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# Soils of New Mexico

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This publication, SOILS OF NEW MEXICO, stands as a memorial to the work of Dr. JAMES U. ANDERSON, recent professor of agronomy at New Mexico State University and one of the authors. Jim died July 27, 1974, at 49 years of age, victim of an accidental drowning. He was on sabbatical leave doing soil research at the University of Hawaii.

Dr. Anderson served as the New Mexico state soil survey leader on the National Cooperative Soil Survey while at New Mexico State University (1957-1974). Under his leadership much information on the soil resources of New Mexico was accumulated and published. This included, in addition to the standard U. S. Department of Agriculture Soil Survey publications, a series of publications on soil associations and land classifications for irrigation for the counties of New Mexico, and an Agricultural Experiment Station report on suitability of New Mexico lands for irrigation. This compilation of soils information will be useful in New Mexico and outside the state.

Dr. Anderson's intense interest and diligent work in the area of soil classification and mineralogy inspired students from all over the world, and his publications will be useful in many areas of soil science, including land-use planning. His expertise, hard work, and high personal character gained for him the respect of colleagues and students.

Arden A. Baltensperger, Head  
and  
Harrison J. Maker, Soil Scientist  
Department of Agronomy

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September 1974

Las Cruces, New Mexico

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## ACKNOWLEDGMENTS

The soils information in this report is based primarily on Agricultural Experiment Station research reports, "Soil Associations and Land Classification for Irrigation," published for each county except Bernalillo and on published soil surveys. Obtaining this information has involved the efforts of many soil scientists from the Soil Conservation Service and the Forest Service, U. S. Department of Agriculture, and also assistance from the Bureau of Reclamation and the Bureau of Indian Affairs of the U. S. Department of Interior.

Climatic data were obtained from U. S. Weather Bureau sources, including Climatological Summaries published by the University of New Mexico Bureau of Business Research and Climatography of the United States, No. 86-25, published by the U. S. Weather Bureau, supplemented by data from the office of the New Mexico State Climatologist.

Geologic information is from C. H. Dane and G. D. Bachman, 1965, Geologic Map of New Mexico. The identification of Physiographic Provinces is based on Fenneman, New Mexico, 1931. Physiography of the Western United States, McGraw-Hill, New York.

# Soils of New Mexico

H. J. Maker, H. E. Dregne, V. G. Link, and J. U. Anderson\*

New Mexico, with an area of 121,666 square miles,<sup>1</sup> has a diversity of climates, soils, vegetation, geologic materials, and topography. This publication describes the characteristics of the major soils of the state. The accompanying map groups the soils into associations of great groups within larger soil regions.<sup>2</sup> The general soil map and report are useful in multi-county or state-wide planning. They provide information on soil resources of large tracts that can be used for preliminary planning for land use, water development, highway engineering, resource development, agricultural research planning, and other planning programs. The general soil map does not replace the need for detailed soil maps for operational planning on individual farms and ranches or the planning of specific locations for houses, roads, parks, and other items of this nature.

## FACTORS OF SOIL FORMATION

The kind of soil that develops in any area is the result of the interaction of five soil-forming factors: climate, vegetation, parent material, topography, and time. The first two are called "active" factors because they act on the soil parent material as conditioned by topography over varying periods of time.

Climate and vegetation frequently are considered together because climate is the major determinant of vegetation. Soils of the high mountains of northern New Mexico are commonly leached, well-

\*Former Soil Scientist, New Mexico State University; Chairman, Department of Agronomy, Texas Tech University, Lubbock; Soil Conservation Service, Hyattsville, Maryland; and Professor of Soils, New Mexico State University, respectively.

<sup>1</sup>From U. S. Dept. of Commerce, Bureau of the Census, 1965, Areas of New Mexico, 1960: Govt. Printing Office, Washington, D. C., GE-20, No. 33 (revised)

<sup>2</sup>See Appendix I for soil taxonomic terms.

developed, and acid because precipitation is relatively high, temperatures are low and the dominant vegetation is coniferous trees which are best suited to these climatic and soil conditions. On the other hand, grasses and desert shrubs are dominant in the hot dry desertic region. Here, the soils are not leached, are less developed, and are neutral or alkaline. Whether the soil determines the kind of vegetation or whether vegetation determines the kind of soil is a much-debated point, but climate certainly is the deciding factor for both.

In New Mexico, temperature and precipitation are related principally to land elevation. For example, in the relatively short distance between the Tularosa Basin and the ski run on Sierra Blanca, temperatures drop, precipitation increases, the vegetation changes from grasses to trees, and the soils change from calcareous and weakly developed to acidic and strongly developed. The growing (frost-free) season varies from about 210 days at the lowest part of the state near Carlsbad to less than 100 days in the Sangre de Cristo Mountains of northern New Mexico. Desert grasses and shrubs are the dominant vegetation in the arid plains of the south, whereas alpine vegetation occurs above the timberline on high mountain peaks. Precipitation distribution patterns differ from eastern New Mexico to western New Mexico. In the east, precipitation is lowest in winter and highest in summer. In the west, precipitation is at a minimum in April and May and a maximum in July and August.

Parent material consists of the geologic material from which soils are developed. Soil on very young alluvium, such as in the valley of the Rio Grande, or on the sand dunes of southern New Mexico are essentially undeveloped, so their characteristics are similar to those of the parent materials. On the other hand, soils of the high mountains of northern New Mexico have characteristics that bear little

relation to the parent material from which they developed. Climate and vegetation are the dominant soil-forming factors in humid areas.

Rocks of Cretaceous, Tertiary, and Quaternary ages dominate the surficial geology, but geologic formations dating as far back as Precambrian occur, mostly in the north-central part of the state.<sup>3</sup> Evidence of volcanic activity can be seen throughout the state except in the southeastern quarter, where only sedimentary formations are found. Lava flows occurred as recently as about 1,000 years ago south of Grants.<sup>4</sup> Limestone and sandstone are the principal sedimentary rocks for the state as a whole, but shale is locally important north and west of Tucumcari and in the northwest corner of the state.

Topography affects soils greatly. Thin, eroded soils are commonplace on steep slopes. In depressions, fine-textured, saline, poorly drained soils are a logical consequence of the topographical conditions. Soils on south-facing slopes are subject to higher temperatures than their counterparts on the north side of a hill. The topography of the state is highly varied. The high plains of eastern New Mexico are relatively flat. The remainder of the state includes basins, plains, plateaus, mesas, mountains with included valleys, and flood plains.

The importance of time to soil formation arises from the fact that natural processes of soil development tend to reach an equilibrium which depends upon local environmental conditions. It takes thousands of years for a mature soil to develop from raw rock materials. The landscape of New Mexico is young, geologically speaking. Nearly all surficial deposits from which soils have developed have been affected by climatic changes occurring in the last million years. Many of them owe their characteristics to the soil-forming processes operating during and since the last glacial period.

## SOIL CLASSIFICATION

Soil scientists use several systems to classify soils. These deal with the soil as a natural body and consider the volume of soil affected by biological activity, which usually extends to a depth of several feet. Such classifications should not be confused with engineering or other classifications, which deal only with the properties of a single soil layer or sample.

<sup>3</sup>C. H. Dane and G. O. Bachman. 1965. Geologic Map of New Mexico. U. S. Geologic Survey.

<sup>4</sup>R. L. Nichols. 1946. McCarty's Basalt Flow, Valencia County, New Mexico. Geol. Soc. Amer. Bull. 57:1049-1086.

The classification system used here is the Soil Taxonomy which the U. S. Department of Agriculture officially adopted in 1965. This system includes all known soils of the world in 10 broad groups called soil orders. These orders are subdivided into suborders, great groups, subgroups, families, and series. The series is the lowest level of the system, and constitutes what we usually recognize as a specific kind of soil. This report deals with great groups, subgroups, and series. Additional information about this classification system can be found in the appendix at the end of this report.

## SOIL SURVEYS

Soil surveys are inventories of land resources. The first soil surveys in the United States were initiated in 1899; the Survey of the Pecos Valley of New Mexico was one of the three begun in that year. Since that time, soil surveys have been made in all parts of the state, although only a few have been published. The published soil surveys are listed below. Those made prior to 1958 are primarily of historical interest now. Copies of the recent surveys can be obtained from the Soil Conservation Service, county extension agents, or the New Mexico State University Agricultural Experiment Station at Las Cruces.

<i>Publication Title</i>	<i>Year of Publication</i>
The Soils of the Pecos Valley, New Mexico	1899
Soils Survey of Mesilla Valley, New Mexico-Texas	1914
Soil Survey of the Middle Rio Grande Valley Area, New Mexico	1914
Soil Survey of the Deming Area, New Mexico	1928
Soil Survey of the Socorro and Rio Puerco Areas, New Mexico	1929
Soil Survey of the Rincon Area, New Mexico	1930
Soil Survey of the Fort Sumner Area, New Mexico	1930
Soil Survey of Lovington Area, New Mexico	1932

Soil Survey of Roswell Area, New Mexico	1933
Soil Survey, Curry County, New Mexico	1958
Soil Survey, Bluewater Area, New Mexico	1958
Soil Survey, Portales Area, New Mexico	1959
Soil Survey, Southwest Quay Area, New Mexico	1960
Soil Survey, Roosevelt County, New Mexico	1967
Soil Survey, Zuni Mountain Area, New Mexico	1967
Soil Survey, Cabezon Area, New Mexico	1968
Soil Survey, Torrance Area, New Mexico	1970
Soil Survey, Eddy Area, New Mexico	1971
Soil Survey, Harding County, New Mexico	1973
Soil Survey, Hidalgo County, New Mexico	1973
Soil Survey, Lea County, New Mexico	1974

Field work has been completed on surveys of the following areas by the Soil Conservation Service in cooperation with other federal agencies and the Agricultural Experiment Station: Albuquerque, East Valencia, Mescalero-Apache, Luna County, Quay County, White Sands Missile Range, and Santa Fe County. In addition, a number of other detailed surveys are in progress.

County soil association maps and reports covering all counties except Bernalillo have been published as research reports by the Agricultural Experiment Station, New Mexico State University. This report summarizes these and other available information and presents soils information for the entire state in a form which is useful for broad-area planning. These research reports are listed in Appendix III.

## SOIL ASSOCIATIONS

Soil associations are groups of soils that occur together, making up recognizable landscapes. The soils of any given association are not necessarily similar; in fact, they are frequently contrasting. Although we usually refer to associations of soil series, this is not the only kind of association that exists. The associations referred to in this report are associations of great groups.

A description of each association is given with the estimated percentage occupied by each of the major subgroup components, and brief descriptions of their characteristics. The more important minor constituents are named, but no percentage estimates are made for these because it is very difficult to account for all association areas at this level of generalization.

### *Dark and Moderately Dark-Colored Soils of the High Plains Region*

The High Plains Region is a part of the Great Plains physiographic province. The High Plains escarpment separates this area from the East-Central Plains and the warm desertic regions. In most places, this escarpment is a prominent topographic feature which drops as much as 100 to 300 feet, but in a few places the edge of the High Plains is marked by only a gradual slope, particularly in the south.

This region, sometimes known as the Llano Estacado, is an extensive plain in which the gently sloping, smooth-lying surface is broken only by a few drainageways and playas. Minor areas of sandy soils have undulating or dunelike topography, and rough broken and steeply sloping lands comprise the breaks contiguous to larger stream valleys and to the basalt or lava cones of the north. For the area as a whole, there is a gentle slope to the south and east. Elevations above sea level range from about 7,200 feet at the northwest boundary to 3,600 feet near Hobbs, in the southeastern part.

All drainages within the High Plains are intermittent. Those with definite stream channels generally traverse the area in a southeasterly direction; numerous smaller drainages fade out within a few miles or drain into shallow depressions called playa lakes. The playa lakes, which contain water only following periods of heavy precipitation, are generally circular and range from a few feet to as much as 50 feet below the level of the surrounding plains.

The High Plains Region includes about 7,889,400 acres, of which 1,400,000 are dry-farmed and 430,000 are irrigated. There are about 5,124,000 acres of potential irrigable land in the region.

## CLIMATE

The High Plains Region has a semiarid continental climate. Most of the precipitation falls in the summer, when moist air moves from the Gulf of Mexico, and occurs as brief and sometimes heavy thundershowers. During winter, a small part of the moisture falls as snow. Table 1 gives data for three weather stations, one each in the northern, central, and southern part of the High Plains.

As is true of most arid and semiarid regions, precipitation varies widely from year to year and from month to month. Frequently, much of a month's precipitation falls in a single shower. Monthly and annual precipitation figures, consequently, are unreliable indications of the effectiveness of the moisture for crop production.

There is a distinct seasonal change in temperature, and the difference between maximum day and minimum night temperature is commonly 30 F or more. Maximum temperatures at Clayton, Clovis and Hobbs were 106, 110, and 110 degrees, respectively. The coldest temperatures were 23, 17, and 7 degrees below zero, respectively.

Average annual humidity is about 50 percent; hail occurs occasionally; and spring winds usually are high. Class A pan evaporation near Portales amounted to 92 inches per year for one 26-year period.

The temperature at a depth of 20 inches is considered in classifying soils. Soils of this region are placed in a Mesic temperature class if the average annual temperature is between 47 and 59 degrees, or in a Thermic temperature class if the average annual temperature is between 59 and 72 degrees. Soils are separated by temperature class on the accompanying map and in the following discussion.

## GEOLOGY

The High Plains are dominantly underlain by the Ogallala formation of Tertiary age. This forma-

tion constitutes the water-bearing stratum that is the source of most domestic and irrigation water. During geologic time, the headward cutting waters of the Pecos and Canadian rivers met and isolated the High Plains from the drainage areas to the west. As a consequence, the only recharge of the Ogallala formation is from rain or snow that falls directly on the High Plains.

## SOIL ASSOCIATIONS (Soils with Mesic Temperatures)

Fifteen soil associations have been recognized on the High Plains. These are shown on the accompanying map and are named after the major great groups of soils that occur within them. A description of each of the soil associations follows:

### 10. Paleustolls (1,041,900 acres)

This soil association encompasses extensive areas in the northeastern part of New Mexico, principally in Union and Harding counties. It is dominated by nearly level to very gently sloping topography but includes occasional small areas of gently to strongly sloping and undulating landscapes occurring adjacent to intermittent drainages. The soils, which are forming in alluvial and eolian sediments, are generally deep and well drained with medium-textured surface layers and loamy to clayey subsoils.

Much of the land in this association is used for range. It supports a relatively dense cover of grass and moderate to high yields of forage are obtained under good management. The more common grasses are blue grama, galleta, western wheatgrass, buffalograss, ring muhly, wolftail, sand dropseed, and three-awns. A limited acreage is used for wheat and sorghum production under irrigation and dry farming. Although a considerable acreage in this association was once dry-farmed, most of it has now been returned to range use because these medium to fine-textured soils are not well suited to dry farming under the prevailing climate.

Table 1. Climatic conditions at three High Plains Stations

Station	Area	Elevation feet	Average Precipitation												Avg. Ann. Temp.	Frost- Free Season days	
			J	F	M	A	M	J	J	A	S	O	N	D			Annual
Clayton	North	4,970	0.35	0.37	0.63	1.19	2.74	1.48	2.33	2.09	1.65	1.00	0.33	0.35	14.51	53.1	179
Clovis	Central	4,280	0.55	0.41	0.49	0.92	2.51	2.30	2.64	2.62	2.10	1.89	0.46	0.59	17.48	57.9	195
Hobbs	South	3,615	0.46	0.38	0.40	0.89	1.97	1.67	2.09	1.73	2.26	1.93	0.37	0.53	14.68	61.2	206





Fig. 1. The deep and well drained Aridic Paleustolls typically occur on nearly level to gently sloping landscapes. They usually have loam or clay loam surface layers and clayey subsoils.

*Soil Characteristics:* Paleustolls, the most extensive in this association, are represented by the subgroups Aridic Paleustolls, Calciorthidic Paleustolls, and Torreritic Paleustolls. The Aridic Paleustolls, which account for 40 percent of the association, typically occur on smooth, nearly level to very gently sloping plains. These soils have a surface layer of brown to grayish-brown noncalcareous loam over thick heavy clay loam subsoils. The upper part of the subsoil consists of a brown noncalcareous heavy clay loam. This grades at a depth of about 20 to 30 inches to a reddish-yellow clay loam that contains a few threads and films of calcium carbonate. The substratum below an average depth of about 48 inches consists of a pinkish-white loam with a moderate accumulation of lime that occurs in the form of films, threads, and small soft masses.

The Calciorthidic Paleustolls, which comprise 15 percent of the association, are characterized by strongly calcareous surface layers and subsoil layers with distinct lime accumulations. They usually have a moderately thick surface layer of brown or grayish-brown strongly calcareous loam which grades through a pale brown or light gray clay loam to a pinkish-white massive clay loam with a high lime content at depths of 12 to 20 inches. Nodules and fragments of weakly cemented caliche are common in the substratum. Although these soils frequently occupy gently to strongly sloping and

undulating landscapes adjacent to intermittent drainages, they also occupy nearly level plains.

The Torreritic Paleustolls, which account for 10 percent of the association, occupy nearly level to very gently sloping land forms in broad basins or plains. They usually have a thin, brown to grayish-brown, noncalcareous loam or clay loam surface layer. Their subsoil is a brown clay that cracks on drying. This grades at a depth of about three feet to a very pale brown and light brown clay loam that is strongly calcareous and contains threads and small soft masses of lime.

Also of importance in this soil association are Torreritic Argiustolls, Aridic Calcicustolls, Petrocalcic Calcicustolls, and Aridic Paleustalfs. The Torreritic Argiustolls are developing in fine-textured sediments on nearly level to very gently sloping valley or slight depressional areas. These soils typically have a surface layer of very dark grayish-brown noncalcareous silty clay loam over thick grayish brown clay and heavy silty clay loam. The substratum below a depth of three to four feet consists of grayish-brown heavy silty clay loam or clay loam. The Aridic Calcicustolls are limited in effective depth, typically at 24 to 40 inches, by soil layers with a high content of lime. These soils usually have a moderately thick surface layer of dark grayish-brown loam that is typically noncalcareous to a depth of three to five inches, but locally is calcareous to the surface. The subsoil is a grayish-brown to brown calcareous clay loam. The Petrocalcic Calcicustolls, which are shallow, typically occupy gently to strongly sloping ridge crests and knolls as well as side slopes adjacent to drainages and playas. These soils have a surface layer of brown calcareous loam or sandy loam over indurated caliche that occurs at depths ranging from about 6 to 20 inches. Aridic Paleustalfs in this association occur principally in Union County. These soils, like those included in soil association 11, are deep and usually occur on gently sloping and undulating landscapes. They have fine sandy loam or loamy sand surface layers, which are neutral in reaction, over thick sandy clay loam, or clay loam subsoils.

*Representative Soil Series:* Gruver, Sherm, LaBrier, Dioxide, Plack.

#### 11. Paleustalfs (400,800 acres)

This association consists of moderately extensive areas in Colfax, Harding, and Union counties. In general, the soils occupy gently sloping and undulating landscapes, but small wind-eroded areas with gently rolling and dune topography are included. The most extensive soils have fine sandy loam or loamy sand surface layers. Wind erosion is a moder-

ate hazard on areas not protected by a good cover of vegetation.

The soils usually support a good cover of native vegetation, with blue grama, sideoats grama, little bluestem, big bluestem, Indiangrass, needle-and-thread, galleta, sand muhly, sand dropseed, and three-awns being the more common species. The principal shrubs are sand sagebrush, broom snake-weed, yucca, and various species of cacti. Although the dominant use is range, a small acreage is cultivated under irrigated and dry farming. Grain and forage sorghums, small grains, corn, and alfalfa hay are the principal crops. In addition to range and cropland uses, this soil area is a good wildlife habitat, particularly for game birds.

*Soil Characteristics:* Aridic Paleustalfs comprise approximately 65 percent of this association. They occur on gently sloping and undulating landscapes and they are grouped into three textural families, fine-loamy, fine, and coarse-loamy, on the basis of their subsoil texture. The Aridic Paleustalfs in the fine-loamy family (40 percent of the association) typically have brown fine sandy loam or loamy sand surface layers, which are neutral in reaction, over thick yellowish-brown to brown sandy clay loam subsoils. They are usually noncalcareous to depths ranging from 15 to 20 inches. The substratum is a very pale brown heavy loam or sandy clay loam that is moderately high in lime. The lime is typically in the form of small soft masses, threads, and as thin



Fig. 2. The Aridic Paleustalfs typically occupy gently sloping and undulating land forms. These deep well drained soils usually have fine sandy loam or loamy fine sand surface layers and fine-loamy subsoils.

coatings on ped surfaces. The Aridic Paleustalfs in the fine family (15 percent of the association) have a thick brown to grayish-brown heavy clay loam subsoil that is free of lime in the upper part. This is underlain at 30 to 40 inches by a brown to reddish-yellow clay loam with a moderate amount of lime, which is typically visible in the form of threads and small soft masses. Those soils that are members of the coarse-loamy family of Aridic Paleustalfs (10 percent of the association) typically have thick yellowish-brown noncalcareous loamy sand surface layers, yellowish-brown to yellowish-red fine sandy loam subsoils, and brown loamy fine sand substrata.

Also in this association are soils of the Aridic Paleustoll, Aridic Calcicustoll, Calciorthidic Paleustoll, and Ustic Torriorthent subgroups.

The Aridic Paleustolls commonly occupy the nearly level to gently sloping landscapes in this association. They have a brown to grayish-brown, noncalcareous, loam surface layer about 6 to 10 inches thick. This is underlain by a brown to light brown, blocky, clay loam subsoil that typically contains a few fine threads and specks of lime in the lower part. The substratum below an average depth of about 48 inches consists of pinkish white loam or sandy clay loam high in lime.

The Aridic Calcicustolls differ primarily from the previously discussed soils in this association in having high lime soil layers at a depth of about 20 to 40 inches. They usually have a moderately thick surface layer of brown loam or fine sandy loam. It is typically noncalcareous to a depth of three to five inches. The subsoil is a brown, calcareous clay loam. This is underlain by a pinkish-white loam substratum high in lime.

The Calciorthidic Paleustolls are forming in calcareous loamy sediments on gently to strongly sloping and undulating landscapes. These soils have a surface layer of brown loamy fine sand, fine sandy loam, or loam over a pale brown calcareous loam which grades into a white or pinkish-white loam with a very high lime content at depths ranging from 15 to 24 inches.

The Ustic Torriorthents, which occur primarily in Colfax and Harding counties, occupy undulating to gently rolling landscapes. They usually have a moderately thick surface layer of grayish-brown loamy fine sand or fine sandy loam over a similar, but more calcareous, subsoil. The substratum is a pale brown loamy sand which typically contains a few small soft masses and threads of segregated lime.

*Representative Soil Series:* Dallam, Rickmore, Vingo, Dioxice, Dumas.

## 12. Haplustolls-Argiustolls-Calciustolls (118,600 acres)

Included in this association are soils forming dominantly in materials of volcanic or basic igneous origin on lava flows in the southwestern part of Union County and adjacent areas in Colfax and Harding counties. Alluvial and eolian sediments have also contributed minor amounts to the parent materials in which these soils are developing. Gently sloping and undulating land forms intermingled with some strongly sloping and rolling areas, particularly near volcanic cones, are characteristic of the areas included in this association. The soils, which range from shallow to deep, are dark colored and often stony or cobbly.

This association is used for grazing and supports a relatively dense cover of native vegetation. The dominant or more common grass species are blue grama, sideoats grama, little bluestem, western wheatgrass, galleta, buffalograss, New Mexico featherglass, and three-awns.

*Soil Characteristics:* The Lithic Haplustolls, which comprise 30 percent of the association, commonly occur on gently sloping to gently rolling lava flows. They are extensive on the slopes surrounding volcanic cones. These soils have a surface layer of grayish-brown calcareous stony or cobbly loam. This is underlain by a brown, stony, or cobbly clay loam subsoil that typically contains moderate to large amounts of segregated lime in the lower part immediately above the basalt bedrock. Basalt fragments typically increase with depth, and bedrock occurs within a depth of 20 inches.

The Aridic Argiustolls, which account for 20 percent of the association, are deep and dark-colored. They usually occupy the nearly level to gently sloping land forms in this association. These soils have a surface of dark grayish-brown, noncalcareous silt loam or loam over a thick clay loam or clay subsoil. A white or pinkish-white layer of high lime accumulation commonly occurs at a depth ranging from about 36 to 50 inches.

The Aridic Calciustolls, which account for 20 percent of the association, are underlain at shallow to moderate depths by soil layers which are high in lime. Those of moderate depth typically have a surface layer of dark grayish-brown loam which is commonly noncalcareous to a depth of three to five inches. The subsoil is a grayish-brown to brown calcareous clay loam. This is underlain by a pinkish-white loam substratum high in lime at 24 to 40 inches.

The shallow Aridic Calciustolls typically have brown calcareous cobbly loam surface layers. These are underlain by pinkish-white and light brown very

cobbly loam or very stony loam with a high content of lime at a depth ranging from 10 to 30 inches. Basalt bedrock may occur below a depth of 36 to 40 inches.

Also in this association are Petrocalcic Paleustolls, Cumulic Haplustolls, and small areas of basalt rock outcrops. The Petrocalcic Paleustolls, which are shallow, have thin grayish-brown calcareous loam surface layers and pale brown calcareous loam subsoils. They are underlain by indurated caliche at depths of 6 to 20 inches. This in turn is often underlain by basalt bedrock at undetermined depths. Angular fragments of caliche range from few in the surface layer to many in the subsoil just above the indurated caliche.

The Cumulic Haplustolls occupy the nearly level to very gently sloping valley bottoms. These soils are deep and typically have grayish-brown loam or clay loam surface layers over thick grayish-brown to dark brown clay loam and clay subsoils.

*Representative Soil Series:* Apache, Torreon, Capulin, Dioxice, Ayon, Manzano.

## 13. Torriorthents-Argiustolls (380,200 acres)

This association occurs principally in Union County but also extends into Colfax and Harding counties. It dominantly occupies gently sloping to gently rolling landscapes underlain by sandstone bedrock. The soils, for the most part, are developing residually in materials weathered from the underlying sandstone. Locally, and particularly where the soils are of moderate depth or deeper, there have been additions of eolian materials.

These soils support a relatively complex mixture of mid and short grasses, including such species as blue grama, sideoats grama, sand dropseed, galleta, and little bluestem. Thin stands of juniper trees and shrubs are also common on the shallow soils and steep Rock Land areas.

*Soil Characteristics:* The Lithic Ustic Torriorthents, which constitute 40 percent of the association, are shallow, gently to strongly sloping soils developing on sandstone mesas and breaks. They have a surface layer of brown sandy loam or stony sandy loam. This is underlain by sandstone bedrock at depths ranging from 4 to 20 inches. Small angular sandstone fragments are common on the surface and throughout the soil, and sandstone bedrock outcrops occasionally.

The Aridic Argiustolls, which account for 20 percent of this association, occupy gently sloping and undulating uplands. They generally have a thin surface layer of brown noncalcareous loam over a subsoil of brown clay loam that is free of lime in

the upper part. This grades through a light-brown sandy clay loam or loam in which threads and small masses of lime are common to the underlying sandstone bedrock. The depth to the bedrock ranges from 20 to 40 inches.

Rock Land, a miscellaneous land type, comprises 15 percent of this association. It consists of a complex of shallow soils and outcrops of sandstone bedrock and other types of sedimentary rocks on escarpments and steep breaks located principally adjacent to drainages. The outcrops of bedrock commonly occur as vertical or nearly vertical exposures or ledges. A thin mantle of stony soil generally occurs between the ledges or outcrops of bedrock. Small isolated pockets of moderately deep to deep soils occasionally occur where benches or areas with lesser slope gradient have formed.

Other soil groups of importance in this association include Lithic Argiustolls, Cumulic Haplustolls, and Ustic Torriorthents. The Lithic Argiustolls, which occupy gently sloping and rolling land forms, have a thin surface layer of brown noncalcareous loam or fine sandy loam over a reddish-brown sandy clay loam subsoil. This is typically underlain by sandstone bedrock at 12 inches, but the depth may range from about 10 to 20 inches. The Cumulic Haplustolls occur in gently sloping swales and valley bottoms adjacent to drainageways. These deep soils have thick, grayish-brown to brown loam or clay loam surface layers over clay loam subsoils and substrata. The Ustic Torriorthents, which are also deep, commonly occupy the valley sideslopes just above the Cumulic Haplustolls. They typically have thin weakly calcareous brown to grayish-brown loam surface layers, light yellowish-brown calcareous light clay loam subsoils, and pale brown loam or sandy clay loam substrata.

*Representative Soil Series:* Travessilla, Carnero, Bernal, Manzano, Kim.

#### **14. Paleustolls-Calciorthids-Calciustolls (229,700 acres)**

This association consists of one area located in the extreme southeastern part of Union County and adjacent areas in Quay and Harding counties. Nearly level to gently sloping and undulating topography prevails throughout most of the area. Small areas adjacent to drainageways, however, are strongly sloping and undulating. The soils, which range from shallow to deep, are forming in alluvial and eolian sediments, much of which is very strongly calcareous.

Although the dominant use is range, a limited acreage of the deep and nearly level soils is culti-

vated under dry farming. Winter wheat and grain sorghums are the principal crops. The areas not under cultivation generally support a good cover of grass, and under good management moderate yields of forage are obtained. The principal grasses are blue grama, hairy grama, galleta, sand dropseed, sideoats grama, black grama, New Mexico feathergrass, and three-awns. The more common shrubs are broom snakeweed, yucca, and some mesquite and various species of cacti.

*Soil Characteristics:* Paleustolls, the most extensive in this association, are represented by Calciorthidic Paleustolls and Aridic Paleustolls. The Calciorthidic Paleustolls, which account for 35 percent of the association, are characterized by strongly calcareous surface layers and by subsoil layers with distinct lime accumulations. They occur on nearly level to gently sloping and undulating plains and valley slopes. These soils have a moderately thick surface layer of brown to grayish-brown strongly calcareous loam or fine sandy loam. This layer grades through a pale brown or light gray clay loam to a pinkish-white massive clay loam with a high lime content at depths of about 12 to 20 inches. Nodules and fragments of cemented caliche are common in the substratum.

The Aridic Paleustolls, which comprise 10 percent of the association, typically occur on the nearly level to very gently sloping plains. These soils have a surface layer of dark brown to brown noncalcareous loam over a thick reddish-brown heavy clay loam subsoil that is calcareous in the lower part. This is underlain by a reddish-brown strongly calcareous sandy clay loam. Numerous soft masses and threads of lime are common in the soil layers between 40 and 60 inches.

The Ustollic Calciorthids, which make up 15 percent of the association, usually occur on undulating to gently rolling uplands. They have a surface layer of brown calcareous loam or fine sandy loam. This grades through a light brown strongly calcareous loam or fine sandy loam to a pinkish-gray very gravelly fine sandy loam high in lime at a depth of 12 to 20 inches. Strongly cemented lime fragments are common and may comprise as much as 50 percent of this soil layer. Below a depth of about 36 inches, there is a gradual decrease in the lime content and a very rapid decrease in the gravel content. Approximately 45 to 60 percent of the Ustollic Calciorthids in this association lack the high gravel content in the underlying soil layers. These soils have a surface layer of grayish-brown, calcareous fine sandy loam or loam over caliche at depths ranging from 5 to 15 inches. The underlying caliche is often weakly cemented in the

upper part and a few cemented caliche fragments are common throughout the surface layers.

The Petrocalcic Calciustolls, typically occupying gently to strongly sloping crests and side slopes of upland ridges and knolls, amount to 10 percent of the association. They have a thin surface layer of brown to grayish-brown calcareous loam or fine sandy loam. This grades through a pale brown strongly calcareous loam to the underlying caliche that occurs at a depth of 6 to 20 inches. The caliche layer is usually platy and indurated in the upper part. Angular fragments of strongly cemented caliche range from a few in the surface layer to many in the subsurface layers above the indurated caliche.

Aridic Calciustolls are nearly as extensive as the Petrocalcic Calciustolls, constituting 10 percent of the association. These moderately deep soils are underlain by soil layers with a high content of lime at 20 to 40 inches. They usually have a moderately thick surface layer of grayish-brown loam or fine sandy loam which is typically noncalcareous to a depth of three to five inches. The brown calcareous loam subsoil is underlain by a pinkish-white loam substratum high in lime.

Also included in this association are small acreages of Ustic Torriorthents, Aridic Paleustalfs, and Cumulic Haplustolls. The Ustic Torriorthents, which are deep and medium-textured, typically occupy the valley slopes and rolling uplands adjacent to depressional areas. The Aridic Paleustalfs are deep and usually occur on gently undulating landscapes. They have fine sandy loam or loamy fine sand surface layers over sandy clay loam subsoils. The Cumulic Haplustolls occur in gently sloping swales and valley bottoms adjacent to drainageways. These deep soils have thick, dark-colored loam or clay loam surface layers over clay loam subsoils and substrata.

*Representative Soil Series:* Gruver, Plack, Dean, Dioxice, Mansker, Kim.

## SOIL ASSOCIATIONS (Soils with Thermic Temperatures)

### 15. Paleustalfs-Ustipsamments (658,700 acres)

This general soil area, often referred to locally as the "sandhills," occurs in the eastern part of Harding County and the northeastern part of Quay County. A characteristic feature of this soil association is the undulating to gently rolling or dunny landscapes. A few of the dunes are bare of vegetation and actively erode during windy periods. The soils, which are dominantly deep and sandy, are

developing in sandy eolian materials. Small areas of soils shallow over caliche or very limy sediments occur locally in the interdune areas. Wind erosion is a moderate to severe hazard when these soils are not protected by a good cover of vegetation.

This association is used mainly as rangeland, and under good management good forage yields are obtained during years of average or above precipitation. It supports a wide variety of grasses including blue grama, sideoats grama, hairy grama, little bluestem, big bluestem, sand dropseed, Indian-grass, switchgrass, giant sandreed, and black grama. Sand sagebrush, yucca, and mesquite are the more common shrubs. Although the dominant use is range, a very limited acreage is used to produce grain and forage sorghums, broomcorn, and sudangrass. This soil area also provides good wildlife habitat, particularly for game birds.

*Soil Characteristics:* Paleustalfs, which are dominant in this association, occur principally in the Udic, Aridic, and Arenic Aridic subgroups. Udic Paleustalfs, which account for 30 percent of the association, occur mainly on the gently sloping and undulating landscapes which are distinctly different from the rolling and dunny topography characteristic of the associated Typic Ustipsamments and dune-land. These Paleustalfs are deep soils with brown to reddish-brown loamy fine sand surface layers, yellowish-red fine sandy loam subsoils, and brown loamy fine sand substrata.

The Aridic Paleustalfs comprise 25 percent of the association and typically occupy the smoother landscapes. These are, nevertheless, usually gently sloping and undulating. They have a surface layer of brown loamy fine sand or fine sandy loam that is leached free of lime. Their subsoil is a thick



Fig. 3. Gently sloping and undulating Paleustalfs are in the foreground. The Typic Ustipsamments are on the gently rolling and dunny landscapes in the background.

reddish-brown to yellowish-red sandy clay loam that is typically free of lime in the upper part. This is underlain by a light reddish-brown sandy clay loam with a high lime content. The lime or calcium carbonate below an average depth of 40 inches is typically visible in the form of threads and small soft masses.

The Aridic Paleustalfs, which constitute only 5 percent of the association, usually occur on gently undulating and hummocky landscapes, and are characterized by their thick, loose, fine sand surface layer. This surface layer is light brown and noncalcareous, and about 20 to 36 inches thick. It rests abruptly on the yellowish-red to red sandy clay loam subsoil that ranges from two to three feet in thickness. It is generally noncalcareous, but may be calcareous in the lower part. This is underlain by a calcareous light sandy clay loam or sandy loam.

Typic Ustipsamments occupy 20 percent of this association, and occur on gently rolling and dune landscapes that are generally elongated in an east-west direction. These soils are characterized by their very rapidly permeable, loose, and sandy profiles. They typically consist of a pale brown or light yellowish-brown noncalcareous fine sand to a depth of 6 feet or more.

Soils of lesser extent in this association include Ustollic Camborthids, Ustollic Calciorthids, Calciorthidic Paleustolls, and Ustollic Haplargids. The Ustollic Camborthids are developing dominantly in gravelly alluvium on strongly sloping and rolling to hilly landscapes. They typically have thin surface layers of brown very gravelly loam or very gravelly sandy loam and subsoils of reddish-brown very gravelly sandy clay loam. A distinct zone of lime accumulation occurs at a depth of 12 to 25 inches. The Ustollic Calciorthids are widely distributed and occur on small nearly level to gently undulating areas between the rolling and dune uplands. These soils have brown or grayish-brown calcareous fine sandy loam surface layers over caliche or very limy sediments that occur at depths ranging from about 6 to 20 inches. The Calciorthidic Paleustolls occur on gently to strongly sloping and undulating landscapes. In this association, these soils usually have a moderately thick surface layer of brown calcareous fine sandy loam. Their subsoil is a brown strongly calcareous loam. This grades into a pinkish-white loam with a high lime content at depths ranging from about 15 to 24 inches. The Ustollic Haplargids, which are not extensive in this association, occur on nearly level to very gently sloping landscapes in the extreme western part of this general soil area. They have a thin surface layer of reddish-brown noncalcareous loam,

over a thick subsoil of reddish-brown calcareous heavy clay loam or clay. Below this is a light reddish-brown clay loam that contains a few small masses and streaks of lime. Duneland, a miscellaneous land type, also occurs to a limited extent in this association. It consists of barren or nearly barren areas of actively eroding sand dunes, about 6 to 15 feet in height.

*Representative Soil Series:* Springer, Amarillo, Brownfield, Tivoli, Gallegos, Potter, Mansker, Tucumcari.

#### **16. Paleustalfs-Camborthids (202,600 acres)**

This soil association occurs in the east-central part of Quay County. The more extensive soils are forming in parent materials dominantly of alluvial and eolian origin on gently sloping and undulating landscapes. Some, however, on gently to strongly sloping and rolling upland ridges, low hills, and mesas, are developing dominantly in sediments weathered residually from sandstone or interbedded shale and sandstone. These soils on the more sloping and rolling lands range from shallow to moderately deep and, in general, are best suited to range use.

The major soils in this association are generally deep and well drained and have moderately coarse-textured surface layers. They have good moisture intake rates and are suited to dry farming. They are susceptible to wind erosion, however, so that practices to minimize damage by wind erosion are essential on cultivated areas. The principal crops are forage sorghums, grain sorghums, and broomcorn. The soils in range use support fair to good stands of native vegetation, including blue grama, hairy grama, sidecoats grama, black grama, sand dropseed, sand muhly, little bluestem, galleta, New Mexico feathergrass, three-awns, and some yucca, broom snakeweed, and various species of cacti.

*Soil Characteristics:* The Aridic Paleustalfs, which comprise 40 percent of the association, occupy the smoother and more gently sloping areas. These soils have a surface layer of reddish-brown or brown fine sandy loam or loamy fine sand that is leached free of lime. Their subsoil is a thick reddish-brown to yellowish-red sandy clay loam that is typically free of lime in the upper part. This is underlain by a light reddish-brown sandy clay loam with a high lime content. The lime or calcium carbonate below an average depth of 40 inches is typically visible in the form of threads and small soft masses.

Ustochreptic Camborthids, which account for 30 percent of this association, occur dominantly on

gently sloping and undulating landscapes with slopes generally averaging less than five percent. A few small areas of hummocky and wind-eroded soils are also included. These soils have reddish-brown noncalcareous loamy fine sand or fine sandy loam surface layers, light reddish-brown calcareous fine sandy loam subsoils, and yellowish-red very fine sandy loam and fine sandy loam substrata. A few fine streaks and small soft masses of lime commonly occur in the lower part of the subsoil and in the substrata. About 20 percent of the Ustochreptic Camborthids consists of shallow to moderately deep soils forming on bedrock that is dominantly sandstone with only minor occurrence of shale and limestone. They have a surface layer of light brown noncalcareous sandy loam. Their subsoil is a reddish-brown calcareous sandy loam that usually contains a few specks and threads of lime in the lower part. This is underlain by sandstone bedrock at depths of 20 to 40 inches.

Ustochreptic Calciorthids, Ustollic Calciorthids, Aridic Paleustolls, Ustic Torriorthents, and Rough Broken and Stony Land comprise the remaining part of this association.

The Ustochreptic Calciorthids, which account for 10 percent of this general soil area, are forming residually in materials weathered from the underlying interbedded shale and sandstone. They have a reddish-brown calcareous loam surface layer that usually contains a few coarse fragments of very hard caliche and lime-coated sandstone pebbles. This grades through a light reddish-brown strongly calcareous clay loam to the underlying interbedded shale and sandstone that typically occurs at depths of 20 to 40 inches. Small lime concretions and fine soft masses of lime are common in these subsurface layers. Thin strata of gravelly clay loam also occurs in the subsurface layers overlying the shale and sandstone. These soils are very susceptible to erosion and as a result are often dissected by gullies.

The Ustollic Calciorthids, which usually occur on undulating to gently rolling uplands, have surface layers of brown to grayish-brown calcareous loam or fine sandy loam. These grade through a light brown strongly calcareous loam or fine sandy loam to pinkish-gray very gravelly fine sandy loam high in lime at a depth of 12 to 20 inches. Strongly cemented lime fragments are common and may comprise as much as 50 percent of this soil layer. Below a depth of about 36 inches there is a gradual decrease in lime content and a very rapid decrease in gravel content. About half of these soils, however, lack the high gravel content in the subsurface layers, and are shallow and underlain by caliche at a depth of 7 to 20 inches. The caliche is platy and weakly cemented in the upper part.

The Ustic Torriorthents occupy the nearly level to gently sloping valley bottoms and flood plains. They are deep, weakly stratified, and range in texture from moderately-coarse to moderately-fine.

The Aridic Paleustolls occur on nearly level to gently sloping plains. These have a surface layer of dark brown to brown noncalcareous loam over a thick reddish-brown heavy clay loam subsoil that is calcareous in the lower part. This is underlain by a reddish-brown strongly calcareous sandy clay loam.

Rough Broken and Stony Land, a miscellaneous land type, consists of a complex of shallow soils and outcrops of thinly bedded shales, sandstone, and other sedimentary rocks.

*Representative Soil Series:* Amarillo, Ima, Los Tanos, San Jon, Bascom, Potter, San Jose, Lacita, Minneosa, Olton.

### 17. Paleustolls (905,800 acres)

This association, one of the larger general soil areas on the High Plains, includes extensive areas in Curry and Quay counties. The soils are dominantly deep and are forming generally in parent materials of eolian origin which have been deposited on the Ogallala formation. They are locally known as "hardland" and occur on smooth, nearly level to gently undulating landscapes with slopes usually averaging less than two percent. The drainage pattern is poorly developed except in the immediate vicinity of the small intermittent lakes which occur throughout the area.

The soils of this association are used for dryland and irrigated farming and range. Winter wheat is the principal cash crop, but grain and forage sorghums and other small grains are also grown. Because of the semiarid climate, farmers cannot rely on continuous high yields under dry farming. Much of this land is under cultivation, but it also contains many native pasture areas. These vary in size from a few acres to several sections; the larger ones are in the western part of the soil association. Blue grama is the dominant grass on the native pasture areas. Other grasses of lesser extent that are commonly associated with blue grama are buffalograss, galleta, tobosa, sideoats grama, spike muhly, and minor amounts of vine mesquite, little bluestem, and western wheatgrass.

*Soil Characteristics:* Paleustolls, the most extensive soils in this association are represented principally by the Aridic, Torriertic, and Calciorthidic subgroups.

The Aridic Paleustolls, which constitute 45 percent of this association, have a surface layer of dark brown to brown noncalcareous loam over a thick



Fig. 4. The deep, nearly level to very sloping Aridic Paleustolls in soil association No. 17 are used for range, irrigated and dry land farming.

reddish brown heavy clay loam subsoil that is calcareous in the lower part. This is underlain by a reddish-brown strongly calcareous sandy clay loam. Soft masses and threads of lime are common in the soil layers between 40 and 60 inches.

The Torricic Paleustolls, which are also moderately extensive, differ from the Aridic Paleustolls in having finer textured subsoils that shrink and crack significantly upon drying. They typically have a thin surface layer of brown or dark grayish-brown loam over thick clayey subsoils. The upper part of the subsoil is dark brown or grayish-brown clay. This is underlain by a brown or dark brown heavy clay loam. The substratum is typically a light brown to reddish-brown calcareous clay loam. Threads and small soft masses of lime are common in the substratum. These soils are normally noncalcareous to depths ranging from 15 to 25 inches.

The Calciorthic Paleustolls constitute 10 percent of this association. Although they occur on nearly level to gently sloping upland plains in association with other soils, they commonly are extensive on the slopes surrounding the playas. They are strongly calcareous to the surface. In general, they have a moderately thick surface layer of grayish-brown loam. This layer grades through a light gray to grayish-brown loam to a pinkish-white loam high in lime at depths of 15 to 20 inches. Nodules and fragments of cemented caliche are common in the layers below a depth of 15 to 20 inches.

Also in this association are the shallow Petrocalcic Calciustolls, and the deep Aridic Paleustolls, Aquic Camborthids, Typic Ustorthents, and Fluventic Haplustolls. The Petrocalcic Calciustolls occur on the outer fringes of the High Plains and on the slopes and ridges adjacent to drainages and playas. These very shallow and loamy soils are underlain by hard caliche at depths of 6 to 15 inches. The Aridic Paleustolls, a minor component of this association commonly occur as small areas near Association 18, Paleustalf, which adjoins this one. They have brown or reddish-brown noncalcareous loam and fine sandy loam surface layers over a thick sandy clay loam subsoil. The Aquic Camborthids are on nearly level to very gently sloping terraces that surround large depressions or playas. They are deep, light-colored, and fine-textured. Typic Ustorthents consist of light-colored strongly calcareous fine sandy loams and loamy fine sands. They occupy gently sloping to rolling uplands that are on the eastern and northeastern sides of the large depressions or playas. The Fluventic Haplustolls are deep and dark-colored soils that lie along intermittent drainageways.

*Representative Soil Series:* Olton, Pullman, Mansker, Kimbrough, Amarillo.

#### 18. Paleustalfs (822,800 acres)

Included in this association are extensive areas in Roosevelt County and the Southeastern part of Curry County that are often locally referred to as "sandy row-crop land." The soils of this unit occupy nearly level to gently undulating landscapes. Slopes generally average less than two percent, but in some of the more undulating sections they may range up to five percent. The soils are dominantly moderately deep and deep, and well drained. Although a few soils with loam or medium-textured surface layers are included, soils with fine sandy loam and loamy fine sand surfaces are the most extensive. These soils are susceptible to wind erosion when not protected by a good cover of vegetation, so management practices to minimize damage from wind erosion are essential.

Approximately 20 to 25 percent of the soils in this association are used for row crops under dry farming, and a small acreage is farmed under irrigation. Water for irrigation is obtained entirely from wells. The principal crops are grain sorghums, sudan-grass, broomcorn, and winter wheat. Under irrigation some alfalfa, peanuts, sweetpotatoes, and other small grains are produced in addition to those previously mentioned. The soils not under cultivation support a wide variety of grasses and under good systems of management produce good yields



of forage. The dominant grasses are sideoats grama, blue grama, little bluestem, black grama, sand bluestem, New Mexico feathergrass, sand dropseed, and three-awns. Principal shrubs on this soil area are sand sagebrush, soapweed yucca, and broom snakeweed.

**Soil Characteristics:** Paleustalfs are the most extensive in this association; the Aridic Paleustalf subgroup constitutes 55 percent of the total area. These soils occur on nearly level to gently sloping and undulating landscapes. They have a surface layer of brown to reddish-brown noncalcareous loamy fine sand or fine sandy loam. Their subsoil is a thick yellowish-red to reddish-brown sandy clay loam that is typically noncalcareous in the upper part. This is underlain by a light reddish-brown strongly calcareous light sandy clay loam. The lime or calcium carbonate below an average depth of 40 inches typically occurs in the form of fine threads and small soft masses. Udic Paleustalfs, which account for five percent of the area, are coarser textured. These soils typically have loamy fine sand surface layers, fine sandy loam subsoils, and loamy fine sand substrata. Petrocalcic Paleustalfs, which also account for five percent of the area, are characterized by their moderate depth over indurated caliche. They have a surface layer of about eight inches of brown to reddish-brown noncalcareous fine sandy loam or loamy fine sand. The subsoil, a reddish-brown to yellowish-red sandy clay loam, rests abruptly on a layer of indurated caliche at a depth of 20 to 40 inches.

Ustalfic Haplargids are the other major component, constituting 15 percent of this association. They are similar to the Aridic Paleustalfs but have a distinct zone of lime accumulation within a depth of 40 inches. In this association these soils usually have a surface layer of reddish-brown noncalcareous fine sandy loam or loamy fine sand over a reddish-brown calcareous sandy clay loam subsoil. This is underlain at depths of two to three feet by pinkish-white and light reddish-brown sandy clay loam in which the maximum lime accumulation usually occurs in the upper part.

Other soils of importance in this association are Calciorthidic Paleustolls and Aridic Calcicustolls. The Calciorthidic Paleustolls are characterized by their strongly calcareous surface layers and their shallow to moderate depth over soil layers with a high content of lime. These soils usually have a moderately thick surface layer of brown to grayish-brown fine sandy loam or loam, which grades through a light brownish-gray and a light gray loam to pinkish-white loam high in lime at depths of 15 to 20 inches. The Aridic Calcicustolls in this associa-



Fig. 5. The Typical Paleustalfs commonly occur on nearly level to gently sloping and undulating landscapes.

tion occupy the nearly level to very gently sloping landscapes. They have a moderately thick surface layer of grayish-brown calcareous loam or fine sandy loam. The subsoil is a light brownish-gray calcareous loam or sandy clay loam. This grades into a pinkish-white loam or soft caliche substratum at depths ranging from 20 to 36 inches. Also scattered throughout this general soil area are small areas of shallow soils. These soils, which are underlain at a depth of about 6 to 20 inches by indurated caliche, are quite variable in other characteristics. The surface layers range from noncalcareous to strongly calcareous and in texture from loamy fine sand to loam.

**Representative Soil Series:** Amarillo, Springer, Redona, Arvana.

#### 19. Ustipsamments-Ustochrepts (188,800 acres)

This association, which is locally known as the "sandhills," occurs along the boundary line between Curry and Roosevelt counties. A characteristic feature of this soil association is the undulating to gently rolling and dunny topography. A few of the dunes are bare of vegetation and actively erode during windy periods. The soils, which are dominantly deep and sandy are developing in sandy eolian sediments. Small areas of soils shallow over caliche or very limy sediments occur occasionally in the interdune areas.

This association is used mainly as native range. Although these soils are sandy, highly susceptible to wind erosion, and generally not suitable for cultivation, they produce moderate to high yields of forage under good management. The range land that is in good condition supports a mixture of tall

and mid grasses including such species as little bluestem, sand bluestem, sideoats grama, Indian-grass, switchgrass, sandreed, black grama, and sand dropseed, sand sagebrush, small soapweed, sand-plum, and Mormon tea are the more common shrubs.

*Soil Characteristics:* Typic Ustipsamments constitute 65 percent of the association, mainly on gently rolling or dune landscapes. These duned areas are usually elongated in an east-west direction. The soils are characterized by their very rapidly permeable, loose, and sandy profiles. They typically consist of a pale brown or light yellowish-brown noncalcareous fine sand to a depth of six feet or more.

The Aridic Ustochrepts, which comprise 15 percent of the association, are gently sloping and undulating on landscapes between the dunes and rolling land forms occupied by the Typic Ustipsamments. Typically the surface layer is a noncalcareous loamy fine sand about 12 to 15 inches thick. It ranges from grayish-brown in the upper part to brown in the lower part. This grades through a pale brown calcareous fine sandy loam or sandy loam to white or pinkish-white moderately-coarse to medium-textured limy sediments.

Also of importance in this association are Udic Paleustalfs and Arenic Aridic Paleustalfs. The soils of these two subgroups commonly occur in close association in this general soil area on gently sloping and undulating landscapes. The Udic Paleustalfs, which account for 10 percent of the area, have a reddish-brown, noncalcareous, loamy fine sand surface layer over yellowish-red fine sandy loam subsoil. This is underlain by a yellowish-red to brown calcareous loamy fine sand. The Arenic Aridic Paleustalfs, which comprise five percent of the area, have a thick surface layer of brown, loose fine sand that is leached free of lime. This rests abruptly on the yellowish-red to red sandy clay loam subsoil. They have a reddish-yellow, strongly calcareous light sandy clay loam substratum.

Small areas of Ustochreptic Calciorthis and Ustollic Calciorthis occur on nearly level to undulating concave surfaces in the interdune areas. The Ustochreptic Calciorthis are shallow, strongly calcareous, light-colored soils. They are underlain by soft caliche or loamy sediments with a high lime content within 20 inches of the surface. The Ustollic Calciorthis have grayish-brown to brown strongly calcareous surface layers and pale brown strongly calcareous subsoils. They are underlain by soft to weakly cemented caliche at depths of 10 to 30 inches.

*Representative Soil Series:* Tivoli, Springer, Brownfield, Gomez.

## 20. Paleustolls-Calcicustolls (559,200 acres)

This association, which consists of extensive areas in the central part of Roosevelt County, occurs on relatively smooth, nearly level to gently undulating landscapes. It is dominated by moderately deep and deep soils with loam and fine sandy loam surface layers. These soils are only slightly to moderately susceptible to wind erosion and can generally be protected by an adequate cover of vegetation or crop residue.

Most small grains produced under dry farming in Roosevelt County are grown on the soils of this association. In years of average or above precipitation, fair to moderate yields are obtained. Although a considerable part of this association is under cultivation, many areas are in native range. These are particularly extensive in the western part of this general soil area. Blue grama is the dominant grass in these areas. Other grasses that commonly occur are tobosa, ring muhly, vine mesquite, buffalograss, sideoats grama, and black grama.

*Soil Characteristics:* Paleustolls, the most extensive in this association, are represented principally by the Aridic and Petrocalcic subgroups. The Aridic Paleustolls constitute 35 percent of the area, commonly on broad nearly level to very gently sloping plains. They typically have brown to dark brown, noncalcareous loam surface layers over thick brown to reddish-brown subsoils that range in texture from sandy clay loam to heavy clay loam. The lower part of the subsoil is typically calcareous. This is underlain by a strongly calcareous sandy clay loam or clay loam containing many threads and soft white masses of lime. A pinkish-white loam or sandy clay loam with a high content of lime occurs occasionally in these soils at a depth ranging from about 24 to 40 inches. The Petrocalcic Paleustolls, which constitute 15 percent of the area, are characterized by their moderate depths over indurated caliche. These soils have a surface layer of dark grayish-brown or brown noncalcareous loam over a brown heavy clay loam or silty clay loam subsoil. A layer of hard caliche commonly occurs at a depth of 20 to 40 inches.

The Aridic Calcicustolls, which account for 20 percent of this general soil area, usually have a moderately thick surface of brown to grayish-brown calcareous loam or fine sandy loam. The subsoil is a light brownish-gray calcareous loam or sandy clay loam. This grades into a pinkish-white loam or clay loam with a high content of lime at a depth of about 18 to 36 inches.

Other soils of importance in this association include those of the Aridic Paleustalf, Ustochreptic Calciorthid, and Petrocalcic Calcicustoll subgroups. The Aridic Paleustalfs, the most extensive of these, account for 15 percent of the association, and consists of those soils with brown, noncalcareous, fine sandy loam surface layers over thick reddish-brown sandy clay loam subsoils. The substratum below a depth of 36 to 48 inches usually consists of a light reddish-brown strongly calcareous sandy clay loam containing many threads and small white masses of lime, but occasionally it consists of pinkish-white soft caliche. Ustochreptic Calciorthids commonly occur on nearly level to gently sloping landscapes adjacent to playas and along the margins of drainages. The surface layer is usually a light brownish-gray calcareous loam or fine sandy loam. This grades through a pale brown strongly calcareous loam to a light-gray or white soft caliche within a depth of 20 inches. Petrocalcic Calcicustolls, which are shallow, are underlain by indurated caliche at depths of about 6 to 20 inches.

*Representative Soil Series:* Olton, Stegall, Portales, Mansker, Amarillo.

## **21. Paleustalfs-Ustipsamments-Paleargids (741,400 acres)**

This association includes an area in southern Roosevelt and northern Lea counties, and a narrow strip along the east side of Lea County. Characteristic features are sandy soils and gently undulating to rolling or dunny topography. The soils, which are generally deep, are developing in sandy eolian and alluvial sediments. The wind erosion hazard is high, and an adequate cover of vegetation or crop residues is essential to minimize damage.

Although the dominant use is range, a limited acreage in this association is cultivated under irrigated and dry farming. Grain and forage sorghums and cotton are the main crops. The native pasture areas that are in good condition support a fair to good cover of grass and shrubs. The more common grasses are sand bluestem, little bluestem, switchgrass, blue grama, New Mexico feathergrass, sand muhly, three-awns, sandreed, Indiangrass, sideoats grama, black grama, and sand dropseed. These soils also support scattered to relatively dense stands of shrubs, including shin oak, yucca, mesquite, sand sagebrush, and various species of cacti.

*Soil Characteristics:* Paleustalfs with fine sand, loamy fine sand, and fine sandy loam surface layers are dominant in this association. They include the Aridic, Arenic Aridic, Petrocalcic, and Udic subgroups.

The Aridic Paleustalfs, which comprise 30 percent of the total area, occupy the smoother landscapes, but are nevertheless usually gently undulating. These soils typically have a surface layer of brown, noncalcareous, fine sand or loamy fine sand. Their subsoil is a thick reddish-brown to yellowish-red sandy clay loam. It is generally noncalcareous, but may be calcareous in the lower part. This is underlain by a light reddish-brown calcareous sandy clay loam. Lime is usually visible in the form of threads and small soft masses below a depth of about 40 inches.

The Arenic Aridic Paleustalfs, which comprise 25 percent of the area, occur on gently undulating and hummocky landscapes. They have a thick surface layer of light brown, loose noncalcareous fine sand about 20 to 36 inches thick. The surface layer rests abruptly on the reddish-brown to yellowish-red sandy clay loam subsoil which is generally noncalcareous. This is underlain by a calcareous sandy clay loam.

The Petrocalcic Paleustalfs, which comprise 10 percent of the area, are mainly on nearly level to very gently sloping landscapes. The surface layer is a brown to reddish-brown noncalcareous fine sandy loam or loamy fine sand. The subsoil is a moderately thick reddish-brown sandy clay loam that is typically neutral in reaction. This is underlain by indurated caliche at depths of 20 to 36 inches.

The Udic Paleustalfs, which comprise 5 percent of the area, are the least extensive of the Paleustalfs. They have brown to reddish-brown loamy fine sand surface layers, yellowish-red sandy loam subsoils, and loamy fine sand substrata.

The Typic Ustipsamments occupy 10 percent of the association, and occur on gently rolling and dunny landscapes. They are characterized by their very rapidly permeable, loose, and sandy profiles. They typically consist of pale brown or light yellowish-brown noncalcareous fine sand to a depth of six feet or more.

The Petrocalcic Ustalfic Paleargids account for 10 percent of the area, typically on nearly level to very gently sloping landscapes. These soils, which are shallow, have brown to reddish-brown noncalcareous fine sandy loam or loamy fine sand surface layers and thin reddish-brown sandy clay loam subsoils. They are underlain by indurated caliche at a depth of about 10 to 20 inches.

Also occurring to limited extent in this association are Aridic Ustochrepts and Aridic Calcicustolls. Aridic Ustochrepts, which are sandy, are underlain by soil layers high in lime at depths of 20 to 40 inches. Aridic Calcicustolls, which have loamy calcareous surface layers and subsoils, are moderately deep over soft caliche or soil layers high in lime.

*Representative Soil Series:* Amarillo, Patricia, Brownfield, Arvana, Springer, Tivoli, Sharvana, Gomez, Portales.

## 22. Calciustolls-Paleustolls (609,800 acres)

This association, which is in the east-central part of Lea County, occurs on broad, nearly level to very gently sloping landscapes characteristic of the Southern High Plains. The soils, in general, are developing over indurated to strongly cemented caliche at moderate to shallow depths. Although the underlying caliche restricts soil depth and root development, there are sufficient fractures to permit percolation of excess moisture.

The soils of this association are used as range and irrigated cropland. Nearly all the irrigated cropland in Lea County, a total of about 113,500 acres, is located within this general soil area. Water for irrigation is obtained entirely from wells. The principal crops are cotton, sorghums, alfalfa, small grains, and vegetables. The land in this unit, which is not irrigated, is used dominantly for grazing of livestock. It supports a good cover of grass with blue grama, hairy grama, sideoats grama, black grama, buffalograss, bush muhly, and tobosa being the more important species. The more common shrubs include broom snakeweed, yucca, cacti, and a few scattered mesquite.

*Soil Characteristics:* Petrocalcic Calciustolls, the most extensive in this association, account for 40 percent of the area. They commonly occur on the ridges or slightly higher parts of the landscape. The surface layer to an average depth of 6 to 8 inches consists of a dark grayish-brown noncalcareous to weakly calcareous gravelly loam. The gravels, which are dominantly angular hard caliche fragments, may comprise as much as 30 percent of the soil volume. Where the soils are deeper than the average depth of six to eight inches, the soil layer immediately above the caliche is commonly strongly calcareous and lighter colored. Indurated caliche occurs at depths ranging from 4 to 20 inches.

Aridic Calciustolls, which constitute 10 percent of this general area, differ in being moderately deep and in lacking the underlying indurated caliche. They occur on nearly level to very gently sloping plains and slight depressional areas. These soils have a surface layer of grayish-brown strongly calcareous loam over a pale brown loam or clay loam subsoil. They are typically underlain by a pinkish-white prominent lime zone, or soft caliche, at depths of 20 to 40 inches.

The Petrocalcic Paleustolls, which constitute 35 percent of the area, occur on nearly level to very gently sloping plains and slight depressional areas.

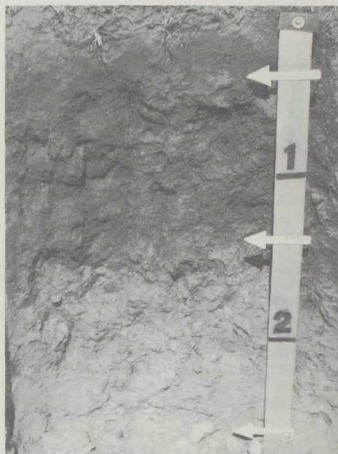


Fig. 6. The nearly level to very gently sloping Petrocalcic Paleustolls in this association are typically underlain by indurated caliche at a depth of 20 to 40 inches.

These soils usually have a surface layer of dark grayish-brown to brown noncalcareous loam. The subsoils range in texture from loam or light clay loam to heavy clay loams and silty clay loams. They are generally underlain by indurated caliche at depths of 20 to 40 inches, but occasionally may be as deep as 60 inches.

Also occurring to a limited extent in this association are soils of the Petrocalcic Paleustalf and Calciorthidic Paleustoll subgroups. The Petrocalcic Paleustalfs are characterized by their reddish-brown fine sandy loam surface layers and sandy clay loam subsoils. They are underlain by indurated caliche at moderate depths. The Calciorthidic Paleustolls are strongly calcareous medium-textured soils underlain by pinkish-white or white soil layers with a high content of lime at depths of about 10 to 20 inches.

*Representative Soil Series:* Kimbrough, Portales, Lea, Stegall.

### 23. Calciustolls (766,300 acres)

This association includes an extensive area along the southwestern margin of the High Plains. It is mainly in Lea County, but a small part of it extends into Eddy and Chaves counties. The soils, which are dominantly shallow, occur on nearly level to very gently sloping upland plains. Although this general soil area is remarkably smooth, a few swales or very shallow indistinct drainageways occur locally and terminate in shallow depressions or playas.

