United States
Department of
Agriculture

Soil
Conservation
Service

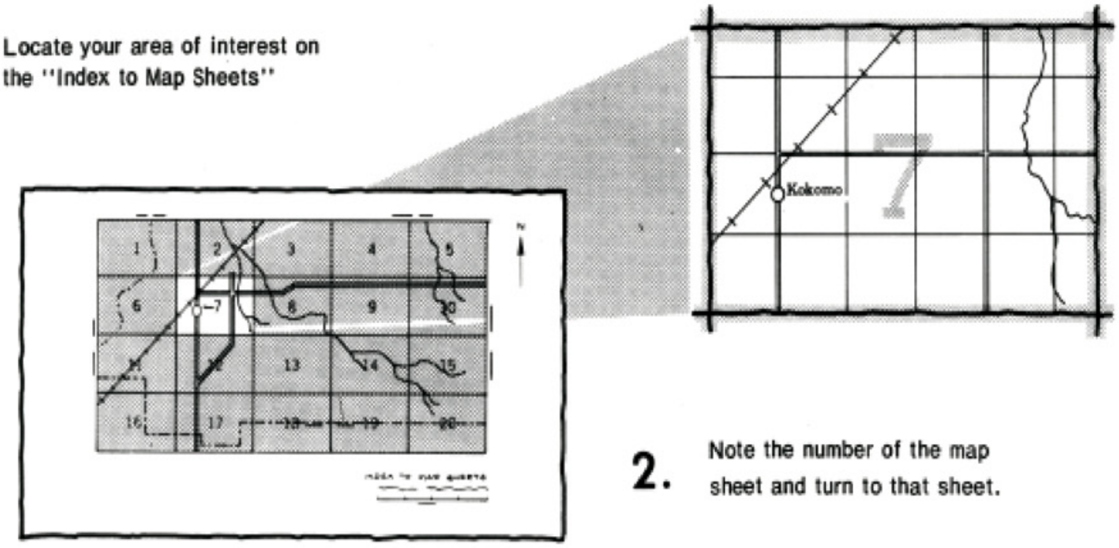
In cooperation with
United States
Department of Interior,
National Park Service
and Texas Agricultural
Experiment Station

Soil Survey of Big Bend National Park

Part of Brewster County, Texas

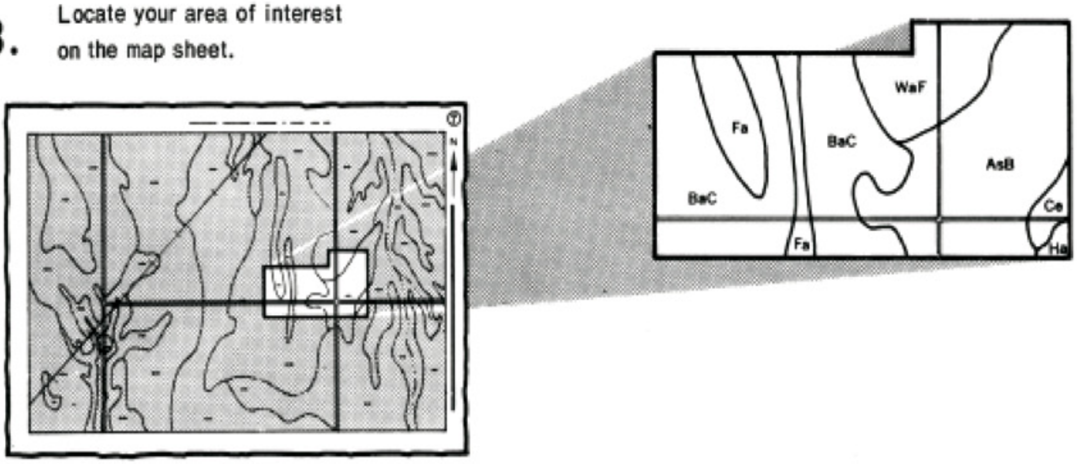
HOW TO USE

1. Locate your area of interest on the "Index to Map Sheets"

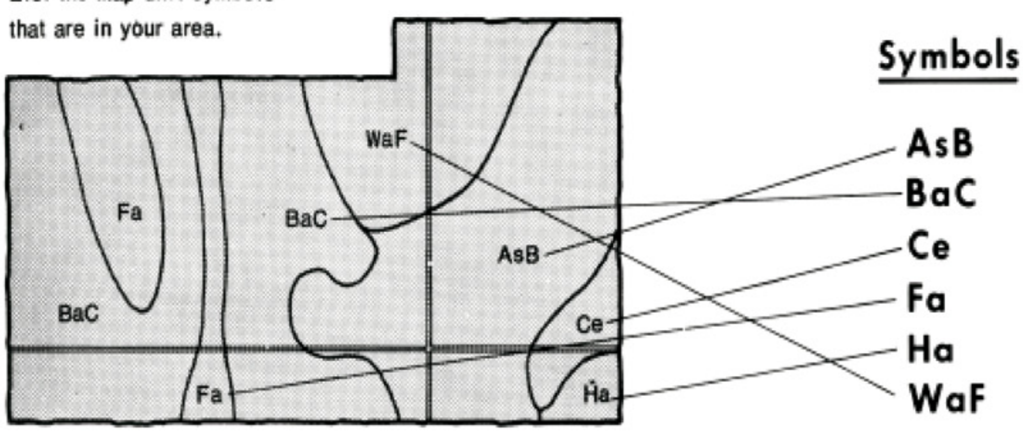


2. Note the number of the map sheet and turn to that sheet.

3. Locate your area of interest on the map sheet.

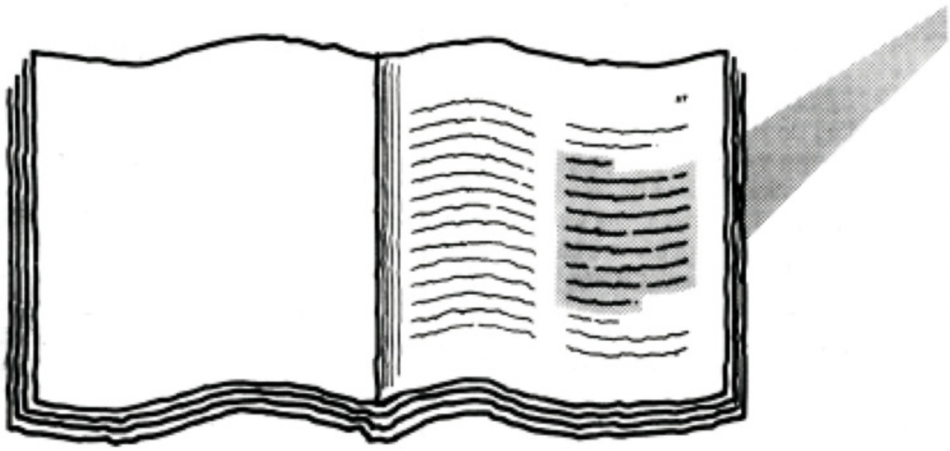


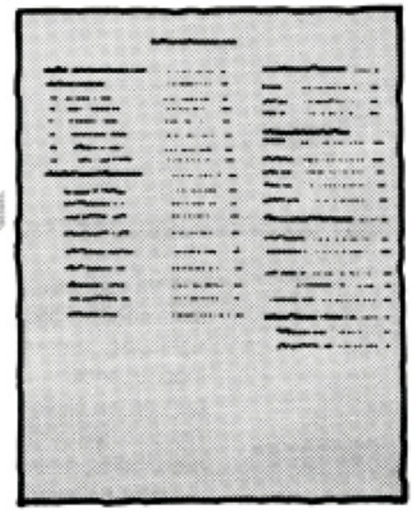
4. List the map unit symbols that are in your area.



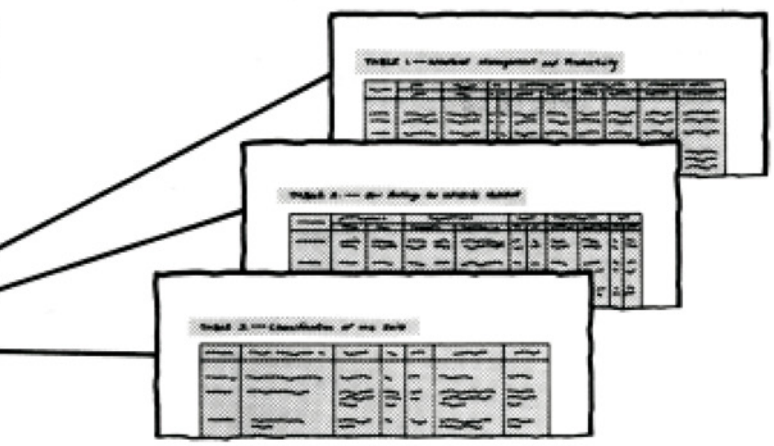
THIS SOIL SURVEY

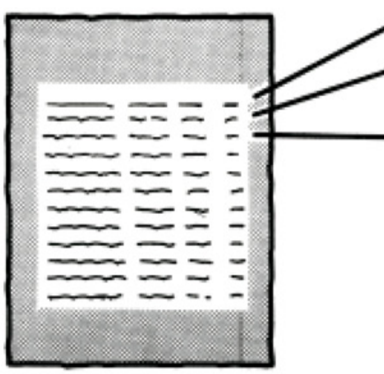
5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.





6. See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.





7. Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in 1981. Soil names and descriptions were approved in 1981. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1981. This survey was made cooperatively by the Soil Conservation Service, the National Park Service, and the Texas Agricultural Experiment Station. It is part of the technical assistance furnished to the Big Bend Soil and Water Conservation District.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

Metric units follow English units in the text, where appropriate. Metric units have been rounded off unless the precise figure is needed.

Cover: *The Rio Grande flows through Santa Elena Canyon, separating the United States from Mexico. In the foreground is Glendale-Harkey association, occasionally flooded, and in the background is Lozier-Rock outcrop complex, very steep.*

Contents

Soil Series

Issued October 1985

Index to Map Units

Summary of Tables

Foreword

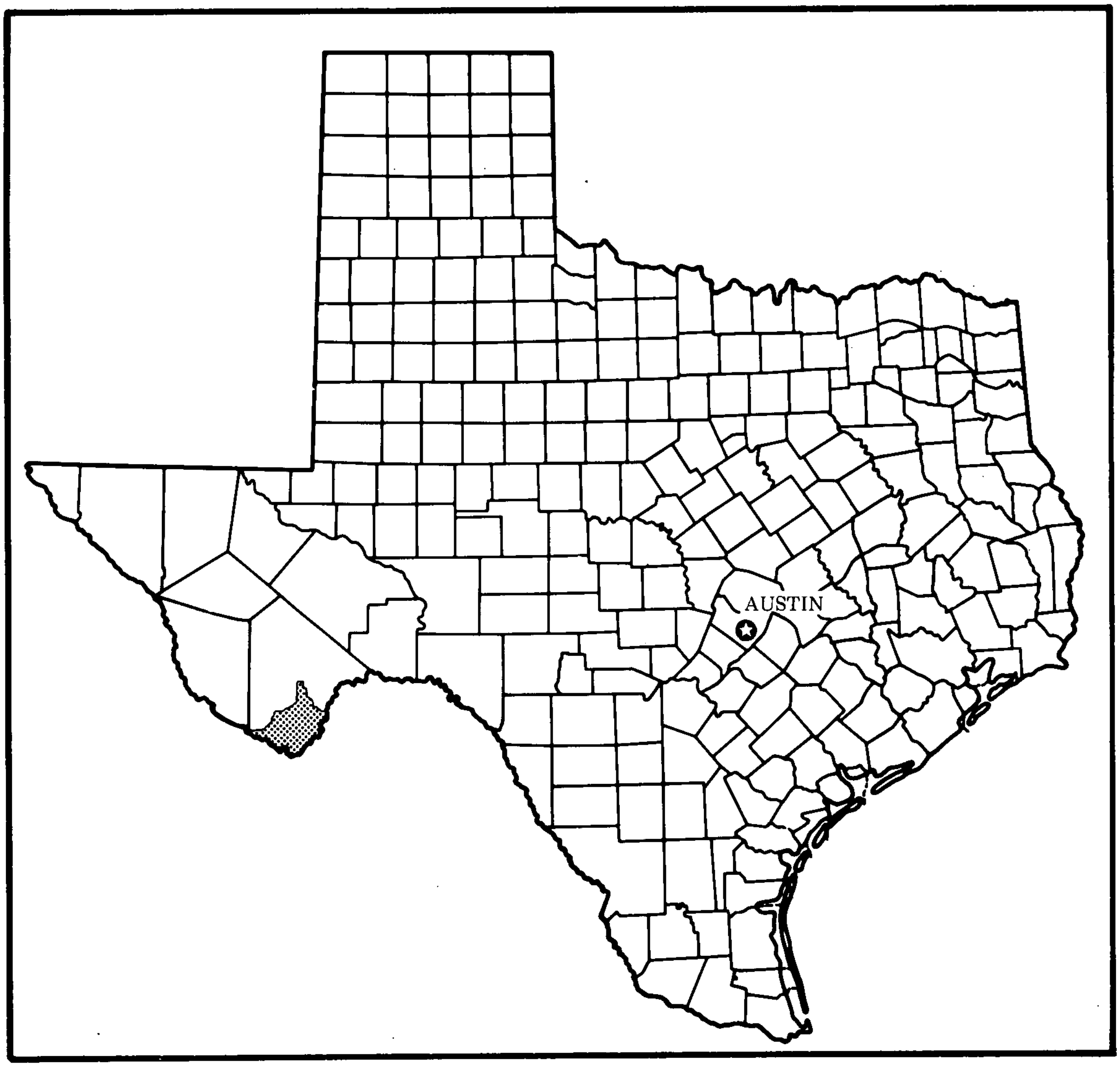
This soil survey contains information that can be used in land-planning programs in Big Bend National Park. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Planners, park officials, and engineers, can use the survey to plan land use, select sites for construction, and identify special practices needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Many are shallow to bedrock, stony, or gravelly. Some are too unstable to be used as a foundation for buildings or roads.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the park headquarters, the local office of the Soil Conservation Service or the Cooperative Extension Service.

Billy C. Griffin
State Conservationist
Soil Conservation Service



Location of Big Bend National Park in Texas.

Soil Survey of
Big Bend National Park
Part of Brewster County, Texas

By Rex A. Cochran and Jerry L. Rives, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service
In cooperation with United States Department of Interior,
National Park Service, and Texas Agricultural Experiment Station

General Nature of the Survey Area

Big Bend National Park comprises 708,281 acres in southern Brewster County in southwestern Texas. The name Big Bend is applied to the area that is surrounded on three sides by the Rio Grande. The park is only a part of this area. The elevation ranges from about 1,700 feet (518 meters) at the point where the Rio Grande leaves the Park to 7,835 feet (2,388 meters) on top of Mount Emory. Big Bend National Park is known for its scenic beauty, which ranges from stark, seemingly barren wastelands to majestic forested mountains to gigantic canyons. Visitors also come to observe the many animals, birds, and plants.

Climate

Prepared by the National Climatic Center, Asheville, North Carolina.

Summers are hot and winters are cool in Big Bend National Park. Winter days are fairly warm, although the temperature drops below freezing most nights. Rainfall is scant in most months but is heaviest in summer, when scattered thunderstorms develop, especially over the mountains. Snow cover in winter is not persistent and is generally confined to higher elevations.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Panther Junction in the period 1956 to 1978. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature is 51 degrees F (10 degrees Celsius), and the average daily minimum temperature is 38 degrees (3 degrees Celsius). The lowest temperature on record, which occurred at Chisos Basin, on January 11,1962 is -2 degrees (-19 degrees Celsius). In summer the average temperature is 80 degrees (27 degrees Celsius), and the average daily maximum temperature is 89 degrees (32 degrees Celsius). The highest recorded temperature, which occurred at Panther Junction on June 28, 1957, is 108 degrees (42 degrees Celsius).

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature of 50 degrees F (10 degrees Celsius). The normal monthly accumulation is the amount of heat available for plant growth between the last freeze in spring and the first freeze in fall.

The total annual precipitation is 13 inches (330 millimeters). Of this, about 10 inches (250 millimeters), or 75 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 3 inches (75 millimeters). The heaviest 1-day rainfall during the period of record was 4.29 inches (110 millimeters) at Chisos Basin on October 5, 1966. Thunderstorms occur on about 35 days each year, and most occur in spring.

The average seasonal snowfall is 1-2 inches (25-50 millimeters). The greatest snow depth at any one time during the period of record was 9 inches (229 millimeters). Snowfall varies greatly from year to year.

The average relative humidity in midafternoon is about 30 percent. Humidity is higher at night, and the average at dawn is about 55 percent. The sun shines 90 percent of the time possible in summer and 80 percent in winter. The prevailing wind is from the north. Average windspeed is highest, 12 miles per hour, late in winter and early in spring.

History

John R. Pearson, Big Bend National History Association, Inc., assisted in preparing this section.

American Indians have inhabited, hunted in, or traveled across the Big Bend area for at least 8,000 years. The earliest inhabitants lived in shallow caves and survived by hunting and gathering food.

The first European probably came into the Big Bend area about 100 years before the Pilgrims landed in Cape Cod Bay. Alvar Nunez Cabeza de Vaca led a band of survivors westward from a shipwreck along the Texas coast in 1528, hoping to find a Spanish settlement. During their 7-year trek, they may have crossed the area that is now Big Bend National Park.

Spanish explorers from New Spain, or Mexico, to the south crossed the Big Bend area in search of gold, silver, or whatever riches could be plundered and shipped back to Spain. Their searches proved fruitless. Unimpressed, they labeled the country 'El Despoblado, or the uninhabited land, and left it alone.

Across the river in Mexico, Mission San Vicente was established in 1774 near the present settlement of San Vicente. After less than a decade it was abandoned.

By the early sixteenth century, the La Junta Indians had established villages at the confluence of the Rio Grande and the Rio Conchos, the site of present-day Presidio, Texas, and Ojinaga, Chihuahua. These Indians were primarily farmers who grew crops on the flood plain.

Nomadic Indians, the Jumanos, Cibolos, and Chisos, traveled through the Big Bend area. During the 1600's and 1700's, the Apaches and Comanches invaded the region and used the rugged topography as a refuge. In the 1870's and early 1880's, Mescalero Apaches from the northwest and Comanches from the southern Great Plains raided ranches throughout the region. In the mid 1800's, cattle ranchers began moving into the area as trade routes were established. The Apache and Comanche raids were troublesome; therefore, an appeal was made to the U.S. Army for protection. The Army established several forts in the area. By the late 1800's, the Indians had been pushed onto reservations in New Mexico and Oklahoma.

The United States Boundary Survey sent a reconnaissance team of topographic engineers into the area in 1852 to survey the boundary between the U.S. and Mexico. The team was led by Major William H. Emory. He provided the first description of the area, including the vegetation and wildlife. The park's highest peak is named in his honor.

In 1859, the United States War Department sent a reconnaissance expedition into the Big Bend area to determine the possible use of camels as a means of transportation for the military. The camel experiment ended at the start of the Civil War and, later, the coming of the railroad removed the need for the experiment.

After the coming of the railroad to Alpine and Marathon in 1882, ranchers, miners, and homesteaders began searching the Big Bend area for unclaimed grasslands and minerals.

Although some of the settlers were successful, most were not. Life was hard without the conveniences of civilization, and water was scarce. All of the ranch headquarters, line camps, and homesteads were located near the few water sources, either reliable springs or the Rio Grande. One of the early successful settlers was J. O. Langford. He homesteaded a section of land along the Rio Grande to take advantage of what he believed to be the natural healing powers of the hot springs there.

The Big Bend National Park was established on June 12, 1944. The park features the lonely expanses of the Chihuahuaian desert floor cut by scenic hills, mesas, and mountains. The park attracts numerous visitors who enjoy the solitude and the rugged scenic beauty of deserts and mountains. Naturalists can enjoy the flora and fauna. The National Park Service seeks to improve the visitor facilities while allowing the forces of nature to continue as undisturbed as possible.

Geologic Summary

Dr. Dennis O. Nelson, Head of Geology Department, Sul Ross State University, prepared this section.

Introduction

The Big Bend area of western Texas is a geologically diverse region characterized by marine sedimentary rocks of Cretaceous Age (65-140 million years ago) that have been intruded and locally covered by volcanic rocks of Tertiary Age (20-45 million years ago). Subsequent erosion, controlled by the relative resistance of the rock and by the imposed structure created by faults and folds, has deeply dissected the region, transforming it into the combined mountainous and lowland terrain seen today.

The igneous rocks, because of their dense crystalline character, are quite resistant to erosion. Consequently, as erosion proceeds, these rocks tend to be left as residual high areas. In Big Bend National Park, the igneous rocks are commonly either massive, irregularly shaped intrusive rocks or thin but extensive extrusive rocks. An intrusive rock is formed by molten rock, or magma, crystallizing below the surface. Examples of intrusive igneous masses are Ward Mountains and Pulliam Peak. Such rocks tend to be rather uniform in character. They weather and erode into rounded mountain masses. The exposure of intrusive igneous rocks at the surface is indicative of the significant amount of erosion that has taken place in the Big Bend area. The eroded material, fragments of the igneous and sedimentary rocks that once covered the intrusive rocks, is now stream-deposited alluvium in the lower areas of the park.

An extrusive igneous rock is formed when magma is erupted onto the surface, becoming lava which crystallizes upon cooling. In the park area, extrusive rocks take the form of lava flows, ash deposits, and volcanic breccias. The lava flows, when crystallized, tend to be highly resistant to erosion and form a protective cap over the underlying rocks. The softer underlying rocks are slowly eroded away, undercutting the overlying lava cap and causing it to collapse downslope. This process has produced Burro Mesa and other flat-topped, steep-sided mesas.

The sedimentary rocks in the region, with the possible exception of some of the massive limestone, are much less resistant to weathering and erosion than are the igneous rocks. Thus, over time, stream drainage has established itself in these softer rocks, eroding them considerably.

Deep dissection as a result of erosion may at first glance appear paradoxical in a region where annual rainfall is low and streams do not continuously flow. The explanation of this seeming contradiction is twofold. First, although annual rainfall is low, it is characterized by intense showers. This intensity causes disruption of the surface layer of the soil and packing of the immediate subsurface layer by raindrop impact. Disruption of the surface loosens materials so that they can readily be transported, and packing inhibits infiltration of the water, increasing runoff. The second cause of extensive erosion in this desert area is the lack of vegetative cover, particularly a lack of dense ground cover. There is no vegetative mat to protect the soil from raindrop damage and to hold the water long enough to allow infiltration and no extensive root system to help keep the soil in place. The result can easily be seen after any heavy rainstorm. The runoff rate is high; the water is muddy and heavily laden with soil debris.

Geologic History

Deposition of marine sedimentary rocks dominates the early geologic history of the Big Bend National Park area. The oldest rocks are exposed in the northern part of the park near Persimmon Gap. They are marine sedimentary rocks of Paleozoic age and belong to the Maravillas (black chert), Caballos (interbedded black chert and novaculite or white chert), and the Tesnus (interbedded sandstone and shale sequence) Formations. Prior to the deposition of younger Cretaceous rocks, the Paleozoic rocks were strongly deformed, folded and faulted, then uplifted and eroded. This erosion resulted in the younger sandstone and conglomerate, whose mineral and rock fragment components were derived from highlands consisting of the Paleozoic formations. During the Cretaceous Period the seas began to advance, and thick deposits of limestone accumulated on the ocean floor. Fluctuations in sea level and sedimentation rate are reflected in the interbedding of limestone, such as that of the Glen Rose, Del Carmen, Telephone Canyon, Santa Elena, Buda, and Boquillas Formations, with shale, such as that of the Sue Peaks Formation and the Del Rio Clay. Local unconformities separate some of the formations, indicating a loss of the sedimentary record by either erosion or nondeposition, a result of the changing sea level.

The close of the Cretaceous period in the survey area was marked by a change in sedimentary environment. The retreat of the seas resulted in the deposition of primary clastic units, shales and sandstones, such as the Pen, Aguja, and Javelina Formations. The oldest Tertiary unit, the Black Peaks Formation, lies unconformably on the eroded surface of the Javelina Formation. The Black Peaks Formation and overlying Hannold Hill Formation have more sandstone than the upper Cretaceous sedimentary units, suggesting a shoreline depositional environment, consistent with continuous retreat of the seas.

The first record of Tertiary volcanic activity in the survey area is in the Canoe Formation, which unconformably overlies the Hannold Hill Formation. Pebbles of volcanic rock, derived from the erosion of an igneous source, are evident within the Canoe Formation. The amount of tuff, or volcanic ash, in the formation increases as the depth decreases, and isolated, local flows have been reported. Mammal remains in the Canoe Formation indicate that it is from the Middle Eocene Age, 45 to 50 million years ago.

The rocks extending from the Canoe Formation into the overlying Chisos and South Rim Formations reveal a dramatic change from the marine sedimentary rocks of the Upper Cretaceous-Lower Tertiary period to the dominantly volcanic rocks of the Middle Tertiary period. Both the Chisos and South Rim Formations record a very active period of volcanic activity, consisting of eruptions of ash, breccias and lava flows, and the emplacement of intrusions ranging from dikes and sills 1 meter thick to stocklike masses, such as Pulliman Peak. These formations include volcaniclastic rocks, which are sedimentary rocks derived from rapid and local erosion of volcanic highlands. Evidence of this rapid erosion can also be seen in the relationship between younger and older volcanic units. For example, several of the extrusive lava flows of the South Rim Formation have filled canyons that were cut in the older, underlying Chisos Formation. Many of these filled canyons are as much as a hundred meters deep, which implies that the process of erosion did not stop during the active volcanic phase of the park's history.

The volcanic rocks of the Big Bend area are part of a large igneous province, called the Trans-Pecos Magmatic Belt, that extends from New Mexico through western Texas into Mexico. Radiometric age determinations of rocks of the Chisos Formation suggest that the volcanic phase may have begun as early as 40 to 45 million years ago and continued until 20 to 23 million years ago.

After the emplacement of the Chisos and South Rim Formations, the Big Bend National Park area was subjected to regional block faulting on a northwestern trend. These normal faults are seen to offset many of the units, including the younger dikes associated with the larger intrusive masses, like Dominguez Mountain. Other faults and warping of the units may be related to the forceful emplacement of the larger stocks.

Recent alluvial sediments are throughout the Big Bend area. They consist of (1) older valley fill, sediment gravel, and high-level terrace deposits. Many of these alluvial deposits, particularly the older ones, have been weakly to moderately cemented by caliche. Caliche forms in arid regions where high rates of evaporation lead to concentration of dissolved salts in the alluvium. Eventually, the concentrations reach a saturation point, and mineral salts precipitate. Calcium carbonate is the most common; however, gypsum is with the carbonate in some places.

The alluvial deposits in the park are evidence of the continuous destruction, through erosion, of the older igneous and sedimentary rocks. Also, the terrace deposits record several periods of uplift and the consequent rejuvenation of the erosion process. These terrace deposits represent earlier valley fills much like those that are presently accumulating in the lower elevations. Subsequent to deposition, an uplift occurred that steepened stream gradients and initiated rapid downcutting of the stream channel. Because lateral erosion by the stream was minimal during this phase of erosion, portions of the valley fill were left as remnants on the walls of the deepening valleys.

Relation Between Soil Groups and Lithologies

There is a general correlation between the characteristics of the general soil map units and the lithologies upon which they developed. It is apparent, however, that factors other than rock chemistry, such as elevation and rainfall, are important in controlling the nature of the developed soil. For example, soils on hills and mountains (general soil map units 2, 3, 6, and 8) are generally on igneous rocks. However, in some areas folding or faulting has brought the sedimentary rocks to a higher elevation; for example, in general soil map unit 3, in the Sierra del Carmen Mountains, Mariscal Mountain, and Mesa De Anguilla areas. Soils on valleys, plains, and basins (general soil map units 1, 4, 5, and 7) formed from the less resistant sedimentary rocks.

Rock Unit Descriptions

The rocks of the Big Bend National Park area can be divided into seven general units based on lithology and physical characteristics: the Paleozoic formations, the lower massive limestones, the upper flaggy limestones, the dominantly shale unit, the dominantly sandstone unit, the volcanic unit, and the alluvial deposits.

Paleozoic Unit—The Paleozoic rocks are exposed near Persimmon Gap and consist of intensely folded and faulted rocks of the Maravillas, Caballos, and Tesnus Formations. The Maravillas Formation is about 300 feet (90 meters) thick. It consists primarily of black chert and includes some minor shale beds. The overlying Caballos Formation is 410 to 620 feet (125-190 meters) thick. It varies from dark chert at its base to white chert in the middle, then grades through an upper green chert into the silicified sands and shales of the Tesnus Formation, which is several thousand feet thick. The Paleozoic unit is a part of general soil map unit 3.

Lower Massive Limestones Unit—This unit of Lower Cretaceous rocks consists of the Glen Rose, Del Carmen, and Santa Elena Formations. These formations vary in thickness and consist of thick massive bedded limestones interbedded with calcareous shale, minor chert, and sandstone. The Del Carmen Formation is 350 to 450 feet (110 to 140 meters) thick, the Glen Rose Formation is about 600 feet (180 meters) thick, and the Santa Elena Formation is 750 to 850 feet (230 to 260 meters) thick. Also included in this unit are the Telephone Canyon Formation, a thin marly limestone about 40 to 130 feet (12 to 40 meters) thick, and the Sue Peaks Formation, a thin interbedded shale and marly limestone about 75 feet (23 meters) thick. These formations are part of general soil map units 1 and 3.

Upper Flaggy Limestones Unit—These Upper Cretaceous rocks are dominated by thin-bedded flaggy limestones of the Del Rio Clay, Buda Limestone, and Boquillas Formations. The lower Del Rio Clay material varies in thickness from 1 to 125 feet (0.3 to 38 meters) and has some shale. The massive Buda Limestone, which is about 100 feet (30 meters) thick, is overlain by Boquillas material, which contains a significant amount of marl interbedded with thin lenses of massive limestone that are less than 3 feet (1 meter) thick. The Bosquillas unit is 800 to 870 feet (245 to 265 meters) thick. This unit is part of general soil map unit 3.

Shale-Dominated Unit—The Upper Cretaceous rocks in this unit are of the Pen, Aguja, and Javelina Formations. They are marine and nonmarine shales. Minor amounts of interbedded limestone and calcareous sandstone are in the lower part of the unit in the Pen Formation, and some interbedded thin sandstone beds are in the Aguja and Javelina Formations. Fossil wood and dinosaur bones have been found in the Aguja and Javelina Formations.

The Pen Formation is 220 to 600 feet (65 to 180 meters) thick, the Aguja Formation is 800 to 1,300 feet (245 to 400 meters) thick, and the Javelina Formation 350 to 850 feet (105 to 260 meters) thick. These formations make up a significant portion of the sedimentary materials in the park. They are a part of general soil map unit 4.

Sandstone-Dominated Unit—The sandstone-dominated unit consists of Lower Tertiary rocks of the Black Peaks and Hannold Hill Formations. The Black Peaks Formation is more than 850 feet (260 meters) thick, and the Hannold Hill Formation is 356 to 770 feet (109 to 235 meters) thick. Both formations consist of clay which is interbedded with sandstone, locally crossbedded, and conglomerates. In outcrops, the clay, which makes up the major part of these formations, is difficult to distinguish from the clays of the underlying shale-dominated unit. These formations are part of general soil map unit 4.

Volcanic Unit—This unit is of Lower to Middle Tertiary rocks and consists of thick accumulations of the Canoe, Chisos, and South Rim Formations. The Canoe Formation is about 1,200 feet (365 meters) thick. The Chisos Formation is 1,500 to 2,600 feet (460 to 795 meters) thick. The South Rim Formation is 1,000 to 1,500 feet (305 to 460 meters) thick. Although these formations contain considerable sedimentary as well as igneous material, they are classified as volcanic because most of the sediment was derived from an igneous, or volcanic, source. Volcaniclastic rocks dominate the Canoe Formation. True volcanic rocks, tuffs, flows, and breccias dominate the Chisos and South Rim Formations. The volcanic unit has been intruded by numerous dikes and sills and a few larger stocklike plutons. The lithology of the flows varies from basalt to rhyolite; rhyolite is the most common. Spectacularly coarse conglomerate can be found in the Chisos Formation, and some stones as much as 1 foot (.3 meter) in diameter can be found locally. The entire volcanic unit, consisting of sandstone, conglomerate, ash, and flows, can be characterized as having a very complex stratigraphy, typical of an area near an eruptive center. This unit includes most of general soil map units 2, 6, and 8.

Alluvial Deposits Unit—This unit is of alluvial Quaternary material and consists of eroded debris from the volcanic and sedimentary highlands which has been deposited in the lowlands. The alluvium, consisting of silt, sand, and gravel, is locally cemented by caliche. This unit includes most of general soil map units 1, 5, and 7.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biologic activity.

The soils in the survey area occur in an orderly pattern that is related to the geology, the landforms, relief, climate, and the natural vegetation of the area. Each kind of soil is associated with a particular kind of landscape or with a segment of the landscape. By observing the soils in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept, or model, of how the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another resulting in gradual changes in characteristics. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

During the course of this survey soil scientists traversed all of the roads by vehicle and examined the soils in close proximity to the roads at close intervals. As there are few roads in the survey area, many traverses were made on foot into remote areas. Traverses by foot were necessary in order to respect the Park policy of restricting vehicles to roads, to protect of the fragile environment.

Traverses were from 1/2 mile to 5 miles (0.8 to 8 kilometers) apart depending on the complexity of the area. A helicopter was used to transport soil scientists into remote areas that were impractical to walk into. The use of the helicopter allowed soil scientists a good overall view of the area and quick and easy access to remote areas for traverses.

When the fieldwork neared completion, 123 random points were statistically selected by computer. Each point was visited by a team of soil scientists and an area 1/8 mile (200 meters) by 1 mile (1.6 kilometers) was examined in detail. The results of these detailed studies were compared to the original fieldwork to determine the statistical accuracy of the survey. A helicopter was also used for this phase of the survey. The use of the helicopter not only provided quick transportation to the points but also allowed the soil scientists the opportunity to visually recheck many other areas at the same time.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, acidity, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. The system of taxonomic classification used in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpreted the data from these analyses and tests as well as the field-observed characteristics and the soil properties in terms of expected behavior of the soils under different uses. Interpretations for all of the soils were field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and new interpretations sometimes are developed to meet local needs. Data were assembled from other sources, such as research information, production records, and field experience of specialists.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can state with a fairly high degree of probability that a given soil will have a high water table within certain depths in most years, but they cannot assure that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, roads, and rivers, all of which help in locating boundaries accurately.

Map Unit Composition

A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by several kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural objects. In common with other natural objects, they have a characteristic variability in their properties. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of soils of other taxonomic classes. Consequently, every map unit is made up of the soil or soils for which it is named and some soils that belong to other taxonomic classes. These latter soils are called inclusions or included soils.

Most inclusions have properties and behavioral patterns similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting (similar) inclusions. They may or may not be mentioned in the map unit descriptions. Other inclusions, however, have properties and behavior divergent enough to affect use or require different management. These are contrasting (dissimilar) inclusions. They generally occupy small areas and cannot be shown separately on the soil maps because of the scale used in mapping. The inclusions of contrasting soils are mentioned in the map unit descriptions. A few inclusions may not have been observed, and consequently are not mentioned in the descriptions, especially where the soil pattern was so complex that it was impractical to make enough observations to identify all of the kinds of soils on the landscape.

The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the soil data. The objective of soil mapping is not to delineate pure taxonomic classes of soils but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but onsite investigation to precisely define and locate the soil is needed to plan for intensive uses in small areas.

General Soil Map Units

The general soil map at the back of this publication shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit on the general soil map is a unique natural landscape. Typically, a map unit consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one unit can occur in other units but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a small tract or for selecting a site for a road or building or other structure. The soils in any one map unit differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The soils in the survey area vary widely in their potential for major land uses. Soil ratings are based on the practices commonly used in the survey area to overcome soil limitations. These ratings reflect the ease of overcoming the limitations. They also reflect the problems that will persist even if such practices are used.

Each map unit is rated for *urban uses* and *recreation areas*. Urban uses include residential, commercial, and industrial developments. Intensive recreation areas are campsites, picnic areas, ballfields, and other areas that are subject to heavy foot traffic. Extensive recreation areas are those used for nature study and as wilderness.

Soil Descriptions

1. Chamberino-Chilicotal-Upton

Deep and very shallow, undulating to rolling, very gravelly and gravelly soils; on uplands

Slopes range from about 1 to 15 percent. This map unit makes up about 35 percent of the park. Vegetation is mostly lechuguilla, creosotebush, whitethorn acacia, ocotillo, and yucca.

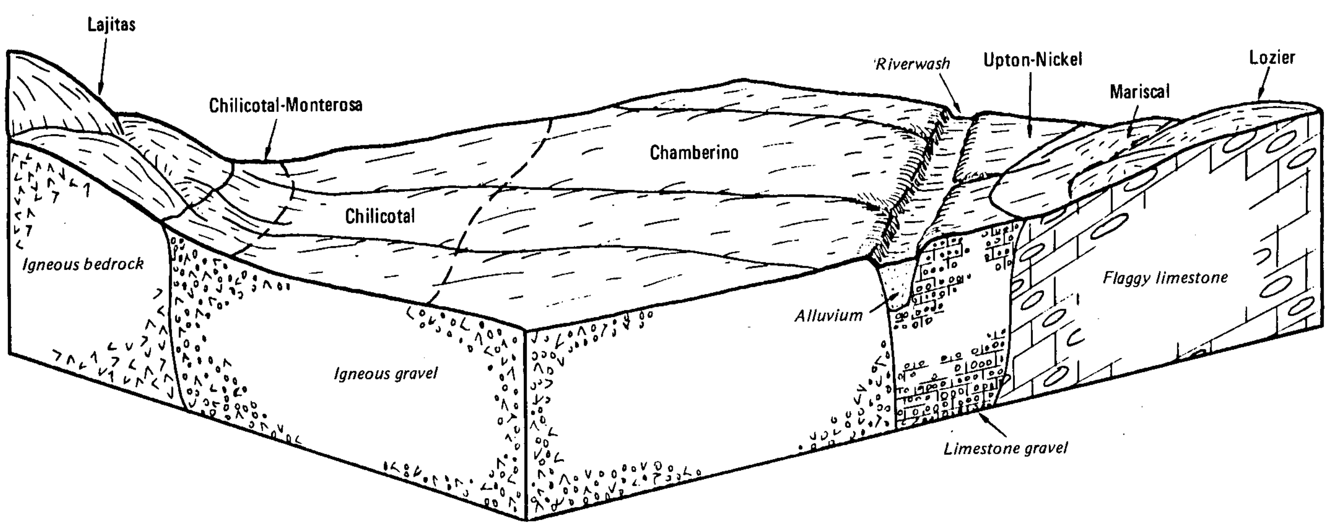


Figure 1.—Typical pattern of soils in the Chamberino-Chilicotal-Upton map unit.

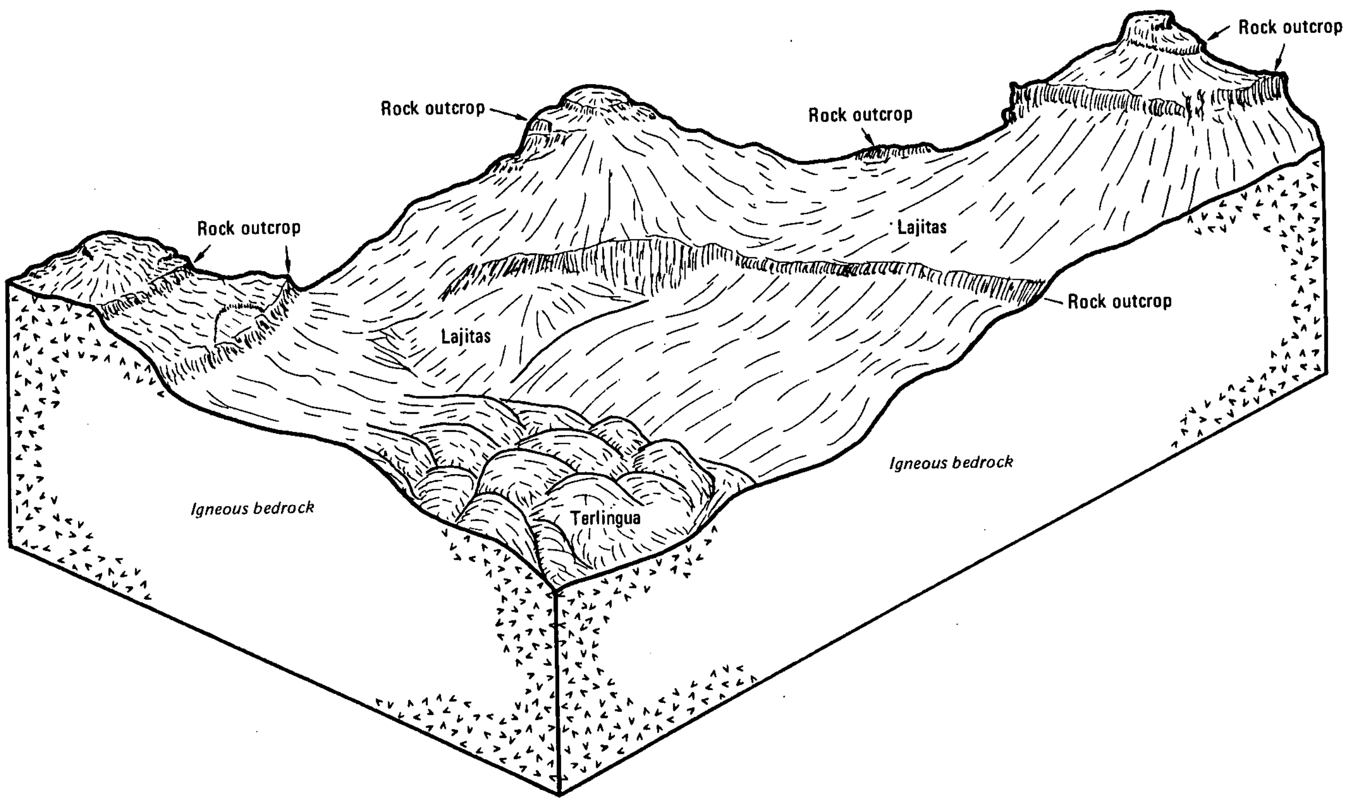


Figure 2.—Typical pattern of soils in the Lajitas-Rock outcrop map unit.

Chamberino soils make up about 35 percent of the unit. Chilicotal soils make up 27 percent, Upton soils 8 percent, and other soils 30 percent (fig. 1).

Chamberino soils have a plane surface and are at a lower elevation than the other major soils in the area. They formed in loamy material that has igneous fragments. Typically, the surface layer is pink very gravelly loam about 4 inches (10 centimeters) thick. The layer below that, to a depth of 13 inches (33 centimeters), is pink very cobbly loam that has caliche coatings on the coarse fragments. Below that, to a depth of 55 inches (140 centimeters), is pink very cobbly loam. The underlying material is light brown very gravelly sandy loam.

Chilicotal soils have a plane or convex surface and are on the upper part of piedmont slopes. They formed in loamy material that has igneous fragments. Typically, the surface layer is brown very gravelly fine sandy loam about 2 inches (5 centimeters) thick. The subsoil to a depth of 14 inches (36 centimeters) is brown very gravelly loam. To a depth of 28 inches (71 centimeters), it is brown very gravelly clay loam that has caliche coatings on the coarse fragments. Below that, to a depth of 40 inches (100 centimeters), is light brown very gravelly loam. Pink very gravelly sandy loam extends to a depth of 61 inches (155 centimeters).

Upton soils have a plane to convex surface. They formed in loamy material that has limestone fragments. Typically, the surface layer is pale brown gravelly loam about 5 inches (13 centimeters) thick. To a depth of 15 inches (38 centimeters) is a layer of pink gravelly loam which rests abruptly on a layer of indurated caliche 4 inches (10 centimeters) thick. The underlying material is pinkish white very gravelly loamy caliche.

Of minor extent are Nickel soils along the side slopes of drains in limestone areas, Monterosa soils on some of the broad ridges in igneous areas, Pantera and Tornillo soils in drains, Riverwash in the large stream channels, Glendale and Harkey soils along the Rio Grande, and scattered areas of Badlands.

This map unit is used for recreation and wildlife habitat. The potential for recreational facilities is limited by small stones.

Desert mule deer, javelina, coyote, bobcat, mountain lion, and many small mammals and birds use these areas. The potential for wildlife habitat is good at higher elevations near the mountains, where a diversity of plants provides food and cover. The quality of habitat steadily decreases downslope from these areas. The lower elevations are drier and have little food and cover for wildlife.

