Soil Survey of Tuzigoot National Monument, Arizona

Bruce A. Lindsay

Technical Report No. 67

United States Geological Survey
Sonoran Desert Field Station
The University of Arizona ◆ Tucson, Arizona

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This soil survey is a project 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 Natural Resources Conservation Service (formerly the Soil Conservation Service) has leadership for the Federal part of the National Cooperative Soil Survey. Major fieldwork for this soil survey was completed in 1998. Soil names and descriptions were approved in May 1998. Statements in this publication refer to conditions in the survey area in 1998.

This survey was made cooperatively by the Natural Resources Conservation Service and the National Park Service. Its publication as a Technical Report of the USGS Sonoran Desert Field Station follows the traditional relationship that established the SDFS as the field data distribution arm of the NPS in southern Arizona.

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.

United States Department of Agriculture

Natural Resources Conservation Service

In cooperation with United States Department of the Interior, National Park Service

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Contents

Cover 1
Contents 5
General Nature of the Survey Area 7
Physiography 7
Climate 7
Vegetation 8
Geology 8
Formation of the Soils 9
Processes of Soil Formation 9
Factors of Soil Formation 10
How This Survey Was Made 12
Classification of the Soils 12
Detailed Soil Map Units 15
Map Unit Descriptions 16
528—Pagesprings-Blancoverde complex, 3 to 60 percent slopes 16
538—Tombstone-Stronghold complex, 2 to 10 percent slopes 18
541—Penthouse-Tombstone complex, 2 to 25 percent slopes 19
Soil Properties 23
Engineering Index Properties 23
Physical and Chemical Properties 24
Water Features 25
Soil Features 25
Use and Management of the Soils 27
Land Capability Classification 27
Rangeland 28
Recreation 29
Engineering 29
Building Site Development 30
Sanitary Facilities 30
Water Management 31
References 33
Glossary 35
Tables 45
Table 1.—Classification of the Soils 46
Table 2.—Acreage and Proportionate Extent of the Soils 46
Table 3.—Engineering Index Properties 47
Table 4.—Physical and Chemical Properties of the Soils 49
Table 5.—Soil Features 50
Table 6.—Rangeland Productivity and Characteristic Plant Communities 51
Table 7.—Recreational Development 53

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Soil Survey of Tuzigoot National Monument, Arizona

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United States Department of Agriculture, Natural Resources Conservation Service,
in cooperation with
the United States Department of the Interior, National Park Service

General Nature of the Survey Area

Tuzigoot National Monument is in Yavapai County, in north-central Arizona. The monument contains an extensive pueblo ruin that was constructed approximately 900 years ago by people of the Sinagua tribe. Construction occurred during several periods spanning more than 400 years. The pueblo was built on top of a small ridge. It was named Tuzigoot in 1933 when it was excavated by Louis Caywood, Edward Spicer, and 48 men in a project funded by the Civil Works Administration. Tuzigoot is a Tonto Apache word meaning "twisted water" and refers to the curved shape of Pecks Lake. The land was declared a national monument by President Franklin D. Roosevelt on July 25, 1939.

Physiography

The monument is in the Verde Valley at an elevation of about 3,500 feet MSL. The Verde Valley makes up about 600 square miles. It is bounded by the Mogollon Rim to the northeast, Big Black Mesa to the northwest, the Black Hills to the southwest, and Fossil Creek to the southeast. The Verde River is a perennial river that drains approximately 6,600 square miles. It runs adjacent to the survey area and eventually drains into the Salt River to the north. Pecks Lake is an abandoned meander channel of the Verde River. The southeastern part of the channel has been filled in by vegetation and is called Tavisci Marsh. The marsh receives runoff from the lake; this water in turn runs off back into the Verde River. The United Verde Copper Company filled a large part of the meander channel with copper mill tailings in the 1920's, when the smelters at Clarkdale and Clemenceau were operating.

Climate

Data were obtained from the USDA Centralized Forecast System (CFS), Portland, Oregon, for the Beaver Creek Ranger Station during the period from 1961 to 1990.

The mean annual air temperature is 61.3 degrees F. The average daily maximum temperature in January is 43.5 degrees F, and the average minimum is 29.4 degrees. The hottest days occur in July, when the average maximum temperature is 81.6 degrees F and the average minimum temperature is 66.5 degrees. The highest recorded temperature was 110 degrees, and the lowest recorded temperature was 1 degree.

The mean annual precipitation is 15.3 inches. Of this total, 5.2 inches, or about 34 percent, usually falls from July through September. The driest period is usually from April through June. About 10 percent of the preciptation, or 1.6 inches, falls during this time. The growing season for most plants is between April and September. In 2 years out of 10, the rainfall from April to September is less than 4.0 inches and the rainfall from July to September is more than 6.7 inches. Mean annual snowfall is 3.0 inches.

The last freezing temperature in spring at 32 degrees F or lower is later than April 10 for 5 years in 10. The first freezing temperature in fall is earlier than October 3 for 5 years in 10.

Vegetation

Tuzigoot National Monument is in Major Land Resource Unit 38-1AZ, Interior Chaparral (Austin, 1965). Creosotebush and catclaw acacia are the dominant plants.

Geology

The Verde Valley is a down-faulted Cenozoic sedimentary basin in the transitional zone of central Arizona. Structurally, it is a half-graben bounded on its southwest margin by the Verde Fault, a high angle normal fault along which the Black Hills have been uplifted. The Mogollon Rim, which marks the edge of the Colorado Plateau, and the Black Hills consist of Paleozoic sediments, most of which extend into the Grand Canyon. The Verde Valley is filled with a much younger sediment called the Verde Formation. This formation has an area of approximately 295 square miles. It extends in length from about 10 miles north of Clarkdale to 10 miles south of Camp Verde, and it is about 9 miles in width from Jerome to the Mogollon Rim near Sedona. The ridge upon which the pueblo is located is part of this formation. The Verde Formation is a lacustrine sediment with clastic, limestone, and evaporitic facies that were deposited when the Verde Valley became an internally drained closed basin as a result of structural subsidence and/or damming of the drainage exit by volcanic lava flows in the late Miocene.

Geologic History of the Verde Valley and the Verde Formation

Long before the Verde Valley was formed, the Laramide orogeny resulted in broad epeirogenic uplift of the entire state. The southern and central parts of the state were higher than the northern parts and had little topographic relief. The Colorado Plateau became an eroded pediment surface, gently sloping north toward the early tertiary lakes of Utah, New Mexico, and Colorado (Peirce and others, 1979). In the Oligocene, a tectonic event induced downcutting that gave rise to a southern Colorado Plateau edge escarpment (the Mogollon Rim) by mid-Miocene. The Verde River captured north- and east-flowing drainage and established drainageways to the southeast (Peirce and others, 1979).