This association supports a relatively dense cover of grass and produces moderate yields of forage under good management. The principal grasses are blue grama, sand dropseed, buffalograss, sideoats grama, black grama, bush muhly, three-awns, New Mexico feathergrass, and tobosa. In the swales and slightly depressed areas, tobosa grass often comprises a relatively high percentage of the plant community. In addition to the grasses, a few mesquite shrubs, broom snakeweed, small soapweed, and various species of cacti commonly occur.

*Soil Characteristics:* Petrocalcic Calciustolls, which are shallow, comprise 70 percent of the soils in this general soil area. They occur on nearly level to gently sloping upland plains. The surface layer to an average depth of 6 or 8 inches consists

of a dark grayish-brown noncalcareous to weakly calcareous gravelly loam. The gravels, which are dominantly angular hard caliche fragments, may comprise as much as 30 percent of the soil volume. These surface layers may range in thickness from 4 to 20 inches; where they are deeper than the average depth of six to eight inches, the soil layer immediately above the caliche is commonly strongly calcareous and lighter colored. Indurated caliche occurs at depths ranging from 4 to 20 inches.

Other soils of importance in this association are those of the Petrocalcic Paleustoll and Aridic Calciustoll subgroups. These soils occur dominantly in the nearly level to slightly depressional areas and swales that are common throughout this association. The Petrocalcic Paleustolls are usually underlain by indurated caliche within a depth of 20 to 40 inches, but occasionally may be as deep as 60 inches. These soils have dark grayish-brown noncalcareous loam surface layers and loam, clay loam, or silty clay loam subsoils. The Aridic Calciustolls typically have a surface layer of grayish-brown calcareous loam over lighter colored strongly calcareous loam or light clay loam subsoils. They are underlain by a pinkish-white prominent lime zone at depths of 20 to 40 inches.

*Representative Soil Series:* Kimbrough, Lea, Stegall, Portales.

### 24. Paleustolls-Calciorthids (274,800 acres)

This association occurs in Curry, Roosevelt, and Quay counties, and consists dominantly of gently to strongly sloping and undulating areas located primarily along drainageways and the larger playas. In general, it includes the side slopes that grade towards the drainageways, as well as the shallow calcareous soils on the upper margins of these slopes. Calcareous soils that are developing over relatively thick beds of caliche are dominant. Although these soils normally occupy gently to strongly sloping and undulating landscapes, they also occur on nearly level areas.

Most of this association is in range use, and with good management, moderate yields of forage are obtained during years of average or above average precipitation. The native vegetation consists of a mixture of mid and short grasses with a scattered stand of shrubs. The more common grass species are blue grama, hairy grama, sideoats grama, sand dropseed, and little bluestem.

*Soil Characteristics:* Calciorthidic Paleustolls, the most extensive soils in this association, comprise 40 percent of the area and normally occupy the slopes that grade towards drainageways and playas. Small

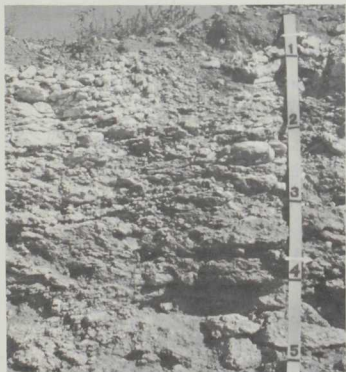


Fig. 7. Petrocalcic Calciustolls are extensive in soil association No. 23. These shallow soils are underlain by thick beds of indurated caliche.

nearly level to gently sloping areas, however, occur on the included upland plains. These soils are strongly calcareous to the surface, and generally have a moderately thick surface layer of grayish-brown loam or fine sandy loam. This layer grades through light brownish-gray and a light gray loam or clay loam to pinkish-white loam high in lime at depths of 15 to 20 inches. Nodules and fragments of cemented caliche are common in the layers below a depth of 15 to 20 inches. Associated with these soils on the nearly level upland plains are small areas of Aridic Paleustolls, which account for five percent of the total area. These soils typically have grayish-brown to brown noncalcareous surface layers over thick blocky heavy clay loam subsoils. The substratum consists of strongly calcareous sandy clay loam that normally contains numerous soft masses and threads of lime between 40 to 60 inches.

The Ustollic Calciorthids, which comprise 20 percent of the association, typically occupy the crests or upper parts of the slopes that grade toward the draws and playas. They have a surface layer of grayish-brown calcareous loam or fine sandy loam over caliche which occurs at depths of 5 to 15 inches. The caliche is often weakly cemented in the upper part and usually becomes friable and more permeable with depth. Cemented fragments of caliche are common on the surface and throughout the surface layers. Small areas of Aridic Calcistolls constitute 10 percent of the total. These soils occur on nearly level plains or in slight depressions. The soils are characterized by grayish-brown to brown calcareous loam or fine sandy loam surface layers and strongly calcareous loam or clay loam subsoils. They are underlain by a prominent lime zone at depths of about 20 to 40 inches.

In addition to the Paleustolls and Calciorthids, soils of the Fluventic Haplustoll, Typic Ustorthent, and Aquic Camborthid subgroups are also in this association. The Fluventic Haplustolls occur on nearly level to gently sloping landscapes in swales and valley bottoms along intermittent drainageways. They are deep, dark-colored and medium to moderately fine-textured. The Typic Ustorthents occupy undulating to rolling landscapes that usually occur on the eastern and northeastern sides of playas and depressions. These deep soils consist of strongly calcareous fine sandy loams and loamy fine sands. The Aquic Camborthids are on nearly level to very gently sloping terraces that surround large depressions or playas. They are deep, light-colored, strongly calcareous, and fine-textured.

*Representative Soil Series:* Mansker, Potter, Olton, Portales, Spur, Drake, and Church.

The Cool Desertic Region lies in the Colorado Plateau physiographic province. Although the general appearance is that of a moderately undulating plain, the area is broken by numerous small mesas and hogback ridges, and by a few igneous dikes. Smooth and nearly level areas border many of the principal drainages, which usually are deeply entrenched below the level of the plain.

The area is drained by the San Juan River, which begins in Colorado and re-enters that state after making a loop through San Juan County, New Mexico. Two other perennial streams in the area are the Animas and La Plata rivers. There are numerous intermittent streams, of which the Chaco River is the largest. Many of the intermittent drainages are rimmed by nearly barren and highly erodible shale hills. During flash floods, they contribute large amounts of silt to the drainage system.

Land elevations vary from 5,000 to 6,700 feet, in the main, with the Shiprock landmark rising to slightly over 7,000 feet.

The Northern Desert includes about 2,836,300 acres, of which 50,000 are irrigated and 742,000 are irrigable. Another 100,000 acres of land will be irrigated when the Navajo Irrigation Project, now under construction, is completed.

## CLIMATE

The climate, like that of most of New Mexico, is semiarid continental. Winters are relatively cold, summers are warm, precipitation is low, and days are sunny. Less than half of the annual precipitation falls in summer, usually in brief thunder-showers. Moderate amounts of snow, generally less than 15 inches, fall in winter. Winds are light to moderate but may be strong in spring. Humidity is low. This area has the least precipitation of any part of New Mexico. Table 2 gives data for three weather stations in San Juan County.

Daily temperatures vary from 30 to 40 degrees. Temperatures over 100 degrees are not uncommon. The maximum recorded at Shiprock was 109 degrees; at Farmington, 103 degrees, and at Chaco Canyon National Monument, 106 degrees. The lowest temperatures at those stations were 18, 16, and 24 degrees below zero, respectively.

The temperature at a depth of 20 inches is considered in classifying soils. All soils in this region have mesic temperature regimes, indicating that average annual soil temperature is between 47 and 59 degrees, and that the average summer and the average winter temperature differ by at least 9 degrees.

**Table 2. Climatic conditions at three stations in the Cool Desertic Region**

Station	Area	Elevation feet	Average Precipitation												Avg. Ann. Temp. °F	Frost- Free Season days	
			J	F	M	A	M	J	J	A	S	O	N	D			Annual
Shiprock	NW	4,972	0.37	0.47	0.56	0.54	0.51	0.36	0.73	0.99	0.97	0.69	0.38	0.47	7.04	53.2	163
Farmington	N	5,495	0.55	0.56	0.56	0.52	0.54	0.32	0.85	1.02	0.96	0.90	0.37	0.62	7.77	51.6	146
Chaco Canyon	S	6,175	0.43	0.60	0.57	0.45	0.74	0.35	1.08	1.39	1.06	0.95	0.43	0.62	8.67	50.5	167

## GEOLOGY

Shales and sandstones of the Kirtland, Fruitland, Menefee, and Mancos formations of Cretaceous age cover most of the Northern Desert region. Tertiary rocks of the San Jose formations are found on the eastern edge of the area. Quaternary alluvium that has been reworked by wind is extensive on the uplands south of Farmington.

## SOIL ASSOCIATIONS

Six soil associations have been recognized in the Cool Desertic Region. These are shown on the accompanying map and named after the major great groups that occur within them. Descriptions of these associations follow:

### 25. Torriorthents (134,200 acres)

This small association lies in the southeastern part of San Juan County. It consists of gently sloping, broad, moderately incised valleys and associated sloping and gently rolling uplands. Deep soils are dominant in the valley bottoms and on the valley slopes, while shallow soils with some outcrops of shale and sandstone are common on the upland areas. The soils are developing residually in materials of sandstone and shale origin, or in alluvium of similar origin. Although the erosion hazard is not particularly great, a few gullies commonly occur in the valley bottoms.

This association is used principally for grazing of livestock, and under good management fair yields of forage are obtained. Common native grasses and shrubs include galleta, blue grama, alkali sacaton, western wheatgrass, Indian ricegrass, big sagebrush, and broom snakeweed. Thin stands of pinyon pine and juniper also occur on the shallow soil and steeply sloping areas. The Badland and Rock Land areas are barren, or support only a sparse cover of vegetation.

*Soil Characteristics:* This association is dominated by Torriorthents, which generally are light-colored, lack distinct pedogenic horizons, and range from shallow to deep. The deep Typic Torriorthents constitute 40 percent of this soil association. These soils are forming mainly in medium to moderately fine-textured calcareous alluvium on gently sloping and undulating valley-filling slopes, alluvial fans, and in valley bottoms. The surface layers, which are mainly light brownish-gray to light olive brown and calcareous, range in texture from loam to clay loam. The subsurface layers to a depth of 60 inches or more consist of weakly stratified very fine sandy loams, loams, and clay loams. In addition, there are small areas of Typic Torriorthents (five percent of the total area) that are shallow to moderately deep. These soils usually have calcareous loam or silty clay loam surface layers over shale that typically occurs within a depth of 20 inches, but is occasionally as deep as three or four feet.

Lithic Torriorthents comprise 20 percent of the association, and occur on the sloping and gently rolling uplands. They are typically shallow over sandstone bedrock and have a surface layer of pale brown calcareous sandy loam or fine sandy loam. This grades through soil layers of similar color and texture to the underlying sandstone bedrock that occurs at a depth ranging from about 10 to 20 inches.

Areas identified as Badland comprise about 15 to 20 percent of this association. These are dominantly in the fringe areas just above the valley-filling slope surfaces, but they occur to a lesser extent throughout this association. They consist mainly of outcrops of soft shale with occasional thin strata of other sedimentary rocks that are in various stages of weathering. The landscape is one of rolling hills and very steep escarpments.

Also included in this general soil area are small areas of Typic Haplargids and Typic Calciorthids. Typic Haplargids occur on nearly level to gently

undulating uplands. These soils are characterized by their thin light brown or brown noncalcareous loam surface layer and clay loam subsoils. The substratum consists of sandy clay loam or clay loam with visible calcium carbonate occurring in finely divided forms and as thin seams and streaks. The Typic Calciorthids are forming principally in old alluvial sediments on gently to strongly sloping uplands. These soils, which are characterized by a moderately strong lime zone at depths of about 12 to 20 inches, have a brown to light brown calcareous surface layer. The subsoil to a depth of 36 to 40 inches consists of a loam or light clay loam that typically contains many pinkish-white medium to large masses of lime. The substratum to a depth of five feet or more is usually a light brown to light yellowish-brown very fine sandy loam or light loam.

*Representative Soil Series:* Turley, Azfield, Farb, Persayo, Doak, and Grandview.

## 26. Torriorthents-Ustifluvents (288,600 acres)

This association includes the entrenched valleys of the San Juan, La Plata, Animas, and Los Pinos rivers, as well as a number of smaller valleys contiguous to intermittent drainage systems. These soils, which are nearly level to gently sloping, are developing in stratified alluvium of mixed origin. In addition to the nearly level to gently sloping valley areas, this unit also includes the adjacent old river terraces and mesas. The mesas or terrace tops, which are usually small and 100 to 300 feet above the valley bottoms, are nearly level to gently sloping. The sides of the mesas or terraces range from moderately steep and hilly to very steep. Although there are occasional exposures of sandstone and shale, a thin veneer of gravelly alluvium commonly occurs on the surface. The gravel and cobbles in the surface layer has helped to stabilize the soils on the steep slopes, and as a result, they are not particularly susceptible to damage by either wind or water erosion. Gullies occur occasionally on the alluvial slopes at the base of escarpments where runoff from high-lying land concentrates.

Essentially, all 49,000 acres of the land now under irrigation in San Juan County are in this association. Alfalfa and corn are the most extensive crops, but tree fruits, small grains, vegetables, and potatoes are also important. A considerable acreage of land in this unit is used for urban and industrial purposes. The soils of this association that are not irrigated or in urban and industrial built-up areas provide limited grazing for livestock and wildlife. Native vegetation includes galleta, blue grama, western wheatgrass, Indian ricegrass, sand dropseed,

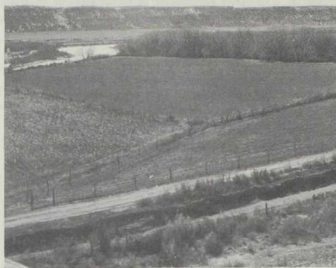


Fig. 8. The deep nearly level to gently sloping Typic Torriorthents shown in foreground on the valley filling slopes are well suited to irrigation. The Aquic Ustifluvents are on the floodplain adjacent to the river.

alkali sacaton, saltgrass, fourwing saltbush, and broom snakeweed. Cottonwood trees and some salt cedar grow on the soils of the floodplains of the major rivers and streams.

*Soil Characteristics:* Typic Torriorthents, which are the most extensive, comprise approximately 40 percent of this association. These soils are forming in alluvium on gently sloping fans and valley-filling slopes that lie between the mesa escarpments or uplands and flood plains. They are grouped into two textural families: fine-loamy and coarse-loamy. The Typic Torriorthents in the fine-loamy family comprise 30 percent of the association. Typically, these soils have light brownish-gray or light olive brown, calcareous loam and clay loam surface layers. The subsurface layers to a depth of 60 inches or more are weakly stratified and range in texture from very fine sandy loam to heavy clay loam and silty clay loam. The Typic Torriorthents in the coarse-loamy family, comprise 10 percent of the association, and are characterized by their rapidly permeable and moderately coarse-textured subsurface layers. The texture to a depth of three to four feet is typically a sandy loam. The substratum below this depth is usually more stratified and may include strata of loamy sand and sand in addition to the sandy loam. These soils are calcareous to the surface and range in color from pale brown or light yellowish brown to brown.



Aquic Ustifluvents occupy 25 percent of this association, typically on the nearly level to very gently sloping flood plains that are contiguous to the perennial streams. These soils have pale brown to grayish-brown, calcareous surface layers of fine sandy loam, loam, or clay loam. These are underlain to a depth of 60 inches or more by stratified subsurface layers of fine sandy loam, loam, silt loam, and clay loam. Strata of loamy sand or gravelly loamy sand may also occur in the substratum. These soils have variable drainage characteristics resulting from watertables that usually fluctuate between about two and seven feet in depth.

Hilly Gravelly Land and soils of Typic Calciorthid and Typic Torripsamment subgroups are also of importance in this general soil area. Hilly Gravelly Land, a miscellaneous land type, occupies the steep and hilly side slopes of old river terraces and mesas. A thin veneer of gravelly loam or cobbly loam commonly occurs on the surface. The underlying materials are quite variable, ranging from loams that contain very little gravel and cobble, to those that are very gravelly and cobbly. These soils or soil materials are usually shallow to gravel and cobble, sandstone, or shale. The Typic Calciorthids typically occupy the nearly level to gently sloping high river terraces and mesa tops that lie several hundred feet above the present flood plains. These soils have pale brown to brown loam, clay loam, or gravelly loam surface layers, which grade to a pinkish-white to white very gravelly loam or very gravelly sandy loam with a high content of lime at a depth of about 10 to 20 inches. This prominent lime layer is often weakly cemented in the upper part. The Typic Torripsamments commonly occupy gently to strongly sloping alluvial fans below escarpments or breaks. These soils are deep and consist of calcareous loamy sands or loamy fine sands to a depth of 60 inches or more.

In addition to the Hilly Gravelly Land, other miscellaneous land types such as Gullied Land, Riverwash, and Marshland comprise about five percent of this association.

*Representative Soil Series:* Fruitland, Turley, Azfield, and Werlow.

## 27. Torriorthents-Badland (768,900 acres)

This association, which is relatively extensive, is widely distributed throughout central and eastern San Juan County. Barren or nearly barren outcrops of shale and sandstone are a characteristic feature. The soils, which are dominantly shallow, light-colored, and calcareous, are developing in materials weathered from shale and sandstone. Surface relief

ranges from nearly level in the alluvial valley bottoms, through undulating and rolling hills to very steep slopes on escarpments and breaks.

The land types and soils of this association are used as rangeland. The Badland and Rock Land components support little or no vegetation, hence are of limited value, even as range. The remaining parts of the association support a sparse cover of native grass, forbs, and brush suitable for grazing of livestock and wildlife. The principal grasses include galleta, Indian ricegrass, and blue grama. Pinyon, juniper, serviceberry, bitterbrush, shadscale, and broom snakeweed represent the more common shrubs and woody species.

*Soil Characteristics:* Shallow, light-colored soils and miscellaneous land types are the principal components of this association. The soils are dominantly in the Typic Torriorthent and Lithic Torriorthent subgroups. The Typic Torriorthents account for 25 percent of the association, and consist principally of shallow soils developing on upland slopes and ridges in a thin layer of calcareous material weathered from the underlying shale. These soils consist dominantly of pale yellow and light yellowish-brown silt loams and silty clay loams



Fig. 9. Badland is a major component of soil association No. 27. The shale outcrops are usually barren. The shallow and light-colored Typic Torriorthents are on the upland ridges and slopes.

with shale occurring at a depth of about 6 to 20 inches. Partly weathered shale fragments, concretions of calcium carbonate, and crystals of calcium sulfate are common in the soil layer immediately above the shale. Approximately one-fourth of the Typic Torriorthents, however, are moderately deep and deep. They occur on nearly level to gently sloping alluvial fans or valley slopes and flood plains adjacent to ephemeral streams. These soils are usually light-colored, weakly stratified, and medium- to fine-textured. Although typically deep, they are occasionally underlain by shale at moderate depths on the valley slopes from the ridges and knolls occupied by shallow soils.

The Lithic Torriorthents, which are shallow over sandstone, comprise 15 percent of this unit. These soils consist mainly of pale brown to yellowish-brown calcareous sandy loams and loamy sands with sandstone occurring at a depth of about 6 to 20 inches. The soil layers above the sandstone often contain a few coarse fragments of sandstone.

Badland, the most extensive of the miscellaneous land types, accounts for 35 percent of this unit, and consists of barren or nearly barren outcrops of shale. It consists primarily of eroded soft shale in various stages of weathering. The landscape is one of rolling hills, separated by very narrow valleys or numerous intermittent drainage channels. Due to the low intake rates and very slow permeability, a large amount of water runs off after a normal rain, and flash floods follow heavy rains. Movement of moisture through the shale materials often causes soluble salts to concentrate in low places and sidehills where seepage water emerges.

Rock Land, the other miscellaneous land type of importance in this association, accounts for 15 percent of the area, and includes escarpments, breaks, and steeply sloping sides of mesas. It is a complex of shallow soils, sandstone outcrops, and exposures of other types of sedimentary rocks. The sandstone outcrops may appear as vertical exposures or as ledges. A thin mantle of rocky or stony soil material commonly occurs between the ledges or outcrops of bedrock.

Typic Haplargids, Typic Torripsamments, and Typic Torrifluents, which are of very limited extent, comprise the remaining parts of this association.

*Representative Soil Series:* Persayo, Farb.

## **28. Torriorthents-Torrifluents-Camborthids (989,300 acres)**

This association occurs mainly in the western part of San Juan County and extends into the northern part of McKinley County. It is character-

ized by undulating to rolling and moderately dissected plains with locally prominent uplands comprising hogbacks, mesas, domes, and volcanic outcrops. Another characteristic feature of the landscape, particularly in the southern part of this unit, is the low tilted ridges and ledges with outcrops and bedrock. Although differences in local relief are not great, the faces or exposures of sandstone and interbedded shale outcrops are very steep. The soils, which are light-colored, calcareous, and highly erodible, are forming dominantly in material weathered from yellow or gray cretaceous clay shales. In localized areas and to a much lesser extent, sandstone has contributed to the soil parent materials.

Although the soils of this association generally support only a sparse cover of vegetation, they are best suited to use as rangeland. Shadscale and galleta are the dominant vegetation. Other grasses and shrubs of importance include Indian ricegrass, alkali sacaton, globemallow, broom snakeweed, and some blue grama, sand dropseed, and various annuals.

*Soil Characteristics:* This association is dominated by Typic Torriorthents, which comprise 55 percent of the area. These soils are mainly shallow and light-colored, and lack distinct pedogenic horizons. They are developing on gently undulating to rolling uplands in a thin layer of calcareous parent materials weathered from the underlying shale. They consist dominantly of pale yellow and light yellowish-brown silt loams, silty clay loams, and clays with shale occurring at a depth of 6 to 20 inches. Partly weathered shale fragments, concretions of calcium carbonate and crystals of calcium sulfate are common in the subsoil layers immediately above the shale. Outcrops of shale occur occasionally. The deep and moderately deep Typic Torriorthents constitute 10 percent of the area and usually occur on nearly level to gently sloping alluvial fans and valley slopes below the uplands occupied by the shallow soils. These soils are usually light-colored, weakly stratified, and medium to fine-textured. Although dominantly deep, they are occasionally underlain by shale at moderate depths on the valley slopes adjacent to the shallow soils.

The Typic Camborthids, which also occupy 10 percent of this association, are typically coarser textured than the Typic Torriorthents. These soils usually have light brown to brown calcareous fine sandy loam or loamy fine sand surface layers and fine sandy loam subsoils. Small soft masses and threads of lime typically occur in the lower part of the subsoil. These soils are moderately deep to deep. Those of moderate depth are usually underlain by sandstone.

Typic Torrifluents and Typic Torripsamments are also of some importance in this general soil area. The Typic Torrifluents occupy the nearly level flood plains of intermittent drainages. These soils are deep, stratified, calcareous throughout, and dominantly medium to fine-textured. The Typic Torripsamments, which are of extremely limited extent, are developing in sandy eolian materials. They occur principally east of the Chaco River and consist of loamy sands and sands to a depth of five feet or more. Wind eroded and dune areas are common. Badland, Rock Land, Alluvial Land, and Gullied Land also comprise minor acreages in this association.

*Representative Soil Series:* Persayo, Chipeta, Billings.

### **29. Haplargids-Torripsamments (418,800 acres)**

This association occurs on gently sloping to gently rolling upland areas south of the San Juan River and east of the Chaco River. The soils, which are dominantly sandy and deep, are developing in sandy alluvial and eolian deposits. These deposits, in turn, are underlain by sedimentary rocks. Although some of the underlying shales have relatively low permeabilities, the alluvial and eolian materials are generally thick enough to permit adequate drainage. Except for the area immediately west of Gallegos Canyon, the ground surface generally slopes to the west and southwest.

The soils of this association, which at present are used principally for the grazing of livestock, generally support a moderately dense cover of vegetation. Under good management, fair to moderate yields of forage are obtained. Native vegetation includes galleta, blue grama, Indian ricegrass, sand dropseed, poverty three-awn, broom snakeweed, big sagebrush, winterfat, and long-leaf ephedra. Wind erosion is a moderate hazard, and careful management is needed, particularly under cultivation, to minimize damage.

*Soil Characteristics:* The soils in this association, in general, range from those with no distinct pedogenic horizons to those with weakly expressed horizons of clay and lime accumulation. The Typic Haplargids, which comprise 45 percent of the area, occur mainly on nearly level to gently sloping and undulating landscapes and are representative of those with weakly expressed horizons of clay accumulation. These soils usually have thin surface layers of light brown to light reddish-brown noncalcareous fine sandy loam or loamy fine sand. The subsoil or horizon of clay accumulation is also typically thin as it extends only to a depth of 15 or

20 inches. It is a brown to reddish-brown noncalcareous heavy fine sandy loam. The substratum to a depth of 60 inches or more consists of a sandy loam or loamy fine sand or occasionally fine sand that usually contains a few fine streaks and small soft masses of lime. Also included are small areas of Typic Haplargids where the subsoils are thicker and range in texture from medium to moderately fine.

The Typic Torripsamments, which constitute 20 percent of this association, occur on gently rolling or dunelike land forms. The ridges and dunes are oriented generally in the direction of the prevailing winds, southwest to northeast. They have surface layers of loose, weakly calcareous pale brown or light reddish-brown loamy fine sand, underlain by a moderately calcareous sand, fine sand, or loamy sand to a depth of five feet or more.

Typic Camborthids and Typic Calciorthis are also of moderate extent in this general soil area. The Typic Camborthids constitute 15 percent of the area. They are usually gently sloping and undulating but may range from nearly level to strongly sloping. These soils are characterized by their slightly calcareous, moderately coarse-textured surface layers and thick, strongly calcareous, moderately coarse- and medium-textured subsoils. The substratum below a depth of 30 to 48 inches ranges in texture from a fine sand or sand to a very fine sandy loam. The Typic Calciorthis, which make up 10 percent of the area, differ in that they have



**Fig. 10.** Gently sloping and undulating landscapes are common in soil association No. 29. The gently sloping Typic Haplargids are shown in the foreground. The Typic Torripsamments occupy the gently rolling ridges.

strongly calcareous surface layers and a prominent pinkish-white horizon of lime accumulation at a depth of about 10 to 20 inches. The soil layers above the prominent lime zone consist usually of pale brown or light brown to yellowish-red sandy loams.

Also in this association are small areas of moderately coarse- to medium-textured soils underlain by interbedded sandstone and shale. Miscellaneous land types such as shale and sandstone outcrops, Gullied Land, and Alluvial Land occur also to a very minor extent.

*Representative Soil Series:* Shiprock, Sheppard, Kinnear, and Nageasi.

### 30. Rock Land-Torriorthents (236,500 acres)

This association consists of three widely distributed areas located principally in San Juan County, with small areas extending into McKinley County. It is a very dissected area in which steep canyon walls, buttes, escarpments, and outcrops of sandstone and shale are interspersed with relatively narrow valley floors. A series of angular tilted ledges of sandstone rock are a particularly distinctive feature of the area. With the exception of the alluvial soils in the valley bottoms, the soils are generally shallow.

The lands in this association are used for the grazing of livestock and wildlife. Although the sandstone and shale outcrops are barren or nearly barren, the more favorable sites have a fair vegetative cover. Galleta, alkali sacaton, Indian ricegrass, and blue grama are the more common grasses. Shrubs and woody species include pinyon pine, juniper, greasewood, shadscale, and broom snake-weed.

*Soil Characteristics:* Rock outcrops and light-colored soils with weakly expressed or no pedogenic horizons comprise a major part of this association. Rock Land, a miscellaneous land type, is particularly extensive, accounting for about 50 percent of this association. It consists generally of a complex of shallow soils and outcrops of sandstone and other types of sedimentary rocks. The sandstone rock outcrops may occur as angular tilted ledges or very steep canyon walls and escarpments. A thin mantle of soil material often occurs between the outcrops of bedrock.

The associated soils are principally in the Lithic Torriorthent and Typic Torriorthent subgroups. Of these, the Lithic Torriorthents are most extensive, comprising 25 percent of the area. They are forming dominantly in materials weathered residually from sandstone or interbedded sandstone

and shale. They are typically calcareous and range in color from pale brown or light brown to reddish-brown, and in texture from sandy loam to clay loam. They are usually underlain by sandstone or hard rock within 20 inches of the surface. The Typic Torriorthents comprise 10 percent of the area, and occupy the nearly level to gently sloping valley-filling slopes and valley bottoms adjacent to intermittent drainages. These soils are deep, light-colored, calcareous, weakly stratified, and moderately coarse to fine-textured.

In addition to these major land types and soils, other components of this general soil area are Typic Torrifluvents, Typic Torripsamments and other miscellaneous land types such as Badland and Gullied Land.

*Representative Soil Series:* Farb is the only established series representative of this unit.

### Light-Colored Soils of the Warm Desertic Region

The Warm Desertic Region occupies parts of the Great Plains physiographic province, which is east of the Sacramento Mountains, and the Basin and Range province, which is west of the Sacramentos. The region is characterized by gently sloping plains that are broken by mountains and by the valleys of the Pecos River and the Rio Grande. Steep and rugged desert mountain ranges and isolated peaks rise abruptly from the floor of the plain in the southwestern part. The mountain ranges, which trend from north to south, generally are not continuous for long distances. It often is possible to go from one valley to the next without crossing over the ranges. Drainage divides are low and inconspicuous, and the valleys form, in reality, one great plain.

The Rio Grande and the Pecos rivers are the principal drainages. A significant part of the total drainage in southwestern and south-central New Mexico are into closed basins. Elevations range from 3,000 to 5,000 feet in the basins and valleys to over 9,000 feet on some of the desert mountain peaks.

The Warm Desertic Region includes about 19,774,000 acres, of which 470,000 are irrigated and 7,708,000 are irrigable.

### CLIMATE

In the Warm Desertic Region, the climate is of the arid continental type, characterized by low

rainfall, warm summers, and mild winter. Somewhat more than half of the annual precipitation falls in summer. The moisture distribution pattern in the Pecos Valley part, as in the remainder of eastern New Mexico, is a minimum in winter rising to a summer maximum, but the western part has the dry springs typical of western New Mexico. Most of the summer precipitation falls as brief but occasionally heavy thundershowers. Prolonged rains are practically unknown. Snow falls a few times each winter but usually disappears within a day. Winds are light to moderate throughout most of the year but may be strong during the spring. Humidities are low, probably ranging from 20 to 60 percent in most of the area. Evaporation from a Class A pan amounts to about 90 inches per year at Las Cruces and 110 inches at Elephant Butte Dam. Table 3 gives data for four weather station in the area.

Maximum day and minimum night temperatures commonly differ 30 degrees or more. Artesia had a record maximum temperature of 116 degrees and a minimum of 35 degrees below zero. Stations west of the Sacramento Mountains do not show as great extremes. Albuquerque had a maximum of 104 degrees and a minimum of 5 degrees below zero.

The temperature at a depth of 20 inches is considered in classifying soils. All soils in this region are considered to have thermic temperature regimes, indicating that the average annual soil temperature is between 59 and 72 degrees, and that the average summer and the average winter temperatures differ by at least 9 degrees.

## GEOLOGY

In the Pecos section of the Warm Desertic Region, surficial materials consist dominantly of Quater-

nary alluvium along the river, San Andres limestone (Permian age) south of the Sacramento Mountains, and other formations of Permian age southwest of Carlsbad. Gypsum and anhydrite beds are extensive along the Pecos River.

West of the Sacramento Mountains there are three major depressions: the Tularosa Basin, the Jornada del Muerto, and the Rio Grande Valley. The basins are grabens and the mountains mainly are fault blocks. The grabens were formed during the Quaternary period. In the southwestern corner of the state, the plains are Quaternary alluvium and the desert mountains are Tertiary igneous rocks. Numerous volcanic cinder cones of early Tertiary age dot the landscape southwest of Las Cruces and serve as reminders of past volcanic activity.

The gypsum dunes of the White Sands National Monument, in the Tularosa Basin, were formed during the Pleistocene epoch. Lava beds west of Carrizozo are believed to be as recent as 1,000 years old.

## SOIL ASSOCIATIONS

Twenty-two soil associations have been recognized in the Warm Desertic Region. These are shown on the accompanying map and named after the major great groups that occur within them. Descriptions of these associations follow:

### 31. Torrifluvents-Calciorthis-Torriorthents (1,445,900 acres)

This association includes the level to very gently sloping flood plain of the Rio Grande in Dona Ana, Sierra, Valencia, Bernalillo, Socorro, and Sandoval counties. It also includes the gently sloping to moderately steep terraces and alluvial fans that occur adjacent to, and just above, the Rio Grande

Table 3. Climatic conditions at stations in the Warm Desertic Region

Station	Area	Elevation feet	Average Precipitation												Avg. Ann. Temp. °F	Frost-Free Season days	
			J	F	M	A	M	J	J	A	S	O	N	D			Annual
Artesia	East	3,375	0.47	0.35	0.50	0.54	1.47	1.32	1.78	1.43	1.62	1.13	0.29	0.43	11.33	60.9	198
Albuquerque	N	5,311	0.41	0.38	0.48	0.47	0.75	0.57	1.20	1.33	0.95	0.75	0.38	0.45	8.13	56.6	204
Las Cruces*	South	3,881	0.47	0.51	0.30	0.17	0.31	0.53	1.29	1.68	1.22	0.75	0.30	0.48	8.01	60.0	201
Lordsburg	West	4,245	0.79	0.90	0.61	0.33	0.13	0.45	1.51	2.21	1.29	0.75	0.49	0.69	10.10	62.0	215

\*New Mexico State University Station

flood plain. Although these fans and terraces are dominantly rolling and steeply sloping they are commonly gently sloping where they approach the nearly level Rio Grande flood plain. The soils on the terraces and alluvial fans, which are forming in coarse-textured alluvial fan sediments of mixed origin, are coarse to medium-textured and often gravelly. Those on the nearly level flood plain are deep, highly stratified, and typically non-gravelly.

The soils in this association are used for irrigated cropland, irrigated pasture, urban and community developments, wildlife, and unimproved native pastures. A high percentage of the soils on the Rio Grande flood plain is irrigated. Although a wide variety of crops is grown, cotton and alfalfa are the most extensive in the southern part of the region below Socorro, while small grains and alfalfa are dominant in the northern part. Other crops of importance include pecans, vegetables, tree fruits, corn, and sorghum. The flood plain soils not under irrigation support a fair cover of vegetation including cottonwood, willow, Russian olive, and salt cedar with an understory of saltgrass, alkali sacaton, and annuals. The soils on upland alluvial fans and terraces support only sparse stands of vegetation that is dominated by creosotebush. Other vegetation includes mesquite, yucca, broom snakeweed, black grama, mesa dropseed, fluffgrass, and a number of annuals and various species of cacti.

*Soil Characteristics:* The Typic Torrifluvents, which constitute 25 percent of the association and are of major importance, occupy the nearly level landscapes adjacent to the Rio Grande. These soils, which are deep, and highly stratified, are developing in alluvium of mixed origin. The texture of the surface layers covers the entire gamut from sand to clay; however, most are medium, moderately fine, or fine. The subsurface layers are similar and may also range in texture from sand to clay, with moderately coarse to fine textures being dominant. Although these soils are usually adequately drained and well suited to irrigation, they are occasionally affected by high water tables or inadequate permeability. Also included are small areas of saline and saline-sodic soils.

The Typic Calciorthisds, which constitute 20 percent of the association, occur on the gently to strongly sloping and rolling alluvial fans and terraces. These soils typically have light-colored, strongly calcareous gravelly sandy loam or very gravelly sandy loam surface layers. These are usually underlain within a depth of about 20 inches by pinkish-white moderately-coarse textured subsurface layers with a high content of lime. These high lime layers are commonly gravelly but the

gravel content ranges from none to 50 percent or more. The degree of carbonate cementation ranges from none to nearly continuous weak cementation. The lime content decreases with depth, and at depths below three or four feet there is often little or no visible segregated lime.

The Typic Torriorthents, which comprise 15 percent of the association, occur on the gently to strongly sloping and rolling uplands above the Rio Grande flood plain. These soils lack the high lime layers which are typical of the Typic Calciorthisds. They generally have gravelly sandy loam surface layers and moderately coarse-textured subsurface layers. The gravel content in the subsurface layers may range from little or none to 50 percent or more.

Rough Broken Land comprises about 15 percent of this association and occupies the steep and rough lands that are dissected by many intermittent stream channels. It consists of a complex of highly variable shallow soils and exposures of alluvial sediments. In addition to the exposures of alluvial



Fig. 11. The Typic Torrifluvents, which occur on the nearly level to very gently sloping flood plain of the Rio Grande, are well suited to irrigation. Gently to strongly sloping soils of the Haplargids-Calciorthisds-Torripsamments association appears just above the irrigated valley, and the steep Argiustolls-Haplargids-Rock Land association is in the background.

sediments, exposures of subsurface layers of many different kinds of soil are common on the steep side slopes. These may include soft or hard caliche layers, as well as old subsurface layers of reddish-brown sandy clay loam or clay loam. A thin mantle of gravelly loam or gravelly sandy loam generally covers much of the land surface. Small areas of exposed bedrock may also occur where this unit joins mountainous and hilly areas.

Less extensive soils in this association include Typic Torripsamments, Typic Paleorthids, and Typic Torrets. The Typic Torripsamments commonly occupy the gently sloping and undulating fans just above the Rio Grande flood plains. They consist of weakly calcareous loamy fine sands and sands to a depth of five feet or more. The Typic Paleorthids, which occur on the crests of upland ridges and terraces, are underlain by indurated caliche within a depth of 20 inches. Riverwash and alluvial land in arroyo bottoms are also minor components of this general soil area.

*Representative Soil Series:* Gila, Glendale, Vinton, Anapra, Brazito, Armijo, Bluepoint, Caliza, Nickel, Dalian, Canutio, and Tencee.

### **32. Haplargids-Calciorthids-Torripsamments (1,026,300 acres)**

The soils in this association occur dominantly on gently to strongly sloping and undulating plains in the northern part of the Rio Grande depression; principally in Bernalillo, Valencia, Sandoval, and Socorro counties. Also included are depressional areas and drainageways of intermittent streams, as well as moderately steep to steep and rolling side slopes of ridges and mesas. It is occasionally dissected by intermittent stream channels that drain into the Rio Grande and Rio Puerco. The soils are forming generally in old alluvium that is dominantly coarse to moderately fine-textured. Sandy eolian sediments comprise a part of the parent materials in localized areas. The soils usually have sandy surface layers and as a result are highly susceptible to wind erosion.

This association is used dominantly for grazing of livestock and wildlife. Vegetation is mainly sand dropseed, mesa dropseed, Indian ricegrass, galleta, fluffgrass, blue grama, black grama, and annual forbs. A few scattered shrubs also commonly occur, including yucca, Mormon tea, smokebush, and sand sagebrush. Wind erosion hazard is high when vegetation is disturbed or depleted.

*Soil Characteristics:* The Typic Haplargids account for 35 percent of the association and occupy the more level upland landscapes. They are typically

nearly level to gently sloping and undulating. Surface soils are a light brown noncalcareous loamy fine sand and occasionally fine sandy loam. The subsoils, which are usually pale brown to light reddish-brown sandy clay loams grade into a pinkish-white loam high in lime at depths of about 20 to 36 inches. Although Typic Haplargids with strong zones of lime accumulation at moderate depths are dominant in this association, small acreages have only weak to moderate zones of lime accumulation. In these soils the lime occurs in the form of small soft masses and threads at depths of about two to four feet.

The Typic Calciorthids, which make up 20 percent of the area, are characterized by their light-colored calcareous surface layers and subsurface layers with high lime contents at shallow to moderate depths. The most extensive of these soils commonly occurs in swales or slight depressional areas. They have loamy fine sand or fine sandy loam surface layers and fine sandy loam subsoils. The underlying sediments are commonly layered, very high in lime, and of sandy loam or loam texture. Approximately one-fourth of Typic Calciorthids, those that occupy the gently sloping to rolling ridges and knolls, are underlain by a prominent zone of lime accumulation at a depth



**Fig. 12.** Gently sloping and undulating landscapes are common in soil association No. 32. The Typic Haplargids typically occur on the nearly level plains or slightly concave broad swales in this association. The Typic Calciorthids usually occupy the convex ridges or slightly higher positions.

of about 10 to 20 inches. These soils usually have loamy fine sand, sandy loam, or gravelly sandy loam surface layers. The white or pinkish-white high lime layers are moderately coarse to medium-textured and range in gravel content from little or none to more than 50 percent.

The Typic Torripsamments, which constitute 20 percent of the association, usually occur on gently sloping to rolling and dunny landscapes. These soils are deep, weakly calcareous, coarse-textured, and very rapidly permeable. Surface layers typically consist of light brown loamy sand. The subsurface layers are weakly stratified light brown loamy sand, loamy fine sand, or sand.

Also of some importance in this general soil area are Typic Torrierts, Typic Torriorthents, and Typic Camborthids. The Typic Torrierts are located principally on the incised flood plain of the Rio Puerco. They are deep, fine-textured, and very slowly permeable, and often saline and sodic. The Typic Camborthids and Torriorthents are deep, calcareous, and moderately coarse- to moderately fine-textured. Miscellaneous land types, including Rough Broken Land, Badland, Basalt Rock Land, and Alluvial Land, also comprise small acreages in this association. The Rough Broken Land, which occurs principally in the northwestern parts of this association on moderately steep to steep and dissected landscapes, consists of a complex of shallow soils and outcrops of weakly consolidated sandstone, conglomerates, clays, gravels, and other materials of the Santa Fe Formation. Badland consists of the steep and highly dissected side slopes of mesas. Geologic erosion is active and vegetation is sparse.

*Representative Soil Series:* Madurez, Wink, Caliza, Latene, Bluepoint, Armijo, Adelino, Tome.

### **33. Haplargids-Camborthids-Torriorthents (280,600 acres)**

This association consists of gently to strongly sloping soils on alluvial fans and piedmont slopes located dominantly at the base of the Sandia and Manzano Mountains in Bernalillo and Valencia counties. Slopes are generally westerly to the flood plain of the Rio Grande. The area is dissected by many weakly defined intermittent stream channels. The soils are dominantly moderately deep to deep and are forming in moderately coarse to moderately fine-textured alluvium. The soils contiguous to intermittent drainages are susceptible to gully erosion if the vegetative cover is depleted or destroyed.

Although this association is used mainly for grazing of livestock and wildlife, part of it is in urban or related uses, and other tracts have been

subdivided for potential building lots. Vegetation consists of short and mid grasses, forbs, and shrubs. The more common plant species are sand dropseed, galleta, burrograss, alkali sacaton, bush muhly, blue grama, black grama, winterfat, broom snakeweed, three-awns, fluffgrass, and annuals. Where the range is in poor condition or has been heavily used, burrograss, broom snakeweed, and annuals are often the dominant plant species.

*Soil Characteristics:* The Typic Haplargids, which comprise 40 percent of this association, are characterized by their thin light brown to brown noncalcareous loam or fine sandy loam surface layers. Gravelly and stony surface layers occur to a limited extent on the alluvial fans adjacent to the mountain fronts. Most of these soils have moderately thick reddish-brown clay loam subsoils with 10 to 15 percent fine gravel over gravelly sandy loam or very gravelly sandy loam substrata high in lime. Below an average depth of 40 inches, the soils typically contain less lime and more gravel and sand. Approximately one-fourth of these Typic Haplargids, however, have coarser-textured subsoils, contain less gravel, and have more limy substrata. These soils, which have heavy fine sandy loam or sandy clay loam subsoils, are underlain by pinkish-white, moderately coarse- to medium-textured sediments high in lime at depths of about 20 to 36 inches.

The Typic Camborthids, which comprise 20 percent of this unit, lack the well developed subsoils of the Typic Haplargids. They are typically deep and usually have thin fine sandy loam or loam surface layers that range from noncalcareous to slightly calcareous. The subsurface layers to a depth of five feet or more are calcareous and dominantly moderately coarse- to medium-textured. A few threads and small soft masses of lime are common between depths of about 18 to 48 inches. Strata of gravelly loam or gravelly sandy loam also occur occasionally in the substratum below a depth of two or three feet.

The Typic Torriorthents account for about 20 percent of the association. They occur on gently sloping valley areas in association with the Typic Camborthids, usually occupying the younger land forms or the lower parts of the landscape. These soils are deep, calcareous to the surface, and dominantly medium-textured. They are, however, weakly stratified and may range in texture from moderately coarse to moderately fine. Due to their low position, some of these soils receive additional moisture as runoff from higher lying lands. They are susceptible to erosion by water, and a few gullies often occur in the immediate valley bottoms.



Other soils and land types in this association include Typic Calciorthids, Typic Torripsamments, Gullied Land, and Alluvial Land.

*Representative Soil Series:* Tres Hermanos, Madurez, Adelino, Agustin, Pajarito, Tome, Largo, Latene.

#### 34. Haplargids-Paleargids (219,100 acres)

Included in this association are the broad, nearly level to gently sloping, remnants of old alluvial fans that extend from the mountain fronts towards the Rio Grande Valley in an easterly or southeasterly direction. Except for small areas of gently sloping to steep and dissected alluvial fans and terraces in the northwestern part, the surface of this association is relatively smooth with a weakly defined drainage system. Slope gradients are dominantly less than five percent, but they may range up to 10 percent near the mountains. The surface of this association is frequently 50 to 100 feet or more above the surrounding dissected areas, particularly in the area approaching the Rio Grande Valley. The soils, which are forming in moderately coarse- to medium-textured alluvial sediments, are usually gravelly and commonly shallow to moderately deep over soft to strongly cemented layers with a high lime content.

These soils support sparse to fair stands of vegetation that are dominated by creosotebush and some tarbush. Other vegetation includes black grama, sideoats grama, tobosa, mesa dropseed, three-awns, bush muhly, fluffgrass, yucca, broom snakeweed, and various species of cacti.



Fig. 13. The Typic Haplargids and Typic Paleargids in this association are on nearly level to gently sloping remnants of old alluvial fans that extend from the mountain fronts towards the Rio Grande Valley.

*Soil Characteristics:* The Typic Haplargids, which constitute 45 percent of this association, are extensive in the upper part near the adjoining mountain foothills. These soils are characterized by their thin surface layers of brown noncalcareous gravelly loam or gravelly sandy loam and their thick reddish-brown gravelly sandy clay loam and very gravelly sandy clay loam subsoils that are usually strongly calcareous in the lower part with lime occurring in the form of distinct fine threads and as thin coatings on the coarse fragments. This grades at a depth ranging from about 20 to 50 inches to a pinkish-white soft to weakly cemented gravelly caliche or gravelly sandy loam with a high content of lime. The Typic Haplargids that occur on the gently sloping terrace tops away from the mountain fronts are underlain at a shallow depth by a prominent lime zone. They usually have brown weakly calcareous to noncalcareous loam or fine sandy loam surface layers and light clay loam or sandy clay loam subsoils with pinkish-white gravelly loam with a high content of lime occurring at depths of about 18 to 26 inches.

The Typic Paleargids, which account for about 20 percent of this association, usually occupy nearly level to very gently sloping landscapes. They are most common in the lower part of this association and often occur in broad very slight depressional areas. These soils typically have a thin surface layer of reddish-brown noncalcareous sandy loam or loamy sand over thick reddish-brown sandy clay loam subsoils. The lower part of the subsoil, which is normally calcareous, contains a few filaments and small soft masses of lime. Indurated caliche occurs within depths of 20 to 40 inches. The laminar and indurated layer normally is confined to the upper 6 to 24 inches of the caliche horizon.

Typic Calciorthids, although not identified in the name, occupy about 15 percent of this general soil area. They typically occur on the outer edges of the terraces and on the sloping areas near drainage-ways. These soils are characterized by their light-colored and strongly calcareous gravelly loam or gravelly sandy loam surface layers. These grade at a depth of 15 to 25 inches to a pinkish-white very gravelly loam, gravelly loam, or very gravelly sandy loam.

In addition to these major soils, Rough Broken Land and soils of the Typic Paleorthid and Typic Torriorthent subgroups comprise small acreages in this association. The Rough Broken Land consists of the moderately steep and steep rough broken lands that are dissected by many intermittent stream channels and arroyos. The Typic Paleorthids, which are shallow, are underlain by strongly

cemented caliche within a depth of 20 inches. The Typic Torriorthents are deep and dominantly moderately coarse to medium-textured.

*Representative Soil Series:* Hap, Pinaleno, Strauss, Caciue, Simona, Nickel, Caliza.

### 35. Haplargids (1,750,200 acres)

This association comprises extensive areas in Luna, Hidalgo, and Grant counties and small areas extending into Dona Ana and Sierra counties in the southwestern part of the state. It occupies the lower parts of the piedmont slopes or plains between the desert mountains and the relatively broad nearly level basin floors. These nearly level to gently sloping soils are forming in old valley-filling sediments dominated by materials of igneous origin.

Except for a few scattered tracts of irrigated land, this association is used for grazing of livestock and wildlife. Under good management and in years of average precipitation or more, fair yields of forage are obtained. The extensive areas of soils with medium-textured surface layers support a fair cover of black grama, tobosa, Arizona cottontop, mesa dropseed, burrograss, three-awns, and some creosotebush, mesquite, and tarbush. Vegetation on the soils occurring in swales, and on other moderately fine-textured soils is dominated by tobosa, burrograss, three-awns and winterfat. Native vegetation on the soils with sandy surface layers consists of a mixture of grasses, principally black grama, bush muhly, dropseed, three-awns, tobosa, and blue grama. Shrubs and perennial forbs are represented by yucca, broom snakeweed, Mormon tea, mesquite, sand sagebrush, and wolfberry.

*Soil Characteristics:* Typic Haplargids, which occupy 50 percent of this association, commonly occur on gently sloping piedmont fans. A major part of the Typic Haplargids consist of soils with a thin surface layer of reddish-brown noncalcareous sandy clay loam or loam. Their subsoil is a reddish-brown clay loam that usually contains a few prominent streaks and soft masses of lime in the lower part. This is underlain by a light reddish-brown sandy clay loam or sandy loam with calcium carbonate occurring in finely divided forms and as thin seams and streaks. The substratum occasionally contains some gravel at depths of four to six feet.

Typic Haplargids with coarser-textured and more permeable surface layers and subsoils are also common in this unit. They usually have thin sandy loam or loamy sand surface layers over thick sandy clay loam subsoils. These are underlain at depths of 30

to 50 inches by soft caliche or a pinkish-white sandy clay loam or sandy loam with a very high lime content. Typic Haplargids with loamy sand surface layers and sandy loam subsoils also occur to a limited extent in this association. The substratum is coarse to moderately coarse-textured and does not have the prominent zone of lime accumulation that is characteristic of the other Typic Haplargids.

Ustollic Haplargids, which occur on nearly level to very gently sloping landforms in close association with the Typic Haplargids, make up 25 percent of this general soil area. They have a thin surface layer of pinkish-gray noncalcareous sandy clay loam or silty clay loam. This is underlain by a thick reddish-brown clay or heavy clay loam subsoil that typically contains seams and soft masses of lime in the lower part. The substratum is a light reddish-brown clay loam or gravelly clay loam with visible calcium carbonate occurring in finely divided forms and as small soft masses and seams.

Other soils of importance in this association include those of the Typic Camborthid, Mollic Torret, and Typic Torripsamment subgroups. The Typic Camborthids and Mollic Torretts, which commonly occur in valley bottoms, are moderately fine and fine-textured, respectively. The Typic Torripsamments are also deep and consist of loamy sands and sands.

*Representative Soil Series:* Mohave, Onite, Berino, Dona Ana, Stellar, Mimbres, Bluepoint, and Verhalen.

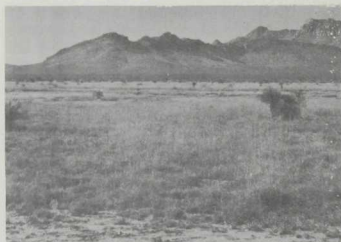


Fig. 14. Typical landscape in the Haplargid association No. 35. The Haplargids, which are dominant in this association, occupy the lower parts of the piedmont slopes or plains between the desert mountains and the broad nearly level basin floors.

### 36. Natrargids-Camborthids (498,200 acres)

This association includes broad, nearly level to very gently sloping basin floors and valley bottoms in Luna and Hidalgo counties. The only significant difference in local relief consists of slightly elevated ridges of sandy soils. These are commonly one to three feet higher than the surrounding nearly level land surfaces. The areas included in this unit are the lower parts of the closed basin drainage complex which is characteristic of southwestern New Mexico. These areas receive the runoff and drainage from surrounding areas, and include playas which are usually covered with water for short periods following severe storms.

The soils, which are deep, are developing in basin-fill sediments of mixed origin. In this association, many soils in their early stages of development were subject to accumulation of soluble salts and exchangeable sodium because of unfavorable drainage conditions. Although they are now generally well drained, a high percentage of the soils in this unit contain a moderate to larger amounts of exchangeable sodium and some soluble salts.

Except for small and scattered tracts of irrigated land, the soils of this association are used as rangeland. In general, they support a fair to good cover of vegetation and produce fair to moderate forage yields under good management. The exceptions to this are the playas and small soil areas with dispersed and sodic surface layers. These support little or no vegetation. Alkali sacaton, tobosa, vine-mesquite, burrograss, and saltgrass are the principal grasses. The more common shrubs are mesquite, desert saltbush, chamiza, shadscale, tarbush, rabbitbrush, and iodinebush.

*Soil Characteristics:* Typic Natrargids, which account for 60 percent of this association, are characterized by their moderate to high exchangeable sodium content. They typically have a light brownish-gray calcareous loam or silt loam surface layer over a thick light brown clay subsoil. The substratum consists of light gray weakly stratified sandy loams, sandy clay loams, and clay loams. The soils are strongly alkaline, usually with moderate amounts of exchangeable sodium in the subsoil. Some have higher levels of exchangeable sodium, and are referred to as strongly alkali-affected. These soils are usually sodic in the surface layers as well as in the subsoils. Slick spots devoid of vegetation are common on the soils with a high content of exchangeable sodium.

Typic Camborthids comprise 15 percent of this association and consist of soils with moderately thick surface layers of light brownish-gray, noncal-

careous to weakly calcareous loams and silty clay loams over thick moderately fine-textured subsoils. The substratum to a depth of five feet consists of medium to moderately fine-textured alluvial sediments. These soils occasionally contain moderate to high amounts of soluble salts or exchangeable sodium with the maximum concentrations occurring in the subsoil and substratum.

Also in this association are soils of the Typic Torripsamment, Typic Haplargid, Typic Paleorthid, and Mollic Torrient subgroups. The Typic Torripsamments and Typic Haplargids, which commonly occur in a complex pattern on the slightly elevated and undulating ridges, have no salinity or exchangeable sodium problems, and are thus a sharp contrast to the major soils in this association. The Typic Torripsamments are deep loamy sands and sands and occur mainly in the form of coppice dunes. The Typic Haplargids occupy the interdune areas and usually have sandy loam or loamy sand surface layers and moderately permeable sandy clay loam subsoils. The Typic Paleorthids are shallow over strongly cemented caliche. The Mollic Torrients are deep, fine-textured, and very slowly permeable. Playas, which comprise about five percent of this association, are the flat-bottomed, undrained basins that contain water for short periods following heavy rains. The alluvial sediments in these playas are generally saline and sodic.

*Representative Soil Series:* Hondale, Mimbres, Berino, Verhalen, Simona, and Bluepoint.

### 37. Calciorthids-Paleorthids (2,113,800 acres)

This association, widely distributed in the southwestern part of the state, consists of gently to strongly sloping and undulating soils on piedmont fans at the base of the major hills and desert mountains. In Otero County, an area of the soils west-northwest of Dell City, Texas, receives more moisture than normal for the mapping unit. These soils are Ustollic or Ustochreptic Aridistols. The soils, which are generally gravelly, are forming in coarse-textured alluvial fan sediments of mixed origin. This unit is dissected by numerous ephemeral streams and arroyos originating in the adjacent mountain areas. Slopes along the ridge crests, fans, and terraces between the arroyos usually average less than five percent, but may range up to nearly 10 percent in the upper part where the association joins the mountainous areas. Slopes on the ridge sides that grade toward arroyo bottoms commonly exceed 10 percent.

The soils are used for grazing and support a sparse to fair cover of vegetation. The more common grasses include black grama, fluffgrass, mesa drop-

seed, and traces of sideoats grama, blue grama, bush muhly, tobosa, and three-awns. In general, this association, is dominated by shrubs, mainly creosotebush, with lesser amounts of broom snake-weed, tarbush, yucca, and various species of cacti.

*Soil Characteristics:* The Typic Calciorthids, which occupy 35 percent of the association, are characterized by their light-colored calcareous surface layers and subsurface layers with high lime content at shallow to moderate depths. These soils generally have thin surface layers of pale brown or light brownish-gray calcareous gravelly sandy loam or gravelly loam. The subsoil is a light brown gravelly or very gravelly loam. This layer grades to white very gravelly and weakly cemented caliche at depths of 15 to 25 inches. The lime content and cementation decrease with depth in contrast to the coarse fragments, which usually increase in size and amount with depth. Small areas of Typic Calciorthids throughout this association contain less gravel or coarse fragments. These soils commonly occupy the gently sloping side slopes and lower parts of the piedmont slopes where they merge with the drainageways. They have sandy loam or sandy clay loam surface layers over strongly calcareous sandy clay loam or light clay loam subsoils with soft to weakly cemented caliche occurring at a depth of about 20 to 40 inches.

The Typic Paleorthids, which constitute 35 percent of this association, consist mainly of light-colored, very shallow and shallow soils underlain by indurated caliche within a depth of 20 inches. The underlying caliche, which is laminar and strongly cemented in the upper 6 to 12 inches, typically becomes less hard with depth. The surface layers are moderately coarse- to medium-textured and range in gravel content from about 10 or 15 percent to more than 35 percent. These surface layers are typically calcareous, but they may range from slightly calcareous to strongly calcareous.

Also of limited extent in this association are Typic Haplargids and Torriorthentic Haplustolls. The Typic Haplargids constitute about 10 percent of the area and occur on the less sloping landscapes. They usually have surface layers of gravelly sandy loam or gravelly sandy clay loam over a reddish-brown gravelly clay loam with a moderate to high content of lime in the lower part. This is underlain by a pinkish-white limy, very gravelly loam. Some small areas of Typic Haplargids contain little or no gravel. These soils typically have sandy loam surface layers and sandy clay loam subsoils over pinkish-white loams with a high content of lime.

The Torriorthentic Haplustolls, which occur on the upper slopes along mountain fronts dominated by igneous rocks, have moderately dark-colored, noncalcareous, gravelly loamy sand or gravelly sandy loam surface layers and moderately coarse-textured underlying layers. Also in this association are small areas of miscellaneous land types, such as Rough Broken Land, Alluvial Land, and Riverwash.

*Representative Soil Series:* Nickel, Tencee, Delnorte, Upton, Turney, Dona Ana, and Aladdin.

### **38. Camborthids-Torrifluvents (185,600 acres)**

This association consists of soils forming on broad, nearly level to very gently sloping basin floors and valley bottoms in the central part of Luna County near Deming. Except for a few dunes, hummocks, and low alluvial ridges, the land surface is relatively smooth with a nearly uniform slope to the south and southeast. The soils, which are dominantly deep, are developing in alluvial materials brought into the basin mainly by the Mimbres River and its tributaries.

Most of the 50,000 acres of irrigated land in Luna County are in this association. Cotton and grain sorghums are the most extensively grown crops. Other crops include alfalfa, corn, small grains, beans, vegetables, and pecans. The soils not now irrigated or in urban or other built-up areas provide limited grazing for livestock. Native vegetation includes tobosa, black grama, mesa dropseed, burrograss, sacaton, creosotebush, mesquite, and chamiza.

*Soil Characteristics:* Typic Camborthids, which occupy 50 percent of the association, consist of soils with weakly expressed pedogenic horizons. They are deep and are forming principally in medium to moderately fine-textured old alluvial sediments derived from igneous and metamorphic rocks, with some admixture of sedimentary rocks. The dominant surface soil textures are loams and silty clay loams. The subsoil is moderately fine-textured and usually contains slightly more clay than the surface layers. The surface layer is generally slightly calcareous, and the lime content tends to increase with depth to about four feet, but it seldom exceeds 10 percent. The substratum below a depth of three to four feet consists mainly of weakly stratified loams, sandy clay loams, and clay loams. Strata of sandy loam or gravelly sandy loam occur occasionally. Although typically free of harmful amounts of exchangeable sodium some small areas of these soils are moderately sodium-affected.

Typic Torrifluvents, which occupy 25 percent of the area, are characterized by their stratified

profiles and lack of pedogenic horizons. These soils, which are deep and calcareous throughout, are developing in moderately coarse- to moderately fine-textured alluvium. Those with subsurface layers of medium to moderately coarse textures and moderate permeability are the most extensive. Typic Torrifluents dominated by stratified subsurface layers consisting of silt loams, very fine sandy loams, and light silty clay loams are moderately extensive. These silty soils are mainly slowly permeable. Typic Torrifluents dominated by moderately coarse and rapidly permeable subsurface layers are of limited extent.

The remaining parts of this association consist mainly of soils in the Mollic Torrert, Typic Haplargid, and Typic Calciorthid subgroups. The Mollic Torrerts occur principally in swales and depressional areas. These soils are deep and have fine-textured and very slowly permeable subsoils. The Typic Haplargids occupy the older landscapes in this unit and have moderately well developed, medium- to moderately fine-textured subsoils. Pinkish-white soil layers with a high content of lime may occur within a depth of 20 to 40 inches, but these are more common below a depth of 40 inches. The Typic Calciorthids are characterized by their light-colored and strongly calcareous surface layers and subsoils. They are underlain by white or pinkish-white soft caliche or high lime soil layers at a depth of 10 to 40 inches.

*Representative Soil Series:* Mimbres, Gila, Harkey, Maricopa, Verhalen, Karro, Jal, Mohave.

### 39. Paleargids-Torripsamments-Paleorhiths (937,300 acres)

Soils of this association occupy nearly level to gently sloping or undulating sandy plains and alluvial fans in Dona Ana and Otero counties. Sand dunes and hummocks are prominent features of the landscape, and frequent sandstorms indicate the instability of the surface materials. Strongly calcareous layers are found in the lower part of the profiles. Native vegetation, which is sparse, is typical of wind eroded areas and consists of black grama, mesa dropseed, fluffgrass, broom snakeweed, yucca, mesquite, and creosotebush. In the more severely eroded parts of this unit, the interdune areas are often barren except for scattered stands of annual weeds.

*Soil Characteristics:* The Typic Paleargids, which comprise 35 percent of the association, are moderately deep over a strongly cemented lime zone that begins at depths ranging from about 20 to 40 inches below the surface. They occupy nearly level



Fig. 15. Profile of Typic Calciorthids showing a high lime layer or caliche that occurs at a depth ranging from about 20 to 36 inches.

to very gently sloping landscapes and are most common some distance from the escarpments. These soils typically have thin noncalcareous sandy loam or loamy sand surface layers over subsoils that range from fine sandy loam to sandy clay loam. Reddish-brown is the dominant color above the pinkish-white or white strongly cemented lime layer. The laminar and indurated part of this caliche layer normally is confined to the upper 6 to 24 inches. In many of the interdune areas, the thin surface layer has been removed by wind erosion.

The Typic Torripsamments account for 20 percent of this association and occupy the coppice dunes and those parts of the association that have gently rolling or duned topography. Commonly, the dunes are from four to six feet high and are forming in and around mesquite bushes and other shrubs. These soils have surface layers of loose, noncalcareous to weakly calcareous brown to reddish-brown fine sand over thick deposits of fine sand, which often grade into sandy loam or sandy clay loam near the bottom of the dune.