The potential for community development is good. Small stones are a problem in leveling and grading for building sites.

2. Lajitas-Rock outcrop

Very shallow to shallow, hilly to steep, very cobbly soils and Rock outcrop; on igneous hills and mountains

Slopes range from about 3 to 60 percent, but are mainly 10 to 45 percent. This unit makes up about 26 percent of the park. Vegetation is mostly lechuguilla, leatherstem, pricklypear, ocotillo, threeawns, chino grama, and sideoats grama.

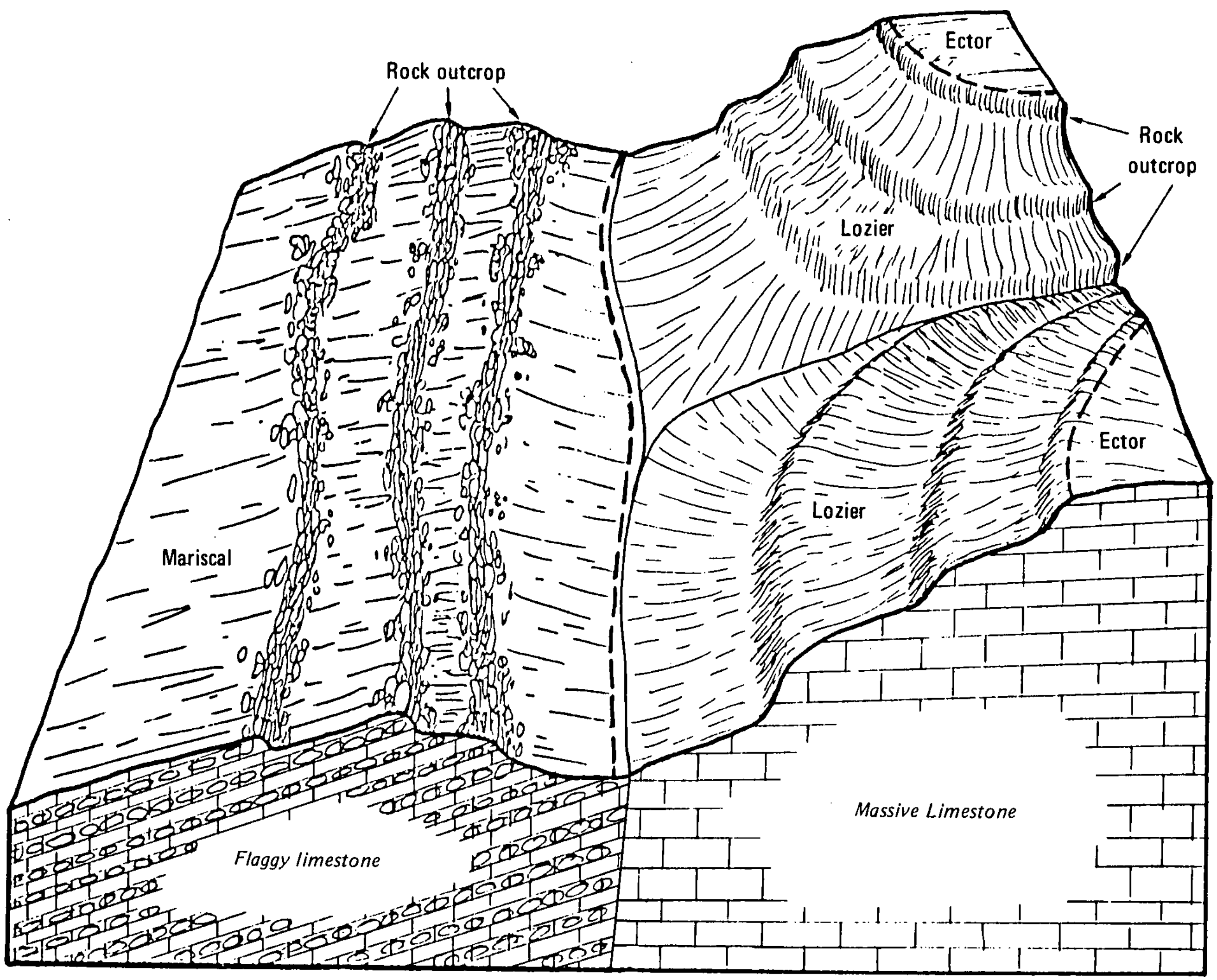


Figure 3.—Typical pattern of soils in the Lozier-Rock outcrop-Mariscal map unit.

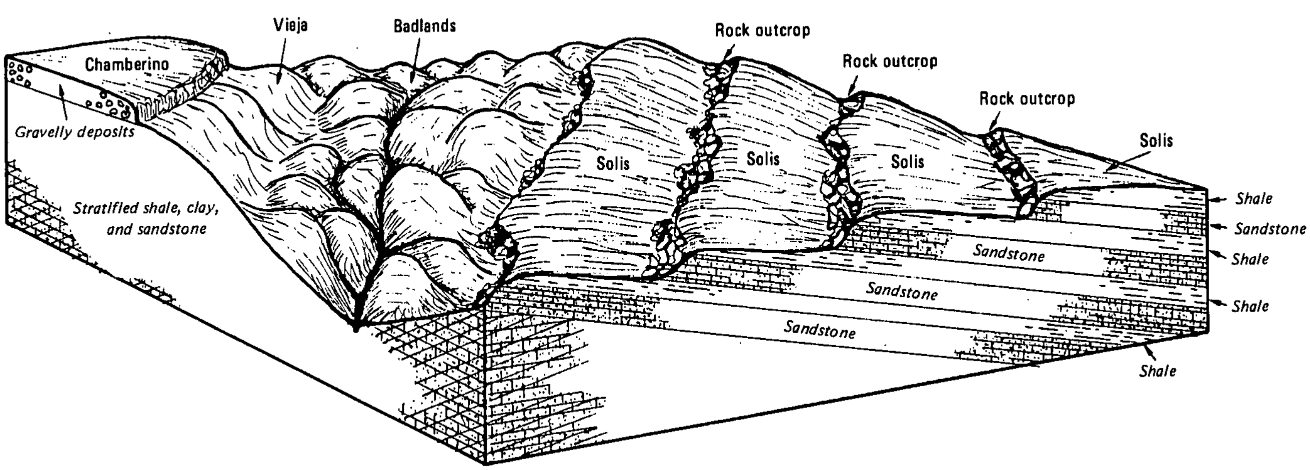


Figure 4.—Typical pattern of soils in the Solis-Rock outcrop-Vieja map unit.

The Lajitas soils make up about 44 percent of the unit, Rock outcrop 25 percent, and other soils 31 percent (fig. 2).

Lajitas soils have convex surfaces on the upper slopes and concave surfaces on the lower slopes. Typically, the surface layer is brown very cobbly loam about 7 inches (18 centimeters) thick. The layer rests abruptly on hard igneous bedrock.

Rock outcrop is igneous ledges and spires on the summits and shoulders of the mountains and exposed bedrock on the back slopes.

Of minor event are Mariscal, Brewster, Chamberino, Hurds, Lozier, Pantera, Tornillo, Upton, Chilicotal, Terlingua, and Monterosa soils. Mariscal and Lozier soils are on limestone hills. Chilicotal, Chamberino, Upton, and Monterosa soils are on gravelly outwash in canyons and around the edges of mountains. Terlingua soils are very shallow over igneous bedrock. Brewster and Hurds soils are on the higher mountains. Pantera and Tornillo soils are in drainageways.

This unit is used for recreation and wildlife habitat. The potential for recreational facilities is limited by the depth to rock, coarse fragments on the surface, and steep slopes. Deer, javelina, and mountain lions, as well as many smaller mammals and birds, use this unit for their home range. Springs provide water, and a diversity of plants provides good food and shelter areas.

The potential for urban development is low because of the shallow depth to rock and steep slopes.

3. Lozier-Rock outcrop-Mariscal

Very shallow to shallow, hilly to very steep, very gravelly, very cobbly, and very channery soils and Rock outcrop; on limestone hills and mountains

Slopes range from about 10 percent to nearly vertical canyon walls. This map unit makes up about 22 percent of the park. Vegetation is mostly creosotebush, lechuguilla, candelilla, cacti, threeawns, chino grama, and sideoats grama.

Lozier soils make up about 42 percent of the unit, Rock outcrop 35 percent, Mariscal soils 11 percent, and other soils 12 percent (fig. 3).

Lozier soils have convex, plane, and concave surfaces and are on massive, tilted limestone mountains. Typically, the surface layer is light brown very cobbly loam about 5 inches (13 centimeters) thick. It is about 50 percent limestone fragments. A layer of caliche-coated limestone fragments that have some soil material in cracks and crevices extends to a depth of 11 inches (28 centimeters). This layer rests abruptly on hard grayish limestone bedrock. In some areas the surface layer is very gravelly loam.

Rock outcrops are limestone ledges, escarpments, and exposures of bedrock.

Mariscal soils are on limestone hills. Typically, the surface layer is pale brown very channery loam about 5 inches (13 centimeters) thick. Alternating layers of platy limestone and marl many feet thick are below a depth of 5 inches (13 centimeters).

Of minor extent are Ector, Pantera, Upton, and Nickel soils. Ector soils are on the summits and shoulders of mountains. Pantera soils are on flood plains of streams. Upton and Nickel soils are in valleys and along drains.

This map unit is used for recreation and wildlife habitat. The potential for recreational facilities is limited by depth to rock, stones on the surface, and steep slopes. Water is the limiting factor for wildlife; large areas of this unit have no permanent source of water.

The potential for urban development is low because of depth to rock and steep slopes.

4. Solis-Rock outcrop-Vieja

Very shallow and shallow, gently undulating to rolling, loamy and very gravelly clayey soils and Rock outcrop; on upland plains

Slopes range from 1 to 16 percent. This unit makes up about 8 percent of the park. Vegetation is mostly scattered cacti, shrubs, and annuals. Sandstone exposures and barren eroding areas are common.

The Solis soils make up about 36 percent of the unit, Rock outcrop 34 percent, Vieja soils 13 percent, and other soils and Badlands 17 percent (fig. 4).

Solis soils are on convex areas of tilted, parallel sandstone ridges. The surface layer is a light yellowish brown fine sandy loam about 2 inches (5 centimeters) thick. Very pale brown fine sandy loam extends to a depth of 7 inches (18 centimeters) thick. Brownish fractured, platy soft sandstone is below a depth of 7 inches (18 centimeters)

Rock outcrop consists of soft sandstone on uplifted and slightly tilted knolls and ridges.

Vieja soils are in areas of clayey shale. The surface layer is pale brown very gravelly silty clay about 2 inches (5 centimeters) thick. From 2 to 13 inches (5 to 33 centimeters) is very pale brown silty clay. Below this is light brownish gray shale.

Of minor extent are Chilicotal and Chamberino soils on narrow ridges and knolls and Pantera and Tornillo soils along drainageways. Also included are areas of badlands, barren eroding shales, clay, and tuffs. The included areas produce high amounts of sediment.

This unit is used for recreation and wildlife habitat. The potential for recreational facilities is low because of active erosion and the great variety of materials in short distances.

Wildlife cross the areas of this unit from time to time. Little food and cover is available.

The potential for community development is low. Depth to rock and different underlying materials are problems in design and installation.

5. Tornillo-Pajarito

Deep, nearly level to gently sloping, loamy soils; in valleys

Slopes range from about 0 to 3 percent. This unit

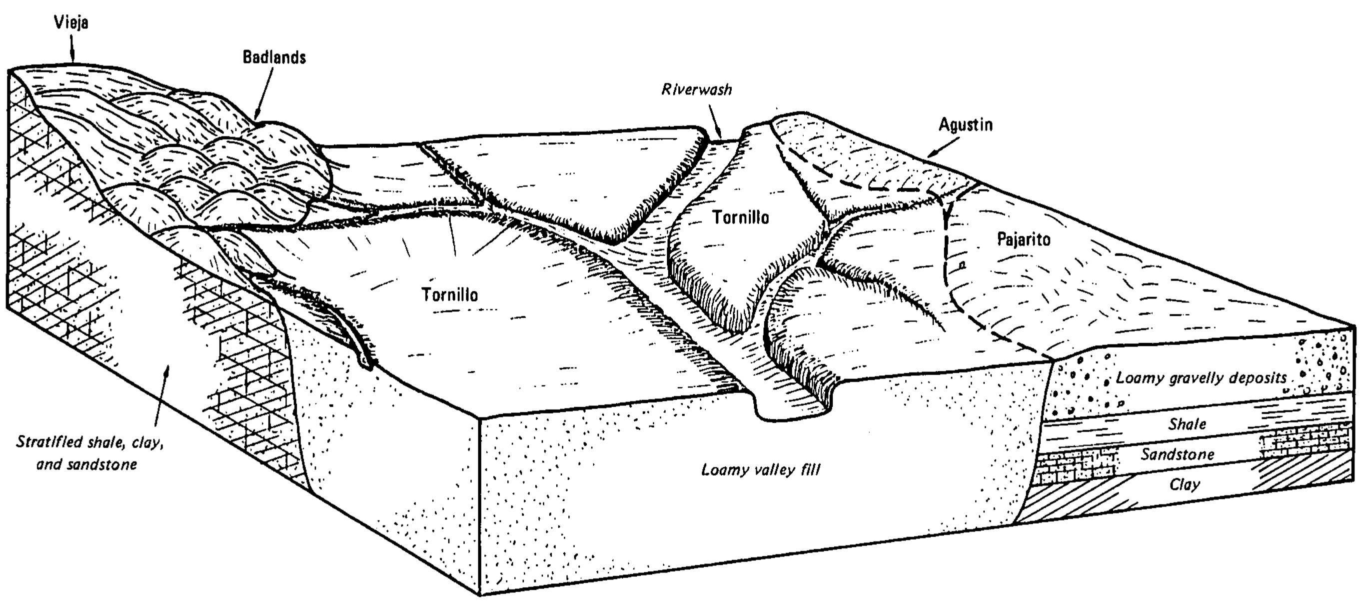


Figure 5.—Typical pattern of soils in the Tornillo-Pajarito map unit.

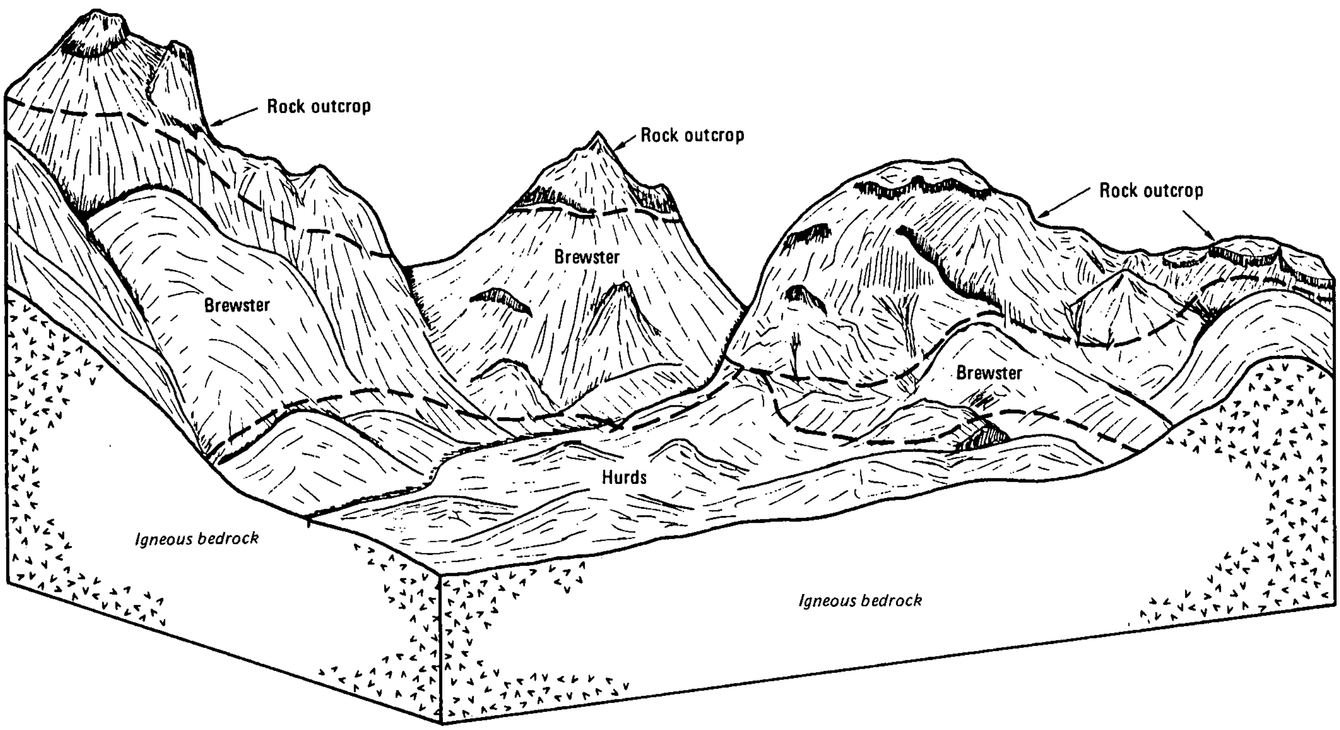


Figure 6.—Typical pattern of soils in the Brewster-Rock outcrop-Hurds map unit.

makes up about 4 percent of the park. Vegetation is mostly a sparse stand of creosotebush, lechuguilla, skeletonleaf goldeneye, and mariola.

The Tornillo soils make up about 67 percent of this unit, Pajarito soils 7 percent, and other soils 26 percent (fig. 5).

Tornillo soils formed in alluvium on broad valley floors. Typically, the surface layer is light yellowish brown loam about 9 inches (23 centimeters) thick. From 9 to 17 inches (23 to 43 centimeters) is pale brown silty clay loam. From 17 to 33 inches (43 to 84 centimeters) is pale brown silty clay loam that has threads and films of calcium carbonate. From 33 to 43 inches (84 to 109 centimeters) is pale brown loam. Stratified brown and pale brown clay loam and silty clay loam extends to a depth of 80 inches (203 centimeters).

Pajarito soils are on uplands, in higher positions than Tornillo soils and have more vegetation. Typically, the surface layer is light brown fine sandy loam about 4 inches (10 centimeters) thick. From 4 to 14 inches (10 to 36 centimeters) is light reddish brown fine sandy loam. The underlying material to a depth of 40 inches (102 centimeters) is reddish brown fine sandy loam. The solum is as much as 15 percent limestone and igneous pebbles.

Of minor extent in this unit are Agustin, Nickel, and Solis soils and Badlands and Riverwash. Agustin and Nickel soils are near the Pajarito soils. Solis soils and Badlands are scattered throughout areas of the Tornillo soils. Pantera soils and Riverwash are along drainageways.

This unit is used for recreation and wildlife habitat. Flooding of the Tornillo soils after heavy rains is the major limitation for recreation uses.

Coyotes, small mammals, some birds, and a small herd of pronghorns use this unit. The lack of cover and food severely limits use by wildlife.

The overflow of sheet water on the Tornillo soils is the major limitation to community development.

6. Brewster-Rock outcrop-Hurds

Very shallow, shallow, and deep, rolling to very steep, very cobbly and very gravelly soils and Rock outcrop; on igneous hills and mountains

Slopes range from about 3 percent to nearly vertical rock cliffs. This unit makes up about 3 percent of the park. It is in the Chisos Mountains. Vegetation is mostly pinyon pine, alligator juniper, drooping juniper, big tooth maple, and several species of oak.

The Brewster soils make up about 20 percent of the unit, Rock outcrop 42 percent, Hurds soils 14 percent, and other soils 24 percent (fig. 6).

Brewster soils have convex surfaces on the summits and shoulders and concave surfaces on the back slopes on the outer edge of the Chisos Mountains, on the western and northern sides. Typically, the surface layer is reddish gray very cobbly loam about 4 inches (10 centimeters) thick. This layer rests abruptly on hard igneous bedrock.

Rock outcrop consists of exposed igneous bedrock on crests of mountains, knolls, ledges, escarpments, spires, and random exposures.

Hurds soils have convex slopes in the valleys and piedmont slopes of the mountains. These soils are in the basin and on the surrounding Chisos Mountains. Typically, the surface layer is reddish brown very gravelly sandy loam about 3 inches (8 centimeters) thick. The subsoil to a depth of more than 41 inches (104 centimeters) is reddish brown very gravelly sandy loam.

Of minor extent are Liv, Madrone, and Puerta soils on crest and shoulders of the mountains, Lajitas soils on the mountains, and Mainstay soils in the basin and on surrounding mountains. Pantera soils are in the drainageways, and Chilicotal soils are on piedmont slopes.

This unit is used for recreation and wildlife habitat. The potential for recreational facilities is limited by the depth to rock, coarse fragments on the surface, and steep slopes. This unit has several trails for hikers and backpackers.

The Carmen Mountains whitetail deer, fox, and mountain lions use this unit for home range, as do many small mammals and birds. The diversity of plants provides food and cover for many species.

The potential for community development is low because of the shallow depth to rock and steep slopes.

7. Glendale-Harkey

Deep, nearly level and gently sloping, loamy soils; on flood plains

Slopes range from 0 to 2 percent. This unit makes up about 1.5 percent of the park. Vegetation is mostly a dense stand of mesquite, saltcedar, and giant reeds.

The Glendale soils make up about 31 percent of this unit, Harkey soils 24 percent, and other soils 45 percent (fig. 7).

Glendale soils are on plane slopes of the outer edges of the flood plain. Typically, the upper part of the surface layer is pale brown silty clay loam about 1 inch (2.5 centimeters) thick. The lower part of surface layer is brown silty clay loam. The underlying material to a depth of 18 inches (46 centimeters) is pale brown silty clay loam. To a depth of 35 inches (89 centimeters), it is light

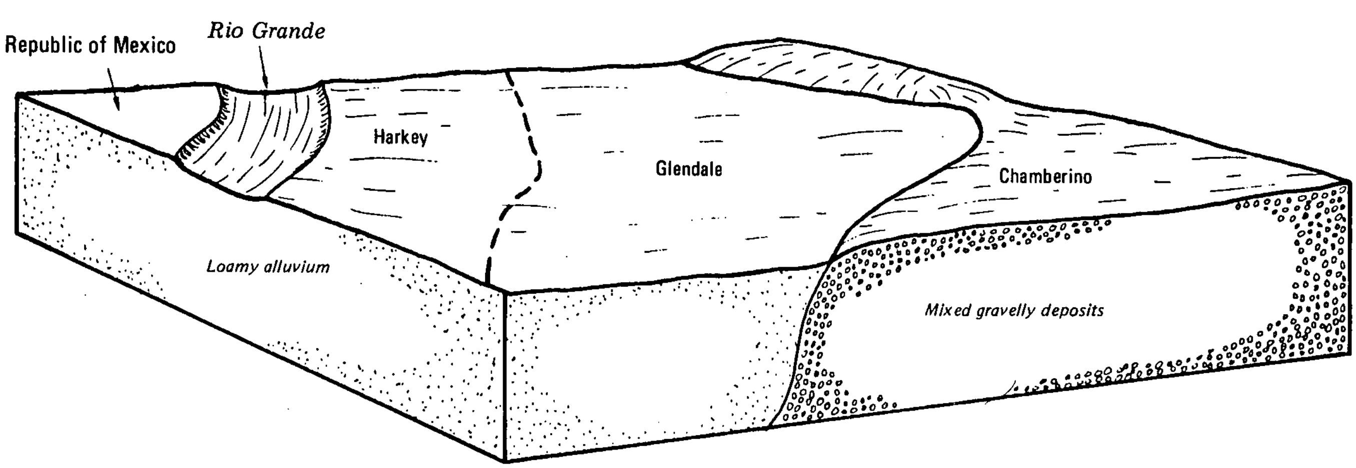


Figure 7.—Typical pattern of soils in the Glendale-Harkey map unit.

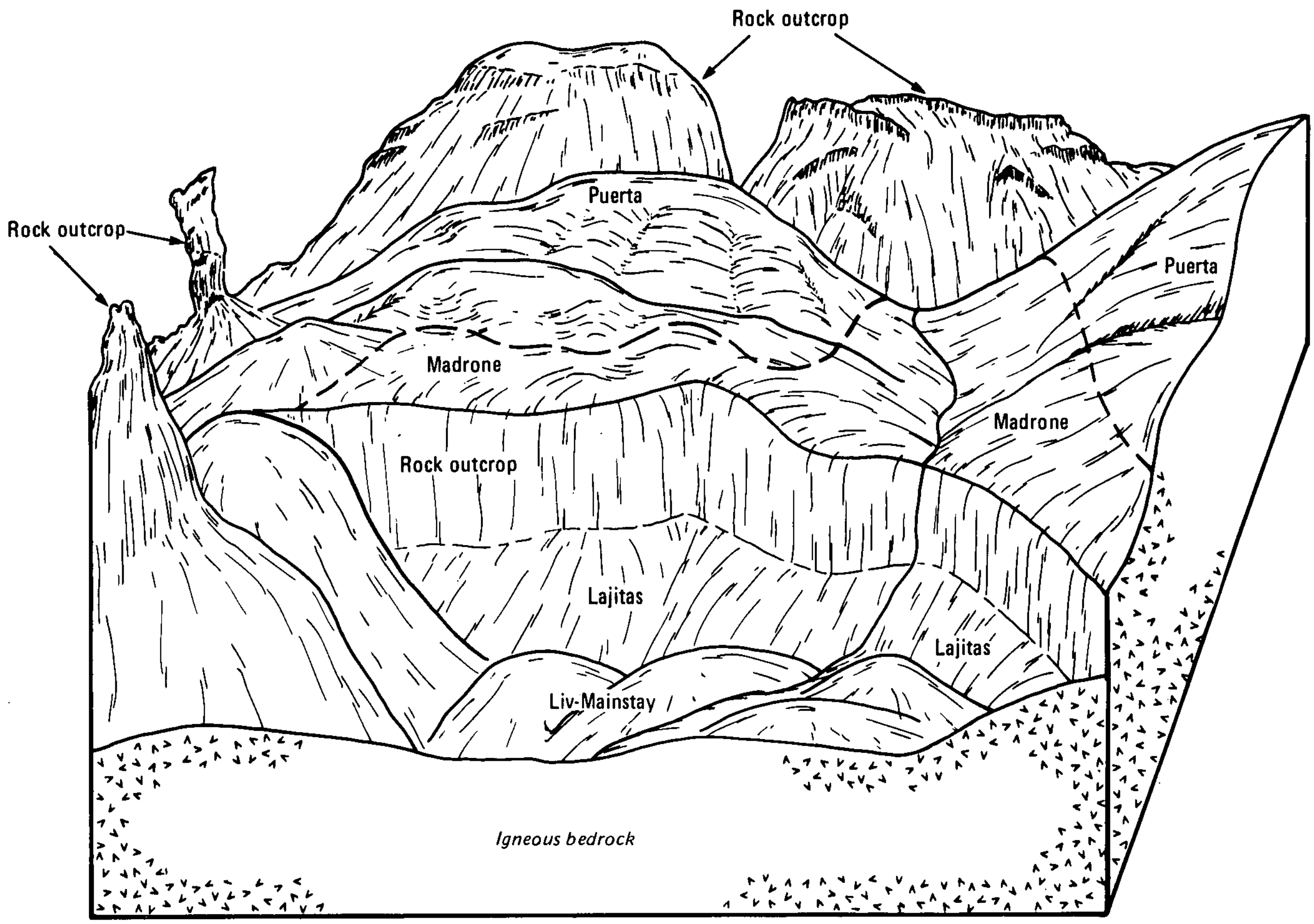


Figure 8.—Typical pattern of soils in the Puerta-Madrone map unit.

yellowish brown silt loam, and to a depth of 60 inches (152 centimeters) it is light yellowish brown loam. The solum has thin strata of coarser and finer material below a depth of 9 inches (23 centimeters).

Harkey soils are along drainageways on plane slopes. Typically, the upper part of the surface layer is pale brown silty clay loam about 2 inches (5 centimeters) thick. The lower part of the surface layer is pale brown very fine sandy loam 8 inches (20 centimeters) thick. The underlying material to a depth of 18 inches (46 centimeters) is brown very fine sandy loam, to a depth of 50 inches (127 centimeters) it is pale brown very fine sandy loam, and to a depth of 60 inches (152 centimeters) it is brown silt loam. The solum has strata of coarser and finer material below a depth of 10 inches (25 centimeters).

Of minor extent are Pantera soils, Tornillo soils, small upland areas of Chamberino soils, and Riverwash.

This unit is used for recreation and wildlife habitat. Occasional flooding is a problem for recreation facilities.

Mule deer, javelina, mountain lions, coyotes, bobcats, small mammals and birds use the areas for food and cover. The dense vegetation provides good cover and nesting places for a variety of birds.

The potential for community development is low because of the hazard of flooding.

8. Puerta-Madrone

Shallow and moderately deep, steep, very gravelly soils; on igneous mountains

Slopes range from 8 to about 60 percent; they are mostly 20 to 45 percent. This unit is about 0.5 percent of the park. It is on the Chisos Mountains at an elevation of more than 6,000 feet (1800 meters). Vegetation is mostly pinyon pine, Arizona cypress, and several kinds of oaks. Ponderosa pine and Douglas fir grow on some north slopes and in canyon bottoms.

The Puerta soils make up about 50 percent of this map unit; Madrone soils make up about 35 percent; and other soils, talus slopes, and Rock outcrop make up about 15 percent (fig. 8).

Puerta soils have convex slopes. Typically, the upper part of the surface layer of the Puerta soils is dark brown very gravelly silt loam about 4 inches (10 centimeters) thick. The lower part of the surface layer is brown very gravelly loam about 1 inch (3 centimeters) thick. The subsoil extends to a depth of 20 inches (50 centimeters) and is reddish brown, very gravelly clay. It rests abruptly on hard igneous bedrock.

Typically, the upper part of the surface layer of the Madrone soils is brown, very gravelly loam about 4 inches (10 centimeters) thick. The lower part of the surface layer is pinkish gray, very gravelly loam about 2 inches (5 centimeters) thick. The subsoil extends to a depth of 32 inches (81 centimeters) and is reddish brown, very gravelly clay. It rests abruptly on hard igneous bedrock.

Of minor extent are talus slopes, igneous rock outcrops, and areas of very shallow and deep soils.

This unit is used for recreation and wildlife habitat. The potential for recreational facilities is limited by the depth to rock and steep slopes.

The Carmen Mountains whitetail deer and mountain lion use this map unit for home range. The Colima warbler and many other birds nest in the area. The diversity of plants provides food and cover for many species.

The potential for community development is low because of the depth to rock and slopes. Access is by backpacking or helicopter.

Detailed Soil Map Units

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under "Use and Management of the Soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the underlying material, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the underlying material. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Chamberino very gravelly loam, undulating, is one of several phases in the Chamberino series.

Some map units are made up of two or more major soils. These map units are called soil complexes, or soil associations.

A *soil complex* consists of two or more soils in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Lajitas-Rock outcrop complex is an example.

A *soil association* is made up of two or more geographically associated soils that are shown as one unit on the maps. Because of present or anticipated soil uses in the survey area, it was not considered practical or necessary to map the soils separately. The pattern and relative proportion of the soils are somewhat similar. Chilicotal-Monterosa association, rolling, is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. The included soils are identified in each map unit description.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Riverwash is an example. Miscellaneous areas are shown on the soil maps.

Table 4 gives the acreage and proportionate extent of each map unit. Other tables (see "Summary of Tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils.

Soil Descriptions

BRG—Brewster-Rock outcrop complex, very steep. This map unit consists of very shallow and shallow soils on the summits, shoulders, and back slopes of igneous hills and mountains. These scenic hills and mountains rise 200 to 3,000 feet (60 to 900 meters) above the desert valley floors. Slopes, which range from 20 to about 80 percent or more, are mainly convex on the summits and shoulders of the mountains and concave on the back slopes.

The Chisos Mountains in this unit surround the west and north sides of the basin (fig. 9). The mapped areas are irregular in shape and range from 80 to 6,000 acres (32 to 2,428 hectares) in size. The shoulders of these mountains are mostly large exposures of bare rock with spires of rock extending upward from the exposed bedrock. There are many talus slopes along the sides of the mountains. The lower slopes are covered with grass and trees. From the summit of the mountains, the view is down into the basin area and across to the higher Chisos Mountains which surround the other parts of the basin. Looking outward from the basin the view is across the desert to other mountains on the horizon. There are springs in canyons along the base of the mountain. Human activities have had little influence on these areas because they are inaccessible by vehicle. Access requires strenuous hiking.

This map unit is about 30 percent Brewster and closely similar soils, 60 percent igneous Rock outcrop,

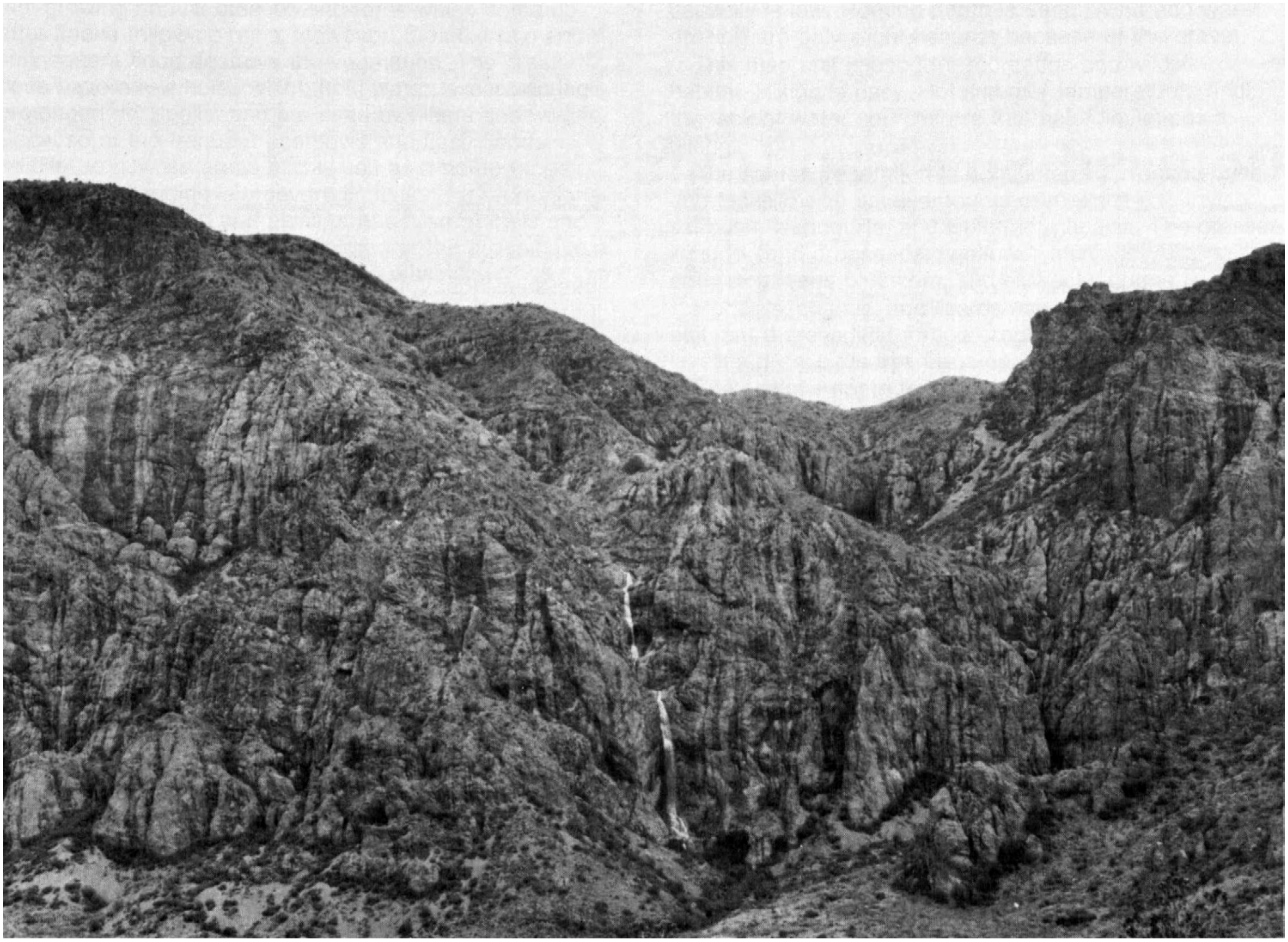


Figure 9.—Water from a summer rain creates a temporary waterfall in an area of Brewster-Rock outcrop complex, very steep.

and 10 percent other soils. Areas of Brewster soils and Rock outcrop are so intricately mixed that it was not practical to map them separately at the scale used. The Brewster soils are mostly on slopes of 20 to 45 percent and include the closely similar Lajitas soil, which has a lighter colored surface layer. Included in this map unit are small areas of Hurds soils. Also included are areas of deeper soils which formed in colluvium on foot slopes.

Typically, the Brewster soils consist of a layer of reddish gray, very cobbly loam about 4 inches (10 centimeters) thick which rests abruptly on hard, coarsely fractured, igneous bedrock.

Brewster soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Rooting zone is very shallow or shallow. Wind and water erosion are only slight hazards because of cobbles and gravel on the surface.

Rock outcrop consists of exposed bedrock on the summits of mountains, ledges, exposed spires, and ridges on the back slopes. Slopes are from 30 to 80 percent. Also included are some sheer drops of as much as 300 feet (91 meters) or more.

This map unit is used for recreation and wildlife habitat. The road from the park headquarters to the basin is close enough to the mountains to give a good view of this unit. A few springs provide water for wildlife and hikers. Hiking is strenuous on the steep slopes, and the loose rocks are a danger.

The vegetation includes Mexican pinyon pine, various species of oak and juniper, Texas madrone, mountain mahogany, sotol, evergreen sumac, littleleaf sumac, skeletonleaf goldeneye, sideoats grama, cane bluestem, and threeawns.

This map unit is used by a wide variety of wildlife. Javelina use areas of this unit for food and shelter. Mule deer use the areas at a lower elevation whereas the Carmen Mountains whitetail deer use the higher elevations. Mountain lions use the areas for hunting, cover, and dens. Coyotes and foxes use the areas for home territories. Ringtails and rock squirrels use the rocks for dens. Raptors and passerine birds use the areas for food, cover, lookout points, and nesting sites. The peregrine falcon occasionally nests in crevices in the cliffs in these areas.

This map unit has severe limitations for recreational uses. Stones, slope, and depth to bedrock make campsite preparation, such as shaping and leveling, impractical. Small stones and steep slopes are limitations for paths and trails. Paths and trails are difficult to build and maintain.

The main limitations for building sites are depth to bedrock and slope. Excavating for foundations, septic systems, and underground utilities is generally not practical because of the hard igneous bedrock.

CHC—Chamberino very gravelly loam, undulating. This is a deep, very gravelly, calcareous soil on uplands. Most areas of the soil are between the Chisos Mountains and the Rio Grande. This soil is on fan piedmonts, or broad alluvial fans, that have many shallow drainageways from 3 to 10 feet (1 to 3 meters) deep and 10 to 60 feet (3 to 18 meters) wide. Slopes are dominantly 1 to 4 percent and several hundred feet long. Short slopes along drainageways are as much as 8 percent. The mapped areas are irregular in shape and range from 35 to 3,250 acres (14 to 1,315 hectares) in size.

The view across the slope gives the impression of smooth and level topography because the tops of the ridges are about the same elevation and tend to hide the drainageways. Looking upslope, the Chilicotal soils can be seen on the upper piedmont slopes nearer the mountains that rise in the background. Downslope, most of the areas drop off into large drainageways. The dominant vegetation is stunted creosotebush less than 30 inches high with scattered patches of dog cacti and dense stands of lechuguilla.

The Chamberino soil makes up 75 to 90 percent of this map unit. The rest is small areas of Tornillo and Pantera soils along drains; sandstone outcrops of the Aguilla Formation on hillsides and bottoms of drains; reddish shales and clays of the Javelina and Canoe Formations on the edges of drains; igneous dikes across drains; and igneous outcrops on ridges. An area south of Mule Ear Peaks has outcrops of tuff along the hillsides and bottoms of drains. The percentages for this map unit were determined by sampling transects across several units.

Typically, the Chamberino soil is pink, very gravelly loam to a depth of about 4 inches (10 centimeters). To a depth of 55 inches (140 centimeters) it is pink, very cobbly loam that has coatings of calcium carbonate on the coarse fragments. To a depth of 80 inches (200 centimeters), it is light brown, very gravelly sandy loam.

This Chamberino soil is well drained. Surface runoff is medium. Permeability is moderate, and available water capacity is low. Rooting zone is deep. Wind and water erosion are slight hazards because of the gravel and cobbles on the surface. A desert pavement of igneous gravel covers about 80 percent of the surface.

This soil is used for recreation and wildlife habitat. The road from Panther Junction to Rio Grande Village crosses an area of this soil from a point below Dugout Wells to Tornillo Creek.

This soil supports a sparse stand of vegetation. The woody vegetation includes scattered creosotebush, dog cacti, lechuguilla, and ocotillo. The major grasses are fluffgrass, threeawns, slim tridens, and chino grama. These grasses grow along drains and in low areas which hold water after rains. The dominance of creosotebush, lack of available seed sources, and high surface temperatures in summer make vegetative recovery of abused areas very slow.

Wildlife use is limited. Mule deer and javelina travel across these desert areas and browse on lechuguilla and other woody species, but very few use this map unit for home ranges. A few passerine birds use the areas for food, shelter, and nesting areas. Rodents, snakes, and lizards use the areas for dens and hunting.

Small stones make campsite preparation, such as shaping and leveling, difficult. Dust and small stones are limitations for paths and trails. Hiking is easier than in most of the steeper areas; however, sturdy footwear is needed for protection from the lechuguilla and cacti. Hot summer temperatures and lack of a dependable source of water are the major limitations.

The limitations for building sites are slight.

CHD—Chamberino very gravelly loam, rolling. This is a deep, very cobbly and very gravelly, calcareous soil on uplands. It is on the lower parts of broad piedmont slopes. Most areas are between the Chisos Mountains and the Rio Grande. Slopes are mainly 5 to 15 percent. However, this unit includes incised drainageways 10 to 40 feet (3 to 12 meters) deep that have short side slopes of 10 to 40 percent. The mapped areas are oval and range from 95 to 2,300 acres (38 to 930 hectares).

The topography is rolling. The tops of the ridges are narrow, rounded, and about the same height. The view downslope is usually of a broad drainageway or a creek. Much of the surface is bare. Creosotebush, generally small and stunted, is the dominant vegetation. Clumps of dog cacti and patches of lechuguilla are scattered across the surface. Areas of smoother, undulating Chamberino soil surround areas of this map unit.

The Chamberino soil makes up 60 to 80 percent of the map unit. The remaining components are small areas of Tornillo soils and gravelly Pantera soils along drainageways, areas of reddish shales and clays of the Javelina and Canoe formations, sandstone of the Aguilla formation, and igneous dikes and outcrops. Areas south of Mule Ear Peaks have outcrops of tuff and tuffaceous sandstone on the sides of ridges and drainageways.

Typically, the Chamberino soil is pale brown very gravelly sandy loam about 3 inches (8 centimeters) thick. Pale brown very cobbly sandy loam that has patchy coatings of calcium carbonate on the coarse fragments extends to a depth of 7 inches (18 centimeters). From 7 to 18 inches (18 to 46 centimeters) is very pale brown very gravelly sandy loam that has coatings of calcium carbonate on the coarse fragments. The surface of the soil is a desert pavement of igneous gravel.

This Chamberino soil is well drained. Surface runoff is medium. Permeability is moderate, and available water capacity is low. Rooting depth is deep. Wind and water erosion are only slight hazards because of the cobbles and gravel on the surface.

This map unit is used for recreation and wildlife habitat. No roads cross these areas.

This soil supports a sparse stand of vegetation. The woody vegetation includes lechuguilla, dog cacti, creosotebush, leatherstem, pricklypear, and range ratany. Grasses are chino grama, threeawns, fluffgrass, and slim tridens. The lack of available seed sources, the dominance of creosotebush, and high ground temperatures during the summer months make re-establishment of grasses difficult.

Use of these areas by wildlife is limited. A few mule deer and javelina feed on lechuguilla and woody shrubs, but do not make these areas their normal home range. Rodents, snakes, and lizards use these desert areas for food and shelter, and a few passerine birds use them for food, shelter, and nesting sites.

Small stones and short steep side slopes are the major limitations to recreational use. Campsite preparation, such as grading and leveling, is difficult. Small stones are limitations for paths and trails. There are no springs or other permanent water sources for wildlife or hikers. High temperatures, in summer, short steep slopes along incised drainageways, and cacti and lechuguilla are problems for hikers.

Slope presents a moderate limitation for use of this soil as building sites.