Along the west and southwest of the Verde Valley is the major Verde Fault. The Verde Fault was active during Proterozoic, Laramide, and Basin and Range events (Ranney, 1988). After 10.1 Ma, renewed movement along the Verde Fault resulted in the uplift of the Black Hills (Waddell, 1972). The Verde Fault System shows evidence of more than 1,000 feet of movement during the Precambrian and post-Paleozoic rejuvenation; this evidence is documented by at least 2,300 feet of displacement along parts of the system. It is this uplift that has exposed the copper ores in the Jerome area at the surface.

Basalts and air fall tuff are interbedded with sediments of the Verde Formation (Ranney, 1988). The first radiometric date on a basalt interbedded with the Verde Formation was 5.7 Ma (McKee and Anderson, 1971). Fossil evidence dates the upper part of the Verde Formation as Pliocene (Nations and others, 1981).

In the late Pliocene the Verde River began to breach the natural barrier that induced lake formation and accumulation of sediments. Instead of deposition, erosion and fluvial downcutting began to be the primary geologic processes in the valley. Occasional short periods of no downcutting and minor deposition have resulted in the formation of stream terraces. Seven distinct levels of stream terraces have been identified for the Verde River. These terraces range in age from late Pliocene to Holocene.

Stratigraphy of the Verde Formation

The Basal Conglomerate

The Verde Formation unconformably overlies the Pennsylvanian-Permian Supai Formation in the eastern part of the Verde Valley. In the western part of the valley it rests unconformably on the Miocene Hickey Basalt. The contact between the Verde and Supai Formations is marked by the basal conglomerate of the Verde Formation, which may contain clasts of the Supai Formation, Kaibab Limestone, Coconino Sandstone, and basalt. The basal conglomerate is primarily on the periphery of the valley and does not occur in the survey area.

The Mudstone Facies

The Mudstone Facies ranges from 13 to 60 meters in thickness and is composed of nonindurated, gypsiferous, varicolored "mudrock," which is actually a silty clay. All of these materials, even when they are 99 percent carbonate, are soft and friable when dry. This unit is as far north as the Clemenceau Airport (Twenter and Metzger, 1963) and may extend as far north as the Clarkdale Smelter (Jenkins, 1923). It is exposed in the south-central part of the valley along both sides of the Verde River.

The presence of gypsum and other evaporites suggests that the Pliocene lake was at times very shallow and was occasionally subjected to almost complete desiccation (Twenter and Metzger, 1963). Waddell (1972) suggests that the conditions may have ranged between a shallow wide lake covering the whole valley to only a river meandering across carbonate mud flats. Cassell (1980) even suggests the possibility that there may have been a physical barrier between the evaporitic-saline lakes and the more fresh-water limestone lakes, the implication being that there may have been several smaller lakes at times. There is no indication that the Mudstone Facies occurs in the survey area.

The Interbedded Member

The Interbedded Member directly overlies the basal conglomerate member. Limestones within the interbedded member are typically 50 to 200 centimeters thick, are white to light pink, do not contain megascopically recognizable fossils, and form prominent ledges in the slopes of clastic rocks. The clastic rock units are generally 3 to 5 meters thick. The bulk of the clastic rocks are silts and sands with great spatial variation. The contacts between the limestones and the clastic rocks are sharp with no transition between adjacent strata. Localized conglomeratic lenses also occur. These lenses probably represent stream channel deposits.

The light pink of the rocks and the iron oxide staining suggest that the bulk of the Verde Formation clastic rocks are the result of reworking Supai sediments. The presence of zircon and tourmaline suggests that some of the source rocks were from the Precambrian rocks of the Black Hills (Cassell, 1980).

The Interbedded Member occurs in the survey area. It makes up the lower part of the ridge upon which the pueblo is located. It is also visible in the form of pink strata in the lower part of the cliffs to the east and northeast of the marsh.

The Limestone Member

The Limestone Member is a sequence of thinly to massively bedded limestones with only clastic rocks consisting of a few mudstones that are 5 to 10 centimeters thick. These limestones are generally white and form steep cliffs and ledges.

The skeletal grains consists of ostracods, gastropods, and bivalves. Nonskeletal grains identified include plant fragments and algal structures, oncolites, pellets, lumps, intraclasts, and calcispheres (Cassell, 1980). Fossil evidence suggests that the limestones were precipitated by blue-green algae during periods when the basin was inundated. The Interbedded Member represents the cyclic nature of inundation and clastic sedimentation. The upper limestone member represents a period of minimal clastic sedimentation when water depths may have reached a few meters (Cassell, 1980).

The Limestone Member occurs above the Interbedded Member and is visible as the white rocks in the upper part of the cliffs to the east and northeast of the marsh. It also occurs in the ridge upon which the pueblo is located.

Formation of the Soils

This section describes the processes of soil formation and relates the major factors of soil formation to the soils in the survey area.

Processes of Soil Formation

Soils are dynamic, natural bodies on the earth's surface that are capable of supporting terrestrial plants. They are composed of mineral and organic constituents as well as dilute solutions, gaseous mixtures, and micro-organisms. Soils are dynamic in that they exist as the result of a combination of processes occurring in the environment and they respond to changes in the environment. Some responses are immediate, such as water content and microbial activity after a rain. Some responses, such as the development of soil morphology, may not become apparent until after a great deal of time has elapsed.

Differences in soil morphology are expressed by differences in horizontal layers in the soil. These layers are called horizons. Pedogenic soil horizons form primarily as the result of eluviation and illuviation. Eluviation is a process by which materials are leached out of a horizon by infiltrating water. Illuviation takes place where these materials have accumulated, below the surface, as the result of deposition from the leaching water. The soil materials on the surface and close to the surface are the most susceptible to being leached by water. These horizons lose clay, calcium carbonate, and other materials that were originally in the sediment at the time of deposition. If conditions are suitable, organic matter will accumulate in surface horizons as the result of plant growth and decomposition. Sometimes calcareous dust and other materials are deposited on the soil surface as windblown material. These materials can also be leached out of surface horizons. As materials are leached out of the surface horizons, they accumulate at various depths in the soil profile below the surface. Thus, clay, calcium carbonate, and other materials accumulate in the subsoil in much higher concentrations than were present in the original sediment. These zones of leaching and accumulation define pedogenic soil horizons and determine how the soil is classified. Important pedogenic soil horizons are defined in the Glossary.