The Typic Paleorhiths, which are shallow over indurated caliche, occur on nearly level to very gently sloping landscapes occupying about 15 percent of this association. These soils typically have light brown or pale brown calcareous surface layers. The subsurface layers, which are similar in color and texture, commonly contain a few angular

caliche fragments. These are underlain at a depth of less than 20 inches by pinkish-white indurated caliche which is strongly cemented in the upper 6 to 12 inches and becomes less cemented with depth.

In addition to these three major soil groups, there are also in this general soil area Typic Calciorthids, Typic Haplargids, and Typic Camborthis. The Typic Calciorthids, which constitute 15 percent of the total area, commonly occupy the lower or slightly depressional areas in this association and are the most extensive of these inclusions. These soils are characterized by calcareous loamy fine sand or fine sandy loam surface layers and moderately coarse-textured subsoils over soft caliche. The underlying lime layer or caliche ranges from non-cemented to weakly cemented, and usually occurs at a depth of 20 to 40 inches. Occasionally, however, it is as shallow as 10 inches. The Typic Haplargids in this unit have loamy sand or sandy loam surface layers and well developed sandy clay loam subsoils. These are underlain at moderate depths by pinkish-white soil layers with a high content of lime or by medium- to moderately coarse-textured soil layers with only small to moderate accumulations of lime. The Typic Camborthis are deep and have only weakly developed subsoils. Those with loamy fine sand surface layers and sandy loam subsoils and substrata are the most common. There is usually some segregated lime in the form of fine seams and small soft masses in the lower part of the subsoil and upper part of the substratum.

*Representative Soil Series:* Cacique, Hueco, Cruces, Pintura, Simona, Wink, Berino, Pajarito.

#### **40. Haplargids-Torripsamments (2,590,700 acres)**

This association consists of extensive areas of sandy soils on undulating to gently rolling and dune landscapes in south-central New Mexico. It includes a large part of the closed basin, Jornada del Muerto, that lies within Socorro, Sierra, and Dona Ana counties. It also includes areas of like soils in Lea, Eddy, Otero, and Luna counties. Much of the land in this association has been affected by wind erosion, and as a result coppice dunes forming in and around mesquite and other shrubs are common. The dunes generally range from three to six feet or more in height and often actively erode during windy periods. In a few small areas, large dunes form a nearly continuous series. Small areas of nearly level to very gently sloping soils in swales and depressional areas are also included, but characteristically the soils in this unit occur on undulating to gently rolling and dune landscapes.

They are generally moderately deep and deep and are developing in eolian and old valley-filling sediments derived from a wide variety of rocks.

The soils with moderately coarse-textured surface layers occur generally on the gently undulating landscapes and support a fair cover of vegetation dominated by grass species including black grama, mesa dropseed, sand dropseed, giant dropseed, and fluffgrass. Shrub species which occur less frequently are mesquite, yucca, broom snakeweed, and sand sagebrush. The deep sands and loamy sands support a sparse to fair cover of vegetation consisting mainly of creosotebush, mesquite, chamiza, and traces of snakeweed, mesa dropseed, spike dropseed, black grama, bush muhly, and annuals. In the severely eroded areas mesquite, creosotebush, and annuals are dominant. Tobosa also occurs to a limited extent in the swales and small depressional areas.

*Soil Characteristics:* Typic Haplargids, which constitute 50 percent of this association, commonly occur on the gently sloping and undulating landscapes. A few low hummocks occasionally occur around shrubs where erosion has been active. In much of this unit, they occupy the gently undulating areas between the dunes and rolling ridges occupied by the deep sands. These soils have a thin surface layer of light brown to light reddish-brown noncalcareous fine sandy loam or loamy fine sand over thick reddish-brown sandy clay loam subsoils. The lower part of the subsoil, which is normally calcareous, contains a few filaments and small soft masses of lime. This is generally underlain at depths of three to four feet by a pinkish-white sandy clay loam that is very high in lime. Occasionally, the soils are underlain by high lime layers at depths of 20 to 36 inches, and these soils are frequently calcareous to the surface. Approximately 20 percent of the Typic Haplargids in this general soil area have



**Fig. 16.** Coppice dunes forming in and around mesquite and other shrubs in the Haplargids-Torripsamments association.

rapidly permeable and moderately coarse-textured subsoils. The substratum of these soils usually consists of sand or loamy sand; however, strata of gravelly sand may occur occasionally below a depth of about three feet.

The Typic Torripsamments occur on the coppice dunes and those parts of this association that are gently rolling and dunny. They have surface layers of loose, noncalcareous to weakly calcareous brown or reddish-brown fine sand over thick deposits of fine sand. The soils are deep and very susceptible to wind erosion.

Soils of the Typic Calciorthid, Typic Gypsiorthid, Typic Paleorthid, and Typic Torrert subgroups are also in this association. The Typic Calciorthids are characterized by their calcareous surface layers and strongly calcareous subsoils and substrata. A major part of this subgroup has loamy fine sand or fine sandy loam surface layers, fine sandy loam, or sandy clay subsoils, and pinkish-white or white soil layers with a high content of lime at depths of about 10 to 40 inches. These lime layers are occasionally weakly cemented. A small acreage of Typic Calciorthids, which occur on the nearly level basin floors, are medium- to moderately fine-textured. These soils consist mainly of silt loams, silty clay loams, and clay loams to a depth of 60 inches or more. Filaments and small soft masses of lime commonly occur below an average depth of about two feet. The Typic Gypsiorthids are gypsiferous, calcareous, and moderately coarse- to medium-textured. The soils layers below

a depth of 6 to 20 inches may contain 50 to 75 percent or more of gypsum. The Typic Paleorthids consist mainly of loamy fine sands and fine sandy loams underlain by undurated caliche within 20 inches of the surface. The Typic Torrerts, which occupy low positions and swales, are deep and fine-textured.

*Representative Soil Series:* Berino, Dona Ana, Onite, Pintura, Bluepoint, Wink, Jal, Turney, Yesum, Simona.

#### **41. Gypsiorthids-Torriorthents-Gypsum Land (1,088,600 acres)**

This association is widely distributed but occurs principally in the Pecos Valley and the Jornada del Muerto and Tularosa basins. It is characterized by outcrops of gypsiferous earth or gypsum intermingled with calcareous soils that are high in gypsum. The landscapes range from broad, nearly level or gently undulating plains to rolling hills. The major soils, which are light-colored and underlain by gypsum or gypsiferous earth at shallow to moderate depths, are forming in gypsiferous and saline valley-filling sediments. The soils occupying low positions adjacent to playas or in depressional areas are often moderately to strongly saline.

The Gypsum Land component of this unit supports little usable vegetation, so it is of very limited value, even as range. The remaining parts of the association support a sparse to fair cover of native grasses, forbs, and brush suitable for grazing by livestock and wildlife. The vegetation consists mainly of alkali sacaton, sand dropseed, gyp dropseed, gyp grama, fluffgrass, coldenia, chamiza, and traces of black grama, bush muhly, winterfat, mesquite, creosotebush, and tarbush. A few small areas in this association receive additional moisture as runoff from surrounding areas. These support dense stands of alkali sacaton and produce relatively high yields of forage.

*Soil Characteristics:* The Gypsiorthids, which make up 40 percent of this association, are about equally divided between the Calcic and Typic subgroups.

The Calcic Gypsiorthids consist of shallow to moderately deep soils with thin pale brown calcareous loam surface layers. These layers grade through a light-colored strongly calcareous clay loam to the underlying gypsiferous earth at depths of 20 to 36 inches. They are moderately to strongly saline in localized areas where drainage is restricted, and in this unit, they usually occupy gently sloping plains or the slightly depressed and swale-type landscapes.



**Fig. 17.** Typic Torripsamments typically occupy gently rolling and dunny landscapes. Undulating and dunny topography are common in the wind eroded areas.

The Typic Gypsiorthids have less lime and more gypsum in the surface layers than the Calcic Gypsiorthids. They are light-colored and moderately coarse- to medium-textured to a depth of 60 inches or more. The gypsum content in the surface layer usually ranges from about 25 to 50 percent, increases to approximately 75 to 80 percent within 10 to 20 inches, and then gradually decreases with depth.

The Typic Torriorthents, which make up 25 percent of the association, commonly occur on low ridges and very gently undulating landscapes. They are thin light-colored gypsiferous and calcareous soils underlain by thick beds of gypsum at a depth of 6 to 20 inches.

Gypsum Land, which accounts for 20 percent of this soil association, consists of a complex of outcrops of gypsiferous earth or rocks and very shallow soils. The gypsiferous materials vary from white "chalky" earths to hard, light-colored, crystalline gypsum rocks. A thin mantle of loamy soil material may occur in small areas between the outcrops of gypsiferous earth or rock. Although Gypsum Land is widely distributed throughout the association, the larger and more extensive areas of this land type occur in the southern part of Eddy County between the community of Black River and the Texas state line. The topography is varied, ranging from gently undulating to moderately steep and rolling.

The remaining parts of this association consist dominantly of Typic Camborthids. Typic Calciorthids, Typic Paleorthids, and Saline Alluvial Land. The Typic Camborthids in this unit commonly occur as relatively small areas in swales and low-lying positions where they are susceptible to the accumulation of salts. They range in texture from medium to fine and are commonly slightly to moderately saline and gypsiferous. The Typic Calciorthids, which occupy nearly level to gently sloping plains and terraces, usually have moderately thick calcareous loam surface layers over moderately fine-textured subsoils and substrata. The Typic Paleorthids are shallow and loamy soils underlain by indurated caliche within a depth of 20 inches.

*Representative Soil Series:* Reeves, Yesum, Holoman, Russler, Marcial, Reakor, and Upton.

#### **42. Calciorthids (944,200 acres)**

This association occurs on nearly level to very gently sloping alluvial plains and terraces that are located generally west of the Pecos River flood plain in Chaves and Eddy counties. It is relatively extensive near Roswell, Artesia, and Carlsbad. The

western fringe of this general soil area is commonly interspersed with undulating to gently rolling ridges and uplands occupied by shallow soils. The soils are forming primarily in old calcareous alluvium from geologic formations dominated by limestone with minor amounts of gypsum, sandstone, and other sedimentary rocks. They are strongly calcareous with the calcium carbonate content ranging from 10 to 15 percent in the surface layers to 30 or 35 percent in the subsoil and substratum.

Much of the presently irrigated cropland in the Pecos Valley is in this association. Although the major soils in this association have a relatively high content of lime, they are productive and well suited to irrigation. The major crops are cotton, alfalfa, grain and forage sorghums, and small grains. Pecans and various vegetable crops are also grown to a limited extent. The remainder of this association is used for grazing by livestock, and moderate yields of forage are obtained on the native ranges that are in good condition. It supports fair stands of native grasses and shrubs. Black grama, burrograss, three-awns, sand dropseed, tobosa, vine-mesquite, and bush muhly are the principal grasses. The more common shrubs include broom snakeweed and some mesquite, creosotebush, and cacti.

*Soil Characteristics:* Typic Calciorthids, which comprise 60 percent of the association, occur on nearly level to gently sloping plains and terraces. They normally have a moderately thick surface layer of light brownish-gray to brown strongly calcareous loam. A light brown strongly calcareous loam subsoil about 24 inches thick underlies the surface layer. The substratum to a depth of 60 inches or more is a light brown very strongly calcareous clay loam. A few to many filaments and small soft masses of lime commonly occur below an average depth of 28 inches.

The Typic Paleorthids, which comprise 15 percent of this association, commonly occur on strongly sloping and rolling ridges and uplands just above the position occupied by the Typic Calciorthids. They typically consist of less than 10 inches of light brownish-gray calcareous gravelly loam or loam over layered and fractured caliche. Angular caliche fragments often occur on the surface and in the soil layers above the caliche, where they may comprise as much as 35 percent of the soil mass. The depth to the underlying caliche ranges from about 6 to 20 inches.

Also of importance in this general soil area are soils of the Pachic Calciustoll and Calcic Gypsiorthid subgroups. The Pachic Calciustolls, which comprise 10 percent, are the deep, nearly level to



very gently sloping soils in swales and on flood plains adjacent to intermittent drainages. They have thick dark-colored silt loam and loam surface layers over brown silty clay loam or clay loam subsoils and substrata. They are strongly calcareous and typically have a few to many filaments and small soft masses of lime in the lower part of the subsoil and substratum. The Calcic Gypsiorthids, which are moderately deep, are underlain by gypsum or gypsiferous earth at depths of 20 to 40 inches. The soil layers above the gypsum are light-colored, strongly calcareous and frequently contain a few gypsum crystals. They are often moderately to strongly saline in localized areas where drainage is restricted.

Other soils of limited extent in this association include those of the Typic Torrifluvent, Vertic Torrifluvent, and Pachic Haplustoll subgroups. The Typic Torrifluvents are mainly on the nearly level flood plains of the Pecos River and tributaries. They are deep and moderately coarse- to medium-textured. The Vertic Torrifluvents, which also occur on the nearly level flood plain adjacent to the Pecos river, are deep and fine-textured. A high percentage of these soils is moderately to strongly saline and inadequately drained. The Pachic Haplustolls are deep, medium- to moderately fine-textured and dark-colored soils on flood plains of intermittent drainages. Gravel and cobble or strata of gravelly loam or gravelly sandy loam occur occasionally in the subsurface layers below a depth of two to three feet.

*Representative Soil Series:* Rakor, Upton, Reeves, Elfrida, Harkey, Arno.



Fig. 18. The level and nearly level Calciorthids of association 42 are very productive under irrigation.

### 43. Calciorthids-Camborthids (274,000 acres)

This association consists of soils on nearly level to gently sloping and occasionally gently undulating alluvial valley-fill areas and piedmont slopes at the base of the Sacramento Mountains in Otero County. These deep gently sloping soils are forming in calcareous medium- and moderately fine-textured alluvial sediments derived principally from sedimentary rocks. They are typically strongly calcareous, and the soils near the basin floors often contain some gypsum and soluble salts in the subsurface layers. These soils are moderately susceptible to water erosion and a few gullied areas occur where there has been a concentration of runoff from the adjacent higher lying lands.

A very small part of this association is used as irrigated cropland, and produces mainly cotton and alfalfa. The remaining lands are either in military use or are used for grazing of livestock and wildlife. The amount of native forage produced varies widely, depending upon the amount of runoff received. A few areas, particularly in the southern part of Otero County, support moderate to good stands of grass. Many parts of this association, however, are dominated by shrubs, mainly creosote-bush with lesser amounts of mesquite, tarbush, broom snakeweed, yucca, and various species of cacti. The more common grasses are black grama, blue grama, bush muhly, tobosa, mesa dropseed, burrograss, and three-awns.

*Soil Characteristics:* The Typic Calciorthids, which account for 35 percent of the association, are deep, calcareous, weakly developed, and moderately permeable. The surface layer is usually a light brownish-gray loam, but it may range from loam to silty clay loam. The subsoil is typically a light brown clay loam, but may also range in texture from a heavy loam to a silty clay loam. The substratum to a depth of 60 inches or more is dominantly moderately fine-textured. Filaments and small soft masses of lime commonly occur below an average depth of 28 inches.

The Typic Camborthids, which comprise 30 percent of this association, usually occur on the lower parts of the piedmont slopes adjacent to the basin floor. They are characterized by their reddish-brown color and the presence of gypsum crystals within a depth of 40 to 50 inches. These soils have a thin surface layer of light brown to reddish-brown calcareous silt loam or loam over a reddish-brown calcareous silty clay loam or clay loam subsoil. The underlying substrata are also typically medium to moderately fine-textured to a depth of 50 to 60 inches or more. Gypsum crystals, which usually increase with depth, are common in

the lower part of the subsoil and in the substratum. Salinity typically ranges from slight to moderate.

The Typic Torriorthents occupy the gently sloping plains and alluvial fans adjacent to arroyos or intermittent drainages. They consist mainly of soils with thin, calcareous loam or silt loam surface layers and weakly stratified medium to moderately fine-textured subsurface layers to a depth of five feet or more. Although dominantly light reddish-brown or reddish-brown, they are quite variable in color and include some that range from pale brown or light brownish-gray to brown. They are susceptible to water erosion where the vegetative cover is depleted and there is a concentration of runoff. A few deep gullies, particularly in the drainageways, are common.

Calcic Gypsiorthids, which are widely distributed throughout the association on gently sloping and undulating landscapes, are underlain at depths of 20 to 40 inches by gypsiferous earths. The soil layers above the gypsum or gypsiferous earths are light-colored, strongly calcareous and medium- to moderately fine-textured. Also occurring to a limited extent, and commonly associated with the Calcic Gypsiorthids, are shallow soils underlain by gypsiferous earth within a depth of 20 inches.

The only other shallow soils of significance in this unit are those with calcareous gravelly loam or gravelly sandy loam surface layers over pinkish-white caliche or very gravelly loam with a very high lime content. These limy soil layers are often weakly cemented in the upper part and generally occur at a depth ranging from 10 to 25 inches. Miscellaneous land types, such as Gullied Land and Alluvial Land also comprise small acreages.

*Representative Soil Series:* Reakor, Russler, and Reeves.

#### **44. Camborthids-Calciorthids (153,300 acres)**

This association is east of the San Andres Mountains in the Tularosa Basin. It consists of soils on nearly level to gently sloping lower parts of piedmont slopes and basin floors. Slope gradients dominantly range from less than one percent to three percent with extremes ranging from none to five percent. These nearly level to gently sloping soils are forming in old valley-filling sediments dominated by materials from sedimentary formations with lesser amounts from igneous rocks.

This association is used for grazing by wild-life and livestock. The density and production of native vegetation varies widely. A few small bottom-land areas receive runoff water from higher-lying lands and support dense stands of vine mesquite, alkali sacaton, and tobosa. A high percentage of the

soils in this association, however, are slightly to moderately saline and support only sparse to fair stands of native vegetation. Alkali sacaton is dominant, while tobosa, vine mesquite, and chamiza comprise lesser amounts. The strongly saline areas are either barren or support only scattered clumps of alkali sacaton, iodinebush, and chamiza.

*Soil Characteristics:* The Typic Camborthids comprise 65 percent of the association. They occur dominantly on nearly level to very gently sloping landscapes with slope gradients that usually average less than one percent. They have a surface layer of strongly calcareous silt loam or silty clay loam over a strongly calcareous silty clay or heavy silty clay loam subsoil. This grades through soil of similar color and texture to the underlying gypsiferous lacustrine materials at depths ranging from 40 to 60 inches. The subsurface layers commonly contain fine threads and specks of lime as well as crystals of gypsum and other salts. Although salinity generally varies from slight to moderate, about 20 percent of these soils is strongly saline. Also included are phases of these soils that have gypsum strata at depths of 20 to 40 inches. Colors are variable and may range from light brown or light yellowish-brown to reddish-brown. Small areas of these soils occupy the gently sloping swales and narrow valley bottoms on the piedmont slopes. They have loamy surface layers and moderately fine-textured subsoils and substrata, and they usually are not as saline and gypsiferous as those on the nearly level basin floors.

The Typic Calciorthids, which comprise 15 percent of the association, occupy the piedmont slopes on the outer fringes of this association. Slope gradients average between one and five percent. They have a thin surface layer of reddish-brown calcareous loam or clay loam which is underlain by a thick reddish-brown calcareous clay loam subsoil that commonly contains a few small soft masses of lime in the lower part. Below an average depth of 50 inches these soils typically become coarser-textured with textures ranging from gravelly sandy loam to gravelly loam or loam.

Less extensive soils include those of the Typic Salorthid, Typic Torriorthent, and Typic Gypsiorthid subgroups. The Typic Salorthids are deep, poorly drained, and saline. They usually have medium-textured surface layers and stratified subsurface layers that are moderately fine- to fine-textured. The Typic Torriorthents and Typic Gypsiorthids, which are developing over thick beds of gypsum or gypsiferous earths, commonly occur on ridges or on the more undulating landscapes in this association. The Typic Gypsiorthids

consist of light brown gypsiferous very fine sandy loam or fine sandy loam to a depth of 60 inches or more. The gypsum content ranges from about 25 to 80 percent with highest concentrations typically occurring between 10 and 20 inches. The Typic Torriorthents in this association consist of light-colored, medium-textured soils underlain within a depth of 20 inches by thick beds of gypsum.

*Representative Soil Series:* Marcial, Ubar, Sotim, Mead, Holloman, and Yesum.

#### **45. Paleorthids-Haplargids (1,237, 700 acres)**

This association, which includes a number of widely distributed areas, lies east of the Pecos River in Chaves and Eddy counties and in the southern part of Lea County. The topography, which is quite varied, ranges from nearly level to gently sloping plains and mesa tops to strongly sloping and rolling uplands. A small acreage of steeply sloping lands on escarpments and breaks is also included. Although small and scattered areas of deep soils occur in this association, it is dominated by shallow soils underlain by fractured strongly cemented or indurated caliche. Exposures of caliche, shale, and sandstone are common on the breaks and escarpment areas.

The entire association is used for grazing of livestock and wildlife. The soils, which are dominantly shallow and droughty, commonly support only a sparse cover of vegetation. Short, mid, and tall grasses with creosotebush, mesquite, broom snake-weed, and long-leaf ephedra comprise most of the vegetation. The more common grass species on the soils with sandy surface layers are black grama, sideoats grama, little bluestem, sand muhly, sand dropseed, and three-awns. On the loamy soils grass species consist mainly of black grama, sideoats grama, hairy grama, blue grama, burrograss, and three-awns.

*Soil Characteristics:* Typic Paleorthids, which comprise 65 percent of this general area, occur on nearly level to strongly sloping and undulating plains and mesa tops. The soils vary relatively widely in texture, color, and reaction but are typically underlain by strongly cemented caliche layers within a depth of 20 inches. Extensive are soils with light brownish-gray calcareous gravelly loam surface layers. Angular caliche fragments are common and may comprise as much as 35 percent of the soil mass in the layers immediately above the underlying indurated caliche. The depth to the caliche, which is usually less than 10 inches, may range from about 4 to 20 inches. Typic Paleorthids

with thin surface layers of calcareous fine sandy loam or loamy fine sand over fine sandy loam subsoils are also extensive. Angular fragments of caliche are common in the subsurface layers. Also occurring to limited extent are Typic Paleorthids with noncalcareous loamy fine sand surface layers. These soils, which occur mainly adjacent to deep sandy soils, are also underlain by extremely hard fractured caliche at a depth of 6 to 20 inches.

The Typic Haplargids, which comprise 15 percent of this association, are dominated by soils with reddish-brown noncalcareous loamy fine sand surface layers over thick sandy clay loam subsoils. The lower part of the subsoil, which is usually calcareous, contains a few to many filaments and small soft masses of lime. This is underlain at depths of three to four feet by loam or sandy clay loam with a high lime content. These high lime layers are occasionally weakly cemented in the upper part.

Also intermingled throughout this general soil area are Typic Camborthids, Typic Calciorthis, Typic Torripsamments, Petrocalcic Paleargids and small areas of Stony and Rough Broken Land. The Typic Camborthids, which are susceptible to wind erosion, commonly occur on gently sloping and hummocky landscapes. They consist of soils with loamy fine sand or fine sand surface layers and moderately coarse-textured subsurface layers to a depth of 60 inches or more. The Typic Calciorthis are characterized by their strongly calcareous surface layers over soil horizons with a moderate to high lime content. They range from those with moderately coarse-textured surface layers and subsoils over white soil layers high in lime to deep medium- and moderately fine-textured soils with a moderate accumulation of lime. The Typic Torripsamments, which occupy gently rolling and duny landscapes consist of sands and loamy fine sands to a depth of five feet or more. The Petrocalcic Paleargids have loamy fine sand or fine sandy loam surface layers, and sandy clay loam subsoils over indurated caliche at depths of about 20 to 40 inches. The Stony and Rough Broken Land occupies the slopes, breaks, and escarpments and is characterized by thin soils and exposures of bedrock.

*Representative Soil Series:* Upton, Simona, Tonuco, Berino, Pajarito, Wink, and Cacique.

#### **46. Rock Land-Torriorthents-Haplargids (266,800 acres)**

This association consists of two widely separated areas, one in the extreme southwestern part of Dona Ana County and the other along the boundary

between Socorro and Sierra counties. Included are soils forming in materials of volcanic or basic igneous origin on old lava flows. Eolian sands, however, have been deposited over much of the basalt rock and are contributing significantly to the parent materials in which these soils are forming. The eolian materials vary in thickness from a thin veneer to a depth of three to five feet or more. Outcrops of basalt rock and associated stoniness provide a rock mantle over much of the land surface. Although small areas have moderately deep and deep soils, the soils of this association are dominantly shallow. The land surface on the mesa tops and lava flows is usually gently to strongly sloping, but it may range from nearly level to rolling and moderately steep. The sides and fronts of the lava flows, hills, and cinder cones are steep to very steep.

This association is used as rangeland. Runoff from exposures of basalt bedrock, boulders, and stones tends to concentrate water on adjoining soils, resulting in a complex and variable pattern of forage production. The more common native vegetation includes black grama, blue grama, tobosa, sand dropseed, spike dropseed, bush muhly, vine mesquite, and various species of shrubs.

*Soil Characteristics:* Lava Rock Land, a miscellaneous land type, occurs on the steep sides and fronts of lava flows, isolated basalt hills, and areas dominated by rock outcrops and comprises 45 percent of the association. It consists of a complex of shallow stony soils and outcrops of basalt bedrock. Much of the surface between the outcrops is covered with boulders and stones. It is only slightly susceptible to erosion because the surface is protected by rocks.

Lithic Torriorthents, developing where eolian sediments have contributed to the parent materials, comprise 20 percent of the association. They have surface layers of pale brown very gravelly loam or very gravelly sandy loam which grade through a very gravelly and cobbly sandy loam or loam to the underlying bedrock at depths of 10 to 20 inches. The basalt cobbles and gravels immediately above the bedrock typically are lime-coated. Basalt boulders and stones intermittently are on the surface and in these soils.

The Haplargids, mainly the Lithic Ustollic Haplargid subgroup, occupy gently sloping and rolling landscapes amounting to about 15 percent of the association. They have a thin surface layer of brown stony loam. The subsoil is a reddish-brown clay loam or clay with 10 to 15 percent basalt stones and gravel. This grades through a very stony clay loam to the underlying basalt bedrock

which usually occurs within 20 inches of the surface. The basalt stones and gravels in the layers immediately above the bedrock are commonly lime-coated.

Also included in this association are small and isolated areas of moderately deep and deep soils. The moderately deep soils are similar to Lithic Torriorthents but are deeper to the underlying bedrock. The deep soils, which are usually medium to moderately fine-textured, occur in the small narrow swales, valley bottoms, and depressional areas.

Typic Haplargids and Typic Torripsamments also occur to a limited extent. The Typic Torripsamments occur primarily in those parts of this unit where there are thick deposits of eolian sand deposited over the underlying basaltic materials.

*Representative Soil Series:* Akela.

#### **47. Calciorthids-Rock Land-Paleorthids (867,100 acres)**

This association occurs south of the Sacramento Mountains in the southeastern part of Otero County and includes areas with variable topography and significant differences in local relief. It consists of gently to strongly sloping and undulating alluvial fans, piedmont slopes, and narrow valley bottoms intermingling with rolling to very steep limestone hills, tilted limestone ridges, and escarpments. The soils on the steep and hilly landscapes are dominantly shallow, cobbly, and stony and are forming mainly in materials weathered from limestone rocks. The soils on the alluvial fans and piedmont slopes are forming in old alluvial fan sediments of mixed origin and often contain some gravel in both surface and subsurface layers. They are dominantly shallow to moderately deep and are underlain by non-cemented to weakly cemented or indurated soil layers with high contents of lime.

This association is used mainly as range land. Under good management, it supports a fair cover of native vegetation. Some of this soil area is also in military reservations. The more common grasses include black grama, dropseed species, bush muhly, triden species, tobosa, fluffgrass, three-awns, and some blue grama and sideoats grama. Common shrubs are creosotebush, mesquite, broom snake-weed, ocotillo, and some Mormon tea, yucca, and various species of cacti.

*Soil Characteristics:* The Calciorthids, which are dominant in this general area, are principally in the Lithic and Typic subgroups. These comprise 25 percent and 20 percent of the association, respectively.

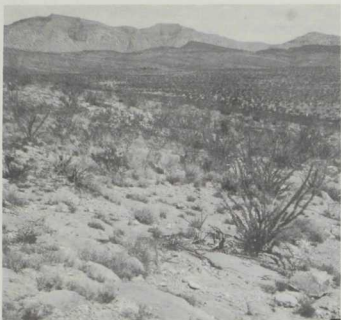


Fig. 19. The shallow and stony Lithic Calciorthids occupy the moderately steep and rolling land form in foreground. Rock Land occurs on the steep escarpment areas in background. Just above the center on the extreme right of the picture is a small area of gently sloping Typic Paleorthids.

The Lithic Calciorthids are extensive on the moderately steep lower slopes and on the rolling limestone hills and upland ridges. They have a thin surface layer of light brownish-gray calcareous stony loam. This is underlain by a light yellowish-brown to light brown very strongly calcareous very stony loam. A thin layer of calcium carbonate accumulation in the form of soft masses and nodules occurs immediately above the limestone bedrock which is usually encountered at a depth of 6 to 20 inches.

The Typic Calciorthids, which are light-colored, calcareous, and shallow to moderately deep, occur on the gently to strongly sloping alluvial fans and piedmont slopes. Those near the base of the hills and mountains on the more steeply sloping and undulating landscapes usually have a thin surface layer of light brown or light brownish-gray calcareous gravelly sandy loam over a subsoil of light brown strongly calcareous very gravelly loam. This grades to a pinkish-white caliche or very gravelly loam with a very high content at a depth of 15 to 25 inches. This is commonly weakly cemented in the upper part, and the lime content and cementation decreases with depth. Coarse fragments usually increase in size and amount with depth. Associated with these soils on the less sloping landscapes are

moderately deep soils with calcareous very fine sandy loam, loam, or silt loam surface layers and strongly calcareous heavy loam or light clay subsoils. A few pebbles usually occur on the surface. The substratum below a depth of about 20 to 36 inches is a pinkish-white to white massive light clay loam containing much lime and some gravel.

Limestone Rock Land, a miscellaneous land type, comprises 25 percent of this association. It consists of a complex of shallow soils and outcrops of limestone with an occasional thin strata of other types of sedimentary rocks. A few outcrops of igneous rocks also occur in the Hueco Mountains. The rock outcrops commonly occur as vertical or nearly vertical exposures and ledges. Small areas and pockets of moderately deep to deep soils are interspersed with the shallow soils and rock outcrops. These are commonly stony and medium-textured. Numerous stones and angular fragments of limestone are also common on the surface.

The Typic Paleorthids account for 20 percent of the association and generally occupy the gently sloping crests of ridges and fans. These soils have a thin surface layer of light brown to pale brown calcareous very gravelly loam or gravelly loam. This layer grades through soil of similar color and texture that contains numerous fragments of caliche to the underlying indurated caliche at a depth of 6 to 20 inches. The caliche layer, which is laminar and strongly cemented in the upper 6 to 18 inches, typically becomes less hard with depth.

Typic Camborthids, Typic Torriorthents, and Alluvial Land comprise a small acreage in this general soil area. Typic Camborthids, which usually occur in swales and gently sloping areas, are deep and medium- to moderately fine-textured. The Typic Torriorthents, moderately coarse to medium in texture, are usually gravelly or cobbly. Strata of gravel or cobble may occur below a depth of three to four feet.

*Representative Soil Series:* Lozier, Nickel, Delnorte, Tencee, Mimbres.

#### 48. Rock Land-Haplargids (2,383,200 acres)

Included in this association are desert mountain ranges, isolated mountain peaks, and hills that are widely distributed throughout the southwestern and south-central parts of the state. Characteristic features of this unit are the steep to extremely steep slopes and shallow and rocky soils with numerous exposures of bedrock. Although a wide variety of bedrock types is included, many of the soils are developing in material of igneous origin. Limestone and other types of sedimentary rocks have contributed varying amounts to the parent materials.

Although the association is used primarily for grazing, access for livestock is often limited by steep slopes and roughness of land surface. These features also tend to restrict the density of vegetation, but it does support a wide variety of grasses and shrubs and a few trees. Black grama, sideoats grama, blue grama, hairy grama, bush muhly, little bluestem, galleta, sand dropseed, and threeawns are the more dominant grasses. The more common shrubs and woody species include juniper, shrub liveoak, wolfberry, Apache plume, yucca, and various species of cacti. A few pine and pinyon trees occasionally occur on the north and east sides of the mountains at the high elevations.

*Soil Characteristics:* Rock Land, a miscellaneous land type, constitutes 45 percent of this association. It is a complex of very shallow soils and rock outcrops. The bedrock usually occurs as vertical or nearly vertical exposures and ledges. In many parts of this unit, a large amount of loose rock occurs on the surface. A thin mantle of cobbly or stony soil material commonly occurs between the outcrops of bedrock. Although the intermingled soils are dominantly shallow, small areas of moderately deep and deep soils occur as pockets among the rock outcrops and ledges. These small areas of soil interspersed with the rock outcrops are highly variable; their characteristics are greatly influenced by the type of rock from which the parent materials are weathered. For example, those forming in materials weathered from granite and monzonite are usually moderately coarse-textured and gravelly; those developing in materials from limestone are commonly medium- to moderately fine-textured and cobbly.

The Haplargids, which constitute 20 percent of the area, commonly occur on rolling to hilly and moderately steep landscapes and are dominantly in the Lithic subgroup. These soils usually have thin moderately coarse- and medium-textured surface layers over finer-textured, moderately well developed subsoils. The texture of the subsoils is mainly moderately fine and fine but may range from medium to fine. The surface and upper subsoils are typically noncalcareous. Gravel, cobble, and stones frequently occur in both surface and subsoil layers. The depth to bedrock is generally between 10 and 20 inches, but some may be moderately deep.

Lithic Argiustolls and Lithic Torriorthents are also of importance in this general soil area. The Lithic Argiustolls, which constitute 10 percent of the association, are similar to the Lithic Haplargids, but have darker-colored surface layers. They usually occur on north and east aspects, or at higher elevations, where more precipitation is received or where

the moisture is more effective. The Lithic Torriorthents, which comprise 15 percent of this association, are forming generally in materials weathered from limestone or other sedimentary rocks. These soils, which are also extensive on the moderately steep and rolling to hilly landscapes, lack distinct pedogenic horizons or well developed subsoils. They are dominantly moderately coarse to moderately fine-textured and generally gravelly, cobbly, or stony.

Typic Calciorthids, Typic Paleorthids, Torriorthentic Haplustolls, and other miscellaneous land types, none of which are extensive, comprise most of the remaining parts of this general soil area.

*Representative Soil Series:* Lehmans, Lozier, Gilland, Latom.

#### **49. Rock Land-Calciorthids (290,000 acres)**

Included in this association are rolling to hilly and very steep mountain footslopes along the west and south sides of the Sacramento Mountains in Otero County. The landscapes are steep and very steep, and are dissected by numerous narrow drainageways. There is a wide difference in relief and in much of this association, a difference of 500 feet or more is common between the ridge crests and the adjacent valley floor. The soils, which are dominantly shallow, cobbly, and stony, are forming mainly in materials weathered from limestone rocks. Other types of sedimentary rocks are of extremely small extent.

The association is used principally for grazing by livestock and wildlife, although the livestock is somewhat restricted by the steep slopes and the rocky or stony nature of the land surface. These factors tend to limit vegetation density, but the association supports a wide variety of grasses and shrubs and a few trees. Some of the less sloping areas support a good cover of grass. The vegetation cover and the rough topography make this a good habitat for many species of wildlife. Black grama, blue grama, sideoats grama, bush muhly, plains bristlegrass, burrograss, sand dropseed, and threeawns are some of the more common grasses. It also supports numerous shrubs including creosote-bush, yucca, mesquite, beargrass, soto, century plant, ocotillo, various species of cacti, and scattered and thin stands of juniper trees, particularly at the higher elevations.

*Soil Characteristics:* Rock Land, a miscellaneous land type, comprises 50 percent of this association. It consists of a complex of shallow soils and outcrops of limestone with occasional thin strata of other types of sedimentary rocks. Although shallow

soils are the most extensive, small areas and pockets of moderately deep to deep soils occur interspersed with the shallow soils and rock outcrops. The rock outcrops commonly occur as vertical or nearly vertical exposures and ledges. The interspersed shallow soils are commonly stony and medium-textured. Stones and angular fragments of limestone are common on the surface.

The Calciorthids, which are also an extensive component of this association, occur within the Lithic and to a much lesser extent in the Typic subgroups. These comprise 35 and 5 percent of the area, respectively.

The Lithic Calciorthids are forming mainly in materials weathered residually on the moderately steep lower slopes and on the rolling limestone hills and upland ridges. They have a thin surface layer of light brownish-gray calcareous stony loam underlain by a light yellowish-brown to light brown very strongly calcareous very stony loam. A thin layer of calcium carbonate accumulation in the form of soft masses and nodules occurs immediately above the limestone bedrock which is usually present at a depth of about 6 to 20 inches.

The Typic Calciorthids are forming in gravelly alluvium on gently to strongly sloping alluvial fans located in the lower parts of this unit at the base of the hills and mountains. These soils typically have light-colored, calcareous, gravelly loam or gravelly sandy loam surface layers over strongly calcareous and very gravelly loam subsoils which are underlain by a pinkish-white weakly cemented gravelly caliche or very gravelly loam with a very high content of lime at depths of 10 to 25 inches.

Also included in the association are Typic Haplustolls, Typic Paleorthids, Lithic Calcicustolls, Rough Broken and Stony Land and Gravelly Alluvial Land. These inclusions, none of which is extensive, comprise about 10 percent of the association. The Typic Haplustolls usually occur in the narrow valley bottoms adjacent to arroyo or drainage channels. They typically have grayish-brown to very dark grayish-brown gravelly loam surface layers over very gravelly subsurface layers. The coarse fragments are dominantly of gravel size but may range in size from gravel to stone. The Typic Paleorthids are shallow, gravelly, and underlain by indurated caliche. The Lithic Calcicustolls resemble the Lithic Calciorthids, but have darker surface layers.

*Representative Soil Series:* Lozier and Nickel.

#### **50. Haplargids-Argiustolls (115,700 acres)**

This association includes the area locally known as the upper Animas Valley in the southwestern

part of Hidalgo County. It occurs dominantly on gently to strongly sloping piedmont slopes and alluvial fans between the Peloncillo and Animas mountains. Small areas of nearly level to very gently sloping basin floors and floodplains occur to a very limited extent in the central part of this soil area. The soils in general are moderately deep to deep and often gravelly, particularly on the upper slopes adjacent to the mountain ranges. Although they are developing in old alluvium of mixed origin, material of acid igneous origin are dominant. These soils in general have darker-colored surface layers than most of the other soils in the Warm Desertic Region because they have developed in an area that receives more precipitation than most of the region.

This association, which supports a good cover of vegetation, is used for grazing of livestock and wildlife. During years of average or above precipitation moderate yields of forage are obtained. The more common grasses are blue grama, tobosa grass, vine mesquite, sideoats grama, cane beardgrass, three-awns, ring muhly, black grama, and fluffgrass. Shrubs include mesquite, chamiza, white thorn, Mormon tea, and some beargrass and cholla cactus. Thin and scattered stands of pinyon pine and juniper trees also occur on the strongly sloping areas on the outer fringes of unit adjacent to the mountain ranges.

*Soil Characteristics:* The Haplargids, which are the most extensive in this general soil area, are principally in the Typic and Ustollic subgroups.

The Typic Haplargids, which comprise 45 percent of the association, are mainly on the alluvial fans and piedmont slopes at the base of mountain ranges. Slopes are usually long and range from gently sloping to strongly sloping. These soils have a thin surface layer of reddish-brown very gravelly loam or very gravelly clay loam. The subsoil is red or reddish-brown very gravelly clay, or clay. This is underlain at depths ranging from 20 to 36 inches by pinkish-white weakly cemented caliche with more than 50 percent gravel and cobble.

The Ustollic Haplargids, which account for 10 percent of the association, occupy the more gently sloping lower parts of the piedmont slopes and swales. These soils, which are not as gravelly or stony as the Typic Haplargids, typically have thin noncalcareous loam or sandy clay loam surface layers and moderately fine- to fine-textured subsoils.

The Argiustolls, like the Haplargids, are represented by two subgroups in this association. The Torrtic Argiustolls, which account for 20 percent, have a surface layer of dark grayish-brown

clay loam over a thick very dark grayish-brown clay subsoil that is very slowly permeable and subject to cracking on drying. The gravelly clay substratum is of variable color and usually contains a few fine filaments and small soft masses of lime. These soils occur dominantly on broad piedmont slopes with gradients usually less than three percent. In the upper parts of the piedmont slopes, small areas of these soils occasionally have stony surface layers and slope gradients that exceed three percent. The Typic Argiustolls, which account for 15 percent of the association, have dark-colored surface layers and subsoils like Torreritic Argiustolls but contain more coarse fragments and have slightly more permeable subsoils. These soils typically have noncalcareous gravelly loam surface layers and gravelly clay loam or gravelly clay subsoils. The substratum consists of stratified very gravelly loams and clay loams.

The small remaining parts of this association consist of Typic Camborthids and miscellaneous land types, principally Alluvial Land. The Typic Camborthids in this association occupy the nearly level basin floors. They are deep, weakly developed, fine-textured, and very slowly permeable.

*Representative Soil Series:* Eba, Forrest, Stellar, Cloverdale, Eicks, and Anamite.

#### 51. Gypsum Land (339,900 acres)

This association consists dominantly of miscellaneous land types located in the extreme west-central part of Otero County and adjoining areas in Dona Ana and Sierra counties. It includes the scenic and well known White Sands National Monument as well as the adjacent barren or nearly barren playas and basin floors. It is used primarily for recreation.

Although the area is generally barren or supports little vegetation, small localized areas between the dunes and on the outer fringes of this unit have a sparse to fair cover of vegetation. The more common grasses and shrubs are alkali sacaton, gygrass, dropseed species, burrograss, and traces of gypsum, chamiza, coldenia, iodinebush, allthorn, graythorn, mesquite, and Mormon tea.

The Gypsum Dune Land or those areas occurring on undulating to rolling and dune land forms consist of almost pure gypsum sands. The source of the gypsum sand is believed to be from the closed basins and intermittent lake areas adjacent to the dunes. Winds have picked up the gypsum crystals from these basin floor areas and carried them in an easterly direction, building up the present dunes. The dunes, generally void of vegetation, shift and erode continually during windy periods. Gypsum

Land, the other major component of this association, occupies the nearly level basin floor. Large basin floor areas are dominant in the western and southwestern parts of this general soil area. The surface is very smooth and nearly level except for the outer perimeter that is occasionally dissected with rills and shallow gullies formed by runoff from the adjacent higher landscapes. It consists of gypsiferous earth and gypsum deposits over lacustrine sediments. The thickness of gypsum over the underlying lacustrine sediments ranges from about one foot along the outer margins of the basin area to over five feet near the center. The area is barren except for scattered iodinebushes where the gypsum is about two to three feet over lacustrine materials with a shallow watertable.



Fig. 20. Gypsum dunes that are a major component of the Gypsum Land association No. 51.

#### 52. Lava Rock Land (108,000 acres)

Included in this general soil area are relatively recent basalt or lava flows located principally in the southwestern and northwestern parts of Lincoln and Otero counties, respectively. A small area in the southwestern part of Dona Ana County is also included. A distinctive feature of this unit is its extremely rocky or stony and rough broken surface that ranges from a few feet to as much as 50 feet above the adjacent land surface. It is dominated by basalt rocks with sharp jagged surfaces, numerous crevices, and relatively few smooth areas.

The basalt rock covering this area is slow to weather, so the entire area is practically devoid of soil. The small pockets of soil that occur are extremely variable. They range in depth from shallow to deep, and in texture from stony sandy





Fig. 21. Lava Rock Land association No. 52. The land surface is extremely rocky and rough, so that access into the area is difficult.

loams to heavy clay loams. Although these small and isolated pockets are generally inaccessible to livestock, they support a cover of grasses and shrubs that are grazed by wildlife, particularly deer. Blue grama, sideoats grama, black grama, vine mesquite, sand dropseed, ring muhly, chamiza, winterfat, and some brush and various species of cacti are some of the more important grass and shrub species. The major part of the unit, which consists of basalt rock, is essentially void of vegetation or supports only an occasional shrub.

### *Moderately Dark-Colored Soils of the East-Central Plains Region*

The East-Central Plains lie in the Great Plains physiographic province between the Rocky Mountains on the west and the High Plains on the east. The area is characterized in general by gently undulating to rolling uplands interspersed with relatively smooth valleys and basins. Isolated small

mountains, hills, mesas, and volcanic cinder cones are found within the area, particularly in the central and northern section. Rough broken and steeply sloping land occurs along the larger streams, as well as around the mesas and cones. Elevations over most of the area range from 4,000 to 7,000 feet, with some small mountains and hills rising to 8,000 feet or more.

The Pecos, Canadian, and Cimarron rivers provide the principal drainageways. In the western part, particularly in Torrance County and adjacent areas, surface drainage flows into closed basins, of which ancient Lake Estancia is the largest. Although there are no major drainage systems in the west, numerous intermittent streams flow into the closed basins from surrounding higher areas.

The Central Plains cover 18,802,000 acres, of which 97,000 are irrigated and 5,212,000 are irrigable.

### **Climate**

The climate of the Central Plains is semiarid continental. Two-thirds to three-quarters of the annual moisture comes during the summer, primarily on winds from the Gulf of Mexico. Most of the summer precipitation falls in the form of brief and sometimes heavy thundershowers, especially in the central and southern section. Hail occasionally accompanies the summer thundershowers. Much of the winter moisture falls as snow in the north. Winds are light to moderate, generally, and humidities are low, ranging from 10 to 80 percent during the year. Table 4 gives data for three weather stations, one in the north and two in the center. No stations in the south have long records.

Monthly and annual precipitation may vary widely. On occasions in nearly every month of the year, the average monthly precipitation has been exceeded in one twenty-four hour period.

Daily temperature ranges commonly amount to 30 to 40 degrees, and summer nights usually are

Table 4. Climatic conditions at three stations in the East-Central Plains Region

Station	Area	Elevation feet	Average Precipitation												Avg. Ann. Temp. °F	Frost- Free Season days	
			J	F	M	A	M	J	J	A	S	O	N	D			Annual
Springer	North	5,857	0.46	0.33	0.59	1.11	1.96	1.68	2.39	3.00	1.76	1.35	0.61	0.35	15.59	50.8	154
Estancia	W-Cen	6,107	0.54	0.51	0.59	0.63	0.69	0.89	1.79	2.36	1.20	1.19	0.37	0.61	11.37	50.2	137
Santa Rosa	E-Cen	4,620	0.43	0.42	0.65	0.70	1.80	1.36	2.51	2.47	1.66	1.14	0.36	0.52	14.02	57.9	193

cool except in the south. The lowest temperature recorded at Springer was 31 degrees below zero and at Estancia, 33 degrees below zero. At Santa Rosa, the lowest was 18 degrees below zero. The highest temperature at Springer was 104 degrees, at Estancia 103 degrees, and at Santa Rosa 108 degrees.

The temperature at a depth of 20 inches is considered in classifying soils. Where the average summer and the average winter temperatures differ by at least nine degrees, the soils are placed in a Mesic temperature class if the average annual temperature is between 47 and 59 degrees, or in a Thermic temperature class if the average annual temperature is between 59 and 72 degrees. Soils are separated by temperature class on the accompanying map and in the following discussion.

## GEOLOGY

Apparently, the Ogallala formation so prominent in the High Plains region once covered much of the Pecos-Canadian area. The bedrock underlying the region is Triassic and Permian in age; Quaternary alluvial deposits are widespread on the surface. Readily soluble rocks overlying harder formations have been dissolved irregularly and their solution is responsible for the undulating and sloping topography of the central and southern parts. Castile anhydrite and Salado halite are the soluble formations that mainly influenced the distribution of gypsum and soluble salts on the surface and underground in the closed basin near Estancia and on the fringes of the Pecos Valley from Roswell to Carlsbad.

East and north of Santa Rosa, red clays of the Chinle formation deposited during the Triassic age are extensive. They are easily dispersed and highly erodible. North of Guadalupe County, there are large areas of Dakota sandstone and Pierre shale of Cretaceous age, and Quaternary basalt flows cover hundreds of square miles. Volcanic cones such as Capulin Mountain indicate that volcanism was widespread during the Cenozoic era.

## SOIL ASSOCIATIONS (Soils with Mesic Temperatures)

### 53. Haplustolls-Camborthids (111,700 acres)

This association roughly parallels the Colorado state line in the northern part of Union County. It consists principally of nearly level to gently sloping flood plains of the Cimarron River and adjacent tributary drainages, and the strongly sloping coalescing alluvial fans or valley slopes that

extend from the base of the escarpments or canyon walls to these flood plains. The steep escarpments and canyon walls that mark the outer fringes of this association are generally excluded, but small areas of steep rock land are included where the valleys are narrow, or where such lands occur within the interior parts of this general soil area. The soils, which are forming dominantly in medium- to moderately fine-textured alluvium of mixed origin, are typically deep and well drained. Elevations range from slightly less than 4,400 feet where the Cimarron River enters Oklahoma to about 5,400 feet in the western part of general soil area.

The soils of this association are used mainly for grazing of livestock and wildlife and, in general, support a good cover of vegetation consisting of a mixture of mid and short grasses. Blue grama, side-oats grama, galleta, alkali sacaton, western wheatgrass, ring muhly, switch grass, and three-awns are some of the more common grasses. Shrubs and woody species include broom snakeweed, rabbitbrush, Apache plume, yucca, various species of cacti, and some pinyon pine, juniper, serviceberry, and oakbrush. The latter four species are principally on steep rock land. A very small acreage is used for the production of hay and other feed crops under irrigation.

*Soil Characteristics:* This association is dominated by deep, well drained soils with weakly expressed subsoils and moderately dark-colored surface layers. The Cumulic Haplustolls, which constitute 45 percent of the area, commonly occur on nearly level to very gently sloping flood plains. These soils have a surface layer of grayish-brown to brown noncalcareous loam or light clay loam over a thick brown to dark brown clay loam subsoil that has a moderate blocky structure. The substratum typically consists of weakly stratified loam, clay loam, and fine sandy loam.

The Ustollic Camborthids, which constitute 20 percent of the area, are forming in medium- to fine-textured silty sediments derived principally from reddbed formations. They typically occupy the gently to strongly sloping valley side slopes that extend from the base of escarpments or canyon walls towards the valley bottoms. These soils usually have a surface layer of light reddish-brown, weakly calcareous loam or silt loam, which rests on a moderately thick subsoil of reddish-brown silty clay loam. This grades at a depth of about 30 inches to a light reddish-brown silt loam or light silty clay loam that contains a few small soft masses and threads of lime.

Typic Torriorthents are also of moderate extent in this association. They occur on the alluvial



Fig. 22. The Haplustolls-Camborthid association is dominated by loamy, deep, and nearly level to strongly sloping soils. The Cumulic Haplustolls are on the nearly level flood plains, while the Ustollic Camborthids and Ustic Torriorthents typically occur on the gently to strongly sloping valley slopes. The steep escarpments and canyon walls on the outer fringes to the valley are in soil association No. 54.

fans and valley-filling slopes like the Ustollic Camborthids, but are more permeable, and not as silty and erodible. They typically have weakly calcareous, brown to grayish-brown loam surface layers, and loam, light clay loam, or sandy clay loam subsurface layers that extend to a depth of 60 inches or more.

Also in this association are small areas of Rock Land, Torrertic Argiustolls, Lithic Ustic Torriorthents, and Aridic Calcistolls. The Torrertic Argiustolls are mainly in swales, depressional areas, and lower parts of alluvial fans on nearly level to very gently sloping land forms. These soils are characterized by their thick dark-colored silty clay loam surface layers and clayey subsoils. The Lithic Ustic Torriorthents are shallow over sandstone and interbedded sandstone and shale. Textures of surface layers range from sandy loam to light silty clay loams. The Aridic Calcistolls in this unit are shallow to moderately deep, calcareous, and medium-textured.

*Representative Soil Series:* Manzano, Alicia, Kim, La Brier, Excabosa, and Rizofo.

#### 54. Torriorthents-Argiustolls-Rock Land (441,900 acres)

This extensive association consists of soils that are developing on gently sloping to moderately steep and rolling uplands adjacent to the Cimarron Valley in the extreme northeastern part of the state. Steep canyon walls, escarpments, and breaks are also quite common, particularly in the northern part of this association immediately adjacent to the Cimarron Valley. Most of the soils in this unit are developing residually in materials weathered from sandstone, with other sedimentary rocks contributing minor amounts. Locally, and particularly where the soils are moderately deep or deeper, there have been additions of eolian and alluvial sediments. Outcrops of sandstone and some shale and other types of sedimentary rocks are common on the steep canyon walls and escarpments.

Soils of this association are in native range, and under good management fair to good forage yields are obtained. They support a mixture of mid and short grasses including such species as blue grama, sideoats grama, little bluestem, New Mexico feathergrass, galleta, spike muhly, and three-awns. A

number of shrubby species such as broom snake-weed, rabbitbrush, fringed sage, yucca, and cholla cactus are also present on these soils. The steep rocky and stony escarpments and mesa breaks usually have, in addition to the grasses and shrubs listed, thin stands of oakbrush, pinyon pine, and juniper trees. These areas provide a good habitat for many species of wildlife as well as domestic range.

*Soil Characteristics:* Lithic Ustic Torriorthents comprise 40 percent of this association and consist generally of gently to strongly sloping soils developing on sandstone mesas and breaks. The surface layers are dominantly sandy loam or stony sandy loam, but they may range from loamy sand to loam or silt loam. The medium-textured layers usually occur where the underlying sandstone is interbedded with strata of shale. The depth of sandstone bedrock ranges from about 4 to 20 inches. In addition to small angular sandstone fragments, which are common on the surface and throughout the soil, sandstone bedrock outcrops occasionally.

The Aridic Argiustolls occupy 20 percent of the association and occur mainly on gently sloping and undulating uplands. They generally have a thin surface layer of brown to grayish-brown noncalcareous loam over a subsoil of brown or yellowish-brown clay loam and clay that is free of lime in the upper part. This grades through a brown clay loam or clay, in which threads and small masses of lime are common, to sandstone bedrock at depths ranging from 20 to 40 inches.

Also included are small areas of sodic soils, or slick spots. These slick spots usually contain a moderate amount of exchangeable sodium in the lower part of the subsoil and substratum. The surface soil is often removed by erosion and revegetation is very slow.

Rock Land, which comprises 20 percent of this association, consists of a complex of shallow soils, and outcrops of sandstone and other types of sedimentary rocks. The outcrops of bedrock commonly occur as vertical or nearly vertical exposures or ledges. A thin mantle of rocky or stony soil generally occurs between the ledges or outcrops of bedrock. Shallow soils and rock outcrops are dominant, but small isolated pockets of moderately deep to deep stony soils occur on the escarpments where benches or areas with a lesser slope gradient have formed. These occur throughout the association, particularly adjacent to the Cimarron Valley.

Less extensive soils in this association include those of the Cumulic Haplustoll, Ustic Torriorthent, Aridic Ustochrept, Petrocalcic Calciustoll,

and Aridic Calciustoll subgroups. Cumulic Haplustolls occur in gently sloping swales and valley bottoms adjacent to drainageways. These deep soils have thick dark-colored loam or clay loam surface layers over clay loam subsoils and substrata. The Ustic Torriorthents, which are deep and medium-textured, occupy the valley slopes just above the Cumulic Haplustolls. The Aridic Calciustolls are characterized by their moderately dark-colored calcareous surface layers and strongly calcareous subsoils. These medium-textured soils are underlain by bedrock at depths ranging from 20 to 40 inches. A 6- to 18-inch gravelly loam layer with a high content of lime usually occurs above the bedrock. The Aridic Ustochrepts and Petrocalcic Calciustolls are underlain within a depth of 20 inches by soft and indurated caliche, respectively. Of extremely limited extent are deep stratified loamy sands and sands which occur occasionally on low terraces and flood plains along intermittent drainages.

*Representative Soil Series:* Travessilla, Rizozo, Carnero, and Partri.

#### **55. Argiustolls-Haplustolls-Calciustolls (875,400 acres)**

This association includes dark-colored soils forming in materials of volcanic or basic igneous origin on old lava flows, cinder cones, and basaltic mesas. Although these soils occur dominantly on land forms that are nearly level to gently sloping and undulating with slope gradients of less than five percent, some are strongly sloping and steep.

The steeply sloping areas occur on the sides and terminal points of lava flows and mesas, as well as on the old volcanic hills scattered throughout this general soil area. The soils range from shallow to deep. The stone and cobble content is quite variable, ranging from none or an occasional stone in the deep soils to many cobbles and stones in some of the shallow soils. Outcrops of basalt rock are common on the fronts and sides of the lava flows. These outcrops also occur in the form of squeeze-ups in the vicinity of Capulin Mountain in association with shallow and stony soils.

This association is used for grazing by livestock and wildlife, and it supports a relatively dense cover of native vegetation. The more common grass species are blue grama, sideoats grama, little bluestem, western wheatgrass, galleta, buffalograss, Indiangrass, New Mexico feathergrass, and threeawns. Thin stands of pinyon pine, juniper, oakbrush, and other shrubs often occur on the breaks and at the higher elevations.



Fig. 23. The Lithic Haplustoll component of soil association No. 55. These shallow and cobbly soils typically support a good cover of grass and are well suited to grazing.

*Soil Characteristics:* The Aridic Argiustolls, which comprise 50 percent of this unit, are moderately deep to deep and commonly occur on nearly level to gently sloping landscapes. These soils have surface layers of dark grayish-brown, noncalcareous loam, clay loam, or silty clay loam over thick moderately fine and fine-textured subsoils. The upper part of the subsoil is typically brown to dark brown, noncalcareous, and blocky, and the lower part is usually lighter colored and weakly calcareous. This grades at a depth of about 36 inches to a calcareous clay loam or silty clay loam. A white or pinkish-white layer of high lime accumulation commonly occurs in the deep soils at a depth of 40 to 60 inches. The depth to bedrock is generally more than 40 inches, but it ranges from about two feet to five feet or more. The texture, color, and reaction of the soils underlain by basalt bedrock at depths of 24 to 40 inches are similar to those in the deep soils. The subsoil layers are thinner, and the high lime layers occur at shallower depths or just above the underlying rock. The high lime layers are occasionally laminar and strongly cemented. A few basalt fragments or stones sometimes occur in both the surface and subsoil. Torricertic Argiustolls also comprise a small acreage in this association. These soils are commonly found in concave and slightly depressional areas on nearly level landscapes. They resemble the Aridic Argiustolls but have thicker dark-colored surface horizons and heavy clay subsoils that crack on drying.

The stony soils with dark-colored surface layers that occur in a complex pattern with stony ridges, or squeeze-ups, are in the Pachic Argiustoll subgroup. These soils have noncalcareous cobbly or stony silt loam surface layers and very cobbly clay subsoil which grades at a depth of about three

feet to a very cobbly clay loam that contains from 75 to 90 percent gravel, cobbles, and stones.

The Lithic Haplustolls, which make up 20 percent of the association, commonly occur on the gently sloping and undulating crests of lava flows and on the outer fringes of basalt capped mesas. These shallow and stony soils typically have grayish-brown granular surface layers that contain variable amounts of angular and semi-rounded fragments of basalt. They are commonly calcareous and of a loam or clay loam texture. Basalt fragments typically increase with depth, and unweathered basalt is usually encountered within a depth of 18 to 20 inches. The lower part of the profile just above the basalt typically contains a moderate to high amount of segregated lime. Nearly all areas of these soils include exposures of basalt, and in many places the basalt fragments comprise a large percentage of the soil mass.

The Aridic Calcicustolls, which account for 15 percent of the association, often occur with the Lithic Haplustolls forming in very stony and cobbly parent sediments derived principally from basalt. Typically, these soils have brown calcareous cobbly loam or very cobbly loam surface layers. These are underlain by pinkish-white and light brown very cobbly loam or very stony loam with a high lime content at a depth ranging from 10 to 30 inches. Basalt may occur below a depth of 40 inches.

Basalt Rock Land, a miscellaneous land type, accounts for 10 percent of the association. It commonly occurs on the steep to very steep fronts of lava flows and sides of basalt-capped mesas and hills. It consists of a complex of basalt outcrops and very stony and rocky soils. The basalt outcrops occur generally as vertical or nearly vertical cliffs in the upper part of the unit near the mesa tops. Below the basalt outcrops, it consists dominantly of very stony colluvial soil material with highly variable characteristics. A limited acreage of soils in this unit is forming in material weathered from cinders. These soils have calcareous gravelly and very gravelly loam or gravelly sandy loam surface layers, and are underlain at a depth ranging from about 6 to 24 inches by cinders or volcanic ash. Outcrops of cinders and very thin gravelly loam soils underlain by cinders at a depth of less than four to six inches are common on the steep and very steep slopes. Also occurring to a limited extent in this unit are dark-colored loamy soils underlain by indurated caliche which, in turn, is usually underlain by basalt bedrock at variable depths, but generally within 40 inches of the surface.

*Representative Soil Series:* Torreon, Capulin, Thunderbird, Apache, Ayon, La Brier.

## 56. Torriorthents-Haplustolls-Argiustolls (1,031,500 acres)

This association consists of an extensive area of gently sloping and undulating soils in the central part of Colfax County and in the northern parts of Mora and Harding counties. Intermingled with the gently sloping and undulating uplands are numerous nearly level to very gently sloping valley bottoms and a few strongly sloping to moderately steep ridges. Elevations range from about 5800 to 7000 feet, but elevations above 6500 occur only on the outer fringes of the association near the mountain fronts. The soils are dominantly moderately deep and deep, but range from shallow to deep. They are mainly medium- to fine-textured and are forming in parent materials weathered residually from shale and other sedimentary rocks, or in alluvial sediments from such rocks. Erosion generally is not a serious problem because of adequate plant cover. The deep soils in the valley bottoms are susceptible to gully erosion, however, and usually include a few deep gullies.

The land in this association is used dominantly for grazing by livestock and wildlife, and to a limited extent for the production of alfalfa and other hay crops under irrigation. Other crops of importance include corn and small grains. The non-cultivated areas support a good cover of grass with blue grama, galleta, western wheatgrass, buffalograss, ring muhly, creeping muhly, sand dropseed, and three-awns, the more important species. Some alkali sacaton, inland saltgrass, and vine mesquite usually occur in the swales and on the flood plains adjacent to intermittent drainages. A few juniper trees occur along the margins adjacent to the mountain fronts and in the rough broken area.



Fig. 24. General view of the gently sloping and undulating landscape that is characteristic of the Torriorthents-Haplustolls-Argiustolls association No. 56.

*Soil Characteristics:* The Torriorthents, mainly in the Ustic Torriorthent subgroup, constitute 35 percent of the association. They are quite variable in characteristics, ranging from shallow to deep, and medium to fine textured. Deep fine-textured Ustic Torriorthents comprise nearly one-half of the soils in this subgroup. They occur on broad, gently sloping alluvial fans and in wide nearly level valley bottoms. These soils usually have calcareous silty clay loam or clay surface layers and very slowly permeable silty clay and clay subsurface layers that extend to a depth of 60 inches or more. Deep medium-textured Ustic Torriorthents, which comprise about one-fourth of the soils in this subgroup, occupy the upper and more sloping alluvial fans in this general soil area. These soils typically consist of brown to light yellowish-brown calcareous loams or light clay loams to a depth of 60 inches or more. A few specks and streaks of segregated lime are common below a depth of 15 to 20 inches. The remainder of the Ustic Torriorthents consist dominantly of light brownish-gray to brown calcareous silty clay loams overlying shale at a depth ranging from about 7 to 20 inches. Some segregated lime is usually visible immediately above the shale.

