasture and the "other non farm" range one twenty second or only 4.5 percent as much. The low yield in comparison with plowable pasture on the National Forests is explained by a number of factors as the shorter growing season, trees preventing grass growth and inaccessibility of much of the land due to rough topography (Figures 2 and 3). The relatively low production per acre on the "other non farm" range lying largely in the low rabbitbrush snakeweed gramagrass, pinyon juniper and sagebrush types, is largely due to lack of control and has been discussed more fully above (see page 46).

The table shows that the non farm, which is non patented range land, furnishes 40 percent and the farm or patented range and pasture land produces 60 percent of the total range and pasture forage. The area of the former is over twice as great as that of the latter. The very low efficiency of the "other non farm" range, furnishing only 18 percent of the total forage produced on ranges and pastures while its area is 36 percent of the total, is strikingly brought out by this table. This low productivity is due to physical factors as low precipitation and rapid drainage limiting the growth of the forage plants, especially gramagrass (see page 15), to the lack of regulation of grazing as shown in Tables 6 and 7 and to the destruction caused by rodents.

### RANGE IMPROVEMENT

Discussion of methods for improving the range may be summarized as the principles of giving the valuable plants opportunity to grow and spread so they can produce forage, and of eliminating undesirable plants. Provision for the first usually brings about the attainment of the second. If the vegetation is so handled that the plants are vigorous and reproducing themselves, those plants that are best adapted to the site or habitat will force out those that are

less well adapted. On a badly overgrazed range the vegetation frequently consists chiefly of annual weeds. There is much bare ground. Under conditions that give the vegetation a chance to grow and spread, perennial weeds and grasses begin to appear. The amount of bare soil decreases. If suitable conditions are continued, perennial grasses cover more and more of the soil. The weeds cannot endure the competition of the grasses and they decrease rapidly in number. The greatest amount of forage, largest percentage of ground cover and the most palatable and nutritious feeds are usually produced by this stage, largely because it is best suited to the environmental factors.

This principle applies especially to the low rabbitbrush-snake-weed-gramagrass zone which falls largely in "other non-farm" pasture, Table 13. As stated above, this type of range is very low in productivity. It has been severely overgrazed due largely to lack of control. If the vegetation is given a chance to grow, gramagrass would increase in vigor. Since it is the plant best suited to the conditions in this type as a whole, it would spread at the expense of other less valuable plants. The forage production would increase greatly. The first steps that must be taken in order to give the vegetation a chance are some sort of control or regulation of the state- and federal-owned grazing land and the eradication of rodents.

Large areas are badly infested with prairie dogs (Figure 16). It has been demonstrated that 32 prairie dogs eat as much grass as one sheep<sup>5</sup> and that they have destroyed 80 to 100 percent of the total annual forage production, preferring the most valuable range grasses as gramagrass<sup>22</sup>. On an area of 650,000 acres in southern Arizona, occupied by more than 5,000,000 black-tail prairie dogs, these pests were completely exterminated in 3 years.<sup>8</sup> Taylor<sup>21</sup> states that prairie-dog elimination from the range resulted in an increased stand of palatable grasses and the disappearance of the poisonous pingue. The eradication of prairie dogs in the San Luis Valley would increase the forage production in all the types of vegetation and increase greatly the number of total animal-unit days as given in Table 13.

Grazing methods that give the forage plants a chance to become vigorous would also improve the grazing capacity of the pinyon-juniper zone where the trees are usually scattered, and of the grass openings in the sagebrush and greasewood types. In these two latter types, however, other methods are required, because the grasses cannot usually displace the shrubs and cactus (Figures 2, 20, 22, 24). There are a few localities where grasses appear to be displacing greasewood but this is not common (Figure 9). Eradication of the shrubs is usually followed by an increased stand of grasses. It would be

feasible to sow tame forage plants resistant to alkali and a shallow water-table on much of the greasewood land, after clearing and suitable preparation of the soil. Plants adapted to these conditions and which are on the market are yellow sweet clover, slender wheat grass, smooth brome grass, meadow fescue and redtop. Excellent forage grasses, as wheat grass and gramagrass (Figure 21), increase in abundance on areas that have been drained. Lowering of the water-table gives the grasses an advantage over greasewood.