Factors of Soil Formation

Five major environmental factors affect soil formation. These factors are parent material, climate, living organisms, topography, and time. Tremendous diversity exists in soil morphology as a result of unique combinations of these soil-forming factors. Soil horizons are constantly forming or changing in response to these environmental factors over time. All of the soil-forming factors are connected, and no single factor alone completely determines a soil property.

Parent Material

Parent material is the mineral and organic material in which soils form. It can be derived in place from weathered bedrock or transported by wind, water, or gravity. The influence of parent material is accounted for in soil taxonomy by mineralogy and particle-size classes. Criteria for each class are defined in "Soil Taxonomy" (USDA, 1999).

Residuum is the unconsolidated mineral material that accumulates in place as bedrock disintegrates. The kind of rock from which the residuum has weathered greatly determines the properties and characteristics of the soil that forms. Residuum derived from sandstone typically has large amounts of sand. Parent materials derived from shale have a high content of clay and a low content of sand. Many types of shale may contain large amounts of sodium, gypsum, or sulphur-bearing minerals. These parent materials can cause many problems for all kinds of soil uses. Parent material consisting of basalt rocks typically results in soils that have a large content of clay. Residuum derived from limestone rocks has varying amounts of clay, depending on the composition of the rock.

Alluvium is unconsolidated sediment deposited by water. These materials include deposits made by rivers, creeks, intermittent streams, and materials at the base of mountains forming alluvial fans, fan terraces, and bajadas.

Colluvium is material transported by gravity. Materials sloughed downhill as the result of landslides are an example of colluvium. On some steep mountain slopes, materials slowly creep downhill even though they may be covered by abundant vegetation. Even trees may be bent downslope as the result of soil creep.

Eolian materials are materials transported by wind. Sand dunes are examples of eolian deposits.

Most of the map units in the survey area consist of soils that formed in alluvium. Penthouse soils, for example, formed in alluvium on stream terraces. Tombstone and Stronghold soils formed in alluvium on fan terraces. Most of these soils are very deep. Pagesprings soils formed in the Limestone Member of the Verde Formation. These soils are very shallow to limestone bedrock. Blancoverde soils formed in the Interbedded Member of the Verde Formation. They are shallow to soft sandstone.

Climate

Climate, past and present, has a strong influence on soil formation. Temperature and moisture affect the weathering of parent material, the activity of micro-organisms, and the release, leaching, and accumulation of nutrients. They also affect the plant community growing on the soil, which in turn influences soil development. Wind and water can transport soil material over long distances. Solar radiation affects soil moisture retention, temperature, and oxidation of surface organic matter. In general, the intensity of the weathering processes increases with increasing temperature and moisture.

Soil classification includes categories based on the temperature and moisture regime of the areas in which the soils occur. A soil temperature regime is based on the mean annual temperature of the soil at a depth of 50 centimeters. If bedrock or another hard layer is at a depth of less than 50 centimeters, then the soil temperature regime is based on the average temperature at the top of the bedrock or other hard layer. The average annual soil temperature in the survey area is about 2 degrees warmer than the average annual air temperature. The soils in the survey area have a thermic soil temperature regime, which means that the mean annual soil temperature is not lower than 15 degrees C or higher than 22 degrees C.

Soil moisture regimes are based on the amount of time the soil profile is moist and the time of year that rainfall occurs. Generally, if the soil is dry most of the year in most years, the soil has an aridic moisture regime. If the soil is frequently moist in most years and the rainfall occurs mostly during the growing season, the soil has an ustic moisture regime. Intergrades are allowed, such as an ustic-aridic moisture regime. Moisture regimes are defined in "Soil Taxonomy" (USDA, 1999). The mean soil temperature and the amount of precipitation are given for each soil in the section "Detailed Soil Map Units."

The present climate of the Tuzigoot National Monument is semi-arid. Most of the precipitation occurs from July through September from convection storms during the monsoon season. The soil moisture regime in the survey area is ustic-aridic. This regime is determined by estimating the number of days that the soil is moist at certain depths.

Living Organisms

Living organisms that influence soil development include soil micro-organisms as well as plants and animals. Within the soil, the life processes of bacteria and fungi decompose organic matter and minerals to release carbon dioxide, nitrogen, and other essential nutrients to plants. Insects and worms burrow into the soil, redistributing soil material and creating channels for air and water movement. At the soil surface, animals trample and mix soil material, add and bury organic debris, and burrow into the ground.

Plants are the major influence of living organisms on soil formation. They provide a source of organic matter, create pores and channels with rooting networks, and reduce the effects of erosion and surface runoff. The decomposed residue of these plants also influences physical and chemical soil properties.

Distinct native plant communities occur in the survey area in riparian areas, on stream terraces and fan terraces, and on rocky ridges. These distinct communities are the result of moisture availability, rooting depth, and chemical characteristics of the soil. Because they are very droughty, Penthouse, Tombstone, and Stronghold soils support mainly creosotebush and catclaw acacia. The driest soils in the survey area are the Pagesprings and Blancoverde soils, which are on the ridge upon which the pueblo was built. These soils are shallow to the Verde Formation. Runoff in areas of these soils is heavy because of the steep slopes, and the plant community consists of species that are tolerant of extremely dry conditions.

Topography

Topography influences soil development through its effect upon water movement and on the stability of soil material. Steep slopes increase the rate of surface runoff and the hazard of water erosion. Soils on steep and very steep slopes are commonly unstable, and erosion by water occurs faster than the processes of soil formation. Soils on steep slopes are commonly shallow and have poorly developed soil horizons. Pagesprings and Blancoverde soils are examples.

Soils in the less sloping areas tend to be more stable and develop distinct soil horizons over time. Surface runoff collects in level and concave areas from adjoining uplands, where organic matter and sediments accumulate. In these areas of alluvial deposition, the surface horizons are somewhat thicker and higher in organic matter and may form a mollic epipedon. Penthouse soils are examples of soils that formed on a stable surface. These soils have well developed horizons of clay and calcium carbonate accumulation. Such horizon development takes place only over a long period of time.

Time

Time as a soil-forming factor refers to the period of time during which parent material has been in place and has been influenced by the other soil-forming factors. Generally, the more stable a soil is, the older it is and the more developed its morphology. For example, unprotected soils on steep slopes and soils on active flood plains are unstable and subject to erosion; therefore, these soils generally are young soils. They do not have many, if any, pedogenic soil horizons.