The Aridic Haplustolls constitute 20 percent of the association and are mainly on the side slopes of ridges and fans, or on nearly level to gently sloping and undulating areas. Slope gradients seldom exceed five percent. These soils have a thick surface layer of grayish-brown to brown calcareous silt loam or loam over a pale brown to light yellowish-brown subangular blocky silty clay loam subsoil. This is underlain by a medium to moderately fine-textured substratum that is strongly calcareous and commonly contains a few small soft masses and filaments of lime.

The Aridic Argiustolls, which also constitute 20 percent of the association, commonly occupy the smoother and nearly level to gently sloping landscapes. They typically have a thin surface layer of brown to grayish-brown noncalcareous silt loam or loam over a thick brown blocky clay or heavy silty clay loam subsoil. A moderate to strong lime zone typically occurs in the clay loam or silty clay loam substratum at depths of 30 to 40 inches.

Ustollic Camborthids, which occupy 15 percent of this association, occur on gently sloping to gently undulating uplands. They are developing in moderately fine-textured material weathered residually from the underlying shale at depths of 20 to 40 inches. These soils usually have a thin surface layer of grayish-brown calcareous silty clay loam or silt loam and a subsoil of light brownish-gray silty clay loam or clay. Thin threads

of lime and gypsum crystals are common in the subsoil immediately above the underlying shale.

Also in this association are small areas of shallow gravelly soils forming in gravelly alluvium on strongly sloping to moderately steep side slopes of ridges and knolls. Shallow soils underlain by interbedded limestone and shale also occur to limited extent on similar forms. They have loam or clay loam surface and subsurface layers that usually contain some limestone and shale fragments. Ustolic Haplargids, another inclusion of minor importance in this unit, resembles the Aridic Argiustolls. They differ primarily in having lighter-colored and thinner surface layers. These soils are deep and usually have loamy fine sand or fine sandy loam surface layers over medium- to moderately fine-textured subsoils. Playas, lakes, and miscellaneous land types such as Gullied Land, Saline Alluvial Land, and Sandstone and Shale Outcrops comprise the remaining parts of this association.

*Representative Soil Series:* Vermejo, Midway, Kim, Colmor, Swastika and Little.

#### **57. Argiustolls-Torriorthents-Paleustolls (1,153,600 acres)**

This association is found mainly in San Miguel County, but it is also in Harding, Santa Fe, and Guadalupe counties. The soils, which range from shallow to deep, occupy gently sloping to moderately steep and rolling uplands. Most are underlain by sandstone bedrock and a few by indurated caliche, shale, and other sedimentary rocks. Locally, and particularly where the soils are moderately deep or deep, there have been additions of eolian and alluvial sediments.

These soils are used for grazing of livestock and wildlife and to a very limited extent for irrigated farming. Blue grama, sideoats grama, little bluestem, ring muhly, sand dropseed, galleta, and three-awns are the more common grasses. Thin to moderate stands of pinyon and juniper trees are also scattered throughout this association. Although these tree species have invaded some on the moderately deep and deep soils, they are more common on the shallow soils underlain by sandstone.

*Soil Characteristics:* The Argiustolls, which comprise approximately 50 percent of this association, are within the Lithic Argiustoll and Aridic Argiustoll subgroups, comprising 20 and 30 percent, respectively. The Lithic Argiustolls occupy gently sloping and rolling land forms. These soils usually have thin surface layers of brown noncalcareous fine sandy loam or loam over a reddish-brown sandy clay loam subsoil. This is typically underlain by sandstone



**Fig. 25. Representative gently sloping to moderately steep and rolling landscapes of the Argiustolls-Torriorthents-Paleustolls association No. 57. The shallow and stony Lithic Torriorthents are in the foreground.**

bedrock at about 12 inches, but the depth ranges from about 10 to 20 inches. The most extensive of the Aridic Argiustolls is underlain by sandstone bedrock at depths of 20 to 40 inches. This soil generally has a surface layer of brown to dark brown noncalcareous loam over a brown or reddish-brown clay loam subsoil that is free of lime in the upper part. A few fine threads and small soft masses of lime are common in soil layers immediately above the bedrock. Approximately one-third of the Aridic Argiustolls are deep and well drained. They typically have a surface layer of brown to grayish-brown noncalcareous silt loam or loam and a moderately thick brown blocky clay or heavy clay loam subsoil. This is underlain by a depth ranging from about 30 to 36 inches by a pale brown to light yellowish-brown clay loam or sandy clay loam substratum. A moderate zone of lime accumulation in the form of small soft masses and threads commonly occurs at depths of 24 to 50 inches.

The Lithic Ustic Torriorthents, which constitute 20 percent of the association, are gently sloping to moderately steep soils developing mainly on sandstone mesas and breaks. They have a surface layer of brown stony fine sandy loam or stony loam. This is underlain by sandstone bedrock at depths ranging from 4 to 20 inches. In addition to the angular sandstone fragments which are common on the surface and throughout the soil, sandstone

bedrock outcrops occasionally. A small percentage of the Lithic Ustic Torriorthents are developing residually in materials weathered from limestone. They are similar to the soils forming on sandstone in depth, slope, and content of coarse fragments, but are usually slightly finer-textured and darker-colored.

The Petrocalcic Paleustolls account for 10 percent of the area and are mainly on the gently sloping and undulating uplands. They frequently occupy ridge crests that are slightly higher than adjacent soils. These soils typically have a thin surface layer of dark grayish-brown noncalcareous loam or silt loam over a heavy clay loam or silty clay loam subsoil of similar color. This is underlain by indurated caliche which usually occurs within a depth of 20 inches, but occasionally may be as deep as three feet.

In addition to these principal soil groups, there are included small acreages of Ustollic Camborthids, Ustollic Paleorthids, and miscellaneous land types. The Ustollic Camborthids, which occupy gently to strongly undulating ridges, are developing in parent materials weathered residually from the underlying shale. The depth to shale varies from about 20 to 40 inches. They are usually moderately fine to fine in texture. The Ustollic Paleorthids, like the Petrocalcic Paleustolls, are shallow to indurated caliche, but are calcareous and lack the clayey subsoil. Rock Land, the major miscellaneous land type, consists dominantly of a complex of shallow stony soils and outcrops of sandstone bedrock, and occasionally outcrops of shale, limestone, and basalt bedrock.

*Representative Soil Series:* Carnero, Bernal, Rednun, Travessilla, Penrose, Litle, Pastura.

#### **58. Argiustolls-Paleustolls (602,500 acres)**

This association occurs in the south-central and north-central parts of Mora and San Miguel counties, respectively. Nearly level to gently undulating uplands and plains with slopes seldom exceeding five percent dominate this general soil area. The intermingled valley areas are nearly level to gently sloping, however, and small areas of moderately steep and rolling uplands are included. These areas with the more sloping topography occur mainly on the side slopes of upland ridges and those areas that grade towards drainages. Although the soils vary in depth, extensive areas are moderately deep and deep. They are developing in medium- to fine-textured alluvial and eolian sediments, and from materials weathered from the underlying bedrock. Those of shallow and moderate depth are underlain mainly by sandstone or indurated caliche.

These soils are used for grazing of livestock and wildlife and to a very limited extent for irrigated farming. They support a good cover of grass with blue grama, galleta, western wheatgrass, sideoats grama, mesa dropseed, ring muhly, alkali sacaton, and three-awns being the more common species. Thin to moderate stands of pinyon pine and juniper trees are also scattered throughout this association. These woody species are more common on the shallow soils and along the margins of this unit where it joins areas of rough broken and stony land. Except in the valley areas, where a few deep gullies occur, these soils are not particularly susceptible to erosion.

*Soil Characteristics:* The Argiustolls, which comprise approximately 55 percent of the association, range in depth from shallow to deep. The deep Aridic Argiustolls (25 percent) typically have a surface layer of brown to grayish-brown noncalcareous silt loam or loam, and a moderately thick brown or reddish-brown blocky clay or heavy clay loam subsoil. This is underlain at a depth ranging from about 30 to 36 inches by a pale brown to light yellowish-brown clay loam or sandy clay loam substratum. A moderate zone of lime accumulation in the form of small soft masses and threads commonly occurs at depths of 24 to 50 inches. The moderately deep Aridic Argiustolls (20 percent) generally have a thin surface layer of brown to dark brown noncalcareous loam over a subsoil of brown or reddish-brown clay loam that is free of lime in the upper part. This grades through a light brown sandy clay loam or loam in which threads and small soft masses of lime are common to underlying sandstone bedrock that occurs at a depth ranging from 20 to 40 inches.

The Lithic Argiustolls (10 percent) are shallow and commonly occur in association with the moderately deep Aridic Argiustolls on the more sloping and rolling land forms. These soils usually have a noncalcareous fine sandy loam or loam surface layer over a reddish-brown sandy clay loam subsoil. This is typically underlain by sandstone bedrock within a depth of 20 inches.

The Petrocalcic Paleustolls, which comprise 15 percent of this association, are moderately deep and shallow. Those which are moderately deep have brown to grayish-brown noncalcareous silt loam or loam surface layers. Their subsoil is a brown clay loam or clay that is noncalcareous in the upper part. This is underlain by hard or strongly cemented caliche at depths ranging from 20 to 50 inches. These soils commonly occur on broad nearly level to gently sloping and undulating upland plains. Approximately one-third of the Petrocalcic Paleus-



tolls are shallow. These are underlain by indurated caliche within a depth of 20 inches. They frequently occur on ridge crests that are slightly higher than adjacent soils.

Soils of lesser extent in this association include those of the Lithic Ustic Torriorthent, Cumulic Haplustoll, Mollic Torrert, Ustic Torriorthent, and Ustollic Camborthid subgroups. The Lithic Ustic Torriorthents, which occupy gently sloping to moderately steep landscapes, are typically underlain by sandstone or limestone bedrock at depths of about 4 to 20 inches. The Cumulic Haplustolls, Mollic Torrerts, and Ustic Torriorthents occupy nearly level to gently sloping landscapes in valley bottoms and swales. The Cumulic Haplustolls are deep, dark-colored, and moderately fine-textured; the Mollic Torrerts are deep, dark-colored, and fine-textured; and Ustic Torriorthents are deep, moderately dark-colored, and fine-textured. The Ustollic Camborthids, occurring on gently sloping and undulating uplands, are forming dominantly in materials weathered from shale. The depth to shale is usually 20 to 40 inches, but occasionally may be 60 inches or more. Clay loams, silty clay loams, and clays are the more common textures. Miscellaneous land types, including Rock Land and Gullied Land are of extremely small extent in this general soil area.

*Representative Soil Series:* Rednun, Swastika, Carnero, Bernal, Tricon, Penrose, Travessilla, Manzano, Vermejo, and Litle.

#### **59. Haplargids-Calciorthids (486,500 acres)**

This association, in the central part of the state, includes parts of Santa Fe and Torrance counties. It is dominated by moderately deep and deep soils forming on piedmont slopes and plains east of the Manzano and Sandia mountains. These nearly level to strongly sloping soils are forming in old valley-filling sediments of mixed origin. They are slightly to moderately susceptible to both water and wind erosion when the vegetative cover is depleted or removed.

This unit was formerly a major area for dryland farming, but because of frequent crop failures due to the unfavorable climate, the majority of the dry cropland has returned to range use. A small acreage in this association is irrigated by water from wells. Irrigated crops are corn, alfalfa, small grain, and potatoes. The remainder of the land in this association is used for grazing, and it generally supports a good cover of short and mid grasses. The more common grasses include blue grama, hairy grama, sideoats grama, New Mexico feathergrass, galleta, little bluestem, and needle-and-thread. Thin and scattered stands of pinyon

pine and juniper trees also occur in the southern and western parts of this association that border the mountain foothills.

*Soil Characteristics:* Ustollic Haplargids, which constitute 45 percent of the association, are mainly on the broad gently sloping piedmont crests or plains between the drainageways. They have a thin surface layer of light brown loam that is leached free of lime. Their subsoil is a thick reddish-brown clay loam that is noncalcareous in the upper part. This is underlain by pinkish-white very limy loam at depths of 20 to 50 inches. Those underlain at a depth of 20 to 35 inches by the pinkish-white limy loam or caliche occasionally contain indurated caliche fragments which may comprise as much as 25 to 35 percent of this horizon. In the southern part of this association, moderately extensive areas of this subgroup have coarser-textured surface layers and subsoils. These soils are also normally leached of lime in the surface layer and upper part of the subsoil. They have a thin surface layer of brown or reddish-brown fine sandy loam or loamy fine sand over subsoils of heavy fine sandy loam or sandy clay loam. These are underlain at an average depth of three feet by fine sandy loam substratum that contains much visible lime.

The Ustollic Calciorthids occupy 25 percent of the association, mainly on the crests of undulating uplands and side slopes of fans. They typically have light brown or grayish-brown calcareous surface layers. The subsoil is similar, but it contains more lime and is slightly lighter-colored. This layer grades to pinkish-white very limy loam that begins at a depth of about 6 to 20 inches. The lime content decreases slightly below 30 or 36 inches.

Cumulic Haplustolls, which account for 10 percent of this association, occur on nearly level to very gently sloping areas in swales and depressions. These soils are deep and are characterized by their thick dark-colored surface layers and upper subsoils. Typically they have a surface layer, about 8 to 12 inches thick, of a grayish-brown to dark brown noncalcareous loam. The subsoil is a dark grayish-brown clay loam with moderately blocky structure. The substratum is medium- to moderately fine-textured and contains some visible lime.

Other inclusions of importance in this general soil area are Lithic Ustollic Calciorthids and Ustic Torriorthents. The Lithic Ustollic Calciorthids are located on the moderately steep and rolling ridges, and they are characterized by their brown or grayish-brown calcareous channery loam surface layer. This grades through soil of similar texture that becomes lighter-colored and more limy with depth. Fractured and partly weathered bedrock is

typically encountered at a depth of 6 to 20 inches. The Ustic Torriorthents are typically moderately coarse-textured and limy. They usually have a moderately thick surface layer of light brown fine sandy loam or loamy fine sand over a similar but more limy subsoil. The substratum is a fine sandy loam with more visible lime than the subsoil.

*Representative Soil Series:* Witt, Clovis, Harvey, Dean, Manzano, Pinon, Penistaja, Palma, and Otero.

#### **60. Calciorthids-Haplargids-Paleorthids (685,600 acres)**

This association consists dominantly of shallow to moderately deep soils underlain by soft to strongly cemented caliche. They are forming mainly in medium- to moderately fine-textured old alluvial sediments on gently to strongly sloping and undulating landscapes where slopes seldom exceed 10 percent. Although the major part of this unit occurs in the eastern part of Torrance County, it extends into Santa Fe, Guadalupe, and Lincoln counties.

It is used mainly as native range, and under good management moderate forage yields are obtained. Blue grama, galleta, sand dropseed, western wheatgrass, Indian ricegrass, sideoats grama, ring muhly, and three-awns are the more common grasses. A few scattered juniper and traces of broom snakeweed, cactus, and other shrubs also occur.

*Soil Characteristics:* The Ustollic Calciorthids, which constitute 40 percent of this association, are characterized by strongly calcareous surface layers and by subsurface layers with distinct zones of lime accumulation. These soils are about equally divided between those that are shallow and those that are of moderate depth. The shallow soils occur mainly on the crests and side slopes of undulating uplands. They normally have a thin surface layer of light brownish-gray calcareous loam. This is underlain at a depth of 6 to 10 inches by a light gray gravelly loam that is usually weakly cemented with lime in the upper part. This extremely limy layer grades to a less limy substratum of very pale brown gravelly loam at depths of two to four feet. The moderately deep Ustollic Calciorthids are principally on the truncated side slopes of fans and are gently sloping to strongly sloping. They typically have light brown or grayish-brown calcareous surface layers. The subsoil is similar except that it contains more lime and is slightly lighter-colored. This layer grades to pinkish-white very limy loam that begins at a depth of about 20 inches. The lime content decreases slightly below a depth of 30 or 36 inches.

The Ustollic Haplargids constitute 30 percent of the association and commonly occur on the broad and smooth crests of piedmont slopes or upland plains. They are nearly level to gently sloping and moderately deep. In general they have a thin, noncalcareous surface layer of brown loam, over a brown to light brown clay loam subsoil. This is generally underlain at depths of 20 to 35 inches by pinkish-white, fractured caliche. However, approximately 10 percent of the soils in this unit lack the indurated caliche fragments, and a very small percentage is underlain by sandstone bedrock instead of caliche. In addition, small areas are coarser-textured and have less distinct layers of lime accumulation. These soils have a surface layer of fine sandy loam or loamy fine sand over a subsoil of heavy fine sandy loam or sandy clay loam. The zone of lime accumulation usually occurs below a depth of about three feet in the form of small soft masses and fine threads.

The Ustollic Paleorthids, the other important component of this association, constitute 10 percent of the area and commonly occur on both the crests and sideslopes of low ridges. They normally consist of less than 12 inches of light brownish-gray to pale brown loam over indurated caliche. The strong cementation of the caliche layer is usually confined to the upper 6 to 18 inches with a gradual decrease of cementation below this depth.

Soils of lesser extent in this association include those of the Ustollic Camborthid, Ustic Torriorthent, Lithic Haplustoll, and Cumulic Haplustoll subgroups. The Ustollic Camborthids resemble the Ustollic Haplargids but lack the well developed subsoils. They are deep and medium-textured. The Ustic Torriorthents, which occur mainly on valley slopes, are deep and moderately coarse- to medium-textured. The Lithic Haplustolls are dark-colored shallow soils. Coarse fragments are common in the surface layers and limestone bedrock usually occurs within a depth of 20 inches. Rock outcrops occur occasionally on the side slopes of the ridges occupied by these soils. The Cumulic Haplustolls, which occur mainly in swales and valley bottoms, are deep and medium- to moderately fine-textured.

*Representative Soil Series:* Tapia, Clovis, Penistaja, Palma, Harvey, Dean, Pastura, Otero, and La Porte.

#### **61. Haplargids-Argiustolls-Torriorthents (376,500 acres)**

This association occurs principally in the southwestern and northeastern parts of San Miguel and Torrance counties, respectively, but small areas extend into adjoining counties of Santa Fe and

Guadalupe. The topography ranges from nearly level to strongly sloping and undulating on the upland summits and in the valley areas to rolling and very steep on the low hills, ridges, and mesa escarpments. The deep soils on the valley-filling slopes and in the valley bottoms are forming principally in alluvial and eolian sediments of mixed origin. The shallow to moderately deep soils on the upland summits and mesa tops are developing in residual materials weathered mainly from sandstone but occasionally from limestone. Miscellaneous land types and shallow soils developing over sandstone and limestone are dominant on the low hills, ridges, mesa escarpments, and breaks.

This association is used for grazing of livestock and wildlife. The deep soils produce moderate yields of forage and under a good level of management support a mixture of tall, mid, and short grasses. The principal grass species include blue grama, sand dropseed, mesa dropseed, lovegrass, sand bluestem, little bluestem, Indiangrass, black grama, sideoats grama, needle-and-thread, and New Mexico feathergrass. In addition, light to heavy stands of pinyon pine and juniper occur in the shallow soils and miscellaneous land types occupying the low hills, ridges, and escarpments.

*Soil Characteristics:* Ustollic Haplargids, which account for 40 percent of the unit, are moderately deep and deep, and occur on gently sloping and undulating upland plains and valley-filling slopes at the base of upland ridges. They consist generally of soils with thin surface layers of brown to light brown noncalcareous fine sandy loam or loam. Their subsoils are dominantly moderately thick brown to reddish-brown sandy clay loams or light clay loams that are leached free of lime in the upper part. A few threads and small soft masses of lime commonly occur in the lower part of the subsoil. Approximately one-fourth of the Ustollic Haplargids are underlain at a depth of 20 to 40 inches by a substratum of white or pinkish-white caliche that is usually fractured and strongly cemented in the upper 6 to 12 inches and contains numerous hard caliche fragments below this. A small acreage of these soils has sandstone bedrock under the caliche. In the deep Ustollic Haplargids, the subsoils are underlain by calcareous sandy loams and loams to a depth of 60 inches or more.

The Aridic Argiustolls, which constitute 15 percent of the association, are characterized by their moderately dark- to dark-colored surface layers. They are forming generally on the more gently sloping landscapes and at the higher elevations. They usually have brown, noncalcareous loam or fine sandy loam surface layers over reddish-

brown noncalcareous sandy clay loam or clay loam subsoils. They are underlain by sandstone bedrock at depths which are typically 12 to 20 inches but range from about 10 to 36 inches.

The Lithic Ustic Torriorthents, the other major component of this association, occur on gently sloping to moderately steep ridges and outer fringes of the mesa tops. These soils usually have a thin surface layer of brown to light reddish-brown, weakly calcareous, fine sandy loam. This grades through a light brown stony fine sandy loam or stony loam to the underlying sandstone bedrock at depths ranging from 4 to 20 inches. In addition to sandstone outcrops that occasionally occur, angular fragments of sandstone are common in the soil layers immediately above the bedrock.

Rock Land and soils of the Ustollic Camborthid, Ustollic Calciorthid, Cumulic Haplustoll, and Lithic Ustollic Calciorthid subgroups are less extensive. Rock Land, a miscellaneous land type, consists of a complex of shallow soils and outcrops of sandstone and other sedimentary rocks. It commonly occurs on steep and very steep breaks and escarpments in which ledges and stairstep topography are common. A thin mantle of soil, which usually occurs between the outcrops of bedrock, supports most of the plant life. The Ustollic Camborthids are deep, reddish-brown soils that typically occupy gently to strongly sloping piedmont surfaces and alluvial fans. They are medium- to moderately fine-textured and usually have some visible lime accumulations in the lower part of the subsoil and substratum. The Ustollic Calciorthids are light-colored, medium-textured, and shallow to moderately deep over soft caliche or soil layers with a lime content.

The Cumulic Haplustolls consist of the deep, medium- to moderately fine-textured soils on nearly level to gently sloping swales and flood plains adjacent to intermittent drainages. The Lithic Ustollic Calciorthids occupy strongly sloping and rolling ridges. They have brown or grayish-brown calcareous channery loam surface layers which grade through a limy very gravelly loam to the underlying limestone bedrock that usually occurs within a depth of about 20 inches.

*Representative Soil Series:* Penistaja, Tapia, Hagerman, Bernal, Carnero, Travessilla, La Fonda, Dean, Harvey.

## **62. Calciorthids-Torriorthents (348,800 acres)**

This association includes the acres locally known as Estancia, Encino, and Pinos Well lake basins of Torrance County. Except for the wind-deposited dunes or hills on the leeward side of playas, the

soils in the unit are developing on nearly level to gently sloping and undulating landscapes. They are forming in alluvium, including lacustrine sediments, and are commonly saline, particularly in low parts of the unit near the playas which receive runoff and drainage from surrounding areas.

A major part of this association is used as rangeland. Salt-tolerant grasses, which are dominant on the moderately to strongly saline soils, provide moderate yields of forage. Alkali sacaton, vine mesquite, salt grass, mat muhly, blue grama, western wheatgrass, galleta, sand dropseed, and three-awns are the principal grasses. The more common shrubs include chamiza, winterfat, and rabbitbrush. The saline lake bottoms are barren or nearly barren of vegetation. There are also about 13,000 acres of pump-irrigated land in this association. It is generally located on the outer fringes of this unit where the soils are moderately well-drained and non-saline or only slightly saline. Alfalfa, pasture, corn, and barley are the principal crops.

*Soil Characteristics:* The Ustollic Calciorthids, which are the most extensive, typically occur on the nearly level to very gently sloping basin floors and terraces. Those on the basin floors, which constitute 40 percent of the area, are slightly saline on the outer lake margins and become progressively more saline toward the center of the basins. These soils have a moderately thick surface layer of light brownish-gray loam and a subsoil of pale brown limy clay loam. Below this is very limy, light yellowish-brown loam or clay loam. Lacustrine sediments normally begin at a depth of about two feet, but they may occur at depths of 15 to 36 inches. The Ustollic Calciorthids, which constitute 15 percent of the area, occupy the old shoreline benches or terraces on the margins of the lake basins. They are typically non-saline and coarser-textured and have gravelly to very gravelly subsoils and substrata. They usually have pale brown to brown calcareous fine sandy loam surface layers and a subsoil of pale brown, calcareous, gravelly fine sandy loam. Below this is a very pale brown, very limy, gravelly fine sandy loam.

The Ustic Torriorthents, which comprise 20 percent of this association, are also represented by two major soil families. Those that occupy the wind-deposited dunes or hills on the leeward side of the playas normally found near the center of the lake basins are typically moderately to strongly saline. These soils usually have a thin surface layer of light gray, strongly calcareous loam over several feet of pale yellow silt loam with a high content of lime, gypsum, and soluble salts. The other Ustic

Torriorthents are developing in moderately coarse- to medium-textured calcareous eolian and stratified lacustrine sediments on nearly level to gently undulating terraces in the lake basins. These soils consist of pale brown to brown calcareous loamy fine sands and fine sandy loams, over medium- to moderately fine-textured lacustrine deposits at depths ranging from about 15 to 40 inches.

Also in this association are 10 percent Cumulic Haplustolls, which are characterized by their moderately thick grayish-brown loam surface layers over blocky clay loam subsoils. They are usually underlain within a depth of three to four feet by stratified lacustrine sediments medium to moderately fine in texture. The remaining parts of this association consist of playas and Ustollic Camborthids and other soils of extremely small extent.

*Representative Soil Series:* Willard, Karde, Idefonso, Pedrick, Manzano.

### **63. Haplargids-Torriorthents (240,600 acres)**

Included in this association are four widely distributed areas in eastern Torrance County and west-central Guadalupe County. The largest delineation includes the Pedernal Hills area in north-eastern Torrance County. Gently to strongly sloping and rolling land forms are dominant, but they range from nearly level to gently sloping in the valley areas to steep and very steep on the few included hills and low mountains. The soils, which are generally medium- to moderately coarse-textured, are forming dominantly in old alluvial sediments of mixed origin and to a much lesser extent in materials weathered residually from the underlying acid igneous bedrock. Soil layers with a high lime content are common at moderate depths.

The soils support moderate to good stands of native vegetation. The more common grass and shrub species are blue grama, sideoots grama, sand dropseed, galleta, ring muhly, three-awns, winterfat, yucca, and broom snakeweed. There are also thin stands of pinyon pine and juniper trees, with some scrub oak on the hills and Rock Land areas at the higher elevations.

*Soil Characteristics:* Haplargids, which comprise about 60 percent of this association, are dominantly in the Ustollic Haplargid subgroup. These soils occur on gently to strongly sloping plains and valley-filling slopes. They typically have a noncalcareous surface layer of brown loam. Their subsoil is light brown to brown clay loam that contains a few small soft masses and streaks of lime in the lower part. A substratum of pinkish-white loam, high in lime, is

encountered at an average depth of about 30 inches. Approximately 10 percent of the Ustollic Haplargids consist of shallow to moderately deep, medium-textured, gravelly soils on undulating and rolling landscapes. The surface layer consists of a brown noncalcareous gravelly loam. Their subsoil is a gravelly clay loam that is reddish-brown and noncalcareous in the upper part and light brown and strongly calcareous in the lower part. This grades at depths ranging from 15 to 20 inches to a substratum of pinkish-white massive gravelly loam. The gravel content ranges from about 20 percent in the surface layer to about 30 to 40 percent in the substratum. Lithic Ustollic Haplargids are of small extent in this association, mainly in the Pederal Hills area, and are normally underlain by bedrock within a depth of 20 inches. They usually have gravelly loam noncalcareous surface layers and clay loam subsoils that typically contain some accumulated lime in the lower part.

The Ustic Torriorthents, comprising 15 percent of the association, are mainly on valley-filling slopes in the western and southern parts. They are gently to strongly sloping and are slightly hummocky in many places. They normally have a thick surface layer of light brown fine sandy loam. Their subsoil is light brown fine sandy loam which contains a few small soft masses and streaks of lime. The very pale brown fine sandy loam substratum contains more segregated lime than the subsoil. About one-fifth of the Ustic Torriorthents are underlain at depths ranging from 15 to about 40 inches by medium- to moderately fine-textured lacustrine deposits. These lacustrine sediments are very limy and often saline. The soil layers above the lacustrine deposits are typically fine sandy loams or loamy fine sands.

Rock Land, Ustollic Calciorthids, Cumulic Haplustolls, and Ustollic Paleorthids, the more important inclusions, comprise most of the remaining parts of this association. Rock Land, a complex of shallow soils and rock outcrops, usually occurs on the strongly sloping to very steep hills. Coarse fragments of all sizes and shapes are common on the surface. The soils between the stones and rock outcrops are highly variable and may range in texture from moderately coarse to moderately fine. The Ustollic Calciorthids are characterized by calcareous surface layers and subsurface layers of distinct lime accumulations. They are usually medium-textured, with high lime layers at depths of 6 to about 20 inches. The Cumulic Haplustolls are deep, dark-colored medium- to moderately fine-textured soils in valley bottoms. Ustollic Paleorthids, which are shallow, are underlain within a depth of 20 inches by indurated caliche.

*Representative Soil Series:* Clovis, Scholle, Kech, Karde, Pedrick, Otero, Harvey, Dean.

#### 64. Calciorthids-Haplargids (638,100 acres)

This association includes a number of widely distributed areas in the eastern part of Socorro County, as well as a moderately extensive area surrounding the Gallinas Mountains in Lincoln and Torrance counties. It occurs mainly on gently to strongly sloping plains and valleys interspersed with moderately steep and rolling upland ridges and hills. There are also a few steep escarpments or breaks and nearly level to gently sloping valley bottoms. The moderately steep and rolling uplands and breaks areas are more extensive in the eastern part of this association. The soils are shallow on the upland ridges and low hills and moderately deep and deep on the less sloping areas.

The moderately steep and rolling upland ridges and low hills support moderate to heavy stands of pinyon and juniper trees which provide not only good habitat for wildlife but also fence posts and firewood. Although there are some thin and scattered stands of pinyon and juniper in the remaining areas of this unit, short and mid grasses are dominant. The more common grasses include blue grama, western wheatgrass, Indian ricegrass, black grama, galleta, needle-and-thread, little bluestem, sideoats grama, and spike muhly. A few shrubs, including chamiza, rabbitbrush, winterfat, sagebrush, and cholla cactus, also occur in this association.

*Soil Characteristics:* The Calciorthids, which comprise approximately 45 percent of this association, are dominantly in the Ustollic (25 percent) and Lithic Ustollic (20 percent) subgroups. The Ustollic Calciorthids are mainly on gently to strongly sloping valley side slopes. They consist dominantly of



Fig. 26. The gently to strongly sloping Ustollic Haplargids are commonly on plains and broad valley areas as shown in foreground.

soils with light brown or grayish-brown, calcareous loam surface layers. The subsoil is similar, except that it contains more lime and is slightly lighter-colored. A pinkish-white very limy loam commonly occurs at a depth of about 15 to 20 inches. The lime content decreases slightly below a depth of 30 to 36 inches. Small acreages of Ustollic Calciorthiss are coarser-textured and are underlain by limestone bedrock at moderate depths. These soils usually have a calcareous loamy fine sand or fine sandy loam surface layer over moderately coarse-textured subsoils that commonly contain 10 to 30 percent angular fragments of limestone. The Lithic Ustollic Calciorthiss are located on the moderately steep and rolling ridges and low hills that occur throughout this association and are particularly extensive in the units in the eastern part of the county. They are characterized by their brown or grayish-brown calcareous channery loam surface layer which grades through soil of similar texture that becomes lighter-colored and more limy with depth. The light brown to pinkish-white channery loam subsurface layer rests abruptly on partly weathered, fractured limestone bedrock at a depth of 10 to 20 inches.

The Ustollic Haplargids, 30 percent of this association, commonly occur on gently to strongly sloping uplands and piedmont slopes at the base of hills and ridges. These soils normally have a surface layer of brown to light brown noncalcareous fine sandy loam or loam over a thick subsoil of brown to reddish-brown clay loam or sandy clay loam that is noncalcareous in the upper part. A few threads and small soft masses of lime are common in the lower subsoil. This is usually underlain by a pinkish-white very limy loam or sandy loam at depths of 40 to 50 inches. Although the Ustollic Haplargids are dominantly deep, a small acreage of these is underlain by sandstone bedrock at moderate depths. Surface layers and subsoils are like those of the other Ustollic Haplargids in this unit.

Also in this association are deep and medium-textured Ustollic Camborthiss, deep and medium- to moderately fine-textured Cumulic Haplustolls, and shallow Ustollic Paleorthiss. The Ustollic Paleorthiss are medium-textured and are underlain by indurated caliche. In addition to these soils, approximately 10 percent of this association consists of miscellaneous land types including steep Rock Land, Gypsum Land, and Alluvial Land. Steep Rock Land occurs generally on mesa breaks, escarpments, and side slopes of ridges. It consists of a complex of shallow soils and outcrops of bedrock, with sandstone and limestone being the most extensive. Gypsum Land is less steep and consists of a complex of outcrops of gypsiferous

earth or rocks and shallow soils. Alluvial Land occupies arroyo and drainage bottoms or flood plains, and consists of highly stratified soil materials extremely variable in texture.

*Representative Soil Series:* Harvey, Chupadera, Pinon, Penistaja, Witt, Hagerman, Manzano, and Pastura.

#### **65. Camborthiss-Torriorthiss-Rock Land (571,600 acres)**

Included within this association are a number of widely distributed areas in Torrance, Socorro, Guadalupe, and Lincoln counties. The topography is varied, ranging from gently to strongly sloping and undulating on the valley slopes and plains to steep, rough, and broken on the escarpments, breaks, and rock outcrop areas. Although geographically associated, the soils included in this general soil area have highly contrasting characteristics. They range from shallow soils developing over sandstone, limestone, or interbedded sandstones and shales to deep medium- and moderately fine-textured soils forming in alluvium. In general, the soils are moderately susceptible to erosion. Gullies often occur in many of the valley bottoms.

This association, which is used mainly as range land, supports a moderately good stand of native vegetation. Thin to moderately dense stands of pinyon and juniper trees are on the shallow soils, steep breaks, and rough broken areas. The principal grasses are blue grama, sideoats grama, alkali sacaton, galleta, bush muhly, three-awns, black grama, and sand dropseed. The more common shrubs include rabbitbrush, chamiza, winterfat, and Apache plume. In the southeastern part of this association, tobosa grass often comprises a high percentage of the grass species in the swales and valley bottoms.

*Soil Characteristics:* The Ustollic Camborthiss, characterized by weakly expressed pedogenic horizons, occur on gently to strongly sloping and undulating piedmont surfaces or fans and occupy 40 percent of the association. Those on the crests and side slopes of the low ridges or fans are the most extensive and consist of soils with reddish-brown, calcareous loam surface layers. These layers grade to a subsoil, about 8 to 20 inches thick, of light reddish-brown heavy loam. The lower part of the subsoil is usually more limy and coarser-textured than the upper part. This is underlain by a light reddish-brown strongly calcareous loam that commonly contains many small soft masses and fine threads of lime. In the swales and on the lower parts of the piedmont, these soils are also deep,

with reddish-brown, weakly calcareous loam surface layers, but they have finer-textured clay loam and silty clay loam subsoils and substrata that typically contain a few specks and threads of lime.

The Lithic Ustic Torriorthents, which comprise 25 percent of the association, are shallow, light-colored, gently to strongly sloping soils developing dominantly on sandstone mesas and breaks. They have thin surface layers of light brownish-gray to light brown sandy loam or gravelly sandy loam which grade through a pale brown to light yellowish-brown calcareous gravelly sandy loam or sandy loam to the underlying sandstone bedrock at depths ranging from 8 to 20 inches. The coarse fragments in the soil layers above the bedrock consist dominantly of small angular fragments of sandstone. Approximately one-fifth of the Lithic Ustic Torriorthents are forming residually in materials weathered from limestone and have somewhat different profiles. These soils have brown or grayish-brown calcareous channery loam surface layers over subsoils that become lighter colored and more limy with depth. Angular fragments of limestone are common and may comprise 50 percent or more of the soil mass above the limestone bedrock that usually occurs within a depth of 20 inches.

Rock Land, a miscellaneous land type that makes up 20 percent of the association, commonly occupies the steep breaks and escarpments on the sides of mesas, hills, and upland ridges. It consists of a complex of shallow stony soils and outcrops of sandstone and other types of sedimentary rocks. A thin mantle of soil is generally found between the ledges or outcrops of bedrock. Although dominated by shallow stony soils with highly variable characteristics, pockets or extremely small areas of moderately deep and deep soils occur intermingled with the outcrops of bedrock. The surface often contains boulders and stones.

Other soils and land types in this association include Alluvial Land, Gullied Land, and soils of Ustollic Calciorthid, Ustollic Haplargid, Cumulic Haplustoll, and Lithic Ustollic Haplargid subgroups. The Ustollic Calciorthids, which are underlain at shallow depths by soil layers high in lime, occur on gently to strongly sloping alluvial fans and side slopes of drainageways. They are medium-textured. The Ustollic Haplargids are deep soils with distinct and well developed subsoils that range in texture from sandy clay loam to clay. The Cumulic Haplustolls are the deep dark-colored medium- to moderately fine-textured soils that occur mainly in swales and depressional areas adjacent to drainages. The Lithic Ustollic Haplargids are shallow soils developing over interbedded sandstone and shale.

*Representative Soil Series:* La Fonda, Alicia, Travessilla, Pinon, Rednun, Penistaja, Witt, and Newkirk.

#### **66. Calciustolls-Paleorthids (892,800 acres)**

This association is mainly in the northeastern part of Lincoln County with lesser amounts extending into Chaves, Guadalupe and De Baca counties. The soils comprising this general soil area are dominantly gently sloping to moderately steep or rolling. They are usually shallow to bedrock or indurated caliche. Some moderately steep and steep breaks or escarpments and nearly level to gently sloping valley bottoms are also included.

This association is used for grazing by livestock and wildlife. In general, it supports a fair to good cover of native vegetation. Native vegetation includes blue grama, hairy grama, galleta, sideoats grama, sand dropseed, three-awns, and some New Mexico feathergrass, spike muhly, and needle-and-thread. Shrubs and woody species include broom snakeweed, cholla cactus, mesquite, and a few juniper trees.

*Soil Characteristics:* Lithic Calciustolls are dominant in this association, constituting 65 percent of the total area. They usually occur on nearly level to strongly sloping and gently rolling landscapes. These soils have a surface layer of grayish-brown to brown calcareous stony loam. This grades through a dark grayish-brown very stony loam to the underlying limestone bedrock at a depth of 6 to 20 inches. Coarse angular fragments generally comprise about 25 to 40 percent of the surface layer to as much as 70 percent in the subsurface layers immediately above the limestone bedrock, but in some small areas the cobble and stone content does not exceed 35 percent.

The Ustollic Paleorthids, which comprise 15 percent of the association, are also shallow and are developing on indurated caliche. These soils have a surface layer of grayish-brown calcareous gravelly loam. This grades through a pale brown calcareous loam to the underlying caliche, which usually occurs within 12 inches of the surface but may range in depth from 6 to 20 inches. Coarse fragments of very hard caliche are common in the subsurface layers. The degree of cementation of the caliche layer usually decreases gradually with depth and becomes soft to weakly cemented one to three feet below its upper surface. Limestone bedrock may occur below the indurated caliche layer at variable depths.

Cumulic Haplustolls, Ustollic Calciorthids, and Ustollic Haplargids also occur to a limited extent in this association. The Cumulic Haplustolls are the

most extensive of these inclusions. They occur on nearly level to gently sloping land forms in swales and on flood plains of intermittent drainages. The surface layer, about nine inches thick, is a grayish-brown to dark brown noncalcareous loam. The subsoil is a dark grayish-brown clay loam that has a moderate blocky structure. This is underlain by a substratum of brown light clay loam that usually contains a few pinkish-white specks and threads of segregated lime. The Ustollic Calciorthids are limy and occur on gently to strongly sloping valley side slopes. The light brownish-gray to grayish-brown surface layers of these soils are underlain by a pinkish-white very limy loam at depths of about 6 to 20 inches. The Ustollic Haplargids are characterized by their thin brown, noncalcareous loam surface layers and light brown clay loam subsoils. They are underlain at moderate depths by a layer consisting of indurated caliche gravels and cobbles that are commonly weakly cemented in the upper part. In addition to these soils, there are small areas of unclassified alluvial soils and miscellaneous land types, such as Limestone Rock Land.

*Representative Soil Series:* Deama, LaPorte, Pastura, Manzano, Harvey, Dean, and Tapia.

#### **67. Calciorthids-Paleorhthids (499,100 acres)**

This association is within De Baca, Guadalupe, and Lincoln counties and mainly near the common boundaries of these counties. Included are weakly defined nearly level to gently sloping valley areas that are intermingled with gently to strongly sloping and undulating upland ridges and plains. Although the slopes extending from the upland ridges into the valley areas are typically gently to strongly sloping, some are moderately steep. The soils, which are usually calcareous and of variable depth, are developing dominantly in materials weathered from limestone or other sedimentary rocks.

Soils in the association are used for grazing, and under good management moderate yields of forage are obtained when precipitation is average or above. Native vegetation includes blue grama, sand dropseed, spike dropseed, sideoats grama, ring mulhly, poverty three-awns, and some New Mexico feathergrass, needle-and-thread, black grama, Indian ricegrass, broom snakeweed, and yucca. A few scattered pinyon pine and juniper trees also occur in this association north of the Capitan Mountains.

*Soil Characteristics:* The Ustollic Calciorthids, comprising 40 percent of this general soil area, occur dominantly on the gently to strongly sloping

valley side slopes. They are characterized by their strongly calcareous surface layers and distinct layers of lime accumulation. They typically have light brown or grayish-brown calcareous loam surface layers. The subsoil is similar except that it contains more lime and is slightly lighter-colored. This layer grades to a pinkish-white very limy loam that usually begins at a depth of about 15 to 20 inches and decreases slightly in lime content below a depth of 30 or 36 inches. In about 10 percent of these soils, this high lime layer begins at depths of 6 to 10 inches. These lime layers may be weakly cemented in the upper part and contain coarse fragments of hard caliche.

The Ustollic Paleorhthids, which constitute 30 percent of the association, are also extensive in this general soil area. They occur mainly on the crests of the upland plains or ridges and on the upper part of the valley side slopes. These soils typically have thin grayish-brown calcareous loam or gravelly loam surface layers and pale brown calcareous loam or gravelly loam subsoils. They are underlain by indurated caliche at depths ranging from 6 to 20 inches. The cementation of the caliche layer is usually strongest in the upper 6 to 18 inches, and decreases below this depth. Limestone bedrock may occur below the caliche layer.

Less extensive soils in this general soil area include those of the Ustollic Camborhthid, Ustollic Haplargid, Cumulic Haplustoll, and Lithic Calcicustoll subgroups. The Ustollic Camborhthids, which comprise 10 percent of the area, are deep and well drained. They occupy gently sloping and undulating upland ridges and alluvial fans. They have a reddish-brown calcareous loam surface layer over a loam or sandy clay loam subsoil and substratum. A weak, but distinct lime zone in the form of fine soft masses and coatings on pebbles typically occurs at depths of 18 to 40 inches. The Ustollic Haplargids usually occur on gently sloping uplands or plains. These moderately deep and deep soils usually have brown noncalcareous loam or fine sandy loam surface layers over sandy clay loam or clay loam subsoils. These are underlain by a white or pinkish-white very limy loam at depths of 20 to 50 inches. In the moderately deep soils (20 to 35 inches) these high lime layers commonly contain indurated caliche fragments. The Cumulic Haplustolls, which occur mainly in swales and depressional areas, have grayish-brown loam or clay loam surface layers over thick grayish-brown to dark brown clay loam subsoils. The Lithic Calcicustolls, which are shallow have a surface layer of grayish-brown to brown stony loam. This grades through a dark grayish-brown very stony loam to the underlying limestone bedrock at a depth of 6 to 20 inches. Limestone



Rock Land, arroyo bottoms, and other miscellaneous land types comprise the remaining parts of this association. Rock Land comprises the small steep breaks or escarpment areas on the side of the upland areas occupied by the Lithic Calciustolls.

*Representative Soil Series:* Harvey, Dean, Pastura, La Fonda, Tapia, Deama, and Manzano.

#### **68. Calciustolls-Rock Land-Calciorthids (774,400 acres)**

Included in this soil association are nine widely separated areas in Lincoln and Socorro counties. It consists of soils and land types on moderately steep to very steep limestone hills, escarpments, and mountain footslopes intermingled with gently to strongly sloping and rolling uplands and some nearly level to gently sloping valley bottoms. Elevations generally range between 5200 and 7000 feet. The soils, which range from shallow to deep, are developing primarily in materials weathered residually from limestone or in alluvial sediments from limestone and lesser amounts of other sedimentary rocks. The shallow soils are commonly cobbly or stony.

These soils are used as range for livestock and wildlife. Although the density and amount of forage produced is somewhat restricted on the Limestone Rock Land component of this association, moderate yields of forage are obtained on the associated soils. The steep upland ridges and hills support moderate to heavy stands of pinyon and juniper trees, but the rolling areas at the lower elevations support no more than thin and scattered stands. Shrubs of importance are beargrass, yucca, and shrub live oak. The more common grasses are blue grama, black grama, sideoats grama, galleta, sand dropseed, muhly species, tridens, three-awns, wolftail, needle-and-thread, and some New Mexico feathergrass.

*Soil Characteristics:* Lithic Calciustolls are the most extensive in the association, comprising 35 percent of the total area. They commonly occur on rolling uplands, and slopes range from gently sloping to steep and hilly. These soils have a surface layer of grayish-brown to brown calcareous stony loam. This grades through a dark grayish-brown very stony loam to the underlying limestone bedrock at a depth of 6 to 20 inches. Angular coarse fragments comprise about 25 to 40 percent of the surface layer and as much as 70 percent of the underlying material above the limestone bedrock.

Limestone Rock Land comprises 25 percent of this association. It consists dominantly of a complex of very shallow soils and outcrops of lime-



Fig. 27. Gently sloping to moderately steep, rolling, and hilly landscapes are common in soil association No. 68. The shallow and stony Lithic Calciustolls, which are the most extensive, occur on these land forms. Limestone Rock Land occupies the steep slopes, breaks, and escarpments.

stone. Other types of sedimentary rocks occur to a very limited extent. It is characterized by numerous rock outcrops, bare ledges, and a large amount of loose rock and stones on the surface. A thin mantle of stony or gravelly materials is common between the outcrops and exposure of bedrock. Although it is dominated by shallow soils, small areas of moderately deep and deep soils do occur interspersed with the shallow soils and rock outcrops. It commonly occurs on steep slopes, escarpments, and breaks.

Ustollic Calciorthids, which comprise 15 percent of this general soil area, usually occupy gently to strongly sloping valley side slopes below ridges occupied by the Lithic Calciustolls. These soils have a surface layer of light brown or grayish-brown calcareous loam. The subsoil is similar, but it contains more lime and is slightly lighter-colored. This layer grades to a pinkish-white very limy loam that begins at a depth of about 15 to 20 inches. The lime content decreases slightly below a depth of 30 to 36 inches.

Gypsum Land, Ustic Torriorthents, Ustollic Haplrgids, Aridic Argiustolls, Ustollic Paleorthids, and Lithic Ustic Torriorthents comprise most of the remaining parts of this association. Gypsum Land occupies the areas dominated by gypsiferous rock and earth. It consists of outcrops of gypsiferous earth, rocks, and very shallow soils. The gypsiferous materials vary from white to light gray gypsiferous earths to hard, light colored, crystalline gypsum rocks. A thin mantle of loamy soil material commonly occurs between the outcrops of gypsiferous

earth or rock. The Ustic Torriorthents, which occur in association with Gypsum Land, consist of pale brown or light brownish-gray, shallow to moderately deep medium-textured soils. They are underlain by gypsiferous material at a depth ranging from 15 to 35 inches. The deep Ustollic Haplagids occupy relatively broad, gently sloping valley slopes and plains. These soils have a thin surface layer of brown, noncalcareous loam or fine sandy loam over a sandy clay loam subsoil. This is underlain by a fine sandy loam that commonly contains thin seams and small soft masses of lime in the upper part. The Aridic Argiustolls occupy similar landscapes, but are finer-textured and have darker-colored surface layers. These deep soils have loam or clay loam surface layers and heavy clay loam to clay subsoils. The Ustollic Paleorthids and Lithic Ustic Torriorthents are underlain by indurated caliche and sandstone bedrock, respectively, within a depth of 20 inches.

*Representative Soil Series:* Deama, Harvey, Rance, Penistaja, and Rednun.

#### **69. Calciorthids-Haplustolls-Gypsiorthids (86,900 acres)**

This association consists of a relatively small area in the vicinity of Carrizozo in Lincoln County. It includes valley areas and alluvial plains with gently to strongly sloping and undulating landscapes. Interspersed through this area are nearly level to gently sloping valley bottoms which commonly contain a few deep gullies or arroyos. The soils are dominantly moderately deep to deep and are forming in alluvium of mixed origin.

They support fair to moderate stands of native vegetation, and under good management moderate yields of forage are produced. The more common kinds of native vegetation are black grama, blue grama, alkali sacaton, sideoats grama, tobosa, sand dropseed, burrograss, fluffgrass, three-awns, chamiza, broom snakeweed, and yucca.

*Soil Characteristics:* Typic Calciorthids, which constitute 45 percent of this association, occur on gently to strongly sloping valley side slopes and plains. They normally have a surface layer, 6 to 12 inches thick, of light brownish-gray to brown calcareous loam. A light brown strongly calcareous loam, or light clay loam subsoil about 24 inches thick underlies the surface layer. The substratum to a depth of 60 inches or more is a light brown very strongly calcareous clay loam. A few to many small lime concretions and small soft masses of lime commonly occur below an average depth of 28 inches.

The Fluventic Haplustolls occupy 15 percent of the association. They occur on gently sloping valley bottoms and flood plains of intermittent drainages. They typically have a moderately thick surface layer of dark brown to dark grayish-brown calcareous loam. This is underlain to a depth of 60 inches or more by light brownish-gray or light brown stratified soil layers consisting dominantly of loam, sandy clay loam, and clay loam.

The Calcic Gypsiorthids, which also occupy 15 percent of the association, are moderately deep and are underlain by gypsiferous earth at depths of 20 to 36 inches. Although widely scattered throughout this association on gently sloping and undulating valley slopes, they generally occur down slope from sedimentary formations containing gypsum. These soils usually have pale brown to brown strongly calcareous loam surface layers. The subsoil is a pale brown to light gray massive strongly calcareous light clay loam.

In addition to these major soils, miscellaneous land types, including Gypsum Land, Gullied Land, and Rough Broken Land comprise small acreages in this association. Also included are small areas of Typic Paleorthids and unclassified deep moderately fine- and fine-textured soils. The Typic Paleorthids have gravelly or cobbly loam surface layers and are underlain by strongly cemented caliche within 20 inches.

The unclassified soils occur in nearly level to gently sloping drainageways, in ponded areas, and on the lower parts of alluvial fans. These soils typically have a surface layer of reddish-brown to brown strongly calcareous silty clay loam. This is underlain to a depth of five feet or more by a reddish-brown clay or heavy silty clay loam with increasing amounts of carbonates and salts in the lower part.

*Representative Soil Series:* Reakor, Toyah, and Reeves.

#### **70. Rock Land-Torriorthents (553,000 acres)**

This association consists of moderately extensive and widely distributed areas located generally in the northeastern section of the state. A characteristic feature of this association is the rough and broken topography, very steep slopes, and rock outcrops. Included are escarpments, steep canyon walls, rocky ridgetops, rock ledges, and steep breaks, all of which are dominated by rock outcrops and small areas of highly variable soils. The escarpment and steep breaks area separating the upland plains on the Las Vegas Plateau from the lower-lying valleys and plains to the south and east is representative of this association. The exposed bedrock is domi-

nantly sandstone and shale, but it includes other sedimentary materials as well as small areas of igneous rocks or basalt. In addition to the land types there are included moderately extensive areas of shallow soils on the ridge crests and mesa tops. The deep soils are confined generally to small areas in the narrow valley bottoms and colluvial slopes at the base of escarpments.

The soils and land types comprising this association are used principally for grazing by livestock and wildlife. Although the density of vegetation is limited by rock outcrops, thin soils, and steep slopes, this unit supports a wide variety of grasses and shrubs. Blue grama, hairy grama, galleta, side-oats grama, little bluestem, switchgrass, needle-and-thread, New Mexico feathergrass, sand dropseed, and three-awns are the principal grasses. The more common shrubs and woody species include pinyon, juniper, oakbrush, bitterbrush, serviceberry, broom snakeweed, rabbitbrush, and a few scattered ponderosa pine on north slopes and at the higher elevations. This association provides a good habitat for many species of wildlife.

*Soil Characteristics:* Rock Land, a miscellaneous land type comprising 45 percent of the association, occurs dominantly on the steep escarpment and breaks areas. It is a complex of very shallow soils, outcrops of interbedded sandstone and shale, and other sedimentary rocks. The sandstone outcrops commonly occur as vertical or nearly vertical exposures and ledges. A thin mantle of stony or gravelly soil material usually occurs between the ledges and outcrops of bedrock. Although shallow soils are the most extensive, small areas of moderately deep and deep soils do occur interspersed with the shallow soils, rock outcrops, and ledges. These soils are commonly stony or gravelly and moderately coarse to medium-textured. Numerous stones and boulders are common over much of the land surface.

The Lithic Ustic Torriorthents, which account for 15 percent of the association, consist of shallow light-colored, gently to strongly sloping soils on sandstone mesas. They also occur on the moderately steep breaks intermingled with Rock Land and Rough Broken Land. They range in texture from loamy fine sand or fine sandy loam to loam. Small angular sandstone fragments are common, particularly in the layers immediately above the underlying bedrock which typically occurs within a depth of 6 to 20 inches.

Rough Broken Land, which also accounts for 15 percent of the association, is usually moderately steep to steep and severely dissected. This land type consists of a complex of shallow soils and

outcrops of shale and other types of sedimentary materials. Although there are some rock outcrops, much of the exposed sedimentary material is unconsolidated or poorly consolidated. The included soils are quite variable and range in texture from moderately coarse to fine. A few stones and some rock usually occur over much of the land. Vegetation is typically sparse, so that geologic erosion is active throughout much of this unit.

Also in this association are soils of the Lithic Argiustoll, Ustochreptic Calciorthid, Ustic Torriorthent, and Ustollic Camborthid subgroups. The Lithic Argiustolls, which are usually on crests of ridges and mesas, are gently sloping to rolling. These soils have a thin surface layer of brown non-calcareous fine sandy loam or loam over a reddish-brown sandy clay loam subsoil. This is typically underlain by sandstone bedrock at about 12 inches, but the depth may range from about 10 to 20 inches.

The Ustochreptic Calciorthids occur on gently to strongly sloping and rolling ridges and low hills. These soils have a surface layer of reddish-brown calcareous loam that usually contains a few coarse fragments of very hard caliche and lime-coated sandstone pebbles. This grades through a light reddish-brown strongly calcareous clay loam to the underlying interbedded shale and sandstone at depths of 20 to 40 inches. Small and scattered areas of deep Ustic Torriorthents and Ustollic Camborthids also occur in this association. The Ustic Torriorthents, which are deep and silty,



Fig. 28. Rock Land, a major component of association 70, is mainly on steep to very steep mesa sides, escarpments, and canyon walls. The Lithic Ustic Torriorthents occur principally on the gently sloping ridge crests or mesa tops above the Rock Land.

usually occupy nearly level to gently sloping valley bottoms and flood plains. They are subject to overflow and are frequently dissected by gullies. The Ustollic Camborthids occupy the gently sloping and undulating ridges. They have noncalcareous loam surface layers and calcareous loamy subsoils.

*Representative Soil Series:* Travessilla, Bernal, San Jon, Lacita.

## SOIL ASSOCIATIONS (Soils with Thermic Temperatures)

### 71. Calciorthids-Torriorthents (1,139,800 acres)

This association is located mainly in an extensive valley area below the Las Vegas Plateau in San Miguel County, with small amounts extending into Guadalupe, Harding, and Quay counties. The association occurs generally on gently sloping to rolling landscapes which range in elevation from about 4000 to 5800 feet, but it also includes steep escarpments and breaks as well as nearly level to gently sloping valley bottoms. The long, narrow steep escarpment and rock outcrop areas, which occur throughout the association, usually have a difference in relief of less than 100 feet, but occasionally exceed 200 feet. This association is dominated by shallow and moderately deep soils that are forming residually in parent materials of sandstone and shale origin. Thin deposits of alluvial and eolian sediments occur locally. The included deep soils that commonly occur on the valley-filling slopes and in the valley bottoms are forming principally in medium- and moderately fine-textured alluvium from sedimentary formations.

This association is used as rangeland. In general, it supports a fair to good cover of short and mid grasses, principally blue grama, galleta, sideoats grama, ring muhly, sand dropseed, and three-awns. Thin and scattered stands of pinyon pine and juniper are also common on shallow soils and rock outcrop areas. Other shrubs include mesquite, rabbit-brush, snakeweed, yucca, and various cactus species.

*Soil Characteristics:* The Calciorthids in this general soil area are mainly within the Ustollic and Ustochreptic subgroups, which constitute 35 and 10 percent of the association, respectively.

The Ustollic Calciorthids typically have a thin surface layer of brown calcareous loam and a reddish-brown strongly calcareous clay loam subsoil, which has distinct powdery carbonate coatings on many of the soil peds and worm casts. Soft to firm nodules and filaments of lime are also common in the lower part of the subsoil. This is underlain at

depths of 20 to 40 inches by interbedded sandstone and shale.

The Ustochreptic Calciorthids occur mainly on gently sloping fans extending from the base of escarpments and breaks to the lower-lying valleys. These soils have reddish-brown calcareous loam or fine sandy loam surface layers, reddish-brown calcareous light clay loam subsoils, and pinkish-white loam substrata high in lime. The pinkish-white lime zone commonly occurs at depths of 15 to 40 inches. The lime content is not uniform and is often found as highly concentrated layers stratified with a less limy soil. Although these soils are dominantly deep, some are moderately deep with interbedded shale and sandstone occurring at a depth of 20 to 40 inches.

The Torriorthents, which comprise 25 percent of this association, are dominantly shallow and within the Lithic Ustic Torriorthent subgroup. These soils have a thin surface layer of light reddish-brown noncalcareous to weakly calcareous stony sandy loam. This grades through soil material of similar color and texture to the underlying bedrock which occurs at depths of 6 to 20 inches. In addition to the small angular fragments that are common the surface and throughout the soil, there are occasional outcrops of sandstone bedrock. Quartzite pebbles also occur on the surface in some areas. These soils commonly occupy gently sloping to rolling ridgetops and side slopes with slope gradients usually averaging less than 15 percent. Approximately one-fifth of the Torriorthents are deep and within the Ustic Torriorthent subgroup. These soils occur on nearly level to gently sloping dissected valley bottoms and alluvial fans. They typically have a thin surface layer of reddish-brown calcareous loam or silt loam which is underlain to a depth of five feet or more by weakly stratified reddish-brown medium to moderately fine-textured alluvial sediments. They are susceptible to water erosion and gullies frequently occur where there is a concentration of runoff from higher lying lands.

Rock Land, a miscellaneous land type comprising 10 percent of the association, is widely distributed in the form of long narrow escarpments and breaks that usually have a difference in local relief of less than 100 feet. It consists of a complex of very shallow soils, outcrops of interbedded sandstone and shale, and other types of sedimentary rocks.

Other soils of minor importance in this association include those of the Ustalfic Haplargid, Lithic Ustollic Haplargid, Ustollic Camborthid, Ustochreptic Camborthid, and Mollic Torrert subgroups. The Ustalfic Haplargids, which are deep, typically occupy gently sloping and undulating plains. These soils have a surface layer of reddish-brown noncal-

careous fine sandy loam over a thick sandy clay loam subsoil. The Lithic Ustollic Haplargids, which have a sandy loam or loam surface layer and a sandy clay loam subsoil, are underlain by sandstone and sandy shale at depths of 10 to 20 inches. The Ustollic Camborthids, which are developing in gravelly alluvium on old stream terraces, also comprise a small acreage in the eastern part of this association. These gravelly loam or gravelly sandy loam soils are underlain by very gravelly sediments high in lime at a depth of about 12 to 25 inches. The Ustochreptic Camborthids occupy gently to strongly sloping fans and valley filling slopes, and are deep, moderately coarse-textured, and rapidly permeable soils. The Mollic Torrerts, in contrast, are deep, fine-textured, and very slowly permeable. They commonly occur on nearly level to gently sloping flood plains of intermittent drainages.

*Representative Soil Series:* Conchas, Quay, Latom, Lacita and Gallegos.

#### **72. Haplargids-Torriorthents-Calciorthids (616,100 acres)**

This association is located in an extensive valley area in San Miguel and Guadalupe counties at elevations that generally range between 4000 and 5800 feet. Widely distributed, it is dominated by a gently sloping to undulating topography with smooth nearly level to gently sloping areas bordering the drainages. A few small steep mesa escarpments and buttes are included where their small size did not justify separation on the soil association map. The soils are dominantly deep and are forming generally in medium- to fine-textured alluvial and eolian sediments from redbed formations. They are susceptible to erosion, particularly gully erosion where vegetative cover is depleted or destroyed. Gullies frequently occur in the immediate valley bottoms with small scattered areas being dissected by a network of gullies.

The dominant use of the soils in this association is for livestock grazing. The principal grasses on the loam and clay soils are alkali sacaton, galleta, blue grama, switchgrass, and vine-mesquite. Blue grama, sideoats grama, little bluestem, and sand dropseed are common on the sandy soils. Snakeweed and cholla cactus are the more common shrubs. Some pinyon pine and juniper trees occur on the outer fringes of this unit where it joins the escarpment areas or rough broken lands.

*Soil Characteristics:* The Ustalfic Haplargids occur dominantly on nearly level to very gently undulating plains and comprise 30 percent of the association. They have a thin surface layer of brown



**Fig. 29.** Typical landscapes in the Haplargids-Torriorthents-Calciorthids association No. 72. Ustic Torriorthents in the immediate foreground. Mollic Torrerts, an important inclusion in this association, occur in the valley area near stock tank.

to reddish-brown noncalcareous fine sandy loam or loam. Their subsoil is a thick reddish-brown sandy clay loam that is noncalcareous in the upper part. This is usually underlain by a light reddish-brown or pinkish-white very limy loam at depths ranging from about 28 to 40 inches. The maximum lime accumulation usually occurs in the upper part and gradually decreases with depth. Approximately one-fourth of the soils included in this subgroup lack the high lime zone at moderate depths. The substratum of these soils consists of calcareous sandy clay loam, in which small soft masses and threads of lime are common.

The Ustic Torriorthents, which are also deep, occur dominantly on nearly level to gently sloping channeled valley bottoms and alluvial fans, and comprise 25 percent of the association. They have a thin surface layer of reddish-brown calcareous loam or silt loam which is underlain to a depth of five feet or more by weakly stratified reddish-brown calcareous silt loams and loams. These soils are susceptible to water erosion where the vegetative cover is depleted and where there is a concentration of runoff. A few deep gullies occur, particularly in the drainageways.