CLC—Chilicotal very gravelly fine sandy loam, undulating. This is a deep, very gravelly soil on dissected piedmont slopes that surround the Chisos Mountains. The dissecting drainageways are 3 to 10 feet (1 to 3 meters) deep, 10 to 60 feet (3 to 18 meters) wide, and 200 to 1,000 feet (60 to 300 meters) apart. A desert pavement of igneous gravel covers about 80 percent of the surface. Slopes are dominantly 1 to 6 percent. Short side slopes along drainageways range to about 10 percent. The mapped areas are irregular in shape and range from 35 to 6,500 acres (14 to 2,630 hectares) in size.

The landscape is a shrub grassland. The shrubs are largely sotol, creosotebush, and tarbush. Chino grama is the major grass. Lechuguilla is present in most areas and ocotillo in many places. The high Chisos Mountains extend upslope from this map unit. Downslope, most areas grade into a drier, hotter part of the piedmont slope where the grass disappears and the shrubs become stunted.

There are several springs on this unit which provide water for wildlife and hikers and were once used by Indians and early settlers. Old cabin ruins and graves can be found in the vicinity of many of the springs. Cottonwood trees mark the location of many of the springs and can be seen for a considerable distance across the landscape.

The Chilicotal soil makes up 60 to 80 percent of the map unit. Included are a few areas of Monterosa soils on the broad gently sloping ridgetops and areas of the closely similar Chamberino soils. The remaining areas are alluvial soils along the drainageways, and small igneous hills and ridges that outcrop throughout the area.

Typically, the surface layer of the Chilicotal soil is very gravelly fine sandy loam about 2 inches (5 centimeters) thick. Brown very gravelly loam extends to a depth of 7 inches (18 centimeters). Brown very gravelly loam that has films and threads of calcium carbonate extends to a depth of 14 inches (36 centimeters). Brown very gravelly clay loam that has calcium carbonate coatings on the coarse fragments extends to a depth of 28 inches (71 centimeters). Light brown very gravelly loam extends to a depth of 40 inches (102 centimeters). Pink very gravelly sandy loam that has patchy coatings of calcium carbonate on the coarse fragments extends to a depth of 61 inches (155 centimeters).

This Chilicotal soil is well drained. Surface runoff is medium. Permeability is moderate. Available water capacity is low. Rooting depth is deep. Wind and water erosion are only slight hazards because of the gravel and cobbles on the surface.

This unit is used for recreation and wildlife habitat. The road from Panther Junction north to Hannold's grave crosses some of the areas. A few springs provide water for hikers and wildlife. Hiking is easier than in the steeper, rocky areas, but sturdy footwear is needed for protection in the dense patches of lechugilla.

The vegetation includes chino grama, lechuguilla, sotol, creosotebush, tarbush, ocotillo, pricklypear, skeletonleaf goldeneye, mariola, threeawns, bush muhly, plains bristlegrass, Arizona cottontop, plains blackfoot, paperflower, and black grama.

Mule deer and javelina use this map unit for food, shelter, and home ranges. Lechuguilla and other shrubs provide a variety of forage. Coyote and fox inhabit the areas in considerable numbers, feeding on the many rodents, snakes, and lizards. Many types of passerine birds use the areas for food, resting, and nesting.

Small stones are a limitation for shaping and leveling the soil for campsites and picnic areas.

The limitations for building sites are slight.

CMD—Chilicotal-Monterosa association, rolling. This map unit consists of deep, shallow and very shallow, very gravelly and cobbly soils on rolling uplands. Areas of these soils are near the base of the Chisos Mountains. These soils are on ballenas, or rounded ridges, partial ballenas, and piedmont slopes of 3 to 8 percent. The landscape is incised with frequent drainageways that have side slopes of mostly 8 to 20 percent, although a few are as much as 40 percent. In most areas slopes are 5 to about 15 percent. The mapped areas are oval and range from 60 to 6,100 acres (24 to 2,468 hectares). The soil surface has a desert pavement of igneous gravel.

The view upslope across these areas is of low rolling gravelly ridges below the foot slopes of mountains, which form a majestic background. The view downslope is of a smooth gravelly piedmont slope receding into the desert valley floor. Springs located at various places throughout the map unit provided water for wildlife, Indians, and early settlers. There are cabin ruins near many of the springs, most of which are located in the drainageways.

The Chilicotal soils make up about 60 percent of this map unit, ranging from 50 to 70 percent. These soils are on concave side slopes of drainageways and the concave and more sloping parts of ridges. Monterosa soils make up about 20 percent of the unit, ranging from 10 to 30 percent. They are on the convex ridgetops. The remaining 20 percent is Pantera and Tornillo soils in drainageways; reddish colored shales and clays along the side slopes of larger drainageways; sandstone outcrops along drains; and igneous rock dikes and outcrops. Areas of Chilicotal and Monterosa soils form a regular pattern. However, use and management are so similar that mapping the soils separately was not justified.

Typically, the surface layer of the Chilicotal soils is pinkish gray, very gravelly fine sandy loam about 1 inch (2.5 centimeters) thick. The layer below that, to a depth of 6 inches (15 centimeters) is brown, very gravelly sandy loam that has coatings of calcium carbonate on the coarse fragments. Pale brown, very gravelly loam that has coatings of carbonate on the coarse fragments extends to a depth of 20 inches (50 centimeters). Pink, very gravelly sandy loam that has coatings of calcium carbonate on the coarse fragments extends to a depth of 38 inches (96 centimeters).

Chilicotal soils are well drained. Surface runoff is medium. Permeability is moderate. Available water capacity is low. Rooting depth is deep. Wind and water erosion are only slight hazards because of gravel on the surface.

Typically, the surface layer of the Monterosa soils is light brown, very gravelly sandy loam about 1 inch (2.5 centimeters) thick. The layer below that extends to a depth of 4 inches (10 centimeters) and is light brown, very gravelly sandy loam that has coatings of calcium carbonate on the coarse fragments. Light brown, very gravelly sandy clay loam that has coatings of calcium carbonate on the coarse fragments extends to a depth of 12 inches (30 centimeters). This layer rests abruptly on hard, pinkish white carbonate-cemented caliche about 4 inches (10 centimeters) thick. Pink, very gravelly loam that has coatings of calcium carbonate on the coarse fragments is below a depth of 16 inches (40 centimeters).

Monterosa soils are well drained. Surface runoff is medium. Permeability is moderate, and available water capacity is very low. Rooting zone is shallow or very shallow. Because of the gravel and cobbles on the surface, wind and water erosion are only slight hazards.

This map unit is used for recreation and wildlife habitat. The road from the Chisos Basin junction to Paint Gap Hills junction crosses a part of this unit. A few springs provide water for hikers and wildlife. Heavy footwear is needed to protect hikers from the lechuguilla and cacti.

These areas are brush grassland. Sotol and ceniza are the major brush species. Chino grama is the dominant grass (fig. 10). Other vegetation is lechuguilla, ocotillo, whitethorn acacia, mariola, pricklypear, ephedra, skeletonleaf goldeneye, guayacan, red grama, and sideoats grama.

Mule deer and javelina use areas of this map unit as home ranges. The lechuguilla and other shrubs provide a good variety and quantity of food. Coyote and fox use the areas for hunting and dens. Rodents, snakes, and lizards use the areas for dens. Passerine birds use the areas for food, cover, and nesting.

Small stones and short, steep side slopes are limitations for shaping and leveling campsites and picnic areas.

The cemented pan of the Monterosa soils presents some problems in excavating for foundations, septic systems, and underground utilities for building sites. The short, steep slopes present problems in leveling areas for building sites.

ERF—Ector-Rock outcrop complex, steep. This map unit consists of very shallow and shallow, very gravelly and very cobbly soils on limestone hills and mountains. It is on the summits and shoulders of peaks in the Dead Horse Mountains in the eastern part of the survey area. These hills and mountains rise 1,000 to 3,000 feet (305 to 914 meters) above the desert valley floors. Slopes are mainly convex and range from 8 to 45

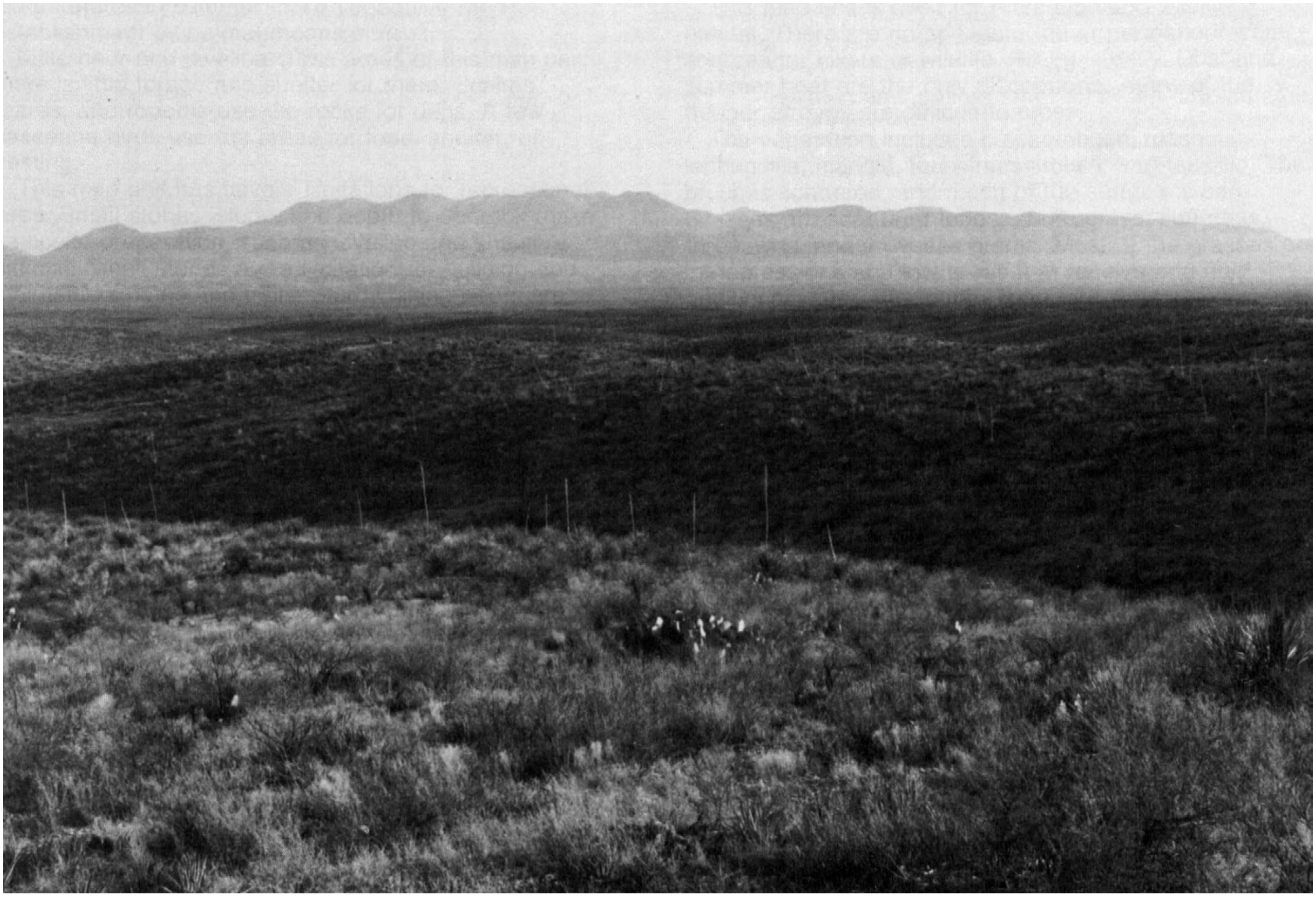


Figure 10.—Chino grama in an area of Chilicotal-Monterosa association, rolling.

percent. The mapped areas are irregular in shape and range from 150 to 3,200 acres (60 to 1,295 hectares) in size.

From the summits of these mountains the view is a vast panorama across broad desert areas to other mountains on the horizon. Also, spectacular views of deep canyons can be seen from the shoulders of the mountains. Because of the scarcity of water, very little use has been made of these areas, and there is no evidence of any permanent dwellings.

Ector soils make up 50 to 75 percent of this map unit. Rock outcrop makes up 10 to 40 percent, and other soils and components make up 10 to 30 percent. The other components are precipitous cliffs and canyon walls, gravelly soils on foot slopes and in drains, and areas of Upton and Lozier soils. The percentages of this map unit were determined by sampling transects across several units. Areas of the Ector soils and Rock outcrop are so intricately mixed that it was not practical to map them separately.

Typically, the surface layer of the Ector soils is brown, very cobbly loam about 6 inches (15 centimeters) thick. The underlying layer is hard limestone bedrock that has accumulations of calcium carbonate in the seams in the upper 6 inches (15 centimeters). Limestone gravel lag and cobbles cover about 80 percent of the surface.

The Ector soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Rooting zone is very shallow to shallow. Because of the gravel and cobbles on the surface, wind and water erosion are slight hazards or none at all.

Rock outcrop consists of limestone ledges, escarpments, and steep random exposures intermingled with the Ector soils.

This map unit is used for recreation and wildlife habitat. There are no roads and very few trails. Hiking is hazardous because of steep slopes and loose rocks. These areas have no springs or other dependable water supplies; water for wildlife and hikers is limited to a few undependable tinajas in drainage courses.

The vegetation includes sideoats grama, black grama, slim tridens, green sprangletop, muhlys, sotol, junipers, giant yuccas, and scattered Mexican pinyon pine. Low rainfall and the very low available water capacity limit the amount of forage produced. These soils have had limited use by livestock because of the rugged terrain and extremely limited water supplies. Because grazing of these areas has been extremely limited in the past few decades, they are probably very close to a climax condition at present.

This map unit is used seasonally by most wildlife. Mule deer and javelina use the areas temporarily during the rainy season when potholes in the rock exposures hold water for short periods. Wildlife is scarce during the rest of the year. Rodents, snakes, and lizards use the rocks for cover and dens. This map unit is also used by coyote, ringtail, rock squirrel, and mountain lion which den in the rocks. A few raptors and passerine birds use the areas for food, cover, lookout points, and nesting sites.

This map unit has severe limitations for recreational uses. Small stones, slope, and depth to bedrock make campsite preparation, such as shaping and leveling, difficult. Small stones and steep slopes are limitations for paths and trails.

The main limitations for building sites are depth to bedrock and slope. Excavating for foundations, underground utilities, and septic systems in most places is impractical.

GHA—Glendale-Harkey association, occasionally flooded. This map unit consists of deep, well drained soils on the flood plain of the Rio Grande, along the southern border of the park. Slopes are plane and range from 0 to 2 percent. Heavy rains on the Rio Conchos in Mexico and other watersheds cause the river to overflow its banks and flood these areas with 1 to 10 feet (0.3 to 3 meters) of water. Flooding occurs about once every 3 to 5 years. Inundation usually lasts from 2 to 20 days. Thin layers of fresh alluvium are deposited during each flood. The mapped areas are long and narrow and range from 40 to 400 acres (16 to 162 hectares).

The view across these areas is of dense trees, shrubs, and brush. From these areas, the Rio Grande can be seen, and across the river, cliffs and mountains in Mexico. Early settlers used these areas extensively. The permanent dwellings are mostly on the adjacent uplands above the flood plain. The paved road from Castolon to Santa Elena Canyon runs along the edge of several areas of this map unit.

Glendale soils make up 40 to 50 percent of this map unit, Harkey soils make up 30 to 40 percent, and other soils make up about 10 to 30 percent. The other soils have coarser or finer texture and are scattered throughout the map unit. The soils form a regular pattern; Harkey soils are near the river channel, and Glendale soils are farther from the channel. Use and management of the Harkey and Glendale soils are similar; it was not practical to map the soils separately.

Typically, the surface layer of the Glendale soils is brown silty clay loam about 9 inches (23 centimeters) thick, including a 1-inch (2.5 centimeters) thick deposit of pale brown alluvium from the 1981 flood. Pale brown silt loam which is stratified extends to a depth of 18 inches (46 centimeters). Light yellowish brown stratified silt loam extends to a depth of 35 inches (89 centimeters). Light yellowish brown stratified loam extends to a depth of 60 inches (150 centimeters).

Glendale soils are well drained. Surface runoff is slow to medium. Permeability is moderately slow, and available water capacity is high. Rooting depth is deep. Wind erosion is a moderate hazard.

Typically, the upper part of the surface layer of the Harkey soils is fresh, pale brown, calcareous, silty clay loam alluvium about 2 inches (5 centimeters) thick. The lower part of the surface layer extends to a depth of 10 inches (25 centimeters) and is pale brown very fine sandy loam. The layer below that extends to a depth of 18 inches (46 centimeters) and is stratified brown very fine sandy loam. Stratified pale brown very fine sandy loam extends to a depth of 50 inches (126 centimeters). Brown silt loam extends to a depth of 60 inches (150 centimeters).

Harkey soils are well drained. Surface runoff is slow to medium. Available water capacity is high, and permeability is moderate. Rooting depth is deep. Wind erosion is a moderate hazard.

This map unit is used for recreation and wildlife habitat. Many of these areas were farmed to cotton in the past. However, since the establishment of the park they have been allowed to revert back to native vegetation. Remains of old irrigation systems are evident in many of the areas. This map unit has no water for hikers, but the Rio Grande, which forms one boundary of the area, provides ample water for wildlife. Thick brush in many areas is a problem for hikers.

The vegetation includes saltcedar, mesquite, cottonwood, willow, tree tobacco, whitebrush, spiny aster, bermudagrass, and common and giant reed. The vegetation is dense in most areas.

A few mule deer and javelina use these areas for food and shelter. The Mexican beaver builds dens in the riverbank and feeds on the willows and other trees. Coyotes use this map unit for hunting and dens. Rodents, snakes, and lizards use the areas for dens.

Many passerine birds use the areas for food, shelter, and nesting.

Occasional flooding is the major limitation for campsites and picnic areas. The soils are highly erodible if used for paths and trails.

The major limitation for building sites is the hazard of flooding, which is difficult to overcome.

HRD—Hurds very gravelly sandy loam, rolling

This map unit consists of deep, very gravelly soils in valleys and on the upper parts of piedmont slopes below igneous mountains. These soils are on foot slopes and in the valleys on the northern and northeastern sides of the Chisos Mountains. These areas are mainly sloping and strongly sloping piedmont and foot slopes dissected by incised drainageways. There are some gently sloping areas on lower slopes and some moderately steep areas on upper slopes and on side slopes of drainageways. Slopes range from 3 to 20 percent. Elevation is from 4,500 to about 5,600 feet (1,370 to 1,700 meters). The mapped areas are roughly rectangular and range from 200 to 1,000 acres (80 to 405 hectares).

The view across these areas is of a mountain valley that supports a great variety of vegetation. The view from these areas is of the mountains along the sides of the valley or down the mouth of the valleys across piedmont slopes to distant mountains. Early settlers apparently did not establish permanent dwellings in these areas, although old wells attest to their attempts to locate water. The road that goes to the basin and the Pine Canyon road cross areas of this unit.

Hurds and closely similar soils make up about 70 percent of this map unit. One closely similar soil ranges from having a dark surface layer less than 10 inches (25 centimeters) thick to being light colored throughout. Another is less than 35 percent coarse fragments in the solum. Also included are some areas of Hurds very cobbly loam. Also included, and making up about 30 percent of this unit, are small areas of Chilicotal soil on lower slopes; some sandy soils on lower slopes; soils that do not have clay accumulations in the subsoil; soils that do not have clay accumulations in the subsoil and also have a darkened surface layer more than 20 inches (50 centimeters) thick; some igneous rock outcrops; and some areas of Pantera soil in the bottoms of narrow drainageways.

Typically, the surface layer of the Hurds soils is reddish brown very gravelly sandy loam about 3 inches (8 centimeters) thick. Reddish brown sandy clay loam that is about 45 percent igneous gravel extends to a depth of 29 inches (74 centimeters). Reddish brown sandy clay loam that is about 35 percent igneous gravel extends to a depth of 41 inches (104 centimeters).

Hurds soils are well drained. Surface runoff is medium. Permeability is moderate, and available water capacity is low. Rooting depth is deep. Wind erosion is a slight hazard, and water erosion is a moderate hazard.

This map unit is used for recreation and wildlife habitat. Hiking is moderately strenuous. There are no springs or other permanent water supplies for hikers or wildlife.

The vegetation includes Mexican buckeye, foothills basketgrass, littleleaf leadtree, Apacheplume, juniper, sotol, catclaw, century plant, little bluestem, hairy grama, and cane bluestem. Mexican pinyon pine grow above an elevation of about 4,900 feet, as do a few of the scarce Texas madrone trees.

Mule deer and Carmen Mountains whitetail deer range on this map unit. The Carmen Mountains whitetail deer use the areas above an elevation of 5,000 feet (1,500 meters), whereas the mule deer usually stay below this elevation. Mountain lion, coyote, and fox use areas of this map unit for hunting and for dens. Javelina use the arroyos for food and as resting areas. The variety and abundance of plants provides good cover and food sources for wildlife. Many passerine birds use areas of this map unit for nesting and feeding.

Small stones and slope are the major restrictions for recreational development, such as campsites and picnic areas.

Small stones and slopes are the major restrictions for building sites.

HRF—Hurds very cobbly loam, steep. This map unit consists of deep, very cobbly soils on steep colluvial foot slopes and alluvial fans of igneous mountains. These soils are on the northern and northeastern sides of the Chisos Mountains. Slopes are plane to concave and are mostly 20 to 45 percent, although in a few areas they range to about 70 percent. These soils are dissected by drainageways and are in bands at the base of mountains, grading into the less sloping, broad, piedmont slopes in desert valleys below. Areas of this map unit are irregular in shape and range from 80 to about 200 acres (30 to 80 hectares) in size.

The view from these areas is either across a narrow valley to mountains on the other side or upward to the top of the mountains. The view out of the valley is across the piedmont slope to the badlands and distant mountains beyond. Trees and other mixed prairie-type vegetation make this one of the most beautiful and scenic units in the park. However, because of the steepness, early settlers did not build permanent dwellings in areas of this map unit. The road to the basin crosses small areas of this unit.

Hurds soils and closely similar soils make up about 70 percent of this map unit. One of the closely similar soils has a darkened surface layer less than 10 inches (25 centimeters) thick; one has a dark surface layer more than 20 inches (50 centimeters) thick; another has bedrock between depths of 20 and 35 inches (50 and 89 centimeters), and others are less than 35 percent igneous rock fragments in the solum. Also included are some Hurds soils whose texture is very gravelly loam.

Also included, and making up about 30 percent of this unit, are areas of Brewster soils on convex upper slopes, areas of a soil that does not have clay accumulations in the subsoil and has a darkened surface layer more than 20 inches (50 centimeters) thick; some igneous rock outcrops; and some very steep talus slopes.

Typically, the surface layer of the Hurds soils is dark reddish gray very cobbly loam about 10 inches (25 centimeters) thick that is about 40 percent igneous fragments. The subsoil extends to a depth of 46 inches (117 centimeters) and is reddish brown very cobbly sandy clay loam that is about 45 percent igneous fragments.

Hurds soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is low. Rooting zone is deep. Wind erosion is a slight hazard; water erosion is a severe hazard.

This map unit is used for recreation and wildlife habitat. Hiking is strenuous because of the steep slopes. Loose stones are a danger to hikers. There are no springs or other permanent water supplies in these areas to furnish water for hikers or wildlife.

The vegetation includes Mexican pinyon pine, redberry juniper, gambel oak, catclaw, foothill basketgrass, Mexican sagewort, wolftail, deer muhly, bracken fern, little bluestem, hairy grama, and cane bluestem. A few of the scarce Texas madrone trees grow in areas of this map unit.

Mule deer and Carmen Mountains whitetail deer range in this unit. The mule deer use areas at a lower elevation, and the Carmen Mountains whitetail use the higher elevations. This map unit produces a good variety and quantity of forage for deer. Mountain lions use the area for hunting. Many passerine birds use the area for nesting and feeding sites.

Steep slopes and stones are the major limitations for recreational development. Leveling for campsites and picnic areas is difficult. Steep slopes are the major restriction for paths and trails and for building sites.

LAE—Lajitas-Rock outcrop complex, hilly. This map unit consists of very shallow and shallow, very cobbly and very gravelly soils on igneous hills and mountains scattered throughout the survey area. These scenic hills and mountains rise 300 to 5,000 feet (90 to 1,500 meters) above the desert floors. Slopes are convex or plane and are mostly 10 to 30 percent, although they range from 3 to 45 percent. The mapped areas are irregular in shape and range from 40 to 4,000 acres (16 to 1,618 hectares) in size.

The view of these areas includes single mountains and large areas of mountain complexes. The slopes are covered with chino grama in most areas. Large boulders and exposed bedrock are on the side slopes and crests of the mountains (fig. 11). From the crests of the mountains the view is across the lower desert floor to distant mountains and majestic canyons, such as Santa Elena, or to other mountains in this unit. Springs furnish water. However, because of the roughness of the mountains, only a few homesites have ever been located in these areas.

The Lajitas and closely similar soils generally make up about 60 percent of this map unit, ranging from 30 to 75 percent; Rock outcrop makes up about 10 percent, ranging from 5 to 30 percent; and dissimilar soils make up about 30 percent, ranging from 0 to 50 percent. The Lajitas soils dominate the areas. One of the closely similar soils is a Brewster soil that has a darker surface layer. Another closely similar soil differs only in having carbonates in the bedrock fractures. This soil containing carbonates makes up about 5 percent of the map unit. It is on the foot slopes of Chilicotal and Tally Mountains and grows candelilla. Rock outcrop is on steep cliffs and as barren exposures scattered throughout the areas. The included dissimilar soils are mostly Chamberino, Chilicotal, Hurds, Monterosa, and Upton soils, mostly on gravelly foot slopes and in drainageways. The percentage composition of this unit was determined by sampling transects across several units. Areas of Lajitas soils and Rock outcrop are so intricately mixed or so small that it was not practical to map them separately at the scale used.

Typically, the Lajitas soils consist of brown very cobbly loam about 7 inches (18 centimeters) thick, resting abruptly on hard igneous bedrock.

The Lajitas soils are well drained. Permeability is moderate, and available water capacity is very low. Rooting zone is very shallow to shallow. Wind and water erosion are only slight hazards because of the gravel and cobbles.

The Rock outcrop consists mainly of igneous rocks, mostly rhyolite.

This map unit is used for recreation and wildlife habitat. Although few of the park roads actually cross these areas, many are close by. The paved park road from Old Ranch to Mule Ears Peak overlook gives a good view of the areas. Numerous scenic trails cross this map unit. The Dodson Trail, trails on Burro Mesa, Mule Ear Spring, and Grapevine Hills Trail are a few that hikers and backpackers enjoy. Many of the areas have springs that furnish water for wildlife and hikers. Hiking is strenuous and hazardous because of loose rocks and steep slopes and, in the summer, high temperatures.

The vegetation includes lechuguilla, leatherstem, skeletonleaf goldeneye, pricklypear, ocotillo, ceniza, ephedra, feather dalea, sotol, guayacan, yuccas, chino grama, tanglehead, sideoats grama, black grama, fluffgrass, cane bluestem, and threeawns.

This map unit is utilized by most wildlife. Mule deer and javelina use the areas for food and cover. Mountain lions and bobcats use the areas for dens and hunting areas. Rodents, snakes, and lizards use the rocks for cover and dens. Coyotes, ringtails, and foxes use the areas for dens and as home territories. Raptors and

Figure 11.—Large boulders and areas of exposed bedrock are typical of Lajitas-Rock outcrop complex, hilly.

passerine birds use the areas for food and cover and as lookout and nesting areas.

This map unit has severe limitations for recreational uses. Stones, slope, and depth to bedrock make campsite preparation, such as leveling and shaping, difficult. Stones are a limitation for paths and trails.

The main limitations for building sites are depth to bedrock and slope. Excavating the hard igneous rock for foundations, septic systems, and underground utilities is difficult and usually impractical because blasting is required.

LAF—Lajitas-Rock outcrop complex, steep. This map unit consists of very shallow and shallow, very cobbly and very gravelly soils and Rock outcrop on igneous hills and mountains in the central part of the survey area. Large areas are south of the South Rim and scattered throughout the western part of the survey area. These hills and mountains rise 500 to 5,000 feet (150 to 1,500 meters) above the desert floors. Slopes are convex on summits and shoulders and concave on back slopes. Slopes are mostly 20 to 45 percent, although they range from 15 to 60 percent. The mapped areas are irregular in shape and range from 90 to 3,500 acres (36 to 1,416 hectares) in size.

The most spectacular characteristic of this unit is the large amount of exposed bedrock. These areas of bedrock are on the crests and summits of the mountains and many extend for several hundred feet above the vegetated slopes (fig. 12). From the mountaintops, a panorama extending across the desert floor to distant mountains unfolds. Although some springs furnished water for wildlife, Indians, and early settlers, the roughness and steepness of the terrain caused the areas to be inaccessible to most travelers. Few, if any, permanent dwellings were established in these areas.

Lajitas and closely similar soils make up about 35 percent of this map unit, ranging from 20 to 60 percent; Rock outcrop makes up 55 percent, ranging from 40 to 70 percent; and other soils make up about 10 percent, ranging from 0 to 20 percent. The Lajitas soils are mostly on mid slopes and foot slopes. The other soils are mostly gravelly soils along drainageways. The percentages of this map unit were determined by sampling transects across several units. Areas of Lajitas soils and Rock outcrop are so intricately mixed that it was not practical to map them separately.

Typically, the Lajitas soils consist of pale brown very cobbly loam about 5 inches (12 centimeters) thick, resting on hard igneous bedrock.

The Lajitas soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Rooting zone is very shallow to shallow. Wind and water erosion are only slight hazards because of the gravel and cobble lag.

The Rock outcrop consists of exposed bedrock on the crests of mountains, steep ledges, escarpments, and random exposures intermingled with the Lajitas soils.

This map unit is used for recreation and wildlife habitat. Although none of the park roads traverse these areas, the mountains and hills are visible as part of the scenic vista from the road. Parts of the Dodson and Elephant Tusk trails cross this map unit. A few springs furnish water for wildlife and hikers. Hiking is strenuous. Steep slopes and loose rocks are hazards for hikers and backpackers.

The vegetation includes lechuguilla, skeletonleaf goldeneye, sotol, ratany, leatherstem, pricklypear, ceniza, and feather dalea. The grasses are chino grama, tanglehead, threeawns, black grama, and sideoats grama.

This map unit is used by mule deer and javelina for food and cover and by mountain lions for dens and hunting areas. Rodents, snakes, and lizards use the rocks for cover and dens. Raptors use the areas for food, cover, lookout points, and nesting areas.

This map unit has severe limitations for recreational uses. Stones, slopes, and depth to bedrock make campsite preparation, such as shaping and leveling, impractical. Stones and steep slopes make paths and trails difficult to establish and maintain.

Slopes, stones, and depth to bedrock are severe limitations for building sites. Excavating for foundations, septic systems, and underground utilities is impractical. Blasting is required.

LMF—Liv-Mainstay-Rock outcrop complex, steep. This map unit consists of shallow and deep, very cobbly and very gravelly soils and Rock outcrop on igneous hills and mountains in the Chisos Mountains. Slopes are mostly steep, from 20 to 45 percent, although they range from 8 percent to vertical rock walls. Elevation ranges from 5,000 to about 6,200 feet (1,500 to 1,900 meters). Stones and large boulders that have fallen from igneous rock ledges are scattered across the surface of these areas. The areas are irregular in shape and range from 1,000 to 1,500 acres (400 to 600 hectares) in size.

These scenic mountains include an intermountain basin. This map unit has woodland-grassland vegetation. The trees and grasses add an interesting contrast to the surrounding desert. From the basin floor, the view is of surrounding mountains. Through the window on the west side of the basin, the view is across the desert floor to distant mountains. Sunsets are very beautiful when viewed through this notch in the mountains. The square-topped igneous peak of Casa Grande on the east side is impressive, especially at sunrise. From the summit or side slopes of the mountains one can view the entire basin. Many endemic and unusual species of trees, such as the drooping juniper, grow in this map unit. A few springs provided water for wildlife, Indians, and early settlers, but because of the inherent ruggedness of the area, there were no permanent buildings until recent times. The basin lodge, several other permanent buildings, and a campground are now located in this area. The park road into the basin and numerous trails from the basin trailhead cross this map unit.

Liv and closely similar soils make up about 40 percent of this unit, Mainstay and closely similar soils about 25 percent, Rock outcrop about 20 percent, and other soils about 15 percent. One of the soils similar to the Liv soils has darkening from the surface less than 20 inches (50 centimeters) thick, another has a clay loam surface layer, another has a light colored subsurface layer, another has less than 50 percent clay in the subsoil, and another has less than 35 percent rock fragments in the solum. One of the soils similar to Mainstay has a light colored surface layer, another has less than 35 percent rock fragments in the solum, and another has less than 35 percent clay in the subsoil. Other inclusions are some talus slopes, Brewster soils, Hurds soils on slopes near the lower edges of the areas of this complex, Puerta and Madrone soils near the upper edges of these areas, a soil formed in cobbly and gravelly colluvium that does not have an accumulation of clay in the subsoil, a soil formed over clayey shale, and another soil where the lower part of the surface layer is light in color. Areas of the Liv and Mainstay soils and the Rock outcrop are so intricately mixed that it was not practical to map them separately.

Typically, the surface layer of the Liv soils is dark reddish brown, very cobbly loam about 9 inches (23 centimeters) thick. Below that, reddish brown, very

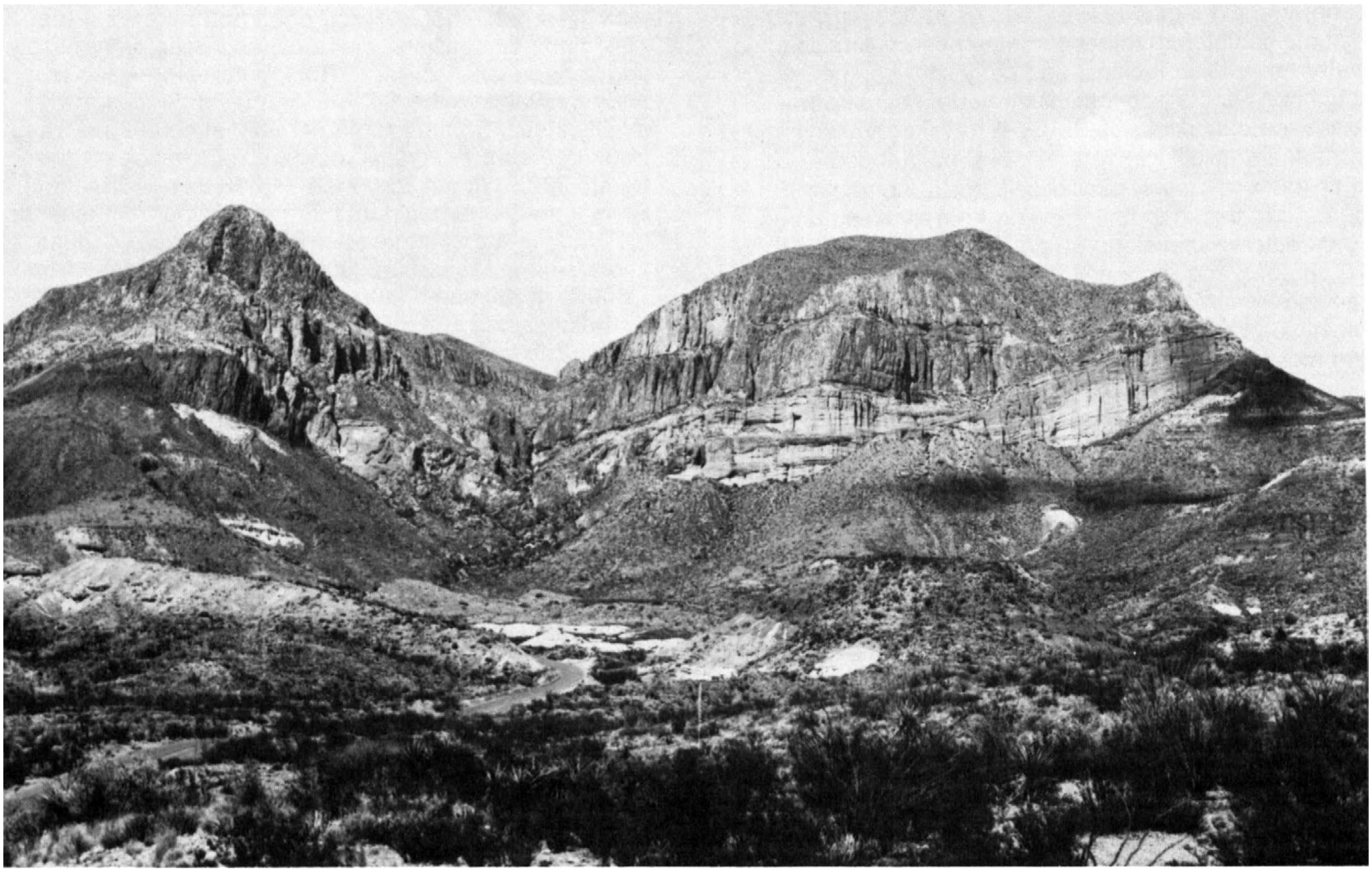


Figure 12.—View of Goat Mountain. Chilicotal soils are in the foreground; Lajitas soils and Rock outcrop are in the background.

cobbly clay extends to a depth of about 68 inches (173 centimeters).

Liv soils are well drained. Surface runoff is rapid. Permeability is moderately slow, and available water capacity is low to very low. Rooting zone is deep. Water erosion is a severe hazard because of steep slopes.

Typically, the surface layer of the Mainstay soils is very dark grayish brown, very gravelly loam about 5 inches (12 centimeters) thick. The subsoil is reddish brown, very gravelly clay which rests on igneous bedrock at a depth of about 18 inches (46 centimeters).

Mainstay soils are well drained. Surface runoff is rapid. Permeability is moderately slow, and available water capacity is very low. Rooting zone is shallow. Water erosion is a severe hazard because of steep slopes.

The Rock outcrop consists of exposed igneous bedrock on the crests of mountains, knolls, ledges, escarpments, and random exposures intermingled with the Liv and Mainstay soils.

This map unit is used for recreation and wildlife habitat. A few springs furnish water for hikers and wildlife. Hiking is strenuous. Steep slopes and loose rock are hazards for hikers and backpackers.

The vegetation includes pinyon pine, gray oak, Graves oak, Emory oak, Chisos red oak, drooping juniper, oneseed juniper, alligator juniper, Texas madrone, green ash, bigtooth maple, evergreen sumac, littleleaf sumac, agave, sotol, lechuguilla, pricklypear, skeletonleaf goldeneye, whitethorn acacia, sideoats grama, cane bluestem, buffalograss, green sprangletop, dropseeds, and tridens.

This map unit is used by the endemic Carmen Mountains whitetail deer for food and shelter. Javelina make limited use of areas along drains. Mountain lions use areas of this map unit for hunting and dens. Fox, ringtails, and rock squirrels use the areas for dens. Raptors use the high mountains for food, cover, lookout points, and nestings. Peregrine falcons sometimes nest on the high rocky cliffs. Passerine birds use areas of this unit for food, cover, and nesting.

This map unit has severe limitations for recreational uses. Stones, slope, and depth to bedrock make campsite preparation, such as shaping and leveling, difficult. Stones and steep slopes make establishment and maintenance of paths and trails difficult.

Slopes, stones, and depth to bedrock are severe limitations for building sites. Excavating for foundations, septic systems, and underground utilities is difficult.

LRF—Lozier-Rock outcrop complex, steep. This map unit consists of very shallow and shallow, very gravelly and very cobbly soils on summits, shoulders, back slopes, and foot slopes of limestone hills and mountains. These hills and mountains rise 300 to 3,000 feet (90 to 900 meters) above the floor of the desert valley. Large areas of this map unit are on the Sierra del Carmen Mountains in the eastern part of the park, on Mariscal Mountain in the southern part, and on the Mesa de Anguilla in the western part. Slopes are convex on the summits and shoulders and concave on the back slopes and foot slopes. Slopes range from 15 to about 50 percent. The mapped areas are irregular in shape and range from 40 to 6,600 acres (16 to 2,670 hectares) in size.

This map unit is on majestic limestone mountains that can be seen from many vantage points in the Big Bend area. From the summits of the mountains, the view is a panorama across the desert floor into the mountains of the Chisos complex, other mountains in the Big Bend area, and mountains across the border in Mexico. There are no dependable water supplies or springs. Therefore, Indians and early settlers did not set up permanent residence; no old ruins have been found in these areas. Today most people enjoy the scenery from a distance. These areas are inaccessible to vehicles. A few people hike or backpack.

Lozier soils make up 45 to 65 percent of the map unit. Rock outcrop makes up 30 to 55 percent and other soils less than 10 percent. The other soils are mostly Ector and Mariscal. The percentages of this map unit were determined by sampling transects across several units. Areas of the Lozier soils and Rock outcrop are so intricately mixed that it was not practical to map them separately.

Typically, the surface layer of the Lozier soils is light brownish gray very gravelly loam about 3 inches (8 centimeters) thick. Very pale brown, very gravelly loam that has coatings of calcium carbonate on the coarse fragments extends to a depth of 9 inches (23 centimeters). Grayish hard limestone bedrock that has calcium carbonate in the seams is below a depth of 9 inches (23 centimeters). Limestone gravel and cobbles cover about 80 percent of the surface.

The Lozier soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Rooting depth is shallow or very shallow. The hazard of wind erosion is slight because of gravel and cobble lag on the surface. The hazard of water erosion is severe because of steep slopes.

Rock outcrop consists of limestone bedrock on steep ledges and escarpments and as random exposures intermingled with the Lozier soils. These areas have undergone uplifting, and the limestone strata are slightly tilted.

This map unit is used for recreation and wildlife habitat. No roads and few trails cross these areas. Parts of the Strawhouse Trail and trails on the Mesa de Anguilla provide access. Hiking is hazardous because of steep slopes and loose rocks. Water for wildlife and hikers is limited to a few tinajas and water that remains in potholes in the rock for a few days after rains.

The vegetation includes sideoats grama, slim tridens, chino grama, tanglehead, and threeawn grasses mixed with lechuguilla, sotol, false agave, leatherstem, candelilla, skeletonleaf goldeneye, and resurrection plant. Limited rainfall and the very low available water capacity limit the amount of forage produced.

This map unit is generally used seasonally by wildlife. Mule deer and javelina inhabit these areas temporarily during the rainy season, when potholes in the rock exposures hold water for short periods. Coyote, gray fox, rock squirrel, ringtail, and mountain lion, which den among the rocks, are also occasional inhabitants. A few raptors and passerine birds use the areas for food, cover, lookout points, and nesting sites. Wildlife is scarce during the dry season.

This map unit has severe limitations for recreational uses. Small stones, slope, the rugged terrain, and depth to bedrock make campsite preparation, such as shaping and leveling for tents, difficult. Small stones and steep slopes are limitations for paths and trails.

LRG—Lozier-Rock outcrop complex, very steep. This map unit consists of very shallow and shallow, very cobbly and very gravelly soils on limestone hills and mountains which rise 300 to 3,000 (90 to 900 meters) feet above the desert valley floors. This map unit is on the summits, shoulders, and back slopes of the Sierra del Carmen Mountains in the eastern part of the park, on Mariscal Mountain in the southern part, and on the Mesa De Anguilla in the western part. Slopes are convex on the summits and shoulders and concave on the back slopes. Slopes commonly range from 30 to about 60 percent, but vertical canyon walls are also included. The mapped areas are irregular in shape and range from 40 to 6,000 (16 to 2,428 hectares) acres in size.

The majestic limestone mountains of this map unit can be viewed from many vantage points in the Big Bend area. From the summits of the mountains, one can see a panorama across the desert floor to the high Chisos and other mountains. Deep, rugged canyons offer spectacular views from both the upper rims and the canyon floors. There are no dependable water sources or springs in this unit. Therefore, these areas were not used for permanent dwelling places. Exploration of these areas has been limited because of inaccessibility and lack of water.

Lozier soils make up about 50 percent of the map unit, Rock outcrop about 40 percent, and other soils about 10 percent. The main included soils are Ector and Mariscal. The percentages were determined by sampling transects across this unit.

The Lozier soils are in the less sloping areas and as pockets between areas of Rock outcrop. Rock outcrop consists of vertical canyon walls, short steep escarpments, and exposed bedrock ledges scattered throughout areas of the Lozier soils. The mountains have been uplifed, and the limestone bedrock is slightly tilted. Areas of the Lozier soils and Rock outcrop are so intricately mixed that it was not pracitcal to map them separately.