Penthouse soils are examples of very old soils in the survey area. These soils formed in alluvium on stream terraces. They have horizons containing a high content of clay and calcium carbonate. These horizons formed as the result of pedogenic processes over long periods of time.

Most soils result from the interaction of all five of the soil-forming factors. Some soils on the modern landscape actually formed under different climatic or vegetative conditions of the past. The diversity of soil types in the survey area expresses the complexity of the environmental factors that influenced their development.

How This Survey Was Made

This survey was made to provide information about the soils and miscellaneous areas in the survey area. The information includes a description of the soils and miscellaneous areas and their location and a discussion of their suitability, limitations, and management for specified uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of native plants growing on the soils; and the kinds of bedrock. They dug 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 biological activity.

The soils in the survey area occur in a pattern that is related to the geology, landform, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils in the survey area and relating their position to specific segments of the landform, 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 a considerable degree of accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. 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.

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, reaction, 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.

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 predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict 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, fields, roads, and rivers, all of which help in locating boundaries accurately.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories, or taxons. 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 1 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Twelve 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 Aridisol.

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 Argids (*Arg,* a reference to the accumulation of clay in the profile, plus *ids,* from Aridisol).

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 Calciargids (*Calci,* meaning an accumulation of calcium carbonate in the profile, plus *argids*, the suborder of the Aridisols that has an accumulation of clay in the profile).

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. An example is Ustic Calciargids.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, 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 fine, mixed, thermic Ustic Calciargids.

SERIES. The series consists of soils that have similar horizons in their profile. The texture of the surface layer or of the substratum can differ within a series. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. If there is a significant difference in one or several of these characteristics that influences use and management, then a different series is recognized. The Penthouse series is a soil series in this survey area.

Detailed Soil Map Units

The map units delineated on the detailed soil map in this survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this section, along with the map, can be used to determine the suitability and potential of a unit for specific uses. They also can be used to plan the management needed for those uses.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. 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 other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some "included" areas that belong to other taxonomic classes.

Most included soils have properties 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, or similar, inclusions. They may or may not be mentioned in the map unit descriptions. Other included soils and miscellaneous areas, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, inclusions. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the map. The included areas of contrasting soils or miscellaneous areas are mentioned in the map unit descriptions.

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

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives some of the important properties and characteristics of the map unit components.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, 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, slope, stoniness, salinity, 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 map are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Tombstone very gravelly sandy loam is a phase of the Tombstone series.

The map units in this survey are made up of two or more major soils. These map units are called complexes. A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Penthouse-Tombstone complex, 2 to 25 percent slopes, is an example.

Table 2 gives the acreage and proportionate extent of each map unit. Other tables give properties of the soils and the limitations, capabilities, and potentials for some specific uses. The Glossary defines many of the terms used in describing the soils.

In each map unit description, a pedon, a small three-dimensional area of soil, that is typical of the associated soil series in the survey area is described. These descriptions are called taxonomic unit descriptions. The detailed description of each soil horizon follows standards in the "Soil Survey Manual" (USDA, 1993). Many of the technical terms used in the descriptions are defined in "Soil Taxonomy" (USDA, 1999). Unless otherwise stated, matrix colors in the descriptions are for dry soil. Following the pedon description are selected soil properties and qualities and a description of the range of important characteristics of the soils in the taxonomic unit.

Map Unit Descriptions

528—Pagesprings-Blancoverde complex, 3 to 60 percent slopes

Setting

Landform: Hills
Position on the landform: Pagesprings—summits and ledges; Blancoverde—side slopes
Flooding: None
Slope range: Pagesprings—3 to 15 percent; Blancoverde—15 to 60 percent
Elevation: 3,500 to 4,500 feet
Mean annual precipitation: 12 to 14 inches
Mean annual soil temperature: 62 to 65 degrees F
Frost-free period: 180 to 220 days

Composition

Pagesprings and similar soils: 65 percent
Blancoverde and similar soils: 25 percent
Contrasting inclusions: 10 percent
Rock outcrop
Similar inclusions:
Very shallow, loamy soils that have less than 35 percent rock fragments in the profile

Taxonomic Unit Description

Pagesprings

Classification: Loamy-skeletal, carbonatic, thermic Lithic Ustic Haplocalcids
Surface features: The surface is partially covered by 35 percent gravel and 5 percent cobbles.

A—0 to 1 inch; brown (7.5YR 5/4) very gravelly loam, dark brown (7.5YR 3/4) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; few very fine roots; few very fine and fine tubular pores; 35 percent gravel, 5 percent cobbles; violently effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bk1—1 to 5 inches; brown (7.5YR 5/4) very cobbly silt loam, dark brown (7.5YR 3/4) moist; moderate fine subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine roots; common very fine tubular pores; 20 percent gravel, 25 percent cobbles; few seams and filaments of calcium carbonate; violently effervescent; moderately alkaline (pH 8.3); abrupt smooth boundary.

Bk2—5 to 7 inches; pinkish white (7.5YR 8/2) very cobbly loam, brown (7.5YR 5/4) moist; moderate fine subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common very fine roots; few very fine tubular pores; 15 percent gravel, 25 percent cobbles; common moderately thick coatings of calcium carbonate on rock fragments; calcium carbonate is disseminated throughout; violently effervescent; moderately alkaline (pH 8.4); abrupt irregular boundary.

R—7 inches; white (10YR 8/1) limestone.

Blancoverde

Classification: Fine-loamy, mixed (calcareous), thermic Ustic Torriorthents

A1—0 to 3 inches; light brown (7.5YR 6/4) very stony loam, brown (7.5YR 5/4) moist; moderate fine subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular pores; 5 percent cobbles, 40 percent stones; violently effervescent; moderately alkaline (pH 8.4); clear smooth boundary.

A2—3 to 10 inches; light brown (7.5YR 6/4) very cobbly silt loam, brown (7.5YR 5/4) moist; moderate coarse subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; common very fine to medium roots; common very fine to medium tubular pores; 20 percent gravel, 30 percent cobbles; violently effervescent; moderately alkaline (pH 8.4); clear smooth boundary.

Cdk1—10 to 30 inches; light reddish brown (5YR 6/4) loam, yellowish red (5YR 4/6) moist; massive; hard, friable, slightly sticky and slightly plastic; common very fine to medium and few coarse roots; common very fine tubular pores; 10 percent gravel; few coarse soft masses of calcium carbonate; violently effervescent; moderately alkaline (pH 8.4); clear smooth boundary.