The Calciorthids are represented by the Ustochreptic and Ustollic subgroups, which constitute 15 percent and 5 percent of the association, respectively. The Ustochreptic Calciorthids occur mainly on gently sloping fans extending from the base of escarpments, and breaks to the lower-lying valleys. These soils have reddish-brown calcareous loam or fine sandy loam surface layers, reddish-brown calcareous light clay loam subsoils, and pinkish-white loam substrata high in lime. The

pinkish-white lime zone normally occurs at depths of 15 to 40 inches. The lime content is not uniform and commonly occurs as highly concentrated layers stratified with a less limy soil. The Ustollic Calciorthids are moderately deep and nearly level to gently sloping. These soils have brown calcareous loam surface layers over reddish-brown strongly calcareous clay loam or silty clay loam subsoils. The depth to bedrock ranges from about 20 to 40 inches.

The Mollic Torrets, which account for 10 percent of this association, occur on broad very gently sloping fans and on smooth nearly level to gently sloping flood plains. They normally have reddish-brown calcareous clay loam surface layers and very slowly permeable clay subsoils and substrata, and they crack when dry.

Other soils of importance in this general soil area include those of Ustollic Camborthid and Petrocalcic Ustalfic Paleargid subgroups. The Ustollic Camborthids usually occur on gently sloping valley side slopes. These soils are deep and usually have loam or silt loam surface layers over medium- to moderately fine-textured subsoils and substrata. The Petrocalcic Ustalfic Paleargids, which are moderately deep, are underlain by indurated caliche at 20 to 36 inches. These soils usually have loamy fine sand or fine sandy loam surface layers and sandy clay loam subsoils. Miscellaneous land types, including Gullied Land, Rough Broken and Stony Land, and Alluvial Land also comprise small acreages in this association. Gullied Land includes those areas dissected by a network of deep gullies. The Rough Broken and Stony Land consists of a complex of very shallow soils and outcrops of shale, sandstone, and other sedimentary rocks. It commonly occurs on the sides of ridges and mesas or on steep escarpments. Alluvial Land includes the highly variable recent alluvial sediments that occur in arroyo bottoms and drainages or on their immediate flood plains.

*Representative Soil Series:* Redona, Lacita, Quay, Montoya, Conchas, La Lande, and Alama.

### **73. Haplargids (221,875 acres)**

This association, consisting of four widely separated areas, is mainly in the northern part of Quay County. However, small areas extend into San Miguel and Harding counties. The soils, which have developed in parent materials dominantly of alluvial and eolian origin, occupy gently sloping and undulating landscapes. They generally have moderately coarse-textured surface layers and are susceptible to wind erosion when not protected by an adequate cover of vegetation or crop residue.

Formerly a considerable acreage in this area was dry-farmed. However, most of this land either has been returned to range use or is being farmed under irrigation. Dry farming is hazardous because of the limited precipitation and prevailing high summer temperatures. The small acreage of irrigated land is used mainly for the production of alfalfa, grain and forage sorghums, and small grains. A major part of this association is in range use and, in general, supports fair to good stands of native vegetation, consisting of black grama, blue grama, hairy grama, sideoats grama, sand dropseed, buffalograss, tobosa, sand muhly, New Mexico feathergrass, three-awns, yucca, broom snakeweed, and some mesquite, sand sagebrush, and cholla cactus.

*Soil Characteristics:* Haplargids, which are well developed soils with distinct pedogenic horizons, are dominant in this association. The Ustalfic Haplargids, which comprise 55 percent of the association, are the most extensive. They have a thin brown to reddish-brown noncalcareous surface layer which is usually fine sandy loam, but they may range from loamy fine sand to loam in texture. Their subsoil is a thick reddish-brown sandy clay loam that is noncalcareous in the upper part. This is underlain by a light reddish-brown or pinkish-white very limy loam at depths ranging from about 28 to 40 inches. The maximum lime accumulation usually occurs in the upper part and gradually decreases with depth. Ustollic Haplargids constitute 15 percent of the area and do not have the high lime zone or caliche horizon within 40 inches of the surface. These soils usually have a surface layer of brown noncalcareous fine sandy loam or loamy fine sand over a thick brown or reddish-brown noncalcareous sandy clay loam subsoil. This is underlain to a depth of 60 inches or more by calcareous sandy clay loam soil horizons, in which small soft masses and threads of lime are common.

The Ustochreptic Calciorthids constitute 10 percent of this association. They occur mainly on fans and valley-filling slopes extending from the base of the escarpments and breaks to the lower-lying valleys. These soils have reddish-brown to brown calcareous loam or fine sandy loam surface layers reddish-brown calcareous light clay loam subsoils, and pinkish-white very calcareous substrata. The pinkish-white lime zone normally occurs at depths of 20 to 40 inches. The amount of lime in this horizon is not uniform. It commonly occurs as highly concentrated layers stratified with layers of less lime content.

Other soils of minor importance in this association include those of the Ustochreptic Calciorthid, Mollic Torrert, Ustic Torriorthent, Ustollic Calciorthid, Mollic Torrert, Ustic Torriorthent, Ustollic Calciorthid, and Ustollic Camborthisd subgroups. The Ustochreptic Camborthisd, which occupy gently sloping and undulating landscapes, are deep and moderately coarse-textured. The Mollic Torrerts occur on nearly level to gently sloping valley bottoms and the lower parts of alluvial fans. They are deep and moderately fine and fine in texture. The Ustic Torriorthents occupy positions on the landscape similar to those of the Mollic Torrerts but have moderately coarse- to medium-textured profiles. The Ustollic Calciorthisds are underlain at a shallow depth by a pinkish-gray to white, limy, very gravelly sandy loam. Their surface layers are usually a light brown to brown calcareous fine sandy loam. The Ustollic Camborthisds typically have thin brown very gravelly loam or very gravelly sandy loam surface layers and very gravelly sandy clay loam subsoils. A distinct zone of lime accumulation occurs at depths of about 12 to 15 inches.

*Representative Soil Series:* Redona, Canez, Quay, Ima, Montoya, San Jose, Bascom, and Gallegos.

#### **74. Calciorthisds-Torrerts-Torriorthents (601,400 acres)**

This association is located north of the High Plains escarpment in the central part of Quay County. A gently sloping to moderately undulating topography with smooth nearly level areas bordering the drainages prevails throughout this unit. This type of topography, however, is broken by a number of small mesas, buttes, and hills. The slopes on the sides of these mesas, buttes, and hills are moderately steep to steep. The soils are dominantly deep and are forming generally in moderately coarse- to fine-textured alluvium eroded from red-bed formations. Erosion, particularly gully erosion, can become a problem on these soils under misuse. Those contiguous to the intermittent drainages are susceptible to gully erosion if the vegetative cover is depleted or destroyed. Although dryland farming was practiced to a very limited extent on the loamy and sandy soils of this unit, it is no longer being attempted. Farming without irrigation is hazardous in this part of the county because of erratic and limited precipitation and high summer temperature. With the exception of the sandy lands in the northern part of the Tucumcari irrigated area, much of the presently irrigated land in Quay County is in this association. Alfalfa, grain and forage sorghums, cotton, and small grains are the principal crops.

The dominant use of the soils in this association is for grazing of livestock. The principal grasses on the loam and clay soils are alkali sacaton, tobosa, blue grama, switchgrass, and vine-mesquite. Blue grama, sideoats grama, little bluestem, and sand dropseed are common on the sandy soils. Some pinyon pine and juniper trees occur on the outer fringes of this unit where it joins the escarpment areas.

*Soil Characteristics:* The Ustochreptic Calciorthisds constitute 30 percent of the area and occur mainly on gently sloping fans and valley-filling slopes extending from the base of escarpments and breaks to the lower-lying valleys. These soils have reddish-brown calcareous loamy surface layers, reddish-brown calcareous light clay loam subsoils, and pinkish-white very calcareous substrata. The pinkish-white lime zone normally occurs at depths of 20 to 40 inches. Small areas are underlain by interbedded shale and sandstone at a depth of 20 to 40 inches. Ustollic Calciorthisds also occur to a very limited extent in this general soil area. These soils are strongly calcareous and shallow. They are underlain at a depth of 12 to 20 inches by a pinkish-gray very gravelly fine sandy loam with numerous coarse fragments of strongly cemented lime.

The Mollic Torrerts, which comprise 20 percent of this unit, occur on broad, very gently sloping fans and wide nearly level to gently sloping flood plains. They normally have reddish-brown calcareous clay loam surface soils and heavy clay subsoils and substrata that crack when dry.

The Ustic Torriorthents, which are also deep soils, comprise 15 percent of the unit, dominantly on nearly level to gently sloping channeled valley bottoms and alluvial fans. They have a thin surface layer of reddish-brown calcareous loam or silt loam. This is underlain to a depth of five feet or more by weakly stratified reddish-brown, calcareous silt loams and loams. These soils, like the Mollic Torrerts, are susceptible to water erosion where the vegetation cover is depleted and there is a concentration of runoff. A few deep gullies, particularly in the drainageways, occur in most areas of this soil.

Also in this association are soils of the Ustochreptic Camborthisd, Ustollic Haplargid, Aridic Argiustoll, Ustollic Camborthisd, Ustalfic Haplargid, and Fluventic Haplustoll subgroups. The deep and moderately coarse-textured Ustochreptic Camborthisds, occupying 10 percent of the area, commonly occur on gently sloping and undulating landscapes. The Ustollic Haplargids are deep reddish-brown soils with loam or clay loam surface layers and

clayey subsoils. The Aridic Argiustolls are similar, but have moderately thick to thick dark-colored surface layers. The Ustollic Camborthids, which are deep, well drained, and loamy, occur dominantly on crests and side slopes of upland ridges and alluvial fans. A weak but distinct lime zone, in the form of fine soft masses and coatings on pebbles, normally occurs at depths of 18 to 40 inches. The Ustalfic Haplargids also occur to a limited extent in the eastern part of this association. These soils have a surface layer of fine sandy loam or loamy fine sand over thick sandy clay loam subsoils. The Fluventic Haplustolls, which are deep and have dark-colored surface layers, occur on nearly level to gently sloping plains or valley bottoms adjacent to intermittent drainages.

Miscellaneous land types such as Gullied Land and Rough Broken and Stony Land comprise most of the remaining parts of this association. Rough Broken and Stony Land consists of outcrops of interbedded shale, siltstone, sandstone, and other sedimentary rocks intermingled with small areas of thin and highly variable soils.

*Representative Soil Series:* Quay, San Jon, Bascom, Montoya, Lacita, Ima, La Lande, and Tucumcari.

#### **75. Camborthids-Calciorthids (869,700 acres)**

Included in this association are lands adjacent to both sides of the Pecos River along its entire course through Guadalupe and De Baca counties and the northern part of Chaves County. In Guadalupe and De Baca it also includes valley areas bordering some of the larger intermittent tributaries. The topography is varied, ranging from nearly level to gently sloping in the broad valley areas, and gently to strongly sloping and rolling on the plains, to steep, rough, and broken on the escarpment and breaks areas. The soils are developing dominantly in alluvium from sedimentary rocks including shale, sandstone, limestone, and gypsum, but some are forming residually in parent materials weathered from these rocks. In general, these soils are moderately to highly susceptible to erosion, and most are at least slightly eroded. Gullies are common in many of the valley bottoms.

This association is used as rangeland and has a highly variable capability for such use. Where it is dominated by moderately deep and deep soils, fair to moderate yields of forage are obtained under good management, but the Rough Broken and Stony Land component supports only a sparse to fair cover of usable vegetation. Vegetation consists of blue grama, black grama, gyp grama, sand dropseed, three-awns, tobosa, and some sideoats grama,

little bluestem, needle-and-thread, New Mexico feathergrass, mesquite, and a number of other forbs and shrubs. In the northern part of this association thin and scattered stands of pinyon pine and juniper trees are common, particularly in the rough broken areas.

*Soil Characteristics:* The Camborthids in this association are mainly in the Ustochreptic and Ustollic subgroups. The Ustochreptic Camborthids, which constitute 20 percent of the area, are about equally divided between moderately deep and deep soils. The deep soils occupy gently to strongly sloping alluvial fans and side slopes. These soils have noncalcareous surface layers that range in texture from fine sand to fine sandy loam. They are typically underlain to a depth of five feet or more by a calcareous fine sandy loam. A few distinct small soft masses and filaments of lime are common in the substratum and lower part of the subsoil. Coppice dunes, forming in and around shrubs, dominate the microrelief of the eroded phases, which are quite common in this association. The moderately deep Ustochreptic Camborthids occur on gently to strongly sloping and undulating upland ridges, mesas, and low hills. They have a surface layer of light brown to light reddish-brown sandy loam or loamy sand that is typically noncalcareous, but it may be calcareous in some eroded areas. Their subsoil is a reddish-brown calcareous sandy loam that usually contains a few specks and threads of lime in the lower part. This is underlain by sandstone bedrock at depths of 20 to 40 inches.

The Ustollic Camborthids, which are deep, well drained, and loamy, occur dominantly on crests and side slopes of upland ridges and alluvial fans. The granular weakly calcareous surface layer is medium-textured and about six to eight inches thick. This is underlain by a reddish-brown, calcareous loam. A weak but distinct lime zone, in the form of fine soft masses and coatings on pebbles, normally occurs at depths of 18 to 40 inches.

The Calciorthids, like the Camborthids, are represented by two subgroups in this association. The Ustochreptic Calciorthids, which comprise 15 percent of the area, occur mainly on fans and valley-filling slopes extending from the base of escarpments and breaks to the lower-lying valleys. These soils have reddish-brown calcareous loamy surface layers, reddish-brown calcareous light clay loam subsoils, and pinkish-white very calcareous substrata. The pinkish-white lime zone normally occurs at depths of 20 to 40 inches. The amount of lime in this horizon is not uniform, and highly



concentrated layers are commonly stratified with layers of less lime content. Although most of these soils are deep, approximately one-third of them are moderately deep. The surface layers and subsoil of these are similar in color, texture, and reaction to the deep soils, but they may contain a few pebbles or fragments of sandstone and shale. Interbedded shale and sandstone typically occurs at a depth of 20 to 40 inches. Ustollic Calciorthids, which comprise five percent of this unit, consist of shallow soils on gently undulating to rolling uplands. They have brown, calcareous loam or fine sandy loam surface layers. These grade through a thin subsoil with similar texture but lighter color and high lime content to a pinkish-gray very gravelly fine sandy loam with a high lime content at a depth of about 12 to 20 inches.

Miscellaneous land types, including Rough Broken and Stony Land, Gullied Land, Gypsum Land, and Riverwash comprise approximately 25 percent of this general soil area.

Rough Broken and Stony Land includes the steep escarpment and dissected breaks areas. It consists dominantly of a complex of shallow soils and outcrops of interbedded shales, sandstone, and other sedimentary rocks. Stones, boulders, and gravel are common over much of the surface. The included soils are quite variable and range in texture from moderately coarse to moderately fine. The Gypsum Land has a varied topography ranging from gently sloping and undulating to moderately steep and rolling. It consists of those areas dominated by outcrops of gypsiferous earths or gypsum rock. The areas severely dissected by deep gullies are included in Gullied Land.

Soils of the Ustic Torriorthent, Mollic Torrert, and Ustollic Haplargid subgroups comprise most of the remaining parts of this association. The Ustic Torriorthents, which are dominantly deep, are forming mainly in medium- to moderately fine-textured silty alluvium. These soils, which are often dissected by gullies, consist of light reddish-brown to reddish-brown silt loams and light silty clay loams to a depth of six feet or more. There are also in this unit small areas of Ustic Torriorthents underlain by gypsum or gypsiferous earth at shallow to moderate depths. These soils are usually medium-textured, light brownish-gray, and calcareous. The Mollic Torrerts occur on broad, very gently sloping fans and wide nearly level to gently sloping flood plains. These soils normally have reddish-brown calcareous silty clay loam or clay loam surface layers and clay subsoils and substrata. The Ustollic Haplargids consist of those soils with well developed subsoils that range in texture from sandy clay loam to clay. The surface layers are

typically noncalcareous and moderately coarse- to moderately fine-textured. These soils are dominantly deep, but small areas of Ustollic Haplargids in this association are underlain by shale at depths ranging from 30 to 50 inches.

*Representative Soil Series:* Ima, Los Tanos, La Lande, Quay, San Jon, Bascom, Montoya, Lacita, Tucumcari, and Hassell.

#### **76. Paleargids-Paleorthids (458,600 acres)**

This association consists of nearly level gently sloping and undulating soils forming on plains west of the Pecos River in Guadalupe and De Baca counties. A few hummocks and low dunes occur around shrubs in some of the wind-eroded areas. These soils, in general, have developed over indurated to strongly cemented caliche at shallow to moderate depths. Although the underlying caliche restricts plant roots, fractures in the caliche permit deep percolation of excess soil moisture. These soils characteristically have fine sandy loam or loamy fine sand surface layers and are susceptible to wind erosion if the vegetative cover becomes depleted. The shallow soils usually have some caliche fragments on the surface.

This association, which is used as rangeland, supports moderate to good stands of native vegetation. Blue grama, hairy grama, sideoats grama, little bluestem, sand dropseed, sand muhly, black grama, New Mexico feathergrass, and three-awns are the principal grass species. The more common shrubs are yucca, broom snakeweed, skunk brush, and some mesquite.



**Fig. 30.** The nearly level to gently sloping and undulating soils comprising association No. 76, are usually underlain by indurated caliche at shallow to moderate depths. The shallow Ustochreptic Paleorthids shown in foreground commonly have some hard caliche fragments on the surface.

*Soil Characteristics:* Petrocalcic Ustalfic Paleargids make up 55 percent of this association and consist dominantly of soils that have a surface layer of reddish-brown noncalcareous fine sandy loam, or loamy fine sand. Their subsoil is a reddish-brown to yellowish-red fine sandy loam or sandy clay loam that is typically noncalcareous in the upper part. A few small soft masses and threads of lime are common in the lower part of the subsoil immediately above the underlying indurated caliche. The depth to the caliche layer ranges from about 20 to 40 inches; and it is usually indurated or strongly cemented in the upper 12 to 18 inches. The degree of cementation usually decreases gradually with depth. In addition to these moderately deep soils, approximately 20 percent of the Petrocalcic Ustalfic Paleargids are shallow. Their effective soil depth is limited by indurated caliche, which occurs at a depth of about 12 to 20 inches. These shallow soils typically have a surface layer of brown to reddish-brown noncalcareous fine sandy loam over a reddish-brown sandy clay loam subsoil.

The Ustochreptic Calciorthids are shallow and occupy about 20 percent of the association on the crests and side slopes of slightly elevated ridges. These gently sloping soils have a thin surface layer of light brown to reddish-brown noncalcareous loamy fine sand or fine sandy loam. This is underlain by a pale brown to light reddish-brown fine sandy loam subsoil. A white or pinkish-white indurated caliche occurs at a depth of 10 to 20 inches. The strong cementation is typically confined to the upper 12 to 20 inches and gradually decreases with depth.

Miscellaneous land types and soils of minor extent comprise approximately 25 percent of the association. The land types include Rough Broken and Stony Land, Gullied Land, and Alluvial Land in drainage bottoms. Deep Ustollic Calciorthids are the most extensive of the minor soils. These soils, which commonly occur in slightly depressional areas, have a surface layer of grayish-brown strongly calcareous loam. This grades through a light brown clay loam containing small soft masses and threads of lime to a pinkish-white clay loam with a high content of lime. The high lime layers usually begin at 20 to 30 inches below the surface. Ustollic Haplargids, which are also deep, are nearly as extensive as the deep Ustollic Calciorthids. These soils occupy nearly level to gently sloping and undulating landscapes. They have a surface layer of reddish-brown fine sandy loam or loamy fine sand over a thick sandy clay loam subsoil.

Also in this association are small areas of shallow and moderately deep Ustollic Calciorthids. The shallow soils usually occur on the crests of low

ridges and are underlain within a depth of 20 inches by caliche and very gravelly materials. The moderately deep soils, which have brown, calcareous loam surface layers and reddish-brown strongly calcareous clay loam subsoils, are underlain at depths of 20 to 40 inches by interbedded sandstone and shale.

*Representative Soil Series:* Douro, Wickett, Sharvana, Blakeney, Ratliff, Conchas, Bascom, and Redona.

#### **77. Haplargids-Calciorthids (310,600 acres)**

Included in this association are five widely distributed areas in De Baca and Guadalupe counties. The soils, which are forming dominantly in parent materials of alluvial and eolian origin, occupy nearly level to gently sloping and undulating landscapes. There are a few small eroded areas in which sand has accumulated around shrubs in the form of low coppice dunes. These soils generally have brown to reddish-brown fine sandy loam, loamy fine sand, or light loam surface layers and moderately permeable sandy clay loam or light clay loam subsoils. The included shallow soils are usually underlain by caliche or soil layers with a high content of lime. Although the soils of this association are slightly to moderately susceptible to wind erosion, it is generally not a serious problem because of the adequate cover of native vegetation. The more common grasses and shrubs are black grama, blue grama, sideoats grama, sand dropseed, buffalograss, tobosa, sand muhly, New Mexico feathergrass, little bluestem, three-awns, yucca, broom snakeweed, and some mesquite, and cholla cactus.

*Soil Characteristics:* Ustollic Haplargids, which constitute 45 percent of the association, typically have a thin surface layer of brown to reddish-brown noncalcareous fine sandy loam or loamy fine sand. Their subsoil is a thick reddish-brown sandy clay loam that is noncalcareous in the upper part. This is underlain by a light reddish-brown or pinkish-white very limy loam at depths ranging from about 28 to 40 inches. The maximum lime accumulation usually occurs in the upper part and gradually decreases with depth. Approximately 20 percent of the Ustollic Haplargids in this unit differ from those just described in not having a high lime horizon within 40 inches of the surface. Instead, the substratum consists of a calcareous sandy clay loam in which small soft masses and threads of lime are common.

The Calciorthids, which are characterized by their calcareous surface layers and subsurface layers



Fig. 31. The nearly level to gently sloping and undulating soils shown in the foreground are suitable for many uses. They usually have fine sandy loam, loamy fine sand, or light loam surface layers over medium-textured subsoils.

with distinct horizons of lime accumulation, are also an extensive component of this association. Ustollic Calciorthids and Ustochreptic Calciorthids are the two principal subgroups. The Ustollic Calciorthids, which usually occur on low or slightly elevated ridges, occupy 25 percent of the association. They have a surface layer of brown calcareous loam or fine sandy loam which grades through a light brown strongly calcareous loam or fine sandy loam to a pinkish-gray very gravelly fine sandy loam high in lime at a depth of 10 to 20 inches. Strongly cemented lime fragments are common and may comprise as much as 50 percent of this soil layer. Below a depth of about 36 inches there is a gradual decrease in the lime content. In addition, small areas which occur in slight depressions are moderately deep. These soils have strongly calcareous loam surface layers over medium-textured subsoils and high lime zones which occur at depths of about 20 to 30 inches. The Ustochreptic Calciorthids commonly occur on gently sloping and undulating valley-filling slopes and occupy five percent of the association. They have reddish-brown loam surface layers and clay loam subsoils over a pinkish-white very limy substrata.

Also in this association are soils of the Petrocalcic Ustalfic Paleargid, Ustochreptic Paleorthid, Ustic Torriorthent, and Ustochreptic Camborthid subgroups. The Petrocalcic Ustalfic Paleargids usually have reddish-brown noncalcareous loamy fine sand or fine sandy loam surface layers. Their subsoil is a reddish-brown sandy clay loam that is typically noncalcareous in the upper part. A few small foot

masses and threads of lime are common in the lower part of the subsoil immediately above the underlying indurated caliche. The depth to the caliche layer generally ranges from about 20 to 36 inches, but occasionally it is less than 20 inches. The Ustochreptic Paleorthids, which are shallow sandy loams, are underlain by fractured and strongly cemented caliche within a depth of 20 inches. The Ustic Torriorthents, which occur in nearly level to gently sloping valley bottoms, are deep and medium to moderately fine in texture. The Ustochreptic Camborthids are also deep and consist dominantly of fine sandy loams or sandy loams to a depth of 60 inches or more. Small acreages of Duneland, Alluvial Land in arroyo bottoms, and other miscellaneous land types comprise the remaining part of this association.

*Representative Soil Series:* Redona, Canez, Bascom, Quay, Douro, Blakeney, San Jose, and Ima.

#### 78. Haplargids-Ustipsamments (779,100 acres)

This association, lying mainly in Chaves and De Baca counties, consists of the gently sloping and undulating to gently rolling sandy plains just west of the High Plains escarpment. The soils are generally deep, developing in sandy eolian and alluvial sediments. In general, they are very susceptible to wind erosion, particularly when the vegetative cover becomes depleted. Hummocky and duned areas are, therefore, common in this association. A few dunes, which are essentially barren of vegetation, actively erode during windy periods.

The soils are used for livestock grazing. A high level of management is essential to prevent depletion of vegetative cover and soil deterioration by wind erosion. Under good management, moderate yields of forage are obtained. The vegetative cover consists dominantly of tall and mid grasses, and some short grasses, mesquite, shinnery oak, yucca, and sand sage. The more common grasses include sand bluestem, little bluestem, sand dropseed, giant dropseed, sideoats grama, three-awns, switchgrass, plains bristlegrass, blue grama, silver bluestem, and black grama.

*Soil Characteristics:* Haplargids, the major component of this association, are principally within the Arenic Ustalfic and Ustollic subgroups. The Arenic Ustalfic Haplargids, on gently undulating and hummocky landscapes, occupy 30 percent of the association. They have a thick surface layer of light brown to brown fine sand over a subsoil of red to reddish-brown sandy clay loam. This, in turn, is underlain by a yellowish-red light sandy clay loam. A white fractured caliche layer is often present at

depths between four and six feet. The Ustollic Haplagrids, like the Arenic Ustalfic Haplagrids, are found on gently sloping and undulating landscapes, and they occupy about 20 percent of the association. Where they are wind-eroded, hummocky and dunny landscapes are common. These soils usually have a surface layer of brown noncalcareous loamy fine sand or fine sandy loam over a brown or reddish-brown noncalcareous sandy clay loam subsoil. This is dominantly underlain to a depth of 60 inches or more by calcareous sandy clay loam soil horizons, in which small soft masses and threads of lime are common. They are, however, occasionally underlain by a light reddish-brown or pinkish-white very limy loam at depths ranging from about 30 to 40 inches. The maximum lime accumulation usually occurs in the upper part and gradually decreases with depth.

The Typic Ustipsamments occupy land forms that are gently rolling, with duneline topography, and they account for about 25 percent of the area. They have surface layers of loose, noncalcareous yellowish-brown fine sand over thick deposits of fine sand.

Also in this association are small areas of active Duneland and soils of the Petrocalcic Ustalfic Paleargid, Ustochreptic Calciorthid, Ustochreptic Camborthid, and Ustochreptic Paleorthid subgroups. Active duneland includes the barren or nearly barren sand dunes that are actively eroding. The Petrocalcic Ustalfic Paleargids, which have fine sandy loam surface layers and sandy clay loam subsoils, are underlain by indurated caliche at depths of 20 to 40 inches. The Ustochreptic Calciorthids have fine sandy loam or loamy fine sand surface layers over a fine sandy loam subsoil. This is underlain by a strong lime zone at depths of 20 to 40 inches. The Ustochreptic Camborthids are deep sandy loam soils in depressions and side slopes. The Ustochreptic Paleorthids are shallow sandy loam soils underlain by fractured indurated caliche. These minor soils and land types comprise about 25 percent of the association.

*Representative Soil Series:* Jalmar, Canez, Redona, Tivoli, Ima, Kinco, Douro, and Blakeney.

#### **79. Gypsiorthids-Calciorthids-Torriorthents (392,600 acres)**

This association is mainly in the western part of De Baca County and the north-central part of Chaves County. The varied topography includes nearly level to gently sloping valley areas that are intermingled with undulating to hilly uplands. The valley side slopes extending from the upland ridges into the valley areas are usually gently to strongly

sloping. A few steep escarpments and breaks, located mainly along Yeso Arroyo and Salado Creek, are also included. The soils, which are developing dominantly in materials weathered from sedimentary rocks including shale, sandstone, siltstone, and gypsiferous earth and rocks, are susceptible to erosion. Many of the valley bottoms, as well as adjacent side slopes, are dissected by gullies or arroyos. Small areas of exposed gypsiferous earths, shale, and other types of sedimentary rocks are on the steep rough and broken areas along the drainageways.

Although eroded areas and small areas of gypsum and rock outcrops are included in this unit, it generally supports a good cover of vegetation. The density of this cover, however, ranges from barren or nearly barren on the rock outcrop areas to relatively thick stands of grass in the swales and valley bottoms. The more common species are alkali sacaton, blue grama, black grama, tobosa, gyp grama, sand dropseed, bush muhly, burrograss, chamiza, broom snakeweed, and traces of mesquite.

*Soil Characteristics:* Calcic Gypsiorthids, which are moderately deep over gypsiferous materials, constitute 25 percent of this association. These soils occur dominantly on gently sloping and undulating uplands and occasionally on moderately steep to rolling uplands. They typically have a thin light reddish-brown to light brownish-gray calcareous loam surface layer. This layer grades through a light reddish-brown or pale brown clay loam, high in lime, to the underlying gypsiferous earth at depths of 20 to 40 inches.

The Ustochreptic Calciorthids, which also account for 25 percent of this association, are mainly deep, but they range from moderately deep to deep. The deep soils occur normally on gently to strongly sloping and undulating alluvial fans and valley side slopes. These soils have reddish-brown calcareous loam or silt loam surface layers, reddish-brown calcareous light clay loam subsoils, and pinkish-white loam substrata high in lime. The pinkish-white lime zone normally occurs at depths of 15 to 40 inches. The lime content is not uniform and commonly occurs as highly concentrated layers stratified with a less limy soil. The moderately deep Ustochreptic Calciorthids typically occur on the strongly sloping and undulating upland ridges. These soils, which consist of reddish-brown loams and clay loams, are underlain at a depth ranging from about 20 to 40 inches by interbedded shale and sandstone.

The Torriorthents in this general soil area are within the Typic Torriorthent and Ustic Torriorthent subgroups. The Typic Torriorthents, which

constitute 20 percent of the area, are shallow and occur on gently sloping and undulating to rolling uplands. They have a thin surface layer of light brownish-gray to brown strongly calcareous loam or silt loam. This grades through soil of similar color and texture to the underlying gypsiferous earth or gypsum that usually occurs at a depth of 4 to 20 inches. The Ustic Torriorthents, which constitute only five percent of the area, are deep and are found mainly in the valley bottoms on flood plains contiguous to intermittent drainages. They consist dominantly of stratified silt loams and light silty clay loams.

In addition, Gullied Land, Rough Broken and Stony Land, and soils of the Ustochreptic Camborthid, Ustollic Camborthid, and Mollic Torriert subgroups comprise about 25 percent of this association. The Rough Broken and Stony Land consists of a complex of very shallow soils and outcrops of interbedded shale, sandstone, siltstone, and gypsiferous and other sedimentary rocks. The Ustochreptic Camborthids, which occupy gently sloping and undulating landscapes, are moderately deep and deep sandy loams. The moderately deep soils are underlain by sandstone bedrock at depths of about 20 to 40 inches. The Ustollic Camborthids commonly occur on gently sloping and undulating ridges and usually have calcareous loam surface layers and loamy subsoils. A weak but distinct lime zone in the form of fine soft masses and coatings on pebbles normally occurs at depths of 18 to 40 inches. The Mollic Torrierts are deep, fine-textured, and slowly permeable. They occupy the nearly level to gently sloping flood plains and valley bottoms.

*Representative Soil Series:* Quay, San Jon, Holloman, La Lande, Ima, Los Tanos, Montoya.

#### **80. Haplargids-Paleargids (352,400 acres)**

This association consists of one relatively large area in the northeastern part of Chaves County. The soils, which are developing in parent materials dominantly of alluvial and eolian origin, occupy gently sloping and undulating landscapes. These soils generally have brown to reddish-brown fine sandy loam or light loam surface layers and moderately permeable sandy clay loam subsoils. In general, the soils of this unit are only slightly to moderately susceptible to erosion, but a few small hummocky and wind eroded areas are interspersed throughout.

The soils support fair to good stands of native vegetation, consisting of black grama, blue grama, hairy grama, sidecoats grama, sand dropseed, buffalo-grass, tobosa grass, spike muhly, three-awns, yucca,

broom snakeweed, and some mesquite and cholla cactus.

*Soil Characteristics:* Ustollic Haplargids constitute 60 percent of this association. They have a thin surface layer of brown to reddish-brown noncalcareous fine sandy loam or loam over a thick reddish-brown sandy clay loam subsoil that is noncalcareous in the upper part. This is underlain in about half of the area by a light reddish-brown or pinkish-white very limy loam at depths ranging from about 28 to 40 inches. The maximum lime accumulation usually occurs in the upper part and gradually decreases with depth. The soils of the other half of the area lack the lime zone within 40 inches of the surface. In these soils the substratum consists of a calcareous sandy clay loam in which small soft masses and threads of lime are common.

Petrocalcic Ustalfic Paleargids, the other major member of this association, have a surface layer of reddish-brown noncalcareous loamy fine sand or fine sandy loam. Their subsoil is a reddish-brown sandy clay loam that is typically noncalcareous in the upper part. A few small soft masses and threads of lime are common in the lower part of the subsoil immediately above the underlying indurated caliche. The depth to the caliche layer ranges from about 20 to 36 inches and is usually indurated or strongly cemented in the upper 12 to 18 inches. The degree of cementation usually decreases gradually with depth.

Also in this association are Ustollic Camborthids, Ustochreptic Camborthids, Ustochreptic Paleorthids, Ustic Torriorthents, and small areas of miscellaneous land types such as Rough Broken and Stony Land, Alluvial Land, and Duneland. The Ustollic Camborthids consist of deep, reddish-brown soils on nearly level to gently sloping and undulating landscapes. Those on the crests and side slopes of upland ridges are typically medium-textured and have a weak but distinct lime zone at a depth of about 20 to 40 inches. The Ustollic Camborthids on the nearly level to gently sloping fans usually have silt loam surface layers and silty clay loam subsoil. The Ustochreptic Camborthids are dominantly deep and consist generally of fine sandy loams or sandy loams to a depth of 60 inches or more, although sandstone bedrock occurs occasionally at a moderate depth. The Ustochreptic Paleorthids, which are shallow sandy loam soils, are underlain by fractured, strongly cemented caliche within a depth of 20 inches. The Ustic Torriorthents are deep, and consist dominantly of weakly stratified loams, silt loams, and silty clay loams. They are in the immediate valley bottoms on

flood plains contiguous to intermittent drainages. The Rough Broken and Stony Land, which is the most extensive of the miscellaneous land types, consists of a complex of very shallow soils and outcrops of interbedded shales, siltstones, sandstone, and other sedimentary rocks.

*Representative Soil Series:* Redona, Canez, Douro, La Lande, Alama, and Blakeney.

#### **81. Camborthids-Torriorthents (309,500 acres)**

This association includes a moderately extensive area in Chaves and De Baca counties. Although a gently sloping and undulating topography is characteristic of most of the unit, a few steep escarpments or breaks, as well as nearly level to gently sloping valley bottoms, are included. The soils are forming dominantly in materials from sedimentary formations consisting of interbedded shale, sandstone, siltstone, and gypsiferous material. They range from shallow to deep, but moderately deep and deep soils are the most extensive. These soils are susceptible to water-erosion where the vegetative cover is depleted and there is a concentration of runoff. A few deep gullies, particularly in the drainageways, are common.

This association supports fair to good stands of both mid and short grasses, the more common of which are blue grama, black grama, sideoats grama, hairy grama, tobosa, alkali sacaton, three-awns, burgrass, and sand dropseed. Mesquite, yucca, rabbitbrush, snakeweed, chamiza, and a few cholla cactus are the more prevalent shrubs.

*Soil Characteristics:* Ustollic Camborthids, which comprise 65 percent of this association, are within the fine-loamy and fine-silty textural families. Those in the fine-loamy family are deep and well drained, occurring dominantly on crests and side slopes of upland ridges and alluvial fans. The granular noncalcareous surface layer is medium-textured and about six to eight inches thick. This layer is underlain by a reddish-brown, calcareous loam. A weak but distinct lime zone, in the form of fine soft masses and coatings on pebbles, normally occurs at depths of 18 to 40 inches. The fine-silty soils comprise approximately one-third of the Ustollic Camborthids. These occur on nearly level to gently sloping alluvial fans. They have a thin, granular, reddish-brown silt loam surface layer over a thick subsoil of reddish-brown silt clay loam. This grades into a light reddish-brown or reddish-yellow silt loam at depths of 26 to 30 inches. A few soft masses and threads of segregated lime and gypsum crystals are usually present in this horizon.

The Ustic Torriorthents, which are also deep,

occur dominantly on nearly level to gently sloping channeled valley bottoms and alluvial fans, comprising 10 percent of the association. They have a thin surface layer of reddish-brown calcareous loam or silt loam which is underlain to a depth of five feet or more by weakly stratified reddish-brown, calcareous silt loams and loams. These soils are susceptible to water-erosion where the vegetative cover is depleted and there is a concentration of runoff. A few deep gullies, particularly in the drainageways, are common.

Gullied Land, Rough Broken and Stony Land, and soils of the Ustochreptic Calciorthid, Mollic Torriert, and Lithic Ustollic Haplargid subgroups comprise about 25 percent of this unit. Rough Broken and Stony Land, the most extensive of the miscellaneous land types consists of a complex of very shallow soils and outcrops of thinly bedded siltstone, shale, sandstone, and other sedimentary rocks. The Ustochreptic Calciorthids, which are characterized by their strongly calcareous loamy surface layers and moderately fine-textured subsurface layers with distinct horizons of lime accumulation, are moderately deep and deep. The moderately deep soils are underlain by interbedded shale and sandstone at depths of about 20 to 40 inches. The Mollic Torrierts are deep, fine-textured, and slowly permeable. They occupy the nearly level to gently sloping flood plains and broad valley bottoms. The Lithic Ustollic Haplargids, which are moderately fine to medium in texture, are underlain within a depth of 20 inches by sandstone interbedded with sandy shale.

*Representative Soil Series:* La Lande, Alama, Lacita, Quay, San Jon, and Newkirk.

#### **82. Calciustolls-Rock Land (2,181,000 acres)**

This association, the largest in the Central Plains Region, includes the limestone hills east of the Sacramento and Guadalupe Mountains in the southeastern part of the state. The soils, which are dominantly shallow, stony, and rocky, occur on strongly sloping and rolling to very steep uplands underlain mainly by limestone bedrock.

It is used for grazing of livestock and wildlife, and under good management fair to moderate yields of forage are obtained. The dominant vegetation on the soils of this association consists of black grama, blue grama, hairy grama, tobosa, three-awns, beargrass, ocotillo, snakeweed, tarbush, and yucca. Thin and scattered stands of juniper trees occur at the higher elevations where this unit joins the mountain ranges. Creosotebush and a few mesquite also occur in the southern part of this association.

*Soil Characteristics:* Lithic Calcicustolls comprise 40 percent of this association. They occupy strongly sloping to moderately steep and hilly land forms which are typically not as steep as the associated Rock Land unit. These soils have a thin surface layer of grayish-brown calcareous stony or cobbly loam. This grades through a very stony and very cobbly loam to the underlying limestone bedrock which commonly occurs at depths of about 4 to 15 inches. The content of angular limestone fragments ranges from about 35 to 75 percent. The underlying limestone bedrock, which is typically fractured, has thin lime coatings in the upper part.

Limestone Rock Land, a miscellaneous land type comprising 30 percent of the association, occurs on the steep and very steep land forms. It consists of a complex of very shallow soils and outcrops of bedrock. The soils, although variable in characteristics, are generally stony, moderately coarse to medium in texture, and shallow. Small areas or pockets of deep dark-colored soils occur occasionally. Numerous stones and angular fragments of limestone are common on the surface between the vertical or nearly vertical exposures of bedrock.

Ustollic Paleorthids, which are also moderately extensive in this association, generally occur on moderately sloping and rolling landscapes in the lower part and outer fringes of this mapping unit. They have grayish-brown calcareous gravelly loam surface layers. These are underlain by fractured, platy, strongly cemented to indurated caliche at depths of 6 to 20 inches. Angular caliche fragments are common in the soil layers above the underlying cemented caliche. In this association, limestone bedrock commonly occurs at varying depths below the caliche.

Included in this association are also small acreages of Pachic Calcicustolls, Pachic Haplustolls, Cumulic Haplustolls, and Typic Paleorthids. Soils of the first three subgroups occupy the flood plains and valley bottoms of intermittent drainages that traverse this general soil area. These soils are characterized by their dark-colored loamy surface layers. The subsurface layers, however, are variable and range in texture from medium to moderately fine, and in gravel and cobble content from little or none to high contents of coarse fragments. The Typic Paleorthids occupy the small areas of nearly level to gently sloping landscapes. They are moderately deep, light-colored, calcareous, loamy soils underlain by indurated or strongly cemented caliche. Alluvial Land, Riverwash, Alluvial Land in arroyos, and other miscellaneous land types comprise the remaining parts of this association.

*Representative Soil Series:* Ector, Conger, Elfrida, Santo Tomas, Dev, and Atoka.

### **83. Rock Land-Torriorthents (198,800 acres)**

This association, which is located dominantly within Quay County, includes the steep and precipitous canyon walls and breaks adjacent to the Canadian River, as well as the steep and very steep escarpment between the High Plains uplands and the lower-lying valleys and plains. It is characterized by its extreme slope gradients. The fans and valley slopes below the escarpment or breaks are gently to strongly sloping. The escarpment is very steep with vertical or nearly vertical cliffs near the upper part.

The soils and land types comprising this association are used principally for grazing by livestock and wildlife. Although the density of vegetation is restricted due to rock outcrops, thin soils, and steep slopes, this unit supports a wide variety of grasses and shrubs. Blue grama, hairy grama, galleta, side-oats grama, little bluestem, switch grass, needle-and-thread, New Mexico feathergrass, sand dropseed, and three-awns are the principal grasses. The more common shrubs and woody species include pinyon, juniper, big sagebrush, bitterbrush, serviceberry, snakeweed, rabbitbrush, and cactus. This association provides a good habitat for many species of wildlife.

*Soil Characteristics:* Rock Land, a miscellaneous land type, comprises 45 percent of this association. It occurs dominantly on the steep escarpment and breaks areas. It is a complex of very shallow soils and outcrops of interbedded sandstone and shale and other types of sedimentary rocks. The sandstone outcrops commonly occur as vertical or nearly vertical exposures and ledges. A thin mantle of stony or gravelly soil material usually occurs between the ledges and outcrops of bedrock.

The Ustic Torriorthents, which comprise 40 percent of the association, consist of soils without distinct pedogenic horizons which are variable in depth and other characteristics. Those soils on the steep slopes are usually shallow to moderately deep and moderately coarse to medium in texture. Numerous stones and boulders are common over much of the land surface. The Ustic Torriorthents on the gently to strongly sloping fans on the lower slopes near the base of the escarpment are typically deep and medium- to moderately fine-textured. Reddish-brown silt loams and silty clay loams are common. They are susceptible to erosion, and gullies frequently occur where vegetative cover is depleted or where there is a concentration of runoff.

Also in this unit are small areas of Rough Broken and Stony Land, and soils of the Ustollic Camborthid and Ustochreptic Calciorthid subgroups. Rough Broken and Stony Land occurs in this association where the land surface is covered by thick deposits of old alluvial sediments. These lands, which are usually moderately steep to steep and severely dissected, consist of a complex of shallow soils and exposures of unconsolidated sedimentary deposits. Ustollic Calciorthids are developing in old gravelly alluvium and typically have gravelly loam or very gravelly loam surface layers and very gravelly sandy clay loam subsoils. A distinct zone of lime accumulation occurs at depths of about 12 to 25 inches. The Ustochreptic Calciorthids occur on gently to strongly sloping fans and valley slopes in the lower part of this unit. These soils, which are medium to moderately fine in texture, are slowly permeable. They also have a distinct lime zone, which occurs at a depth ranging from 15 to 36 inches.

*Representative Soil Series:* Consists mainly of land types or soils classified only at the subgroup level.

### Moderately Dark-Colored Soils of the Plateau Region

Most of this region is in the Colorado Plateau physiographic province, but a part of the northern section is in the Basin and Range and Southern Rocky Mountain provinces.

The Plateau Region is an area of broad mesas and plateaus interspersed with numerous deep canyons and dry washes, steep, picturesque mesa-breaks, and canyon walls. The Gila and Frijoles Canyon cliff dwellings, among others, were built in these canyons. There are some isolated volcanic peaks and

cones scattered throughout the region, and lava flows are a distinctive feature of extensive parts of the area. One large closed basin, the San Agustin Plains west of Socorro, lies in the area.

Although rivers such as the Rio Grande, San Francisco, San Juan, and Gila drain some of the area, a significant part drains into intermittent stream channels. The Rio Puerco, Rio Salado, Largo Creek, and the Chaco River are some of the major intermittent streams.

Elevations dominantly are in the 5,000 to 7,500 feet range, but they reach to more than 8,500 feet on a few of the small isolated mountain peaks.

The western plateaus and mesas cover approximately 14,848,200 acres, of which 52,000 are irrigated and 3,452,000 are irrigable.

## CLIMATE

In the Plateau Region, the climate is semiarid continental. Winters are rather cold; summers are warm; and days are sunny. In most of the region, slightly more than half of the annual precipitation comes in summer, in brief afternoon and evening thundershowers. Snowfall is common, averaging from about 15 to 40 inches per year. Humidity is low, probably in the 30 to 70 percent range most of the time. Days are warm and nights are chilly in summer. Table 5 gives data for four weather stations scattered over the region.

Daily temperatures vary by 30 to 40 degrees. Temperatures over 90 degrees are uncommon in most of the area, but Silver City has experienced 103 degrees, and the maximum at Augustine was 100 degrees. At Gallup, the maximum was 99 degrees, and at Santa Fe, 98 degrees. The minimum was 12, 15, 23, and 26 degrees below zero at Silver City, Santa Fe, Gallup, and Augustine, respectively.

Table 5. Climatic conditions at four stations in the Plateau Region

Station	Area	Elevation feet	Average Precipitation												Avg. Ann. Temp.	Frost-Free Season days	
			J	F	M	A	M	J	J	A	S	O	N	D			Annual
Santa Fe	NE	7,200	0.68	0.69	0.78	0.83	1.38	1.17	2.14	2.23	1.41	1.09	0.60	0.70	13.70	50.0	164
Gallup	NW	6,530	0.64	0.69	0.78	0.65	0.55	0.46	1.74	1.81	1.05	1.00	1.51	0.77	10.65	48.5	121
Augustine	Cen	7,020	0.44	0.52	0.53	0.47	0.45	0.64	2.06	2.24	1.44	0.90	0.27	0.55	10.51	47.9	123
Silver City	South	5,373	1.12	1.34	0.98	0.54	0.33	0.72	2.50	3.07	2.06	1.24	0.64	1.10	15.64	54.2	180



The temperature at a depth of 20 inches is considered in classifying soils. All soils in this region are considered to have Mesic temperature regimes, indicating that the average annual soil temperature is between 47 and 59 degrees. In the central part of the state, near the Colorado border, some soils may have Frigid temperatures, indicating that the soil temperatures are between 32 and 47 degrees.

## GEOLOGY

There is a great diversity of geologic formations in this area. The Santa Fe formation along the Rio Grande depression, the basalt flows near the Rio Grande and west toward Arizona, the basaltic and andesitic flows in the western uplands, and the Gila conglomerate are all Quaternary and Tertiary rocks that cover most of the area. Tertiary sandstones and shales occur in the north. There also are Triassic, Cretaceous, and Precambrian rocks.

## SOIL ASSOCIATIONS

Twenty-three soil associations have been recognized in the Plateau Region. These are shown on the enclosed map and named after the major great groups that occur within them. Descriptions of these associations follow:

### 84. Rock Land-Torriorthents-Haplargids (2,874,100 acres)

This association, the largest in this region, lies within San Juan, McKinley, Rio Arriba, and Sandoval counties in the northwestern part of the state. A characteristic feature of this association is the rough broken topography with considerable variation in local relief. The relatively narrow valley floors and upland summits are separated by steep canyon walls and escarpments. The fans and valley floors below the canyon walls or escarpments are gently to strongly sloping. The mesa tops and upland areas are gently sloping to rolling. Outcrops of sandstone bedrock and some shale are common on the steep canyon walls and escarpments. Thin deposits of gravelly alluvium also occur occasionally on the breaks adjacent to some of the larger drainages.

The soils of this association are used principally for grazing by livestock and wildlife. Although many of the outcrops of sandstone and shale are barren or nearly barren, this association in general supports a fair to good cover of native vegetation consisting of a relatively wide variety of grasses and shrubs. Blue grama, galleta, sideoats grama, Indian

ricegrass, western wheatgrass, little bluestem, alkali sacaton, three-awns, and sand dropseed are the principal grasses. The more common shrubs and woody species include pinyon pine, juniper, sagebrush, bitterbrush, serviceberry, mountain mahogany, snakeweed, and rabbitbrush. A few ponderosa pine also occur on the north- and east-facing slopes at the higher elevations. The use of land in this unit for recreational purposes is also of considerable importance as it provides a good habitat for many species of wildlife.

*Soil Characteristics:* Rock Land, which comprises 30 percent of the association, consists of a complex of shallow soils and outcrops of sandstone and other sedimentary rocks. It characteristically occupies the steep and very steep mesa side slopes, escarpments, and breaks in which ledges and stairstep topography are common. The outcrops or bedrock commonly occur as vertical or nearly vertical exposures or ledges, and a thin mantle of stony soil generally occurs between them. Although shallow soils and rock outcrops are dominant, small



Fig. 32. Representative steep and rough topography in the Rock Land-Torriorthent-Haplargid association No. 84. Rock Land is dominated by rock outcrops which are mainly on moderately steep to very steep breaks and escarpments. Lithic Ustic Torriorthents are common on the ridge and mesa tops.

isolated pockets of moderately deep to deep soils occur on the escarpments where benches or areas with a lesser slope gradient have formed.

Lithic Ustic Torriorthents, which are underlain by sandstone at shallow depths, occur on gently sloping to moderately steep and rolling upland areas and mesa tops comprising 30 percent of the association. They have a thin surface layer of light brownish-gray or light brown, slightly calcareous fine sandy loam or stony fine sandy loam. This grades through soil of similar color and texture to the underlying sandstone bedrock at depths which typically range from 8 to 12 inches, with extremes of 4 to 20 inches. Small angular fragments of sandstone are common at the surface and typically become more numerous with depth.

Haplargids, which are soils with well developed subsoils, constitute 20 percent of the association. They are dominantly within the Ustollic Haplargid subgroup and to a very limited extent in the Lithic Ustollic Haplargid subgroup. The Ustollic Haplargids are mainly on nearly level to gently sloping and undulating mesa tops or on the crests and higher parts of the landscape in this unit. These soils have a thin surface layer of brown noncalcareous fine sandy loam or loam. The subsoil is a moderately thick brown to reddish brown clay loam or sandy clay loam that is leached free of lime in the upper part. Below the subsoil is a light reddish-brown calcareous loam or light clay loam with some visible lime in the form of fine soft masses and threads. Sandstone bedrock may occur at a depth of 26 to 40 inches. The Lithic Ustollic Haplargids occupy similar positions, but are underlain by sandstone bedrock within 20 inches of the surface. Approximately 15 percent of the Haplargids are in this subgroup.

Other soils of importance in this association are those of the Ustollic Camborthid and Ustic Torripsamment subgroups. The Ustollic Camborthids consist of soils forming dominantly in materials weathered from shale on gently sloping to rolling uplands and valley slopes. They usually have pale brown loam or clay loam surface layers over moderately fine and fine-textured subsoils. Shale is typically encountered at depths of about two to five feet. The Ustic Torripsamments, which also occur to a limited extent, are characterized by their light brown loamy fine sand surface layers and fine sand and loamy fine sand subsurface layers.

Also in this association are small areas of unclassified alluvial soils, as well as a number of other miscellaneous land types. The deep alluvial soils occupy nearly level to gently sloping landscapes in narrow valley bottoms. They range in

color from light brown to grayish-brown and in texture from medium to fine. The land types are Badland, Alluvial Land, and Gullied Land. Badland includes areas dominated by outcrops of shale and consists of a complex of shale outcrops and small areas of shallow and clayey soils. The landscape is one of rolling hills and steep escarpments. Alluvial Land includes the highly variable and stratified soil materials in the immediate flood plain of arroyos and drainage channels. The areas severely dissected by deep gullies are included in Gullied Land.

*Representative Soil Series:* Travessilla, Del Rio, Silver, Hagerman, Penistaja, Bond, Litle, Las Lucas, and Valent.

### **85. Torriorthents-Torrifluvents-Badland (441,500 acres)**

This association, consisting of a number of widely separated areas, occurs mainly in the western part of Sandoval County and extends into Rio Arriba, San Juan, and McKinley counties. The topography is variable, consisting of broad, gently sloping valleys intermingled with strongly sloping to moderately steep and rolling uplands. The included escarpments and breaks are usually steep or very steep. Deep soils are dominant in the valley bottoms and on the valley side slopes, while shallow soils with some outcrops of shale and sandstone are more common in the upland areas. The soils are developing residually in materials weathered from shale and sandstone, and in alluvium from these materials. They are highly susceptible to water-erosion; deep gullies usually occur in the valley bottoms.

This association in general supports a fair cover of grasses and shrubs, including some sparse and scattered stands of pinyon pine and juniper trees. The more common grasses are galleta, alkali sacaton, western wheatgrass, Indian ricegrass, blue grama, and sand drowseed. Winterfat, chamiza, shadscale, and rabbitbrush occur in small amounts. Big sagebrush is also common, except in the southern part of this unit in Sandoval County adjacent to the Rio Puerco. The vegetation density and forage production are also slightly less there than in the northern areas.

*Soil Characteristics:* Ustic Torriorthents, which constitute 35 percent of this association, are developing on upland slopes and ridges in a thin layer of calcareous material weathered from the underlying shale. They have a thin surface layer of light yellowish-brown calcareous silty clay loam. This is underlain by light yellowish-brown or pale yellow silty clay loam that typically contains a

moderate amount of partly weathered shale fragments. Concretions of calcium carbonate and crystals of gypsum are also common throughout this subsurface layer. The depth to shale ranges from about 6 to 18 inches.

The Ustic Torrifluvents, occurring dominantly on gently sloping and undulating valley-filling slopes and flood plains in the valley areas, also constitute 35 percent of the association. They are calcareous throughout, deep, and medium, moderately fine, or fine in texture. These soils usually have a thin surface layer of light brownish-gray loam, clay loam, or silty clay loam. This is underlain by stratified loams, clay loams, silty clay loams, and clays to a depth of five feet or more. They are occasionally saline and are susceptible to erosion, particularly gully erosion.

Badland is also a moderately extensive component of this association, particularly in the southern part, and constitutes 15 percent of the area. It consists of barren or nearly barren outcrops of shale with small amounts of other sedimentary rocks. The landscape is one of rolling hills and steep breaks. Due to low intake rates and very slow permeability, much of the precipitation runs off, and flash floods follow heavy rains. Erosion is active, so the runoff carries a large content of sediment. Moisture moves slowly through shale materials, often causing soluble salts to concentrate in low places and sidehills where seepage emerges.

Also included in this association are small areas of Ustollic Camborthids, Ustollic Haplargids, unclassified deep alluvial soils, Rock Land, and Gullied Land. The Ustollic Camborthids are moderately deep and deep soils forming dominantly in materials weathered from shale on gently sloping and undulating uplands and valley slopes. These soils typically have pale brown loam or clay loam surface layers over moderately fine- and fine-textured subsoils and substrata. They are usually underlain by shale at depths ranging from about 20 inches to 60 inches or slightly more. The Ustollic Haplargids, which are deep, are forming in moderately coarse- to moderately fine-textured alluvial and eolian sediments on the more stable and older landscape in this unit. They are dominated by soils with light brown noncalcareous fine sandy loam surface layers and sandy clay loam subsoils. Rock Land typically occurs on the steep breaks and escarpments; it includes areas dominated by outcrops of sandstone. The small areas that are highly dissected by deep gullies are included in Gullied Land.

*Representative Soil Series:* Lohmiller, Litle, and Las Lucas.

## 86. Haplargids-Torripsammets (873,500 acres)

Included in this association are 12 widely distributed areas that extend from the southwestern part of Taos County to the San Augustin Plains in Catron County. Extensive and representative areas of this unit occur in the western part of McKinley and Valencia counties along the Arizona state line. In addition to these general locations, a number of delineations lie in the northwestern part of Sandoval County and adjacent areas of Rio Arriba, San Juan, and McKinley counties. All areas are dominated by deep, well drained soils that are forming in coarse- to moderately fine-textured alluvial and eolian sediments of mixed origin. These soils are mainly on nearly level to gently sloping and undulating landscapes, but strongly sloping and rolling ridges are included. The latter also include small areas of moderately steep to steep outcrops of sandstone and shale, and associated rough lands. Although the soils are dominantly deep, small areas of shallow soils occur on some of the upland ridges.

The typical vegetation is a grass-sagebrush mixture. The more common grasses are blue grama, sand dropseed, western wheatgrass, Indian ricegrass, galleta, three-awns, and ring muhly. In addition to sagebrush, shrub and woody species include rabbitbrush, broom snakeweed, Mormon tea, and scattered stands of pinyon pine and juniper trees. Some of these soils have been dry-farmed, but they have been returned to range because of unfavorable climatic conditions and frequencies of droughts. Many of the formerly cultivated areas have been reseeded to crested wheatgrass and native grasses.



Fig. 33. The deep well-drained soils of the Haplargid-Torripsammets association No. 86 commonly occur on gently to strongly sloping landscapes.

*Soil Characteristics:* Ustollic Haplargids, which constitute 50 percent of the association, typically occupy gently sloping and undulating plains. These soils, dominantly deep and well drained, have well developed subsoils. Subsoil textures range from a heavy fine sandy loam to a heavy clay loam. They also vary in the amount of accumulated lime and in the depth to a prominent lime zone. The more extensive soils in this unit have a thin surface layer of light brown to brown, noncalcareous, fine sandy loam, loam, or light clay loam over a subsoil of light brown or reddish-brown sandy clay loam and clay loam. This is underlain by a light brown to reddish-yellow light sandy clay loam or sandy loam that commonly contains small soft masses and fine threads of segregated lime. A prominent lime zone occasionally occurs at depths of about 24 inches to 40 inches or more. These high lime layers are usually pinkish-white or pale brown and medium to moderately fine in texture. Sandstone or sandy shale occasionally occurs within a depth of 60 inches. In addition to these soils with medium- to moderately fine-textured subsoils, approximately 10 percent of the Ustollic Haplargids in this association are coarser-textured. These have a surface layer of brown or reddish-brown noncalcareous loamy fine sand. Their subsoil is a reddish-brown heavy fine sandy loam that is usually noncalcareous in the upper part and underlain to a depth of 60 inches or more by a light reddish-brown fine sandy loam or sandy loam. Thin seams and small soft masses of segregated lime are common in the lower part of the subsoil and upper part of the substratum.

Ustic Torripsamments, the other important component of this association, account for about 20 percent of the area. They usually occur on undulating to gently rolling landscapes. These soils, which are characterized by their sandy textures and very rapid permeability, have a surface layer of light brown, noncalcareous loamy fine sand over subsurface layers of pale brown to light brown, fine sand and loamy fine sand to a depth of five feet or more.

Also in this association are Lithic Ustic Torriorthents, Ustic Torriorthents, Cumulic Haplustolls, Ustollic Camborthids, and small areas of unclassified soils and miscellaneous land types. The Lithic Ustic Torriorthents, which are shallow, are underlain by sandstone at depths of 6 to 20 inches. The Ustic Torriorthents are deep, gently to strongly sloping soils on valley slopes. They are usually calcareous, weakly stratified, and moderately fine in texture. The Cumulic Haplustolls, which occupy the lower lying and nearly level to gently sloping landscapes in this association, have thick grayish-brown to

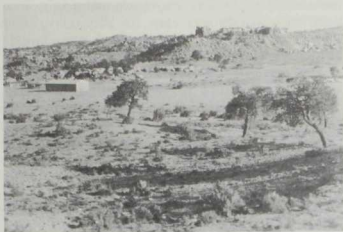
brown loamy surface layers and heavy loam or clay loam subsoils and substrata. The Ustollic Camborthids are of extremely limited extent, and consist of soils forming in materials weathered from shale. They have medium- to moderately fine-textured surface layers and moderately fine- to fine-textured subsoils. Shale usually occurs at depths of two to five feet. The unclassified soils, none of which is extensive, are dominated by moderately deep soils underlain by sandstone and shale. The more important land types include Alluvial Land and Rock Outcrops. Alluvial Land consists of stratified and highly variable soil materials in the immediate flood plain of arroyos and drainage channels. The Rock Outcrops occur generally in association with the Lithic Ustic Torriorthents on the small areas of rough and broken lands adjacent to some of the larger drainages.

*Representative Soil Series:* Penistaja, Clovis, Silver, Palma, Valent, Travessilla, and Manzano.

#### **87. Torriorthents-Rock Land (790,200 acres)**

Included in this general soil area are moderately extensive areas of rough and broken lands in Sandoval, McKinley, Rio Arriba, and Bernalillo counties. This association includes a number of distinct and significantly different land forms, but they occur in such a complex pattern that the area in general is best described as being rough and broken. These land forms include nearly level to gently sloping flood plains, gently to strongly sloping alluvial fans or valley slopes, strongly sloping to moderately steep and rolling uplands, and steep to very steep canyon walls, escarpments, and breaks. The soils on the strongly sloping and rolling uplands, which are generally shallow and light-colored, are forming residually in materials weathered mainly from sandstone and shale. The nearly level to strongly sloping soils on the flood plains and adjacent alluvial fans or valley slopes are dominantly deep, medium- to moderately fine-textured, and often saline and sodic. The valley bottoms are typically dissected by many gullies and intermittent drainageways. The control of runoff and erosion are major problems.

In general, it supports a sparse to fair cover of native vegetation consisting dominantly of blue grama, galleta, western wheatgrass, alkali sacaton, Indian ricegrass, sand dropseed, three-awn, chamiza, winterfat, and rabbitbrush. Scattered and thin stands of pinyon pine and juniper trees and some big sagebrush also occur, particularly where the soils are forming over sandstone. The very steep escarpments typically support only a very sparse cover of vegetation. The sandstone and shale out-



**Fig. 34.** General view of the Torriorthents-Rock Land association south of Gallup. The Lithic Ustic Torriorthents occupy the gently to strongly sloping and rolling uplands in foreground. The steep breaks and escarpments in background are included in the Rock Land component of this association.

crops are usually barren or nearly barren and serve as a source of sediments.

*Soil Characteristics:* Torriorthents, which are dominant in this association, are principally within the Lithic Ustic and Ustic subgroups. The Lithic Ustic Torriorthents comprise 30 percent of the total and consist of shallow, moderately light colored, gently sloping and moderately steep soils on sandstone mesas and breaks. They have a thin surface layer of light brownish-gray calcareous fine sandy loam or loamy sand. The subsurface layers consist of pale brown or light brownish-gray fine sandy loam that commonly contains small angular fragments of sandstone. This is underlain by sandstone bedrock at depths of about 4 to 20 inches.

The Ustic Torriorthents include both shallow and deep soils. The shallow soils, which comprise 25 percent of the area, occupy the gently to strongly sloping and rolling shale ridges and knolls that are scattered throughout this association. They have a thin surface layer of light yellowish-brown calcareous silt loam or silty clay loam. This is underlain by a light yellowish-brown silty clay loam that usually contains some partly weathered shale fragments. A few fine streaks and soft masses of lime and crystals of gypsum are also common in this soil layer immediately above the underlying shale which occurs at a depth of less than 20 inches. The deep Ustic Torriorthents occur throughout this association as small areas on alluvial fans and flood plains of intermittent drainages, and

constitute only five percent of the area. They are nearly level to gently sloping, usually medium to fine in texture, and occasionally saline or saline and sodic.