Typically, the surface layer of the Lozier soils is light brown, very cobbly loam about 5 inches (12 centimeters) thick. A layer of limestone fragments, coated with caliche, and soil material in the cracks and crevices extends to a depth of 11 inches (28 centimeters). This layer rests abruptly on hard grayish limestone bedrock. Limestone gravel and cobbles cover about 80 percent of the surface.

The Lozier soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Rooting depth is shallow or very shallow. Wind erosion is a slight hazard because of the gravel and cobbles on the surface. Water erosion is a severe hazard because of very steep slopes.

This map unit is used for recreation and wildlife habitat. There are no roads crossing these areas. However, from the ends of the roads a spectacular view of the limestone cliffs can be seen at Santa Elena Canyon and Boquillas Canyon. The Telephone Canyon trail crosses this map unit along the floor of Telephone Canyon. Hiking is hazardous because of the loose rocks, steep slopes, and vertical walls along canyons. The limestone is too soft for technical climbing. These areas have no springs; water for wildlife and hikers is limited to a few tinajas. Some potholes in the rock hold water for a few days after rains.

The vegetation includes black grama, chino grama, sotol, lechuguilla, yuccas, mariola, candelillia, resurrection plant, and false agave. Low rainfall and very low available water capacity limit the amount of forage produced.

This map unit is used seasonally by most wildlife. Mule deer and javelina use the areas temporarily during the rainy season when potholes in the rock exposures hold water for short periods. Wildlife is scarce during the rest of the year. Rodents, snakes, and lizards use the rocks for cover and dens. The soil complex is also used by coyote and mountain lions which den in the rocks. A few raptors and passerine birds use the areas for food, cover, lookout points and nesting sites. Peregrine falcons use the sheer canyon walls for nesting sites.

This map unit has severe limitations for recreational uses. Stones, slope, and depth to rock make campsite preparation, such as shaping and leveling, difficult. Steep slopes and stones are limitations which make paths and trails difficult to construct and maintain.

The main limitations for building sites are depth to bedrock, slope, and stones. Excavating the hard limestone for foundations, underground utilities, and septic systems is usually impractical, requiring blasting.

MRE—Mariscal-Rock outcrop complex, hilly. This map unit consists of very shallow and shallow, very channery or very flaggy soils and Rock outcrop on limestone hills and mountains. The areas are in the eastern and southern parts of the park. Slopes are mainly convex or plane and range from 10 to 30 percent. The mapped areas are irregular in shape and range from 50 to 200 acres (20 to 81 hectares) in size.

The view from the crests of the hills in this unit extends across the desert floor to the Chisos complex or the Sierra del Carmen mountain range. Early settlers used flagstone from the limestone hills for building their cabins. Because there are no springs in this map unit most of the remaining cabins are in surrounding areas that are less sloping and have available water.

Mariscal and closely similar soils make up 60 to 80 percent of this map unit, Rock outcrop makes up about 10 to 30 percent, and other soils make up 10 to 20 percent. Some of the soils closely similar to Mariscal do not have accumulations of calcium carbonate on the coarse fragments and in the bedrock seams, and some are more than 65 percent coarse fragments in the surface layer. The other soils include small areas of Lozier soils, areas of deep gravelly soils along drainageways, and small areas where slopes are greater or lesser than is typical for the map unit. Areas of the Mariscal soils and Rock outcrop are so intricately mixed that it was not practical to map them separately. The percentages of this map unit were determined by sampling transects across the map unit.

Typically, the surface layer of the Mariscal soils is calcareous, moderately alkaline, pale brown very channery loam about 5 inches (12 centimeters) thick. Limestone bedrock that has thin layers of marl and shale is below a depth of 5 inches (13 centimeters). Flat limestone fragments cover 60 percent of the surface.

The Mariscal soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Rooting depth is very shallow or shallow. Wind and water erosion are slight hazards because of the limestone lag on the surface.

Rock outcrop consists of ledges of slightly tilted layers of limestone that give the slopes a stairstepped effect (fig. 13). Areas of bare limestone are also intermingled with the Mariscal soils.

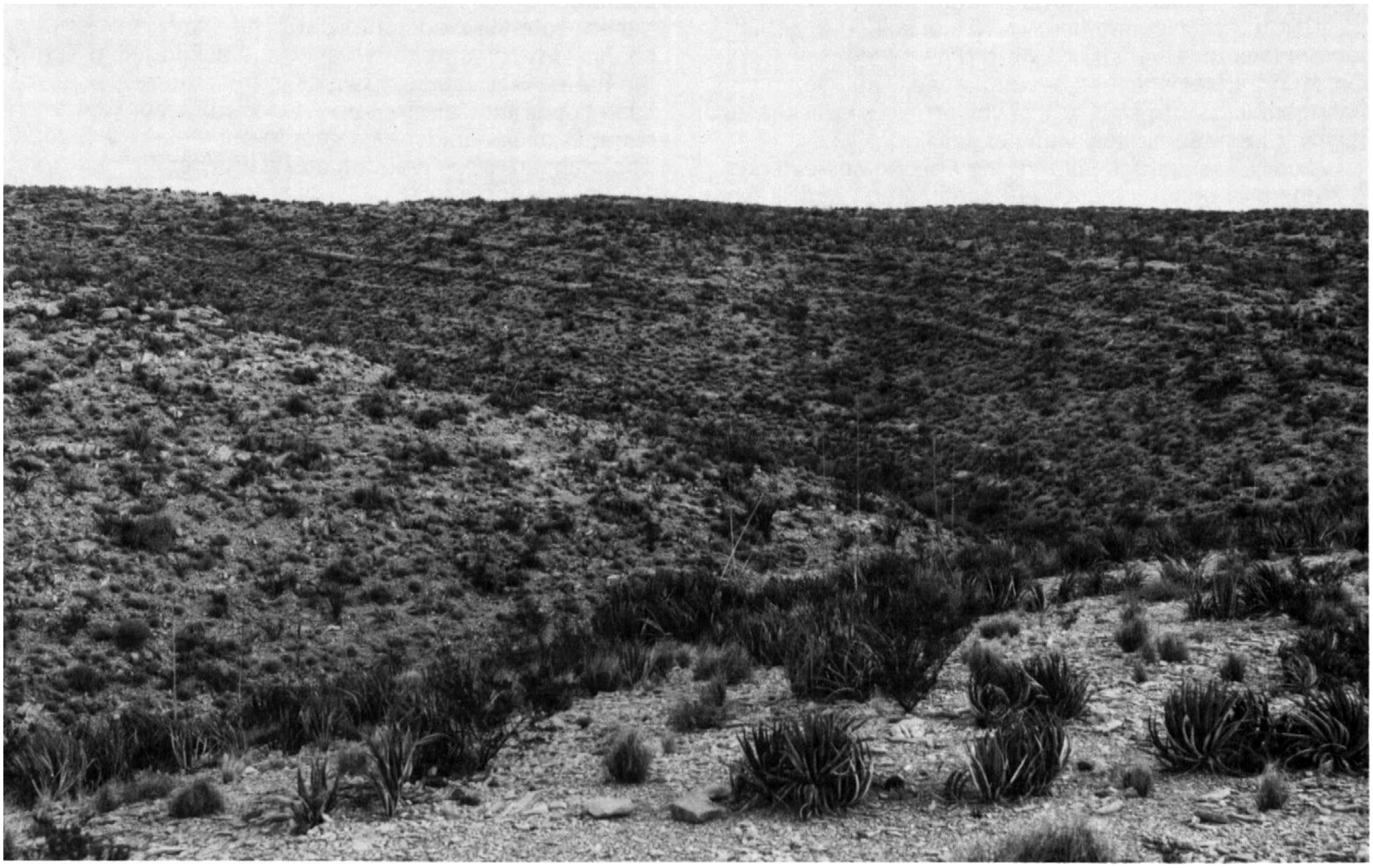


Figure 13.—Thin layers of channery limestone are evident in this area of Mariscal-Rock outcrop complex, hilly.

This map unit is used for recreation and wildlife habitat. The Hot Springs road and parts of the Old Ore Road cross the unit. Water for wildlife and hikers is limited to a few tinajas.

The vegetation is grasses and scattered shrubs, including lechuguilla, candelilla, leatherstem, creosotebush, resurrection plant, skeletonleaf goldeneye, ephedra, and cacti. The major grass is chino grama. Low rainfall and very low available water capacity limit the amount of forage produced.

Mule deer and javelina use the lechuguilla, pricklypear, and other shrubs for food and shelter. Some passerine birds find food, shelter, and nesting sites in this map unit, and rodents, jackrabbits, and coyotes use the areas for dens and hunting.

This map unit has severe limitations for recreational uses. Stones, slope, and depth to rock make site preparation, such as leveling and grading, difficult. Small stones are a limitation for paths and trails.

The major limitations for building sites are slope, depth to rock, and stones. Excavating for septic tanks, foundations, and underground utilities is difficult.

PAA—Pajarito-Agustin association, gently sloping. This map unit consists of deep, well drained soils on uplands. These soils are on a plain in the northern part of the survey area. Slopes are plane and range from 1 to 3 percent. The mapped areas are rectangular and range from 200 to 600 acres (81 to 243 hectares).

This map unit is dominated by shrub vegetation, mostly creosotebush. The Rosillas Mountains rise to the west of this unit. The Sierra del Carmens are across Tornillo flats to the east and north, and the piedmont slopes of the Chisos Mountains are visible to the south. No dependable water sources are available, and there is no evidence of permanent residence by early settlers.

Pajarito soils make up about 40 percent of the map unit, Agustin soils make up 40 percent, and other soils make up 20 percent. The other soils are very similar to

Pajarito and Agustin soils. One is more than 35 percent gravel in the profile; another is a Nickel soil. The percentages of this map unit were determined by sampling transects across several areas. The use and management of the soils in this unit are so similar that mapping them separately was not justified.

Typically, the surface layer of the Pajarito soil extends to a depth of about 4 inches (10 centimeters) and is light brown fine sandy loam that is about 5 percent, by volume, mixed pebbles. The subsoil extends to a depth of 14 inches (35 centimeters) and is light reddish brown fine sandy loam that is about 5 percent mixed pebbles. Reddish brown fine sandy loam that is about 10 percent mixed pebbles is below a depth of 14 inches (35 centimeters).

Pajarito soils are well drained. Surface runoff is very slow. Permeability is moderately rapid, and available water capacity is moderate. Rooting zone is deep. Wind and water erosion are moderate hazards.

Typically, the surface layer of the Agustin soils extends to a depth of about 2 inches (5 centimeters) and is pale brown gravelly fine sandy loam that is about 15 percent mixed limestone and igneous pebbles. Pale brown gravelly fine sandy loam that is about 15 percent mixed pebbles extends to a depth of 11 inches (28 centimeters). The underlying material is light yellowish brown stratified gravelly loam and gravelly fine sandy loam that is about 30 to 35 percent mixed gravel.

Agustin soils are well drained. Surface runoff is slow. Permeability is moderately rapid, and available water capacity is low to moderate. Rooting depth is deep. Water erosion is a slight hazard, and wind erosion is a moderate one.

This map unit is used for recreation and wildlife habitat. No roads or trails cross the areas of the unit. There are no springs or other permanent water sources to provide water for hikers or wildlife. Use by wildlife is limited. Hiking is easy.

The vegetation includes creosotebush, lechuguilla, tasajillo, pricklypear, dog cacti, and mariola and some scattered chino grama and threeawns.

Mule deer and javelina sometimes travel across areas of this map unit but do not use them for home ranges. Rodents, snakes, and lizards use the areas for shelter and dens. Only a few passerine birds use the areas for shelter, food, and nesting.

These soils have a high potential for recreational uses. Dusty surfaces are a problem for playgrounds and picnic areas.

These soils have few or no limitations for building sites. Seepage can be a problem for septic systems in some areas.

PNA—Pantera very gravelly sandy loam, frequently flooded. This map unit consists of deep, well drained soils on broad flat drainageways or arroyos. Slopes are mostly plane and range from 0 to 5 percent. The drainageways are incised from 1 to 15 feet (0.3 to 4.6 meters) into the piedmont slope. They have braided channels which spread out and run back together across the areas. High intensity rainfall in the mountains causes flash floods that last for short periods of time. Floods occur from several times a year to once every two years. The mapped areas are long and narrow and range from 100 to 700 acres (40 to 283 hectares).

From areas of this soil, the close view is one of piedmont slopes with sparse brush cover. Upslope, the Chisos or other mountains create a backdrop to the scenery. Downslope are broad flats or the Rio Grande. Some of the drainageways have high arroyo banks that block the view of adjoining uplands. Water is scarce except immediately after hard rains, when areas in the mountains are subject to flooding. This map unit has not been used for permanent dwellings because of the hazard of flooding.

This map unit is about 80 percent Pantera soils and 20 percent other soils and land types. Included are small areas of Chamberino and Chilicotal soils and Badlands on small upland areas. Tornillo soils and Riverwash are included in the drainageways. Also included are a few areas of a Pantera soil that is occasionally or rarely flooded.

Typically, the surface layer of the Pantera soil is light brownish gray, very gravelly sandy loam about 15 inches (38 centimeters) thick. The underlying material to a depth of 60 inches (152 centimeters) is pale brown, stratified, very gravelly sandy loam.

Pantera soils are well drained. Permeability is moderately rapid. Surface runoff is medium. Available water capacity is very low to low. Rooting zone is deep. Wind erosion is a slight hazard. Scouring occurs during flash floods.

This soil is used for recreation and wildlife habitat. The cobbles and gravel on the surface make hiking somewhat difficult. Water is trapped in potholes in channels for short periods following rainstorms; however, most of the time, no water is available for wildlife and hikers.

The river road running west from the Glen Springs Junction crosses this map unit for a short distance.

The vegetation includes desert willow, Texas persimmon, whitethorn acacia, creosotebush, threeawns, dropseeds, fluffgrass, ocotillo, dog cacti, catclaw, and lechuguilla. Javelina, coyotes, and other small mammals use the brush along the channels for resting areas. Passerine birds use areas of this unit for nesting.

This soil has severe limitations for recreational uses. Small stones are a limitation to installing paths and trails. Flash floods are a hazard.

Flooding is a limitation for building sites and in most areas is difficult to control.

PRF—Puerta-Madrone complex, steep. This map unit consists of shallow and moderately deep, very cobbly and very gravelly soils on the summits and shoulders of the Chisos Mountains. Elevation is above 6,000 feet (1,800 meters). Slopes are convex or plane, and are mostly 20 to 45 percent, although they range from 8 to 60 percent. The mapped areas are irregular in shape and range from 800 to 1,500 acres (320 to 600 hectares) in size.

This unit is dominated by woodland vegetation. It consists of high mountain ridges and canyons and small grassy meadows. The tall trees on the mountaintops make this one of the most beautiful areas in the park. The view from the northern edge of the area is across the basin below to other mountains on the horizon. From the rim on the east and south, one can see across the lower mountains, such as the Sierra Quemada, to the distant mountains across the border in Mexico. From some vantage points, the mouth of Santa Elena Canyon and Mesa de Anguilla can be seen. Boot Spring furnishes the only water in the map unit. The remains of an old log cabin attest to use of the area by early settlers.

Puerta and similar soils make up about 50 percent of this map unit, Madrone and similar soils make up 35 percent, and other soils and rock outcrops make up 15 percent. Some of the soils similar to Puerta have a light colored surface layer; some are less than 35 percent coarse fragments in the solum; some have a clay loam subsoil; some are less than 12 inches (30 centimeters) deep to bedrock; and some formed over shale. Some of the soils similar to Madrone have a light colored surface layer; some have a clay loam subsoil; some are less than 35 percent coarse fragments in the subsoil; some formed over shale; and some are more than 40 inches deep to igneous bedrock. Also included are areas of talus slopes, outcrops of igneous bedrock, soils that do not have clay accumulations in the subsoil, and nongravelly soils in small valley fills. Areas of the Puerta and Madrone soils are so intricately mixed that it was not practical to map them separately.

Typically the upper part of the surface layer of the Puerta soils is dark brown, very gravelly silt loam about 4 inches (10 centimeters) thick. The lower part of the surface layer is brown, very gravelly loam about 1 inch (2 centimeters) thick. The subsoil is reddish brown, very gravelly clay which rests on igneous bedrock at a depth of about 20 inches (50 centimeters).

Puerta soils are well drained. Surface runoff is moderate to rapid. Permeability is moderately slow, and available water capacity is very low. Rooting depth is shallow. Water erosion is a moderate hazard because of the steep slopes.

Typically, the upper part of the surface layer of the Madrone soils is brown, very gravelly loam about 4 inches (10 centimeters) thick. The lower part of the surface layer is pinkish gray, very gravelly loam about 2 inches (5 centimeters) thick. The subsoil from 6 to 32 inches (15 to 81 centimeters) is reddish brown very gravelly clay. Below this is hard igneous bedrock.

Madrone soils are well drained. Surface runoff is moderate to rapid. Permeability is moderately slow, and available water capacity is low or very low. Rooting depth is moderately deep. Water erosion is a moderate hazard because of the steep slopes.

This map unit is used for recreation and wildlife habitat. Hiking is strenuous. Steep slopes and loose rocks are hazards for hikers and backpackers. Trails from Laguna Meadow to the South Rim cross this map unit.

The vegetation includes pinyon pine, Arizona cypress, fir, juniper, oaks, aspen, junegrass, pine dropseed, finestem needlegrass, pinyon ricegrass,and muhlys.

This map unit is used by the endemic Carmen Mountains whitetail deer for food and shelter. Mountain lions use the areas for hunting and dens. Raptors use the areas for cover, lookout points, and nesting. The colima warbler, an uncommon bird, uses areas of this unit for nesting, along with many other kinds of passerine birds. Rock squirrels and other rodents use the rocks for dens.

This map unit has severe limitations for recreational uses. Stones, slope, and depth to bedrock make grading and leveling for camp areas difficult. Stones and slope make the establishment and maintenance of paths and trails difficult.

The slopes, stones, and depth to bedrock are severe limitations for building sites. Excavating for foundations, septic systems, and underground utilities is difficult.

RVW—Riverwash. This map unit consists of the streambeds and channels of the larger creeks. These areas are barren sandy, silty, gravelly, and cobbly lag alluvium. The creeks overflow during each rain and are subject to frequent flash floods. Areas of this map unit are dry for long periods between rains. Because of frequent flooding, the alluvial deposits are constantly being eroded, moved, reworked, and redeposited. Bridges on the upper and lower parts of Tornillo Creek cross areas of Riverwash.

These deposits are well drained. Surface runoff is slow. Permeability is moderately rapid to rapid, and available water capacity is moderate to low. Water erosion and soil blowing are severe hazards. A water table is at a depth of about 4 feet (1.1 meters) most of the time.

Included in mapping are small areas of the Tornillo, Pantera, Glendale, and Harkey soils. These soils are on benches scattered along the edges of the mapped areas or on islands in the channels. The areas are too small to be mapped separately. These included soils make up less than 15 percent of any mapped area and commonly have permanent vegetation.

This map unit is used for recreation and wildlife habitat. Any vegetation in the creek beds consists of fast-growing annual grasses and forbs which come up after floods following rains. However, the next rain and subsequent flood destroys the vegetation. The creek beds have a few holes which hold water, except during prolonged dry spells, and are used by hikers and wildlife. Because of the frequent overflows and flash floods, wildlife do not use areas of this unit as a home range.

Frequent flooding is a severe limitation for recreational uses, such as camp and picnic areas. Use of trails and paths is limited to dry periods. Some of the areas have a sandy surface which makes walking difficult.

SCB—Solis-Chamberino association, gently undulating. This map unit consists of very shallow to deep soils on uplands in the western part of the park. Slopes range from 1 to 5 percent. The mapped areas are irregular in shape and range from 100 to 800 acres (40 to 324 hectares) in size.

These areas are characterized by desert shrub on tilted sandstone ridges and gravelly knolls and ridges. The view from these areas is of the Chisos Mountains, or Santa Elena Canyon in the distance. Early settlers did not establish permenent dwellings because of the lack of permanent water. The Old Maverick Road crosses this unit southwest of Luna's Jacal.

The Solis soils make up about 55 percent of this map unit, ranging from 45 to 75 percent; Chamberino soils make up 20 percent, ranging from 5 to 35 percent; and other soils and land types make up 25 percent, ranging from 5 to 35 percent. Solis soils are on tilted sandstone knolls and ridges. Chamberino soils are on knolls and ridges, and are slightly higher on the landscape than Solis soils. The other inclusions are small areas of sandstone rock outcrop and areas of Tornillo and Pantera soils along drainageways. The use and management of the soils are so similar that mapping them separately was not justified. The percentages were determined by sampling transects across several areas.

Typically, the surface layer of the Solis soils is pale brown loam about 2 inches (5 centimeters) thick. Brown loam extends to a depth of 10 inches (25 centimeters). Light brown soft sandstone bedrock is below a depth of 10 inches (25 centimeters).

Solis soils are well drained. Surface runoff is medium. Permeability is moderate, and available water capacity is very low. Rooting depth is shallow to very shallow. Wind and water erosion are medium hazards.

Typically, the surface layer of the Chamberino soils is light brown gravelly fine sandy loam about 6 inches (15 centimeters) thick that is about 20 percent igneous fragments. Light brown very gravelly sandy loam that is about 40 percent igneous fragments coated with caliche extends to a depth of 22 inches (38 centimeters). Below that, gravelly loamy sediment extends to a depth of 40 inches (102 centimeters) or more.

Chamberino soils are well drained. Surface runoff is medium. Permeability is moderate, and available water capacity is low. Rooting depth is deep. Wind and water erosion are only slight hazards because of the gravel.

This map unit is used for recreation and wildlife habitat. Hiking is easy. Hot summer temperatures and the lack of water sources are the major limitations to hiking.

The sparse vegetation is dominated by creosotebush and tasajillo with small amounts of mesquite, fourwing saltbush, lechuguilla, and whitethorn acacia. The grasses include sand dropseeds, twoflower trichloris, Arizona cottontop, cane bluestem, and sixweeks grama.

Rodents, snakes, and lizards use areas of this map unit, but there is little forage produced for mule deer and javelina. Few birds use the areas for cover and nesting.

The shallow depth to sandstone is the major limitation in establishing campsites and picnic areas.

The shallow depth to sandstone presents some problems in excavating for foundations, septic systems, and underground utilities.

SRD—Solis-Rock outcrop complex, rolling. This map unit consists of very shallow and shallow soils and sandstone outcrops on desert floors on uplands. The Solis soils are between the sandstone outcrops. The sandstone outcrops have been uplifted and form a series of cuestas which give the landscape a ridged effect. Sandstone boulders and outcrops are common along the faces of the cuesta. Slopes are mostly 5 to 16 percent, although in a few areas they range from 3 to 30 percent. The mapped areas are irregular in shape and range from 100 to 2,750 acres (40 to 1,113 hectares) in size.

The view across these cuestas presents many interesting shapes of the sandstone outcrops. The vegetation is sparse and stunted. The view from the tops of the cuestas is to the broad flats below or above to the mountains on the horizon. Because of the lack of permanent water and the barrenness of these areas, early settlers did not establish permanent residence.

Solis soils make up about 40 to 50 percent of this map unit, Rock outcrop about 40 to 50 percent, and other soils 10 to 15 percent. Included in mapping are small areas of Chamberino soils on high narrow ridges along the edges of delineations or as isolated knolls. Also included are areas of deeper soils in valleys and Tornillo soils along drainageways. Areas of the Solis soils and Rock outcrop are so intermingled that it was not practical to map them separately.

Typically, the surface layer of the Solis soils is light yellowish brown fine sandy loam about 2 inches (5 centimeters) thick. Light brown fine sandy loam that is about 10 percent gravelly sandstone fragments extends to a depth of 6 inches (15 centimeters). Soft, partially weathered, very pale brown sandstone extends to a depth of 22 inches (56 centimeters). Alternating layers of sandstone and shale are below a depth of 22 inches (56 centimeters).

Solis soils are well drained. Surface runoff is medium. Permeability is moderate, and available water capacity is very low. Rooting depth is shallow or very shallow. Wind erosion is only a slight hazard because of the desert pavement of coarse fragments. Water erosion is a medium hazard.

The Rock outcrop in this unit consists of exposed soft sandstone on uplifted knolls and ridges (fig. 14). There is no soil development. The areas are layered sandstone. Surface runoff is rapid. A small amount of water soaks into the soft sandstone.

This map unit is used for recreational areas and wildlife habitat. There is no permanent water available for wildlife or hikers. No roads or trails cross this unit. Hiking is moderately strenuous on the short steep slopes. The loose and brittle sandstone makes a poor surface for hiking.

The vegetation includes a sparse cover of creosotebush, dog cacti, whitethorn acacia, tasajillo, and annuals. The major grasses are false grama, fluffgrass, and threeawns. Much of the surface of the Rock outcrop is barren.

This map unit produces very little forage for mule deer or javelina. Rodents, snakes, and lizards use the rocks for dens and cover. Only a few desert birds use the areas for food, cover, or nesting.

Stones, short steep slopes, and dusty conditions are the major restrictions to recreational uses.

The main limitations for building sites are short steep slopes and depth to rock. Excavating for septic systems, foundations, and underground utilities is difficult.

TAE—Terlingua-Mariscal association, hilly. This map unit consists of very shallow and shallow soils on limestone and igneous hills. The characteristic pattern of the landscape was apparently caused by igneous intrusions, exposed now as sills and dikes throughout the area, into the limestone bedrock. Weathering and soil development has resulted in the present pattern of soils. In most of the areas the Terlingua soils, formed in igneous material, are on side slopes and foot slopes, and the Mariscal soils, formed in limestone material, are on shoulders and crests (fig. 15). These soils are on hills in the northeastern part of the park and on the Mesa de Anguilla in the western part of the park. Slopes are convex and concave and range from 8 to 30 percent. The mapped areas are irregular in shape and range from 65 to 1,100 acres (26 to 445 hectares) in size.

This map unit has desert shrub vegetation with scattered grasses. Skeletonleaf goldeneye and mariola are the major shrubs, and chino grama is the major grass. Vegetation is sparse; much of the area is bare. From the crests of the hills the view outside these areas is over broad areas of gravel outwash piedmont slopes. As is typical of most areas of the park, the Sierra del Carmens and Chisos Mountains can be seen in the distance. An old windmill tower in one draw is testimony to attempts by early settlers to locate water in these areas. No old ruins have been found in this map unit, probably because of the lack of water.

Terlingua soils make up about 50 percent of this map unit, ranging from 30 to 70 percent; Mariscal soils make up 25 percent, ranging from 10 to 35 percent; and rock outcrops and other soils make up 25 percent, ranging from 5 to 40 percent. Exposed outcrops of limestone and igneous rocks are the most extensive inclusions. Also included are small areas of Lozier soils that formed in limestone and small areas of Lajitas soils that formed in igneous rock. Also included are small areas of the Chamberino, Pantera, and Tornillo soils in gravelly deposits and alluvium. Use and management of the Terlingua and Mariscal soils are similar enough that mapping them separately is not justified.

Typically, the surface layer of the Terlingua soils is pale brown, very gravelly sandy loam about 6 inches (15 centimeters) thick. The layer below that extends to a depth of 10 inches (25 centimeters) and is pale brown, very gravelly sandy loam that is about 65 percent igneous fragments, most of which are coated with calcium carbonate. Weathered bedrock that has coatings of calcium carbonate in the fractures extends to a depth of 14 inches (36 centimeters). Hard igneous bedrock is below a depth of 14 inches (36 centimeters).

Terlingua soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Rooting depth is very shallow or shallow. Wind and water erosion are only slight hazards because of gravel on the surface.

Typically, the surface layer of the Mariscal soils is pale brown, very channery loam about 5 inches (13 centimeters) thick. Alternating layers of limestone and marl are below a depth of 5 inches (13 centimeters), to a depth of 40 inches (102 centimeters).

Mariscal soils are well drained. Surface runoff is rapid. Permeability is moderate, and available water capacity is very low. Rooting depth is very shallow or shallow. Wind and water erosion are only slight hazards because of the flat limestone fragments that cover the surface.

This map unit is used for recreation and wildlife habitat. The Dagger Flat Road crosses parts of this unit. There is no water for wildlife or hikers.

The vegetation consists of lechuguilla, ephedra, yucca, sheletonleaf goldeneye, mariola, chino grama, fluffgrass, black grama, and threeawns. Low rainfall and very low available water capacity limit production. The Mariscal soils produce more vegetation than the Terlingua soils. Much of the surface of the Terlingua soils is barren.

A few mule deer and javelina use areas of this map unit for food and shelter. The Terlingua soils produce very little vegetation that can be used by wildlife for food or shelter. Rodents, snakes, and lizards live among the rocks. A few passerine birds use the draws for food, cover, lookout points, and nesting sites.

This map unit has severe limitations for recreational use. Small stones, slope, and depth to bedrock make campsite preparation, such as shaping and leveling, difficult. Small stones are a limitation for paths and trails.

The main limitations for building sites are depth to bedrock, slope, and small stones. Excavating for foundations, underground utilities, and septic systems is usually impractical.

TLE—Terlingua-Rock outcrop complex, hilly. This map unit consists of very shallow and shallow, very gravelly soils and Rock outcrop. These soils are on the summits, shoulders, back slopes, and foot slopes of igneous hills and mountains scattered throughout the northern, southern, and western parts of the survey area. Slopes are mostly convex and are mainly 10 to 30 percent, although they range from 2 to 40 percent. The mapped areas are irregular in shape and range from 40 to 6,000 (16 to 2,428 hectares) acres in size.

The view across this unit is one of mostly barren areas and exposed rock. Small stunted shrubs are scattered across the landscape. The view from the summit of the hills is generally into other mountainous areas that have more vegetation or across gravelly outwash areas. The lack of water and the roughness of the areas were probably the reasons permanent dwellings were not established.

Terlingua soils make up 20 to 50 percent of the map unit, Rock outcrop makes up 40 to 70 percent, and other components make up 5 to 30 percent. The inclusions

Figure 14.—Sandstone ledges and boulders are characteristic of Solis-Rock outcrop complex, rolling.

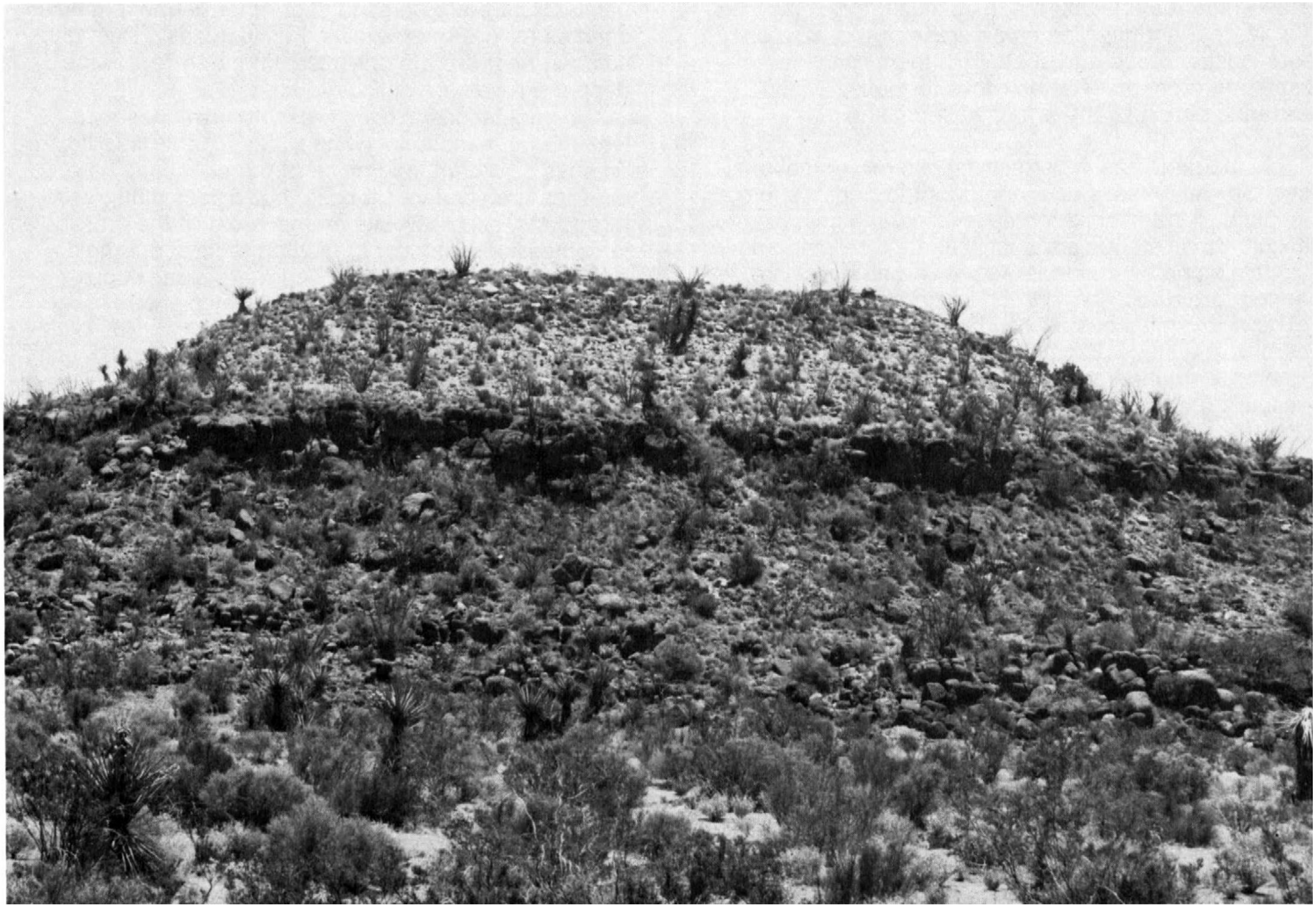


Figure 15.—A limestone cap of Mariscal soils rests on an igneous sill of Terlingua soils, in an area of Terlingua-Mariscal association, hilly.

are small areas of deeper gravelly soils along drains and small areas of sandstone outcrops below the igneous rock outcrops. Areas of the Terlingua soils and Rock outcrop are so intricately mixed that it was not practical to map them separately.

Typically, the surface layer of the Terlingua soils is a yellowish brown, very gravelly coarse sandy loam about 4 inches (10 centimeters) thick. Yellowish brown, very gravelly sandy loam that has caliche coatings on the coarse fragments extends to a depth of 8 inches (20 centimeters). Weak, red, partially weathered igneous bedrock extends to a depth of 16 inches (40 centimeters). Porous igneous bedrock is below a depth of 16 inches (40 centimeters).

The Terlingua soils are well drained. Permeability is moderate, and surface runoff is rapid. Available water capacity is very low. Rooting depth is very shallow to shallow. Wind and water erosion are only slight hazards because of the gravel and cobbles.

Rock outcrop occurs as short ledges and convex exposures of bedrock scattered throughout the areas.

This map unit is used for recreation and wildlife habitat. The west end of the river road and the paved road to Castolon, below Castolon Peak, cross parts of this unit. There are no springs or other water sources for wildlife or hikers.

The vegetation includes a very sparse stand of lechuguilla, ocotillo, skeletonleaf goldeneye, leatherstem, range ratany, feather dalea, whitethorn, fluffgrass, chino grama, tanglehead, false grama, threeawns, bush muhly, and tridens. Low rainfall, the very low available water capacity, and the high percentage of bare soil severely limit the amount of forage produced. High soil temperatures in summer make vegetative re-establishment by natural means difficult.

Mule deer and javelina cross areas of this map unit; there is little forage and shelter for them. Snakes, lizards, and rodents use the rocks for dens. A few passerine birds use the areas for food, shelter, or nesting.

This map unit has severe limitations for recreational uses. Small stones, slope, and depth to bedrock make campsite preparation, such as leveling and shaping, difficult. Small stones are a limitation for building and maintaining paths and trails. Sturdy hiking boots are needed for protection from the rocks on the surface.

The main limitations for building sites are depth to bedrock and slope. Excavating for foundations, septic systems, and underground utilities is impractical. Blasting is usually required.

TOA—Tornillo loam, occasionally flooded. This map unit consists of a deep, nearly level and gently sloping soil on broad alluvial flats in valley floors. Slopes are plane and range from 0 to 3 percent. The mapped areas are rectangular and range from 60 to 600 acres (24 to 243 hectares). The paved park road from the upper Tornillo Creek bridge to the Dagger Flat road crosses this unit. Other areas are in Nine Point Draw and Bone Spring Draw.

The broad, gently sloping areas are mostly bare except for creosotebush. Some of the low, nearly level areas, where water stands after rains, support pockets of grass. The upslope view is across broad piedmont slopes to high mountains on the horizon. Because no water was available, early settlers built permanent dwellings only on the edges of this map unit, where permanent water was available from springs or streams.

Tornillo soil makes up 70 to 100 percent of this map unit. The rest is Pantera soils, alluvial soils that are shallow over sandstone, badlands, and sandstone outcrops. The percentages of this map unit were determined by sampling transects across several areas.

Typically, the surface layer of the Tornillo soil is light yellowish brown loam about 9 inches (23 centimeters) thick. Pale brown or brown, stratified silty clay loam, clay loam, and loam that has a few films and threads of calcium carbonate extends to a depth of 83 inches (211 centimeters).

Tornillo soil is well drained. Surface runoff is slow to medium. Permeability is moderate, and available water capacity is high. Rooting zone is deep. This soil receives outside runoff from areas higher on the landscape, and during high intensity rainstorms it is flooded by sheet water as much as several inches deep. This brief flash flooding occurs about once every 3 to 8 years. The surface of this soil crusts and seals over so that most of the rainfall runs off and water enters the soil very slowly (fig. 16). This soil is very erosive and has narrow, deep arroyos in many of the areas. Wind erosion is a moderate hazard, and water erosion is a severe hazard.

This map unit is used for recreation and wildlife habitat. There are no springs or other permanent water sources for hikers or wildlife. Hiking is easy. Dust and summer heat are the only discomforts. A few of the deeper arroyos are difficult to cross.

The vegetation includes creosotebush, mesquite, lechuguilla, mariola, fourwing saltbush, and tasajillo. The brush is scattered, and much of the surface is bare. Grasses are scattered tobosa, burrograss, fluffgrass, threeawns, and sixweeks grama. Most of the grasses are in depressions and low areas that receive and hold additional water after rains. There are small coppice dunes around the bases of the brushy plants.

This map unit has limited use by most wildlife. Mule deer and javelina occasionally cross areas of this unit, but do not use them for home ranges. Rodents, snakes, and lizards use the areas for dens. A few passerine birds use the areas for food and nesting. A small herd of pronghorns uses the Tornillo Flat area for their home range.

Dust and flooding are the major limitations for recreational uses.

The possibility of flash flooding precludes the use of these areas for building sites. Dirt roads that cross arroyos are difficult to maintain.

UNC—Upton-Nickel association, undulating. This map unit consists of deep, shallow, and very shallow, gravelly and very gravelly soils on broad dissected piedmont slopes (fig. 17). The dissecting drainageways are 3 to 17 feet (1 to 5 meters) deep and 10 to 60 feet (3 to 18 meters) wide. Slopes are mostly 1 to 6 percent, although short drainageway side slopes range from 4 to about 10 percent. The mapped areas are irregular in shape and range from 40 to 2,700 acres (16 to 1,092 hectares) in size.

This map unit is between Tornillo Creek and the Sierra del Carmen Mountains in the eastern part of the survey area. The view across these areas is of an undulating landscape with desert shrubs. The major shrub is creosotebush. Beyond these areas to the east, the view is of the Sierra del Carmen mountains. To the west the Chisos Mountains can be seen in the distance. Indians and early settlers did not build permanent residences because there is very little water.

Upton and closely similar soils make up about 80 percent of this map unit, ranging from 70 to 95 percent; Nickel and closely similar soils make up about 15 percent, ranging from 5 to 30 percent; and other soils make up about 5 percent, ranging from 0 to 15 percent. Some of the soils closely similar to Upton are more than 35 percent coarse fragments in the solum; some have calcium carbonate equivalent of less than 40 percent in the subsoil; and some are more than 20 inches (50 centimeters) to the petrocalcic horizon. The Upton soils are on gently sloping piedmont ridges. Some of the soils closely similar to Nickel soils are less than 35 percent

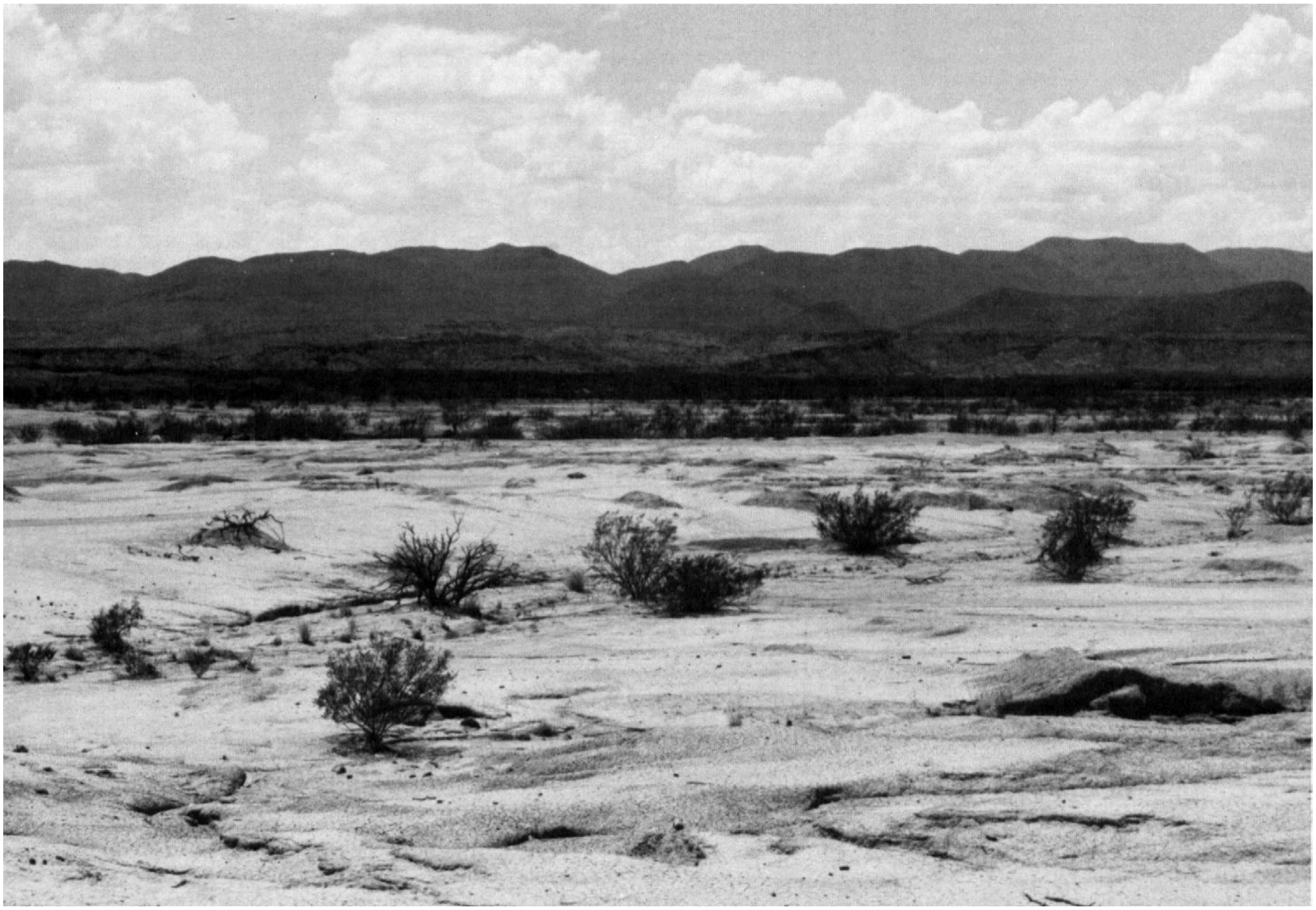


Figure 16.—Most areas of this Tornillo soil are bare except for some scattered creosotebush. The surface layer tends to seal, causing most of the rainfall to run off.

coarse fragments, and some do not have a prominent accumulation of calcium carbonate in the subsoil. The Nickel soils are along the gently sloping to strongly sloping drainageways. The other soils are mainly Pantera soils in drainageways. The soils in this map unit are in a regular pattern and could be mapped separately; however, because use and management are so similar, separation is not justified. The percentages were determined by sampling transects across several areas.

Typically, the surface layer of the Upton soils is about 5 inches (13 centimeters) thick and is pale brown gravelly loam that is about 30 percent limestone gravel. Pink gravelly loam extends to a depth of 15 inches (38 centimeters). This layer rests abruptly on a layer of indurated caliche about 4 inches (10 centimeters) thick, which is laminar in the upper part. The underlying material is gravelly and loamy.