When sagebrush land has been cleared, wheat grasses, gramagrass and other valuable range plants often increase rapidly if proper grazing methods are used.

Important methods of range improvement are summarized below:

**CONTROL OF GRAZING ON STATE- AND FEDERAL-OWNED LAND.**—Some kind of regulation is necessary so that overgrazing, too early grazing in the spring, etc., may be prevented, and so that the individuals who practice good methods may derive benefit from them.

**EXTERMINATION OF RODENTS.**—It has been estimated that rodents consume enough forage annually to support 1500 head of beef cattle<sup>20</sup>. The entire valley should be treated as a unit and all agencies and individuals concerned work together.

**RANGE-MANAGEMENT METHODS ADAPTED TO THE REQUIREMENTS OF FORAGE PLANTS WHENEVER PRACTICABLE.**—The numbers of stock should be adjusted to the capacity of the range. The use of indicator plants is an excellent way to determine the proper grazing capacity. Important plants indicating overgrazing in the valley are prickly-pear cactus, three-awn grass, snakeweed, pingue and other unpalatable weeds and shrubs. Deferring the grazing in the spring, until the grasses have made a good start, results in increased forage yields. Rotation grazing gives the vegetation a chance to grow and increase in vigor between grazing periods, giving higher yields and greater carrying capacities, and thus paying for the additional cost and labor in a few years. Good distribution of the stock prevents overgrazing in spots. This is often attained by suitable salting and water development. The grazing of the range by the class of stock that can best utilize the kind of forage composing the vegetation is important and the adjustment of grazing to seasons is another factor to consider.

**ERADICATION OF POISONOUS PLANTS.**—Plants that may cause poisoning are greasewood, pingue, oak brush, locoweed, lupine and larkspur. Little damage is caused by the first three if there is sufficient other feed available. Small areas badly infested with the three latter should be cleared of the poisonous plants. However, when they are scattered over large areas the most practical kind of control is the use of grazing methods that will permit grasses to grow and thus hold the

poisonous plants in check. This will reduce the danger in two ways. The poisonous plants are usually much less attractive to stock if there is other palatable feed available and they do not grow so well when other forage plants are abundant.

**NATURAL AND ARTIFICIAL REVEGETATION.**—Grasses as a rule do not thrive when growing in competition with shrubs or cacti. The shrubs may prevent grass growth by shading, the cacti reduce the soil moisture. If the shrubs and prickly pear cactus are eradicated, the grasses become more vigorous and increase in density. This applies especially to the sagebrush and greasewood types in the San Luis Valley. In the greasewood type, especially, there are many sites where the seeding of certain tame pasture plants as yellow sweet clover, slender wheat grass, smooth brome grass, meadow fescue and redtop, would greatly increase the production of forage. Tame pasture plants begin growth earlier than most native range plants. By having more tame pastures it would be possible to defer grazing longer in the spring on the native ranges. Reseeding ranges, however, is as a rule not successful unless the soil is prepared by plowing, disking or harrowing so that there is a suitable seedbed.

**LOWERING THE WATER-TABLE.**—The seepage areas in parts of the greasewood type are supporting inferior forage plants such as salt grass and alkali sacaton. If the water-table were lowered, more valuable grasses as wheat grasses, gramagrass and others would replace the less nutritious and palatable ones.

## CONCLUSION

**GREASEWOOD TYPE.**—This type occupies most of the floor of the San Luis Valley. As shown on the map (Figure 1) the boundaries of this type coincide remarkably closely with the boundaries of the area of flowing wells. In topography it is flat and the soil varies from silt loams to clays, the latter occurring especially in the subsoil. Due to poor drainage and excess water brought in by irrigation and flowing artesian wells, the water-table is generally very shallow. This has resulted in a concentration of alkali salts in the surface soil. Due very likely to an increase in the size of the area with a shallow water-table and accumulation of alkali, the greasewood zone has increased in extent about five times since 1869. Soil moisture and alkali are, then, the dominating factors in determining the vegetation of this type. The chief plants—greasewood, salt grass, alkali sacaton, western wheat grass, rabbitbrush and shadscale—are able to grow under these conditions. They are also able to withstand the high evaporating power of the air caused by low humidity, rapid radiation and drying winds. The shortness of the frostless season, 97 to 119 days,

affects the vegetation by shortening the growing season, thus reducing the amount of forage produced.