Rock Land, a miscellaneous land type, accounts for 25 percent of this association. It occurs dominantly on the steep escarpment and breaks areas. It is a complex of very shallow soils and outcrops of interbedded sandstone and shale and other types of sedimentary rocks. The sandstone outcrops commonly occur as vertical or nearly vertical exposures and ledges. A thin mantle of stony or gravelly soil material often occurs between the ledges and outcrops of bedrock.

Ustollic Camborthids and miscellaneous land types such as Badland, Alluvial Land, and Gullied Land comprise most of the remaining parts of this association. The Ustollic Camborthids are forming in materials weathered mainly from shale on gently sloping and undulating uplands and valley slopes. They are moderately fine and fine in texture and are typically underlain by shale at a depth ranging from about two to five feet. Badland includes those areas dominated by outcrops of shale in various stages of weathering. These areas are often barren or support only a sparse cover of vegetation which commonly occurs on the thin soils intermingled with the shale outcrops. Alluvial Land, which usually occurs in arroyo and drainage bottoms, consists of recent alluvial sediments that are highly variable in texture. The areas that are highly dissected by deep gullies and that commonly occur on flood plains and the adjacent alluvial fans are included in Gullied Land.

*Representative Soil Series:* Travessilla, Las Lucas, and Little.

#### **88. Camborthids-Torriorthents (691,000 acres)**

Included in this association are a number of widely separated areas in Sandoval, McKinley, and Valencia counties, which are characterized by a gently to strongly sloping and rolling topography. Although slope gradients are generally less than 10 percent, small areas are moderately steep and rolling with slopes up to 25 percent. The included escarpments and breaks areas, consisting of outcrops of shale and sandstone, are commonly steep to very steep.

The soils, which are light to moderately light-colored, calcareous, and highly erodible are forming dominantly in materials weathered from gray and olive-colored shale. The small area in the northwestern corner of McKinley County and the southwestern corner of San Juan County differs in that it consists mainly of reddish-brown soils.

These soils, which are dominantly deep, are developing in medium- and moderately fine-textured sediments derived from Jurassic and Triassic redbeds. The area occurring in western Valencia County also differs because of more sandstone and eolian sediments. The soils in this area, which are mainly moderately deep and shallow, are forming residually in materials weathered from sandstone and shale, or in alluvial and eolian sediments of similar origin.

The soils in this association in general support fair to good stands of native vegetation, and under good management moderate yields of forage are obtained. The overstory vegetation consists of pinyon pine and juniper trees that range in density from an occasional tree, or thin and scattered stands, to moderately dense stands. The moderately dense stands of pinyon pine and juniper trees are mainly in Valencia County. Vegetation on the moderately fine- and fine-textured soils consists mainly of alkali sacaton, western wheatgrass, and Indian ricegrass, with lesser amounts of galleta, ring muhly, three-awn, winterfat, chamiza, rabbitbrush, and broom snakeweed. Thin and scattered stands of scrubby pinyon pine and juniper also occur in this association. The soils with loam surface layers, in general, support the same kinds of vegetation except that some big sagebrush is present, particularly on the moderately deep and deep soils. The vegetation on these loam soils, however, is dominated by galleta, blue grama, western wheatgrass, Indian ricegrass, sand dropseed, mesa dropseed, winterfat, and chamiza.

*Soil Characteristics:* The Ustollic Camborthids, which include moderately deep and deep soils, typically occupy gently sloping and undulating uplands, alluvial fans, and valley side slopes. The deep soils, which constitute 25 percent of the area, are dominated by soils with a surface layer of pale brown calcareous loam or light clay loam. Their subsoil consists of a yellowish-brown to brown strongly calcareous silty clay loam with a few threads and small soft masses of lime. This grades through a light yellowish-brown clay loam or light silty clay loam to the underlying shale which commonly occurs at depths between 40 and 60 inches. Small areas of deep soils, particularly in the western parts of this association, are reddish-brown. They are also usually deeper than 60 inches to bedrock or shale. The moderately deep soils, which also constitute 25 percent of the area, are forming in fine-textured material weathered residually from the underlying shale. The depth to shale varies from 20 to 40 inches. These soils usually have a thin surface layer of light olive-

brown calcareous silty clay loam and a subsoil of light yellowish-brown clay or silty clay. Thin threads of lime and gypsum crystals are common in the layers immediately above the shale.

The Torriorthents, principally within the Ustic subgroup, constitute 30 percent of the total area. They consist mainly of shallow soils forming on gently to strongly sloping and rolling shale ridges and knolls. They have a thin surface layer of light yellowish-brown calcareous silt loam or silty clay loam. This grades through a light yellowish-brown silty clay loam that usually contains some partly weathered shale fragments, to the underlying shale which occurs at a depth of less than 20 inches. Gypsum crystals and threads and small soft masses of lime are common in the subsurface layers. In addition, there are small areas of Ustic Torriorthents on gently sloping fans and valley slopes that are moderately deep or deep and medium to moderately fine in texture. Lithic Ustic Torriorthents also comprise a small portion of the Torriorthents. These soils are moderately coarse to medium in texture and are typically underlain by sandstone within a depth of 20 inches.

In addition to the two major components of this association, soils of Ustic Torrifluent, Mollic Torriert, and Ustollic Haplargid subgroups also occur to a limited extent. The Ustic Torrifluents, which are in nearly level to gently sloping valley bottoms and on flood plains adjacent to intermittent drainages, are deep, stratified, and usually medium to fine in texture. The Mollic Torrierts consist of deep soils with dark-colored surface layers and fine-textured, very slowly permeable subsoils and substrata. They occupy nearly level to very gently sloping land forms in swales and valley bottoms. The Ustollic Haplargids usually occupy the less sloping parts of the ridge tops and side slopes. These soils, which are moderately deep and deep, are usually underlain within a depth of four feet by sandstone, interbedded shale and sandstone, or pinkish-white soil layers with a high content of lime. They typically have noncalcareous fine sandy loam or loam surface layers over subsoils that are medium to moderately fine in texture.

Shale and Sandstone Rock Land also form a moderately extensive component of this association. This consists of exposures of interbedded shale and sandstone on steep escarpments and breaks that serve as a source of sediments. A thin mantle and pockets of soil often occur between the exposures of bedrock. Alluvial Land, Gullied Land, and Alkali Alluvial Land, none of which are extensive, comprise most of the remaining parts of this association.

*Representative Soil Series:* Little, Las Lucas, and Moriarty (no series in the Ustic Torriorthent subgroup is known).

#### **89. Haplargids-Camborthids (206,600 acres)**

This association, located in Taos County, occurs mainly on gently sloping and undulating alluvial fans and valley-filling slopes that extend westward from the base of the Sangre de Cristo Mountains to the Rio Grande Gorge. Although it is dominated by gently sloping and undulating landscapes, small areas on the side slopes adjacent to arroyos and drainages are strongly sloping to moderately steep. The soils, which are dominantly moderately deep and deep, are forming in old alluvium of mixed origin.

Most of the soils in this association are in native range and provide fair to good yields of forage under good management. The more common shrub and grass species are big sagebrush, blue grama, galleta, western wheatgrass, Indian ricegrass, and three-awns. Thin and scattered stands of pinyon pine and juniper are encountered on the strongly sloping areas along the drainages and in the upper



**Fig. 35.** A profile of the Ustollic Haplargids, showing the loam surface layer, clay or heavy clay loam subsoil, and the pinkish-white or white lime layer. The soil layers with a high content of lime typically occur at a depth of 20 to 40 inches.

part of this unit where it joins the mountains. The removal of sagebrush and other shrubs and re-seeding to crested wheatgrass or other adapted grasses is an accepted practice. Most of the irrigated land in this association occurs in north-central part of the county, in the area locally known as Sunshine Valley. The irrigation water supply in this area is from wells.

*Soil Characteristics:* Ustollic Haplargids, which are dominant in this association, are represented by soils in the fine and fine-loamy textural families. Those with fine texture account for 40 percent of the total acreage and occupy the broad nearly level to gently sloping areas between drainageways. These soils, which are moderately deep over soil layers with a high lime content, have a thin surface layer of brown noncalcareous loam or light clay loam. The subsoil is a reddish-brown to brown clay or heavy clay loam that typically contains some segregated lime in the lower part in the form of fine threads and small soft masses. This is typically underlain at a depth of about 20 to 30 inches by a pinkish-white clay loam with a high content of lime. The depth to this high lime layer, however, ranges from 10 to 40 inches. It is common for these high lime layers to contain a few rounded igneous pebbles, and at depths of 48 to 60 inches gravel may comprise as much as 25 to 40 percent of the soil mass.

The members of the fine-loamy textural family constitute 25 percent of this unit. These soils commonly occur on long, gently sloping and undulating alluvial fans and valley-filling slopes near the base of mountain fronts. They are deep and have a thin surface layer of brown, noncalcareous loam or light clay loam. The subsoil is a yellowish-brown to brown clay loam or silty clay loam, about 15 to 25 inches thick. This is underlain by a light brown or light reddish-brown strongly calcareous, light clay loam substratum with lime occurring in the form of fine seams and small soft masses. A pinkish-white light clay loam or loam with a high lime content occasionally occurs below a depth of four to six feet. These layers also commonly contain 10 to 15 percent gravel.

The Ustollic Camborthids constitute about 20 percent of this association and are particularly extensive in the Sunshine Valley area. They typically have a thin surface layer of brown, noncalcareous loam or sandy loam. The subsoil is a reddish-brown to brown gravelly loam or gravelly sandy clay loam, about 10 inches thick. This grades through a gravelly sandy loam containing 35 to 50 percent gravel to thick strata of sand and gravel at a depth of about 24 to 30 inches.

Soils of minor extent in this association include those of the Cumulic Haplustoll and Ustic Torriorthent subgroups, as well as small areas of unclassified saline and alkali soils and miscellaneous land types. The Cumulic Haplustolls, which occur mainly in swales and depressional areas, are deep and dark-colored. They have grayish-brown loam surface layers over thick grayish-brown to dark brown clay loam subsoils and light clay loam, sandy clay loam, or loam substrata. The Ustic Torriorthents occur on the strongly sloping to moderately steep and rolling breaks bordering the drainageways. These soils have a surface layer of reddish-brown calcareous sandy clay loam that usually contains rounded igneous gravels. This is underlain to a depth of five feet or more by weakly stratified gravelly sandy loam, gravelly loam, or gravelly sandy clay loam. A few pinkish-white masses of segregated lime usually occur in these subsurface layers. The unclassified saline and sodic soils are of small extent, and are usually deep and medium to fine in texture. The important miscellaneous land types are Rock Land, Rough Broken Land, and Wet Alluvial Land. Rock Land includes steep to very steep breaks, fronts of lava flows, and isolated ridges dominated by outcrops of basalt and shallow, extremely stony soils. Much of the surface between the rock outcrops is covered with stones and boulders. The Rough Broken Land usually occurs in association with the Ustic Torriorthents on the breaks bordering drainageways. It includes the moderately steep and dissected areas consisting of a complex of shallow soils and exposures of unconsolidated to weakly consolidated alluvial deposits. Wet Alluvial Land consists of those areas that have watertables at or near the surface during much of the growing season. These soils are variable in texture and thickness, but are dark-colored and high in organic matter.

*Representative Soil Series:* Hondo, Cerrillos, Fernando, Tenorio, and Manzanao.

#### **90. Torriorthents-Haplargids-Calciorthisds (586,500 acres)**

This association, located in Taos and Rio Arriba counties in the north-central part of the state, includes areas in which the soils are forming dominantly in materials of volcanic or basic igneous origin on old lava flows. Characteristically, the soils are stony and cobbly. Although varying in depth or thickness, the soils are mainly shallow to moderately deep over basalt bedrock, stones, or soil layers with a content of lime. Outcrops of basalt rock occur on the escarpments and fronts of the lava flows. A gently to strongly sloping and



**Fig. 36.** Cobbly and stony soils are common in soil association No. 90. These soils typically occupy gently sloping and undulating landscapes.

undulating topography with slope gradients of less than 10 percent prevails throughout most of this general area. There are, however, a number of igneous cones and isolated low mountains or hills distributed throughout this general soil area. These, as well as the canyon walls, escarpments, and breaks adjacent to the Rio Grande, are steep and very steep. Small areas of moderately steep and rolling landscapes also occur on low hills and ridges, fronts of lava flows, and side slopes of draws or intermittent drainages.

This association supports a fair to good cover of shrubs and grasses, and is used principally for livestock grazing. Some of the more important grass species are blue grama, galleta, western wheatgrass, needle-and-thread, sideoats grama, and little bluestem. Thin, scattered stands of pinyon pine and juniper trees grow on some of the low hills and rough broken areas. A few ponderosa pine, Gambel oak, and associated mountain grasses are found at the higher elevations and on the isolated mountains.

*Soil Characteristics:* Lithic Ustic Torriorthents comprise 35 percent of the association and are typically shallow and stony. Small areas of basalt outcrops are common. These soils have a brown calcareous stony loam surface layer, about 3 to 18 inches thick. This grades through a pale brown to



light gray strongly calcareous stony loam or stony clay loam to the underlying fractured bedrock that occurs within a depth of 20 inches. The basalt fragments in the soil layer just above the bedrock are usually lime-coated. This soil layer also commonly contains some segregated lime in the form of small soft masses.

The Ustollic Haplargids comprise 30 percent of the association and commonly occur as relatively small areas intermingled with the Lithic Ustic Torriorthents on the more level landscapes. Some have few or no stones, but most of them contain many cobbles and stones throughout the entire soil profile. They have a brown calcareous cobbly loam surface layer over a thin brown to pale brown light clay loam subsoil. This is underlain by a pale brown gravelly or cobbly loam substratum to a depth of 60 inches or more. A very strong soft lime layer commonly occurs between 15 and 36 inches. Approximately one-third of the Ustollic Haplargids are non-stony. These soils are characterized by their light brown to brown loam or fine sandy loam surface layers and reddish-brown clay loam or clay subsoils. A zone of lime accumulation typically occurs at a depth of about 20 to 36 inches.

The Ustollic Calciorthents commonly occupy the areas free of cobble and stone in this association and consist of about 20 percent of the total area. They typically have a light brown or grayish-brown calcareous loam surface layer. The subsoil is similar except that it contains more lime and is slightly lighter-colored. This layer grades to a pinkish-white very limy loam that begins at a depth of about 10 to 20 inches. The lime content decreases slightly below a depth of 30 or 36 inches.

Rock Land, a miscellaneous land type, is a major inclusion. The steep to very steep canyon walls, escarpments, and breaks adjacent to the Rio Grande are representative of this land type. It also includes the fronts of lava flows, isolated ridges, and small basalt mountains and hills. It consists mainly of a complex of shallow stony soils and exposures or outcrops of basalt bedrock. Although the soils are dominantly shallow, they are quite variable in depth and other characteristics. Much of the soil surface between the outcrops of basalt is covered with stones and boulders. Other inclusions are small areas of Aridic Argiborolls and Typic Eutroboralfs. These soils, which occur at the high elevations, are cold and have dark-colored, cobbly and stony, loamy surface layers over cobbly and stony subsoils with moderately fine to fine textures.

*Representative Soil Series:* Dormilon, Stoneham, Panky, Fernando, Harvey, and Dean.

#### 91. Torriorthents-Rough Broken Land (660,000 acres)

This association consists of undulating to rolling and hilly uplands in northern Santa Fe and south-eastern Rio Arriba and Sandoval counties. It is dissected by numerous intermittent drainages and arroyos that drain towards the Rio Chama and Rio Grande, and it is an important source of sediments. Steep to very steep slopes are common on the breaks and severely dissected areas. A few nearly level to gently sloping valley bottoms and flood plains adjacent to intermittent streams are also included. The soils of this association are forming principally on unconsolidated or weakly consolidated sedimentary materials which are dominantly coarse to medium in texture and gravelly. A thin mantle of scattered gravel and cobble is common over much of the land surface.

These soils support sparse to moderate stands of native vegetation including blue grama, sideots grama, black grama, Indian ricegrass, ring muhly, sand dropseed, three-awns, snakeweed, rabbitbrush, chamiza, small soapweed, and various species of cacti. Scattered and thin stands of pinyon pine and juniper occur on about one-half of this general soil area.

*Soil Characteristics:* The Ustic Torriorthents, which comprise 45 percent of this association, occur mainly on ridge tops and on the more stable landscapes between the drainageways. They are on gently sloping to moderately steep and rolling landscapes that are intermingled with the steep and dissected rough broken lands. They are dominated by soils that have a surface layer of light reddish-brown calcareous sandy clay loam or sandy loam that usually contains a few rounded igneous gravels. The underlying material to depths of five feet or more consists of weakly stratified gravelly sandy loam, gravelly loam, or gravelly sandy clay loam. The coarse fragments, which make up about 15 to 35 percent of this material, are mainly gravel with small amounts of cobble. A few small pinkish-white masses of segregated lime also occur in these subsurface layers. Strata of sand and gravel are common below a depth of about 40 inches. Small areas of Ustic Torriorthents are nongravelly. These include soils that are dominated by sandy clay loam textures to a depth of five feet or more, as well as those with sandy loam or moderately coarse-textured profiles.

Rough Broken Land, a miscellaneous land type, also comprises 45 percent of this association. It consists of a complex of shallow soils and exposures of unconsolidated to weakly consolidated sedimentary deposits of the Santa Fe formation. This

sedimentary material, which is quite variable, is dominantly moderately coarse-textured and gravelly. A thin mantle of soil commonly occurs on the ridge tops between the outcrops of sedimentary materials. A surface layer of gravel also occurs on the upper part of some of the ridges. The areas occupied by this unit are generally steep and highly dissected. They are commonly broken by numerous v-shaped intermittent drainage channels and sharp ridges. Geologic erosion is active and vegetation is sparse. Where medium-textured or finer materials predominate, the ridges are sharper and the slopes steeper than in areas of gravel deposits.

Also in this association are small areas of Ustollic Haplargids and Torriorthentic Haplustolls. The Ustollic Haplargids, which typically occupy nearly level to gently sloping land forms, have fine sandy loam or loam surface layers and clay loam subsoils. A zone of moderate to high lime accumulation commonly occurs at moderate depths. The Torriorthentic Haplustolls are deep, moderately dark-colored, and moderately fine-textured. They usually occur on nearly level landscapes in swales and valley bottoms. In addition to soils and land types already discussed there are small areas of Riverwash, Alluvial Land, Gullied Land, and Rock Land.

*Representative Soil Series:* Pojoaque, El Rancho, and Panky.

## **92. Argiustolls-Haplargids-Rock Land (1,520,200 acres)**

This association is widely distributed, mainly in Valencia and Catron counties and to a lesser extent in Sandoval and Santa Fe counties. The soils, forming dominantly in materials of volcanic or basic igneous origin on old lava flows, are characteristically stony and cobbly. Eolian and alluvial sediments of mixed origin have also contributed minor amounts to the parent materials in which these soils are developing, particularly where there are small areas of deep soils. Although the depth of the soils varies, they are dominantly shallow to moderately deep. The land surface on the tops of these lava flows and basalt-capped mesas is dominantly gently to strongly sloping. Although the differences in local relief are not great, the sides or fronts of the lava flows and mesas are generally steep or very steep.

This association supports thin and scattered stands of pinyon pine, juniper, numerous native grasses, and some shrubs. There are, however, large areas in this unit dominated by grass vegetation including such species as sideoats grama, blue

grama, hairy grama, vine mesquite, Arizona cotton-top, creeping muhly, and three-awns.

*Soil Characteristics:* The Argiustolls, the most extensive in this association, are mainly within the Lithic and Aridic subgroups. The Lithic Argiustolls, which occupy 20 percent of the total area, are shallow and dark-colored, and occur on gently to strongly sloping and rolling mesa tops and fronts of lava flows. Surface stones and a few outcrops of basalt are common. They have a surface layer of dark grayish-brown, noncalcareous, stony loam or stony clay loam. Their subsoil is a brown cobbly clay. This is underlain by basalt bedrock at depths ranging from 10 to 20 inches. A zone of lime accumulation frequently occurs in the soil layers immediately above the bedrock. The Aridic Argiustolls, which comprise 25 percent of the total area, commonly occupy the nearly level to gently sloping grassland areas. They have a thin surface layer of grayish-brown to dark brown noncalcareous stony clay loam or clay loam. Their subsoil is a brown noncalcareous cobbly clay. This grades through a strongly calcareous gravelly or cobbly clay loam to the underlying bedrock at depths of 20 to 40 inches. This strongly calcareous or limy clay loam soil usually extends into fractures in the underlying rock.

Intermingled with these moderately deep soils are small areas of Aridic Argiustolls that are deep. These soils typically have dark-colored loam or light clay loam surface layers over thick blocky clay subsoils. There are also small areas of moderately deep Aridic Argiustolls on moderately steep and hilly landscapes. They differ in that they have cobbly fine sandy loam or cobbly loam surface layers over very cobbly sandy clay loam subsoils. A weakly to strongly cemented lime layer commonly occurs at a depth of 20 to about 40 inches. Cindery material frequently occurs below the lime layer.

The Haplargids, like the Argiustolls, are within two subgroups: Lithic Ustollic and Ustollic. The Lithic Ustollic Haplargids occupy 15 percent of the association. Shallow and usually stony, they are forming on gently to strongly sloping and undulating lava flows. Outcrops of basalt bedrock are also common. These soils have a thin surface layer of brown, noncalcareous stony loam or stony clay loam. Their subsoil is a brown to reddish-brown cobbly or stony clay. This is underlain by basalt bedrock, which is commonly fractured and is typically lime-coated in the upper part. The Ustollic Haplargids, which account for only five percent of the association, occur mainly on nearly level to gently sloping broad swales or

slightly depressed areas on mesa tops. They have a surface layer of brown noncalcareous loam or fine sandy loam over thick subsoils that are moderately fine to fine in texture. These are commonly underlain by medium- to moderately fine-textured soil layers containing a moderate to high content of lime at depths of about 20 to 40 inches.

Basalt Rock Land, a miscellaneous land type comprising about 15 percent of the area, is also an important component of this association. It occurs on the steep breaks or fronts of lava flows and isolated ridges dominated by outcrops of basalt and extremely stony soils. It consists of a complex of shallow rocky soils and exposures or outcrops of basalt bedrock. Much of the surface between the outcrops of basalt is covered with stones and boulders.

Also of importance in this association are Lithic Haplustolls, Ustollic Camborthids, and Torriorthentic Haploborolls. The Lithic Haplustolls are moderately dark-colored, medium-textured, shallow and stony soils forming on basalt. Basalt fragments increase with depth, and unweathered basalt is usually encountered within a depth of 8 to 20 inches. The Ustollic Camborthids, which are deep, occur dominantly on nearly level to strongly sloping broad swales and plains around basalt ridges and hills. These soils, medium to moderately fine in texture, are moderately dark-colored. The depth to the high lime zone, which is weakly to strongly cemented in the upper part, ranges from about 40 to 60 inches. The Torriorthentic Haploborolls, which are forming on strongly sloping to moderately steep and rolling cinder cones, are underlain at a depth ranging from about 10 to 20 inches by cinders or volcanic ash. They usually have calcareous gravelly and very gravelly loam or gravelly sandy loam surface layers. Also in this association are small areas of Rough Broken Land and Alluvial Land. Alluvial Land consists of the immediate flood plains of intermittent drainages, arroyo bottoms, and intermittent lakes.

*Representative Soil Series:* Cabezon, Thunderbird, Torreon, Majada, Montoso, Prieta, Silver, Apache, Calabasas, and Bandera.

### **93. Haplargids-Torriorthents-Calciorthids (244,500 acres)**

This association consists mainly of gently to strongly sloping and undulating alluvial fans and valley plains in the west-central part of Santa Fe County and lesser amounts in the adjacent counties of Sandoval and Rio Arriba. Interspersed through this unit are a few nearly level to gently sloping valley bottoms which commonly contain a few

deep gullies or arroyos. The areas bordering the intermittent drainages are typically moderately steep and rolling. The delineation of this association in the south-central part of Rio Arriba County also contains small areas of escarpments and rough broken lands. The soils, which are developing in old alluvium of mixed origin, generally have light-colored and moderately coarse- to medium-textured surface layers. Erosion hazard is slight except for the dissected areas along the draineways, which are susceptible to water erosion.

This association supports moderately good stands of native vegetation and under good management produces moderate yields of forage. The more common kinds of native vegetation are blue grama, galleta, western wheatgrass, sand dropseed, Indian ricegrass, ring muhly, three-awns, and broom snake-weed. Thin, scattered stands of pinyon pine and juniper trees also grow on the moderately steep, and rolling rough broken lands.

*Soil Characteristics:* Ustollic Haplargids, which comprise 45 percent of the association, typically occupy the broad nearly level to gently sloping upland plains between the draineways. They consist dominantly of soils with thin light brown to brown, noncalcareous, loam or fine sandy loam surface layers and reddish-brown clay loam or clay subsoils. This is underlain by pinkish-white medium-textured soil layers with a high content of lime at a depth usually of 20 to 40 inches but with extremes of about 10 to more than 40 inches.

Small areas of these soils in Rio Arriba County are underlain by sandstone bedrock at moderate depths, but have similar surface layers and subsoils. In addition, small acreages of Ustollic Haplargids lack the strong zone of lime accumulation but have lime in the form of small soft masses and threads in the lower part of the subsoil and substratum.

The Ustic Torriorthents occupy the moderately steep and rolling breaks bordering the draineways and account for 25 percent of the total area. These soils have a surface layer of light reddish-brown calcareous sandy clay loam that usually contains a few rounded igneous gravels. This is underlain to a depth of five feet or more by weakly stratified gravelly sandy loam, gravelly loam, or gravelly sandy clay loam. The content of coarse fragments, which ranges from about 15 to 35 percent, is mainly gravel with small amounts of cobble. A few small pinkish-white masses of segregated lime also usually occur in these subsurface layers. Strata of sand and gravel are common below a depth of about 40 inches.

Ustollic Calciorthids occur on gently to strongly sloping alluvial fans and side slopes of the drainage-

ways and constitute 20 percent of the association. They typically have a light-brown or grayish-brown calcareous loam surface layer. The subsoil is similar, but it contains more lime and is slightly lighter-colored. This layer grades to a pinkish-white very limy loam that begins at a depth of about 16 to 20 inches. The lime content usually decreases slightly below a depth of 30 to 36 inches.

Ustollic Camborthids and Ustic Torrifluents also comprise small acreages in this general area. The Ustollic Camborthids are moderately dark-colored, deep, and moderately fine-textured. The Ustic Torrifluents, commonly occur on nearly level to gently sloping flood plains adjacent to intermittent drainages. They are typically deep, stratified, and moderately coarse to moderately fine in texture. Miscellaneous land types such as Rough Broken Land, Rock Land, and Alluvial Land comprise most of the remaining parts of this association.

*Representative Soil Series:* Panky, Silver, Cerrillos, Fernando, Pojoaque, Harvey, and Calabasas.

#### **94. Torriorthents-Argiustolls-Rock Land (172,700 acres)**

This association is located mainly in the south-central and southeastern parts of Santa Fe and Sandoval counties, respectively. The topography ranges from nearly level to gently sloping and undulating on the alluvial fans and valley floors to steep and very steep on the mountain footholds. The unit includes moderately extensive areas of gently to strongly sloping and rolling uplands, as well as nearly level to gently sloping mesa tops that are separated by steep canyon walls and escarpments. The soils, like the topography, are highly variable. They range in depth from very shallow to deep. Some of the soils are developing residually in materials weathered from sandstone, shale, and other sedimentary rocks; others are forming in alluvium of similar origin, and in alluvium of a more mixed origin, including igneous rocks. The soils which are forming dominantly in materials of shale origin are susceptible to water erosion, and, as a result, gullies are common in the valleys and depression areas where runoff is concentrated.

This association supports a fair to good cover of native grass and shrubs, including scattered stands of pinyon pine and juniper trees. Blue grama, side-oats grama, sand dropseed, galleta, western wheatgrass, Indian ricegrass, ring muhly, alkali sacaton, vine mesquite, and three-awns are some of the more important grasses. Big sagebrush, snakeweed, chamiza, rabbitbrush, and various species of cactus also occur to a limited extent.

*Soil Characteristics:* The Torriorthents comprise 35 percent of this association and occur in about equal proportions in the Ustic and Lithic Ustic subgroups. The Ustic Torriorthents consist of deep soils on nearly level to gently sloping alluvial fans and some valley bottoms. These soils usually have reddish-brown or brown, calcareous loam or clay loam surface horizons over medium- to fine-textured subsurface layers to a depth of five feet or more. They are susceptible to erosion, and gullies are common, particularly in the immediate valley bottoms. The Lithic Ustic Torriorthents, which are shallow, occur on gently sloping to moderately steep upland ridges and on the outer fringes of the mesa tops. They have a thin surface layer of light brown to light reddish-brown, calcareous fine sandy loam or loam. This grades through soils of similar color and texture to the underlying sandstone bedrock at depths ranging from about 6 to 20 inches. Sandstone outcrops occasionally, and angular fragments of sandstone are common in the soil layers above the bedrock.

The Argiustolls occupy 25 percent of the association, and like the Torriorthents, are also represented by two subgroups. The Aridic Argiustolls are the most extensive and are on the lower parts of the piedmont slopes which typically have gradients of less than five percent. These soils have a moderately thick surface layer of reddish-brown noncalcareous loam. The subsoil is a brown heavy clay loam about 16 inches thick. This is underlain by brown clay loam or sandy clay loam that contains threads and small soft masses of calcium carbonate. Sandstone bedrock may occur occasionally below a depth of 40 inches. The Lithic Argiustolls, which comprise approximately one-fourth of the Argiustolls, occur on nearly level to gently sloping upland plains or mesa tops. These soils typically have thin noncalcareous fine sandy loam surface layers and sandy clay loam or clay subsoils with sandstone bedrock occurring within a depth of about 20 inches.

Rock Land, a miscellaneous land type comprising 15 percent of this association, occurs dominantly on the steep to very steep mesa sides and escarpments scattered throughout this association, as well as in the steep mountain foothill areas. A thin mantle of highly variable soil material commonly occurs between the outcrops of sedimentary and igneous bedrock. It is generally cobbly and stony, and much of the surface between the outcrops is covered with coarse rock fragments of various sizes. A few small areas or pockets of deep soils are included.

Soils of the Aridic Calcicustoll, Ustollic Camborthid, Ustollic Haplargid, and Fluventic Haplustoll

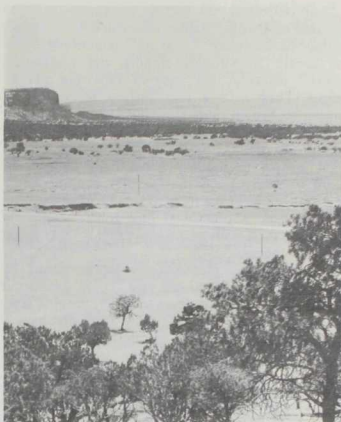
subgroups comprise most of the remaining parts of the unit. The Aridic Calcicustolls typically occur on the moderately steep piedmont slopes along the mountain fronts. They have a thin surface layer of reddish-brown noncalcareous stony clay loam. This grades through a calcareous very gravelly clay loam to a weakly cemented lime zone at depths of 15 to 30 inches. The lime layer contains about 70 to 90 percent gravel, cobbles, and stones. The Ustollic Calciorthisds are mainly on gently to strongly sloping and undulating uplands. These soils typically have pale brown to brown calcareous loam or clay loam surface layers over yellowish-brown strongly calcareous clay loam and silty clay subsoils that commonly contain a few threads and small soft masses of lime. Shale usually underlies these soils at depths between 40 and 60 inches. The Ustollic Haplargids, which have loam or fine sandy loam surface layers and moderately fine to fine-textured subsoils, are underlain by pinkish-white soil layers with a high content of lime at depths ranging from 10 to 40 inches. The Fluventic Haplustolls occur mainly in swales and on flood plains that are nearly level to gently sloping. These dark soils are deep and dominantly medium to moderately fine in texture. Also in this association are small areas of Badland, Alluvial Land, and Gullied Land.

*Representative Soil Series:* Galisteo, Rednun, Bernal, Travessilla, Pena, Las Lucas, Panky, and Prewitt.

#### **95. Torrifluvents-Haplargids-Haplustolls (726,200 acres)**

This association, which is widely distributed, occurs mainly in Valencia County, with lesser amounts in Catron and McKinley counties. It consists principally of nearly level to gently sloping flood plains along intermittent drainages and adjacent alluvial plains and fans that extend from adjoining uplands to the flood plains. The alluvial plains are typically gently to strongly sloping and undulating. A few small areas of steep breaks and rolling to hilly uplands on the outer fringes of this unit are also included. The soils, which are forming dominantly in alluvial sediments of mixed origin, are generally deep, well drained, and moderately coarse to moderately fine in texture. Although they are usually free of toxic accumulations of soluble salts, they include small areas of saline and sodic soils. Most of these are fine-textured or have inadequate drainage.

Except for small tracts of irrigated land such as occur in the vicinity of Bluewater and Zuni, this association is used principally for livestock grazing.



**Fig. 37. The deep nearly level to gently sloping soils of association No. 95 typically occur in meandering valley areas as shown in the center of picture.**

Forage production varies considerably, but the soils are moderately productive and, in general, support moderately good stands of native vegetation. Small areas of bottomland receiving runoff from higher lying lands are highly productive. The more common grasses are blue grama, galleta, alkali sacaton, western wheatgrass, Indian ricegrass, sand dropseed, ring muhly, sideoats grama, and three-awns. Shrubs include chamiza, winterfat, rabbitbrush, and various species of cacti.

*Soil Characteristics:* The Ustic Torrifluvents, which comprise approximately 35 percent of this association, commonly occur on the nearly level to gently sloping flood plains adjacent to intermittent drainages. These deep and well drained soils usually have a surface layer of calcareous loam, clay loam, or silty clay loam. This is underlain to a depth of five feet or more by stratified soil layers that range in texture from moderately coarse to fine but are dominantly loams, fine sandy loam, and clay loams. Soils with subsurface layers dominated by stratified heavy clay loams, silty clay loams, and clays are moderately extensive. Small areas of the soils with fine-textured subsurface layers are saline and sodic.

Approximately 20 percent of this association consists of Ustollic Haplargids, which have distinct pedogenic horizons. These soils commonly occur on gently to strongly sloping and undulating alluvial plains at the base of hills and upland ridges. They have a thin surface layer of light brown to brown, noncalcareous, fine sandy loam over a subsoil of light brown or reddish-brown sandy clay loam or light clay loam. Below this is a light brown to reddish-yellow light sandy clay loam or sandy loam that usually contains some segregated lime in the form of small soft masses and thin threads. A prominent lime zone occasionally occurs in these soils at a depth ranging from about 30 to 50 inches.

The Fluventic Haplustolls comprise about 15 percent of this general soil area. These soils occur dominantly on nearly level to gently sloping landscapes in valley bottoms. They typically have a moderately thick, brown, calcareous loamy surface layer over a blocky clay loam subsoil. This is underlain to a depth of five feet or more by stratified clay loams, sandy clay loams, and heavy loams with occasional thin strata of clay and fine sandy loam. These soils are also occasionally underlain by fine sand or sandy loam below about 30 inches.

Other soils of importance in this unit include those of the Mollic Torrtorr, Typic Torrtorr, and Ustollic Camborthid subgroups. The Mollic Torrtorrs are forming in fine-textured calcareous alluvium. They typically have a surface layer of reddish-brown, calcareous clay or silty clay loam. The underlying soil horizons to a depth of five feet or more usually consists of a dense clay or silty clay that often contains some salt crystals. Vertical cracks form as the clay dries and shrinks. Some of these soils are saline- and alkali-affected. The Typic Torrtorrs resemble the Mollic Torrtorrs, but the surface layers contain less organic matter and are much lighter-colored. The Ustollic Camborthids are of limited extent and occur on gently sloping and undulating uplands. These soils, which are underlain by shale at depths of about 20 to 40 inches, usually have silty clay loam surface layers and silty clay or clay subsoils.

Also in this association are small areas of unclassified shallow soils over sandstone and shale, and miscellaneous land types. The land types, none of which is extensive, include Gullied Land, Alluvial Land, and Rock Land. Alluvial Land includes the highly variable and stratified soil materials in the immediate flood plain of arroyos and drainage channels. The small areas severely dissected by deep gullies are included in Gullied Land. Rock Land includes those areas dominated by outcrops of

sandstone and shale. It occurs as knolls, low hills, or ridges, usually on the outer fringes of the association.

*Representative Soil Series:* Lohmiller, San Mateo, Sanson, Barnum, Penistaja, Clovis, Prewitt, Moriarty, and Puerco.

#### **96. Haplargids-Torriorrhents-Rock Land (1,009,700 acres)**

This association, which is one of the larger units in the Western Plateau Region, occurs mainly in Valencia and Catron counties and to a small extent in western McKinley County. The topography is varied, ranging from nearly level to strongly sloping and gently rolling in the valley areas and on the mesa and ridge tops to steep and very steep on the mesa sides and on the intermingled hilly and rough broken lands. In McKinley County, this association is generally not as rough and broken as in Catron and Valencia, but it is dominated by relatively broad, gently sloping mesas and plateaus interspersed with a few narrow valley areas. The soils in this association, like the topography, are quite variable but usually have fine sandy loam or loam surface layers and subsoils that are moderately coarse to fine in texture. The shallow and moderately deep soils on the mesa tops are mainly forming residually in materials weathered from sandstone. The deep soils are developing dominantly in alluvial and eolian sediments of mixed origin.

The soils in general support moderate to good stands of native vegetation, and under good management, produce moderate yields of forage. The overstory vegetation consists of pinyon pine and juniper trees that range in density from an occasional tree to moderately dense stands. The density of the tree cover typically increases on the outer fringes of the mesas and on the steep breaks and outcrop areas. The more common grasses are blue grama, needlegrass, galleta, hairy grama, sideoats grama, Indian ricegrass, junegrass, muhly spp., western wheatgrass, alkali sacaton, and three-awns. It also supports a number of shrubs including rabbitbrush, snakeweed, and some big sagebrush, mountain-mohogany, and oak brush.

*Soil Characteristics:* The Ustollic Haplargids, which comprise approximately 35 percent of this association, consist of moderately deep and deep soils with distinct pedogenic horizons. The soils are found dominantly on gently sloping and undulating uplands and to a limited extent on slopes at the base of upland ridges. These soils typically have thin, brown or reddish-brown, non-calcareous loam and fine sandy loam surface

layers over thick moderately fine- to fine-textured subsoils that are usually noncalcareous in the upper part. The moderately deep soils, which commonly occur on the mesa and ridge tops, are generally about 30 inches deep over sandstone, but range from about 20 to 40 inches in depth. The deep Ustollic Haplargids have substrata that range in texture from moderately coarse to moderately fine and that usually contain some visible lime in the form of fine threads and small soft masses. On the valley slopes, the substratum normally continues to a depth of 60 inches or more. However, on the mesa tops sandstone interbedded with thin strata of shale is often encountered within a depth of 60 inches.

Approximately 20 percent of this association consists of Torriorthents, principally in the Lithic Ustic subgroup. These soils are underlain by sandstone at shallow depths. They occur on gently sloping to moderately steep and rolling upland areas and mesa tops. They have a thin surface layer of light brownish-gray or light brown sandy loam or stony sandy loam. This grades through soil of similar color and texture to the underlying sandstone bedrock at depths ranging from about 4 to 20 inches. Small angular fragments of sandstone are common in the soil layers immediately above the bedrock. Ustic Torriorthents, which comprise about one-fourth of the Torriorthents are nearly equally divided between shallow and deep soils. The shallow soils are light-colored, calcareous, silt loams and silty clay loams underlain by shale at a depth of 6 to 20 inches. The deep Ustic Torriorthents, which usually occur on the gently to strongly sloping alluvial fans, are weakly stratified and moderately coarse to moderately fine in texture.

Rock Land, also an important component, comprises about 15 percent of this association. It occurs dominantly on the steep escarpments, breaks, and hilly areas. It is a complex of very shallow soils and outcrops of sandstone and some basalt, conglomerate, and shale. The sandstone outcrops commonly occur as vertical or nearly vertical exposures and ledges. A thin mantle of stony or gravelly soil material usually occurs between the ledges and outcrops of bedrock. Although shallow soils are the most extensive, small areas of moderately deep and deep soils occur. The soils are commonly stony or gravelly and moderately coarse- to medium-textured. Numerous stones and boulders are common over much of the land surface.

Rough Broken Land, Badland, and soils of Lithic Argiustoll, Ustic Torrifluvent, and Ustollic Camborthid subgroups comprise most of the remaining parts of this general soil area. Rough

Broken Land occurs where the land surface is usually covered by thick deposits of old alluvial sediments. These lands, which are usually steep to very steep and severely dissected, consist of a complex of shallow soils and exposures of unconsolidated to weakly cemented sedimentary deposits. Badland consists of barren or nearly barren outcrops of shale with small amounts of other sedimentary rocks. The topography ranges from low hills to steep breaks. The Lithic Argiustolls, which are forming in materials weathered from interbedded sandstone and shale, occur on gently to strongly sloping mesas and upland ridges. They have a thin surface layer of brown, noncalcareous, gravelly fine sandy loam over a reddish-brown heavy clay loam or clay subsoil that usually contains a few sandstone fragments. Sandstone bedrock typically occurs at a depth of 10 to 20 inches. The Ustic Torrifluvents commonly occur on the nearly level to gently sloping flood plains adjacent to intermittent drainages. They are deep, calcareous, and usually medium- to fine-textured. The Ustollic Camborthids, which are also of some importance in this association, are forming in fine-textured soil materials weathered residually from the underlying shale. These soils, which occur on gently to strongly sloping and undulating upland ridges, have a thin surface layer of light olive brown, calcareous, silty clay loam over a light yellowish-brown clay or silty clay subsoil. The depth to shale varies from 20 to 40 inches.

*Representative Soil Series:* Hagerman, Ponil, Silver, Penistaja, Travessilla, and Encierro.

#### **97. Rock Land-Torriorthents-Argiustolls (914,000 acres)**

This association occurs mainly in northeastern Catron County, northwestern Socorro County, and south-central Valencia County. It is dominated by rough and broken topography, and consists of gently to strongly sloping mesa tops and steep to very steep mesa side slopes and escarpments. Interspersed with these upland ridges and mesas are also gently to strongly sloping alluvial fans and narrow valley bottoms. The more extensive soils in this association are developing residually in materials weathered from sedimentary rocks dominated by sandstone or interbedded sandstone and shale. These soils are shallow and often gravelly and stony. Rock outcrops are common along the rims of the mesas. Outcrops of sandstone bedrock and some shale are common on the steep canyon walls and escarpments. Thin deposits of gravelly alluvium also occur occasionally on the breaks adjacent to some of the larger drainages.

The soils of this association are used principally for grazing by livestock and wildlife. Many of the outcrops of sandstone and shale are barren or nearly barren, but this association in general supports a fair to good cover of native vegetation consisting of a relatively wide variety of grasses and shrubs. Blue grama, galleta, sideoats grama, Indian ricegrass, western wheatgrass, little bluestem, poverty, three-awns, and sand dropseed are the principal grasses. The more common shrubs and woody species include pinyon pine, juniper, big sagebrush, bitterbrush, serviceberry, mountain hogany, snakeweed, and rabbitbrush. The use of land in this unit for recreational purposes is also of considerable importance as it provides a good habitat for many species of wildlife.

*Soil Characteristics:* Rock Land, which comprises approximately 35 percent of this association, consists of a complex of shallow soils and outcrops of sandstone and other types of sedimentary rocks. It characteristically occupies the steep and very steep mesa sideslopes, escarpments, and breaks in which ledges and stairstep topography are common. The outcrops of bedrock commonly occur as vertical or nearly vertical exposures or ledges. A thin mantle of stony soil generally occurs between the ledges or outcrops of bedrock. Although shallow soils and rock outcrops are dominant, small isolated pockets of moderately deep to deep soils occur on the escarpments where benches or areas with a lesser slope gradient have formed.

Approximately 25 percent of the general soil area consists of Lithic Ustic Torriorthents, which are underlain dominantly by sandstone at shallow depths. These occur on gently sloping to moderately steep and rolling upland areas and mesa tops. They have a thin surface layer of light brownish-gray or light brown, slightly calcareous fine sandy loam or stony fine sandy loam. This grades through soil of similar color and texture to the underlying sandstone bedrock at depths typically 8 to 12 inches but with extremes of 4 to 20 inches. A few small angular fragments of sandstone are common at the surface and typically become more numerous with depth.

Lithic Argiustolls comprise about 15 percent of this association. They commonly occupy the strongly sloping to moderately steep and rolling ridge crests and side slopes. The surface layer consists of about six inches of brown gravelly fine sandy loam or brown stony gravelly loam over a thin reddish-brown heavy clay or clay subsoil. This grades through a gravelly or cobbly clay loam to the underlying interbedded sandstone and shale within a depth of 20 inches. The coarse

fragments comprise about 10 to 15 percent of the subsoil. These soils are weakly calcareous to noncalcareous. A small percentage of these soils are developing in materials weathered mainly from sandstone with little or no shale. They typically have sandy clay loam subsoils.

Other soils of importance in this association include those of the Ustollic Haplargid, Ustic Torrifluvent, Mollic Torriert, and Lithic Haplustoll subgroups. The Ustollic Haplargids typically occur on nearly level to gently sloping uplands. These soils, which are moderately deep and deep, usually have noncalcareous loam or fine sandy loam surfaces over blocky moderately fine- and fine-textured subsoils which are underlain by sandstone bedrock. The Ustic Torrifluvents are typically on nearly level to gently sloping flood plains and valley bottoms. They are deep, calcareous, stratified, and moderately coarse to medium in texture. The Mollic Torrierts are characterized by their moderately thick and dark-colored silty clay loam or clay loam surface layers over dense silty clay or clay subsoils that often contain some salt crystals. The Lithic Haplustolls, which are forming in materials weathered residually from limestone, occur on gently sloping and rolling to steep and hilly uplands. They have a brown to grayish-brown calcareous stony loam or loam surface layer. This grades through a pale brown or brown strongly calcareous stony or cobbly loam to the underlying limestone bedrock at a depth of 8 to 20 inches.

In addition to these named soils, there are also small areas of shallow soils over shale and basalt and Alluvial Land, which occurs in the immediate flood plain and bottoms of arroyos and intermittent drainages.

*Representative Soil Series:* Travessilla, Encierro, Bernal, Silver, Hagerman, Penistaja, Lohmiller, Moriarty, and LaPorte.

### **98. Haplargids (382,700 acres)**

This association, which occurs on gently sloping to rolling and hilly landscapes, is principally in the north-central part of Catron County. Slope gradients generally range between one and 20 percent, but small areas with steep and very steep slopes are adjacent to drainage ways and on the fronts and sides of mesas and areas dominated by outcrops. Elevations generally range between about 6400 and 7900 feet. The soils, which usually have fine sandy loam or loam surface layers and loamy subsoils, are forming dominantly in old alluvial sediments of mixed origin. Lime zones or soil layers with a high content of lime are common in these soils at depths of 15 to more than 40 inches.





Fig. 38. Gently sloping and rolling landscapes are dominant in the Haplargids association.

The soils are moderately productive and support moderate to good stands of native vegetation. The overstory vegetation consists of scattered to moderately dense stands of pinyon pine and juniper trees. Grasses are almost exclusively blue grama with some sideoats grama, hairy grama, western wheatgrass, sand dropseed, and ring muhly. Some of the more desirable browse species are chamiza, winterfat, Apache plume, and wild buckwheat. Other common shrubs are rabbitbrush, yucca, and various species of cactus.

*Soil Characteristics:* This association is dominated by Ustollic Haplargids that have noncalcareous surface layers, well developed subsoils, and distinct layers of lime accumulation. They vary primarily in texture and permeability of subsoil layers, depth to soil layers high in lime, and in content of gravel. Ustollic Haplargids that are shallow over a zone high in lime comprise about 25 percent of this general soil area. These soils occur dominantly on the nearly level to gently sloping and rolling ridge tops and side slopes. They typically have a thin surface layer of light brown to brown very fine sandy loam to loam that is neutral to mildly alkaline in reaction. The subsoil to about 15 inches is reddish-brown clay loam to light clay that is noncalcareous, and mildly alkaline in reaction in the upper part and calcareous and moderately alkaline in reaction in the lower part. The underlying substratum is pinkish-white to pale brown, strongly calcareous sandy clay loam to clay loam that is high in lime. The amount of calcium carbonate decreases with depth below about 30 inches.

Approximately 20 percent of the Ustollic Haplargids in this unit are moderately deep over a

zone high in lime. Their subsoils are thicker than those just described and range from sandy clay loam to clay loam in texture. Soil layers with a high content of lime commonly occur at a depth of about 30 inches but the depth may range from 20 to 40 inches.

The deep Ustollic Haplargids, which comprise about 25 percent of this association, commonly occupy the toe slopes and sloping areas between the rolling uplands. These soils have a thin brown to dark brown noncalcareous fine sandy loam surface layer over noncalcareous light brown to reddish brown mildly alkaline sandy clay loam or light clay loam subsoil to about 28 inches. The substratum, to 60 inches or more, becomes calcareous and is a sandy loam or sandy clay loam. Although a prominent lime zone occasionally occurs below a depth of 40 inches, the accumulated lime usually occurs in the form of small soft masses and fine threads.

Other Ustollic Haplargids of importance in this association include those forming in gravelly alluvium on gently to strongly sloping and rolling uplands. These soils are characterized by their gravelly loam surface layers and gravelly clay loam or gravelly clay subsoils. A very moderate to strong lime zone is commonly encountered at a depth of 20 to 36 inches. They comprise about 10 percent of the association. Other important inclusions are the shallow soils of the Lithic Ustic Torriorthent and Lithic Argiustoll subgroups. These soils are forming in materials weathered residually from the underlying sandstone, or sandstone interbedded with shale. In addition, shallow to moderately deep fine-textured soils over shale and shallow stony soils over basalt also comprise a small acreage in this general soil area. Small areas of deep alluvial soils, which are generally calcareous and medium to fine in texture, commonly occur on the flood plains adjacent to the intermittent drainageways. Miscellaneous land types, consisting of Rock Land and Rough Broken Land comprise the remaining 10 percent of this association.

*Representative Soil Series:* Cerrillos, Clovis, Penistaja, Poley, Lonti, Encierro, and Travessilla.

### 99. Torrets-Torriorthents (100,600 acres)

This association occurs on the San Augustin Plains in the east-central part of Catron County. Included are nearly level basin floors and the broad first terraces or plains surrounding the old lake basins. The unit receives surface drainage from surrounding areas, and flooding is common during periods of high runoff. Although dominated by nearly level to gently sloping landscapes with

gradients averaging less than one percent, slightly elevated ridges and low hummocks occur principally on the outer margins of the association. The surface of the basin floor is often interrupted by mounds and depressions that are two to five feet across and one to two feet deep. This difference in relief is formed in these clayey soils because of expansion and contraction with changes in moisture. Large cracks are common during dry periods. The soils are developing in fine-textured alluvial sediments from mixed sources. They are typically deep, fine-textured, calcareous, and saline and sodic.

The soils are moderately productive, in general supporting fair to good stands of native vegetation, dominantly salt-tolerant species. Small areas, 100 to 500 feet across and scattered throughout this unit, and a relatively large basin floor area in the western part, however, are either barren or support little vegetation. The more common grasses and shrubs are alkali sacaton, salt grass, western wheatgrass, chamiza, greasewood, shadscale, and suaeda.

*Soil Characteristics:* This association is dominated by fine-textured saline and sodic soils. Typical Torrierts, which comprise about 45 percent of this association, typically have a thin surface layer of light brownish-gray calcareous silty clay, clay, or heavy silty clay loam. The underlying material to a depth of five feet or more usually consists of clay or silty clay that is strongly alkaline in reaction and typically contains moderate to high amounts of exchangeable sodium. Vertical cracks form as the clay dries and shrinks.

The Ustic Torriorthents, which comprise approximately 30 percent of the area, also consist of deep, fine-textured and somewhat poorly drained soils that are located on the nearly level to gently sloping areas on the outer margins of this association. They

have a grayish-brown calcareous surface layer 6 to 10 inches thick. This is underlain to a depth of five feet or more by a light brownish-gray to light olive brown silty clay, clay, or heavy clay loam. These soils are moderately to strongly alkaline in reaction, and typically contain moderate to high amounts of exchangeable sodium.

Miscellaneous land types and soils of the Ustic Torrifluvent, Ustic Torripsamment, and Ustollic Calciorthid subgroups comprise most of the remaining 25 percent of this association. The land types include Alluvial Land and Alkali Alluvial Land which are dominant in the playas or small intermittent lakes. The Ustic Torrifluvents, like the Ustic Torriorthents, are deep and fine-textured, but differ in being highly stratified. The Ustic Torripsamments, which usually occur on the outer margins of this general soil area, typically occupy the hummocky and undulating areas. These soils consist of deep sands and loamy sands. Also associated with these soils are small areas of deep, light brownish-gray to grayish-brown, calcareous, sandy loams. The Ustollic Calciorthids, which occur as long narrow ridges, are deep calcareous gravelly sandy loams and very gravelly sandy loams.

*Representative Soil Series:* Puerco, Vermejo, and Lohmiller.

#### 100. Haplargids-Torriorthents (403,600 acres)

This association includes five widely separated areas in Catron and Socorro counties. It is dominated by gently to strongly sloping and undulating soils on alluvial fans and valley filling slopes that are located generally at the base of mountain ranges. Slope gradients are usually less than five percent but they may range up to 15 percent near the base of mountains. Small areas of strongly sloping to moderately steep soils also occur adjacent to drainageways. The soils, which are characteristically gravelly, are developing in old valley-fill sediments of mixed origin.

This general soil area supports fair to moderate stands of grasses and shrubs. The more common grasses are blue grama, black grama, galleta, ring muhly, sideoats grama, dropseed spp, and bush muhly. Shrub species include yucca, snakeweed, and traces of little-leaf sumac, Apache plume, oakbrush, pinyon pine, and juniper trees. The latter five species usually grow on the upper slopes near the mountain front and along drainageways or arroyos.

*Soil Characteristics:* The Ustollic Haplargids, which are found on gently to strongly sloping piedmont slopes at the base of mountain ranges,



Fig. 39. Deep, fine-textured, and saline-sodic soils of the Torrierts-Torriorthents association No. 99.

comprise about 75 percent of the association. They usually have a thin surface layer of brown to reddish-brown, noncalcareous, gravelly sandy loam or gravelly loam. Their subsoil to a depth of about 18 to 20 inches consists of a reddish-brown to brown gravelly sandy clay loam or gravelly light clay loam. This is underlain by a substratum that generally ranges in texture from a gravelly sandy loam to gravelly clay loam or very gravelly clay loam. It is strongly calcareous and typically contains many pinkish-white mottles and soft masses of lime. Thin strata of gravelly sand or very gravelly sand may occur below a depth of 24 inches. Slightly less than one-half of these Ustollic Haplargids differ from those just described in having a higher content of coarse fragments and lime. In these soils, the subsoil consists of a reddish-brown to brown very gravelly clay loam or very gravelly sandy clay loam about 20 inches thick. This is underlain by a pinkish-gray very gravelly sandy loam with a high content of lime that occurs dominantly as large soft masses and thick coatings on the coarse fragments. A few discontinuous lenses of cemented caliche are also commonly present in these high lime layers. This grades to a brown calcareous gravelly sandy loam below a depth of about 50 inches. Small areas of Ustollic Haplargids in this unit are nongravelly. These soils usually have a thin surface layer of noncalcareous loam over a thick subsoil of reddish-brown loam. A pinkish-white very limy loam commonly occurs at depths of about 40 to 50 inches.

The Ustic Torriorthents comprise about 15 percent of the association. Those on gently sloping landscapes in valley bottoms and on flood plains contiguous to intermittent drainages typically have surface layers of light brownish-gray gravelly sandy loam. This is underlain to a depth of 60 inches or more by stratified gravelly and sandy soil layers that average a gravelly loamy sand in texture. Those on the strongly sloping to moderately steep and rolling side slopes of drainages have brown gravelly loam surface layers over light brown very gravelly loam subsurface layers.

A small acreage of miscellaneous land types, such as Rock Land, Riverwash, and Alluvial Land, comprise the remaining parts of this association. Rock Land, which commonly occurs in the upper part of this unit near the mountain fronts and as isolated hills, consists of a complex of shallow soils and rock outcrops. A large amount of loose rock and stones usually occurs on the surface of the soils between the rock outcrops. Riverwash and Alluvial Land, which usually occur in arroyos and drainage bottoms, consist of recent alluvium that is highly variable in texture.

*Representative Soil Series:* Millett, Sedillo, Witt, Leo, and Chilton.

#### **101. Haplargids-Rough Broken Land (899,600 acres)**

A major part of this association occurs within Grant County, but it also includes a number of widely separated areas in the western and southern parts of Socorro and Catron counties, respectively. The topography is quite varied, ranging from gently to strongly sloping and undulating on the alluvial fan and terrace tops to moderately steep or very steep on the sides of the upland ridges and terraces. It is dissected by numerous intermittent drainages and arroyos, and steep and rough and broken landscapes are common adjacent to these drainage-ways and arroyos. The rough and broken lands typically become more extensive in the upper part of the association near the base of the adjoining mountain ranges. A few narrow valley bottoms and flood plains on nearly level to gently sloping landscapes are also included.

The soils in this association are forming generally in old alluvial sediments of mixed origin. These soils, which are typically neutral to mildly alkaline in reaction, are deep and generally gravelly. The amount of gravel and cobble in the substratum often increases with depth.



**Fig. 40. Representative landscapes in the Haplargid-Rough Broken Land association. The Ustollic Haplargids occur on the gently to strongly sloping ridge crests and old terrace tops. The steep to very steep side slopes are included in Rough Broken Land.**

The dominant use made of the land in this association is grazing. Under good management, it produces moderate yields of herbage. It supports a wide variety of grasses, including black grama, sideoats grama, blue grama, bush muhly, little bluestem, Arizona cottontop, sand dropseed, fluffgrass, and three-awns. The more common shrubs and woody species are oakbrush, catclaw, Apache plume, chamiza, broom snakeweed, and thin and scattered stands of pinyon pine and juniper trees.

*Soil Characteristics:* The Ustollic Haplargids, which occupy the more stable landscapes, comprise about 45 percent of this association. These soils typically occur on the gently to strongly sloping and rolling terrace tops, ridge crests, and side slopes with similar gradients. They have a thin surface layer of brown noncalcareous gravelly loam or gravelly sandy loam over a thick reddish-brown gravelly clay loam or gravelly clay subsoil. The substratum, beginning at an average depth of about 30 inches, consists of gravelly or very gravelly loams and sandy loams, with lime content ranging from a few specks and thin coatings on the coarse fragments to high accumulations. The gravelly and cobbly layers with a high lime content are frequently weakly cemented in the upper part. Although these soils are dominantly gravelly, approximately 10 percent of them have nongravelly surface layers and subsoils. They also differ in having a thin brown, noncalcareous loam or fine sandy loam, surface layer that is underlain by a thick, light brown silty clay or clay subsoil that becomes progressively more calcareous with depth. The substratum is strongly calcareous, pinkish-gray gravelly sandy loam.

Rough Broken Land includes the steep to very steep and severely dissected land in this association. It consists of a complex of shallow gravelly soils and exposures of unconsolidated to weakly consolidated sedimentary deposits dominated by gravelly and loamy or sandy sediments. Erosional remnants capped by moderately erosion-resistant conglomerates occur frequently through this unit. Erosion is active, and as a result the Rough Broken Land component of this association contributes considerable sediments to the drainage system. About 30 percent of the association is included in this land type.

Also in this association are small acreages of a number of other miscellaneous land types such as Rock Land, Alluvial Land, Gullied Land, and Riverwash. Rock Land, a complex of shallow soils and rock outcrops, including igneous dikes and sills, occasionally occurs in the upper part of this unit where it joins the mountainous areas. Gullied

Land, Alluvial Land, and Riverwash commonly occur in the narrow valley bottoms. Other inclusions of importance are soils of the Ustic Torriorthent and Ustollic Paleorthid subgroups and small acreages of unclassified alluvial soils. The unclassified soils, which occur adjacent to drainageways are deep, usually calcareous, and moderately coarse- to medium-textured. The Ustic Torriorthents commonly occur on the strongly sloping and rolling ridge crests and moderately steep side slopes bordering drainages. These soils, which are deep, light-colored, and gravelly, are forming in old alluvial sediments of mixed origin. They typically have gravelly loam surface layers and very gravelly loam subsurface layers with a gravel content ranging from about 35 to 85 percent. The Ustollic Paleorthids, which are principally in those parts of this association occurring in Grant County, occupy nearly level crests of upland plains and ridges. These light brownish-gray, calcareous, gravelly loam soils are underlain by indurated caliche within a depth of 20 inches.

*Representative Soil Series:* Lonti, Poley, Silver, Chilton, and Pastura.

#### **102. Calciorthids-Haplargids (162,600 acres)**

This association includes three widely separated areas in the northwestern part of Socorro County. They consist mainly of gently to strongly sloping upland plains and valleys interspersed with moderately steep and rolling upland ridges and hills. There are also included a few steep escarpments or breaks and nearly level to gently sloping valley bottoms. The soils, which are dominantly medium to moderately fine in texture, range in depth from shallow on the upland ridges and low hills to moderately deep and deep on the less sloping areas.

These soils support a fair to good stand of native vegetation dominated by short and mid grasses. There are also some thin and scattered stands of pinyon pine and juniper trees, particularly on the outer fringes near the mountain fronts. The more common grasses include blue grama, western wheatgrass, Indian ricegrass, black grama, galleta, needle-and-thread grass, little bluestem, sideoats grama, and spike muhly. A few shrubs, including chamiza, rabbitbrush, winterfat, sagebrush, and cholla cactus, also occur in this association.

*Soil Characteristics:* Ustollic Calciorthids, which consist of soils with calcareous surface layers and distinct zones of lime accumulation, comprise about 30 percent of this general soil area. These soils are mainly on gently to strongly sloping and undulating plains and valley side slopes. They

typically have a moderately thick surface layer of light brown or grayish-brown calcareous loam. The subsoil is similar, but it contains more lime and is slightly lighter-colored. This layer grades to pinkish-white very limy loam at a depth of about 15 to 20 inches.

The Ustollic Haplargids, which also comprise about 30 percent of this association, commonly occupy the broad gently sloping plains and valley slopes between the drainageways. They have a thin surface layer of light brown noncalcareous loam or fine sandy loam over a thick subsoil of brown to reddish-brown clay loam or sandy clay loam that is noncalcareous in the upper part. A few threads and small soft masses of lime are common in the lower part of the subsoil. This is usually underlain by a pinkish-white very limy loam at depths of 40 to 50 inches. Although the high lime layers are common, these soils occasionally have only a low to moderate amount of lime accumulation in the form of fine threads and small soft masses. In addition, small acreages are forming in gravelly alluvium. These soils typically have a thin surface layer of reddish-brown noncalcareous gravelly loam over a reddish-brown gravelly clay or gravelly clay loam subsoil. This is underlain by a soft to weakly cemented gravelly and cobbly caliche.

Lithic Ustic Torriorthents and Lithic Ustollic Calciorthids, which are located on the gently sloping to moderately steep and rolling ridges and low hills, are typically shallow but quite variable in other characteristics. Approximately 20 percent of this association consists of these kinds of soils. They are usually moderately coarse to medium in texture and often gravelly or cobbly. Various types of sedimentary and igneous bedrock occurs within a depth of 20 inches.