Upton soils are well drained. Surface runoff is medium. Permeability is moderate, and available water capacity is very low. Rooting depth is very shallow or shallow. Wind and water erosion are only slight hazards because of the gravel on the surface.

Typically, the surface layer of the Nickel soils is about 3 inches (8 centimeters) thick and is pale brown, very gravelly sandy loam that is about 45 percent limestone gravel. The upper part of the subsoil, to a depth of 12 inches (30 centimeters) is pale brown, very gravelly sandy loam that is about 50 percent gravel. The middle

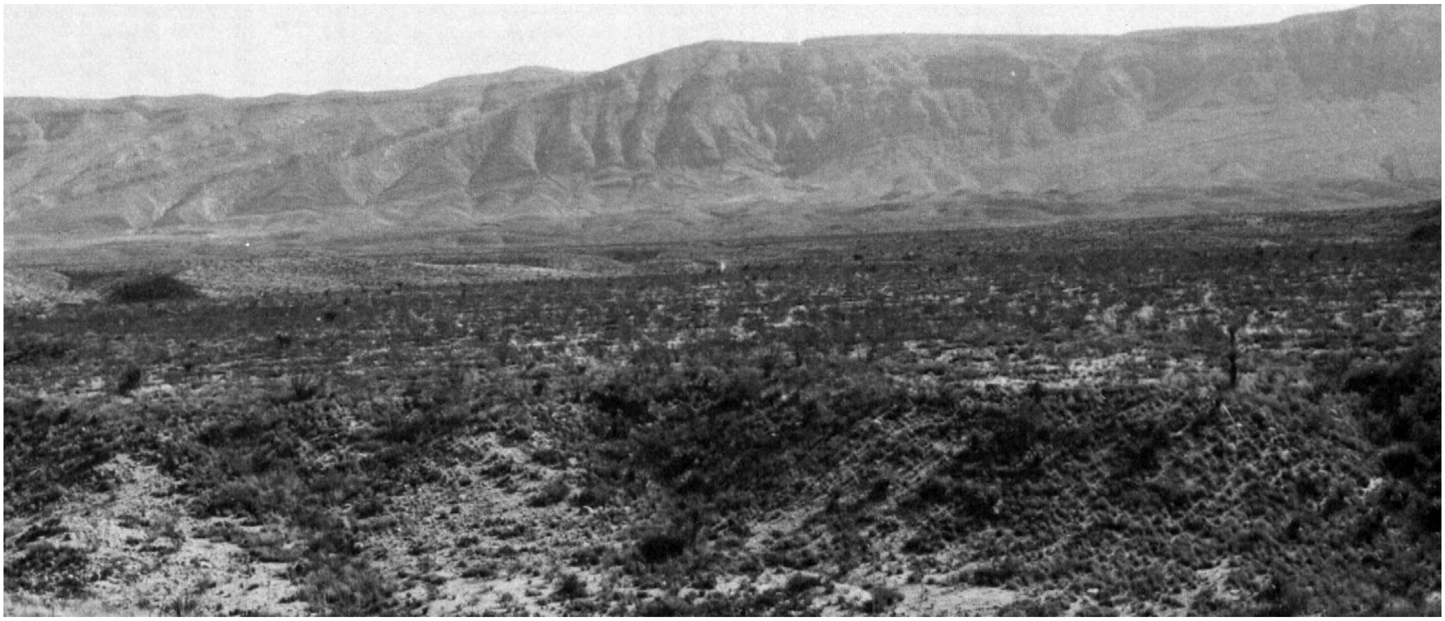


Figure 17.—Area of Upton-Nickel association, undulating. The Upton soils are in the smoother areas, and the Nickel soils are on the sloping sides of the ridges. The Sierra del Carmen Mountains are in the background.

part of the subsoil, to a depth of 22 inches (56 centimeters), is very pale brown, very gravelly sandy loam that is about 50 percent limestone gravel coated with caliche. The lower part of the subsoil, to a depth of 30 inches (76 centimeters), is very pale brown, very gravelly loam that is about 60 percent gravel.

Nickel soils are well drained. Surface runoff is medium. Permeability is moderately slow, and available water capacity is very low to low. Wind and water erosion are only slight hazards because of the gravel on the surface.

This map unit is used for recreation and wildlife habitat. The Dagger Flat Road crosses this unit. A few springs provide water for wildlife and hikers. Hiking is easy, but sturdy footwear is needed for protection from the lechuguilla.

The sparse vegetation includes creosotebush, lechuguilla, mariola, ceniza, candelilla, dog cacti, pricklypear, and ephedra, as well as grasses such as chino grama, threeawn, fluffgrass, slim tridens, and sixweeks grama.

Mule deer and javelina use the lechuguilla and other woody shrubs for food. Shrubs and woody vegetation along drainageways provide shelter and travelways. Rodents, snakes, and lizards use areas of this unit for food and dens. Coyotes and foxes hunt across the areas. Passerine birds use the areas for food and nesting.

Small stones and the cemented pan make campsite preparation, such as leveling and shaping, difficult. Dusty conditions and small stones are limitations for paths and trails.

The major limitations for building sites are the small stones and the cemented caliche layer at a shallow depth in the Upton soils, which makes excavating for foundations, septic systems, and underground utilities difficult.

VBD—Vieja-Badland complex, rolling. This map unit consists of very shallow and shallow, very gravelly clayey soils and Badland in areas where geologic materials are exposed. These areas are on uplands and in valleys. Slopes are mostly 2 to 15 percent but are as much as 35 percent. The mapped areas are irregular in shape and range from 40 to 800 acres (16 to 324 hectares) in size.

These areas are picturesque and aesthetically pleasing (fig. 18). Many of the areas are easily viewed from the surrounding rim. From the valley below they appear as short steep slopes leading to the piedmont slopes above. These multicolored areas are very striking, especially early in the morning or at twilight, when the sun creates a "painted desert" effect. Erosion has carved the geologic exposures into many interesting forms and shapes, such as those that extend above the valley floor in Tornillo flat. Other areas are exposures of volcanic tuff with igneous intrusions or extrusions and volcanic boulders scattered over the surface, giving rise to the name, "jungle of volcanoes." In other areas water erosion has cut deep into tuff, resulting in scenic Tuff Canyon. The distant mountains rise above piedmont slopes and add a majestic backdrop to the scenery. There is no permanent water in these areas, and early settlers did not establish permanent dwelling places. The paved road that begins at the west entrance to the park crosses this unit.

The Vieja soils make up about 65 percent of this map unit, Badland makes up about 15 percent, and other soils and land types make up about 20 percent. The Vieja soils are mostly on the valley floors and side slopes and on benches within the barren eroding areas of Badland. Badland is along drainageways and arroyos in the valley floors and on the steeper slopes along basin and valley side slopes where geological materials are exposed. Other soils are mostly gravelly Chamberino soils on small knolls or hills or on long narrow ridges extending into areas of this map unit. Other inclusions are mostly outcrops of sandstone, igneous bedrock, and dikes and areas that are covered with igneous stones and cobbles. Also included are areas of whitish volcanic tuff and tuffaceous sandstone in and near Tuff Canyon. Areas of Vieja soils and Badland are so intermingled that it was not practical to map them separately.

Typically, the upper part of the surface layer of the Vieja soil is pale brown, very gravelly silty clay about 2

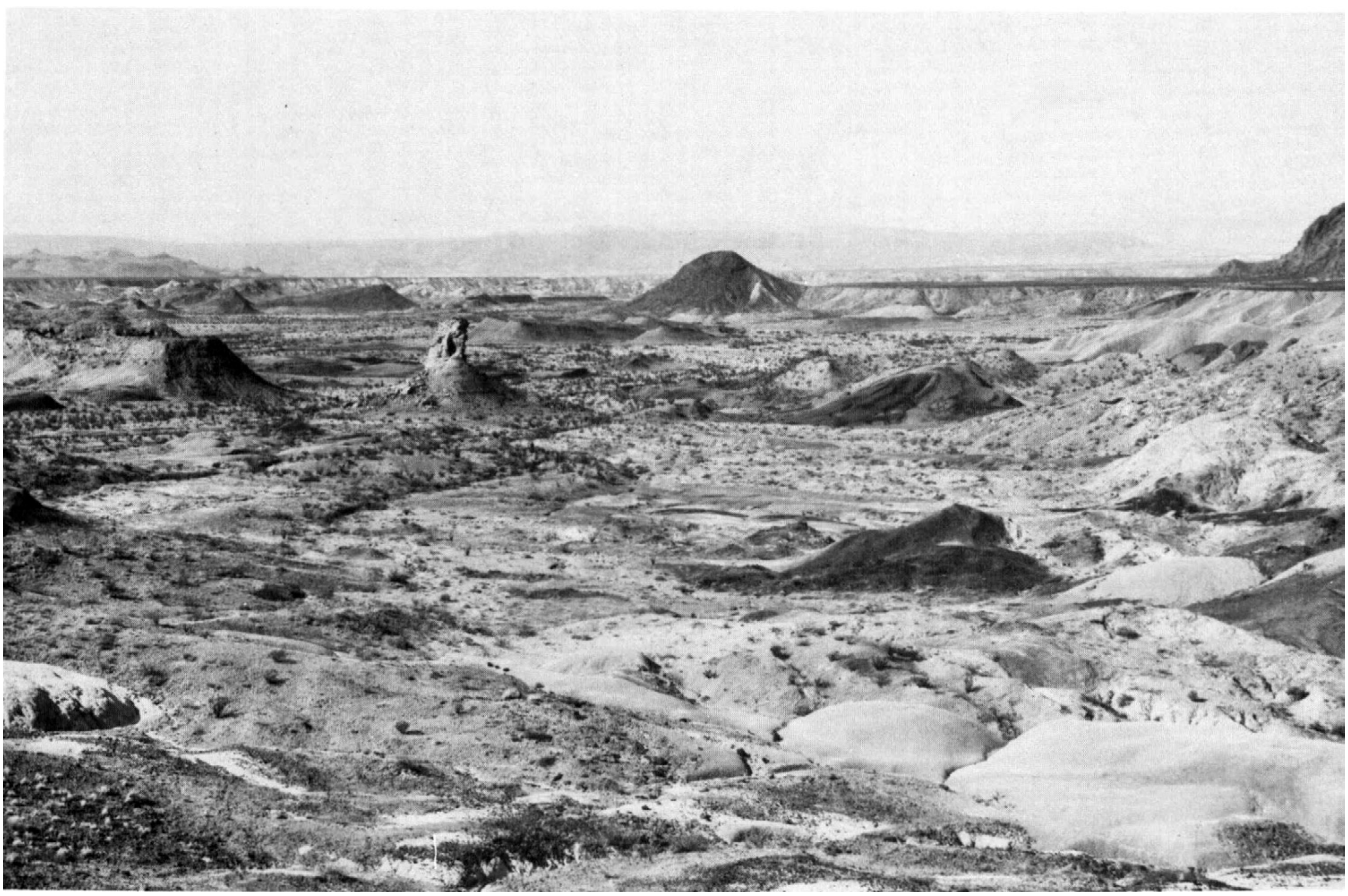


Figure 18.—This starkly beautiful area of Vieja-Badland complex, rolling, is almost void of vegetation.

inches (5 centimeters) thick. The lower part of the surface layer is very pale brown silty clay about 11 inches (28 centimeters) thick. The underlying material, to a depth of 40 inches (102 centimeters) or more, is light brownish gray shale that has platy rock structure.

Vieja soils are well drained. Surface runoff is rapid. Permeability is slow, and available water capacity is low. These soils have high shrink-swell potential. Wind and water erosion are moderate hazards.

Badland consists of barren, eroding geologic exposures of variously colored shales, clays, volcanic tuff, and tuffaceous sandstones. Surface runoff is very rapid, and little or no water enters the soil. Wind erosion is a slight hazard. Water erosion is a severe hazard. Badland produces a large amount of sediment.

This map unit is used for recreation and wildlife habitat. There is little permanent water for wildlife or hikers. Hiking is fairly easy in most areas. The high temperatures in summer are a discomfort to hikers.

The Vieja soils have sparse vegetation of stunted creosotebush, fluffgrass, dog cacti, and sixweek grama. Various fast-growing, short-lived annuals appear after rainstorms in some areas. Badland is mostly barren of vegetation.

Lizards and rodents are about the only wildlife in this map unit. Mule deer and javelina occasionally cross areas of this unit, but because there is little food and cover, they do not use them as home ranges.

Preparation of recreational sites is difficult in most areas because of stones and bedrock. In other areas the soils are too clayey.

Stones, rock outcrops, and high shrink-swell potential of soils over shale are limitations for building sites.

Prime Farmland

There are no prime farmland soils in this survey area. All of the map units are in the aridic soil zone.

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavior characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils as rangeland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, and playgrounds.

Rangeland

Winfred R. Bauer, range conservationist, Soil Conservation Service, prepared this section.

Grazing by domestic livestock started when Spanish expeditions brought cattle and horses into the Big Bend area. Actual ranching operations did not begin until after the Mexican War in 1848. Settlement began with the arrival of the railroad in 1882.

Cattle, sheep, goats, horses, and donkeys grazed the area that is now the park until the 1940's, when Texas deeded the land to the Federal Government. When the area became a national park, grazing by domestic livestock ceased.

Today no grazing by domestic stock is allowed. However, cattle and horses occasionally cross the Rio Grande from Mexico and graze the areas adjacent to the river.

Records of early settlers indicate that at one time all the park area had a good grass cover. Continuous grazing by different classes of livestock severely depleted the vegetative cover, and erosion increased. Range recovery from overuse has been very slow in some areas.

Within the park, elevation and rainfall vary greatly to create four distinct vegetative zones: mountain savannah, mixed prairie, desert grassland, and desert shrub.

The mountain savannah vegetative zone is found at 5,500 feet (1,675 meters) elevation and higher and receives more than 15 inches (380 millimeters) annual precipitation. Characteristic vegetation in mountain savannah is pinyon pine, oak species, mountain mahogany, Texas and New Mexico bluestem, bull muhly, and blue grama.

The mixed prairie vegetative zone is located between 4,500 and 5,500 feet (1,370 and 1,675 meters) in elevation and receives 12 to 15 inches (300 to 380 millimeters) annual rainfall. Characteristic vegetation in the mixed prairie vegetative zone is sideoats grama, cane bluestem, green sprangletop, black grama, blue grama, oak species, feather dalea, apacheplume, menodora, globemallow, and perennial bladderpod.

Between 2,600 and 4,500 feet (790 and 1,370 meters) elevation is desert grassland, which receives 10 to 12 inches (250 and 300 millimeters) annual precipitation. Dominant grasses in this zone are sideoats grama, black grama, bush muhly, burrograss, perennial threeawns, dropseeds, tanglehead, and slim tridens. Common woody species in the desert grassland vegetative zone are creosotebush, tarbush, skeletonleaf goldeneye, range ratany, catclaw, feather dalea, mariola, butterflybush, narrowleaf foresteria, and wolfberry. Important forbes are bladderpod, mendora, bushsunflower, globemallow, and verbena.

The desert shrub vegetative zone is dominated by drought-tolerant grasses and shrubs. The desert shrub zone lies below 2,600 feet (790 meters) elevation and receives less than 10 inches (250 millimeters) annual rainfall. Characteristic grasses are chino grama, perennial threeawn, fluffgrass, bush muhly, slim and rough tridens, and tanglehead. Common woody shrubs are lechuguilla, whitethorn acacia, guayacan, mariola, ocotillo, range ratany, yucca species, creosotebush, and ceniza. Important forbs are bladderpod, zinnia, cutleaf aplopappus, daleas, bushsunflower, and menodora.

Many species of cactus and ephemerals are found in both the desert shrub and desert grassland vegetative zones.

Since grazing by domestic livestock ceased, the mixed prairie and mountain savannah vegetative zones have improved in range condition and are now in a static state.

At one time, wildfires set by lightning kept brush suppressed in the mountain savannah and mixed prairie zones (fig. 19). For these two vegetative zones to improve, some manipulation of the plant community is needed to improve the vigor of the plants and reduce excessive canopy cover.

The desert grassland and desert shrub vegetative zones have not improved significantly since total deferment began. These zones are quite fragile, and once they have been damaged, recovery is very slow. Low precipitation, high temperatures, and shallow soils prevent quick recovery.

There are only a few areas in the park where water is available on a yearlong basis, and these areas have the highest concentration of wildlife. Additional water development would improve the area and increase wildlife numbers for the park area.

Recreation

The soils of the survey area are rated in table 5 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to lakes amd streams, potential water impoundment sites, availability of drinking water, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential. Also needed is an assessment of the availability of shade for protection from the summer heat and of shelter for protection from the cold winds in winter.

In table 5, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 5 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 7 and interpretations for dwellings without basements and for local roads and streets in table 6.

Camp areas require site preparation such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking and horseback riding, should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Wildlife Habitat

Willard Richter, biologist, Soil Conservation Service; Bruce Leopold, graduate student, University of Arizona; and Dr. Donna Howell, James Trustee Professor, Southern Methodist University, prepared this section.

Soils found in Big Bend National Park support a wide diversity of vegetation. This vegetation provides a variety of wildlife habitat types, enabling the park to support one of the most diverse wildlife populations in the state of

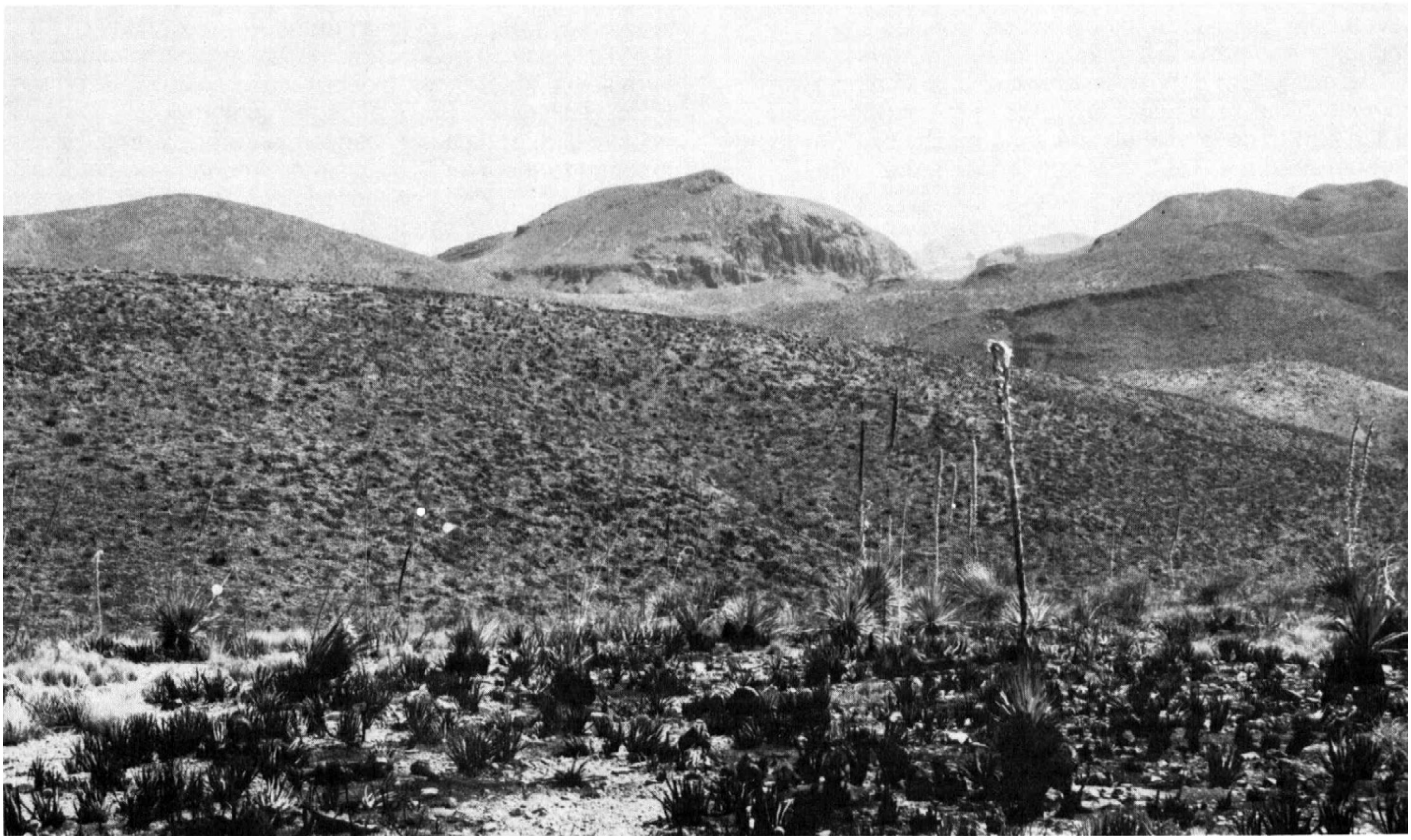


Figure 19.—Area of the Chilicotal-Monterosa association, rolling, that has been burned by fire set by lightning.

Texas. Approximately 500 species of mammals, amphibians, reptiles, and birds, including both seasonal migrants and yearlong residents, have been recorded in the park.

Wildlife indigenous to the park exhibit many behavioral characteristics. Some species are scattered throughout the park whereas others are restricted to specific areas where their more specialized habitat needs can be met. For example, some species are found only in the mountainous regions, others in the desert shrub zones, and some in niches along the river. Some species of wildlife are diurnal, active only during the day; some are nocturnal, active only at night; and others are crepuscular, active at dawn and at dusk.

Several species of large mammals inhabit the park, including desert mule deer, Carmen Mountains whitetail deer, pronghorn, collard peccary, mountain lion, coyote, and bobcat. Smaller mammals common to the park are blacktail jackrabbit, desert cottontail, rock squirrel, ground squirrels (3 species), gray fox, kit fox, skunks (4 species), badger, longtail weasel, ringtail, raccoon, bats (19 species), gophers (2 species), beaver, and rats and mice (20 species).

Big Bend National Park has a relatively large population of desert mule deer. In 1981, the population was estimated to be between 800 and 1,000 animals. The mule deer range throughout the park in areas below an elevation of 5,000 feet (1,500 meters). However, they are usually seen near the outlying hills and mountains in the desert and on the foothill slopes of the Chisos Mountains, where perennial springs and preferred browse and forb species are common. Areas receiving extra moisture along washes and runoff areas produce significant stands of browse, such as Apache plume, littleleaf sumac, guayacan, acacias, spiney hackberry, honey mesquite, and cenizas. In the more arid desert shrub areas, mule deer browse on lechuguilla, cholla, pricklypear, and several species of shrubs and forbes.

The Carmen Mountains whitetail deer can be seen in the Chisos Mountains above an elevation of 4,300 feet (1,300 meters). The Chisos Mountains support a variety of preferred browse plants, including evergreen and littleleaf sumacs, mountain mahogany, whitebrush, and several oak species. A variety of forb species are abundant and provide additional forage for these deer.

The pronghorn population consists of a small group of animals in the semidesert lowlands in the northern part of the park. These animals are seen mostly on Tornillo Flat between the Rosillos Mountains and McKenney Hills. The pronghorn prefers woody species, such as cholla, daleas, Apacheplume, and goldeneye, and forbs, such as perennial broomweed, Texas virginbower, desert baileya, euphorbia species, horehound, and sida species.

The collard peccary, or javelina, can be seen throughout the park. They range from the flood plain of the Rio Grande to the higher elevations of the Chisos Mountains. The javelina prefers the dense vegetation in the draws and drainageways, which is more succulent and provides cooler bedding areas. The diet of the javelina varies seasonally and includes many fruits, such as acorns, berries, and drupes. However, the major year-round food preference is pricklypear pads and fruits, followed closely by lechuguilla.

The primary mammalian predators in the park are the mountain lion, coyote, and bobcat. The coyote and bobcat prey primarily on smaller animals, such as rodents and rabbits. The mountain lion is the prime carnivore in the park and preys on the entire mammalian population, including both species of deer and the javelina. Recent studies have shown that the mountain lion population in the park is approximately 18 to 21 lions, yearlong. The population is large, especially if one considers the transient lions that frequent the neighboring ranches as well as the desert areas of the park. Mountain lion range throughout the park, whereas the coyote and bobcat range in the more open areas and on foothill slopes.

The four species of skunk in the park are the western spotted, hooded, hognosed, and striped. Many species of rodents inhabit the park. Among these, the rock squirrel is the most common and is often seen on boulder-strewn slopes throughout the park. This large squirrel and three species of smaller ground squirrels feed on seeds, green vegetation, and insects. The spotted ground squirrel inhabits the mesquite and creosotebush flats, whereas the antelope ground squirrel prefers rocky areas in foothills and mountain canyons.

Records show approximately 220 species of birds as spring and fall migrants, 144 species as winter residents, and 110 species as summer residents.

The songbirds are usually concentrated in the more densely vegetated areas adjacent to the Rio Grande, in the basin of the Chisos Mountains, and around springs and abandoned livestock watering facilities. The most commonly seen birds in the high elevations of the Chisos Mountains include the Mexican jay, tufted titmouse, white-winged dove, acorn woodpecker, rufous-sided towhee, and bushtit. The colima warbler uses the high mountain areas for summer residence. The park is the only place in the United States where this warbler can be seen. Birds common to the low elevations of the desert are scaled quail, common raven, turkey vulture, pyrrhuloxia, roadrunner, black-chinned sparrow, Scott's oriole, Bell's vireo, Say's phoebe, nighthawk, mockingbird, and cactus, canyon, and rock wrens. Birds common to the river flood plain are roadrunner, cardinal, mockingbird, Bell's vireo, house finch, vermillion flycatcher, spotted sandpiper, black phoebe, yellow-breasted chat, and rough-winged swallow.

Winter-resident raptors include the golden eagle, Cooper's hawk, sharp-shinned hawk, Swainson's hawk, marsh hawk, and American kestral. They can be seen in both the mountainous and the lowland areas of the park. Most of the red-tailed hawks are year-round residents and can be seen throughout the park. Ten species of owls have been recorded. The most common species are great horned owl, screech owl, and elf owl.

At least 10 species of frogs and toads are common to Big Bend National Park. The Madrean cliff frog can be seen only in the montane areas of the park. Many frogs and toads are aquatic. Others live in the desert, including the spadefoot toad which spends most of the year underground and becomes active during the rainy periods in summer, coming to the surface to breed. A few of the frogs are diurnal.

Of the four species of turtles that inhabit the park, three are diurnal and the other is crespuscular. The Sonoran mud, western soft-shelled, and yellow-necked turtles are aquatic. The ornate box turtle is terrestrial.

Thirty species of snakes have been recorded in Big Bend National Park. Most of these are crepuscular or nocturnal; however, several species are diurnal. Some species, such as coachwhip, bullsnakes, and western diamond rattlesnake can be seen throughout the park. Others require a specialized habitat and therefore are restricted to certain areas. For example, the western black-necked garter snake, checkered garter snake, and the Big Bend patch-nose snake are generally found in the cooler and higher elevations of the Chisos Mountains. Some species of snakes are seldom seen, such as the trans-Pecos and New Mexico blind snakes, which live a subterranean life. The habitat of some snakes is restricted to areas along draws and around watering places which support dense vegetation and attract rodents and various birds on which many of the snakes feed. Rat snakes are generally found in this type of area. Six species of poisonous snakes are common to the park, including the western copperhead and five species of rattlesnakes. The western diamondback is the most common of the rattlesnakes. Other rattlesnakes are the black tailed, prairie, rock, and the less common Mojave.

The habits of the different species of lizards are extremely variable and species specific. Fossorial, terrestrial, saxicolous (rock-dwelling), arboreal, and aquatic species of lizards inhabit the park. Most of the lizards are diurnal. A few are nocturnal or crepuscular and are less frequently seen. Certain species can be seen throughout the park. However, others, such as the Texas alligator lizard, can be seen only in the mountainous areas. The canyon lizard, tree lizard, and crevice spiny lizard are most abundant on rocky hillsides. The light colored, brilliantly marked greater earless lizard is abundant in sandy arroyos. Many lizards, including the four species of the wary and fast-moving whiptail lizard, spend most of their active time on the ground surface.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building site development, Sanitary facilities, Construction materials, and Water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet (1.5 to 1.8 meters). Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations need to be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 6 feet (1.5 to 1.8 meters) of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of construction conditions; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Building Site Development

Table 6 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet (1.5 or 1.8 meters) for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and small commercial buildings are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet (1.5 to 1.8 meters) are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet (1.8 meters). The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic supporting capacity.

Sanitary Facilities

Table 7 shows the degree and the kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 7 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches (60 and 180 centimeters) is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet (1.2 meters) below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet (0.6 to 1.5 meters). Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 7 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet (0.3 to 0.6 meter) of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 7 are based on soil properties, site features, and observed performance of the soils.

Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet (1.8 meters). For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to soil blowing.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

Table 8 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a probable or improbable source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet (1.5 or 1.8 meters).

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet (1.8 meters) high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet (1.5 or 1.8 meters). It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet (1.5 meters) of suitable material, low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet (1 meter). Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet (0.3 to 1 meter). Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 1 foot (0.3 meter). They may have layers of suitable material, but the material is less than 3 feet (1 meter) thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 8, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 3 feet (1 meter) thick and less than 50 percent, by weight, large stones. All other soils are rated as an improbable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches (100 centimeters) of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable loamy material to a depth of at least 40 inches (100 centimeters). They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches (50 to 100 centimeters) of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches (50 centimeters) of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics. These results are reported in table 15.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classifications, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

Engineering Index Properties

Table 9 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet (1.5 to 1.8 meters).

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil series and their morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as 15 percent, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the Glossary.

Classification of the soils is determined according to the Unified soil classification system (*2*) and the system adopted by the American Association of State Highway and Transportation Officials (*1*).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches (7.5 centimeters) in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches (7.5 centimeters) in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest. The AASHTO classification for soils tested, with group index numbers in parentheses, is given in table 15.

Rock fragments larger than 3 inches (7.5 centimeters) in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches (7.5 centimeters) in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

The estimates of grain-size distribution, liquid limit, and plasticity index are rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is omitted in the table.

Physical and Chemical Properties

Table 10 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, and plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3 bar moisture tension. Weight is determined after drying the soil at 105 degrees C (221 degrees F). In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C (77 degrees F). Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion and the amount of soil lost. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are extremely erodible, and vegetation is difficult to establish.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion are used.

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible. Crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible. Crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to wind erosion.

Organic matter is the plant and animal residue in the soil at various stages of decomposition.

In table 10, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter of a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients.

Soil and Water Features

Table 11 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding, the temporary inundation of an area, is caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, nor is water in swamps and marshes.

Table 11 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, common, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal conditions; *occasional* that it occurs, on the average, no more than once in 2 years; and *frequent* that it occurs, on the average, more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; November-May, for example, means that flooding can occur during the period November through May.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons that form in soils that are not subject to flooding.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Depth to bedrock is given if bedrock is within a depth of 5 feet (1.5 meters). The depth is based on many soil borings and on observations during soil mapping. The rock is specified as either soft or hard. If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

Cemented pans are cemented or indurated subsurface layers within a depth of 5 feet (1.5 meters). Such pans cause difficulty in excavation. Pans are classified as thin or thick. A thin pan is less than 3 inches (7.5 centimeters) thick if continuously indurated or less than 18 inches (46 centimeters) thick if discontinuous or fractured. Excavations can be made by trenching machines, backhoes, or small rippers. A thick pan is more than 3 inches (7.5 centimeters) thick if continuously indurated or more than 18 inches (46 centimeters) thick if discontinuous or fractured. Such a pan is so thick or massive that blasting or special equipment is needed in excavation.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Physical and Chemical Analyses of Selected Soils

The results of physical analysis of several typical pedons in the survey area are given in table 12 and the results of chemical analysis in table 13. Information on mineralogy of selected soils is given in table 14. The data are for soils sampled at carefully selected sites. The pedons are typical of the series and are described in the section "Soil Series and Their Morphology." Soil samples were analyzed by Texas A & M University.

Most determinations, except those for grain-size analysis and bulk density, were made on soil material smaller than 2 millimeters in diameter. Measurements reported as percent or quantity of unit weight were calculated on an oven-dry basis. The methods used in obtaining the data are indicated in the list that follows. The codes in parentheses refer to published methods (*6*).

Coarse materials—(2-75 mm fraction) weight estimates of the percentages of all materials less than 75 mm (3B1).
Sand—(0.05-2.0 mm fraction) weight percentages of materials less than 2 mm (3A1).
Silt—(0.002-0.05 mm fraction) pipette extraction, weight percentages of all materials less than 2 mm (3A1).
Clay—(fraction less than 0.002 mm) pipette extraction, weight percentages of materials less than 2 mm (3A1).
Water retained—pressure extraction, percentage of oven-dry weight of less than 2 mm material; 1/3 or 1/10 (3/10) bar (4B1).
Moist bulk density of less than 2 mm material, sarancoated clods (4A1).
Linear extensibility charge in clod dimission based on less than 2 mm material (4D).
Organic carbon—dry combustion (6A2b).
Organic matter—peroxide digestion (6A3).
Total nitrogen—Kjeldahl (6B1a).
Total nitrogen—semimicro Kjeldahl (6B2a).
Extractable bases—ammonium acetate pH 7.0, uncorrected; calcium (6N2e), magnesium (602d), sodium (6P2b), potassium (6Q2b).
Cation exchange capacity sodium acetate, pH 8.2 (5A2a).
Reaction (pH)—1:1 water dilution (8C1a).
Electrical conductivity—saturation extract (8A1a).

Sodium-adsorption ratio (5E).
Total phosphorus—perchloric acid; colorimetry (6S1a).
Available phosphorus—(method of reporting laboratory).
Mineralogy-X-ray diffraction.
Exchangeable sodium percentage sodium-absorbtion ratio method (*5*).
Calcium carbonate equivalent manometric method (*3*).

Engineering Index Test Data

Table 15 shows laboratory test data for several pedons sampled at carefully selected sites in the survey area. The pedons are typical of the series and are described in the section "Soil Series and Their Morphology." The soil samples were tested by the Texas Department of Highways and Public Transportation.

The testing methods generally are those of the American Association of State Highway and Transportation Officials (AASHTO) or the American Society for Testing and Materials (ASTM).

The tests and methods are: AASHTO classification—M 145 (AASHTO), D 3282 (ASTM); Unified classification—D 2487 (ASTM); Mechanical analysis—T 88 (AASHTO), D 2217 (ASTM); Liquid limit—T 89 (AASHTO), D 423 (ASTM); Plasticity index—T 90 (AASHTO), D 424 (ASTM); Shrinkage—T 92 (AASHTO), D 427 (ASTM); Specific gravity (particle index)l100 (AASHTO), D 653 (ASTM).

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (*7*). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 16 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Entisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Orthent (*Orth*, meaning true, plus *ent*, from Entisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Torriorthents (*Torr*, meaning hot and dry, plus *Orthent*, the suborder of the Entisols that represents the central concept of that order).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Torriorthents.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is loamy, mixed (calcareous), thermic, shallow Typic Torriorthents.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the Soil Survey Manual (*4*). Many of the technical terms used in the descriptions are defined in Soil Taxonomy (*7*). Unless otherwise stated, colors in the descriptions are for dry soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed Soil Map Units."

Agustin Series

The Agustin series consists of deep, well drained soils on uplands. These soils formed in loamy, mixed, gravelly sediment. Slopes range from 1 to 3 percent.

Typical pedon of Agustin gravelly fine sandy loam, in an area of Pajarito-Agustin association, gently sloping; from the ranger station at Persimmon Gap, 0.5 mile (0.8 kilometer) south on paved park road and 510 feet (155 meters) west of the road:

A—0 to 2 inches (0 to 5 centimeters); pale brown (10YR 6/3) gravelly fine sandy loam, brown (10YR 4/3) moist; weak medium platy structure; slightly hard, very friable; about 15 percent, by volume, mixed limestone and igneous pebbles; calcareous; moderately alkaline; clear smooth boundary.

Bw—2 to 11 inches (5 to 28 centimeters); pale brown (10YR 6/3) gravelly fine sandy loam, brown (10YR 4/3)moist; weak medium granular structure; slightly hard, very friable; many pores; about 15 percent, by volume, mixed pebbles; few thin patchy coatings of calcium carbonate on undersides of pebbles; calcareous; moderately alkaline; clear smooth boundary.

C1—11 to 28 inches (28 to 70 centimeters); light yellowish brown (10YR 6/4) gravelly loam, dark yellowish brown (10YR 4/4) moist; massive; slightly hard, very friable; about 30 percent, by volume, mixed pebbles that have thin patchy coatings of calcium carbonate; calcareous; moderately alkaline; gradual smooth boundary.

C2—28 to 40 inches (70 to 100 centimeters); light yellowish brown (10YR 6/4) gravelly fine sandy loam, dark yellowish brown (10YR 4/4) moist; massive; slightly hard, very friable; about 35 percent, by volume, mixed pebbles that have a few patchy coatings of calcium carbonate; calcareous; moderately alkaline.

Thickness of the solum ranges from 11 to 36 inches (28 to 91 centimeters). Mixed limestone and igneous coarse fragments make up 15 to 35 percent, by volume, throughout the solum.

The A horizon is pale brown (10YR 6/3) or brown (7.5YR 5/4). It is gravelly fine sandy loam or gravelly sandy loam. It is 2 to 11 inches (5 to 28 centimeters) thick.

The Bw horizon is pale brown (10YR 6/3), brown (10YR 5/3), yellowish brown (10YR 5/4), or reddish brown (5YR 5/3). It is 8 to 25 inches (20 to 64 centimeters) thick.

The C horizon is light yellowish brown (10YR 6/4), light brown (10YR 6/3 or 7.5YR 6/4), or reddish brown (5YR 5/4). It is gravelly loam, gravelly fine sandy loam, or gravelly sandy loam. Some pedons have sandy strata below a depth of 40 inches (100 centimeters).

Brewster Series

The Brewster series consists of very shallow and shallow, well drained soils on hills and mountains. These soils formed in material weathered from igneous bedrock. Slopes range from 20 to 45 percent.

Typical pedon of Brewster very cobbly loam, in an area of Brewster-Rock outcrop complex, very steep; from Panther Junction, 3.3 miles (5.3 kilometers) west on park road, 2.75 miles (4.4 kilometers) south on road to basin in Green Gulch and 1,800 feet (548 meters) east of road, on mountain:

A—0 to 4 inches (0 to 10 centimeters); reddish gray (5YR 5/2) very cobbly loam, dark reddish brown (5YR 3/2) moist; weak medium granular structure; slightly hard, friable; about 50 percent, by volume, igneous fragments, of which 20 percent is cobbles and 80 percent gravel; neutral; abrupt irregular boundary.

R—4 to 10 inches (10 to 25 centimeters); coarsely fractured, hard, igneous bedrock.

Depth to igneous bedrock ranges from 4 to 20 inches (10 to 50 centimeters) (fig. 20). Colors throughout are reddish gray (5YR 5/2), reddish brown (5YR 4/3), brown (7.5YR 5/2, 4/2), or dark grayish brown (10YR 4/2). Coarse fragments make up 35 to 70 percent, by volume, of the solum. Cobbles make up 0 to 25 percent of the solum. Texture is very gravelly loam or very cobbly loam. Reaction ranges from mildly alkaline to slightly acid.

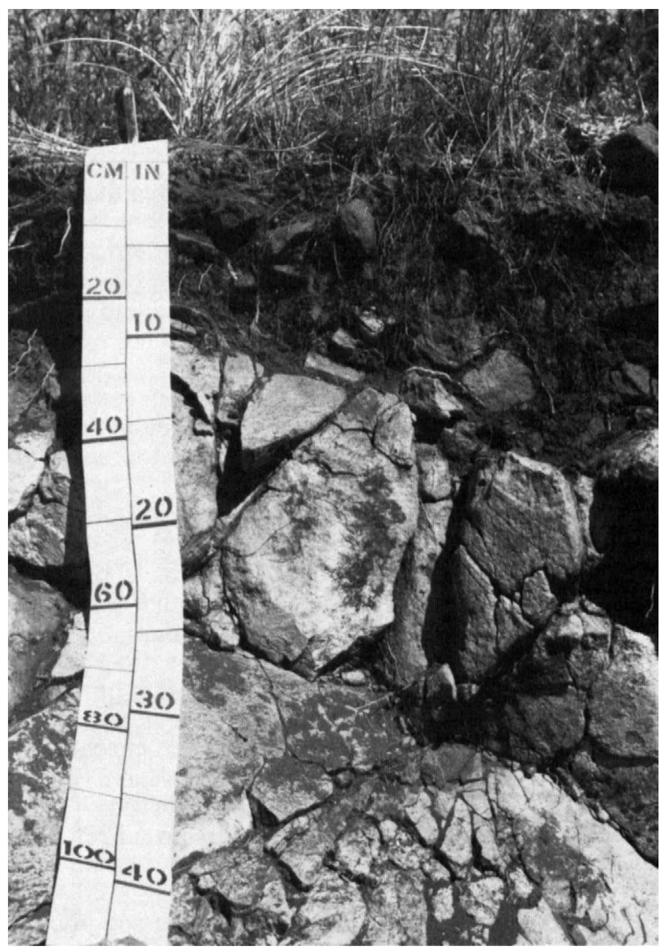


Figure 20.—Profile of Brewster very cobbly loam. Igneous bedrock is at a depth of about 10 inches (25 centimeters).

Chamberino Series

The Chamberino series consists of deep, well drained, very gravelly or very cobbly soils on undulating to rolling uplands. These soils formed in colluvium from igneous hills and mountains. Slopes range from 1 to 15 percent.

Typical pedon of Chamberino very gravelly loam, in an area of Chamberino very gravelly loam, undulating; from park headquarters, 15.35 miles (24.7 kilometers) southeast and 55 feet (16.8 meters) north of pavement:

A—0 to 4 inches (0 to 10 centimetes); pink (7.5YR 7/4) very gravelly loam, brown (7.5YR 5/4) moist; weak medium granular structure; slightly hard, friable; about 45 percent, by volume, igneous fragments, of which about 3 percent are larger than 2 centimeters (0.75 inch); calcareous; moderately alkaline; clear smooth boundary.

Bk1—4 to 13 inches (10 to 33 centimeters); pink (7.5YR 7/4) very cobbly loam, brown (7.5YR 5/4) moist; weak granular structure; hard, friable; about 50 percent, by volume, igneous fragments, thickly coated with calcium carbonate, of which about 3 percent are larger than 7.5 centimeters (3 inches); calcareous; moderately alkaline; gradual smooth boundary.

Bk2—13 to 31 inches (33 to 79 centimeters); pink (7.5YR 7/4) very cobbly loam, brown (7.5YR 5/4) moist; weak granular structure; hard, friable; about 60 percent, by volume, igneous fragments, of which about 15 percent are larger than 7.5 centimeters (3 inches); thick coatings of calcium carbonate on fragments; calcareous; moderately alkaline; gradual smooth boundary.

Bk3—31 to 55 inches (79 to 140 centimeters); pink (7.5YR 7/4) very cobbly loam, brown (7.5YR 5/4) moist; massive; slightly hard, friable; about 60 percent, by volume, igneous fragments, of which 12 percent are larger than 7.5 centimeters (3 inches); some stratification of gravel; patchy coatings of calcium carbonate on fragments; calcareous; moderately alkaline; diffuse smooth boundary.

C—55 to 80 inches (140 to 238 centimeters); light reddish brown (7.5YR 6/4) very gravelly sandy loam, reddish brown (7.5YR 5/4) moist; massive; loose, very friable; about 80 percent, by volume, igneous gravel; calcareous; moderately alkaline.

Thickness of the solum ranges from 30 to more than 60 inches (75 to more than 150 centimeters). Coarse fragments make up 35 to about 75 percent of the 10- to 40-inch (25 to 100 centimeters) control section. The fine earth fraction of the A and Bk horizons is loam or fine sandy loam.

The A horizon is light brown (7.5YR 6/4), pale brown (10YR 6/3), or pink (7.5YR 7/4). It is 3 to 8 inches (7.5 to 20 centimeters) thick. Coarse fragments make up 25 to about 60 percent of this horizon.

The Bk horizon is pink (7.5YR 7/4, 8/4), light brown (7.5YR 6/4), pale brown (10YR 6/3), light yellowish brown (10YR 6/4), or very pale brown (10YR 7/3). The coarse fragments have coatings of calcium carbonate.

The C horizon is light brown (7.5YR 6/4) or pink (7.5YR 7/4, 8/4). The fine earth fraction is loam, fine sandy loam, or sandy loam.

In most areas variable gravelly strata are below a depth of 60 inches (150 centimeters).

Chilicotal Series

The Chilicotal series consists of deep, well drained, moderately permeable soils that formed in gravelly sediment from igneous mountains. Slopes range from 1 to 25 percent.