The most valuable forage plant is western wheat grass. Alkali sacaton and salt-grass are also very valuable if grazed closely. A variety of other grasses and forbs ("weeds") are also important. Greasewood and pingue may cause poisoning, especially of sheep.

A large variety of grasses, grass-like and broad-leaved plants, are found in the natural meadows scattered throughout the valley. The total area of these meadows, in 1925, comprised about 109,000 acres (Table 6). The composition of the meadows varies somewhat with location. The chief plants are redtop, timothy, western wheat grass, tufted annual drop-seed, squirrel-tail grass and a rush. The grazing value of the meadows is high, as shown in Table 12. One and one-half acres of uncut meadow used for pasture, of which there are many, or 9 acres of cutover meadow, are equal in feed value to 1 ton of native hay, whereas 7 acres of the greasewood range (valley type of natural pasture in (Table 12) are equal to 1 ton of native hay.

Most of the greasewood zone is patented grazing land (Table 6), and fenced so that grazing may be controlled. In 1925, it produced considerable more forage than the non-patented uncontrolled range or the National Forest ranges (see Table 13, C). This is due partly to control but also to the larger amount of soil moisture and the longer growing season, permitting greater production of forage. According to Table 13, section C, the "other farm" range (mostly greasewood type, including grazed meadows) comprised 28 percent of the total area of the 5 counties and furnished 47 percent of the total forage production. The National Forests, comprising 35 percent of the area, furnished 22 percent of the forage, and the "other non-farm" range—unfenced, without grazing control, lying between the floor of valley and National Forest boundaries as shown on map (Figure 1), comprising 36 percent of the area—furnished only 18 percent of the forage.

The method of range improvement that has most immediate application to the greasewood type of vegetation is supplanting stands of greasewood with grass. After eradication of the greasewood and suitable preparation of the soil, various tame forage plants may be sown. Tame forage plants that are best adapted to grow in alkaline water-saturated soils are slender wheat grass, meadow fescue, redtop, yellow sweet clover and smooth brome grass. Other methods of range improvement applicable to this type are the use of range management methods, as deferred rotation grazing, that provide for the requirements of the forage plants; eradication of poisonous plants

and rodents where they are troublesome, and lowering of the water table which will permit growth of better forage plants

**TALL RABBITBRUSH GREASWOOD TYPE**—This type, varying considerably in width is a transition zone between the greasewood and the low rabbitbrush snakeweed gramagrass types. It is characterized by a mixture of tall rabbitbrush and greasewood in varying proportions. The soil contains less alkali and the water table is deeper than in the greasewood type. Other environmental conditions are similar. Due to the better soil conditions, plants from higher zones are more abundant in this zone than in the greasewood. Such plants which are valuable for forage are gramagrass, sand dropseed and Indian millet. Most of this type falls into patented grazing land in Table 6 or into 'other farm' pasture in Table 13.

**LOW RABBITBRUSH-SNAKEWEED-GRAMAGRASS TYPE** — This type forms a zone varying in width around the tall rabbitbrush greasewood zone. In the southern part of the valley it is very extensive. The soil usually containing more or less gravel or rock, is well drained, free from alkali and limited in soil moisture. The annual precipitation is about 8 to 10 inches. These dry conditions, increased somewhat by high evaporation rates, account for the kind of plants found in this type. Gramagrass, particularly is able to grow under such conditions. It grows rapidly when moisture is available, matures seed rapidly and is able to endure drought for long periods by going into dormant condition. The low species of rabbitbrush and snakeweed are also drought resistant but require more moisture than gramagrass. Other important species in this type are the muhlenbergias, western wheat grass, dropseeds, three awn grass, prickly pear cactus and winter fat. Due partly to lack of control, most of this type has been considerably injured by overgrazing. The damage to the range is seen in the decrease in numbers of the most palatable plants as western wheat grass, porcupine grass and winter fat and an increase in unpalatable plants especially prickly pear, three awn grass, snakeweed, rabbitbrush and pingue.