Cdk2—30 to 50 inches; reddish yellow (5YR 6/6) loam, reddish brown (5YR 5/4) moist; massive; hard, friable, sticky and plastic; common very fine to medium and few coarse roots; common very fine tubular pores; common fine seams of calcium carbonate; violently effervescent; moderately alkaline (pH 8.4); clear smooth boundary.

Cdk3—50 to 60 inches; reddish yellow (7.5YR 7/6) loam, yellowish red (5YR 4/6) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few very fine and medium roots; few fine and medium tubular pores; 10 percent gravel; violently effervescent; moderately alkaline (pH 8.4).

Soil Properties and Qualities

Pagesprings

Parent material: Residuum derived from limestone of the Verde Formation
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: 0.6 inch to 2.0 inches per hour
Available water capacity (total): 0.1 to 0.8 inch
Potential rooting depth: 7 to 18 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Slight
Shrink-swell potential: Low
Calcium carbonate content: 40 to 60 percent below a depth of 2 inches
Corrosivity: To steel (uncoated)—high; to concrete—low
Content of rock fragments: 40 to 75 percent
Content of clay: 18 to 27 percent
Depth to bedrock: 7 to 18 inches

A horizon:
Hue—7.5YR or 10YR
Value—3 to 6 dry, 4 or 5 moist
Chroma—2 to 4 dry or moist
Content of organic matter—1 to 2 percent
Calcium carbonate equivalent—30 to 50 percent

Bk horizon:
Hue—7.5YR or 10YR
Value—3 to 6 dry, 4 or 5 moist
Chroma—2 to 4 dry or moist
Content of organic matter—0.1 to 0.5 percent
Calcium carbonate equivalent—40 to 60 percent
Texture—silt loam, sandy loam, or loam

Blancoverde

Parent material: Colluvium and residuum derived from lacustrine sediments of the Verde Formation
Depth class: Deep
Drainage class: Well drained
Permeability: 0.06 to 0.20 inch per hour
Available water capacity (total): 7 to 11 inches
Potential rooting depth: 40 to 60 inches
Runoff: Rapid or very rapid
Hazard of water erosion: Moderate or severe
Hazard of wind erosion: Slight
Shrink-swell potential: Low
Calcium carbonate content: 10 to 40 percent below a depth of 14 inches
Corrosivity: To steel (uncoated)—high; to concrete—low
Content of rock fragments: 0 to 35 percent gravel in any one horizon; averages less than 35 percent in the control section
Depth to bedrock: 40 to 58 inches
Depth to Cd horizons: 5 to 20 inches

A horizon:
Hue—5YR, 7.5YR, or 10YR
Value—5 or 6 dry, 4 or 5 moist
Chroma—3 or 4 dry or moist
Content of organic matter—0.5 to 1.0 percent
Calcium carbonate equivalent—20 to 40 percent

Cdk horizon:
Description—dense sediments that are intergrades between soft sediment (C material) and soft bedrock (Cr material); these naturally compacted sediments have been subjected to a slow reduction in volume and increase in density from lithostatic pressure in the geologic past. These materials easily break down in water, and roots can penetrate when the soils are moist. The materials are root restrictive when dry.
Hue—7.5YR, 5YR
Value—5 to 7 dry, 4 or 5 moist
Chroma—4 to 6 dry or moist
Content of organic matter—0.1 to 0.5 percent
Calcium carbonate equivalent—10 to 40 percent
Electrical conductivity—0 to 2 dS/m
Content of gypsum—0 to 15 percent
Texture—loam, silt loam, clay loam, sandy clay loam, or sandy loam

Biotic Components

Present vegetation: Pagesprings—desert needlegrass, needleandthread, creosotebush, spike dropseed, bush muhly, sideoats grama, Indian ricegrass, blue threeawn, red threeawn, fluffgrass, slim tridens, banana yucca, range ratany, plains blackfoot, twinleaf senna; Blancoverde—New Mexico feathergrass, sideoats grama, black grama, slim tridens, hairy tridens, purple threeawn, needleandthread, canotia, algerita, mesquite, broom snakeweed, pricklypear cactus, wait-a-bit mimosa, Utah juniper, range ratany, cliffrose, indigo bush

Interpretive Groups

Land capability classification: Pagesprings—VIIs, nonirrigated; Blancoverde—VIIe, nonirrigated
Major Land Resource Unit: 38-1AZ, Interior Chaparral
Ecological site: Pagesprings—038XA120AZ, Limestone Upland, 12- to 16-inch precipitation zone; Blancoverde—038XA126AZ, Limy Slopes, 12- to 16-inch precipitation zone
Hydrologic group: D

538—Tombstone-Stronghold complex, 2 to 10 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Slope range: 2 to 10 percent
Elevation: 3,300 to 3,600 feet
Mean annual precipitation: 12 to 14 inches
Mean annual soil temperature: 62 to 65 degrees F
Frost-free period: 180 to 220 days

Composition

Tombstone and similar soils: 45 percent
Stronghold and similar soils: 40 percent
Contrasting inclusions: 15 percent
- Very gravelly sandy soils
- Soils in channels that are subject to common flooding
- Rock outcrop
- Soils that are shallow to hard bedrock

Similar inclusions:
- Soils that have slopes of more than 10 percent

Taxonomic Unit Description

Tombstone

Classification: Loamy-skeletal, mixed, thermic Ustic Haplocalcids
Surface features: The surface is partially covered by 20 percent gravel, 15 percent cobbles, and 5 percent stones.

A—0 to 4 inches; pale brown (10YR 6/3) very gravelly sandy loam, dark yellowish brown (10YR 4/4) moist; weak fine subangular blocky structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; few very fine roots; few very fine irregular and tubular pores; 10 percent cobbles, 30 percent gravel; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bk1—4 to 20 inches; brown (7.5YR 5/4) very gravelly sandy loam, brown (7.5YR 4/4) moist; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; common very fine roots; few very fine irregular and tubular pores; 5 percent cobbles, 35 percent gravel; common calcium carbonate filaments; common thin calcium carbonate coatings on undersides of rock fragments; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bk2—20 to 40 inches; light brown (7.5YR 6/4) extremely gravelly coarse sandy loam, brown (7.5YR 5/4) moist; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; few very fine roots; few very fine irregular and tubular pores; 5 percent cobbles, 60 percent gravel; many calcium carbonate filaments; common thin calcium carbonate coatings on undersides of rock fragments; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bk3—40 to 60 inches; white (7.5YR 8/1) very gravelly loamy coarse sand, light brown (7.5YR 6/4) moist; massive; soft, very friable, nonsticky and nonplastic; few very fine roots; few very fine irregular and tubular pores; 5 percent cobbles, 35 percent gravel; common thin calcium carbonate coatings on undersides of rock fragments; violently effervescent; moderately alkaline (pH 8.2).