Typical pedon of Chilicotal very gravelly fine sandy loam, undulating, from park headquarters at Panther Junction; 3.2 miles (5.15 kilometers) west on paved road, 2.9 miles (4.7 kilometers) north on Grapevine Hills road and 900 feet (274 meters) west of road:

A—0 to 2 inches (0 to 5 centimeters); brown (7.5YR 5/4) very gravelly fine sandy loam, brown (7.5YR 4/4) moist; weak fine granular structure; slight hard, very friable; many roots; about 40 percent, by volume, igneous gravel; weakly effervescent; moderately alkaline; abrupt smooth boundary.

Bw—2 to 7 inches (5 to 19 centimeters); brown (7.5YR 5/4) very gravelly loam brown (7.5YR 4/4) moist; weak fine subangular blocky structure; slightly hard, friable; common roots; few fine threads and films of calcium carbonate; about 30 percent, by volume, igneous fragments less than 3 inches (7.5 centimeters) across; weakly effervescent; mildly alkaline; clear smooth boundary.

Bk1—7 to 14 inches (19 to 36 centimeters); brown (7.5YR 5/4) very gravelly loam, brown (7.5YR 4/4) moist; weak fine subangular blocky structure; slightly hard, friable; common roots; common threads and films of calcium carbonate; about 50 percent, by volume, igneous fragments that are mostly gravel with a few cobbles and have patchy coatings of calcium carbonate on undersides; strongly effervescent; mildly alkaline; clear smooth boundary.

Bk2—14 to 28 inches (36 to 71 centimeters); brown (7.5YR 5/4) very gravelly clay loam, brown (7.5YR 4/4) moist; weak fine subangular blocky structure; slightly hard, friable; common roots; common threads and films of calcium carbonate; about 55 percent, by volume, igneous gravel that has patchy coatings of calcium carbonate; strongly effervescent; moderately alkaline; clear wavy boundary.

Bk3—28 to 40 inches (71 to 101 centimeters); light brown (7.5YR 6/4) very gravelly loam, brown (7.5YR 5/4) moist; weak very fine granular structure; very hard, friable; few roots; about 70 percent, by volume, igneous fragments that are mostly gravel with a few cobbles and have patchy coatings of calcium carbonate; violently effervescent; mildly alkaline; clear smooth boundary.

2Bkl—40 to 51 inches (101 to 130 centimeters); pink (7.5YR 7/4) very gravelly sandy loam, brown (7.5YR 5/4) moist; weak very fine granular structure; slightly hard, very friable; few roots; about 50 percent, by volume, igneous gravel that has thick coatings of calcium carbonate; violently effervescent; moderately alkaline; clear smooth boundary.

2Bk2—51 to 61 inches (130 to 156 centimeters); pink (7.5YR 7/4) very gravelly sandy loam, brown (7.5YR 5/4) moist; weak very fine granular structure; slightly hard, friable; few roots; about 70 percent, by volume, igneous gravel that has patchy coatings of calcium carbonate; violently effervescent; moderately alkaline.

Depth to the Bk horizon ranges from 6 to 20 inches (15 to 50 centimeters). Coarse fragments make up 30 to about 80 percent of all horizons. The soil is calcareous and mildly alkaline or moderately alkaline in the upper 60 inches.

The A horizon is brown (7.5YR 5/2, 5/4), light brown (7.5YR 6/4), pale brown (10YR 6/3), or pinkish gray (7.5YR 6/2). It is very gravelly loam or very gravelly fine sandy loam. It is generally less than 3 inches (7.5 centimeters) thick.

The Bw horizon is similar in color to the A horizon. It is very gravelly loam, very gravelly clay loam, very gravelly sandy clay loam, or very gravelly fine sandy loam. It is 3 to 17 inches (7.5 to 43 centimeters) thick.

The Bk horizon is brown (7.5YR 5/4), light brown (7.5YR 6/4), light yellowish brown (10YR 6/4), light gray (10YR 7/2), pink (7.5YR 7/4), or pinkish gray (7.5YR 6/2). The coarse fragments have coatings of calcium carbonate (fig. 21). The calcium carbonate equivalent of the fine earth fraction ranges from 2 to about 25 percent. The Bk horizon is very gravelly loam, very gravelly fine sandy loam, very gravelly clay loam, or very gravelly sandy clay loam.

Some pedons have a C horizon or a buried Bt horizon of varying texture below a depth of 60 inches (150 centimeters). Some of the buried horizons are strongly alkaline.

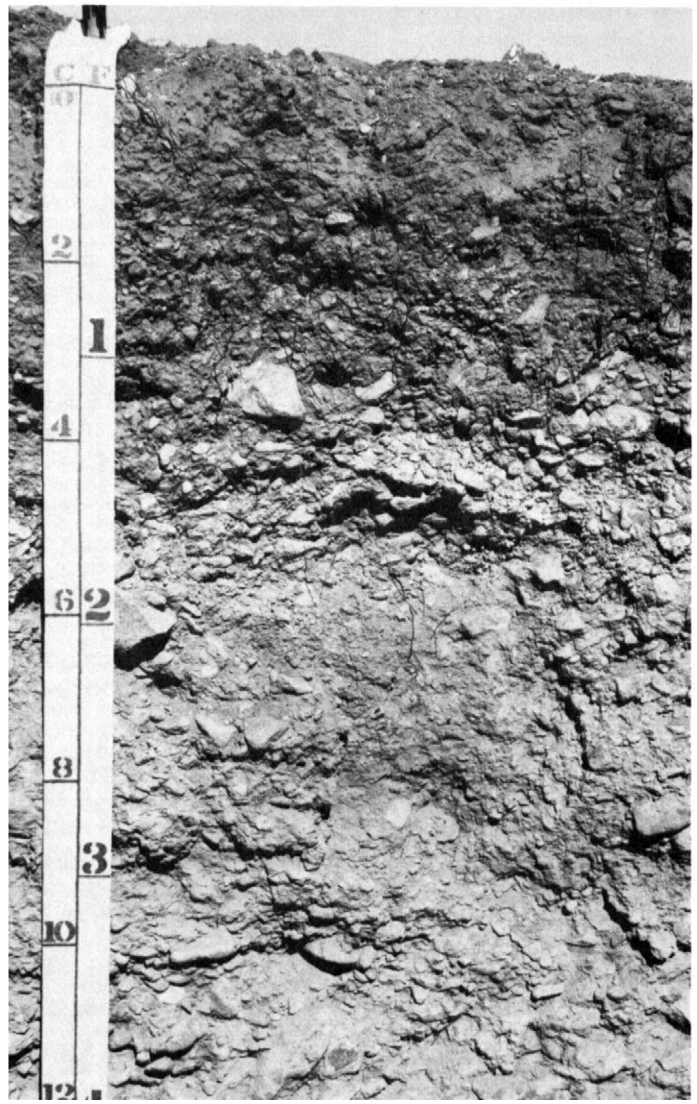


Figure 21.—Profile of Chilicotal very gravelly fine sandy loam. The gravel is of igneous origin and is coated with calcium carbonate below a depth of 14 inches (36 centimeters). The figures on the left should be multiplied by 10 to obtain the depth in centimeters.

Ector Series

The Ector series consists of very shallow and shallow, well drained soils on hills and mountains. These soils formed in material weathered from limestone. Slopes range from 8 to 45 percent.

Typical pedon of Ector very cobbly loam, in any area of Ector-Rock outcrop complex, steep; 1.2 miles (1.9 kilometers) west-northwest of the northern peak of Sue Peaks on an east facing slope of a mountain; approximately 5 miles (8 kilometers) east of the Telephone Canyon trail head and 2.6 miles (4.2 kilometers) north:

A—0 to 6 inches (0 to 15 centimeters); brown (7.5YR 4/2) very cobbly loam, dark brown (7.5YR 3/2) moist; moderate medium granular structure; hard, friable; about 40 percent, by volume, limestone fragments, of which about 10 percent is cobbles and 30 percent gravel; coatings of calcium carbonate on fragments; calcareous; moderately alkaline; abrupt wavy boundary.

R&Bk—6 to 10 inches (14 to 25 centimeters); fractured platy limestone; calcium carbonate coated fragments and partially sealed fractures; thin seams of loamy material in upper fractures and between upper layers; gradual wavy boundary.

R—10 to 18 inches (25 to 45 centimeters); hard, slightly fractured limestone bedrock.

The solum ranges from 4 to 14 inches (10 to 35 centimeters) in thickness. Limestone gravel and cobbles make up 40 to 60 percent, by volume, of the solum. Cobbles make up 0 to 20 percent, by volume, of the solum. Coarse fragments have coatings of calcium carbonate.

The solum is brown (10YR 5/3; 7.5YR 5/2, 4/2) or dark grayish brown (10YR 4/2). It is very gravelly loam, very gravelly clay loam, very cobbly loam, or very cobbly clay loam.

Glendale Series

The Glendale series consists of deep, well drained soils on bottom lands. These soils formed in loamy calcareous alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Glendale silty clay loam, in an area of Glendale-Harkey association, occasionally flooded; from the scenic overlook at Santa Elena Canyon, 2.3 miles (3.7 kilometers) east on paved park road and 295 feet (272 meters) south of the pavement along a trail:

A1—0 to 1 inch (0 to 3 centimeters); pale brown (10YR 6/3) silty clay loam, brown (10YR 4/3) moist; weak medium platy structure; slightly hard, very friable; many very fine pores; calcareous; moderately alkaline; abrupt smooth boundary.

A2—1 to 9 inches (3 to 23 centimeters); brown (10YR 5/3) silty clay loam, brown (10YR 4/3) moist; weak medium granular structure; slightly hard, very friable; common fine pores; common fine roots; calcareous; moderately alkaline; clear smooth boundary.

C1—9 to 18 inches (23 to 46 centimeters); pale brown (10YR 6/3) silt loam, brown (10YR 4/3) moist; massive; slightly hard, very friable; stratified; common fine pores; common fine roots; calcareous; moderately alkaline; gradual smooth boundary.

C2—18 to 35 inches (46 to 89 centimeters); light yellowish brown (10YR 6/4) silt loam, dark yellowish brown (10YR 4/4) moist; massive; slightly hard, very friable; stratified, common fine pores; common fine roots; calcareous; moderately alkaline; gradual smooth boundary.

C3—35 to 60 inches (89 to 150 centimeters); light yellowish brown (10YR 6/4) loam, dark yellowish brown (10YR 4/4) moist; massive; slightly hard, very friable; stratified; common very fine pores; few fine roots; calcareous; moderately alkaline.

These bottom land soils are more than 40 inches (100 centimeters) deep and are calcareous throughout. They are silt loam, silty clay loam, or loam throughout. These soils are stratified, and bedding planes are evident (fig. 22). The 10- to 40-inch layer is 18 to 35 percent clay and less than 15 percent fine and coarser sand.

The A horizon is brown (10YR 5.3), pale brown (10YR 6/3), light brown (7.5YR 6/4), or light yellowish brown (10YR 6/4). It is 6 to 12 inches (15 to 30 centimeters) thick.

The C horizon is light reddish brown (5YR 6/4), light brown (7.5YR 6/4), pale brown (10YR 6/3), very pale

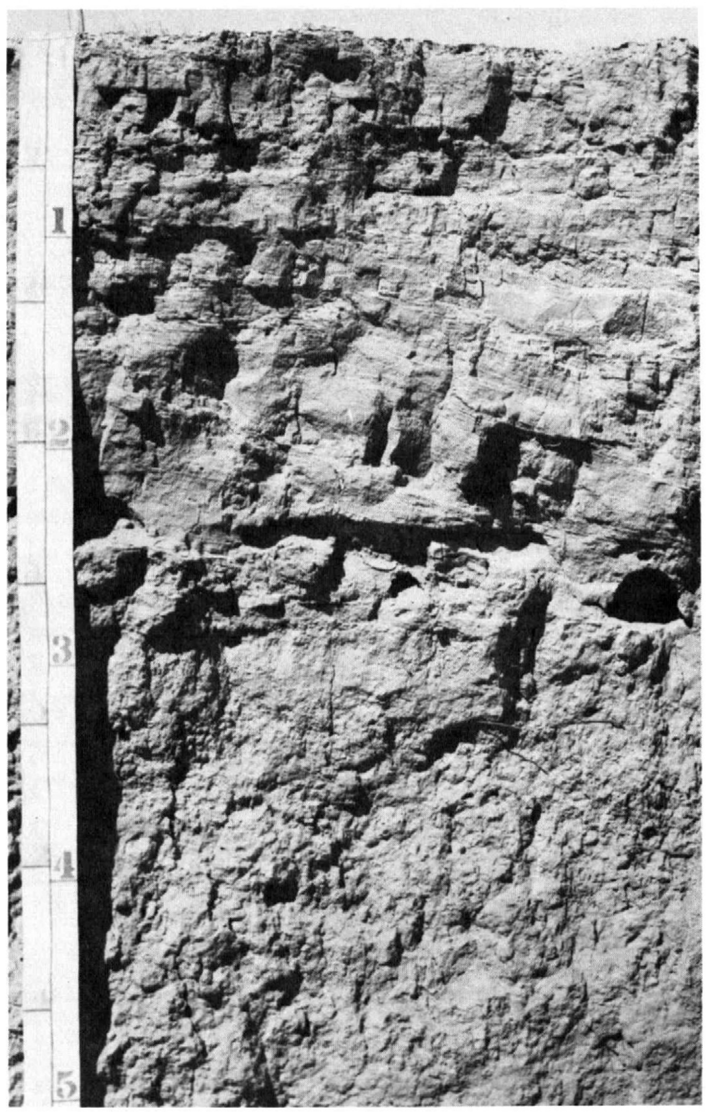


Figure 22.—Profile of Glendale silty clay loam. Note stratification. Measurement is in feet.

brown (10YR 7/3), light yellowish brown (10YR 6/4), or yellowish brown (10YR 5/4).

Harkey Series

The Harkey series consists of deep, well drained soils on bottom lands. These soils formed in loamy calcareous alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Harkey silty clay loam, in an area of Glendale-Harkey association, occasionally flooded; from the scenic overlook at Santa Elena Canyon, 2.3 miles (3.7 kilometers) east on paved park road and 170 feet (52 meters) south of the road along trail:

A1—0 to 2 inches (0 to 5 centimeters); pale brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; weak medium platy structure; slightly hard, very friable; many fine roots; calcareous; moderately alkaline; abrupt smooth boundary.

A2—2 to 10 inches (5 to 25 centimeters); pale brown (10YR 6/3) very fine sandy loam, brown (10YR 4/3) moist; weak medium granular structure; slightly hard, very friable; common fine roots; calcareous; moderately alkaline; clear smooth boundary.

Cl—10 to 18 inches (25 to 46 centimeters); brown (10YR 5/3) very fine sandy loam, brown (10YR 4/3) moist; single grained; slightly hard, very friable; common fine roots; thin strata of finer material; calcareous; moderately alkaline; gradual smooth boundary.

C2—18 to 32 inches (46 to 81 centimeters); pale brown (10YR 6/3) very fine sandy loam, brown (10YR 4/3) moist; single grained; slightly hard, very friable; common fine roots; thin strata of finer and coarser materials; calcareous; moderately alkaline; gradual smooth boundary.

C3—32 to 50 inches (81 to 126 centimeters); pale brown (10YR 6/3) very fine sandy loam, brown (10YR 4/3) moist; single grained; slightly hard, very friable; few fine roots; stratified; calcareous; moderately alkaline; gradual smooth boundary.

C4—50 to 60 inches (126 to 150 centimeters); brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; massive; hard, firm; calcareous; moderately alkaline.

These bottom land soils are more than 40 inches (100 centimeters) deep and are calcareous throughout. They are stratified with varying textures, and bedding planes are evident. The 10- to 40-inch (25 to 100 centimeters) layer ranges from 10 to 18 percent clay and less than 15 percent fine and coarser sand.

The A horizon is brown (7.5YR 5/4), light brown (7.5YR 6/4), pale brown (10YR 6/3), or light yellowish brown (10YR 6/4). It is 2 to 12 inches (5 to 30 centimeters) thick.

The C horizon is brown (7.5YR 5/4, 10YR 5/3), light brown (7.5YR 6/4), pale brown (10YR 6/3), or light yellowish brown (10YR 6/4).

Hurds Series

The Hurds series consists of deep, very gravelly and very cobbly, well drained soils on igneous mountain foot slopes. These soils formed in loamy and sandy, gravelly material. Slopes range from 3 to 45 percent.

Typical pedon of Hurds very gravelly sandy loam, in an area of Hurds very gravelly sandy loam, rolling; from the headquarters of Big Bend National Park at Panther Junction; 3 miles (4.8 kilometers) west on paved park road; 2.2 miles (3.5 kilometers) south on basin road; 40 feet (12 meters) east of road:

A—0 to 3 inches (0 to 5 centimeters); reddish brown (5YR 5/3) very gravelly sandy loam, dark reddish brown (5YR 3/3) moist; weak medium subangular blocky structure; slightly hard, very friable; about 35 percent, by volume, igneous fragments; slightly acid; clear smooth boundary.

Bt1—3 to 15 inches (5 to 38 centimeters); reddish brown (5YR 4/3) very gravelly sandy clay loam, dark reddish brown (5YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable; about 50 percent, by volume, igneous fragments; slightly acid; clear smooth boundary.

Bt2—15 to 29 inches (38 to 74 centimeters); reddish brown (5YR 5/3) very gravelly sandy clay loam, reddish brown (5YR 4/3) moist; moderate medium subangular blocky structure; hard, friable; about 45 percent, by volume, igneous fragments; slightly acid; clear smooth boundary.

Bt3—29 to 41 inches (74 to 104 centimeters); reddish brown (5YR 5/4) very gravelly sandy clay loam, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; hard, firm; about 35 percent, by volume, igneous fragments; slightly acid.

The solum is 35 to about 60 inches (90 to 150 centimeters) thick. The mollic epipedon is 10 to 20 inches (25 to 50 centimeters) thick. The average clay content of the Bt horizon is 20 to 35 percent.

The A horizon is reddish brown (5YR 5/3), reddish gray (5YR 5/2), or dark reddish gray (5YR 4/2). It is a very gravelly or very cobbly phase of sandy loam or loam. It ranges from neutral to slightly acid. It is 3 to 15 inches (8 to 38 centimeters) thick.

The Bt horizon is mostly reddish brown (5YR 4/3, 5/3, 5/4). It is very gravelly sandy clay loam or very cobbly sandy clay loam. It ranges from slightly acid to medium acid.

Lajitas Series

The Lajitas series consists of very shallow and shallow, very gravelly and very cobbly well drained soils on hills and mountains. These soils formed in material weathered from igneous bedrock. Slopes range from 3 to 60 percent.

Typical pedon of Lajitas very cobbly loam, in an area of Lajitas-Rock outcrop complex, hilly; from the headquarters of Big Bend National Park at Panther Junction; 3.4 miles (5.5 kilometers) west on park road, 6.5 miles (10.5 kilometers) north on Grapevine Hills road, and 250 feet (76 meters) south of road:

A—0 to 7 inches (0 to 18 centimeters); brown (7.5YR 5/4) very cobbly loam, brown (7.5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, very friable; about 60 percent, by volume, igneous fragments, of which about 40 percent is cobbles and 60 percent gravel; noncalcareous; moderately alkaline; abrupt wavy boundary.

R—7 to 30 inches (18 to 76 centimeters); slightly fractured igneous bedrock, a small amount of loamy material similar in color and texture to the A horizon in the fractures.

Depth to igneous bedrock ranges from 4 to 20 inches (10 to 50 centimeters). The A horizon is brown (7.5YR 5/4, 5/3, 10YR 5/3), reddish brown (5YR 5/3), light reddish brown (5YR 6/3, 6/4), reddish gray (5YR 5/2), light brownish gray (10YR 5/2), or pale brown (10YR 6/3). The fine earth fraction is loam or clay loam. Coarse fragments are igneous and make up 0 to 40 percent, by volume, of stone content. Cobbles make up 0 to 50 percent of the coarse fragments, and gravel makes up 35 to 60 percent.

Liv Series

The Liv series consists of deep, very gravelly and cobbly well drained soils on hills and mountains. These soils formed in clayey, gravelly and cobbly material weathered from igneous rock and tuff. Slopes range from 8 to 45 percent.

Typical pedon of Liv very cobbly loam, in an area of Liv-Mainstay-Rock outcrop complex, steep; from the trailhead in the basin, south on the trail to Laguna Meadows to junction with abandoned trail to window; west on abandoned trail 200 yards (182 meters); on cut on east side of trail:

A—0 to 9 inches (0 to 23 centimeters); dark brown (7.5YR 4/2) very cobbly loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure; hard, firm; about 45 percent, by volume, igneous coarse fragments, of which 15 percent are larger than 3 inches (76 milimeters) in diameter; neutral; abrupt smooth boundary.

Bt1—9 to 25 inches (23 to 64 centimeters); reddish brown 5YR 4/3) very cobbly clay, dark reddish brown (5YR 3/3) moist; moderate medium sutangular blocky structure; very hard, very firm; about 45 percent, by volume, igneous coarse fragments, of which 20 percent are larger than 3 inches (76 millimeters) in diameter; neutral; gradual smooth boundary.

Bt2—25 to 47 inches (64 to 119 centimeters); reddish brown (5YR 4/4) very cobbly clay, dark brown (5YR 3/4) moist; moderate medium subangular blocky structure; very hard, very firm; about 50 percent, by volume, igneous coarse fragments, of which 20 percent are larger than 3 inches (76 millimeters) in diameter; neutral; gradual smooth boundary.

Bt3—47 to 68 inches (119 to 173 centimeters); reddish brown (5YR 5/4) very cobbly clay, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; very hard, very firm; about 55 percent, by volume, igneous coarse fragments, of which 20 percent are larger than 3 inches (76 millimeters) in diameter; neutral.

The solum is more than 40 inches (100 centimeters) thick. It is 35 to 60 percent, by volume, igneous cobbles and gravel. The mollic epipedon is more than 20 inches (50 centimeters) thick.

The A horizon is dark reddish gray (5YR 4/2) or dark brown (7.5YR 4/2). It is very gravelly loam or very cobbly loam. It is 4 to 14 inches (10 to 35 centimeters) thick.

The Bt horizon is dark brown (7.5YR 4/2; 4/4), dark reddish brown (5YR 3/2), reddish gray (5YR 5/2), dark reddish gray (5YR 4/2), reddish brown (5YR 5/4, 5/3, 4/4, 4/3), or brown (7.5YR 5/4). It is very gravelly clay or very cobbly clay. It ranges from slightly acid to mildly alkaline.

Liv soils in the survey area are a taxadjunct to the Liv series because they are more than 40 inches (1 meter) deep to bedrock. However, this difference does not affect the use and management of the soils.

Lozier Series

The Lozier soils consist of shallow and very shallow, very cobbly to very gravelly, well drained soils on hills and mountains. These soils formed in loamy material weathered from limestone. Slopes range from 10 to about 60 percent.

Typical pedon of Lozier very cobbly loam, in an area of Lozier-Rock outcrop complex, very steep; about 17.5 miles (28.2 kilometers) southeast of Panther Junction on the Rio Grande Village road, 200 feet (61 meters) west of tunnel, 100 feet (30 meters) south of pavement:

Ak—0 to 5 inches (0 to 13 centimeters); light brown (7.5YR 6/4) very cobbly loam, brown (7.5YR 5/4) moist; weak fine subangular blocky structure; slightly hard, friable; few roots; about 50 percent, by volume, limestone gravel and cobbles; fragments coated with calcium carbonate; calcareous; moderately alkaline; clear wavy boundary.

R&Bk—5 to 11 inches (13 to 28 centimeters); caliche coated limestone fragments; small amount of soil material in cracks and crevices; abrupt irregular boundary.
R—11 to 15 inches (28 to 38 centimeters); hard, grayish limestone bedrock.

Depth to bedrock ranges from 4 to 14 inches (10 to 35 centimeters). The A horizon is light brown (7.5YR 6/4), light brownish gray (10YR 6/2), brown (10YR 5/3), pale brown (10YR 6/3), very pale brown (10YR 7/3), or grayish brown (10YR 5/2). Coarse limestone fragments make up 35 to 75 percent by volume. The coarse fragments have a thin coating of calcium carbonate. The A horizon is very gravelly loam or very cobbly loam.

Madrone Series

The Madrone series consists of moderately deep, very gravelly, well drained soils on the tops of mountains. These soils formed in clayey sediment over igneous bedrock. Slopes range from 8 to 45 percent.

Typical pedon of Madrone very gravelly loam, in an area of Puerta-Madrone complex, steep; about 1 mile (1.6 kilometers) east on trail from Laguna Meadows to the junction of the South Rim and Boot Springs trails, south on the South Rim trail 900 feet (274 meters) and 10 feet (3 meters) east of trail:

A—0 to 4 inches (0 to 10 centimeters); brown (7.5YR 4/2) very gravelly loam, dark brown (7.5YR 3/2) moist; weak medium granular structure; slightly hard, friable; common roots; about 35 percent, by volume, igneous gravel; neutral; clear smooth boundary.
E—4 to 6 inches (10 to 15 centimeters); pinkish gray (7.5YR 6/2) very gravelly loam, brown (7.5YR 4/2) moist; weak very fine subangular blocky structure; slightly hard, friable; common very fine roots; about 35 percent, by volume, igneous gravel; slightly acid; clear smooth boundary.
Bt1—6 to 19 inches (15 to 48 centimeters); reddish brown (5YR 5/3) very gravelly clay, reddish brown (5YR 4/3) moist; moderate medium subangular blocky structure; very hard, very firm; few very fine roots; clay films on ped faces; about 45 percent, by volume, igneous gravel and a few cobbles; medium acid; gradual smooth boundary.
Bt2—19 to 32 inches (48 to 81 centimeters); reddish brown (5YR 5/4) very gravelly clay, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; very hard, very firm; few very fine roots; clay films on ped faces; about 50 percent, by volume, igneous gravel and a few cobbles; strongly acid; abrupt smooth boundary.
R—32 to 40 inches (81 to 100 centimeters); hard igneous bedrock.

The solum is 21 to 40 inches (53 to 100 centimeters) thick. Igneous coarse fragments make up 35 to 75 percent, by volume, of the solum.

The A horizon is dark grayish brown (10YR 4/2) or brown (10YR 4/3, 7.5YR 5/4, 5/2). The fine earth fraction is loam or clay loam. The A horizon is 3 to 6 inches (8 to 15 centimeters) thick. It is neutral to slightly acid.

The E horizon is pinkish gray (7.5YR 6/2, 7/2), pink (7.5YR 7/4), light brown (7.5YR 6/4), very pale brown (10YR 7/3. 7/4), light brownish gray (10YR 6/2), or pale brown (10YR 6/3). The fine earth fraction is loam or clay loam. The E horizon is 2 to 12 inches (5 to 30 centimeters) thick. It ranges from neutral to slightly acid.

Mainstay Series

The Mainstay series consists of shallow, gravelly or cobbly well drained soils on uplands. These soils formed in clayey, gravelly material weathered from igneous rock. Slopes range from 2 to 45 percent.

Typical pedon of Mainstay very gravelly loam, in an area of Liv-Mainstay-Rock outcrop complex, steep; from the maintenance building south of the lodge in the basin of Big Bend National Park, 200 feet (61 meters) northwest in road cut:

A—0 to 5 inches (0 to 12 centimeters); very dark grayish brown (10YR 3/2) very gravelly loam, very dark brown (10YR 2/2) moist; moderate medium subangular blocky structure; slightly hard, friable; many fine roots; 50 percent, by volume, igneous fragments mostly 1 to 8 centimeters in diameter; noncalcareous; neutral; clear smooth boundary.
Bt1—5 to 11 inches (12 to 28 centimeters); reddish brown (5YR 4/3) very gravelly clay, dark reddish brown (5YR 3/3) moist; strong fine and medium blocky structure; very hard, very firm; shiny ped faces and clay films; many fine roots; 45 percent, by volume, igneous fragments mostly 1 to 15 centimeters in diameter; noncalcareous; neutral; clear smooth boundary.
Bt2—11 to 18 inches (28 to 46 centimeters); reddish brown (5YR 5/3) very gravelly clay, reddish brown (5YR 4/3) moist; strong fine blocky structure; very hard, very firm; shiny ped faces and clay films; common fine roots; 60 percent, by volume, igneous fragments mostly 1 to 15 centimeters in diameter noncalcareous; mildly alkaline; abrupt irregular boundary.
R—18 to 30 inches (46 to 76 centimeters); hard igneous bedrock.

The solum is 10 to 20 inches (25 to 50 centimeters) thick. It is 35 to 80 percent, by volume, igneous coarse fragments.

The A horizon is very dark grayish brown (10YR 3/2), dark brown (7.5YR 4/2), brown (7.5YR 5/2), or grayish brown (10YR 5/2). It is very gravelly loam or very cobbly loam. It is 3 to 9 inches (8 to 23 centimeters) thick. Reaction is neutral or mildly alkaline.

The Bt horizon is dark brown (7.5YR 4/2), dark reddish gray (5YR 4/2), grayish brown (10YR 5/2), or reddish brown (5YR 4/3, 5/3). It is very gravelly clay, very cobbly clay, or very stony clay. It is 7 to 17 inches (18 to 43 centimeters) thick. Reaction is slightly acid to mildly alkaline.

Mariscal Series

The Mariscal series consists of shallow and very shallow, well drained, very channery or flaggy soils on hills and mountains. These soils formed in material weathered from thick beds of alternating platy limestone and marl. Slopes range from 2 to 45 percent.

Typical pedon of Mariscal very channery loam, in an area of Mariscal-Rock outcrop complex, hilly; on paved park road 4.5 miles (7.2 kilometers) west of Rio Grande Village, south 0.65 miles (1 kilometer) on Hot Springs Road, and 280 feet (85 meters) east in rangeland:

A—0 to 2 inches (0 to 5 centimeters); pale brown (10YR 6.3) very channery loam, brown (10YR 5/3) moist; moderate medium granular structure; slightly hard, friable; about 60 percent, by volume, platy limestone fragments, a few more than 6 inches (15 centimeters) across; calcareous; moderately alkaline; abrupt smooth boundary.

Ak—2 to 5 inches (5 to 13 centimeters); pale brown (10YR 6/3) very channery loam, brown (10YR 5/3); moderate medium granular structure; slightly hard, friable; about 60 percent, by volume, platy limestone fragments, a few more than 6 inches (15 centimeters) across; fragments coated with calcium carbonate; calcareous; moderately alkaline; abrupt smooth boundary.

Rk—5 to 10 inches (13 to 25 centimeters); platy fractured limestone that has secondary coatings of calcium carbonate in seams and between plates; gradual smooth boundary.

R—10 to 40 inches (25 to 100 centimeters); alternating layers of limestone bedrock and marl.

The solum ranges from 4 to 14 inches (10 to 35 centimeters) in thickness. Calcium carbonate equivalent of the fine earth fraction averages 40 to 60 percent.

The A horizon is pale brown (10YR 6/3) or very pale brown (10YR 7/3, 7/4) when dry. Coarse fragments make up 40 to 80 percent, by volume, and are channery or flaggy limestone and caliche. The A horizon is very channery loam or very flaggy loam.

The R horizon typically has layers of limestone 2 to 8 inches (5 to 20 centimeters) thick, separated by layers of marl 2 to 12 inches (5 to 30 centimeters) thick. The layers are tilted about 15 degrees from the horizontal.

Monterosa Series

The Monterosa series consists of shallow and very shallow, very gravelly or very cobbly well drained soils on undulating to rolling uplands. These soils formed in fan alluvium from igneous hills and mountains. Slopes range from 3 to 12 percent.

Typical pedon of Monterosa very gravelly sandy loam, in an area of Chilicotal-Monterosa association, rolling; from the headquarters of Big Bend National Park, 5 miles (8 kilometers) southeast on paved park road, 1 mile (1.6 kilometers) south and west on Glen Springs Road, 100 feet (30 meters) north of road:

Ak—0 to 1 inch (0 to 3 centimeters); light brown (7.5YR 6/4) very gravelly sandy loam; weak medium granular structure; slightly hard, very friable; common roots; about 45 percent igneous gravel; thin patchy coatings of calcium carbonate on lower sides of coarse fragments; calcareous; moderately alkaline; abrupt smooth boundary.

Bk1—1 to 4 inches (3 to 10 centimeters); light brown (7.5YR 6/4) very gravelly sandy loam, dark yellowish brown (10YR 4/4) moist; moderate medium granular structure; slightly hard, very friable; common roots; about 50 percent, by volume, igneous gravel; fragments coated with calcium carbonate; calcareous; moderately alkaline; clear smooth boundary.

Bk2—4 to 12 inches (10 to 30 centimeters); light brown (7.5YR 6/4) very gravelly sandy clay loam, brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; hard, friable; common roots; about 60 percent, by volume, igneous fragments coated with calcium carbonate; calcareous; moderately alkaline; abrupt wavy boundary.

Bkm—12 to 16 inches (30 to 40 centimeters); pinkish white (7.5YR 8/2) carbonate cemented caliche, upper 1 centimeter laminar; massive; extremely hard; calcareous; moderately alkaline; gradual wavy boundary.

2Bk—16 to 20 inches (40 to 50 centimeters); pink (7.5YR 7/4) very gravelly loam, brown (7.5YR 5/4) moist; massive; slightly hard, very friable; about 55 percent, by volume, igneous fragments coated with calcium carbonate; calcareous; moderately alkaline.

Depth to the petrocalicic horizon ranges from 7 to 20 inches (18 to 50 centimeters). Coarse fragments make up 35 to about 75 percent of the A and B horizons.

The A horizon is brown (7.5YR 5/4), light brown (7.5YR 6/4), or pale brown (10YR 6/3). It is 1 to 3 inches (2.5 to 7.5 centimeters) thick. The fine earth fraction is sandy loam.

The B horizon is brown (7.5YR 5/4, 5/2), light brown (7.5YR 6/4), or pinkish gray (7.5YR 6/2). The fine earth fraction is sandy loam or sandy clay loam.

The Bkm horizon is pink, pinkish white, or white. The underlying 2Bk horizon is light brown (7.5YR 6/4) or pink (7.5YR 7/4).

Nickel Series

This series consists of deep, very gravelly well drained soils. These soils formed in loamy, gravelly limestone material. Slopes range from 2 to 10 percent.

Typical pedon of Nickel very gravelly sandy loam, in an area of Upton-Nickel association, undulating; from the park headquarters at Panther Junction, 12 miles (19.3 kilometers) north on paved park road, 1.75 miles (2.8 kilometers) east on Dagger Flat road, and 400 feet (122 meters) north of road:

A—0 to 3 inches (0 to 8 centimeters; pale brown (10YR 6/3) very gravelly sandy loam, brown (10YR 4/3) moist; weak medium granular structure; slightly hard, very friable; about 45 percent, by volume, gravel, mostly limestone; calcareous; moderately alkaline; clear smooth boundary.

Bw—3 to 12 inches (9 to 30 centimeters); pale brown (10YR 6/3) very gravelly sandy loam, brown (10YR 4/3) moist; weak fine granular structure; slightly hard, very friable; about 50 percent, by volume, gravel, mostly limestone; thin patchy coatings of calcium carbonate; calcareous; moderately alkaline; gradual wavy boundary.

Bk1—12 to 22 inches (30 to 56 centimeters); very pale brown (10YR 7/3) very gravelly sandy loam, pale brown (10YR 6/3) moist; massive; slightly hard, friable; about 50 percent, by volume, gravel, mostly limestone; thick coatings of calcium carbonate; calcareous; moderately alkaline; gradual smooth boundary.

Bk2—22 to 30 inches (56 to 76 centimeters); very pale brown (10YR 8/3) very gravelly sandy loam, pale brown (10YR 6/3) moist; massive; slightly hard, friable; about 60 percent, by volume, gravel, mostly limestone; thin coatings of calcium carbonate; calcareous; moderately alkaline.

Depth to the calcic horizon ranges from 6 to 20 inches (15 to 50 centimeters). The solum is 35 to 75 percent, by volume, limestone coarse fragments. Texture of all horizons is very gravelly sandy loam or very gravelly loam, less than 18 percent clay.

The A and Bw horizons are pale brown (10YR 6/3) or very pale brown (10YR 7/3).

The Bk horizons are pale brown (10YR 6/3), very pale brown (10YR 7/3, 8/3), or light gray (10YR 7/2). The coarse fragments are coated with calcium carbonate.

Pajarito Series

The Pajarito series consists of deep, loamy, well drained soils in upland valleys. These soils formed in moderately sandy, mixed alluvial sediment. Slopes range from 1 to 3 percent.

Typical pedon of Pajarito fine sandy loam, in an area of Pajarito-Agustin association, gently sloping; from the headquarters of Big Bend National Park, 17.5 miles (28.2 kilometers) north on paved park road and 1.5 miles (2.4 kilometers) west across range to a site 100 feet (30 meters) east of park boundary fence:

A—0 to 4 inches (0 to 10 centimeters); light brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 4/4) moist; weak medium granular structure; slightly hard, very friable; about 5 percent, by volume, mixed limestone and igneous pebbles; calcareous; moderately alkaline; clear smooth boundary.

Bw—4 to 14 inches (10 to 35 centimeters); light reddish brown (5YR 6/3) fine sandy loam, reddish brown (5YR 5/3) moist; moderate medium granular structure; slightly hard, very friable; about 5 percent, by volume, mixed limestone and igneous pebbles; calcareous; moderately alkaline; gradual smooth boundary.

C—14 to 44 inches (35 to 112 centimeters); reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; single grained; slightly hard, very friable; about 10 percent, by volume, mixed limestone and igneous pebbles; few threads and films of calcium carbonate on coarse fragments in upper 18 inches (46 centimeters); calcareous; moderately alkaline.

The solum is 14 to more than 40 inches (35 to 100 centimeters) thick. Coarse fragments make up 0 to 15 percent, by volume, throughout the solum.

The A horizon is reddish brown (5YR 5/4) or light brown (7.5YR 6/4). It is fine sandy loam or loamy fine sand. It is 4 to 10 inches (10 to 25 centimeters) thick.

The Bw horizon is light reddish brown (5YR 6/3), light brown (7.5YR 6/4), or brown (7.5YR 5/4). It is fine sandy loam or sandy loam.

The C horizon is fine sandy loam or sandy loam.

Pantera Series

The Pantera series consists of deep, very gravelly, well drained soils on alluvial fans and valley floors of wide arroyos. Slopes range from 0 to 5 percent.

Typical pedon of Pantera very gravelly sandy loam, frequently flooded; from park headquarters at Panther Junction, 15 miles (24.1 kilometers) southeast to River Road, 19.9 miles (32 kilometers) southwest and west on River Road to junction of old abandoned road at

Mariscal Mine, 0.3 mile (0.5 kilometer) east on old road, and 200 feet (61 meters) north of road in arroyo bank:

A—0 to 15 inches (0 to 22 centimeters); light brownish gray (10YR 6/2) very gravelly sandy loam, grayish brown (10YR 5/2) moist; weak medium granular structure; slightly hard, very friable; common fine roots; stratified with various sizes and amounts of gravel and thin bedding planes; about 50 percent, by volume, waterworn igneous fragments; calcareous; moderately alkaline; gradual wavy boundary.

C1—15 to 31 inches (22 to 78 centimeters); pale brown (10YR 6/3) very gravelly sandy loam, brown (10YR 4/3) moist; single grained; slightly hard, very friable; stratified with various sizes and amounts of gravel and thin bedding planes; about 65 percent, by volume, waterworn igneous fragments, of which about 30 percent are 0.75 to 2 inches (2 to 5 centimeters) in diameter; calcareous; moderately alkaline; gradual wavy boundary.

C2—31 to 60 inches (78 to 112 centimeters); pale brown (10YR 6/3) very gravelly sandy loam, brown (10YR 4/3) moist; single grained; slightly hard, very friable; stratified with various sizes and amounts of gravel and thin bedding planes; about 60 percent, by volume, waterworn igneous fragments mostly less than 0.75 inch (2 centimeters) in diameter; calcareous; moderately alkaline.

The solum is 6 to 15 inches (15 to 38 centimeters) thick over 40 to 80 inches (100 to 200 centimeters) or more of stratified, loamy, gravelly or cobbly alluvial materials. Texture is very gravelly sandy loam, very gravelly loam, very cobbly sandy loam, or very cobbly loam.

The A horizon is pinkish gray (7.5YR 6/2, 7/2), light brownish gray (10YR 6/2), or pale brown (10YR 6/3). Coarse fragments make up 35 to 70 percent by volume.

The C horizon is light brownish gray (10YR 6/2), light gray (10YR 7/2), pale brown (10YR 6/3), or very pale brown (10YR 7/3). Coarse fragments make up 35 to 80 percent by volume. The soils are stratified, and bedding planes are evident.

Puerta Series

The Puerta series consists of shallow, very gravelly, well drained soils on the tops of mountains. These soils formed in gravelly clayey material weathered from igneous bedrock. Slopes range from 8 to 45 percent.

Typical pedon of Puerta very gravelly loam, in an area of Puerta-Madrone complex, steep; 100 feet (30 meters) southwest of the southeastern corner of the corral at Boot Springs:

A—0 to 4 inches (0 to 10 centimeters); dark brown (7.5YR 4/2) very gravelly silt loam, dark brown (7.5YR 3/2) moist; moderate fine granular structure; slightly hard, friable; many roots; about 40 percent, by volume, igneous gravel and a few cobbles; neutral; abrupt smooth boundary.

E—4 to 5 inches (10 to 12 centimeters); brown (7.5YR 5/2) very gravelly loam, brown (7.5YR 4/2) moist; moderate very fine subangular blocky structure; slightly hard, friable; many very fine roots; about 40 percent, by volume, igneous gravel; slightly acid; abrupt smooth boundary.

Bt1—5 to 15 inches (12 to 38 centimeters); reddish brown (5YR 5/3) very gravelly clay, dark reddish brown (5YR 3/3) moist; moderate medium blocky structure; very hard, very friable; common very fine pores; common very fine roots; patchy clay films on ped faces; about 40 percent, by volume, igneous gravel and a few cobbles; slightly acid; clear smooth boundary.

Bt2—15 to 20 inches (38 to 51 centimeters); reddish brown (5YR 5/4) very gravelly clay, reddish brown (5YR 4/4) moist; weak medium blocky structure; very hard, very firm; few fine roots; many pores; distinct clay films on ped faces; about 40 percent, by volume, igneous gravel and a few cobbles; slightly acid; abrupt irregular boundary.

R—20 to 30 inches (51 to 75 centimeters); hard igneous bedrock.

The solum is 12 to 20 inches (30 to 50 centimeters) thick. Igneous gravel and cobbles make up 35 to 60 percent of the solum.

The A horizon is brown (7.5YR 5/2, 4/2) or dark brown (7.5YR 3/2, 4/2). The fine earth fraction is loam or silt loam. The A horizon is 4 to 6 inches (10 to 15 centimeters) thick.

The E horizon is brown (7.5YR 5/2) or light reddish brown (5YR 6/3) very cobbly loam or very gravelly loam. It is 1 to 7 inches (2 to 18 centimeters) thick.

The Bt horizon is dark reddish gray (5YR 4/2), reddish brown (5YR 4/3, 5/3, 4/4, 5/4), or dark brown (7.5YR 4/2). It is very gravelly clay or very cobbly clay.

Solis Series

The Solis series consists of very shallow and shallow, loamy, well drained soils in soft sandstone. These soils formed on uplands. Slopes range from 3 to 30 percent.

Typical pedon of Solis fine sandy loam, in an area of Solis-Rock outcrop complex, rolling; from headquarters of Big Bend National Park at Panther Junction, 15 miles (24.1 kilometers) southeast on paved Park road, 10.3 miles (16.6 kilometers) southwest and west on River road to junction with Glen Springs road, 3.3 miles (5.3 kilometers) west on River road, 320 feet (97 meters) northwest of road in rangeland:

A—0 to 2 inches (0 to 5 centimeters); light yellowish brown (10YR 6/4) fine sandy loam, yellowish brown

(10YR 5/4) moist; weak medium granular structure; slightly hard, very friable; few fine roots; about 5 percent, by volume, gravelly sandstone fragments; calcareous; moderately alkaline; clear smooth boundary.

C—2 to 6 inches (5 to 15 centimeters); light brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) moist; single grained; slightly hard, very friable; about 10 percent, by volume, gravelly sandstone fragments; calcareous; moderately alkaline; clear wavy boundary.

Cr—6 to 22 inches (15 to 56 centimeters); very pale brown (10YR 7/4) fractured platy sandstone, yellowish brown (10YR 5/4) moist; sandstone can be cut with a spade and is breakable by hand; calcareous; moderately alkaline; abrupt wavy boundary.

Crk—22 to 28 inches (56 to 71 centimeters); light yellowish brown (10YR 6/4) coarsely fractured platy sandstone with hardness of less than 3 on Moh's scale; coatings of calcium carbonate on some of the fracture surfaces; calcareous; moderately alkaline; abrupt smooth boundary.