Also in this association are Cumulic Haplustolls and miscellaneous land types including Rock Land, Rough Broken Land, and Alluvial Land. The Cumulic Haplustolls, which occur in swales and valley bottoms adjacent to drainages, are deep, dark-colored, and medium to moderately fine in texture. Rock Land is steep or very steep and consists generally of a complex of shallow soils and outcrops of bedrock. Rough Broken Land includes the moderately steep to steep lands that consist of a complex of shallow soils and exposures of unconsolidated to weakly consolidated sedimentary materials. Alluvial Land occupies arroyo and drainage bottoms or flood plains and consists of very highly stratified soil materials with extremely variable textures.

*Representative Soil Series:* Harvey, Penistaja, Witt, Poley.

### 103. Haplargids-Argiustolls-Rock Land (180,000 acres)

This association is relatively extensive and consists of an area in the west-central part of Socorro County. The topography is dominated by gently rolling to very steep and hilly landscapes interspersed with gently to strongly sloping valley bottoms, alluvial fans, and plains. A few steep to very steep canyon walls and breaks are also included. The soils are developing in a wide variety of parent materials which have weathered from rhyolite, latite, andesite, basalt conglomerates, and old alluvial sediments. They are generally shallow and stony in those areas dominated by steep and hilly landscapes. Those soils forming in materials from conglomerates and old alluvial sediments on gently rolling to moderately steep landscapes generally range from moderately deep to deep. The deep soils are common on the alluvial fans and in the valley areas between the upland hills and ridges. Gravel and a few cobbles and stones are common over much of the land surface.

This association supports a fair to good cover of vegetation which is dominated by short and mid grasses and scattered to moderate stands of pinyon pine and juniper trees. Grasses common to the association are blue grama, sideoats grama, western wheatgrass, wolf tail, galleta, and three-awns. Rabbitbrush, winterfat, chamiza, shrub liveoak, and yucca are the principal shrubs.

*Soil Characteristics:* The Ustollic Haplargids, which consist of moderately deep and deep soils



Fig. 41. The topography of the Haplargids-Argiustolls-Rock Land association No. 103 is dominated by gently rolling and hilly landscapes interspersed with gently to strongly sloping valley bottoms and alluvial fans.

with distinct and well developed subsoils, comprise approximately 45 percent of this association. They occupy gently to strongly sloping and undulating alluvial fans and valley slopes that extend from the base of hills and upland ridges. Ustollic Haplargids with a thin surface layer of reddish-brown noncalcareous gravelly sandy loam or gravelly loam are dominant. Their subsoil to a depth of about 18 to 30 inches consists of a reddish-brown to brown gravelly sandy clay loam, gravelly clay loam, or gravelly clay. The underlying substratum generally ranges in texture from a gravelly sandy loam to gravelly clay loam or very gravelly clay loam. It is strongly calcareous, and typically contains many pinkish-white mottles and soft masses of lime. Thin strata of gravelly sand or very gravelly sand sometimes occur below a depth of 30 inches. Approximately one-third of the Ustollic Haplargids in this unit are nongravelly. These nongravelly soils typically have brown, noncalcareous, fine sandy loam or loam surface layers over thick subsoils that may range in texture from a sandy clay loam to clay. The substratum, which has moderately coarse to moderately fine textures, usually contains some visible lime in the form of small soft masses or fine threads. A prominent lime zone occurs occasionally at a depth of about 40 to 50 inches.

The Lithic Argustolls, which comprise about 25 percent of this association, occur on moderately steep and hilly landscapes. They are moderately dark-colored noncalcareous or neutral in reaction, and shallow. The surface layer is usually a thin brown gravelly or cobbly loam. This is underlain by a brown to dark reddish-brown noncalcareous heavy clay loam, stony clay, or gravelly clay. Igneous bedrock or conglomerate commonly occurs within 20 inches of the surface. The underlying bedrock is generally fractured and weathered in the upper part.

Approximately 20 percent of this association consists of Rock Land. It is characterized by numerous outcrops of bedrock, and usually occurs on steep to very steep slopes. It consists of a complex of rock outcrops and shallow soils with variable characteristics. The soils are generally gravelly or stony and moderately coarse to medium in texture. Stones and boulders occur on much of the soil surface. Although the soils are usually shallow, small areas of moderately deep soils occur.

The remaining parts of this association consist of miscellaneous land types including Rough Broken Land and Alluvial Land, soils of the Cumulic Haplustoll subgroup, and small acreages of deep unclassified soils. The Cumulic Haplustolls are deep and have a moderately thick surface layer of grayish-brown loam over a thick subsoil of dark

grayish-brown clay loam. These soils usually occur in swales and narrow valley bottoms. The majority of the unclassified soils are similar to Cumulic Haplustolls, but the subsurface layers consist dominantly of sandy loams or light loams. They occur as a complex in the form of small areas or pockets with extensive areas or other soils in this association.

*Representative Soil Series:* Millett, Sedillo, Lonti, Penistaja, Silver, Luzena, and Cabezon.

#### **104. Haplargids-Haplustolls-Rock Land (274,400 acres)**

This association includes a relatively extensive area of rolling to hilly mountain foothills in Sierra and Grant counties. Interspersed with the rolling and hilly landscapes are steep to very steep canyon walls and breaks, gently sloping to moderately steep alluvial fans, and some relatively narrow gently to strongly sloping valley bottoms. Rock outcrops and shallow soils are common on the steep to very steep canyon walls and breaks. In the areas dominated by rolling to hilly landscapes the soils range from shallow to moderately deep. The small areas of soils included in the valley bottoms and on many of the terraces and piedmont slopes are generally moderately deep or deep and often gravelly.

Although the vegetation density is somewhat restricted because of rock outcrops, thin soils, and steep slopes, this association supports a wide variety of grasses and shrubs and a few shrub trees, mainly pinyon pine and juniper. This vegetative cover, together with associated land features, provide a good habitat for many species of wildlife. Black grama, blue grama, sidecoats grama, muhly spp., galleta, sand dropseed, fluffgrass, and three-awns are some of the more common grasses. Shrubs include Apache plume, wolfberry, oakbrush, yucca, and some creosotebush at the lower elevations in the southern part of the association.

*Soil Characteristics:* The Haplargids, which comprise approximately 40 percent of this general soil area, are about equally divided between the Lithic and Typic subgroups. The Lithic Haplargids occur on the moderately steep and rolling to hilly landscapes. They usually have a thin surface layer of brown stony loam or gravelly sandy loam that is neutral in reaction. The subsoil is a reddish-brown gravelly clay loam or gravelly and stony clay. The coarse fragments are often lime-coated on the underside in the soil layer immediately above the bedrock. These soils are typically underlain by acid igneous bedrock within 20 inches of the sur-

face. The Typic Haplargids occupy the gently to strongly sloping alluvial fans at the base of steeply sloping uplands. The most extensive have a thin surface layer of calcareous gravelly loam or light gravelly clay loam over a gravelly clay loam subsoil. This is underlain by a pinkish-white limy very gravelly loam at a depth of two to three feet. Small areas of Typic Haplargids have noncalcareous surface layers and coarser-textured gravelly sandy clay loam subsoils.

The Lithic Haplustolls, which comprise about 20 percent of this association, occur generally on the moderately steep north-facing slopes at the higher elevations. Typically these soils have a surface layer of grayish-brown to brown weakly calcareous stony loam. This grades through a light brownish-gray very stony clay loam to acid igneous bedrock that commonly occurs within a depth of 20 inches. A few thin lime coatings usually occur on the bottom sides of stones or coarse fragments below a depth of 10 inches.

In addition to these two major soil groups, approximately 20 percent of this unit consists of Rock Land. This miscellaneous land type is dominated by outcrops of bedrock and very shallow soils that occur in a very complex pattern. Most of the bedrock is igneous, but other types of rocks occur to a very limited extent. Rock Land commonly occurs as steep slopes, escarpments, and breaks. It is characterized by numerous rock outcrops, bare ledges, and a large amount of loose rock and stones on the surface. The soils intermingled with the rock outcrops are usually gravelly or stony, and shallow or very shallow. However, small areas or pockets of moderately deep or deep soils occur.

Also in this association are soils of the Typic Calciorthid subgroup. These soils occupy gently to strongly sloping piedmont slopes at the lower elevations in this general soil area. They typically have light brown or light brownish-gray strongly calcareous gravelly loam surface layer. These grade at a depth of 15 to 25 inches to a pinkish-white very gravelly loam or gravelly loam with a high content of lime. In addition, there are also in this unit small acreages of deep unclassified alluvial soils and miscellaneous land types such as Alluvial Land and Gullied Land. The unclassified alluvial soils commonly occur on the nearly level to gently sloping flood plains of intermittent drainages. They are deep and generally range from moderately coarse to moderately fine in texture. Alluvial Land dominantly includes the highly variable alluvial sediments in the bottoms of drainages and arroyos. Gullied Land includes the small areas severely dissected by gullies.

*Representative Soil Series:* Lehmans, Luxor, Tres Hermanos, Hap, Lonti, and Oro Grande.

#### **105. Argiustolls-Haplustolls-Rock Land (608,100 acres)**

This association is mainly in Grant and Sierra counties, but small areas extend into Catron and Socorro counties. It consists dominantly of mountain foothills and is characterized by rolling to hilly landscapes interspersed with narrow valley bottoms and terraces. The relatively narrow valley floors and upland summits are commonly separated by steep canyon walls, escarpments, and steep side slopes. The ridge tops, which are narrow and comparatively small, are gently to strongly sloping and rolling. The narrow valley floors below the steep canyon walls and steep side slopes are gently to strongly sloping. Although there is a relatively wide range in altitude, much of this area ranges between 6000 and 7000 feet in elevation. The soils, which are forming in materials from a wide variety of rocks including conglomerates and mixed igneous rocks, are dominantly shallow. Rock outcrops are common along canyon walls and on the steep side slopes below the upland ridges. Although the content of gravel and stone is highly variable, most of the soils have stony or gravelly surface layers.

These rolling and hilly lands support a wide variety of grasses and shrubs, and some trees. Vegetation on much of this area, however, is dominated by mid and short grasses with a scattered canopy of pinyon pine and juniper trees, oakbrush, and various other shrubs. Some of the more common grasses are blue grama, sideoats grama, black grama, little bluestem, needle-and-thread, New Mexico feathergrass, bush muhly, mesa dropseed, Arizona cottontop, hairy grama, and three-awns. Shrubs, in addition to oakbrush, include sacahuista, buckbrush, mountain mohogany, Apache plume, rabbitbrush, chamiza, and winterfat. There are a few ponderosa pine, particularly on north slopes and at the higher elevation. Cottonwood, desert willow, and walnut trees also occur in the valley bottoms adjacent to drainages in the southern part of this unit. The steep slopes, rock ledges, and escarpments tend to restrict livestock grazing in parts of this association. The areas with these characteristics, however, provide a good habitat for many species of wildlife.

*Soil Characteristics:* The major components of this association, Argiustolls, Haplustolls, and Rock Land, are in nearly equal proportions as each constitutes about 25 percent of this general soil area. The Argiustolls, dominantly in the Lithic

subgroup, consist of shallow and moderately dark-colored soils forming mainly in materials weathered from acid igneous bedrock or conglomerate. They have a thin brown noncalcareous cobbly loam surface layer over a brown to dark reddish-brown clay or gravelly clay subsoil. Igneous bedrock or conglomerate typically occurs within 20 inches of the surface. These shallow soils commonly occur on moderately steep and hilly landscapes. The Aridic Argiustolls, of limited extent, usually occupy the more gently sloping landscapes. They typically have dark-colored, noncalcareous, stony or cobbly loam surface layers over cobbly or stony subsoils with moderately fine to fine texture. Bedrock usually occurs at depths of 20 to 40 inches, but occasionally it may not be encountered within a depth of 60 inches.

The Lithic Haplustolls, like the Aridic Argiustolls, are shallow and occur on moderately steep and rolling to hilly landscapes. These soils commonly have grayish-brown to brown neutral to slightly acid stony or cobbly loam surface layers. These grade through a brown cobbly or stony loam or light clay loam of similar reaction to the underlying bedrock, usually within a depth of 20 inches. Approximately one-half of these soils have neutral to weakly calcareous surface layers and calcareous subsurface layers. In these soils, a few thin lime coatings usually occur on the bottom sides of stones or coarse fragments below a depth of 10 inches.

Rock Land, the other major component of this association, is characterized by numerous outcrops of bedrock that usually occur on the steep to very steep slopes. Shallow soils with variable characteristics are intermingled in complex patterns. These shallow soils are generally gravelly or stony, and moderately coarse to medium in texture. Stones and boulders are common on much of the soil surface. Small areas of moderately deep soils are interspersed with the shallow soils, rock outcrops, and rock ledges.

The remaining 25 percent of this association consists of Ustollic Haplargids, Cumulic Haplustolls, unclassified deep alluvial soils, and other miscellaneous land types including Rough Broken Land and Alluvial Land. The Ustollic Haplargids, which are principally in the southern part of the association, occupy gently sloping to moderately steep alluvial slopes and fans near the base of hills and ridges. They consist of deep soils with thin dark-colored gravelly sandy clay loam surface layers, heavy clay loam, and gravelly clay loam subsoils, and gravelly sandy clay loam or gravelly sandy loam substrata. The Cumulic Haplustolls are deep and have a moderately thick surface layer of grayish to brown loam over a thick subsoil of dark

grayish-brown clay loam. These soils are usually in swales and valley bottoms. The majority of the unclassified soils are similar to the Cumulic Haplustolls but lack the thick dark-colored surface layers and are moderately coarse to medium in texture.

*Representative Soil Series:* Luzena, Santa Fe, Santana, Oro Grande, and Balon.

#### **106. Lava Rock Land (125, 900 acres)**

This association occurs south of Grants in central Valencia County. Much of this unit consists of relatively recent basalt or lava flows. A distinctive feature is the extremely rocky and broken nature of the land surface. The basalt rock covering this area is slow to weather, so most of this association is practically devoid of soil and consists mainly of basalt rock and stones. Small and isolated pockets of soil, however, do occur intermingled throughout the part of the association dominated by basalt rock and stones. These small pockets of soil are generally inaccessible to livestock and are quite variable. Some are medium to moderately fine in texture, while others are sandy. The sandy soils are forming dominantly in eolian sediments deposited over the basalt rocks and boulders. These small soil areas, however, support a cover of grasses and shrubs, which are grazed by wildlife, particularly deer. Vegetation is sparse or nonexistent on the Basalt Rock Land. A few shrubs, as well as a few pinyon pine, juniper, and ponderosa pine trees, however, do occur. These shrubs and trees are usually growing in the cracks and fractures in the basalt rock.

Soils have developed in approximately 25 percent of this association where there has been a deposition of eolian sediments over the basalt rocks, or where the lava flows are apparently older, or the basalt rocks and volcanic materials are less resistant to weathering. These soils, although variable in depth and other characteristics, are dominantly within the Lithic Ustollic Haplargid and Lithic Argiustoll subgroups.

The Lithic Ustollic Haplargids, which are shallow and usually stony, are forming on gently to strongly sloping and undulating landscapes. Outcrops of basalt rock are common. These soils have a thin surface layer of brown, noncalcareous stony loam or stony clay loam. Their subsoil is a brown to reddish-brown cobbly or stony clay. This is underlain by basalt bedrock at depths ranging from 10 to 20 inches. The underlying basalt bedrock, which is commonly fractured, is typically lime coated in the upper part.

The Lithic Argiustolls, which are darker and contain more organic matter than the Lithic



Ustollic Haplargids, also occur to a limited extent in this association. They have a thin surface layer of dark grayish-brown, noncalcareous stony loam or stony clay loam. The subsoil is a brown cobbly or stony clay. This is underlain by basalt bedrock at depths ranging from 10 to 20 inches. Surface stones and a few outcrops of basalt are common.

Also associated with shallow and stony soils are small areas of unclassified moderately deep soils. They usually have thin surface layers of brown stony loam over brown to reddish-brown clay loam subsoils that typically contain numerous fragments of basalt. Basalt bedrock usually occurs within 40 inches of the surface. These soils, as well as the shallow stony soils, support a fair cover of native vegetation including short and mid grasses, shrubs, and a few pinyon pine and juniper trees. The more common grasses are blue grama, sideoats grama, hairy grama, sand dropseed, vine mesquite, Arizona cottontop, muhly spp., and three-awns.

*Representative Soil Series:* Prieta and Cabezon.

### *Moderately Dark- and Dark-Colored Soils of the Mountainous Region*

This area consists of mountains and valleys. The mountains include the Sangre de Cristo and Jemez ranges and the southern extension of the San Juan range in the northern part of the state. In the southern part and central parts of the state it includes the Sacramento, Manzano, Zuni, Sandia, Mogollon, and other ranges. It occurs in the Southern Rocky Mountain, Colorado Plateau, and the Basin and Range physiographic provinces. The topography, strongly sloping to precipitous in the

mountains, is gently to moderately sloping in the stream valleys and on the plateaus. The San Juan Mountains are characterized by broad undulating plateaus and valleys. Elevations, which range from 6,000 to 13,000 feet, are dominantly 7,000 to 10,000 feet in the north and 7,000 to 11,000 feet in the south. The highest peak in New Mexico, Mt. Wheeler, in the Sangre de Cristo range, rises to more than 13,000 feet.

The area contains numerous perennial streams, none large. The major ones to the north are the Pecos, Chama, Cimarron, and Jemez rivers, and the major ones to the south are the Hondo, Gila, San Francisco, and Mimbres rivers.

The mountainous region consists of about 12,707,000 acres, of which 28,000 are irrigated and 240,000 are irrigable.

### CLIMATE

The mountainous region has a semiarid to sub-humid continental climate. The precipitation generally increases with elevation. In the northern part, less than half of the annual precipitation falls in the summer, but half to two-thirds falls in the summer in the southern part. Most rain falls as brief thundershowers, but occasional prolonged rains occur at higher elevations in the northern part. Snowfall is heavy at the higher elevations and provides most of the runoff water that feeds the Pecos River and the New Mexico section of the Rio Grande. Humidity is low and variable, probably ranging from 20 to 80 percent. Table 6 gives data for six weather stations in this region. There are no good records for the higher elevations.

Table 6. Climatic conditions at six stations in the Mountainous Region

Station	Elevation feet	Average Precipitation												Avg. Ann. Temp. °F	Frost- Free Season days	
		J	F	M	A	M	J	J	A	S	O	N	D			Annual
Red River	8,676	1.07	1.10	1.35	1.60	1.90	1.24	2.56	3.07	1.49	1.47	0.98	0.93	18.66	38.8	88
Wolf Canyon	8,135	1.64	1.77	1.90	1.50	1.45	1.04	2.91	3.28	2.14	1.62	1.16	1.51	21.92	40.1	36
Chama	7,810	1.80	1.67	1.51	1.37	1.40	0.92	1.58	2.32	1.86	1.57	0.96	1.63	18.59	42.6	112
Tajique	7,100	1.08	1.07	1.30	1.28	1.47	1.27	2.55	2.75	2.06	1.57	0.87	1.21	18.48	48.1	139
Cloudcroft	8,695	1.80	1.70	1.63	0.85	1.09	1.86	5.79	4.73	2.37	1.61	0.85	1.46	25.74	45.1	145
Luna	7,050	1.04	0.80	0.76	0.62	0.48	0.73	2.59	2.90	1.71	1.36	0.59	0.95	14.53	45.7	100

Both daily and annual temperature variations are great. In the northern part maximum recorded temperatures at Wolf Canyon and Chama were 99 degrees, and the maximum at Red River was 94 degrees. The lowest temperatures at these stations were 41, 28, and 35 degrees below zero, respectively. Freezing temperatures can occur almost any day of the year. In the southern part the maximum temperatures at Tajique, Cloudcroft, and Luna, were 96, 87, and 100 degrees, respectively, while the minimum temperatures were 21, 11, and 32 degrees below zero.

The temperature at a depth of 20 inches is considered in classifying soils. The soils are placed in a frigid temperature class if the average annual temperature is less than 47 degrees. Where the term "cryo" is used, the summer temperature is also less than 47 degrees. Soils are in a mesic temperature class if the temperature is between 47 and 59 degrees. The soils in this region occur in both frigid and mesic temperature classes, and are not separated on the map because of the difficulty of determining the boundaries and the complexity of the pattern.

## GEOLOGY

The geology of the region is highly varied. The Sangre de Cristo Mountains are mainly of Precambrian rocks and of various Pennsylvanian formations. The top of the Jemez Mountains is the Valle Grande caldera, which is about 16 miles in diameter, one of the world's largest. The volcanic eruption that formed it discharged volcanic ash over much of New Mexico and into Texas, Oklahoma, and Kansas. Basalt beds are common in the north-central and northeastern parts of the state.

Volcanic rocks including rhyolite, latite, andesite, and tuff are extensive in the Jemez Mountains and in areas farther north. Extensive areas of sedimentary rocks dominated by shales and sandstones also occur in this mountainous region.

The Sacramento Mountains consist mainly of San Andres limestone of Permian age, but the Yeso formation of the same age outcrops on the west side. These mountains also include some Pennsylvanian rocks, and Sierra Blanca is the eroded core of a Tertiary volcano. The Sandia and Manzano Mountains are Permian and Pennsylvania limestone and sandstone.

At the higher elevations there are also Precambrian crystalline igneous and metamorphic rocks, including granite, schist, gneiss, and quartzite. In the west, between Silver City and Gallup, the mountains include Quaternary and Tertiary basalt,

andesite, and conglomerate as well as some undifferentiated Triassic igneous rocks. In addition, sandstone and other sedimentary rocks are common in the Zuni mountain range.

## SOIL ASSOCIATIONS

Twenty associations have been recognized in the mountainous region. These are shown on the accompanying map, and are named after the great groups of soils that occur in them. The soils of this region are not known as well as those previously discussed, and there is therefore more likelihood of changes in the names of soil series. Descriptions of the associations follow.

### 107. Eutroboralfs (1,224,400 acres)

Included in this association is an extensive high mountainous and plateau area in the western, northwestern, and central parts of Mora, Colfax, and Rio Arriba counties, respectively. The altitude ranges from about 6,500 feet in the foothill areas to slightly over 9,200 feet on some of the high mountain peaks, but it is most commonly between 7,500 and 8,500 feet. It is characterized by mountainous topography that ranges from gently sloping to moderately steep on the ridge tops to steep and very steep on the side slopes that extend into the canyons. The included small mountain valleys or parks are typically nearly level to strongly sloping and rolling. The soils are forming dominantly in parent materials weathered from sedimentary rocks; principally sandstone and shale. Igneous rocks have also contributed minor amounts to the parent materials. The soils on the steep mountain landscapes typically have cobbly or stony medium- and moderately coarse-textured surface layers that are neutral to slightly acid in reaction. The subsoils are usually fine-textured and often cobbly or stony.

This association is used principally for timber production, range, and recreation. The soils in some of the included valley areas are also used to a limited extent for irrigated and dry-land farming. It is also an important watershed area, and the numerous springs and seeps in the area give rise to many small perennial streams. The major soils generally support good stands of native vegetation dominated by trees and shrubs. Ponderosa pine, pinyon pine, and juniper are the principal tree species, but Engelmann spruce, limber pine, Douglas fir, and white fir also occur on the north-facing slopes and at the higher elevations. The more common shrubs include Gambel oak, mountain hohogany, serviceberry, and bitterbrush. Although there is little grass in areas of dense tree and shrub

cover, this association does support a wide variety of grasses, and stands are dense in the valley and park areas. Some of the more common grass species are Arizona fescue, Thurber's fescue, western wheatgrass, bluegrass, mountain muhly, blue grama, sideoats grama, Indian ricegrass, little bluestem, big bluestem, pine dropseed, Junegrass, and mountain brome.

*Soil Characteristics:* Eutroboralfs comprise about 70 percent of this association. The principal subgroups are Typic, Mollic, and Lithic. The Typic Eutroboralfs, the most extensive in the association, typically occur on moderately steep to steep mountain slopes facing north, northeast, and northwest, as well as on ridge crests. These soils usually have a thin dark grayish-brown, neutral loam, cobbly loam, or stony loam surface layer, which is commonly covered by a one- to three-inch layer of fresh or partly decomposed organic material. This grades through a pale brown or very pale brown loam or cobbly loam that is neutral to slightly acid in reaction to the underlying thick

subangular blocky cobbly clay or clay subsoil at a depth of about 12 to 15 inches. This is usually underlain by a cobbly clay substratum that usually begins at a depth ranging from 30 to 50 inches. The content of coarse fragments ranges from little or none to as much as 50 percent or more of the soil mass. On the gently sloping to moderately steep ridge crests, these soils are commonly underlain at moderate depths by interbedded shale and sandstone. Otherwise they have characteristics similar to the other Typic Eutroboralfs.

The Mollic Eutroboralfs resemble the Typic, but the surface layers and upper subsoil are darker and contain more organic matter. These soils are characterized by their dark gray loamy surface layers and blocky clay subsoils. A few gravels and cobbles are usually present in all soil layers.

The Lithic Eutroboralfs, which are shallow, are forming residually in materials weathered from the underlying sandstone and shale. They occur mainly on gently sloping to moderately steep ridges and mesas at elevations of about 7,000 to 9,000 feet. These soils have grayish-brown, neutral stony

Fig. 42. General view of the steep mountainous areas and the nearly level to strongly sloping valleys in soil association No. 107. The Eutroboralfs, which are on the mountain slopes in the background, are the most extensive. The Pachic Argiborolls and Fluvaquentic Haplaquolls occupy the nearly level to strongly sloping landscapes in the valley areas.



moderately coarse- to medium-textured surface layers over brown moderately fine to fine-textured subsoils. Sandstone or interbedded sandstone and shale occurs at a depth ranging from about 10 to 20 inches. Coarse fragments are mainly sandstone and usually comprise 5 to 25 percent of the surface layer and 5 to 50 percent of the subsoil.

Also in this association are soils of the Aridic Argiboroll, Aridic Haploboroll, Typic Ustochrept, Pachic Argiboroll, and Fluvaquentic Haplaquoll subgroups, unclassified alluvial soils, and miscellaneous land types including Rock Land, Stony Land, and Alluvial Land. The Aridic Argiborolls and Aridic Haploborolls, which are principally in Rio Arriba County, are forming dominantly in parent materials weathered from the underlying shale. They occupy moderately steep to steep side slopes and rolling to hilly uplands. The Aridic Haploborolls are shallow and typically have thin grayish-brown to brown, calcareous silt loam surface layers, which grade through grayish-brown silty clay loam subsurface layers to the underlying shales within a depth of 20 inches. The Aridic Argiborolls are moderately deep and commonly occur on north- and east-facing slopes that support a good cover of native vegetation. They are characterized by their grayish-brown silty clay loam or clay loam surface layers and grayish-brown to brown clay subsoils. These are underlain by a silty clay loam of similar color, and the underlying shale usually occurs at a depth of about 30 to 40 inches. These soils are typically noncalcareous in the surface layer and upper part of the subsoil. The Typic Ustochrepts are forming in moderately fine-textured alluvial sediments weathered from interbedded sandstone and shale. These soils, which are typically underlain by shale at moderate depths, have thin grayish-brown noncalcareous cobbly silty clay loam surface layers and grayish-brown cobbly silty clay loam or cobbly silty clay subsoils. The Pachic Argiborolls, which are forming in alluvium, occupy nearly level to strongly sloping landscapes in the mountain valleys. These soils are usually dark-colored and have loam or clay loam surface layers over medium- to fine-textured subsoils and substrata. Also occurring to a limited extent are the stratified medium- to fine-textured Fluvaquentic Haplaquolls. They typically occupy the nearly level to gently sloping valley bottoms and flood plains adjacent to the larger streams. The subsurface layers are commonly mottled and the depth to watertable varies with the season and is often less than four feet.

Rock Land, which is the most extensive of the miscellaneous land types, consists mainly of a complex of shallow soils and outcrops of sandstone

and shale. It occurs generally on the steep to very steep side slopes with outcrops occurring as vertical or nearly vertical exposures and ledges. The interspersed soils are usually shallow and moderately coarse to moderately fine in texture. Numerous stones and boulders are common on the surface. Some small areas and pockets of moderately deep to deep soils occur interspersed with the shallow soils, rock outcrops, and rock ledges. Stony Land also commonly occurs on steep slopes. It differs from the Rock Land in having numerous loose rocks, boulders, and stones on the surface rather than outcrops of bedrock. Alluvial Land includes the highly variable alluvial sediments in the immediate flood plains of drainages and arroyo bottoms. It is often gravelly and stony.

*Representative Soil Series:* The few series known include Fuero, Dargol, and Vamer.

#### **108. Cryoboralfs-Paleboralfs-Eutroboralfs (1,317, 800 acres)**

This association occurs in a high mountain area and includes a large part of the Sangre de Cristo Mountains in the north-central part of the state. It is dominated by a complex mountainous terrain that has a wide range in slope gradients. Although much of it is moderately steep to steep, it ranges from gently sloping and rolling on the ridge tops and valley areas to steep and very steep on the canyon and mountain side slopes. The valley areas are not extensive and typically occur as small areas adjacent to drainageways. A representative and one of the larger valley areas occurs in the vicinity of Eagle Nest in the extreme western part of Colfax County. Although the immediate valley bottoms are commonly nearly level to gently sloping, the valley side slopes and fans are often strongly sloping and occasionally moderately steep. The altitude ranges from about 7,500 feet to 13,160 feet on the crest of Wheeler Peak, but is most commonly between 8,000 and 11,000 feet. The soils, which are forming in materials weathered from a wide variety of sedimentary and igneous rocks, are generally well drained, moderately deep, and deep. Small areas of poorly drained or somewhat poorly drained soils, however, frequently occur in the immediate valley bottoms. Rock outcrops are common along canyon walls on the steep mountain slopes. Although the content of gravel and cobble is highly variable, most of the soils in this association have cobbly or gravelly surface layers.

These densely forested lands are used for timber production, recreation, grazing by wildlife, and to a lesser extent, for grazing by livestock. The small



Fig. 43. General view of complex mountain terrain in soil association No. 108. Moderately steep to steep land forms are common, but may range from gently sloping and rolling on the ridge tops and valley areas to very steep on the canyon and mountain side slopes.

included valley areas are used mainly for grazing and occasionally to a very limited extent for irrigated and dryland farming. It is also an important watershed area. Good infiltration, permeability, and adequate soil depth make possible considerable water storage from gentle rains and spring snowmelt. In general, this association supports a good cover of native vegetation consisting of a wide variety of trees, shrubs, forbs, and grasses. The overstory consists mainly of Douglas fir, white fir, Engelmann spruce, corkbark fir, and some aspen, alder, and willow trees. At the lower elevations there is also considerable ponderosa pine and some Gambel oak. Shrubs and forbs include common juniper, Oregon grape, gooseberry, wild raspberry, buffaloberry, kinnikinnick, asters, pussytoes, yarrow, and many others. The more common grasses are Arizona fescue, Thurber's fescue, bluegrass, redtop, oatgrass, mountain brome, western wheatgrass, sleepygrass, timothy, Junegrass, and bearded wheatgrass. The grass species occur mainly in those areas with thin to moderately dense stands of trees, and in the small-wooded valley areas. Sedges, iris, and various species of wet meadow grasses also occur, particularly in the valley where the soils are poorly drained.

*Soil Characteristics:* Typic Cryoboralfs, which are moderately deep to deep soils on moderately steep to steep mountain slopes, comprise about 40 percent of this association. They usually have a

thick surface layer of pale brown, cobbly sandy loam or cobbly loam. It is about 15 to 20 inches thick, medium acid in reaction, and has a surface cover of one to four inches of forest litter. The subsoil commonly extends to a depth of 35 to 45 inches and consists of a brown, cobbly or stony sandy clay loam. The content of coarse fragments in the subsoil ranges from about 10 to 15 percent to as much as 50 percent. The coarse fragments typically increase with depth, and they may comprise as much as 50 to 90 percent of the soil mass in the substratum. Bedrock occurs occasionally at a depth ranging from about 36 to 60 inches. The Cryoboralfs are also represented in this association by the shallow soils of the Lithic Cryoboralf subgroup. These soils are of minor extent and occur dominantly on ridge crests and occasionally on steep mountain slopes. They are not so deep as the Typic Cryoboralfs, and are usually underlain by bedrock within a depth of 20 inches.

Typic Paleboralfs are also a moderately extensive component of this association, and like the Typic Cryoboralfs, they occur on moderately steep to steep mountain slopes. These soils comprise about 20 percent of the association and are characterized by their surface layer of pale brown cobbly fine sandy loam or cobbly loam that is medium acid in reaction. Surface layers commonly extend into the subsoil, resulting in thick transitional horizons. The surface is usually covered by a two- to three-inch layer of fresh and decaying forest litter. The

subsoil is a thick, light yellowish-brown, strongly acid, very cobbly sandy clay or very cobbly sandy clay loam. Coarse fragments ranging in size from gravel to stone typically comprise about 40 to 50 percent or more of the subsoil layers.

Approximately 15 percent of this association consists of Typic Eutroboralfs. These soils typically have a pale brown cobbly loam or cobbly sandy clay loam surface layer that is neutral in reaction and about 6 to 12 inches thick. It is covered by a one- to two-inch layer of partly decomposed forest litter. The upper part of the subsoil to a depth of about 18 to 24 inches consists of a very pale brown cobbly clay loam that is medium acid in reaction. Shale and sandstone fragments of gravel and cobble size comprise about 35 percent of this layer. This is underlain to a depth of 60 inches or more by a very cobbly or very stony clay loam that typically has about 75 to 90 percent coarse fragments. The soil in these layers occurs as small pockets and seams between the coarse fragments.

Also in this association are soils of the Typic Cryochrept, Typic Cryumbrept, and Aridic Argiboroll subgroups, along with some Rock Land, Stony Land, unclassified deep alluvial soils, and drainage ways. The Typic Cryochrepts occupy steep and very steep mountain slopes at high elevations in this general soil area. The soils are characterized by their strongly to extremely acid cobbly loam surface layers and cobbly and very cobbly moderately coarse- to medium-textured subsoils substrata.

The Typic Cryumbrepts occupy strongly sloping to moderately steep mountain slopes above the timberline. These soils typically have a very dark gray gravelly loam or gravelly sandy loam surface layer that is strongly acid in reaction and is covered by a one- to three-inch mat of undecomposed and partially decomposed plant remains of roots and leafy parts of *Kobresia*. The subsoil is a brown strongly acid very cobbly loam or very cobbly sandy clay loam. The Aridic Argiborolls, which are deep and well drained, are forming in loamy alluvium on gently sloping to moderately steep side slopes and alluvial fans that occur principally in the larger valley areas. Typically, the surface layer is a brown to dark grayish-brown noncalcareous loam or clay loam about 10 to 15 inches thick. The subsoil is a brown or reddish-brown, blocky loam, clay loam, or clay. Gravel and a few cobbles also occur occasionally in these subsoil layers.

Rock Land is also a minor component of this association. It consists of a complex of shallow soils, ridges of rock, and rock slides. The small areas or pockets of soil occurring between the outcrops of bedrock are usually stony and gravelly.

Stony Land, like Rock Land, usually occurs on the very steep mountain slopes. This land type has numerous loose rocks, stones, and boulders on the surface. It also usually contains a few outcrops of bedrock. Deep soils forming in alluvium also occur in the narrow valley areas contiguous to drainages. Although quite variable, these soils are generally deep, dark-colored, and moderately permeable, and range in texture from moderately coarse to moderately fine.

*Representative Soil Series:* Gambler, Cundiyo, Angostura, Etoe, Etown, Flechado, Morval.

### 109. Cryochrepts-Cryoboralfs (561,800 acres)

This association, like the previous one, occupies high mountainous areas that are widely distributed in the north-central part of the state. Although the altitude ranges from slightly less than 8,500 feet to 13,102 feet on Truchas Peak, it is usually between 8,500 and 11,500 feet. Steep to very steep mountainous landscapes with slope gradients of 20 to 80 percent or more are characteristic of this general area.

This association is used dominantly for timber production, recreation, grazing by wildlife, and to a much lesser extent, for grazing by livestock. The major soils in this association support good stands of native vegetation consisting of Engelmann spruce, white and Douglas fir, aspen, and ponderosa pine with a sparse understorey of shrubs, forbs, and grasses. The more common grasses are Arizona fescue, bluegrass, Junegrass, little bluestem, side-oats grama, pine dropseed, mountain muhly, western wheatgrass, and blue grama. It also supports a number of desirable browse plants suitable for grazing by wildlife.

*Soil Characteristics:* The Typic Cryochrepts, which commonly occur at elevations above 10,000 feet, are forming in glacial till and colluvial and alluvial sediments. They occupy steep to very steep mountain slopes with gradients ranging from 20 to about 70 percent. The surface layer is a light brown to brown very strongly acid gravelly and stony loams. A two- to three-inch layer of fresh or partly decomposed organic material commonly occurs on the surface. The subsoil is a reddish-brown strongly acid gravelly or stony sandy loam, about 15 to 20 inches thick. This is underlain by a substratum of brown, strongly acid gravelly or stony sandy loam. In the subsoil and substratum, the content of coarse fragments, which vary in size from gravel to stones, ranges from about 30 to 60 percent. Approximately 55 percent of the soils in this general soil area occur within this subgroup.

Typic Cryoboralfs are also extensive, as they comprise about 25 percent of the association. These soils are forming in alluvium derived principally from acid igneous rocks at elevations that generally range between 8,500 and 10,000 feet. They typically have a thick surface layer of light brownish-gray gravelly sandy loam. It is about 20 inches thick and slightly acid in reaction and has a surface cover of about two inches of fresh or partially decomposed organic material. The subsoil commonly extends to a depth of 50 to 60 inches and consists of a light brownish-gray and brown, slightly acid, gravelly or stony sandy loam. The content of coarse fragments in the subsoil ranges from about 30 to 90 percent. These coarse fragments are commonly coated with clay.

Also in this association are soils of the Typic Cryumbrept and Typic Cryoboroll subgroups, as well as small areas of unclassified soils. The Typic Cryumbrepts occur on high mountain tops at elevations of about 12,000 feet or more. These soils are characterized by their very dark gray to dark brown cobbly loam surface layers and very cobbly and very stony subsoils and substrata with the content of coarse fragments ranging from 50 to 80 percent. They are strongly to very strongly acid. The Typic Cryoborolls, which occur in alluvial valley bottoms, are forming in alluvium derived principally from granite, gneiss, and schist. These deep well drained soils have very dark gray loam surface layers over grayish-brown loam subsurface layers that often contain a few pebbles. The unclassified soils, which are poorly drained, occupy basins and low areas in high mountain valleys. These soils have a 3- to 10-inch surface layer of peat over a silt loam mineral soil that is dark grayish-brown in the upper part and of variable color in the lower layers. Many large prominent mottles indicating restricted drainage are common in these lower subsurface layers. Miscellaneous land types such as Rock Land, Rock Slides, and Alluvial Land comprise most of the remaining parts of this general soil area.

*Representative Soil Series:* Nambe, Bobtail, and Cundiyo.

### **110. Ustorthents-Cryoborolls (376,200 acres)**

This association consists of three widely separated areas of steep to very steep mountain land in the north-central part of the state. The elevation ranges from about 7,000 to 10,600 feet, but it is most commonly between 7,500 and 9,500 feet. The soils are generally shallow to moderately deep and are developing dominantly in materials weathered from granite, gneiss, and schist. The surface

soils are usually gravelly to stony and range in reaction from neutral to slightly acid. Although the parent materials are mainly of igneous origin, some included soils, particularly in Sandoval County, are forming in materials weathered from limestone, sandstone, and shale. The soils developing in these materials are dark-colored and generally neutral to slightly acid. They are also typically not as gravelly or stony as those of igneous origin. This association is used dominantly for timber production, range, and recreation. The major soils in this unit generally support good stands of native vegetation. The Typic Ustorthents and Typic Cryoborolls are the principal timber producers, with an overstory vegetation of ponderosa pine, Engelmann spruce, white and Douglas fir, and occasional small areas of aspen. The Lithic Ustorthents occur at slightly lower elevations and usually have an overstory vegetation of pinyon pine, juniper, and some oakbrush. The principal grasses are western wheatgrass, sideoats grama, little bluestem, mountain brome, Arizona fescue, galleta, blue grama, and dropseed. The soils also support a number of desirable browse plants suitable for grazing by wildlife.

*Soil Characteristics:* The Ustorthents, which are dominant, comprise about 65 percent of this general soil. They are nearly equally divided between the Lithic and Typic subgroups. The Lithic Ustorthents, which typically occur at the lowest elevations in this association, have a surface layer of grayish-brown stony loam. It is about six inches thick, neutral in reaction, and commonly has a surface cover of about two inches of undecomposed and partially decomposed needles, leaves, twigs, and cones. The subsurface layers are a light brownish-gray noncalcareous cobbly loam underlain by granite, gneiss, or schist at a depth of less than 20 inches. The Typic Ustorthents have a thin surface layer of dark grayish-brown to grayish-brown noncalcareous stony loam. This grades through a brown very stony loam to the underlying granite and gneiss bedrock at a depth of about 20 to 30 inches.

Typic Cryoborolls, the other major component, comprise approximately 20 percent of the association. These soils have a moderately thick surface layer of dark gray, noncalcareous gravelly sandy loam. A two- to three-inch layer of partially decomposed and undecomposed needles, leaves, and twigs commonly occurs on the surface. The subsurface layer consists of a dark grayish-brown slightly acid gravelly sandy loam. This grades through a very gravelly loamy sand, about one foot thick, to the underlying granite, gneiss, or

schist bedrock that occurs at a depth of about 20 to 30 inches.

Also in this association are Pachic Argiborolls, unclassified alluvial soils, and miscellaneous land types. The Pachic Argiborolls, which are characterized by their thick dark-colored surface layers, are forming dominantly in materials weathered from sedimentary rocks including limestone, sandstone, and shale. The surface layers are mainly moderately coarse- to medium-textured and neutral to slightly acid in reaction. The subsoils are moderately fine to fine in texture. The depth to bedrock or shale is usually 30 to 40 inches, but it may range from 20 to 60 inches or slightly more. The unclassified alluvial soils commonly occur as small areas in valley bottoms and on narrow flood plains adjacent to drainages. These soils are usually deep, moderately dark to dark colored and moderately coarse to medium in texture. Rock Land, which consists of a complex of very shallow soils and outcrops of igneous and sedimentary rocks, is mainly on steep canyon walls, escarpments, and breaks.

*Representative Soil Series:* Chimayo, Mirabal, and Supervisor.

#### 111. Argiborolls-Eutroboralfs (453,200 acres)

This association occurs mainly in Colfax and Mora counties and to a small extent in Union County. The topography is extremely variable and ranges from nearly level to strongly sloping and undulating on the tops of the broad basalt-capped mesas to steep on the hills and mountain side slopes. Moderately steep to very steep and hilly landscapes are common on the lands surrounding the basalt-capped mesas. The soils are developing dominantly in materials of volcanic or basic igneous origin, principally basalt. They range from shallow to deep, and are often stony and rocky. Outcrops of basalt bedrock are common on the escarpments and mesa fronts. Small ridges also occur on many of the lava flows where bedrock outcrops or the shallow soils are extremely stony. In addition to igneous rocks, sedimentary materials, including sandstone, shale, and limestone, occur to a limited extent. These are principally below the basalt flows on the lower parts of the escarpments and mesa fronts.

The vegetation, like the topography, varies widely on the soils in this association. On the gently sloping mesa tops, there are many park-like areas dominated by such grass species as bluegrass, Arizona fescue, blue grama, buffalo grass, western wheatgrass, and mountain muhly. A few ponderosa pines and clumps of oakbrush and other shrubs

are often scattered or interspersed throughout these grassland areas. The remaining parts of this association have an overstory of trees and shrubs. At the higher elevations this overstory vegetation consists generally of white fir, Douglas fir, limber pine, ponderosa pine, and some Engelmann spruce, aspen, oakbrush, and mountain mahogany. The more common grasses associated with this mixed conifer forest type are Junegrass, Arizona fescue, Thurber's fescue, bluegrass, mountain brome, and mountain muhly. At the lower elevations the overstory vegetation is mainly oakbrush, mountain mahogany, thin and scattered stands of pinyon pine and juniper, and some ponderosa pine, particularly on the north-facing slopes. The grass species associated with this woodland type include blue grama, mountain muhly, bluestem spp., side-oats grama, western wheatgrass, Arizona fescue, and three-awns.

*Soil Characteristics:* The Argiborolls, the most extensive in the association, are represented by the Aridic, Pachic, and Lithic subgroups. The Aridic Argiborolls, which are moderately deep to deep and dark-colored, usually occupy the nearly level to strongly sloping open grassland areas on basalt-capped mesas. These soils, which comprise about 20 percent of the association, have a surface layer of dark gray noncalcareous silt loam over a thick clayey subsoil. The upper part of the subsoil is a brown to dark brown noncalcareous silty clay or stony silty clay. The lower part, which commonly contains more coarse fragments, consists of a stony silty clay or stony silty clay loam. Basalt bedrock usually occurs at a depth between 40 and



Fig. 44. The Aridic Argiborolls are on the nearly level to gently sloping broad basalt-capped mesas. The stony Lithic Argiborolls are on the rolling and hilly landscapes in the far background. Steep slopes and basalt outcrops are common on the mountain and mesa side slopes.



60 inches. The boundary between the soil and basalt bedrock is indistinct as the very stony substratum grades into the fractured basalt bedrock.

Approximately 10 percent of the soils in this general soil area have been classified as Pachic Argiborolls. These soils are developing on nearly level to strongly sloping lava flows as are the Aridic Argiborolls, but their dark-colored soil layers continue to greater depths, more than 20 inches. The surface layers and upper subsoils of these Pachic Argiborolls also contain more cobble and stone. The substratum to a depth of 60 inches or more is also a cobbly clay. The coarse fragments, which are dominantly basalt, range in size from gravel and cobble to boulders. The volume of coarse fragments in these soils may range from a trace to as much as 30 percent, but is generally 5 to 15 percent.

The Lithic Argiborolls, which comprise about 20 percent of the association, are shallow gently sloping and undulating to moderately steep soils on mesa tops and ridge crests. Surface stones and a few outcrops of basalt bedrock are common. They have a dark grayish-brown to dark brown noncalcareous stony silt loam or stony loam surface layer. Their subsoil is a brown very stony clay loam. This is underlain by basalt bedrock at a depth of 10 to 20 inches.

Eutroboralfs, the other major component, comprise about 25 percent of this general soil area. These soils, which are dominantly Mollic Eutroboralfs, are also forming in parent materials of volcanic origin, including basalt, on moderately steep to steep wooded mountain side slopes. The surface layers are reddish-gray to reddish-brown neutral to slightly acid stony loams and cobbly loams. A one- to two-inch layer of fresh or partly decomposed forest litter commonly occurs on the surface. The subsoil is a thick reddish-brown to red cobbly or stony clay that typically contains 20 to 30 percent coarse fragments. This is underlain at an average depth of about 40 inches by clay-coated gravel, cobble, and stones. Approximately one-third of the Eutroboralfs are classified as Typic Eutroboralfs. These soils occur on the moderately steep side slopes of basalt-capped mesas. They are forming in colluvial-alluvial sediments weathered from basalt and sedimentary rocks. They have a light brownish-gray stony sandy clay loam or stony loam surface layer that is medium acid in reaction and is commonly covered by a one- to two-inch layer of fresh or partly decomposed organic material. Their subsoil is a brown to light yellowish-brown clay that is neutral in reaction. This grades to a massive clay substratum at depths ranging from three to four feet.

Basalt Rock Land and soils of the Aridic Argiustoll and Ustic Torriorthent subgroups comprise most of the remaining parts of this association. Basalt Rock Land, a miscellaneous land type, occurs on steep and very steep escarpments, lava flow fronts and isolated basalt hills or outcrops. It consists of a complex of shallow rocky soils and exposures or outcrops of basalt bedrock. Much of the surface between the outcrops of basalt is covered with boulders and stones which protect it from erosion. The Aridic Argiustolls occur on moderately steep and rolling alluvial fans and valley-filling slopes. These soils have a dark grayish-brown noncalcareous clay loam or loam surface layer over a thick grayish-brown to dark grayish-brown blocky clay subsoil. This is underlain to a depth of more than 60 inches by brown calcareous silty clay or clay loam. The Ustic Torriorthents, which occur on nearly level to gently sloping landscapes in valley areas, are deep and fine-textured.

*Representative Soil Series:* Barela, Hillery, Raton, and Burnac.

#### **112. Rock Land-Argiustolls-Haplustolls (152,500 acres)**

Included in this association are hilly and steep mountain foothill and intermediate mountain areas that, in general, border the high mountainous areas in the western parts of Mora and San Miguel counties. It is characterized by rough and broken topography and occurs at elevations ranging from about 6,500 to 8,300 feet. The narrow valley floors and upland summits are commonly separated by steep escarpments, canyon walls, and steep side slopes. The ridge tops, which are generally narrow, are strongly sloping to moderately steep and rolling. The narrow valley floors below the escarpments and steep side slopes are gently to strongly sloping. A wide variety of rocks contributes to the parent materials in which these soils are developing, but sandstone, limestone, and shale are the most common. These rocks often outcrop on the steep slopes and occur in a complex pattern with stony and shallow soils.

These steep mountainous and rocky lands support a wide variety of grasses, shrubs, and trees. The density of the vegetation in many parts of this association, however, is restricted because of the steep slopes, thin soils, and rock outcrops. The escarpments, rock ledges, and steep slopes also tend to limit accessibility to grazing by livestock, but the association does provide a good habitat for many species of wildlife. The vegetation consists of pinyon pine, juniper, and ponderosa pine trees, oakbrush and various other shrubs, and



Fig. 45. Rock Land-Argiustolls-Haplustolls association No. 112 has varied topography including gently to strongly sloping valley floors, strongly sloping to moderately steep and rolling ridge tops, and steep mountain side slopes, escarpments, and canyon walls.

an understory of grasses. The dominant grasses are blue grama, Arizona fescue, sideoats grama, sleepy grass, western wheatgrass, mountain muhly, and three-awns.

Rock Land, which comprises about 30 percent of the association, includes those parts of this general soil area dominated by numerous outcrops of bedrock. These outcrops commonly occur as tilted ledges and escarpments on shallow soils with variable characteristics. The shallow soils are generally cobbly or stony and moderately coarse to moderately fine in texture. Stones and boulders occur on much of the soil surface.

Lithic Argiustolls, which comprise about 30 percent of the association, consist of shallow soils forming dominantly in materials weathered residually from sandstone and sandstone interbedded with shale. Those occurring on strongly sloping to moderately steep and rolling ridge crests and side slopes have a surface layer of reddish-brown stony silty clay loam over a thin reddish-brown silty clay subsoil. This grades through a gravelly or cobbly silty clay loam to the underlying interbedded shale, sandstone, and siltstone within a depth of 20 inches. The coarse fragments, which are both angular and rounded, comprise about 15 to 35 percent of the surface layer and the layer immediately above the underlying sandstone and shale. These soils are weakly calcareous to noncalcareous. The Lithic Argiustolls on the gentler slopes are

forming principally in materials weathered from sandstone and have a thin surface layer of brown noncalcareous loam or fine sandy loam over a reddish-brown sandy clay loam subsoil. This is typically underlain by sandstone bedrock at about 12 inches, but the depth ranges from about 10 to 20 inches. There are also, however, small areas of deep Aridic Argiustolls. These occupy the nearly level to very gently sloping landscapes. They have loamy surface layers and moderately fine-textured subsoils.

Approximately 20 percent of this association consists of Lithic Haplustolls that occur on gently sloping to moderately steep and rolling limestone ridges and hills. These soils have a surface layer of dark grayish-brown calcareous stony loam which grades through a pale brown to grayish-brown stony loam to the underlying limestone bedrock at a depth of 6 to 20 inches. Angular coarse fragments usually comprise about 15 to 35 percent of the soil layers above the bedrock.

Less extensive soils in this unit include those of the Lithic Ustic Torriorthent, Typic Ustorthent and Cumulic Haplustoll subgroups. The Lithic Ustic Torriorthents, which are underlain by sandstone bedrock within 20 inches of the surface, occur on strongly sloping to hilly mountain foothill areas at the lower elevations. They usually have light reddish-brown to brown stony fine sandy loam surface layers. The Typic Ustorthents are also shallow but are forming over gneiss and schist. They have a surface layer of dark grayish-brown to grayish-brown noncalcareous stony loam. This grades through a very stony loam to the underlying bedrock at a depth of about 15 to 26 inches. The Cumulic Haplustolls are deep and occur in the nearly level to gently sloping valley bottoms. They have a thick surface layer of grayish-brown loam or clay loam over a thick subsoil of dark grayish-brown clay loam. Small acreages of Alluvial Land in drainageways and other miscellaneous land types comprise the remaining parts of this association.

*Representative Soil Series:* Bernal, Encierro, LaPorte, Travessilla, and Mirabal.

### 113. Ustorthents-Haplargids-Haplustalfs (159,100 acres)

This association occupies mountain foothill areas of the Sangre de Cristo Mountains in Taos County. Although dominated by moderately steep to steep, hilly, rough and broken lands, the topography is quite variable. It ranges from gently to strongly sloping and rolling on the alluvial fans, valley slopes, and terrace tops to steep and very steep on the mountain side slopes that extend into the

deep canyons or drainageways. The ridge and hill tops are commonly strongly sloping to moderately steep and rolling. Elevations generally range between 6,500 and 9,000 feet. The soils of this association are forming generally in old alluvial sediments of mixed origin and to a limited extent in materials weathered residually from igneous rocks. They are dominantly moderately deep and deep, gravelly, and cobbly. Gravel and cobble are common over much of the land surface, and in many places this thin mantle of coarse fragments has tended to reduce soil erosion.

This association, which is used principally as rangeland, woodland, and as habitat for wildlife, supports a wide variety of grasses, shrubs, and trees. The density of vegetation and its accessibility to livestock are somewhat restricted in parts of this association because of escarpments, rock outcrops, rock ledges, and very steep slopes. The overstory consists principally of pinyon pine and juniper trees and some thin and scattered stands of ponderosa pine at the higher elevations. Some of the more common grasses are blue grama, hairy grama, squirreltail, Kentucky bluegrass, Arizona fescue, western wheatgrass, sideoats grama, June-grass, mountain brome, bluestem species, sand dropseed, and muhly species. Shrubs include such species as mountain mahogany, Gambel oak, buckbrush, rabbitbrush, snakeweed, Apache plume, and some big sagebrush at the lower elevations.

*Soil Characteristics:* The Typic Ustorthents, which comprise about 25 percent of this association, occur on moderately steep and hilly to steep dissected landscapes. These soils usually have a surface layer of light yellowish-brown to brown sandy clay loam or sandy loam that ranges in reaction from neutral to mildly alkaline. These surface layers usually contain a few rounded gravel, and occasionally the gravel content is as much as 15 percent. The underlying materials to a depth of five feet or more consist generally of weakly stratified gravelly sandy loam, gravelly loam, or gravelly sandy clay loam. The content of coarse fragments, which usually ranges from about 15 to 35 percent, is mainly gravel, but small amounts are of cobble size. Although these subsurface layers are typically gravelly, strata of non-gravelly soil occur occasionally. Strata of sand and gravel also occur occasionally, particularly below a depth of three to four feet.

The Borollic Haplargids, which are principally on slopes facing west and south in the northern part of this general soil area, comprise about 20 percent of the association. These soils typically have a thin surface layer of brown to reddish-brown, noncalcar-

eous, gravelly loam or gravelly clay loam. The subsoil is a brown, neutral, very gravelly clay loam about 20 to 30 inches thick. Coarse fragments of gravel to cobble size comprise about 50 to 65 percent of the subsoil. This grades through a reddish-brown very gravelly or very cobbly clay loam to the underlying bedrock that usually occurs at a depth of four to five feet. It is typically fractured and weathered in the upper part.

Approximately 15 percent of this association consists of Aridic Haplustalfs. These soils occupy the more stable and less sloping landscapes that are intermingled with the steep and hilly Typic Ustorthents. They usually have a brown, noncalcareous loam surface layer over a thick clayey subsoil. This grades at a depth of three to four feet to a light reddish-brown cobbly light sandy clay loam. There is typically an increase in coarse fragments with depth in these soils, and they usually become very gravelly and coarse-textured within a depth of five feet.

Although not identified in the association name, the Aridic Argiborolls are moderately extensive as they comprise about 10 percent of the association. These soils are characterized by their moderately thick grayish-brown, noncalcareous and mildly alkaline, gravelly loam or gravelly clay loam surface layers. The subsoil is a brown, mildly alkaline very gravelly clay loam about 24 to 36 inches thick. These subsoil layers usually contain about 40 to 65 percent of coarse fragments that range in size from gravel to cobble. This grades through a light yellowish-brown gravelly sandy clay loam or cobbly sandy clay loam to the underlying bedrock, which usually occurs at a depth of about four to five feet. The underlying bedrock is typically weathered and fractured in the upper part.

Miscellaneous land types, such as Badland, Rough Broken Land, Rock Land, and Riverwash are also of some importance in this association. Badland and Rough Broken Land occur on the very steep and severely dissected lands in association with the Typic Ustorthents. Badland consists of a complex of shallow soils and exposures or outcrops of unconsolidated to weakly consolidated sedimentary deposits. It is barren or nearly barren of vegetation, and geologic erosion is active. The Rough Broken Lands also occupy steep and dissected landscapes. These lands differ from Badland in that much of the surface is covered by a thin mantle of gravelly soil material and erosion is not as active. In contrast to Badland, it usually supports a sparse to fair cover of vegetation. Although the intermingled soils have highly variable characteristics, they are dominantly shallow, gravelly, and

moderately coarse to medium in texture. The recent sandy and gravely alluvial sediments in drainage channels are included in Riverwash. Rock Land is on the escarpment areas or steep to very steep canyon walls and mountain slopes. It consists dominantly of a complex of shallow soils and outcrops of bedrock, ridges or rock, and rock slides. The small areas of soil intermingled with the rock outcrops and rock slides vary greatly. Although generally shallow, they may range from shallow to deep, and they have moderately coarse to moderately fine textures. Typically much of the land surface is covered by varying amounts of cobble, stones, and boulders.

*Representative Soil Series:* No representative or established soil series is known.

#### **114. Entroboralfs-Haploborolls (594,200 acres)**

Included in this association are extensive areas of high mountainous land in Rio Arriba and Sandoval counties. The altitude ranges from about 7,000 feet to slightly more than 11,000 feet, but it is most commonly between 7,500 and 9,500 feet. The topography, which is representative of mountainous areas, ranges from gently sloping to moderately steep on mesa and ridge tops, to steep and very steep on mountain side slopes. The small included valleys range from nearly level to very gently sloping in the immediate valley bottom to gently sloping and undulating on the adjacent side slopes and fans. Most of the soils are developing residually in volcanic materials that consist mainly of rhyolite, andesite, tuff, and pumice, or in alluvium of similar composition. These soils are dominantly neutral to slightly acid in reaction, but they may range from moderately alkaline to slightly acid. They are generally well drained, but in the valley bottoms small areas which receive considerable runoff from surrounding mountains are somewhat poorly drained.

This association is used dominantly for timber production, range, and recreation. The major soils in this unit are relatively productive and support good stands of native vegetation. The overstory vegetation consists generally of ponderosa pine, Engelmann spruce, white and Douglas fir, and some aspen, oakbrush, pinyon pine, and juniper. The more common grasses include Arizona fescue, Thruber's fescue, mountain brome, bluegrass, little bluestem, mountain muhly, Junegrass, timothy, and blue grama. Sedges, yarrow, and iris also occur, particularly in the valley bottoms where the soils are poorly drained. It also supports a number of desirable browse plants that are suitable for grazing by wildlife.

*Soil Characteristics:* The Typic Entroboralfs, which are moderately deep dark-colored soils developing on gently sloping to moderately steep landscapes such as mesa tops, are the most extensive group of soils in this association. These soils comprise about 40 percent of the association and are developing in materials weathered from rhyolitic volcanics including tuffs and pumice. They have a surface layer of dark brown noncalcareous sandy loam over a dark brown slightly acid sandy clay loam subsoil. Tuff usually underlies this soil at a depth of about 30 inches.

The Lithic Haploborolls, which are also extensive in this association (about 25 percent), occupy moderately steep to very steep mountain side slopes and ridge tops. These soils, which are also forming in materials weathered from rhyolitic volcanics, differ from the Typic Entroboralfs in being shallower, darker, having coarser-textured subsurface layers, and in being steep to very steep. They have a surface layer of dark grayish-brown slightly acid sandy loam over light brownish-gray sandy loam subsurface layers. This is commonly underlain by volcanic rocks, mainly rhyolitic, at depths of 10 to 20 inches.

Rock Land, a miscellaneous land type, is common on the rough and steep mountain sides. This type, which comprises about 15 percent of this association, consists of a complex of very shallow soils and outcrops of various types of volcanic rocks including rhyolite, andesite, tuff, and pumice. Other components of importance in this association include Andic Cryaquolls, Typic Cryaquolls, and Andic Argiborolls. The Andic Cryaquolls, which are nearly level to very gently sloping, occur in high mountain valleys. These soils have very dark gray, noncalcareous silt loam surface layers, and gray silt loam subsoils over gravel, sand, and pumice at moderate depths. They are free of lime, have a very high organic matter content, and are affected by a fluctuating water table. The Typic Cryaquolls, which also occur on nearly level to very gently sloping landscapes in valley bottoms where moisture tends to accumulate, are characterized by their dark color and high organic matter content. They have a thick surface layer of very dark gray noncalcareous silt loam. This grades through a thin layer of dark gray mottled silt loam to thick subsurface layers of dark gray clay. These clay horizons typically become lighter-colored with depth. The Andic Argiborolls consist of deep well drained soils on gently sloping and undulating valley side slopes and alluvial fans. These soils have a thick surface layer of very dark grayish-brown noncalcareous silt loam over a dark grayish-brown gravelly clay loam subsoil. This is underlain by

pumice, gravel, and cobble at about 45 inches below the surface. Deep alluvial soils also occur to a limited extent on the narrow flood plains contiguous to the major drainages. Although quite variable, the soils are generally deep, moderately permeable, and range in texture from medium to moderately fine.

*Representative Soil Series:* No series is known for the major soils in this association.

#### **115. Argiborolls-Eutroboralfs-Rock Land (326,500 acres)**

Included in this association is a moderately extensive area of high plateaus and mountains that lie in the northwestern part of Rio Arriba County. Elevations are generally between 6,200 and 8,000 feet. The unit is characterized by hilly and mountainous topography that ranges from gently to strongly sloping and rolling on the ridge crests or mesa tops to moderately steep and very steep on the side slopes that extend into the deep canyons. Interspersed with these rough broken and hilly lands, however, are some gently to strongly sloping narrow valley bottoms and alluvial fans. The soils in this association are developing in materials weathered from sedimentary rocks, principally sandstone and shale. The upland areas are dominated by cobbly and stony soils of variable depths, and those in the narrow valley areas are typically non-stony and deep. Surface textures range from moderately coarse to moderately fine. Outcrops of sandstone bedrock are common on the very steep canyon walls and escarpments.

This association is used for grazing by livestock and wildlife, recreation, and to some extent for timber production. It is moderately productive, except for small areas of rock outcrops, and supports good stands of native vegetation. The overstory vegetation consists generally of pinyon pine, juniper, ponderosa pine, and Gambel oak. Browse species such as bitterbrush, mountain mahogany, serviceberry, and some big sagebrush are also prevalent throughout this association. The more common grasses include blue grama, muttongrass, Arizona fescue, mountain muhly, mountain brome, bluegrass, galleta, sideoats grama, western wheatgrass, sand dropseed, Indian ricegrass, and threeawns.