Stronghold

Classification: Coarse-loamy, mixed, thermic Ustic Haplocalcids
Surface features: The surface is partially covered by 35 percent gravel and 5 percent cobbles.

A—0 to 3 inches; brown (7.5YR 5/4) very gravelly fine sandy loam, dark brown (7.5YR 3/4) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine roots; few fine tubular pores; 40 percent gravel; strongly effervescent; moderately alkaline (pH 8.4); abrupt smooth boundary.

Bk1—3 to 25 inches; light brown (7.5YR 6/4) loam, strong brown (7.5YR 4/6) moist; strong medium subangular blocky structure; hard, friable, sticky and plastic; common very fine and few medium and fine roots; few fine tubular pores; common seams of calcium carbonate in the upper part gradually increasing to many in the lower part; common moderately thick coatings of calcium carbonate on the undersides of rock fragments; 20 percent gravel, 5 percent cobbles; violently effervescent; strongly alkaline (pH 8.6); clear smooth boundary.

Bk2—25 to 60 inches; light brown (7.5YR 6/3) loam, brown (7.5YR 5/4) moist; massive; hard, firm, very sticky and plastic; few very fine to medium roots; few fine tubular pores; many distinct seams of calcium carbonate; common thick coatings of calcium carbonate on the undersides of rock fragments; violently effervescent; strongly alkaline (pH 8.6).

Soil Properties and Qualities

Tombstone

Parent material: Mixed alluvium
Depth class: Very deep
Drainage class: Well drained
Permeability: 2.0 to 6.0 inches per hour
Available water capacity (total): 1 to 4 inches
Potential rooting depth: Greater than 60 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Slight
Shrink-swell potential: Low
Calcium carbonate content: 15 to 40 percent below a depth of 1 inch
Corrosivity: To steel (uncoated)—high; to concrete—low
Content of clay: 10 to 18 percent
Content of rock fragments: Averages 35 to 60 percent gravel and 0 to 10 percent cobbles

A horizon:
Hue—7.5YR or 10YR
Value—5 to 7 dry, 2 to 4 moist
Chroma—3 or 4 dry or moist
Content of organic matter—0.5 to 1.0 percent
Calcium carbonate equivalent—5 to 10 percent

Bk horizon:
Hue—7.5YR or 10YR
Value—5 to 7 dry, 4 to 6 moist
Chroma—3 or 4 dry or moist
Content of organic matter—0.1 to 0.5 percent
Calcium carbonate equivalent—15 to 40 percent
Texture—sandy loam, coarse sandy loam, or loamy coarse sand

Stronghold

Parent material: Mixed alluvium
Depth class: Very deep
Drainage class: Well drained
Permeability: 0.2 to 0.6 inch per hour
Available water capacity (total): 6 to 11 inches
Potential rooting depth: Greater than 60 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Slight
Shrink-swell potential: Low
Calcium carbonate content: 20 to 40 percent below a depth of 2 inches
Corrosivity: To steel (uncoated)—high; to concrete—low
Content of clay: 12 to 18 percent
Content of rock fragments: 0 to 30 percent gravel
Depth to calcic horizon: 1 to 2 inches

A horizon:
Hue—7.5YR or 10YR
Value—5 to 7 dry, 4 to 6 moist
Chroma—3 or 4 dry or moist
Content of organic matter—0.5 to 1.0 percent
Effervescence—strongly effervescent to violently effervescent
Calcium carbonate equivalent—5 to 25 percent

Bk horizon:
Hue—7.5YR or 10YR
Value—5 to 8 dry, 4 to 7 moist
Chroma—3 or 4 dry or moist
Content of organic matter—0.1 to 0.5 percent
Calcium carbonate equivalent—20 to 40 percent
Texture—fine sandy loam, sandy loam, or loam

Biotic Components

Present vegetation: New Mexico feathergrass, sideoats grama, black grama, slim tridens, hairy tridens, purple threeawn, needleandthread, canotia, algerita, mesquite, broom snakeweed, pricklypear cactus, wait-a-bit mimosa, Utah juniper, range ratany, cliffrose, indigo bush

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 38-1AZ, Interior Chaparral
Ecological site: 038XA126AZ; Limy Slopes, 12- to 16-inch precipitation zone
Hydrologic group: Tombstone—B; Stronghold—C

541—Penthouse-Tombstone complex, 2 to 25 percent slopes

Setting

Landform: Stream terraces
Position on the landform: Penthouse—summits; Tombstone—side slopes and shoulders
Flooding: None
Slope range: Penthouse—2 to 10 percent; Tombstone—2 to 25 percent
Elevation: 3,400 to 3,600 feet

Mean annual precipitation: 12 to 14 inches
Mean annual soil temperature: 62 to 65 degrees F
Frost-free period: 180 to 220 days

Composition

Penthouse and similar soils: 60 percent
Tombstone and similar soils: 30 percent
Contrasting inclusions: 10 percent
Rock outcrop
Soils that are shallow to a hardpan
Similar inclusions:
Soils that have a gravelly surface layer

Taxonomic Unit Description

Penthouse

Classification: Fine, mixed, thermic Ustic Calciargids
Surface features: The surface is partially covered by 10 percent gravel.

A—0 to 2 inches; brown (7.5YR 4/4) fine sandy loam, dark brown (7.5YR 3/4) moist; weak moderate subangular blocky structure parting to moderate fine subangular blocky; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine and few fine tubular pores; noneffervescent; moderately alkaline (pH 8.2); abrupt smooth boundary.

Bt1—2 to 26 inches; yellowish red (5YR 4/6) sandy clay, reddish brown (7.5YR 4/4) moist; strong medium subangular blocky structure; slightly hard, very friable, sticky and plastic; common fine and very fine roots; few fine and very fine tubular pores; common faint clay films on faces of peds; noneffervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bk—26 to 60 inches; light brown (7.5YR 6/4) sandy loam, brown (7.5YR 5/4) moist; massive; hard, firm, nonsticky and nonplastic; few very fine roots; common very fine irregular pores; common hard bodies that are moderately cemented with calcium carbonate; 10 percent gravel; violently effervescent; moderately alkaline (pH 8.2).

Tombstone

Classification: Loamy-skeletal, mixed, thermic Ustic Haplocalcids
Surface features: The surface is partially covered by 20 percent gravel, 15 percent cobbles, and 5 percent stones.