The area of this type in the San Luis Valley includes a large part of the total area of uncontrolled range or "other grazing land" in Table 6, comprising a total of nearly one and one half million acres. As shown in Table 8, the grazing capacity is very low, requiring 9 acres per cow per month. According to Table 12, the forage on 7 to 12 acres is considered equal to 1 ton of native hay and, as given in Table 13, section C, the "other non farm" range, consisting largely of this type and comprising 36 percent of the total area of



these 5 counties, contributes only 18 percent of the total range and pasture forage

Range improvement of this large area is dependent first of all upon control of grazing and upon the extermination of rodents. Since the precipitation is not great and the soil moisture limited, it is especially important that grazing methods adapted to the requirements of forage plants be used. These methods must, first of all give the grasses opportunity to grow when soil moisture and temperature are suitable. Such methods are deferred and rotation grazing, especially deferring the grazing in the early part of the growing season. The grasses in this zone cure on the ground forming excellent forage when dry. Excessive trampling and too close grazing are also very injurious. Artificial reseeding in this zone will usually not pay unless more moisture is available through irrigation.

**SAGEBRUSH TYPE**—This type of vegetation is best developed and most extensive in the southeastern part of the San Luis Valley, extending southward from Fort Garland. It is also found to a limited extent in the extreme northern end of the valley. Typically it consists of a scattered stand of sagebrush, 2 to 5 feet tall. Tall dense sagebrush usually grows on deep fertile soil free from alkali. Soil moisture is available for growth, at least in the deeper layers, throughout the summer. Perhaps the limited distribution of sagebrush in the valley may be explained by these soil relations. As shown in Figure 4, the precipitation is somewhat greater in this type than in the greasewood. Other climatic conditions as temperature and evaporating power of the air are very similar to those in the greasewood type.

Rabbitbrush and shadscale may also occur in places. The most important forage grasses growing in openings between bushes, are gramagrass, mountain muhlenbergia, June grass, western wheat grass and porcupine grass. Poisonous plants are pingue, lupine and loco weed. Over grazing is indicated by an increase in unpalatable plants, especially mountain sage, pingue and prickly pear.

Most of the sagebrush type is uncontrolled range falling into the "other non farm" class in Table 13. As discussed under the low rabbitbrush snakeweed gramagrass type the forage production is very low.

The most applicable methods of range improvement, in this type, are control of grazing, eradication of rodents and poisonous plants and the replacement of sagebrush by grass. The grasses cannot compete successfully with the sagebrush but if the brush is removed

the grasses already on the ground will spread. Seeding cleared areas to tame grasses as slender wheat grass and smooth brome grass is, as a rule, not successful unless the soil is suitably prepared.

**PINYON JUNIPER TYPE**—This type of vegetation forms usually a narrow zone at an elevation of 8000 to 8500 feet outside of the low rabbitbrush, snakeweed, gramagrass or sagebrush types. In many places it occurs on the upper portion of the alluvial fans. The soil contains considerable rock and the soil moisture supply is greater and available for a longer season than in the low rabbitbrush, snakeweed, gramagrass type. Many streams arising higher in the mountains find their way into this zone and then the water sinks into the soil. The precipitation is also greater than at lower elevations and the growing season is somewhat shorter.

The pinyon juniper type is dominated by low scattered trees, mostly pinyons and occasional junipers. The most abundant grass is grama but many other very valuable forage plants occur, as mountain muhlenbergia, western wheat grass, June grass, porcupine grass, Arizona fescue, blue grass, winter fat, goosefoots and wild geranium.

The greater variety as well as the better growth of forage plants is due chiefly to increased soil moisture. Plants growing in this zone reported to cause poisoning are oak leaves under certain conditions, locoweed, pingue, dogbane and larkspur. Overgrazing is indicated especially by an increase in abundance of prickly pear cactus, threeawn grass, rabbitbrush, snakeweed and tall groundsel and a decrease in the abundance of palatable plants.

The boundaries of the National Forests usually lie in this zone so the grazing is under the regulation of the Forest Service. The lower parts of this type, outside of the National Forest boundaries, are chiefly non-patented or uncontrolled range land similar in vegetation and grazing capacity to the low rabbitbrush, snakeweed, grama grass type. Range improvement methods would be similar in the two types.

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