2Ck—28 to 42 inches (71 to 107 centimeters); light brownish gray (10YR 6/2) finely fractured shale; thin coatings of calcium carbonate on some fracture faces; calcareous; moderately alkaline.

Depth to soft sandstone is 4 to 20 inches (10 to 50 centimeters). The soil is moderately alkaline and calcareous throughout. It is fine sandy loam, loam, gravelly fine sandy loam, or gravelly loam. Coarse fragments are sandstone and range from 5 to 30 percent by volume.

The A and C horizons are yellowish brown (7.5YR 5/4, 5/6), brown (7.5YR 5/4, 10YR 5/3), light brown (7.5YR 6/4), strong brown (7.5YR 5/6), pink (7.5YR 7/4), pale brown (10YR 6/3), light yellowish brown (10YR 6/4), or very pale brown (10YR 7/4).

The Cr horizon is massive, partially weathered sandstone that is easily cut with a spade. The Crk horizon is harder than the C horizon, but it is less than 3 on Mohs' scale. Some pedons do not have a Crk horizon. In some pedons the Crk horizon is separated from the Cr horizon by a layer of shale or clay. Thin coatings of calcium carbonate are on the fractures of most pedons.

The 2Ck horizon is coarsely fractured shale or clay. In some pedons thin layers of this horizon are above the Cr horizon or between the Cr and Crk horizons. Layers of sandstone are in or below the 2Ck horizon. Thin coatings of calcium carbonate are along fracture surfaces in some pedons.

Terlingua Series

The Terlingua series consists of very shallow, very gravelly, well drained soils. These soils formed in material weathered from igneous rock. Slopes range from 2 to about 40 percent.

Typical pedon of Terlingua very gravelly coarse sandy loam, in an area of Terlingua-Rock Outcrop complex, hilly; from the ranger staton at Castolon, 2.3 miles (3.7 kilometers) north on paved Park Road, 4.4 miles (7.1 kilometers) southeast on River Road to junction to Buenos Aires, 2.4 miles (3.9 kilometers) east on River Road, and 250 feet south (76 meters) south of road in rangeland:

A—0 to 4 inches (0 to 10 centimeters); yellowish brown (10YR 5/4) very gravelly coarse sandy loam, dark yellowish brown (10YR 4/4) moist; moderate very fine granular structure; slightly hard, very friable; common roots; about 50 percent, by volume, igneous fragments 0.75 to 6 inches (2 to 15 millimeters) in diameter; strongly effervescent; calcareous; moderately alkaline; abrupt wavy boundary.

Bk—4 to 8 inches (10 to 20 centimeters); yellowish brown (10YR 5/4) very gravelly sandy loam, dark yellowish brown (10YR 4/4) moist; weak very fine granular structure; slightly hard, friable; common roots; about 50 percent, by volume, igneous gravel coated with calcium carbonate; strongly effervescent; calcareous; moderately alkaline; abrupt wavy boundary.

Crk1—8 to 12 inches (20 to 30 centimeters), weak red (2.5YR 5/2) partially weathered extrusive igneous rock with many seams of calcium carbonate; rock weathered to plates 0.5 centimeter thick that are coated with calcium carbonate on upper and lower surfaces; clear wavy boundary.

Crk—12 to 16 inches (30 to 40 centimeters); weak red (2.5YR 5/2) partially weathered extrusive igneous rock with few seams of calcium carbonate; abrupt wavy boundary.

Rk—16 to 20 inches (40 to 50 centimeters); igneous bedrock with many gas voids and interbedded calcite and opal crystals.

Depth to igneous bedrock ranges from 4 to 12 inches (10 to 30 centimeters). The A and Bk horizons are light brown (7.5YR 6/4), brown (7.5YR 5/4; 10YR 5/3), pale brown (10YR 6/3), yellowish brown (10YR 5/4), or light yellowish brown (10YR 6/4). The fine earth fraction is coarse sandy loam, sandy loam, or loam. Coarse fragments are mostly igneous rock. Of the coarse fragments, 0 to 30 percent are larger than 10 inches (25 centimeters) in diameter, 0 to 40 percent are 3 to 10 inches (7.5 to 25 centimeters), and 35 to 70 percent are less than 3 inches (7.5 centimeters). Accumulations of calcium carbonate are on the pebbles and in fractures.

The R Layer has a hardness of 3 to 4 on Moh's scale.

Tornillo Series

The Tornillo series consists of deep, well drained soils that formed in calcareous, loamy alluvial material. These soils are on broad valley floors. Slopes range from 0 to 3 percent.

Typical pedon of Tornillo loam, in an area of Tornillo loam, occasionally flooded; from the junction of Rio Grande Village road and River Road in Big Bend National Park; 8 miles (12.9 kilometers) southwest on River Road; 0.35 miles (0.56 kilometers) south on the Casa de Piedra Road; 90 feet (27 meters) east of road:

A—0 to 9 inches (0 to 22 centimeters); light yellowish brown (10YR 6/4) loam, yellowish brown (10YR 5.4) moist; weak very fine subangular blocky and granular structure; slightly hard, very friable; common roots; common pores; few limestone fragments as much as 3 millimeters in diameter; strongly effervescent; moderately alkaline; abrupt smooth boundary.

Bw—9 to 17 inches (22 to 44 centimeters); pale brown (10YR 6/3) silty clay loam, brown (10YR 4/3) moist; weak very coarse prismatic structure parting to moderate medium subangular blocky; hard, friable; common roots; common pores; few threads and films of calcium carbonate; strongly effervescent; mildly alkaline; clear smooth boundary.

Bk1—17 to 25 inches (44 to 65 centimeters); pale brown (10YR 6/3) silty clay loam, brown (10YR 4/3) moist; weak very coarse prismatic structure parting to moderate medium subangular blocky; hard, friable; few roots; common pores; common threads and films of calcium carbonate; strongly effervescent; moderately alkaline; clear smooth boundary.

Bk2—25 to 33 inches (65 to 85 centimeters); pale brown (10YR 6/3) loam, brown (10YR 4/3) moist; weak very coarse prismatic structure parting to weak medium subangular blocky; hard, friable; few roots; few pores; common threads and films of calcium carbonate; few pebbles as much as 1.5 centimeters across and 3 centimeters long; strongly effervescent; mildly alkaline; clear smooth boundary.

Bk3—33 to 43 inches (85 to 109 centimeters); pale brown (10YR 6/3) loam, brown (10YR 4/3) moist; weak fine and medium subangular blocky structure; slightly hard, very friable; few roots; few fine and medium pores; few remnants of lenses of fine stratification of similarly textured material; few igneous fragments that have thin and patchy caliche coatings; strongly effervescent; moderately alkaline; abrupt wavy boundary.

Ab1—43 to 49 inches (109 to 126 centimeters); brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; very hard, firm; few roots; many fine and medium pores; few threads and films of calcium carbonate on ped faces and pore surfaces; common thin strata of similarly textured material; few fragments as much as 3 centimeters across; strongly effervescent; strongly alkaline; clear smooth boundary.

Ab2—49 to 63 inches (126 to 162 centimeters); pale brown (10YR 6/3) silty clay loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; very hard, firm; few roots; many fine and medium pores; common threads and films of calcium carbonate; common thin strata of similarly textured material; strongly effervescent; strongly alkaline; clear smooth boundary.

Ab3—63 to 75 inches (162 to 190 centimeters); pale brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; weak coarse subangular blocky structure; very hard, firm; few roots; common pores; few threads and films of calcium carbonate; strongly effervescent; strongly alkaline; clear wavy boundary.

Bb—75 to 83 inches (190 to 211 centimeters); pale brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; weak coarse subangular blocky structrue; very hard, firm; few roots; common pores; few threads and films of calcium carbonate; strongly effervescent; strongly alkaline.

The solum is more than 40 inches (100 centimeters) thick. The soil is mildly alkaline or moderately alkaline and is calcareous in the upper 40 inches (100 centimeters). Texture of all horizons is fine sandy loam, sandy clay loam, loam, silt loam, clay loam, or silty clay loam. Clay content of the 10- to 40-inch (25 to 100 centimeters) control section is 18 to 35 percent with less than 15 percent coarser than very fine sand. Some pedons have a few siliceous pebbles. Some areas have a desert pavement of gravel.

The A horizon is brown(7.5YR 5/2, 5/4; 10YR 5/3), pale brown (10YR 6/3), light brown (7.5YR 6/4), light brownish gray (10YR 6/2), light yellowish brown (10YR 6/4), yellowish brown (10YR 5/4), very pale brown (10YR 7/3), light gray (10YR 7/2), or pinkish gray (7.5YR 6/2). It is 4 to 14 inches (10 to 35 centimeters) thick.

The C, Ab, and Bb horizons where present, and the B horizon are brown (7.5YR 5/2, 5/4; 10YR 5/3), light brown (7.5YR 6/4), pale brown (10YR 6/3), very pale brown (10YR 7/3, 7/4), reddish brown (5YR 5/3, 5/4), light reddish brown (5YR 6/4), grayish brown (10YR 5/2), light brownish gray (10YR 6/2), light gray (10YR 7/2), or pinkish gray (7.5YR 6/2). Subsoil horizons commonly vary in texture and content of organic matter. Bedding planes are evident in most horizons below a depth of 30 inches (75 centimeters) (fig. 23). These deeper layers range to strongly alkaline.

Upton Series

The Upton series consists of shallow and very shallow, well drained, gravelly soils. These soils formed in

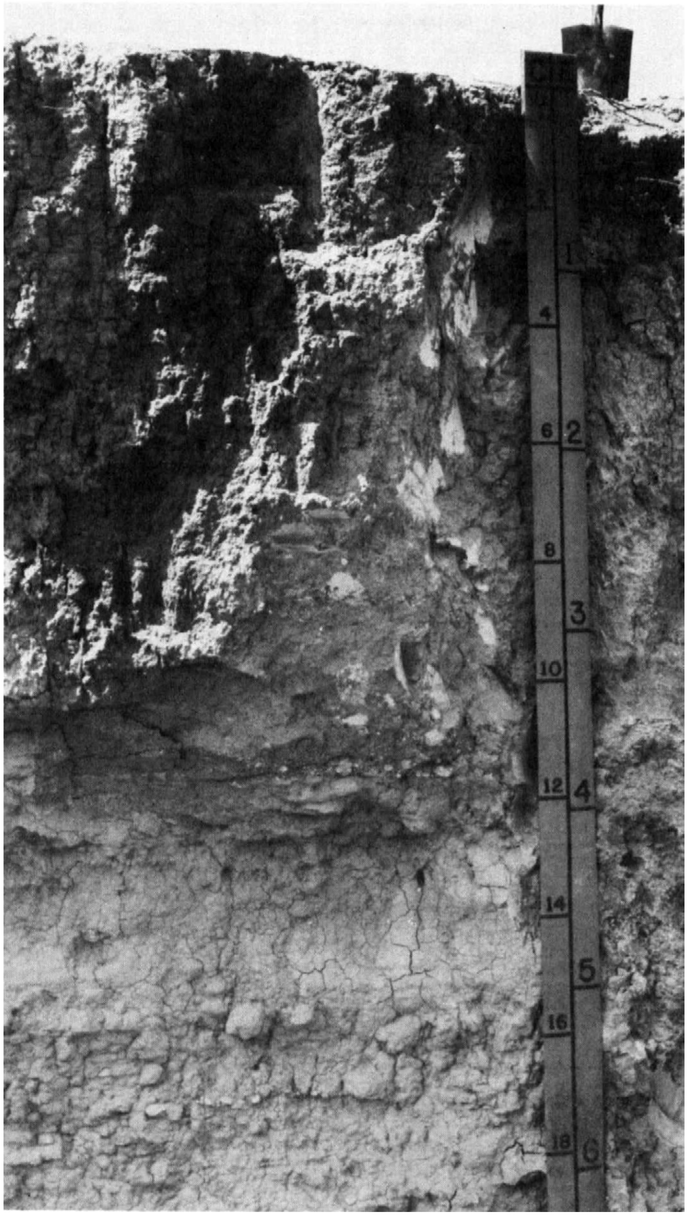


Figure 23.—Profile of Tornillo loam. Note stratification at a depth of about 4 feet (1.2 meters). The figures on the left side of tape should be multiplied by 10 to obtain depth in centimeters.

colluvium from limestone mountains. Slopes range from 1 to 5 percent.

Typical pedon of Upton gravelly loam, in an area of Upton-Nickel association, undulating; from the junction of Dagger Flat Road and Old Ore Road, 0.15 mile (0.24 kilometers) south on Old Ore Road, and 100 feet (30 meters) west of the road:

A—0 to 5 inches (0 to 13 centimeters); pale brown (10YR 6/3) gravelly loam, brown (10YR 5/3) moist; weak medium subangular blocky structure; slightly hard, very friable; about 30 percent, by volume, gravel, mostly limestone, that has thin patchy coatings of calcium carbonate; calcareous; moderately alkaline; clear smooth boundary.

Bk—5 to 15 inches (13 to 38 centimeters); pink (7.5YR 7/4) gravelly loam, brown (7.5YR 5/4) moist; weak medium subangular blocky structure; slightly hard, very friable; about 30 percent, by volume, gravel, mostly limestone, that has thick continuous coatings of calcium carbonate; calcareous; moderately alkaline; abrupt wavy boundary.

Bkm—15 to 19 inches (38 to 48 centimeters); white (10YR 8/1) caliche; indurated and laminar in upper 1 centimeter and cemented below; about 50 percent embedded limestone pebbles; gradual wavy boundary.

C—19 to 30 inches (48 to 66 centimeters); pinkish white (7.5YR 8/2) very gravelly loamy caliche; massive; about 30 percent caliche and limestone pebbles.

Depth to the petrocalcic horizon ranges from 7 to 20 inches (18 to 50 centimeters). Limestone and caliche coarse fragments make up 15 to 35 percent, by volume, of the solum above the petrocalcic horizon. The calcium carbonate equivalent in the solum is more than 40 percent.

The A horizon is pale brown (10YR 6/3) or light brown (7.5YR 6/4). It is very gravelly loam or gravelly loam. It is 4 to 12 inches (10 to 30 centimeters) thick.

The Bk horizon, where present, is very pale brown (10YR 7/3), pale brown (10YR 6/3), brown (10YR 5/3), or pink (7.5YR 7/4). It is as much as 16 inches (40 centimeters) thick.

The petrocalcic horizon is continuous indurated caliche that has only a few fractures. It is underlain by beds of unconsolidated limestone gravel.

Vieja Series

The Vieja series consists of very shallow and shallow, very gravelly, clayey, well drained soils. These soils formed in shale. Slopes range from 2 to 15 percent.

Typical pedon of Vieja very gravelly silty clay, in an area of Vieja-Badlands complex, rolling; from headquarters of Big Bend National Park at Panther Junction, 15 miles (24.1 kilometers) southeast to the River Road; 2.5 miles (4 kilometers) southwest on River Road; 0.3 mile (0.5 kilometer) northwest of road:

A1—0 to 2 inches (0 to 5 centimeters); pale brown (10YR 6/3) very gravelly silty clay, brown (10YR 5/3) moist; moderate fine subangular blocky structure; hard, firm; calcareous; moderately alkaline; abrupt smooth boundary.

A2—2 to 13 inches (5 to 33 centimeters); very pale brown (10YR 7/3) silty clay, pale brown (10YR 6/3) moist; moderate medium subangular blocky structure; hard, firm; few threads and films of calcium carbonate; calcareous; moderately alkaline; clear smooth boundary.

Cr—13 to 40 inches (33 to 100 centimeters); light brownish gray (2.5Y 6/2) shale, grayish brown (2.5Y 5/2) moist; platy rock structure; noncalcareous; moderately alkaline.

The soil is 5 to 20 inches (12 to 50 centimeters) deep to shale. The A horizon is clay loam, silty clay loam, or silty clay. The upper 1 to 3 inches (2.5 to 7.5 centimeters) are as much as 60 percent coarse fragments. The A horizon is light gray (2.5Y 7/2), light yellowish brown (2.5Y 6/2), pale brown (10YR 6/3), or very pale brown (10YR 7/3). Most areas have a desert pavement of coarse fragments.

The Cr horizon is clayey shale. It is grayish brown (2.5Y 5/2), light brownish gray (2.5Y 6/2), or light gray (10YR 7/2).

Formation of the Soils

Soil is a natural, three-dimensional body on the earth's surface. It supports plants and has properties that result from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over a period of time.

Although there are many different soils, each soil is the result of the interaction of the same five major factors. These factors are the physical and chemical composition of the parent material, the effect of climate during and after the accumulation of the parent material, the kind of plants and organisms living in the soil, the relief of the land and its effect on runoff, and the length of time it took the soil to form.

The effect of one or more of these factors can differ from place to place; it is the interaction of all the factors that determines the kind of soil that forms. In the following paragraphs the factors of soil formation are discussed as they relate to the soils in the survey area.

Parent Material

Parent material is the unconsolidated mass from which a soil is formed. It determines the limits of the chemical and mineralogical composition of the soil. The soils of Big Bend National Park have developed from parent materials of Paleozoic, Cretaceous, Tertiary, and Quaternary geologic age. The Quaternary period is subdivided into the Pleistocene epoch and Recent epoch.

Soils that formed from Paleozoic rocks are of minor acreage and importance in the survey area.

The Cretaceous materials are mainly limestone bedrock, interbedded limestone and marl, sandstone, and clayey shale. Lozier soils formed in limestone. Mariscal soils formed in the interbedded limestone and marly material. Solis soils formed over sandstone, and clayey shale is the source of badlands.

The Tertiary materials are mainly igneous rock making up hills and mountains. Lajitas soils formed in these materials.

Pleistocene materials make up the piedmont slopes and valley fills. Chilicotal and Chamberino soils are the major soils on the piedmont slopes, and Tornillo soils are the major soils in the valley fills.

Recent materials consist of sediment that was deposited on the flood plains of streams. Many of these deposits are reworked occasionally by deposition and scouring by flood waters. The Glendale and Harkey soils formed in this sediment.

Climate

The climate of Big Bend National Park is arid. Winters are mild, and summers are hot and dry. The temperature is affected by elevation and may vary by several degrees between the mountains and the desert floor. The major part of the annual precipitation falls during the summer in the form of high-intensity thunderstorms. Rainfall is not sufficient to leach the bases from the soils. As a result, most of the soils have a layer in which calcium carbonate has accumulated, and the deep soils are seldom wet below the root zone. The average annual rainfall is 7.5 inches (190 millimeters) at Rio Grande Village and Castolon, 13 inches (330 millimeters) at Panther Junction, and 17 inches (435 millimeters) in Chisos Basin.

Because the winters are mild and the summers are hot, there is continuous decomposition of plants and animals by micro-organisms.

Living Organisms

Plants, animals, insects, and micro-organisms are important in the formation of soils. Living organisms affect gains or losses in organic matter and plant nutrients in the soil and changes in structure and porosity.

Plants have affected soil formation in this area more than other living organisms. Soils that formed under desert shrubs generally have less organic matter than soils that formed under grasses. Decomposed plant roots leave channels that increase the intake of water and the aeration of the soil.

Animals, such as termites and earthworms, increase porosity by burrowing through the soil and leaving open channels for the movement of water and air. Micro-organisms help to decompose organic matter, release nutrients, and add nitrogen to the soil.

Relief

Relief, or topography, influences soil development through its effect on drainage and runoff. The topography of Big Bend National Park ranges from nearly level along the Rio Grande flood plain to very steep in the mountains.

If the other factors of soil formation are equal, the degree of profile development depends on the amount of water available and the depth of its penetration into the soil. Nearly level soils absorb more moisture and generally have a more developed profile than steeper soils. Many of the steeper soils erode almost as fast as they form, even under natural geologic erosion.

Extensive profile development is exemplified by the nearly level to gently sloping Glendale, Pajarito, and Tornillo soils. Lozier and Lajitas soils are examples of soils that formed on hilly to very steep mountains and are therefore shallow or very shallow. These soils show little profile development.

Time

A long time is generally required for the formation of soils that have distinct horizons. The length of time that parent materials have been in place is generally reflected in the degree to which the soil profile has developed.

Young soils show very little profile development. The soils on the Rio Grande flood plain are examples of young soils.

Some of the older soils that formed in calcareous parent material have a prominent accumulation of calcium carbonate, a calcic horizon, in the lower part of the profile. Chilicotal and Chamberino soils have a calcic horizon. In other soils, calcium carbonate concentrates in the lower horizons and becomes cemented or indurated. An indurated, or petrocalcic, horizon requires a long time to form. The Upton soils have a petrocalcic horizon.

Many of the sloping and steep, shallow and very shallow soils appear to have been in the process of formation for about as long as some of the more developed, less sloping soils. However, geologic erosion removed the soil as fast as it formed. In this case the effect of time has been offset by the effect of relief.

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Glossary

ABC soil. A soil having an A, a B, and a C horizon.

AC soil. A soil having only an A and a C horizon. Commonly such soil formed in recent alluvium or on steep rocky slopes.

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Badland. Steep or very steep, commonly nonstony, barren land dissected by many intermittent drainage channels. Badland is most common in semiarid and arid regions where streams are entrenched in soft geologic material. Local relief generally ranges from 25 to 500 feet (7 to 150 meters). Runoff potential is very high, and geologic erosion is active.

Bedding planes. Fine stratifications, less than 5 millimeters thick, in unconsolidated alluvial, eolian, lacustrine, or marine sediments.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bottom land. The normal flood plain of a stream, subject to flooding.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Broad-base terrace. A ridge-type terrace built to control erosion by diverting runoff along the contour at a nonscouring velocity. The terrace is 10 to 20 inches (25 to 50 centimeters) high and 15 to 30 feet (4.5 to 9 meters) wide and has gently sloping sides, a rounded crown, and a dish-shaped channel along the upper side. It may be nearly level or have a grade toward one or both ends.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche. A more or less cemented deposit of calcium carbonate in soils of warm-temperate, subhumid to arid areas. Caliche occurs as soft, thin layers in the soil or as hard, thick beds just beneath the solum, or it is exposed at the surface by erosion.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Channery soil. A soil that is, by volume, more than 15 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a fragment.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Climax vegetation. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Compressible (in tables). Excessive decrease in volume of soft soil under load.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches (25 centimeters) and 40 or 80 inches (100 or 200 centimeters).

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Decreasers. The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing. Postponing grazing or resting grazingland for a prescribed period.

Dense layer (in tables). A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

Drainage, surface. Runoff, or surface flow of water, from an area.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Erosion pavement. A layer of gravel or stones that remains on the surface after fine particles are removed by sheet or rill erosion.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Excess lime (in tables). Excess carbonates in the soil that restrict the growth of some plants.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Fine textured soil. Sandy clay, silty clay, and clay.

Flagstone. A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist, 6 to 15 inches (15 to 37.5 centimeters) long.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Forb. Any herbaceous plant not a grass or a sedge.

Fragile (in tables). A soil that is easily damaged by use or disturbance.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.5 centimeters) in diameter.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual.* The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue at the surface of a mineral soil.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, alluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil does not have a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, the Arabic numeral 2 precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers. Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake in inches per hour is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, invader plants follow disturbance of the surface.

Large stones (in tables). Rock fragments 3 inches (7.5 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Metamorphic rock. Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement. Nearly all such rocks are crystalline.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Sandy loam and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Outwash plain. A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor filter (in tables). Because of rapid permeability the soil may not adequately filter effluent from a waste disposal system.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 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	9.1 and higher

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock.

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rippable. Bedrock or hardpan can be excavated using a single-tooth ripping attachment mounted on a tractor with a 200-300 draw bar horsepower rating.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone. Sedimentary rock containing dominantly sand-size particles.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet (6 meters) in 100 feet (30 meters) of horizontal distance.

Slope (in tables). Slope is great enough that special practices are required to insure satisfactory performance of the soil for a specific use.

Slow intake (in tables). The slow movement of water into the soil.

Small stones (in tables). Rock fragments less than 3 inches (7.5 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Technically, the A2 horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. 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, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Tinaja. A natural, bowl-shaped depression in rocks in which water accumulates after rains.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Too arid (in tables). The soil is dry most of the time, and vegetation is difficult to establish.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Tuff. A compacted deposit that is 50 percent or more volcanic ash and dust.

Unstable fill (in tables). Risk of caving or sloughing on banks of fill material.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Valley fill. In glaciated regions, material deposited in stream valleys by glacial melt water. In nonglaciated regions, alluvium deposited by heavily loaded streams.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[Recorded in the period 1956-78 at Panther Junction, Tx]

Month	Temperature						Precipitation				
	Average daily maximum	Average daily minimum	Average	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days[1]	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	F	F	F	F	F	Units	In	In	In		In
January----	62.2	36.2	49.2	79	14	90	.45	.09	.71	1	.3
February---	67.0	38.8	52.9	85	17	153	.49	.02	.83	1	.5
March------	75.1	45.0	60.1	90	25	327	.33	---	.57	1	.1
April------	84.0	54.0	69.0	97	36	570	.42	---	.71	1	.0
May--------	89.9	60.6	75.3	101	44	784	1.51	.43	2.37	3	.0
June-------	94.2	66.8	80.5	104	54	915	1.45	.47	2.24	4	.0
July-------	92.9	68.4	80.7	102	59	952	2.07	1.06	2.94	5	.0
August-----	92.1	67.4	79.8	101	58	924	1.61	.39	2.59	3	.0
September--	86.8	62.3	74.6	99	47	738	2.16	.41	3.51	4	.0
October----	79.7	53.5	66.6	93	37	515	1.53	.27	2.50	3	.0
November---	70.2	43.9	57.1	85	25	245	.50	.02	.85	1	.1
December---	63.5	37.8	50.7	80	19	108	.48	.04	.80	1	.2
Yearly:											
Average--	79.8	52.9	66.4	---	---	---	---	---	---	---	---
Extreme--	---	---	---	105	12	---	---	---	---	---	---
Total----	---	---	---	---	---	6,321	13.00	9.45	16.27	28	1.2

[1] A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal plants in the area (50° F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Recorded in the period 1956-78 at Panther Junction, Tx]

Probability	Temperature		
	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	March 6	March 19	March 29
2 years in 10 later than--	February 25	March 11	March 22
5 years in 10 later than--	February 9	February 23	March 6
First freezing temperature in fall:			
1 year in 10 earlier than--	November 26	November 14	November 3
2 years in 10 earlier than--	December 5	November 21	November 9
5 years in 10 earlier than--	December 23	December 3	November 21

TABLE 3.--GROWING SEASON

[Recorded in the period 1956-78 at Panther Junction, Tx]

Probability	Length of growing season if daily minimum temperature is--		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	292	256	233
8 years in 10	297	265	242
5 years in 10	310	283	260
2 years in 10	365	302	279
1 year in 10	365	314	290

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
BRG	Brewster-Rock outcrop complex, very steep	13,325	1.9
CHC	Chamberino very gravelly loam, undulating	73,260	10.3
CHD	Chamberino very gravelly loam, rolling	37,545	5.3
CLC	Chilicotal very gravelly fine sandy loam, undulating	62,250	8.8
CMD	Chilicotal-Monterosa association, rolling	40,775	5.8
ERF	Ector-Rock outcrop complex, steep	6,505	0.9
GHA	Glendale-Harkey association, occasionally flooded	6,625	0.9
HRD	Hurds very gravelly sandy loam, rolling	2,565	0.4
HRF	Hurds very cobbly loam, steep	1,385	0.2
LAE	Lajitas-Rock outcrop complex, hilly	105,155	14.8
LAF	Lajitas-Rock outcrop complex, steep	49,670	7.0
LMF	Liv-Mainstay-Rock outcrop complex, steep	2,815	0.4
LRF	Lozier-Rock outcrop complex, steep	80,450	11.4
LRG	Lozier-Rock outcrop complex, very steep	39,670	5.6
MRE	Mariscal-Rock outcrop complex, hilly	23,660	3.3
PAA	Pajarito-Agustin association, gently sloping	4,420	0.6
PNA	Pantera very gravelly sandy loam, frequently flooded	11,306	1.6
PRF	Puerta-Madrone complex, steep	3,765	0.5
RVW	Riverwash	3,550	0.5
SCB	Solis-Chamberino association, gently undulating	4,295	0.6
SRD	Solis-Rock outcrop complex, rolling	45,845	6.5
TAE	Terlingua-Mariscal association, hilly	11,790	1.7
TLE	Terlingua-Rock outcrop complex, hilly	14,420	2.0
TOA	Tornillo loam, occasionally flooded	22,500	3.2
UNC	Upton-Nickel association, undulating	28,155	4.0
VBD	Vieja-Badland complex, rolling	12,580	1.8
	Total	708,281	100.0

TABLE 5.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
BRG*:				
Brewster	Severe: slope, large stones, small stones, depth to rock.	Severe: slope, large stones, small stones, depth to rock.	Severe: large stones, slope, small stones, depth to rock.	Severe: slope, small stones.
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.
CHC Chamberino	Severe: small stones.	Severe: small stones.	Severe: small stones.	Moderate: dusty.
CHD Chamberino	Severe: small stones.	Severe: small stones.	Severe: slope, small stones.	Moderate: dusty.
CLC Chilicotal	Severe: small stones.	Severe: small stones.	Severe: small stones.	Severe: small stones.
CMD*:				
Chilicotal	Severe: small stones.	Severe: small stones.	Severe: slope, small stones.	Severe: small stones.
Monterosa	Severe: small stones, cemented pan.	Severe: small stones, cemented pan.	Severe: cemented pan, small stones, slope.	Severe: small stones.
ERF*:				
Ector	Severe: slope, small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: slope, large stones, small stones.	Severe: slope, small stones.
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.
GHA*:				
Glendale	Severe: flooding.	Slight	Moderate: flooding.	Severe: erodes easily.
Harkey	Severe: flooding.	Slight	Moderate: flooding.	Severe: erodes easily.
HRD Hurds	Severe: small stones.	Severe: small stones.	Severe: slope, small stones.	Slight.
HRF Hurds	Severe: slope, large stones.	Severe: slope, large stones.	Severe: large stones, slope.	Severe: slope.
LAE*:				
Lajitas	Severe: slope, large stones, depth to rock.	Severe: slope, large stones, depth to rock.	Severe: large stones, slope, depth to rock.	Severe: large stones.
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: slope.

See footnote at end of table.

TABLE 5.--RECREATIONAL DEVELOPMENT--Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
LAF*:				
Lajitas	Severe: slope, large stones, depth to rock.	Severe: slope, large stones, depth to rock.	Severe: large stones, slope, depth to rock.	Severe: slope, large stones.
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.
LMF*:				
Liv	Severe: slope, large stones, small stones.	Severe: slope, large stones, small stones.	Severe: large stones, slope, small stones.	Severe: slope, small stones.
Mainstay	Severe: slope, large stones, small stones, depth to rock.	Severe: slope, large stones, small stones, depth to rock.	Severe: large stones, slope, small stones, depth to rock.	Severe: slope, small stones.
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.
LRF*:				
Lozier	Severe: slope, small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: small stones, slope, depth to rock.	Severe: slope, small stones.
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.
LRG*:				
Lozier	Severe: slope, small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: slope, small stones.
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.
MRE*:				
Mariscal	Severe: slope, large stones, depth to rock.	Severe: slope, large stones, depth to rock.	Severe: large stones, slope, depth to rock.	Severe: small stones.
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: slope.
PAA*:				
Pajarito	Slight	Slight	Moderate: slope.	Slight.
Agustin	Moderate: small stones.	Moderate: small stones.	Severe: small stones.	Slight.
PNA Pantera	Severe: flooding, small stones.	Severe: small stones.	Severe: small stones, flooding.	Severe: small stones.

See footnote at end of table.

TABLE 5.--RECREATIONAL DEVELOPMENT--Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
PRF*:				
Puerta	Severe: slope, small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: slope.
Madrone	Severe: slope, small stones.	Severe: slope, small stones.	Severe: slope, small stones.	Severe: slope.
RVW*. Riverwash	Severe: flooding, wetness, too sandy.	Severe: wetness, too sandy.	Severe: too sandy, wetness, flooding.	Severe: wetness, too sandy.
SCB*:				
Solis	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: dusty.
Chamberino	Moderate: small stones.	Moderate: small stones.	Severe: small stones.	Slight.
SRD*:				
Solis	Severe: depeth to rock..	Severe: depth to rock.	Severe: slope, depth to rock.	Slight:
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: slope.
TAE*:				
Terlingua	Severe: slope, small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: slope, small stones.	Severe: small stones.
Mariscal	Severe: slope, large stones, depth to rock.	Severe: slope, large stones, depth to rock.	Severe: large stones, slope, depth to rock.	Severe: small stones.
TLE*:				
Terlingua	Severe: slope, small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: slope, small stones.	Severe: small stones.
Rock outcrop	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: slope.
TOA. Tornillo	Severe: flooding.	Slight	Moderate: flooding.	Slight.
UNC*:				
Upton	Severe: cemented pan.	Severe: cemented pan.	Severe: small stones, cemented pan.	Moderate: dusty.
Nickel	Severe: small stones.	Severe: small stones.	Severe: slope, small stones.	Severe: small stones.
VBD*:				
Vieja	Severe: small stones, depth to rock.	Severe: small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Moderate: large stones.

See footnote at end of table.

TABLE 5.--RECREATIONAL DEVELOPMENT--Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
VBD*:				
Badland----------------	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: slope.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 6.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
BRG*:						
Brewster	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: small stones, large stones, slope.
Rock outcrop	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, thin layer.
CHC Chamberino	Slight	Slight	Slight	Moderate: slope.	Slight	Severe: small stones.
CHD Chamberino	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: small stones.
CLC Chilicotal	Slight	Slight	Slight	Moderate: slope.	Slight	Severe: small stones.
CMD*:						
Chilicotal	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: small stones.
Monterosa	Severe: cemented pan, small stones.	Severe: cemented pan.	Severe: cemented pan.	Severe: cemented pan.	Severe: cemented pan.	Severe: small stones, thin layer.
ERF*:						
Ector	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: small stones, slope, thin layer.
Rock outcrop	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, thin layer.
GHA*:						
Glendale	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding, low strength.	Moderate: flooding.
Harkey	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: flooding.
HRD Hurds	Severe: cutbanks cave.	Moderate: slope, large stones.	Moderate: slope, large stones.	Severe: slope.	Moderate: slope, large stones.	Severe: small stones.
HRF Hurds	Severe: cutbanks cave, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: small stones, large stones, slope.
LAE*, LAF*:						
Lajitas	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: small stones, large stones, slope.
Rock outcrop	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, thin layer.

See footnote at end of table.

TABLE 6.--BUILDING SITE DEVELOPMENT--Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
LMF*:						
Liv	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: small stones, large stones, slope.
Mainstay	Severe: depth to rock, slope.	Severe: slope.	Severe: depth to rock, slope.	Severe: slope.	Severe: low strength, slope.	Severe: small stones, large stones, slope.
Rock outcrop	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, thin layer.
LRF*, LRG*:						
Lozier	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: small stones, slope, thin layer.
Rock outcrop	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, thin layer.
MRE*:						
Mariscal	Severe: depth to rock, slope.	Severe: slope.	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: large stones, slope, thin layer.
Rock outcrop	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, thin layer.
PAA*:						
Pajarito	Slight	Slight	Slight	Slight	Slight	Slight.
Agustin	Slight	Slight	Slight	Slight	Slight	Moderate: small stones, large stones, droughty.
PNA Pantera	Moderate: large stones, flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: small stones, large stones, droughty.
PRF*:						
Puerta	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, low strength, slope.	Severe: small stones, large stones, slope.
Madrone	Severe: depth to rock, large stones, slope.	Severe: slope, large stones.	Severe: depth to rock, slope, large stones.	Severe: slope, large stones.	Severe: low strength, slope, large stones.	Severe: small stones, large stones, slope.
RVW* Riverwash	Severe: cutbanks cave, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: wetness, flooding.	Severe: wetness, droughty, flooding.
SCB*:						
Solis	Severe: depth to rock.	Moderate: depth to rock.	Severe: depth to rock.	Moderate: depth to rock.	Moderate: depth to rock.	Severe: thin layer.

See footnote at end of table.

TABLE 6.--BUILDING SITE DEVELOPMENT--Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
SCB*:						
Chamberino-------	Slight---------	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: small stones, large stones, droughty.
SRD*:						
Solis------------	Severe: depth to rock, slope.	Severe: slope.	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: slope, thin layer.
Rock outcrop-----	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, thin layer.
TAE*:						
Terlingua--------	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: small stones, slope.
Mariscal---------	Severe: depth to rock, slope.	Severe: slope.	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: large stones, slope, thin layer.
TLE*:						
Terlingua--------	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: small stones, slope.
Rock outcrop-----	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, thin layer.
TOA--------------- Tornillo	Slight---------	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength.	Slight.
UNC*:						
Upton------------	Severe: cemented pan.	Moderate: cemented pan.	Severe: cemented pan.	Moderate: cemented pan.	Moderate: cemented pan.	Severe: thin layer.
Nickel-----------	Slight---------	Slight---------	Slight---------	Moderate: slope.	Slight---------	Severe: small stones.
VBD*:						
Vieja------------	Severe: depth to rock.	Moderate: slope, depth to rock.	Severe: depth to rock.	Severe: slope.	Moderate: depth to rock, slope.	Severe: small stones, large stones.
Badland----------	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Severe: slope, thin layer.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 7.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Daily cover for landfill
BRG*:				
Brewster	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
Rock outcrop	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
CHC Chamberino	Slight	Moderate: seepage, slope.	Slight	Poor: small stones.
CHD Chamberino	Moderate: slope.	Severe: slope.	Moderate: slope.	Poor: small stones.
CLC Chilicotal	Slight	Moderate: seepage, slope.	Slight	Poor: small stones.
CMD*:				
Chilicotal	Moderate: slope.	Severe: slope.	Moderate: slope.	Poor: small stones.
Monterosa	Severe: cemented pan.	Severe: slope, cemented pan.	Severe: cemented pan.	Poor: area reclaim, small stones.
ERF*:				
Ector	Severe: depth to rock, slope.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, slope, large stones.	Poor: area reclaim, slope.
Rock outcrop	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
GHA*:				
Glendale	Severe: flooding, percs slowly.	Severe: flooding.	Severe: flooding.	Good:
Harkey	Severe: flooding.	Severe: flooding.	Severe: flooding.	Good.
HRD Hurds	Moderate: percs slowly, slope, large stones.	Severe: seepage, slope.	Severe: seepage.	Poor: small stones.
HRF Hurds	Severe: slope.	Severe: seepage, slope, large stones.	Severe: seepage, slope, large stones.	Poor: small stones, slope.
LAE*, LAF*:				
Lajitas	Severe: depth to rock, slope.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, slope.	Poor: area reclaim, small stones, slope.
Rock outcrop	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.

See footnote at end of table.

TABLE 7.--SANITARY FACILITIES--Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Daily cover for landfill
LMF*:				
Liv	Severe: percs slowly, slope.	Severe: slope, large stones.	Severe: slope, too clayey.	Poor: area reclaim, too clayey, hard to pack.
Mainstay	Severe: depth to rock, slope.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, slope, too clayey.	Poor: area reclaim, too clayey, hard to pack.
Rock outcrop	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
LRF*, LRG*:				
Lozier	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
Rock outcrop	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
MRE*:				
Mariscal	Severe: depth to rock, slope.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, slope, large stones.	Severe: area reclaim, slope, large stones.
Rock outcrop	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
PAA*:				
Pajarito	Slight	Severe: seepage.	Slight	Good.
Agustin	Slight	Severe: seepage.	Slight	Poor: small stones.
PNA Pantera	Severe: flooding.	Severe: seepage, flooding.	Severe: flooding, seepage, large stones.	Poor: small stones.
PRF*:				
Puerta	Severe: depth to rock, slope.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, slope, too clayey.	Poor: area reclaim, too clayey, hard to pack.
Madrone	Severe: depth to rock, percs slowly, slope.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, slope, too clayey.	Poor: area reclaim, too clayey, hard to pack.
RVW* Riverwash	Severe: flooding, wetness, poor filter.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Poor: seepage, too sandy, wetness.
SCB*:				
Solis	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.

See footnote at end of table.

TABLE 7.--SANITARY FACILITIES--Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Daily cover for landfill
SCB*:				
Chamberino	Slight	Moderate: seepage, slope.	Slight	Poor: small stones.
SRD*:				
Solis	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
Rock outcrop	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
TAE*:				
Terlingua	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
Mariscal	Severe: depth to rock, slope.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, slope, large stones.	Severe: area reclaim, slope, large stones.
TLE*:				
Terlingua	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
Rock outcrop	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.
TOA Tornillo	Moderate: flooding.	Severe: flooding.	Moderate: flooding, too clayey.	Fair: too clayey.
UNC*:				
Upton	Severe: cemented pan.	Severe: cemented pan.	Moderate: cemented pan, large stones.	Poor: area reclaim.
Nickel	Severe: percs slowly.	Moderate: slope.	Slight	Poor: seepage, small stones.
VBD*:				
Vieja	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Poor: area reclaim.
Badland	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reclaim, slope.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," "poor," "probable," and "improbable." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
BRG*:				
Brewster	Poor: area reclaim, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones, slope.
Rock outcrop	Poor: area reclaim, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.
CHC, CHD Chamberino	Good	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, area reclaim.
CLC Chilicotal	Good	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, area reclaim.
CMD*:				
Chilicotal	Good	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, area reclaim.
Monterosa	Poor: thin layer, area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones.
ERF*:				
Ector	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones, slope.
Rock outcrop	Poor: area reclaim, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.
GHA*:				
Glendale	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
Harkey	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
HRD Hurds	Fair: large stones.	Probable	Probable	Poor: small stones, area reclaim.
HRF Hurds	Poor: slope.	Probable	Probable	Poor: small stones, area reclaim, slope.
LAE*:				
Lajitas	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones, slope.
Rock outcrop	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.

See footnote at end of table.

TABLE 8.--CONSTRUCTION MATERIALS--Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
LAF*:				
Lajitas	Poor: area reclaim, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones, slope.
Rock outcrop	Poor: area reclaim, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.
LMF*:				
Liv	Poor: area reclaim, low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, slope.
Mainstay	Poor: area reclaim, low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones, slope.
Rock outcrop	Poor: area reclaim, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.
LRF*, LRG*:				
Lozier	Poor: area reclaim, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones, slope.
Rock outcrop	Poor: area reclaim, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.
MRE*:				
Mariscal	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, large stones, slope.
Rock outcrop	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.
PAA*:				
Pajarito	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
Agustin	Good	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, area reclaim.
PNA Pantera	Fair: large stones.	Improbable: excess fines.	Improbable: excess fines.	Poor: large stones, area reclaim.
PRF*:				
Puerta	Poor: area reclaim, low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones, slope.
Madrone	Poor: area reclaim, low strength, large stones.	Improbable: excess fines, large stones.	Improbable: excess fines, large stones.	Poor: small stones, slope.

See footnote at end of table.

TABLE 8.--CONSTRUCTION MATERIALS--Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
RVW*: Riverwash	Poor: wetness.	Probable	Improbable: too sandy.	Poor: too sandy, wetness.
SCB*:				
Solis	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim.
Chamberino	Good	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, area reclaim.
SRD*:				
Solis	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.
Rock outcrop	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.
TAE*:				
Terlingua	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones, slope.
Mariscal	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, large stones, slope.
TLE*:				
Terlingua	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones, slope.
Rock outcrop	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.
TOA: Tornillo	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
UNC*:				
Upton	Good	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, large stones.
Nickel	Good	Probable	Probable	Poor: small stones, area reclaim.
VBD*:				
Vieja	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones.
Badland	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, slope.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--ENGINEERING INDEX PROPERTIES

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Map symbol and soil name	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
BRG*:											
Brewster	0-4	Very cobbly loam, very gravelly loam.	GC	A-2, A-4, A-6	15-35	35-60	30-55	20-50	15-40	25-40	8-20
	4-10	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
CHC: Chamberino	0-4	Very gravelly loam.	GM, GC, SC, SM	A-1, A-2, A-4	0-15	45-75	40-70	30-60	20-45	20-30	NP-10
	4-55	Gravelly loam, very gravelly loam, gravelly fine sandy loam, very cobbly sandy loam, very gravelly sandy loam.	GM-GC, GC, SM-SC, SC	A-2, A-4, A-1	0-15	45-75	40-70	30-50	15-40	20-30	NP-10
	55-80	Very gravelly loam, very gravelly sandy loam.	GM-GC, GC, GP-GC	A-2, A-1	10-15	20-60	15-55	10-40	5-30	20-30	NP-10
CHD: Chamberino	0-7	Very gravelly loam.	GM, GM-GC, GC	A-1, A-2	0-15	45-60	40-55	30-45	20-35	20-30	NP-10
	7-18	Gravelly loam, very gravelly loam, gravelly fine sandy loam, very cobbly sandy loam, very gravelly sandy loam.	GC, SC, GM, SM	A-2, A-4	0-15	45-75	40-70	30-50	20-40	20-30	NP-10
	18-80	Very gravelly loam, very gravelly sandy loam.	GM-GC, GC, GP-GC, GM	A-2, A-1	10-15	20-60	15-55	10-40	5-30	20-30	NP-10
CLC: Chilicotal	0-2	Very gravelly fine sandy loam.	SC, SM-SC, GC, GM-GC	A-2-6, A-1, A-4 A-6	0-5	50-75	20-55	15-50	15-45	15-30	5-15
	2-40	Very gravelly loam, very gravelly fine sandy loam, very gravelly clay loam, very gravelly sandy clay loam.	SC, SM-SC, GC, GM-GC	A-2-6, A-1, A-4 A-6	0-5	50-75	20-55	15-50	15-45	15-30	5-15
	40-61	Very gravelly sandy clay loam, very gravelly clay loam, very gravelly loam, very gravelly sandy loam.	SC, SM-SC, GC, GM-GC	A-2-6, A-1, A-4 A-6	0-5	50-75	20-55	15-50	15-45	15-30	5-15

See footnote at end of table.