A—0 to 2 inches; pale brown (10YR 6/3) very gravelly sandy loam, dark yellowish brown (10YR 4/4) moist; weak fine subangular blocky structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; few very fine roots; few very fine irregular and tubular pores; 10 percent cobbles, 30 percent gravel; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bk1—2 to 18 inches; brown (7.5YR 5/4) very gravelly sandy loam, brown (7.5YR 4/4) moist; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; common very fine roots; few very fine irregular and tubular pores; 5 percent cobbles, 35 percent gravel; common calcium carbonate filaments; common thin calcium carbonate coatings on undersides of rock fragments; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bk2—18 to 45 inches; light brown (7.5YR 6/4) extremely gravelly sandy loam, brown (7.5YR 5/4) moist; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; few very fine roots; few very fine irregular and tubular pores; 5 percent cobbles, 60 percent gravel; many calcium carbonate filaments; common thin calcium carbonate coatings on undersides of rock fragments; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bk3—45 to 60 inches; white (7.5YR 8/1) very gravelly loamy coarse sand, light brown (7.5YR 6/4) moist; single grain; loose, nonsticky and nonplastic; few very fine roots; few very fine irregular and tubular pores; 5 percent cobbles, 40 percent gravel; common thin calcium carbonate coatings on undersides of rock fragments; violently effervescent; moderately alkaline (pH 8.2).

Soil Properties and Qualities

Penthouse

Depth class: Very deep
Drainage class: Well drained
Permeability: 0.06 to 0.2 inch per hour
Available water capacity (total): 5 to 9 inches
Parent material: Mixed alluvium
Content of clay: 25 to 50 percent
Content of rock fragments: 0 to 30 percent
Depth to argillic horizon: 1 to 5 inches
Depth to calcic horizon: 20 to 40 inches

A horizon:
Hue—5YR or 7.5YR
Value—4 to 6 dry or moist
Chroma—3 to 6 dry or moist
Content of organic matter—0.5 to 1.0 percent
Reaction—slightly alkaline or moderately alkaline
Effervescence—noneffervescent to strongly effervescent

Calcium carbonate equivalent—0 to 10 percent

Bt horizon:
Hue—2.5YR or 5YR
Value—5 to 7 dry, 4 to 6 moist
Chroma—3 or 4 dry or moist
Content of organic matter—0.1 to 0.5 percent
Reaction—slightly alkaline or moderately alkaline
Calcium carbonate equivalent—0 to 10 percent
Texture—clay loam, clay, sandy clay loam, or sandy clay

Bk horizon:
Hue—7.5YR or 10YR
Value—5 to 8 dry, 4 to 7 moist
Chroma—2 to 4 dry or moist
Content of organic matter—0.1 to 0.5 percent
Calcium carbonate equivalent—15 to 40 percent
Texture—sandy loam or coarse sandy loam

Tombstone

Parent material: Mixed alluvium
Depth class: Very deep
Drainage class: Well drained
Permeability: 2.0 to 6.0 inches per hour
Available water capacity (total): 2 to 4 inches
Potential rooting depth: Greater than 60 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Slight
Shrink-swell potential: Low
Calcium carbonate content: 15 to 40 percent below a depth of 1 inch
Corrosivity: To steel (uncoated)—high; to concrete—low
Content of clay: 10 to 18 percent
Content of rock fragments: Averages 35 to 60 percent gravel and 0 to 10 percent cobbles

A horizon:
Hue—7.5YR or 10YR
Value—5 to 7 dry, 2 to 4 moist
Chroma—3 or 4 dry or moist
Content of organic matter—0.5 to 1.0 percent
Calcium carbonate equivalent—5 to 10 percent

Bk horizon:
Hue—7.5YR or 10YR
Value—5 to 7 dry, 4 to 6 moist
Chroma—3 or 4 dry or moist
Content of organic matter—0.1 to 0.5 percent
Calcium carbonate equivalent—15 to 40 percent
Texture—sandy loam, coarse sandy loam, or loamy coarse sand

Biotic Components

Present vegetation: Penthouse—tobosa, sideoats grama, bottlebrush squirreltail, western wheatgrass, plains lovegrass, sand dropseed, curly mesquite, bush muhly, wait-a-bit mimosa, catclaw acacia, mesquite, shrubby buckwheat, desert ceanothus, skunkbush sumac, mariposa lily; Tombstone—New Mexico feathergrass, sideoats grama, black grama, slim tridens, hairy tridens, purple threeawn, needleandthread, canotia, algerita, mesquite, broom snakeweed, pricklypear cactus, wait-a-bit mimosa, Utah juniper, range ratany, cliffrose, indigo bush

Interpretive Groups

Land capability classification: Penthouse—VIs, nonirrigated; Tombstone—VIs, nonirrigated (2 to 15 percent), VIIe, nonirrigated (15 to 30 percent)
Major Land Resource Unit: 38-1AZ, Interior Chaparral
Ecological site: Penthouse—038XA103AZ, Clay Loam Upland, 12- to 16-inch precipitation zone; Tombstone—038XA126AZ, Limy Slopes, 12- to 16-inch precipitation zone
Hydrologic group: Penthouse—D; Tombstone—B

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of some soil 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 map. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics.

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 to characterize key soils.

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

Engineering Index Properties

Table 3 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.

In the table, *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 taxonomic unit under the heading "Detailed Soil Map Units."

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 about 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 (ASTM, 1993) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 1986).

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 in diameter and according to plasticity index, liquid limit, and organic matter content. Gravelly (G) and sandy (S) soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC. These soils have more than half of the material of individual grains visible to the naked eye. The W denotes an even distribution or wide range in grain sizes. If one grain size predominates, then P is used. For gravelly or sandy soils with a significant inclusion of fines, M is used for nonplastic or low plastic fines and C for plastic fines. If more than half of the individual grains are invisible to the naked eye, the soil is considered to be a silty (M) or clayey (C) soil. These soils are classified as ML, CL, MH, or CH. If the soil has a pronounced organic odor, then OL or OH is used. The letter L is used for soils that have a low liquid limit, and H is used for those with a high liquid limit. Soils classified as PT are highly organic (peat). Soils exhibiting engineering properties of two groups can have a dual classification, for example, SC-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 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.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches 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 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 4 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 the 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, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving 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. In the 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 and septic tank absorption fields.

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 retention of water and 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.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. Volume change is influenced by the amount and type of clay minerals in the soil.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

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.