*Soil Characteristics:* The Aridic Argiborolls, which are dominantly in the pinyon-juniper vegetation zone, comprise about 50 percent of this association. These soils are mainly on steep ridge and canyon side slopes and are developing in materials weathered principally from shale and

sandstone. The Aridic Argiborolls, forming dominantly in materials of shale origin, are the most extensive and typically have surface layers of brown to dark brown noncalcareous cobbly clay loam. Small areas of these soils, and particularly those that occur on the gently to strongly sloping ridge crests, have few cobbles in the surface layers. Their subsoil is a reddish-brown noncalcareous clay, about 20 to 30 inches thick. This grades through a reddish-brown silty clay loam to the underlying clayey shale at a depth ranging from about 30 to 50 inches. The underlying shale is typically weathered in the upper part. Approximately one-fourth of the Aridic Argiborolls are forming in materials weathered mainly from sandstone and are coarser-textured. These soils have yellowish-brown, noncalcareous, cobbly sandy loam or sandy loam surface layers over sandy clay loam subsoils. This grades through a brown sandy loam or light sandy clay loam to the underlying sandstone bedrock at a depth ranging from about 30 to 50 inches. The underlying sandstone bedrock is commonly fractured and weathered in the upper part.

The Typic Eutroboralfs, like the Aridic Argiborolls, are forming dominantly in materials weathered from sandstone and shale, but they are more strongly leached and usually have lighter-colored surface layers that contain less organic matter. These soils, which usually occur in the ponderosa pine vegetation zone, comprise about 20 percent of the association. They typically have thin neutral to slightly acid surface layers that range from sandy loam or cobbly sandy loam to clay loam in texture. A one- to three-inch layer of forest litter in various stages of decomposition commonly occurs on the surface. The soils forming in materials weathered dominantly from sandstone usually have sandy clay loam subsoils, while those developing in materials weathered mainly from shale or interbedded sandstone and shale typically have clayey subsoils. The soils forming in materials of sandstone origin are usually underlain by bedrock at a depth of about 30 inches, but may range from 20 to 40 inches. The variable amount of sandstone outcrop associated with these soils results in some very rocky areas. The soils forming in materials weathered from shale or shale interbedded with sandstone are usually deeper. The underlying shale commonly occurs at depths ranging from about 40 to 60 inches or more.

Approximately 20 percent of this general soil area consists of Rock Land. It occurs intermingled throughout this unit on the steep to very steep canyon walls and mesa side slopes and consists of a complex of sandstone and shale outcrops and

shallow soils. Although the included soils are generally shallow, they are highly variable in depth, texture, and amount of rock fragments on the surface. Small areas or pockets of moderately deep to deep stony soils occur on the escarpments where benches or areas with a lesser slope gradient have formed.

Other soils included in this association are those of Lithic Ustollic Haplargid, Ustic Torriorthent, and Cumulic Haplustoll subgroups. The shallow Lithic Ustollic Haplargids occupy gently sloping to moderately steep uplands. They often occur on the crests of ridges where they grade into the moderately deep and deep soils. These soils, which have brown, noncalcareous sandy loam surface layers and brown sandy clay loam subsoils, are underlain by sandstone within a depth of 20 inches. Numerous outcrops of sandstone are intermingled with these soils and typically comprise 10 to 25 percent of this component. The Cumulic Haplustolls and Ustic Torriorthents occur in the gently to strongly sloping valley areas. The Cumulic Haplustolls are deep dark-colored soils with medium-textured surface layers and moderately fine-textured subsoils. The Ustic Torriorthents are also deep but are finer-textured. These soils are characterized by their thin brown clay loam or clay surface layers, and reddish-brown heavy clay subsurface layers. Drainageways, Alluvial Land, and small areas of Gullied Land comprise the remaining parts of this association.

*Representative Soil Series:* No soil series is known for the major soils in this association.

#### **116. Argiborolls-Haploborolls (496,000 acres)**

This association, consisting of a moderately extensive area of soils in the north-central part of Rio Arriba County, occurs at an altitude that is mainly between 6,800 and 8,500 feet. The topography ranges from nearly level to gently sloping and undulating in the valley areas to steep and hilly in the associated uplands. There are also included steep to very steep canyon walls, escarpments, and breaks. The soils, which range from shallow to deep, are forming dominantly in materials weathered from shale, and to a much lesser extent sandstone and other sedimentary materials. In addition, there are small areas of soils on the flood plains of major streams that are forming in alluvial materials of mixed origin that have weathered from a wide variety of rock and geologic materials.

This association is used mainly for grazing of livestock and wildlife, and to a limited extent for irrigated and dry-land farming. The areas used

for farming are small and occur principally in the valley areas. Most of the irrigated land in this association occurs adjacent to the Rio Chama near the town of Chama, where irrigation water is available. It is used mainly for the production of small grains, alfalfa, and other hay and pasture crops. The extensive gently sloping valley areas not under cultivation support a good cover of grass and shrubs, including blue grama, western wheatgrass, slender wheatgrass, Junegrass, squirrel-tail, big bluestem, little bluestem, elk sedge, Arizona fescue, muhly spp., big sagebrush, and yellowbush. Pinyon pine, juniper, and oakbrush occur on the steep and hilly uplands. Ponderosa pine and Rocky Mountain juniper also occur on the steep north-facing slopes. Much of this association, however, has been extensively logged, and there has been little reestablishment of the ponderosa pine.

*Soil Characteristics:* The Aridic Argiborolls included in this association are forming residually in materials weathered from the underlying shale on strongly sloping to steep uplands. They comprise about 30 percent of the association and are mainly on slopes facing north and east. These soils have grayish-brown clay loam or silty clay loam surface layers and grayish-brown to brown clay subsoils. These grade through a silty clay loam of similar color to the underlying shale. The depth to shale averages about 30 inches but ranges from



**Fig. 46.** Nearly level to gently sloping and undulating valley areas are common in the Argiborolls-Haploborolls association No. 116. The soils on these land forms are dominantly deep and fine-textured. Shallow Aridic Argiborolls and small areas of Rock Land occur on wooded slopes in the background.

about 20 inches to slightly more than 40 inches. These soils are typically noncalcareous in the surface layer and the upper subsoil. An additional 20 percent of this association are shallow Aridic Argiborolls. These soils are like the described Aridic Argiborolls, but they are typically underlain within a depth of 20 inches by shale that is commonly slightly weathered in the upper part.

Approximately 20 percent of this general soil area consists of Aridic Haploborolls. These soils, like the shallow Aridic Argiborolls, are dark-colored and are underlain by shale within a depth of 20 inches, but they lack the fine-textured and well developed subsoils of the Argiborolls. These soils, which occupy strongly sloping to steep and rolling uplands, have surface layers of grayish-brown to dark grayish-brown calcareous clay loam or silty clay loam. This grades through a grayish-brown strongly calcareous clay loam that often contains some partly weathered shale fragments to the underlying shale which occurs at a depth of less than 20 inches.

In addition to the three major soil groups, moderately extensive areas of deep medium- to fine-textured soils are found in the nearly level to gently sloping valley areas of the association. These soils, which are developing dominantly in alluvium from shales and sandstone, are characterized by their dark-colored loam, clay loam, or silty clay loam surface layers. The subsoil and subsurface layers are dominantly moderately fine- to fine-textured. Also of importance in this association are Typic Ustifluvents, which are forming in alluvium of mixed origin on the nearly level to gently sloping flood plains and terraces adjacent to the major streams. These soils typically have grayish-brown loam or light clay loam surface layers that are neutral to slightly alkaline in reaction. The subsurface layers usually consist of stratified loams, sandy clay loams, and clay loams. Thick strata of sand and gravel or very gravelly sandy loams and very gravelly loams are common below a depth ranging from about two to three feet. Although there are some small areas of poorly drained soils in the valley bottoms, the majority of these soils are adequately drained or well drained.

Miscellaneous land types such as Rock Land, Badland, Gullied Land, and Alluvial Land, are also included in this association. Rock Land, the most extensive of these inclusions, consists of a complex of shallow, stony soils and outcrops of bedrock dominated by sandstone. It includes the very steep canyon walls and escarpments that usually extend from the mesa tops down towards the valley floors. Colluvial soil materials with

numerous loose boulders and stones on the surface commonly occur on the slopes below the outcrops of bedrock. Badland includes the barren or nearly barren outcrops of shale. The small areas dissected by deep gullies are included in Gullied Land. Alluvial Land usually occurs on terminal points of fans and on the immediate flood plains of streams and arroyos. It consists of recent alluvial sediments that are highly variable in texture and other characteristics, and are subject to overflow and removal or deposition of additional sediments.

*Representative Soil Series:* No representative or established series is known for the principal soils in this association.

#### **117. Rock Land-Ustorthents (342,700 acres)**

This association, which is characterized by rough and broken topography and very steep slopes, includes escarpments, steep canyon walls, rocky ridge tops, rock slides, rock ledges, and steep breaks, all of which are dominated by rock outcrops and small areas of highly variable soils. The exposed bedrock consists of sandstone, shale, tuff, basalt, quartzite, and granite. Those parts of this association with outcrops of tuff, sandstone, and basalt contain vertical or near vertical and precipitous cliffs and escarpments that surround many of the mesas to form colorful canyon walls. This general soil area occurs mainly in the mountain foothill areas in the south-central and north-central parts of Rio Arriba and Sandoval counties, respectively.

These steep rocky lands produce a wide variety of grasses and shrubs, and some trees. Many parts of this association, however, are only sparsely vegetated because of steep slopes, thin soils, and rock outcrops. Livestock grazing is also limited by the escarpments, rock ledges, and steep slopes. It does, however, provide a good habitat for many species of wildlife. Some of the more common grasses are blue grama, sideoats grama, Indian ricegrass, western wheatgrass, sand dropseed, needle-and-thread, little bluestem, and poverty three-awn. The more common shrubs and woody species include pinyon pine, juniper, big sagebrush, bitterbrush, serviceberry, chamiza, rabbitbrush, and broom snakeweed. A few stunted *ponderosa* pine also occur at the higher elevations on the more favorable sites.

*Soil Characteristics:* This association is dominated by miscellaneous land types. Rock Land, which comprises about 70 percent of the association, consists dominantly of a complex of shallow soils and outcrops of sandstone and other sedi-

mentary rocks as well as igneous rocks. Small areas of moderately deep and deep soils occur as pockets among the rock outcrops and ledges. The rock outcrops commonly occur as vertical or nearly vertical exposures and ledges. The small areas of soil interspersed with the rock outcrops are highly variable and their characteristics are greatly influenced by the type of rock from which the parent materials have weathered. For example, the soils forming in materials weathered from granite and tuff are usually moderately coarse to medium in texture, but the soils forming in material weathered from shale are usually moderately fine to fine in texture. Those parts of this unit dominated by outcrops of granite and quartzite occur mainly on steep mountain side slopes. These areas usually contain less rock outcrop, and more loose rock and stones. Typically much of the land surface is covered by cobbles, stones, and boulders.

Rough Broken Land and Typic Ustorthents comprise about 20 percent of the association and include those areas containing numerous outcrops or exposures of shales and clays with some interbedded sandstone. These lands, which are usually moderately steep to steep and severely dissected, consist of a complex of shallow Typic Ustorthents and outcrops of shale and other sedimentary materials. Although there are some rock outcrops, much of the exposed sedimentary material is unconsolidated or poorly consolidated. The included Typic Ustorthents are quite variable and range in texture from moderately coarse to fine. They are typically underlain by clayey shales or other sedimentary materials within a depth of 20 inches, but occasionally they are as deep as 30 inches or more. A few stones and some rock usually occur over much of the land surface. Vegetation is typically sparse, and as a result, geologic erosion is active throughout much of this unit.

In addition to these land types, small areas of deep alluvial soils occur in the narrow valley bottoms adjacent to drainages. These soils are generally light-colored, and range in texture from sandy to clayey.

*Representative Soil Series:* The soils are dominantly land types; no series is known among the included soils.

#### 118. Eutroboralfs-Argiborolls (366,500 acres)

This association consists generally of the Zuni Mountains in McKinley and Valencia counties. The altitude ranges from about 7,000 feet to 9,256 feet on the crest of Mt. Sedgwick, but is most commonly between 7,500 and 8,500 feet. The topography is varied, ranging from nearly level to

strongly sloping in the valley areas to steep and very steep on the mountain side slopes, upland ridges, and escarpment or breaks areas. There are also moderately extensive areas of ridge and mesa tops that are gently sloping to moderately steep and rolling. The soils are forming dominantly in materials weathered from granite, schist, gneiss, and sedimentary rocks including sandstone, shale, limestone, and siltstone. They are usually deep in the valley areas and moderately deep to deep on the gently sloping mesa and ridge tops. Shallow to moderately deep soils and rock outcrops commonly occur on the strongly sloping to steep hilly uplands, canyon side slopes, and steep rough and broken areas.

This association is used for timber production, range, recreation, and as a watershed area. The major soils in this unit support a good cover of native vegetation that is dominated by tree species consisting of ponderosa pine, pinyon pine, juniper, and Gambel oak. Some Douglas fir and limber pine also occur on north-facing slopes and at the higher elevations. A wide variety of grasses and shrubs occurs in open areas and where the tree cover is not particularly dense. Arizona fescue, mountain muhly, squirreltail, Junegrass, blue grama, sand dropseed, and pine dropseed are some of the important grass species. Mountain mahogany, Apache plume, cliffrose, Oregon grape, and rabbitbrush are common shrubs.

*Soil Characteristics:* Eutroboralfs, which are the most extensive in this association, vary somewhat in characteristics because of differences in land



Fig. 47. General view of gently to strongly sloping and undulating crest or mesa top in the Eutroboralfs-Argiboralfs association No. 118. The steep mountain side slopes, breaks, and escarpments, which are also extensive, are not shown.



forms and parent materials. The Typic Eutroboralfs comprise approximately 25 percent of this general soil area, and those forming in materials weathered from sedimentary rocks usually occupy gently sloping to moderately steep and hilly landscapes on mesa tops, ridges, and sideslopes of canyons. These soils commonly occur as complexes with outcrops of sandstone and other sedimentary materials; they vary considerably in texture, stone content, and thickness of the soil horizons. Stones and boulders usually occur on the surface. Typically they have a thin grayish-brown, neutral, stony fine sandy loam or stony loam surface layer over a reddish-brown and light yellowish-brown clay subsoil. The depth to sandstone or interbedded shale and sandstone is usually 20 to 24 inches, but it may range from 18 to as much as 36 inches. Although considerably less extensive, there are small areas of these soils on gently sloping and undulating mesa or ridge crests that are quite uniform in characteristics. These soils typically have fine sandy loam or loam surface layers and sandy clay or clay subsoils that rest on sandstone bedrock at a depth of 20 to 40 inches. The Typic Eutroboralfs forming in materials of igneous origin are mainly on gently to strongly sloping and rolling uplands. These moderately deep to deep and well-drained soils have a sandy loam or gravelly sandy loam surface layer about 12 inches thick and neutral to slightly acid in reaction. It ranges from grayish-brown in the upper part to light reddish-brown or pinkish-gray in the lower part. A one- to two-inch layer of partially decomposed and undecomposed needles, leaves, and twigs commonly lies on the surface. Their subsoil is a reddish-brown or brown clay or heavy clay loam about 15 to 20 inches thick. This grades through a substratum consisting of a reddish-brown, brown, or yellowish-red sandy clay loam mixed with weathered granite to the underlying bedrock. The depth to bedrock is usually between 36 and 48 inches, but it ranges from 20 inches to as deep as 70 inches. In addition to these Eutroboralfs, approximately five percent of soils in this unit are in the Lithic Eutroboralf subgroup. These soils, which occupy strongly sloping to moderately steep and hilly uplands, have pinkish-gray or light brownish-gray, neutral stony sandy loam or sandy loam surface layers over a pinkish-gray to brown stony sandy clay loam or stony clay loam subsoil. This grades through a sandy clay loam containing many fragments of sandstone to the underlying bedrock.

The Argiborolls, the other extensive group of soils in this association, are mainly in the Typic and Lithic subgroups. The Typic Argiborolls, which comprise about 15 percent of the associa-

tion, are forming residually in materials weathered from siltstone, fine-grained sandstone, and some interbedded shales on gently sloping and undulating to moderately steep and hilly uplands. These soils are characterized by their reddish-brown silt loam or stony silt loam surface layer that is neutral in reaction. Their subsoil is a reddish-brown silty clay loam. This grades through soil of similar color and texture that typically contains many fragments of weathered sandstone and siltstone to the underlying bedrock which usually occurs at a depth between 20 and 30 inches. Fractured and slightly weathered bedrock, however, may occasionally be as shallow as 10 inches or as deep as 40 inches. The Lithic Argiborolls, in contrast to the Typic Argiborolls are shallow. They comprise about 10 percent of the association and are forming in materials weathered residually from limestone on gently sloping to steep uplands. These soils have a surface layer of noncalcareous stony loam over a reddish-brown clay subsoil. This is underlain by limestone bedrock at a depth of 10 to 20 inches.

In addition, about 15 and 10 percent of this general soil area consists of Rock Land and Typic Ustorthents, respectively. Rock Land consists dominantly of a complex of shallow soils and outcrops of sandstone and other types of rocks. Although the outcrops of bedrock usually occur as vertical or nearly vertical exposures or ledges on the steep to very steep slopes, they occur in this general soil area on gently sloping to moderately steep uplands. A thin mantle of soil with highly variable characteristics generally occurs as small areas or pockets between the ledges or outcrops of bedrock. Although the soils intermingled with the rock outcrops are typically shallow, small areas or pockets of moderately deep to deep soils occasionally occur where benches or areas with a lesser slope gradient have formed.

The Typic Ustorthents have a surface layer of grayish-brown stony loam or stony sandy loam that is neutral in reaction. This grades through a grayish-brown and pale brown very cobbly or very gravelly sandy loam to the underlying granite or granitic gneiss bedrock at a depth of about 15 to 26 inches. In addition to the coarse fragments that may comprise 45 to 65 percent of subsurface layers, rock outcrops occur occasionally. The strongly sloping and rolling to steep Typic Ustorthents usually occur on low hills, narrow ridge tops, and mountain side slopes.

Other soils of importance in this association include those of the Cumulic Haploboroll, Cumulic Cryoboroll, Ustic Torrifluent, and Udic Haplustoll subgroups. The Cumulic Haploborolls occur mainly on gently to strongly sloping alluvial fans and side

slopes in valley areas. These deep soils are characterized by their thick dark-colored and loamy surface layers over medium- to moderately fine-textured subsoils and substrata. The Cumulic Cryoborolls are the nearly level to gently sloping, deep, dark-colored, and imperfectly drained soils on flood plains and valley floors. They have thick dark grayish-brown loam to clay loam surface layers and silty clay loam subsoils and substrata. The Ustic Torrifluvents, which occur on gently to strongly sloping valley-filling slopes and valley bottoms, are also deep. These soils have a surface layer of reddish-brown loamy fine sand or fine sandy loam over weakly stratified loamy fine sands and fine sandy loams to a depth of 60 inches or more. They are susceptible to both gully and wind erosion. The gently sloping and undulating to moderately steep Udic Haplustolls are forming dominantly in moderately coarse- to medium-textured alluvial and eolian sediments. They have a brown to reddish-brown noncalcareous fine sandy loam surface layer over a yellowish-brown, noncalcareous fine sandy loam and heavy fine sandy loam subsoil. Typically these soils are deep, but occasionally they are underlain by bedrock at moderate depths.

*Representative Soil Series:* Osoridge, Zuni, Fortwingate, Jekley, Kiln, Mirabal, Kettner, McGaffey, Polich, and Savoia.

#### **119. Eutroboralfs-Ustorthents (262,500 acres)**

Included in this association are the Chuska Mountains in the northwestern part of the state. The altitude ranges from about 7,000 to 9,000 feet, but it is most commonly between 7,500 and 8,500 feet. It is characterized by relatively broad gently sloping to rolling plateau or mountain tops and very steeply sloping mountain side slopes and escarpments. The rough, very steep, and mountainous topography typical of the side slopes is more extensive than that occurring on the ridge crests. The soils in this unit are developing dominantly in parent materials of sandstone origin. Other sedimentary materials or rocks and eolian sediments have contributed minor amounts to the parent materials.

The soils of this association are best used for forestry, range, and recreation. The major soils in the unit are relatively productive and support good stands of native vegetation. The overstory vegetation consists dominantly of ponderosa pine, Gambel oak, and some pinyon pine and juniper. The more common grasses include Arizona fescue, mountain brome, bluegrass, needlegrass, and blue grama. They also support a number of desirable

browse plants, such as mountain mahogany, cliffrose, vetch, and peavine. This association, with its capability to produce a wide variety of vegetation, provides good habitats for many species of wildlife.

*Soil Characteristics:* Eutroboralfs, which comprise about 50 percent of the association, are nearly equally divided between the Typic and Lithic subgroups. The Typic Eutroboralfs, which are deep and dark-colored soils, occur mainly on steep mountain slopes. These soils have a thick grayish-brown loam surface layer that is neutral in reaction. This is usually underlain to a depth of four feet or more by a yellowish-brown loam or light clay loam. A few outcrops of sandstone may occur locally. The Lithic Eutroboralfs are forming residually in materials weathered dominantly from sandstone. They occur mainly on gently sloping and undulating ridge and mesa tops at elevations of about 7,500 and 8,500 feet. These soils have a brown to grayish-brown, neutral, loam or cobbly loam surface layer over a brown sandy clay or clay subsoil. Sandstone or interbedded sandstone and shale occur at a depth ranging from about 10 to 20 inches. Coarse fragments are mainly sandstone and usually comprise 5 to 25 percent of the surface layer and 5 to 15 percent of the subsoil.

The Lithic Ustorthents, which are shallow, occur on moderately steep and hilly landscapes. They comprise about 15 percent of this unit and have a thin surface layer of dark brown sandy loam or fine sandy loam that is neutral in reaction. This grades through a light brown sandy loam to the underlying sandstone bedrock at depths ranging from about 8 to 20 inches. Small angular fragments of sandstone are common in the soil layers immediately above the bedrock.

Rock Land, a miscellaneous land type, is common on the steep canyon walls, escarpments, and the steep rough and broken mountain side slopes. It consists dominantly of a complex of shallow soils and outcrops of sandstone and other sedimentary rocks. The outcrops of bedrock commonly occur as vertical or nearly vertical exposures or ledges on the steep to very steep slopes. A thin mantle of soil with highly variable characteristics generally occurs between the rock outcrops. Stones and boulders are common over much of the land surface. Although the soils intermingled with the rock outcrops are generally shallow, small areas or pockets may be moderately deep and deep. About 20 percent of the association is in this land type.

Less extensive soils include a number of moderately deep and deep unclassified soils. The moderately deep soils usually occur on gently sloping to



Fig. 48. The gently sloping and undulating Lithic Eutroboralfs typically occur on high plateau or mountain tops in Eutroboralfs-Ustorthents association No. 119.

rolling upland ridges and mesa tops. Typically, these soils have a thin brown or grayish-brown loam or fine sandy loam surface layer over a sandy clay subsoil. Sandstone or sandstone interbedded with shale usually occurs at a depth of 20 to 40 inches. The unclassified soils also include a deep, dark-colored soil that occurs in association with the Lithic Eutroboralfs on the plateau or mesa tops. It occupies the nearly level to gently sloping open park or valley areas. This soil has thick surface layers of very dark brown, noncalcareous loam. Its subsoil is a brown noncalcareous sandy clay loam or loam. Sandstone bedrock usually occurs at depths greater than 60 inches. Also in this association is a small acreage of deep alluvial soils. They usually occur on narrow flood plains contiguous to intermittent drainages. Although normally quite variable, they are generally deep and moderately permeable, and range in texture from medium to moderately fine.

*Representative Soil Series:* Vamer in the Lithic Eutroboralfs is the only known soil series.

#### 120. Argiustolls-Rock Land (428,700 acres)

This association, which is in McKinley, Valencia, and Sandoval counties, includes the basalt-capped mesas, lava flows, and volcanic hills that surround Mount Taylor. The topography is varied, ranging from gently to strongly sloping and undulating on the mesa and ridge tops to steep and very steep on the mesa sides, escarpments, and breaks. Although

elevations range from about 6,500 feet at the base of mesas to almost 9,000 feet on a few of the high peaks, most of this area occurs between elevations of 7,000 and 8,500 feet. The soils are forming dominantly in materials weathered from basic volcanic rocks, principally basalt. Ash, cinders, and eolian sediments of mixed origin have also contributed to the parent materials in which these soils are developing. Although the depth of the soils varies, they are dominantly shallow to moderately deep. Many are stony or cobbly, and outcrops of basalt rock are common, particularly on the escarpment and steep mesa fronts.

The vegetative cover is variable and consists of extensive grassland or open park-like areas intermingled with areas having an overstory vegetative cover of pinyon pine and juniper trees. Thin and scattered stands of ponderosa pine also occur, particularly on the slopes facing north and east at the higher elevations. The more common grasses are Arizona fescue, blue grama, western wheatgrass, mountain muhly, mountain brome, and little bluestem. The overstory of trees typically occurs on the stony and rocky soils occupying the ridges, hills, mesa breaks, and the outer fringes of the mesa tops.

*Soil Characteristics:* Argiustolls, which are characterized by their dark-colored surface layers and well developed subsoils, are dominant in this association. Aridic Argiustolls, which comprise about 40 percent of the association, consist of moderately deep and deep, nearly level to gently sloping soils on basalt-capped mesas. These moderately deep soils have a thin surface layer of dark brown noncalcareous stony clay loam. Their subsoil is a noncalcareous cobbly clay that ranges in color from dark brown in the upper part to brown in the lower part. This grades through a strongly calcareous gravelly or cobbly clay loam to the underlying basalt bedrock at depths ranging from about 20 inches to as much as 40 inches. This bedrock is usually fractured and broken in the upper part and frequently contains voids that are filled with soil material similar to that in the horizon immediately above the bedrock. The deep Aridic Argiustolls occupy nearly level to gently sloping grassland areas in this association. These soils have a surface layer of brown noncalcareous loam or silt loam over a thick clayey subsoil. This grades at a depth of about 30 inches to a light brown strongly calcareous clay loam that is easily penetrated by roots. A pinkish-gray layer of high lime accumulation commonly occurs at a depth of 48 to 60 inches, but it may occasionally occur within 30 inches of the surface. The Lithic Argiustolls

are not as extensive, comprising only about 10 percent of this association. They consist of shallow dark-colored soils on gently to strongly sloping and rolling mesa tops and fronts of lava flows. Surface stones and a few outcrops of basalt are common. They have a surface layer of dark grayish-brown, noncalcareous, stony loam or stony clay loam. Their subsoil is brown cobbly clay. This is underlain by basalt bedrock at depths ranging from 10 to 20 inches.

Approximately 30 percent of this general soil area consists of Rock Land. This miscellaneous land type occurs on the steep mesa sides, escarpments, lava flow fronts, and isolated hills and ridges dominated by outcrops of basalt. It consists of a complex of shallow stony soils and outcrops of bedrock. The rock outcrops consist dominantly of basalt, but on the lower parts of the steep mesa side slopes or escarpments sandstone and other types of sedimentary rocks outcrop occasionally. Much of the land surface between the rock outcrops is covered with boulders and stones. Although shallow stony soils and outcrops of bedrock are dominant, small areas or pockets of moderately deep and deep soils occur where benches or areas with a lesser slope gradient have formed. This land type is only slightly susceptible to erosion due to the protective cover of stones, boulders, and vegetation.

Also of importance in this association are Lithic Calcistolls and Ustollic Haplargids. The Lithic Calcistolls occur on gently sloping and undulating grassland areas. These soils are also shallow but are strongly calcareous and have a layer with a high



Fig. 49. Rock Land, which occurs mainly on the steep and very steep breaks, escarpments, and mesa side slopes. The Aridic and Lithic Argiustolls are dominantly on the gently to strongly sloping and undulating mesa ridge tops.

lime content above the basalt bedrock. They have grayish-brown strongly calcareous gravelly loam or loam surface layers. This grades through a gray gravelly loam with a high content of lime to the underlying basalt bedrock at a depth of 10 to 20 inches. White lime coatings that are weakly to strongly cemented occur on rock surfaces and in pockets on rock fractures. The lime layer above the bedrock is occasionally strongly cemented. Ustollic Haplargids occur to a limited extent on the mesa tops at the lower elevations in this association. These soils, which have fine sandy loam surface layers and heavy clay loam subsoils, are underlain by soft caliche or pinkish-white loamy layers with a high content of lime at depths ranging from 20 to 40 inches.

The remaining parts of this association consist of small areas of unclassified soils, a number of small intermittent lakes, and other miscellaneous land types. The intermittent lakes usually contain water for short periods following heavy rains during later summer or early fall seasons. The unclassified soils usually occur in small depressional areas and valley bottoms. They are typically deep and range in texture from medium to fine.

*Representative Soil Series:* Thunderbird, Torreon, Cabezon, and Rudd.

#### **121. Argiborolls-Argiustolls-Rock Land (360,600 acres)**

This association consists of soils and land types in the Manzano and Sandia ranges, mainly in Valencia and Bernalillo counties. Although topography is variable and slope gradients may range from less than 10 percent to more than 70 percent, this unit is dominated by moderately steep to very steep mountainous landscapes. The west-facing slopes of these mountain ranges are particularly steep and consist generally of stony and shallow soils intermingled with rock outcrops, rock ledges, and rock slides. The rock areas on these very steep slopes and escarpments are made up mostly of limestone exposed on the uplifted escarpment face and igneous intrusions below the limestone. The mountain crests and the east-facing slopes of the Manzano and Sandia mountains are gently sloping to very steep. Most of the soils in this part of the association are underlain by bedrock at a depth of two to five feet.

This association is used for recreation, grazing by wildlife, and to a lesser extent for timber production and grazing by livestock. The major soils support good stands of native vegetation, mainly ponderosa pine, limber pine, Douglas fir, white fir, and alligator juniper, with an understory of

deciduous oaks and shrubs and a ground cover of short and mid grasses. The overstory vegetation on the very steep west-facing slopes consists dominantly of pinyon pine and juniper trees.

*Soil Characteristics:* The great differences in elevations, which cause significant differences in climate and kinds of vegetation, have contributed to the formation of many kinds of soil in this association. The Typic Argiborolls, although comprising only about 20 percent of this association, are one of the more representative and extensive groups of soils in this unit. These soils normally have moderately thick dark-colored, noncalcareous loam, stony loam, clay loam, or stony clay loam surface layers over clay or stony and cobbly clay subsoils that are usually limy in the lower part. In approximately one-half of these soils limestone bedrock occurs at depths of 20 to 30 inches. In the remainder, bedrock occurs at an average depth of about four feet and is occasionally deeper.

The Aridic Argiustolls, which comprise about 15 percent of this general soil area, are steep and stony. They typically have a surface layer of dark-brown stony or cobbly loam over a reddish-brown cobbly clay loam subsoil. They are usually underlain by schist bedrock at depths ranging from 20 to 50 inches. Coarse fragments in the soil profile range from about 20 to as much as 70 percent.

Rock Land also comprises about 15 percent of this association. It is particularly extensive on the western slopes of the Manzano and Sandia mountains. It consists of a complex of rock outcrops, rock slides, and soils with highly variable characteristics. The relief is normally staircase or is characterized by cliffs. The slope ranges from moderately sloping on the top of the cliffs to very steep or vertical on the escarpments. Limestone outcrops are dominant, but igneous rock, gneiss, and schist also occur. Soil material that is mainly dark-colored, loamy, and shallow occurs as small pockets between the rock outcrops.

Also of importance and of moderate extent in this association are soils of the Typic Cryoboroll and Typic Eutroboralf subgroups. The Typic Cryoborolls are cold soils and typically occur on steep north- and east-facing slopes. They normally have a thin layer of decomposing forest litter over a thick layer of dark grayish-brown loam. This is underlain by a moderately thick layer of grayish-brown very stony loam to a substratum of very pale brown very stony loam, with bedrock at about 30 inches. The Typic Eutroboralfs generally have a thin patchy layer of decomposing litter over a thin dark-colored, neutral to slightly acid surface layer. Below this is a light-colored slightly acid leached

horizon that typically tongues in the underlying subsoil. The subsoil is dominantly reddish-brown and moderately fine to fine in texture. The depth to parent materials is about 24 to 50 inches.

In addition to major soils and land types already listed there are also inclusions of Lithic Haplustolls, which are shallow, and unclassified deep alluvial soils. The alluvial soils usually occur on flood plains and swales and are dark-colored and medium to moderately fine in texture.

*Representative Soil Series:* Wilcoxson, Turkey-springs, Pino, Capillo, Salas, Supervisor, Crest, Jekley, and Fuera.

## 122. Haplargids-Haplustolls-Argiborolls (177,300 acres)

This association is mainly in the foothills on the extreme eastern slopes of the Manzano and Sandia mountains. It consists mainly of rolling to steep mountain foothills and intermingled gently to strongly sloping alluvial fans and valleys. The soils, like the topography, are quite varied. Those on the rolling and hilly foothills are shallow to moderately deep and are forming residually in materials weathered principally from limestone. In the valleys and on the alluvial fans, the soils are forming in alluvium and are generally deep.

Much of this association, particularly on the shallow and moderately deep soils of the foothills and upland ridges, is heavily wooded with pinyon pine and juniper trees. The deep soils in the valleys and on the alluvial fans generally support a fair to good cover of grass. The more common grass and shrub species include blue grama, sidecoats grama, New Mexico feathergrass, galleta, sand dropseed, western wheatgrass, Indian ricegrass, ring muhly, three-awns, and some big sagebrush, rabbitbrush, and broom snakeweed. Many of the deep, gently sloping soils in this association were formerly dry-farmed, but, frequent crop failures resulted from unfavorable climate, and the majority of the dry cropland has been returned to range use.

*Soil Characteristics:* Approximately 30 percent of this association consists of Ustollic Haplargids. These soils are dominant on the broad gently to strongly sloping alluvial fans and piedmont slopes. They typically have a thin surface layer of light brown to brown, noncalcareous loam over a thick subsoil of reddish-brown clay loam that is noncalcareous in the upper part. A few threads and small soft masses of lime are common in the lower part of the subsoil. This is usually underlain by a pinkish-white very limy loam at depths of 40 to 50 inches.

The Lithic Haplustolls, which are extensive on the strongly sloping and rolling to steep hills and ridges, have a grayish-brown, calcareous stony loam or loam surface layer. This grades through a pale brown or brown strongly calcareous stony or cobbly loam to the underlying limestone bedrock at a depth of about 8 to 20 inches.

The Typic Argiborolls comprise about 15 percent of this general soil area. These soils occur on gently to strongly sloping upland ridge crests, on benches between ridges of shallow soils, and on steep mountain side slopes. They typically have moderately thick, dark-colored, noncalcareous, stony loam, or clay loam surface layers over a clay or stony clay subsoil that is usually limy in the lower part. The substratum is a pinkish-white very limy silty clay loam that grades into weathered limestone at a depth of about four feet.

Also in this association are Ustollic Camborthids, Lithic Ustollic Calciorthids, Aridic Argiustolls, and miscellaneous land types including Rock Land, Steep Stony Land, and Alluvial Land. The Ustollic Camborthids usually occupy gently to strongly sloping and undulating piedmont slopes. These deep soils typically have moderately thick, weakly calcareous, reddish-brown loam surface layers, reddish-brown heavy loam or clay loam subsoils, and strongly calcareous loamy substrata that usually contain some segregated lime in the form of soft masses and fine threads. The Lithic Ustollic Calciorthids, which commonly occur on strongly sloping and rolling ridges and low hills, are characterized by their brown or grayish-brown, calcareous, channery loam surface layers. These are underlain by soil of similar texture that becomes lighter colored and more limy with depth. The angular fragments of limestone also commonly increase with depth and may comprise as much as 70 percent of the soil mass above the limestone bedrock that underlies these soils within a depth of 20 inches. The Aridic Argiustolls, which are moderately deep stony soils, typically have dark brown cobbly or stony loam surface layers over cobbly clay loam subsoils. They are usually underlain by chist bedrock at depths of 20 to 50 inches.

*Representative Soil Series:* Witt, Wilcoxson, Turkeysprings, and LaPorte.

### **123. Haploborolls-Cryoborolls (778,800 acres)**

This association consists of an extensive area of high mountainous land in Otero and Lincoln counties. The altitude ranges from about 7,000 feet in the foothills to 12,003 feet on Sierra Blanca, the highest point in the southeastern part of New Mexico, but is most commonly between 7,500

and 10,500 feet. It is characterized by mountainous topography that ranges from gently sloping to moderately steep on ridge tops and valley areas to very steep on the mountain side slopes. The soils are typically dark-colored with a moderate to high content of organic matter and mildly alkaline to slightly acid in reaction. The surface layers commonly contain a few gravel and stones; some areas are very stony. The soils are forming dominantly in materials weathered residually from the underlying limestone bedrock or in colluvial and alluvial sediments from such rocks. Other types of sedimentary rocks, as well as igneous rocks, however, have contributed lesser amounts to the parent materials in which the soils of this association are developing. The soils forming in materials of igneous origin occur dominantly in the northern part of this general soil area.

This association is used principally for timber production, range, and recreation. It is also an important watershed area, and a number of perennial streams originate in this general soil area. With the exception of the small rock outcrop areas, it supports, in general, a good cover of native vegetation that is dominated by tree species. The more common species are ponderosa pine, Douglas fir, white fir, Engelmann spruce, Mexican white pine, and some aspen, Gambel oak, pinyon pine, and juniper. The more common and representative grasses are Arizona fescue, Thurber's fescue, mountain brome, Junegrass, bluegrass, stipa species, blue grama, sideoats grama, and little and big bluestem. It also supports a number of desirable browse plants suitable for wildlife grazing.

*Soil Characteristics:* The Haploborolls, which are dominant in this association, are members of the Typic, Pachic, Lithic, and Cumulic subgroups. Typic Haploborolls comprise about 45 percent of this unit and occur mainly on the moderately steep to steep mountain side slopes. They usually have a thin surface layer of very dark grayish-brown very cobbly or cobbly clay loam that is mildly alkaline in reaction. A one- to three-inch layer of partially decomposed and undecomposed needles, leaves, and twigs commonly lies on the surface. The subsoil is a dark grayish-brown, mildly alkaline, very cobbly clay loam about 7 to 10 inches thick. This grades through a brown, moderately alkaline very cobbly clay loam to the underlying bedrock that commonly occurs at a depth of about 30 inches but may range from 20 to 40 inches below the surface. The upper few inches of the underlying bedrock is usually highly fractured. A weak accumulation of lime occurs in the substratum in the form of small soft masses and

coatings on the underside of the coarse fragments. Approximately 15 percent of this association consists of Pachic Haploborolls, which occur on less sloping landscapes, the gently to strongly sloping and rolling ridge tops, and uplands. They are characterized by a thick surface layer of very dark grayish-brown stony silty clay loam that is neutral in reaction. Their subsoil is a very dark grayish-brown very cobbly silty clay loam or clay loam. This grades through a brown very cobbly clay loam to the underlying fractured limestone bedrock at a depth ranging from 20 to 40 inches. The stones and cobbles, which consist of limestone fragments, may comprise as much as 85 percent or more of the soil mass in the layers immediately above the underlying bedrock. The Lithic Haploborolls are shallow and occur generally on moderately steep to steep ridge tops and mountain side slopes. These soils have a thin surface layer of very dark grayish-brown very stony loam over a dark grayish-brown cobbly heavy loam subsoil. They are typically underlain by igneous bedrock at a depth of 10 to 20 inches. The Cumulic Haploborolls are forming in alluvial sediments of mixed origin in gently sloping to moderately steep valley areas. These deep soils usually have dark-colored loam, clay loam, or silty clay loam surface layers. They typically have a high content of organic matter and are generally neutral to mildly alkaline in reaction. The subsurface layers are medium to fine in texture.

The Pachic Cryoborolls, which comprise about 15 percent of the association, usually occur on the ridge tops and on mountain side slopes facing north and east. They range from strongly sloping and rolling on the ridge crests to very steep on the side slopes. These soils have thick surface layers of very dark grayish-brown clay loam. They are neutral in reaction and usually have thin organic layers of decaying forest litter on the surface. It is also common for these surface layers to contain a few cobbles and stones. The subsoil is a brown cobbly and very cobbly clay loam that ranges in reaction from neutral in the upper 12 to 18 inches to mildly alkaline and calcareous in the lower part. This is underlain at depths of about four to six feet by boulders, flagstone, and fractured bedrock. A small amount of soil material commonly occurs in the fractures and between the coarse fragments.

Rock Land, also important in this association, commonly occurs near the mountain crests and on the steep canyon walls and escarpments. It consists of a complex of shallow soils and outcrops of bedrock. The outcrops occur as vertical or nearly vertical exposures and ledges. The inter-



**Fig. 50.** Steep mountainous landscapes in the Haploborolls-Cryoborolls association No. 123. Eagle Lake, in the foreground, is within the Mescalero Apache Indian Reservation.

persed soils are usually shallow and moderately coarse to moderately fine in texture. Numerous stones and boulders are common on the surface of the included soils. These soils are dominantly shallow, but there are small areas and pockets of moderately deep to deep soils.

The association also includes drainage bottoms, seep areas, and miscellaneous land types such as Alluvial Land. The Alluvial Land commonly occurs as small areas in valley bottoms on narrow flood plains adjacent to drainages. These soils may range in texture from coarse to moderately fine. They are usually very stratified and often contain gravelly and stony layers. The seep and wet areas also usually occur in the valley bottoms in connection with springs. They are usually small but may range in size from a fraction of an acre to several acres or more. Peat and muck layers of variable thicknesses are common in these seep and wet areas.

*Representative Soil Series:* Peso, Mescalero, Firo, Caballo, and Bryan.

#### **124. Calciustolls-Rock Land (1,631,400 acres)**

This association consists of soils and land types on mountain footslopes and limestone hills in the south-central part of the state. The altitude extremes are about 5,000 to 8,000 feet, but the elevation is most commonly between 5,000 and 7,000 feet. The soils, which are dominantly shallow, stony, and rocky are generally underlain by limestone bedrock and less commonly by other sedimentary rocks. Moderately deep and deep soils occur to a limited extent in the swales, valley areas, and flood plains contiguous to drainageways.

These soils are used as range for livestock and wildlife. Although the density and amount of forage produced is somewhat restricted on the Rock Land component of this association, moderate yields of forage are obtained on the associated soils. The more common native vegetation includes blue grama, sideoats grama, bluestem species, western wheatgrass, tridens, three-awns, wolftail, muhly species, galleta, oakbrush, mountain mahogany, and scattered stands of pinyon pine and juniper trees. Thin and scattered stands of ponderosa pine also occur at the higher elevations. A few small tracts of land in the vicinity of High Rolls and Mountain Park are irrigated.

*Soil Characteristics:* The Lithic Calciustolls, which comprise about 50 percent of the association, commonly occur on rolling uplands. Slopes, however, may range from gently sloping to steep and hilly. These soils have a surface layer of dark grayish-brown to brown calcareous stony loam. This grades through a light brownish gray very stony loam to the underlying limestone bedrock at a depth of 6 to 20 inches. Angular coarse fragments comprise about 25 to 40 percent of the surface layer and as much as 70 percent in the underlying material above the limestone bedrock.

Rock Land, which typically occurs on the steep to very steep canyon walls and escarpments, is also moderately extensive as it comprises about 30 percent of this association. It consists dominantly of a complex of shallow soils and outcrops of limestone and occasionally other sedimentary rocks. Outcrops of igneous rocks also occur to a very limited extent in the extreme northwestern part of this general soil area. The outcrops occur as vertical or nearly vertical exposures and ledges. The interspersed soils are usually shallow, and moderately coarse to moderately fine in texture. Numerous stones and boulders are common on the surface of the included soils. These soils are dominantly shallow, with small areas and pockets of moderately deep to deep soils.

Other soils of importance in this general soil area include soils of the Aridic Argiustoll, Pachic Argiustoll, Ruptic-Lithic Haplustoll, Aridic Calciustoll, and Cumulic Haplustoll subgroups. The Argiustolls consist mainly of deep soils on nearly level to strongly sloping valley slopes and alluvial fans. They have dark-colored clay loam or silty clay loam surface layers and clayey subsoils. The Pachic differ from the Aridic Argiustolls in having thicker dark-colored surface layers. Some of the Pachic Argiustolls, however, are moderately deep and occur as small areas on gently sloping to moderately steep ridge tops, crests, and saddles of low



Fig. 51. General view of the Lithic Calciustolls of the Calciustolls-Rock Land association No. 124. The shallow and stony Lithic Calciustolls commonly occur on rolling uplands, but may range from gently sloping to steep and hilly.

rolling limestone hills. These soils, which have dark-colored silt loam surface layers and silty clay loam subsoils, are underlain by limestone bedrock at depths of 20 to 40 inches.

The Ruptic-Lithic Haplustolls are forming residually in materials of sandstone and shale origin. These soils, which occur on strongly to steeply sloping and rolling upland ridges and hills, have a thin brown noncalcareous cobbly loam surface layer over a brown very cobbly sandy clay loam subsoil. Depth to bedrock ranges from 10 to 40 inches, dominantly 20 to 40 inches.

The Aridic Calciustolls are also cobbly and stony, but they are forming in alluvium and are not underlain by bedrock within a depth of 60 inches. These soils have dark grayish-brown gravelly and cobbly loam surface layers and light gray cobbly to very cobbly loam subsurface layers which are high in lime. The high lime layers commonly occur within 10 to 30 inches of the surface.

The Cumulic Haplustolls occur to a limited extent, on terminal points of alluvial fans, valley bottoms, and depressional areas. These soils have a thick surface layer of brown or grayish-brown calcareous loam. This is underlain to a depth of five feet or more by loam or light clay loam. A few gravel and cobbles commonly occur in the subsurface layers. Small acreages of unclassified soils,



drainageways, and other miscellaneous land types comprise the remaining parts of this association.

*Representative Soil Series:* Deama, Remunda, Ruidoso, Jarito, Pinkel, and Pena.

#### **125. Argiborolls-Cryborolls-Ustorthents**

This association includes an extensive area of high mountainous land in Catron, Grant, Sierra, and Socorro counties. The altitude ranges from about 6,000 to 10,000 feet, but much of it occurs at elevations between 7,000 and 9,000 feet. It is characterized by mountainous topography that ranges from gently sloping to moderately steep on the ridge tops and valley areas to steep and very steep on mountain side slopes. The soils are developing dominantly in parent materials from mixed igneous and conglomerate rocks. They are typically dark-colored, with a moderate to high content of organic matter, and neutral to slightly acid in reaction. The surface layers are often gravelly and occasionally stony.

Except for the Rock Land, the soils are moderately productive and support good stands of native vegetation. The overstory vegetation consists generally of ponderosa pine, pinyon pine, juniper, and gambel oak. Douglas fir, white fir, and some spruce and aspen are on the north-facing slopes and at the higher elevations. This association includes the principal timber-producing soils in the southwestern part of the state. Grasses include mountain muhly, mountain brome, Junegrass, sideoats grama, blue grama, Arizona fescue, bluegrass, pine dropseed, New Mexico needlegrass, and little bluestem. It also supports a number of desirable browse plants that are suitable for grazing and wildlife.

*Soil Characteristics:* The Typic Argiborolls, which are moderately deep, gravelly, and dark-colored, comprise about 20 percent of the association. They occur on gently rolling uplands including the moderately steep side slopes of the upland ridges. These soils have a surface layer of dark brown neutral or slightly acid stony or gravelly loam. The subsoil is a brown gravelly clay loam or gravelly clay that is slightly acid to neutral in reaction. This is underlain at depths ranging from 20 to 40 inches by very gravelly soil materials weathered from conglomerate and mixed igneous rocks. Approximately five percent of this unit consists of Pachic Argiborolls. They resemble the Typic Argiborolls, but have thick very dark-colored surface layers that extend to a depth of 16 to 24 inches or more.

Approximately 20 percent of this general soil area consists of Typic Cryborolls that are cold,

deep, dark-colored, and occur on steep mountain sides at elevations that generally range between 8,000 and 10,000 feet. They usually have a surface layer of dark brown neutral to slightly acid gravelly loam. Although the dark-colored surface layers are commonly 6 to 12 inches thick, some soils are dark-colored to depths greater than 15 inches. The subsoil is a brown to dark brown neutral to slightly acid gravelly clay loam or gravelly loam. The gravel and cobble content typically increases significantly below a depth of three feet. These soils are underlain at depths of 48 to 60 inches or more by very gravelly alluvium, conglomerate, or mixed igneous rocks.

Typic Ustorthents, which also comprise about 20 percent of this general soil area, are shallow, occurring on rolling to hilly uplands and steep mountain side slopes. These soils have a surface layer of dark grayish-brown slightly acid to neutral gravelly or stony loam over a brown stony or cobbly clay loam. The depth to bedrock ranges from about 15 to 20 inches. Some rock outcrops occur along ridges where slopes are steep or very steep. The content of coarse fragments in the subsurface layers of these soils typically exceeds 35 percent and may comprise as much as 70 percent of the soil mass. However, the content of coarse fragments varies considerably, and in approximately one-half of these soils it ranges from about 20 to 35 percent.

Rock Land, a miscellaneous land type, is also an important component of this association. It generally is steep and very steep and consists of a complex of very shallow or shallow soils and outcrops of bedrock. The small areas or pockets of soil that occur between the outcrops of bedrock are variable, but they are usually stony and gravelly with varying amounts of cobble, stones, and rocks on the surface. Rock Land is widely distributed and comprises 15 to 20 percent of this general soil area. The remaining parts of this association consists of unclassified alluvial soils, Rough Broken Land, and Alluvial Land. The unclassified alluvial soils are usually dark-colored and deep and range from moderately coarse to moderately fine in texture. Small areas of these soils are also cobbly and stony.

*Representative Soil Series:* Mirabal, a member of Typic Ustorthents, is the only known soil series.

#### **126. Haplustolls-Argiustolls-Rock Land (2,658,500 acres)**

This association, the largest in the mountainous region, consists of hilly to very steep mountain foothill and intermediate mountain areas that are

mainly in Catron, Grant, and Socorro counties. The topography varies extremely, from gently sloping to very steep. The relatively narrow valley floors and upland summits are commonly separated by steep canyon walls, escarpments, and steep side slopes. The ridge tops, which are narrow and comparatively small, are gently to strongly sloping and rolling. The narrow valley floors below the steep canyon walls and steep side slopes are gently to strongly sloping. Although there is also a relatively wide range in altitude, most of this area ranges between 6,000 and 8,000 feet in elevation.

The soils, which are generally gravelly or stony and shallow, are forming in parent materials weathered from a wide variety of rocks, including conglomerates and mixed igneous rocks. Rock outcrops and some rock slides are common along canyon walls and on the steep and very steep side slopes below the ridge tops. Although the content of gravel and stones is highly variable, most soils in this association have gravelly or stony surface layers.

These steep hilly and mountain lands support a wide variety of native vegetation including pinyon pine, juniper, tree oaks, and oakbrush. There are also some ponderosa pine, particularly on the north slopes at the higher elevations. Some of the more common grasses are blue grama, side-oats grama, black grama, little bluestem, needle-and-thread, New Mexico feathergrass, bush muhly, mesa dropseed, Arizona cottontop, hairy grama, and three-awns. Shrubs, in addition to oakbrush, include sacahuista, buck brush, mountain mahogany, Apache plume, rabbitbrush, chamiza, and winterfat. The steep slopes, rock ledges, and

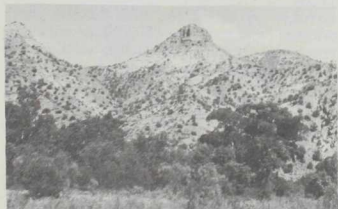


Fig. 52. Hilly and very steep mountainous foothill landscapes are common in the Haplustolls-Argiustolls-Rock Land association. The Lithic Haplustolls and Lithic Argiustolls occupy the saddles and crests of the rolling hills.

escarpments tend to restrict grazing by livestock in parts of this association. It is, however, suitable for a number of uses, including recreation, livestock and wildlife grazing, woodland, and watershed.

*Soil Characteristics:* Lithic Haplustolls are an extensive component of this unit, comprising approximately 25 percent of the area. These soils, typically have grayish-brown to brown, neutral to slightly acid, cobbly or stony surface layers. The subsurface layers consist of loams or light clay loams that contain moderate to high contents of gravel, cobble, and stones. Cobbly loams, very cobbly loams, and very cobbly clay loams are common. Although these soils are dominantly neutral to slightly acid to the underlying bedrock, some have slightly calcareous surface layers and moderately calcareous subsurface layers. They are typically underlain by bedrock within a depth of about 20 inches.

The Lithic Argiustolls also comprise about 25 percent of this association and differ primarily from Lithic Haplustolls in having clayey subsoils. These soils, which are shallow and moderately dark-colored, are forming dominantly on acid igneous bedrock or conglomerate. They have a thin brown noncalcareous cobbly loam surface layer over a brown to dark reddish-brown clay or gravelly clay subsoil. Igneous bedrock or conglomerate typically occurs within 20 inches of the surface. Where these soils are forming in materials weathered from basic igneous rocks or basalt they have a surface layer of dark grayish-brown noncalcareous stony loam over a cobbly clay subsoil. This is underlain by bedrock at depths ranging from about 10 to 20 inches.

Approximately 35 percent of this association is Rock Land, a land type. It is characterized by numerous outcrops of bedrock that usually occur on steep to very steep slopes. It consists dominantly of a complex of rock outcrops and shallow soils with variable characteristics. The shallow soils are generally gravelly or stony and moderately coarse- to medium-textured, with stones and boulders on much of the soil surface. Small areas of moderately deep soils also occur.

Other soils and miscellaneous land types included in this association are unclassified deep alluvial soils, moderately deep and deep gravelly and stony soils, Rough Broken Land, and Alluvial Land. These inclusions, none of which is extensive, comprise less than 15 percent of the association.

*Representative Soil Series:* Santana, OroGrande, Faraway, Luzena.

## APPENDIX I—Soil Classification

The soil classification system used in this report is the Soil Taxonomy of the U. S. Department of Agriculture. It is relatively new, having been in official use by the USDA since 1965. This system has six categories, and various units within each of these. Beginning with the broadest, these categories are: order, suborder, great group, subgroup, family, and series. Soils are classified in each of these categories on the basis of observable or measurable properties, primarily those which can be observed or measured in the field. Classes of this system are briefly defined as follows:

*Order.* Ten soil orders are recognized. The differentiae are defined to group soils which have formed in similar ways. Each order name has three or four syllables and ends in *sol*. An example is Aridisol, which are soils of arid areas.

*Suborder.* Each order is subdivided into suborders to group soils which are most alike in the way they have formed. The names of suborders have two syllables. The last syllable indicates the order. An example is Argid (*Arg* for argillic, or subsoils of clay accumulation, and *id* from Aridisol). Argids are Aridisols with fine-textured subsoils.

*Great Group.* Suborders are subdivided into great groups on the basis of close similarity of soil horizons, or layers making up the vertical section of a soil. The names consist of the suborder name with a prefix suggesting properties of the soil. An example is Durargid (*Dur* for duripan and Argid). These are Argids with duripans which are silica-cemented hardpans.

*Subgroup.* Great groups are subdivided into three kinds of subgroups. The typic represents the central concept of the great group; the intergrades are transitional to other orders, suborders, or great groups; and the extragrades are transitional to non-soil materials such as rock which occurs at shallow depths (lithic). An example is a Typic Durargid.

*Family.* Subgroups are subdivided into families to group soils which respond similarly to use and management. Properties considered include texture, mineralogy, temperature regime, and thickness of soil suitable for plants to root in. An example is a loamy, mixed, thermic family of Typic Durargids.

*Series.* Subgroups are divided into series which are commonly thought of as individual soils, even though they may differ in such characteristics as slope or degree of erosion. They are commonly named for geographic locations. An example is the Clovis series, which is a member of the fine-loamy, mixed, mesic family of Ustollic Haplargids.

More complete information about this classification system can be obtained from a publication entitled Soil Taxonomy which is being prepared for publication by the USDA Soil Conservation Service.

## APPENDIX II— Definition of Terms<sup>1</sup>

*Calcareous Soil:* Soil with enough carbonates to effervesce visibly when treated with cold, dilute hydrochloric acid.

*Caliche:* Soil layers with a high content of calcium carbonate (lime), or deposits of calcium carbonate. It is usually white or pinkish-white and may range from soft and weakly cemented to hard and strongly cemented.

*Saline Soil:* A soil containing sufficient soluble salts to impair its productivity. Generally a soil in which the conductivity of the saturation extract exceeds 4 milimhos per centimeter, or one that contains more than 0.2 percent soluble salts.

*Sodic Soil:* A soil containing sufficient exchangeable sodium to impair its productivity. Specifically, a soil in which 15 percent or more of the total exchangeable bases consist of sodium.

*Soil Association:* A group of defined and named taxonomic units occurring together in a distinctive and proportional pattern over a geographic area or landscape. The soil associations in this report are units of subgroups.

*Soil Color:* The soil colors used in this report are for dry soil unless otherwise noted and are based on Munsell Soil Color Charts.

*Soil Depth:* Terms used to indicate the depth of effective soil material over bedrock, shale, gypsiferous earth, caliche, or other materials that are relatively ineffective for plant root development. Depth classes used are: shallow—less than 20 inches, moderately deep—20 to 40 inches, and deep—more than 40 inches. In a few instances very shallow—less than 10 inches, and very deep—more than 60 inches are used. "Thin" is used to designate surface layers that are less than about six inches thick, and "thick" to designate those more than 15 inches thick.

*Soil Horizon:* A layer of soil which is approximately parallel to the land surface and which differs from adjacent soil horizons in color, texture, structure, consistence, and biological and chemical characteristics.

*Soil Permeability:* The rate water moves through undisturbed and uncompacted soil. Estimates are based on texture, structure, and porosity and refer to saturated soils. Approximate rates are:

very slow . . .	less than 0.2 inch per hour
slow . . . . .	0.2 to 0.6 inch per hour
moderate . . .	0.6 to 2.0 inches per hour
rapid . . . . .	2.0 to 6.0 inches per hour
very rapid . .	more than 6.0 inches per hour

*Soil Reaction:* The degree of acidity or alkalinity of a soil, expressed in pH values. The terms used to indicate reaction are:

extremely acid . . . . .	below 4.5
very strongly acid . . . .	4.6 to 5.0
strongly acid . . . . .	5.1 to 5.5
medium acid . . . . .	5.6 to 6.0
slightly acid . . . . .	6.1 to 6.5
neutral . . . . .	6.6 to 7.3
mildly alkaline . . . . .	7.4 to 7.8
moderately alkaline . . .	7.9 to 8.4
strongly alkaline . . . .	8.5 to 9.0
very strongly alkaline . .	above 9.0

<sup>1</sup>Refer to Soil Survey Manual, Agricultural Handbook, No. 18, for further information, or for terms not included here.

*Soil Slope:* The rise or fall of the land surface in feet per 100 feet, expressed as a percentage. The terms used in this report for soil slope identification are generally as follows:

<u>Simple slopes</u>	<u>Complex slopes</u>	<u>Approx. gradients (%)</u>
nearly level or level . . . . .	gently undulating and undulating . . . . .	0-2
gently sloping . . . . .	undulating and gently rolling . . . . .	2-5
strongly sloping . . . . .	rolling and hilly . . . . .	5-10
moderately steep . . . . .	steep . . . . .	10-25
steep . . . . .	very steep . . . . .	25-75
very steep . . . . .		75 plus

*Soil Texture:* The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles are: sand, loamy sand, sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes are further divided by specifying fine or very fine as appropriate. For example, fine sandy loam is used where more than 30 percent of the sand particles are of fine size.

*Clay:* As a soil separate, the mineral soil particles less than 0.002 millimeters in diameter. As a soil textural class, soil material that contains 40 percent or more of clay-size particles, less than 45 percent of sand-size particles, and less than 40 percent of silt-size particles.

*Silt:* Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeters) to the lower limit of very fine sand (0.05 millimeters).

*Sand:* As a soil separate, individual mineral fragments or particles than range in diameter from 0.05 to 2.0 millimeters in diameter. As a textural class, a soil that consists of 85 percent or more sand particles and not more than 10 percent clay particles.

*Gravel:* Mineral particles or fragments 2 to 75 millimeters in diameter. The adjective gravelly is used in textural class names if the soil contains 15 to 35 percent gravel, and very gravelly is used if there is more than 35 percent gravel.

*Soil Textural Groups:* The terms used in this report to indicate broad textural groups are: coarse, moderately coarse, medium, moderately fine, and fine. The general terms and the textural classes in each follow:

<u>Coarse</u>	<u>Moderately coarse</u>	<u>Medium</u>	<u>Moderately fine</u>	<u>Fine</u>
sands	sandy loam	very fine sandy loam	clay loam	sandy clay
loamy sands	fine sandy loam	loam	silty clay loam	silty clay
		silt loam		clay
		sandy clay loam		

*Subsoil:* The B horizon (argillic, natric, or cambic) of soils with horizons resulting from soil formation. It is below the surface layer, or A horizon, and consists of an altered zone where there has been accumulation of clay, formation of structure, or removal of some carbonates.

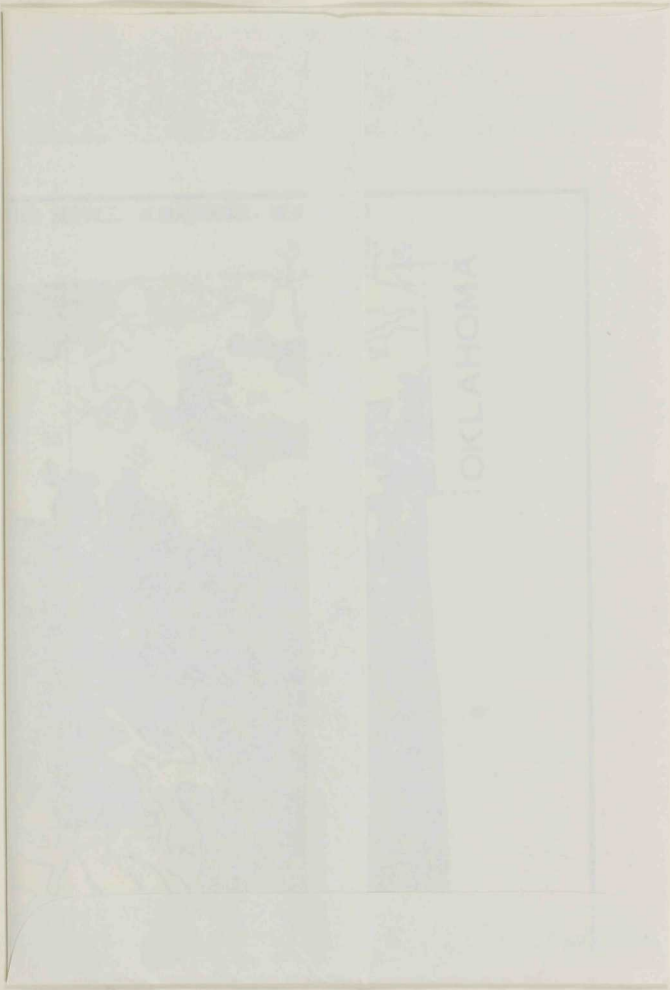
*Stratum:* The soil layers (weathered or partially weathered parent materials) below the solum, or B horizon. In soils without developed subsoils, it refers to layers below a depth of about 40 inches.

*Subsurface Layers:* Those soil layers between the surface layer, or A horizon, and a depth of about 40 inches in soils without developed subsoils, or B horizons.

APPENDIX III  
List of County Reports

*Soil Associations and Land Classification for Irrigation*

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Socorro	234
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<i>Land Classification for Irrigation</i>	
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Roosevelt	163
Torrance	187



W.P.  
OKLAHOMA

New Mexico State University's Agricultural Experiment Station publishes many bulletins and research reports of interest to residents of New Mexico. You may obtain a copy of the latest list of such publications by contacting the County Extension Office in your county, or by writing to:

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New Mexico State University  
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