TABLE 9.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
CMD*:											
Chilicotal------	0-1	Very gravelly fine sandy loam, very gravelly loam.	SC, SM-SC, GC, GM-GC	A-2-6, A-1, A-4 A-6	0-5	50-75	20-55	15-50	15-45	15-30	5-15
	1-38	Very gravelly loam, very gravelly fine sandy loam, very gravelly clay loam, very sandy clay loam.	SC, SM-SC, GC, GM-GC	A-2-6, A-1, A-4 A-6	0-5	50-75	20-55	15-50	15-45	15-30	5-15
Monterosa-------	0-2	Very gravelly sandy loam.	GM, GM-GC	A-1, A-2	0-20	25-55	20-50	15-45	15-30	20-25	NP-5
	2-12	Very gravelly sandy clay loam, very gravelly sandy loam.	GM-GC, GC	A-2, A-1	0-15	35-55	30-50	25-35	20-30	25-30	5-10
	12-16	Indurated--------	---	---	---	---	---	---	---	---	---
ERF*:											
Ector-----------	0-6	Very cobbly loam	GC, CL, SC	A-2, A-4, A-6	25-50	45-80	40-75	35-70	20-60	25-49	8-25
	6-18	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
ERF*: Rock outcrop.											
GHA*:											
Glendale--------	0-9	Silty clay loam, loam, silt loam,	CL	A-6	0	100	100	95-100	75-90	30-40	15-25
	9-60	Silty clay loam, silt loam, loam.	CL	A-6	0	100	100	95-100	75-90	30-40	15-25
Harkey----------	0-2	Silty clay loam--	CL	A-6	0	100	100	95-100	75-95	30-40	10-15
	2-60	Very fine sandy loam, loam, silt loam.	ML, CL-ML	A-4	0	100	100	95-100	75-90	20-30	NP-5
HRD-------------- Hurds	0-3	Very gravelly sandy loam.	GC, SC, GM-GC, SM-SC	A-2, A-1	0-5	45-85	40-80	20-40	10-30	25-35	7-15
	3-41	Very gravelly sandy clay loam.	GC, GP-GC, SC, SP-SC	A-2	2-40	20-60	15-50	10-30	10-25	25-35	8-17
HRF-------------- Hurds	0-10	Very cobbly loam	GC, SC, GM-GC, SM-SC	A-2, A-1	5-40	45-85	40-80	20-40	10-30	25-35	5-15
	10-46	Very gravelly sandy clay loam, very cobbly sandy clay loam.	GC, GP-GC, SC, SP-SC	A-2	2-40	20-60	15-50	10-30	10-25	25-35	8-17
LAE*:											
Lajitas---------	0-7	Very cobbly loam, very cobbly clay loam.	GC, GM-GC,	A-2, A-6	10-50	35-60	30-55	20-50	15-40	35-50	20-32
	7-30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											

See footnote at end of table.

TABLE 9.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
LAF*:											
Lajitas----------	0-5	Very cobbly loam, very cobbly clay loam.	GC, GM-GC,	A-2, A-6	10-50	35-60	30-55	20-50	15-40	35-50	20-32
	5-30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
LMF*:											
Liv--------------	0-9	Very cobbly loam, very gravelly loam.	GC, SC, GP-GC, SP-SC	A-2, A-6	8-50	30-80	20-75	15-65	10-50	30-40	11-19
	9-68	Very cobbly clay, very gravelly clay.	GC, SC, CH	A-2, A-7	8-50	30-80	25-75	20-70	20-60	55-80	30-50
Mainstay---------	0-5	Very gravelly loam, very cobbly loam.	GC, SC, GP-GC, SP-SC	A-2, A-6, A-7	8-50	30-80	25-75	15-65	10-50	35-50	14-25
	5-18	Very gravelly clay, very cobbly clay, very strong clay.	GC, SC, CH, CL	A-2, A-7	8-50	30-80	25-75	20-70	20-60	45-70	22-42
	18-30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
LRF*:											
Lozier-----------	0-9	Very gravelly loam.	GC, SC, GM	A-2, A-4, A-6, A-7	5-20	30-60	25-55	20-50	15-45	25-48	8-26
	9-20	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
LRF*:											
Rock outcrop.											
LRG*:											
Lozier-----------	0-5	Very cobbly loam	GC	A-2, A-4, A-6, A-7	15-40	35-70	30-70	25-65	20-45	25-48	8-26
	5-15	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
MRE*:											
Mariscal---------	0-5	Very channery loam, very flaggy loam.	GC	A-2-4, A-2-6	10-50	30-60	25-55	20-50	15-35	25-35	8-15
	5-40	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
PAA*:											
Pajarito---------	0-4	Fine sandy loam, loamy fine sand.	SM, SM-SC	A-2, A-4	0	100	100	85-100	30-45	15-20	NP-5
	4-14	Fine sandy loam, sandy loam.	SM, SM-SC	A-2, A-4	0	90-100	85-100	60-100	25-45	15-20	NP-5
	14-44	Fine sandy loam, sandy loam.	SM, ML, SM-SC, CL-ML	A-4, A-2	0	90-100	85-100	60-95	20-55	20-30	NP-5

See footnote at end of table.

TABLE 9.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
PAA*:											
Agustin----------	0-2	Gravelly fine sandy loam, gravelly sandy loam.	SM, SM-SC, GM, GM-GC	A-2-4, A-4	0-10	55-85	50-80	35-65	20-45	15-25	2-7
	2-40	Gravelly fine sandy loam, gravelly loam, gravelly sandy loam.	SM, SM-SC, GM, GM-GC	A-2-4, A-4	0-10	55-85	50-80	35-65	20-50	15-25	2-7
PNA-------------- Pantera	0-15	Very gravelly sandy loam.	GP-GC, GC, SC, GM-GC	A-1, A-2	5-40	30-75	25-60	15-40	5-25	20-40	4-20
	15-60	Very gravelly sandy loam, very gravelly loam, very cobbly sandy loam, very cobbly loam.	GP-GC, SC, GC, GM-GC	A-1, A-2	10-50	30-75	25-60	15-40	5-25	20-40	4-20
PRF*:											
Puerta-----------	0-5	Very gravelly silt loam, very gravelly loam.	GC, SC	A-2	8-50	40-75	35-70	20-60	13-35	30-45	11-25
	5-20	Very gravelly clay, very cobbly clay.	GC, CH, SC	A-2, A-7	8-50	40-75	35-70	30-65	25-60	55-80	35-50
	20-30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Madrone----------	0-6	Very gravelly loam, very gravelly clay loam.	GC, SC	A-2, A-6, A-7-6	8-50	40-80	35-75	25-55	15-40	30-45	11-25
	6-32	Very cobbly clay, very cobbly clay loam, very gravelly clay loam, very gravelly clay.	GC, CH, SC	A-2, A-7	8-55	40-80	35-75	30-70	25-60	51-75	30-50
	32-40	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
RVW*------------- Riverwash	0-40	Gravelly sand, very gravelly sand.	SM, SP-SM, GM, GM-GC	A-2-4, A-1	0-5	30-80	30-80	20-50	10-30	<22	NP-7
SCB*:											
Solis------------	0-10	Loam, gravelly loam.	SM, SM-SC, ML, CL-ML	A-2-4, A-4	0-1	85-95	70-95	65-95	25-55	18-26	NP-7
	10-28	Weathered bedrock	---	---	---	---	---	---	---	---	---
SCB*:											
Chamberino-------	0-6	Gravelly fine sandy loam.	SM, GM	A-1, A-2	0-10	60-75	55-70	30-45	20-35	20-30	NP-5
	6-22	Gravelly loam, very gravelly loam, gravelly fine sandy loam, very gravelly sandy loam.	GC, SC, GM, SM.	A-2, A-4	0-15	45-75	40-70	30-50	20-40	20-30	NP-10
	22-40	Very gravelly loam, very gravelly sandy loam.	GM-GC, GC, GP-GC, GM	A-2, A-1	0-15	20-60	15-55	10-40	5-30	20-30	NP-10

See footnote at end of table.

TABLE 9.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
SRD*:											
Solis-----------	0-6	Fine sandy loam, gravelly fine sandy loam.	SM, SM-SC, ML, CL-ML	A-2-4, A-4	0-1	85-95	70-95	65-95	25-55	18-26	NP-7
	6-42	Weathered bedrock	---	---	---	---	---	---	---	---	---
Rock outcrop.											
TAE*:											
Terlingua-------	0-10	Very gravelly sandy loam.	GC, SC	A-2-4, A-2-6, A-4	0-15	25-70	20-60	20-50	15-45	25-40	8-17
	10-20	Weathered bedrock, unweathered bedrock.	---	---	---	---	---	---	---	---	---
Mariscal--------	0-5	Very channery loam, very flaggy loam.	GC	A-2-4, A-2-6	10-50	30-60	25-55	20-50	15-35	25-35	8-15
	5-20	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
TLE*:											
Terlingua-------	0-8	Very gravelly coarse sandy loam, very gravelly sandy loam.	GC, SC	A-2-4, A-2-6, A-4	0-15	25-70	20-60	20-50	15-45	25-40	8-17
	8-16	Weathered bedrock.	---	---	---	---	---	---	---	---	---
	16-20	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
TOA-------------- Tornillo	0-9	Loam-------------	CL	A-4, A-6, A-7-6	0	98-100	95-100	90-100	50-80	25-45	8-25
	9-83	Loam, silt loam, clay loam, sandy clay loam, fine sandy loam, silty clay loam.	CL	A-4, A-6, A-7-6	0	98-100	95-100	90-100	50-80	25-45	8-25
UNC*:											
Upton-----------	0-15	Gravelly loam, very gravelly loam.	CL, GC, SC	A-4, A-6	0-2	65-85	60-75	51-70	36-55	23-38	8-15
	15-19	Cemented---------	---	---	0-50	---	---	---	---	---	---
	19-30	Gravelly loam, gravelly sandy loam, very gravelly loam.	CL, GC, SC	A-4, A-6	0-20	65-85	60-75	51-70	36-55	23-38	8-15
UNC*:											
Nickel----------	0-3	Very gravelly sandy loam, very gravelly loam.	GM, GM-GC	A-1, A-2	0-5	25-55	25-50	15-45	10-35	<25	NP-5
	3-22	Very gravelly sandy loam, very gravelly loam.	GP-GM, GM, GM-GC	A-1, A-2	0-10	30-60	20-55	15-35	5-25	<25	NP-5
	22-30	Very gravelly sandy loam, very gravelly loam.	GP-GM, GM, GM-GC	A-1, A-2	0-10	30-60	20-55	15-35	5-25	<25	NP-5

See footnote at end of table.

TABLE 9.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
VBD*:											
Vieja------------	0-2	Very gravelly silty clay.	GC, CL, CH, SC	A-2, A-6, A-7	15-60	40-80	40-75	35-75	30-70	35-55	15-32
	2-13	Silty clay loam, silty clay, clay loam.	CL, CH	A-6, A-7	0-2	85-100	80-98	80-95	75-95	35-55	15-32
	13-40	Weathered bedrock	---	---	---	---	---	---	---	---	---
Badland.											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol < means less than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink- swell potential	Erosion factors K	Erosion factors T	Wind erodi- bility group	Organic matter
	In	Pct	G/cm^3	In/hr	In/in	pH	Mmhos/cm					Pct
BRG*:												
Brewster---------	0-4	15-27	1.30-1.45	0.6-2.0	0.05-0.14	6.1-7.8	<2	Low--------	0.10	1	8	1-3
	4-10	---	---	---	---	---	---	----------	----			
Rock outcrop.												
CHC--------------- Chamberino	0-4	15-25	1.30-1.45	2.0-6.0	0.08-0.10	7.9-8.4	2-4	Low--------	0.10	3	4L	<1
	4-55	17-27	1.30-1.45	0.6-2.0	0.09-0.11	7.9-8.4	2-4	Low--------	0.10			
	55-80	17-27	1.30-1.45	2.0-6.0	0.08-0.10	7.9-8.4	2-4	Low--------	0.10			
CHD--------------- Chamberino	0-7	15-25	1.30-1.45	2.0-6.0	0.08-0.10	7.9-8.4	2-4	Low--------	0.10	3	4L	<1
	7-18	17-27	1.30-1.45	0.6-2.0	0.09-0.11	7.9-8.4	2-4	Low--------	0.10			
	18-80	17-27	1.30-1.45	2.0-6.0	0.08-0.10	7.9-8.4	2-4	Low--------	0.10			
CLC--------------- Chilicotal	0-2	12-27	1.40-1.60	0.6-2.0	0.08-0.12	7.9-8.4	<2	Low--------	0.10	2	8	.8-2
	2-40	15-27	1.40-1.60	0.6-2.0	0.08-0.12	7.4-8.4	<2	Low--------	0.10			
	40-61	5-30	1.40-1.60	0.6-2.0	0.05-0.12	7.9-8.4	<2	Low--------	0.10			
CMD*:												
Chilicotal-------	0-1	12-27	1.40-1.60	0.6-2.0	0.08-0.12	7.9-8.4	<2	Low--------	0.10	2	8	.8-2
	1-38	15-27	1.40-1.60	0.6-2.0	0.08-0.12	7.4-8.4	<2	Low--------	0.10			
Monterosa--------	0-2	10-25	1.40-1.60	0.6-2.0	0.07-0.09	7.9-8.4	<2	Low--------	0.10	1	46	.8-1.7
	2-12	17-27	1.30-1.50	0.6-2.0	0.07-0.09	7.9-8.4	<2	Low--------	0.10			
	12-16	---	---	---	---	---	---	----------	----			
ERF*:												
Ector------------	0-6	20-35	1.30-1.45	0.6-2.0	0.06-0.12	7.9-8.4	<2	Very low	0.15	1	8	1-3
	6-18	---	---	---	---	---	---	----------	----			
Rock outcrop.												
GHA*:												
Glendale---------	0-9	18-35	1.25-1.35	0.2-0.6	0.16-0.21	7.9-8.4	2-4	Moderate	0.37	5	4L	<1
	9-60	18-35	1.25-1.35	0.2-0.6	0.16-0.21	7.9-8.4	2-4	Moderate	0.37			
Harkey-----------	0-2	28-35	1.25-1.35	0.6-2.0	0.13-0.19	7.9-8.4	<4	Low--------	0.55	5	4L	<1
	2-60	10-28	1.30-1.60	0.6-2.0	0.13-0.19	7.9-8.4	<4	Low--------	0.43			
HRD--------------- Hurds	0-3	12-27	1.40-1.60	0.6-2.0	0.06-0.14	6.1-7.3	<2	Low--------	0.15	5	8	1-3
	3-41	20-35	1.40-1.60	0.6-2.0	0.05-0.12	5.6-6.5	<2	Low--------	0.10			
HRF--------------- Hurds	0-10	12-27	1.40-1.60	0.6-2.0	0.06-0.14	6.1-7.3	<2	Low--------	0.15	5	8	1-3
	10-46	20-35	1.40-1.60	0.6-2.0	0.05-0.12	5.6-6.5	<2	Low--------	0.10			
LAE*:												
Lajitas----------	0-7	18-35	1.40-1.60	0.6-2.0	0.05-0.10	6.6-8.4	<2	Low--------	0.10	1	8	.5-2
	7-30	---	---	---	---	---	---	----------	----			
Rock outcrop.												
LAF*:												
Lajitas----------	0-5	18-35	1.40-1.60	0.6-2.0	0.05-0.10	6.6-8.4	<2	Low--------	0.10	1	8	.5-2
	5-30	---	---	---	---	---	---	----------	----			
Rock outcrop.												
LMF*:												
Liv--------------	0-9	15-27	1.35-1.55	0.6-2.0	0.06-0.14	6.6-7.3	<2	Low--------	0.10	3	8	1-3
	9-68	50-70	1.35-1.55	0.2-0.6	0.05-0.12	6.1-7.8	<2	Moderate	0.10			

See footnote at end of table.

TABLE 10.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea-bility	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH	Mmhos/cm					Pct
LMF*:												
Mainstay--------	0-5	12-27	1.35-1.55	0.6-2.0	0.06-0.14	6.6-7.8	<2	Low--------	0.10	1	8	1-3
	5-18	50-70	1.30-1.50	0.2-0.6	0.05-0.12	6.1-7.8	<2	Moderate	0.10			
	18-30	---	---	---	---	---	---	-----------	-----			
Rock outcrop.												
LRF*:												
Lozier-----------	0-9	18-35	1.30-1.50	0.6-2.0	0.05-0.10	7.9-8.4	<2	Very low	0.10	1	8	<1
	9-20	---	---	---	---	---	---	-----------	-----			
Rock outcrop.												
LRG*:												
Lozier-----------	0-5	18-35	1.30-1.50	0.6-2.0	0.05-0.10	7.9-8.4	<2	Very low	0.10	1	8	<1
	5-15	---	---	---	---	---	---	-----------	-----			
Rock outcrop.												
MRE*:												
Mariscal---------	0-5	10-27	1.30-1.50	0.6-2.0	0.05-0.10	7.9-8.4	<2	Low--------	0.10	1	8	1-2
	5-40	---	---	---	---	---	---	-----------	-----			
Rock outcrop.												
PAA*:												
Pajarito---------	0-4	5-18	1.40-1.60	2.0-6.0	0.09-0.15	7.4-8.4	<2	Low--------	0.24	5	3	<1
	4-14	12-18	1.40-1.60	2.0-6.0	0.13-0.15	7.9-8.4	<2	Low--------	0.24			
	14-44	12-18	1.40-1.60	2.0-6.0	0.13-0.15	7.9-8.4	<2	Low--------	0.24			
Agustin----------	0-2	10-18	1.40-1.60	2.0-6.0	0.05-0.10	7.9-8.4	<2	Low--------	0.10	3	3	<1
	2-40	10-18	1.40-1.60	2.0-6.0	0.05-0.10	7.9-8.4	<2	Low--------	0.10			
PNA--------------- Pantera	0-15	8-18	1.40-1.60	2.0-6.0	0.04-0.08	7.9-8.4	<2	Low--------	0.10	5	8	<1
	15-60	8-18	1.40-1.60	2.0-6.0	0.04-0.08	7.9-8.4	<2	Low--------	0.10			
PRF*:												
Puerta-----------	0-5	15-27	1.30-1.55	0.6-2.0	0.05-0.14	6.6-7.3	<2	Low--------	0.10	1	8	2-5
	5-20	50-70	1.35-1.60	0.2-0.6	0.06-0.15	5.1-6.0	<2	High-------	0.10			
	20-30	---	---	---	---	---	---	-----------	-----			
Madrone----------	0-6	15-30	1.30-1.55	0.6-2.0	0.05-0.14	6.1-7.3	<2	Low--------	0.10	2	8	<1
	6-32	45-60	1.35-1.60	0.2-0.6	0.06-0.15	5.1-6.0	<2	Moderate	0.10			
	32-40	---	---	---	---	---	---	-----------	-----			
RVW*-------------- Riverwash	0-40	5-20	1.40-1.60	2.0-20	0.02-0.12	7.4-8.4	<2	Low--------	0.17	5	2	<1
SCB*:												
Solis------------	0-10	5-18	1.40-1.55	0.6-2.0	0.08-0.12	7.9-8.4	<2	Low--------	0.24	1	3	<1
	10-28	---	---	---	---	---	---	-----------	-----	---	---	
Chamberino-------	0-6	15-20	1.30-1.45	2.0-6.0	0.10-0.12	7.9-8.4	2-4	Low--------	0.15	3	4	<1
	6-22	17-27	1.30-1.45	0.6-2.0	0.09-0.11	7.9-8.4	2-4	Low--------	0.10			
	22-40	17-27	1.30-1.45	2.0-6.0	0.08-0.10	7.9-8.4	2-4	Low--------	0.10			
SRD*:												
Solis------------	0-6	5-18	1.40-1.55	0.6-2.0	0.08-0.12	7.9-8.4	<2	Low--------	0.24	1	3	<1
	6-42	---	---	---	---	---	---	-----------	-----			
Rock outcrop.												
TAE*:												
Terlingua--------	0-10	10-26	1.40-1.60	0.6-2.0	0.05-0.10	7.9-8.4	<2	Low--------	0.15	1	8	<1
	10-20	---	---	---	---	---	---	-----------	-----			
Mariscal---------	0-5	10-27	1.30-1.50	0.6-2.0	0.05-0.10	7.9-8.4	<2	Low--------	0.10	1	8	1-2
	5-20	---	---	---	---	---	---	-----------	-----			

See footnote at end of table.

TABLE 10.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea-bility	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH	Mmhos/cm					Pct
TLE*:												
Terlingua-------	0-8	10-26	1.40-1.60	0.6-2.0	0.05-0.10	7.9-8.4	<2	Low--------	0.15	1	8	<1
	8-20	---	---	---	---	---	---	-----------	-----			
Rock outcrop.												
TOA---------------	0-9	18-27	1.20-1.45	0.6-2.0	0.14-0.20	7.9-8.4	<4	Moderate	0.28	5	4L	<1
Tornillo	9-83	18-35	1.30-1.55	0.6-2.0	0.14-0.20	7.4-9.0	<4	Moderate	0.28			
UNC*:												
Upton------------	0-15	15-27	1.30-1.50	0.6-2.0	0.08-0.14	7.9-8.4	<2	Low--------	0.15	2	4L	<1
	15-19	---	---	---	---	7.9-8.4	<2	Very low	-----			
	19-30	15-30	1.35-1.55	0.6-2.0	0.08-0.14	7.9-8.4	<2	Low--------	0.15			
Nickel-----------	0-3	5-15	1.30-1.60	2.0-6.0	0.07-0.09	7.9-8.4	<2	Low--------	0.17	5	8	<1
	3-22	5-10	1.30-1.60	0.2-0.6	0.04-0.07	7.9-8.4	<2	Low--------	0.10			
	22-30	5-10	1.30-1.60	0.2-0.6	0.04-0.07	7.9-8.4	<2	Low--------	0.10			
VBD*:												
Vieja------------	0-2	35-50	1.35-1.55	0.06-0.2	0.05-0.12	7.9-8.4	<2	High-------	0.10	1	4	<1
	2-13	35-50	1.40-1.60	0.06-0.2	0.10-0.17	7.9-8.4	<2	High-------	0.28			
	13-40	---	---	---	---	---	---	-----------	-----			
Badland.												

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--SOIL AND WATER FEATURES

["Flooding" and "water table" and terms such as "rare," "brief," "apparent," and "perched" are explained in the text. The symbol > means more than. Absence of an entry indicates that the feature is not a concern]

Map symbol and soil name	Hydro-logic group	Flooding			Bedrock		Cemented pan		Risk of corrosion	
		Frequency	Duration	Months	Depth	Hardness	Depth	Hardness	Uncoated steel	Concrete
					In		In			
BRG*:										
Brewster----------	D	None---------	---	---	4-20	Hard	---	---	Moderate	Low.
Rock outcrop------	D	None---------	---	---	0-2	Hard	---	---	High------	Low.
CHC, CHD----------- Chamberino	B	None---------	---	---	>60	---	---	---	High------	Low.
CLC---------------- Chilicotal	B	None---------	---	---	>60	---	---	---	High------	Low.
CMD*:										
Chilicotal--------	B	None---------	---	---	>60	---	---	---	High------	Low.
Monterosa---------	D	None---------	---	---	>60	---	7-20	Thick	High------	Low.
ERF*:										
Ector-------------	D	None---------	---	---	4-20	Hard	---	---	High------	Low.
Rock outcrop------	D	None---------	---	---	0-2	Hard	---	---	High------	Low.
GHA*:										
Glendale----------	B	Occasional	Brief------	Jul-Sep	>60	---	---	---	High------	Low.
Harkey------------	B	Occasional	Brief------	Jul-Sep	>60	---	---	---	High------	Low.
HRD, HRF----------- Hurds	B	None---------	---	---	>60	---	---	---	Low-------	Moderate.
LAE*, LAF*:										
Lajitas-----------	D	None---------	---	---	4-20	Hard	---	---	Moderate	Low.
Rock outcrop------	D	None---------	---	---	0-2	Hard	---	---	High------	Low.
LMF*:										
Liv---------------	D	None---------	---	---	40-80	Soft	---	---	High------	Low.
Mainstay----------	D	None---------	---	---	10-20	Soft	---	---	High------	Low.
Rock outcrop------	D	None---------	---	---	0-2	Hard	---	---	High------	Low.
LRF*, LRG*:										
Lozier------------	D	None---------	---	---	4-16	Hard	---	---	High------	Low.
Rock outcrop------	D	None---------	---	---	0-2	Hard	---	---	High------	Low.
MRE*:										
Mariscal----------	D	None---------	---	---	4-20	Soft	---	---	High------	Low.
Rock outcrop------	D	None---------	---	---	0-2	Hard	---	---	High------	Low.
PAA*:										
Pajarito----------	B	None---------	---	---	>60	---	---	---	High------	Low.
Agustin-----------	B	None---------	---	---	>60	---	---	---	High------	Low.
PNA---------------- Pantera	B	Frequent-----	Very brief	Jan-Dec	>60	---	---	---	High------	Low.
PRF*:										
Puerta------------	D	None---------	---	---	11-20	Hard	---	---	High------	Moderate.

See footnote at end of table.

TABLE 11.--SOIL AND WATER FEATURES--Continued

Map symbol and soil name	Hydro-logic group	Flooding			Bedrock		Cemented pan		Risk of corrosion	
		Frequency	Duration	Months	Depth	Hardness	Depth	Hardness	Uncoated steel	Concrete
					In		In			
PRF*:										
Madrone----------	C	None--------	---	---	21-40	Hard	---	---	High-----	Moderate.
RVW*--------------- Riverwash	A	Frequent----	Brief-----	Jan-Dec	>60	---	---	---	High-----	Low.
SCB*:										
Solis------------	C	None--------	---	---	4-20	Soft	---	---	High-----	Low.
Chamberino-------	B	None--------	---	---	>60	---	---	---	High-----	Low.
SRD*:										
Solis------------	C	None--------	---	---	4-20	Soft	---	---	High-----	Low.
Rock outcrop-----	D	None--------	---	---	0-2	Hard	---	---	High-----	Low.
TAE*:										
Terlingua--------	D	None--------	---	---	4-12	Hard	---	---	Moderate	Low.
Mariscal---------	D	None--------	---	---	4-20	Soft	---	---	High-----	Low.
TLE*:										
Terlingua--------	D	None--------	---	---	4-12	Hard	---	---	Moderate	Low.
Rock outcrop-----	D	None--------	---	---	0-2	Hard	---	---	High-----	Low.
TOA--------------- Tornillo	B	Occasional	Brief-----	Jul-Oct	>60	---	---	---	Moderate	Low.
UNC*:										
Upton------------	C	None--------	---	---	>60	---	7-20	Thin	High-----	Low.
Nickel-----------	B	None--------	---	---	>60	---	---	---	High-----	Low.
VBD*:										
Vieja------------	D	None--------	---	---	5-20	Soft	---	---	High-----	Low.
Badland----------	D	None--------	---	---	0-2	Soft	---	---	High-----	Low.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--PHYSICAL PROPERTIES OF SELECTED SOILS

[Dashes indicate data were not available. The symbol < means less than; > means more than]

Soil series[1] and sample numbers[2]	Depth	Horizon	Particle-size distribution (Percent less than 2 mm)								Fragments > 2.0 mm	Bulk density	Water content	
			Sand						Silt	Clay				
			Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.10-0.05)	Total (2.0-0.05)	(0.05-0.002)	<0.002			Coefficient of linear extensibility	1/3 bar
	In		Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct	G/cc	Cm/cm	Pct(wt)
Chilicotal[3]: (S80TX043-011)														
947	0-2	A	4.3	4.8	7.4	16.3	22.4	55.2	31.5	13.3	43.0	---	---	---
948	2-7	Bw	4.3	3.5	4.0	10.9	21.1	43.8	37.9	18.3	54.0	---	---	---
949	7-14	Bk1	7.1	3.8	3.8	9.6	17.4	41.7	35.8	22.5	73.0	---	---	---
950	14-23	Bk2	9.3	3.6	3.4	7.6	13.5	37.4	35.1	27.5	76.0	---	---	---
951	23-28	Bk2	8.8	3.8	3.8	7.6	14.3	38.3	36.2	25.5	81.0	---	---	---
952	28-40	Bk3	9.8	5.4	5.2	9.5	15.7	45.6	39.3	15.1	80.0	---	---	---
953	40-51	2Bk1	13.9	7.5	6.0	13.3	18.5	59.2	34.8	6.0	69.0	---	---	---
954	51-61	2Bk2	11.5	5.6	6.6	16.7	20.0	60.4	34.4	5.4	81.0	---	---	---
955	61-79	2Bkm	12.0	7.8	8.8	15.3	19.4	63.3	30.4	6.3	80.0	---	---	---
956	79-96	2Ck1	13.1	6.4	7.8	17.1	21.4	65.8	30.5	3.7	66.0	---	---	---
957	96-106	2Ck2	18.9	12.0	11.8	14.9	13.0	70.6	24.3	5.1	76.0	---	---	---
958	106-122	3Btk	14.1	10.3	10.9	15.1	12.1	62.5	23.6	13.9	71.0	---	---	---
959	122-144	3Bk	16.6	15.7	13.0	16.0	11.6	72.9	18.0	9.1	78.0	---	---	---
960	144-158	4Bt	16.8	12.0	6.9	5.5	4.9	46.1	25.5	28.4	73.0	---	---	---
961	158-170	4Btk	8.9	6.4	6.0	8.7	9.2	39.2	33.6	27.2	69.0	---	---	---
Terlingua: (S80TX043-120)														
962	0-4	A	17.2	9.8	9.2	11.4	11.8	59.4	33.4	7.2	40	---	---	---
963	4-8	Bk	14.3	8.6	9.4	10.4	12.3	55.0	34.5	10.5	56	---	---	---
Tornillo: (S80TX043-010)														
938	0-9	A	0.6	0.5	2.8	15.0	19.8	38.7	40.3	21.0	0	1.28	.047	28.6
939	9-17	Bw	0.1	0.2	1.0	5.8	12.3	19.4	51.4	29.2	0	1.31	.059	26.3
940	17-25	Bk1	0.1	0.2	0.6	3.2	10.5	14.6	57.6	27.8	0	1.39	.045	22.8
941	25-33	Bk2	0.6	1.1	2.3	9.3	14.1	27.4	46.2	26.4	0	1.39	.037	19.6
942	33-43	Bk3	1.1	1.1	4.5	20.8	21.8	49.3	30.2	20.5	0	1.39	.038	20.9
943	43-49	Ab1	0.1	0.2	1.4	8.4	17.5	27.6	43.6	28.8	0	1.35	.054	25.0
944	49-63	Ab2	0.1	0.2	0.9	6.1	12.7	20.0	52.4	27.6	0	1.42	.049	22.9
945	63-75	Ab3	---	---	---	---	---	---	---	---	---	1.38	.051	28.8
946	75-83	Bb	0.0	0.0	0.1	1.3	9.8	11.2	59.3	29.5	0	---	---	---

1 The soils sampled were of the typical pedons for the soil series in this survey area. See the section "Soil Series and Their Morphology" for location of the pedons.
2 The Soil Conservation Service sample numbers for the pedons are shown in parentheses; the three-digit numbers not in parentheses are the Texas Agricultural Experiment Station Laboratory numbers for the individual horizon samples within the pedon.
3 The Bk2 horizon was subdivided in the field for sampling purposes.

TABLE 13.--CHEMICAL PROPERTIES OF SELECTED SOILS

Soil name[1] and sample number[2]	Depth	Horizon	Extractable bases: Ca	Mg	Na	K	Sum	Elec. cond.	ESP	SAR	$CaCO_3$	pH Water (1:1)	Organic carbon	CEC
	In		Meq/100g					Mmohs/cm	Pct	Pct	Pct		Pct	Meq/100gm
Chilicotal[3]: (S80TX043-011)														
947	0-2	A	10.7	2.3	0.2	1.0	14.2	0.4	1.5	0.3	0.8	8.0	0.30	13.2
948	2-7	Bw	17.4	1.9	0.2	0.7	20.2	0.8	1.2	0.6	1.0	7.8	0.49	16.9
949	7-14	Bk1	41.1	1.7	0.4	0.5	43.7	1.0	1.9	0.7	1.9	7.8	0.69	20.6
950	14-23	Bk2	56.9	1.6	0.9	0.5	59.9	0.9	4.0	1.0	4.1	7.9	0.43	22.6
951	23-28	Bk2	50.2	1.7	1.1	0.5	53.5	0.9	5.1	1.1	9.0	7.9	0.08	21.4
952	28-40	Bk3	44.9	1.3	1.4	0.3	47.9	1.2	8.6	1.7	13.8	7.8	0.05	15.2
953	40-51	2Bk1	40.5	1.1	0.7	0.2	42.5	1.3	3.8	2.6	14.8	8.0	0.00	13.1
954	51-61	2Bk2	43.9	3.2	2.6	0.3	50.0	1.5	0.9	11.2	12.4	8.3	0.00	18.3
955	61-79	2Bkm	46.2	3.6	3.7	0.3	53.8	1.7	18.4	15.6	17.1	8.7	0.17	16.8
956	79-96	2Ck1	39.1	3.8	5.3	0.3	48.5	2.5	32.8	23.7	13.6	8.9	0.13	13.7
957	96-106	2Ck2	38.7	3.5	6.5	0.3	49.0	6.1	35.2	30.9	10.0	8.8	0.13	12.5
958	106-122	3Btk	34.5	3.5	8.1	0.3	46.4	10.7	37.3	23.6	1.5	8.2	0.03	13.4
959	122-144	3Bk	17.1	2.4	6.3	0.3	26.1	11.0	29.3	23.0	0.9	8.4	0.08	11.6
960	144-158	4Bt	16.8	5.5	14.2	0.6	37.1	11.5	36.4	24.7	0.7	8.1	0.03	22.0
961	158-170	4Btk	47.7	5.6	13.5	0.6	67.4	10.8	35.0	22.5	3.8	8.1	0.01	22.3
Terlingua: (S80TX043-012)														
962	0-4	A	41.9	0.7	0.1	0.4	43.1	0.4	0.7	0.6	5.0	8.4	0.37	15.1
963	4-8	Bk	49.8	0.4	0.2	0.2	50.6	0.4	1.1	0.8	8.4	8.2	0.75	17.9
Tornillo: (S80TX043-010)														
938	0-9	A	58.1	1.2	1.4	0.4	61.1	0.5	4.4	7.0	3.7	8.3	0.16	27.0
939	9-17	Bw	59.5	1.9	2.1	0.4	63.9	2.9	4.3	4.1	6.4	7.7	0.17	34.8
940	17-25	Bk1	63.3	1.9	1.9	0.4	67.5	2.0	3.8	5.4	7.3	7.9	0.14	34.0
941	25-33	Bk2	59.5	1.9	2.2	0.3	63.9	1.9	5.2	6.2	8.7	7.7	0.12	30.5
942	33-43	Bk3	49.6	1.8	3.0	0.2	54.6	1.0	10.2	9.6	8.9	8.4	0.02	25.4
943	43-49	Ab1	56.2	2.5	4.7	0.3	63.7	0.9	12.3	18.2	8.3	8.5	0.10	34.1
944	49-63	Ab2	59.5	2.9	5.6	0.3	68.3	0.8	14.0	20.6	10.0	8.6	0.10	36.5
945	63-75	Ab3	57.5	2.9	5.7	0.3	66.4	0.9	14.2	22.8	9.6	8.7	0.07	36.6
946	75-83	Bb	56.0	3.1	7.2	0.4	66.7	1.1	17.1	24.0	10.0	8.6	0.09	38.0

[1] The soils sampled were of the typical pedons for the soil series in this survey area. See the section "Soil Series and Their Morphology" for location of the pedons.

[2] The Soil Conservation Service sample numbers for the pedons are shown in parentheses; the three-digit numbers not in parentheses are the Texas Agricultural Experiment Station Laboratory numbers for the individual horizon samples within the pedon.

[3] The Bx2 horizon was subdivided in the field for sampling purposes.

TABLE 14.--MINERALOGY OF SELECTED SOILS

[Dashes indicate data were not available. The symbol < means less than; > means more than]

Soil series[1] and sample numbers[2]	Depth	Horizon	Percentage of minerals							
			Clay					Sand and Silt		
			Smectite	Mica	Kaolinite	Quartz	Calcite	Quartz	Feldspar	Calcite
	In									
Chilicotal[3]: (S80TX043-011)										
947	0-2	A	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
948	2-7	Bw	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
949	7-14	Bk1	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
950	14-23	Bk2	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
951	23-28	Bk2	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
952	28-40	Bk3	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
953	40-51	2Bk1	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
954	51-61	2Bk2	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
955	61-79	2Bkm	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
956	79-96	2Ck1	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
957	96-106	2Ck2	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
958	106-122	3Btk	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
959	122-144	3Bk	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
960	144-158	4Bt	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
961	158-170	4Btk	> 50	< 10	< 10	10-50	< 10	> 50	10-50	< 10
Terlingua: (S80TX043-012)										
962	0-4	A	> 50	---	< 10	10-50	10-50	10-50	10-50	< 10
963	4-8	Bk	> 50	---	< 10	10-50	10-50	10-50	10-50	< 10
964	8-12	Crk1	> 50	---	0	10-50	10-50	< 10	10-50	> 50
965	12-16	Crk2	> 50	---	0	10-50	10-50	< 10	10-50	> 50
Tornillo: (S80TX043-010)										
938	0-9	A	> 50	---	< 10	10-50	---	> 50	10-50	< 10
939	9-17	Bw	> 50	---	< 10	10-50	---	> 50	10-50	< 10
940	17-25	Bk1	> 50	---	< 10	10-50	---	> 50	10-50	< 10
941	25-33	Bk2	> 50	---	< 10	10-50	---	---	---	---
942	33-43	Bk3	> 50	---	< 10	10-50	---	---	---	---
943	43-49	Ab1	> 50	---	< 10	10-50	---	---	---	---
944	49-63	Ab2	> 50	---	< 10	10-50	---	---	---	---
945	63-75	Ab3	> 50	---	< 10	10-50	---	---	---	---
946	75-83	Bb	> 50	---	< 10	10-50	---	---	---	---

[1] The soils sampled were of the typical pedons for the soil series in this survey area. See the section "Soil Series and Their Morphology" for location of the pedons.

[2] The Soil Conservation Service sample numbers for the pedons are shown in parentheses; the three-digit numbers not in parentheses are the Texas Agricultural Experiment Station Laboratory numbers for the individual horizon samples within the pedon.

[3] The Bk2 horizon was subdivided in the field for sampling purposes.

TABLE 15.--ENGINEERING TEST DATA

[NP means nonplastic]

Soil name, report number, horizon, and depth in inches	Classification		Grain size distribution[1]												Liquid limit[2]	Plasticity index[2]	Specific gravity	Shrinkage		
			Percentage passing sieve--									Percentage smaller than--								
	AASHTO	Unified	7/4 inch	6/4 inch	7/8 inch	5/8 inch	3/8 inch	No. 4	No. 10	No. 40	No. 200	.05 mm	.005 mm	.002 mm				Limit	Linear	Ratio
															Pct		G/cc	Pct	Pct	Pct
Chamberino very gravelly loam[3]: (S79TX043-004)																				
A--------0 to 3	A-4 (1)	SC	100	100	94	88	83	75	69	60	44	34	17	11	22	08	2.67	15.0	4.1	1.87
Bk2-----14 to 26	A-2-4 (0)	SC	100	91	86	81	70	53	41	30	19	16	06	04	30	09	2.70	21.0	4.5	1.71
Lajitas very cobbly loam[4]: (S79TX043-005)																				
A--------0 to 7	A-2-7 (1)	GC	100	83	72	60	49	40	33	29	22	20	11	08	46	24	2.61	17.0	12.8	1.77
Lozier very cobbly loam[4]: (S79TX043-002)																				
Ak-------0 to 5	A-2-6 (0)	GM	87	63	59	54	49	41	35	29	22	19	08	05	37	11	2.65	25.0	5.4	1.58
Mainstay very gravelly loam[4]: (S79TX043-001)																				
A--------0 to 5	A-2-7 (2)	SC	100	92	85	76	70	64	59	49	34	30	14	10	46	19	2.53	22.0	9.8	1.56
Bt1------5 to 11	A-2-7 (3)	GC	100	84	65	60	54	47	41	34	27	25	17	14	52	31	2.65	15.0	15.3	1.78
Bt2-----11 to 18	A-2-7 (3)	SC	100	78	67	61	57	51	46	39	30	27	17	14	46	28	2.67	11.0	15.4	1.93
Mariscal very channery loam[5]: (S79TX043-003)																				
A--------0 to 4	A-2-4 (0)	GM or GC	95	79	67	60	53	44	38	33	25	22	08	05	32	09	2.65	22.0	5.0	1.65

[1] For soil materials larger than 3/8 inch, square mesh wire sieves were used that are slightly larger than equivalent round sieves, but the difference does not seriously affect the data.

[2] Liquid limit and plasticity index values were determined by the AASHTO-89 and AASHTO-90 methods except that soil was added to water.

[3] Chamberino very gravelly loam: 11.6 miles S.E. of Panther Junction on paved park road, 200 feet S. of road.

[4] See the section "Soil Series and Their Morphology" for location of the pedon.

[5] Mariscal very channery loam: From U.S. 90 in Alpine, 44 miles S. on TX 118, 7.5 miles S.E. on Nine Point Mesa Road, 100 feet N. of road. This is the type location for the series and is outside the National Park boundary.

TABLE 16.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Agustin	Coarse-loamy, mixed, thermic Typic Camborthids
Brewster	Loamy-skeletal, mixed, thermic Lithic Haplustolls
Chamberino	Loamy-skeletal, mixed, thermic Typic Calciorthids
Chilicotal	Loamy-skeletal, mixed, thermic Ustollic Calciorthids
Ector	Loamy-skeletal, carbonatic, thermic Lithic Calciustolls
Glendale	Fine-silty, mixed (calcareous), thermic Typic Torrifluvents
Harkey	Coarse-silty, mixed (calcareous), thermic Typic Torrifluvents
Hurds	Loamy-skeletal, mixed, thermic Aridic Argiustolls
Lajitas	Loamy-skeletal, mixed, nonacid, thermic Lithic Torriorthents
*Liv	Clayey-skeletal, montmorillonitic, thermic Pachic Paleustolls
Lozier	Loamy-skeletal, carbonatic, thermic Lithic Calciorthids
Madrone	Clayey-skeletal, montmorillonitic, mesic Udic Paleustalfs
Mainstay	Clayey-skeletal, montmorillonitic, thermic, Lithic Argiustolls
Mariscal	Loamy-skeletal, carbonatic, thermic Lithic Ustollic Calciorthids
Monterosa	Loamy-skeletal, mixed, thermic, shallow Ustollic Paleorthids
Nickel	Loamy-skeletal, mixed, thermic Typic Calciorthids
Pajarito	Coarse-loamy, mixed, thermic Typic Camborthids
Pantera	Loamy-skeletal, mixed (calcareous), thermic Typic Torrifluvents
Puerta	Clayey-skeletal, montmorillonitic, mesic Alfic Lithic Argiustolls
Solis	Loamy, mixed (calcareous), thermic, shallow Typic Torriorthents
Terlingua	Loamy-skeletal, mixed (calcareous), thermic Lithic Torriorthents
Tornillo	Fine-loamy, mixed, thermic Fluventic Camborthids
Upton	Loamy, carbonatic, thermic, shallow Typic Paleorthids
Vieja	Clayey, montmorillonitic (calcareous), thermic, shallow Typic Torriorthents

* The soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series.

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