Erosion factors are shown in the table as the K factor (Kw) and the T factor. 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 Revised Universal Soil Loss Equation (RUSLE) 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 (as much as 4 percent) and on soil structure and permeability. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

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 soils to wind erosion. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are as follows:

1. Coarse sands, sands, fine sands, and very fine sands.

2. Loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, ash material, and sapric soil material.

3. Coarse sandy loams, sandy loams, fine sandy loams, and very fine sandy loams.

4L. Calcareous loams, silt loams, clay loams, and silty clay loams.

4. Clays, silty clays, noncalcareous clay loams, and silty clay loams that are more than 35 percent clay.

5. Noncalcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material.

6. Noncalcareous loams and silt loams that are more than 20 percent clay and noncalcareous clay loams that are less than 35 percent clay.

7. Silts, noncalcareous silty clay loams that are less than 35 percent clay, and fibric soil material.

8. Soils that are not subject to wind erosion because of coarse fragments on the surface or because of surface wetness.

Water Features

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The hydrologic soil group for each map unit is listed in the map unit descriptions.

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 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.

Soil Features

Table 5 gives estimates of various soil features. The estimates are used in land use planning that involves engineering considerations.

A *restrictive layer* is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness and thickness of the restrictive layer, both of which significantly affect the ease of excavation. *Depth to top* is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

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 results in a severe hazard of corrosion. 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 also is expressed as *low, moderate,* or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

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 to prevent 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 behavioral 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 for predicting soil behavior.

Information in this section can be used to plan the use and management of soils as rangeland and as sites for parks and other recreational facilities. It can be used to identify the potentials and limitations of each soil for certain other 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 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, playgrounds, lawns, and trees and shrubs.

Land Capability Classification

The system of land capability classification used by the Natural Resources Conservation Service shows, in a general way, the suitability of soils for most kinds of agricultural field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, or for engineering purposes.

In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit (USDA, 1961). Only class and subclass are used in this survey.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, VIs. The letter *e* shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w, s,* or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

Generally, soils in capability classes I, II, III, and IV have a dependable supply of moisture from precipitation or irrigation that is adequate for the establishment of agricultural field crops. Because of limited precipitation in the survey area, irrigation is needed on most soils to supply sufficient moisture for plant growth. The limited precipitation, however, does not preclude the establishment of adapted species for rangeland reseeding or reclamation efforts on nonirrigated soils. Typically, a soil classified as Vw has a water table close enough to the surface for the establishment and growth of adapted plant species. A soil classified as VIc might have soil properties that would place it in class I or class II if it were irrigated. Therefore, a soil classified as VIc could be ideal for reseeding efforts if the timing of seasonal precipitation is taken into account during the planning process.

In this survey area, capability classes VI and VII are used for nonirrigated soils. The capability classification of each soil is given in the section "Detailed Soil Map Units."

Also given in the map unit descriptions are the major land resource unit and the ecological site for each map unit. Information regarding these interpretive groups is available at the local office of the Natural Resources Conservation Service.

Rangeland

In this soil survey, rangeland is considered a type of land rather than a kind of land use. If well managed, some woodland can produce enough understory vegetation to support grazing of livestock or wildlife, or both, without damage to the trees. Understory vegetation consists of grasses, forbs, shrubs, and other plants.

In areas that have similar climate and topography, differences in the kind and amount of vegetation produced on rangeland are closely related to the kind of soil. Effective management is based on the relationship between the soils and vegetation and water.

Table 6 shows, for each soil that supports rangeland vegetation suitable for grazing, the ecological site; the total annual production of vegetation in favorable, normal, and unfavorable years; the characteristic vegetation; and the average percentage of each species. An explanation of the column headings in table 6 follows.

An *ecological site* is a distinctive kind of rangeland that produces a characteristic natural plant community that differs from natural plant communities on other ecological sites in kind, amount, and proportion of range plants. The relationship between soils and vegetation was ascertained during this survey; thus, ecological sites generally can be determined directly from the soil map. Soil properties that affect moisture supply and plant nutrients have the greatest influence on the productivity of range plants. Soil reaction, salt content, and a seasonal high water table also are important.

Total production is the amount of vegetation that can be expected to grow annually on well managed rangeland or woodland understory that supports the potential natural plant community. Except for the overstory trees on woodland sites, it includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. It is expressed in pounds per acre of air-dry vegetation for favorable, normal, and unfavorable years. In a favorable year, the amount and distribution of precipitation and the temperature make growing conditions substantially better than average. In a normal year, growing conditions are about average. In an unfavorable year, growing conditions are well below average, generally because of low available soil moisture.

Dry weight is the total annual yield per acre of air-dry vegetation. Yields are adjusted to a common percent of air-dry moisture content. The relationship of green weight to air-dry weight varies according to such factors as exposure, amount of shade, recent rains, and unseasonable dry periods.

Characteristic vegetation—the grasses, forbs, and shrubs that make up most of the potential natural plant community on each soil—is listed by common name. Under *composition*, the expected percentage of the total annual production is given for each species making up the characteristic vegetation. The amount that can be used as forage depends on the kinds of grazing animals and on the grazing season.

Recreation

The soils of the survey area are rated in table 7 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 water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation also are important. Soils that are subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 7, 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 a combination of these.

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.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

Engineering

The information in tables 3, 4, and 5, along with the soil map, the soil descriptions, and other data provided in this survey, can be used by qualified personnel to make interpretations relating to building site development, sanitary facilities, and water management. 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 feet. 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 and local ordinances and regulations should be considered in planning, site selection, and project design.

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 feet 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 kinds 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 evaluate the potential of areas for residential and recreational site development; make preliminary estimates of construction conditions; evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; plan detailed onsite investigations of soils and geology; locate potential sources of gravel, sand, earthfill, and topsoil; plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

Building Site Development

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for building sites, utility lines, open ditches, and other purposes. The ease of digging, filling, and compacting is affected by the depth to bedrock, 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.

Sanitary Facilities

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Usually, only that part of the soil between depths of 24 and 72 inches is evaluated. Permeability, a high water table, depth to bedrock, and flooding affect absorption of the effluent. Large stones and bedrock 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 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. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Considered are slope, permeability, a high water table, depth to bedrock, flooding, large stones, and content of organic matter.

Excessive seepage resulting from rapid permeability in 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 and bedrock 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 should be considered.

Permeability, depth to bedrock, 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 landfills. Usually, only that part of the soil within a depth of about 6 feet is considered. Deeper trenches may have limitations beyond the depth of observation. Onsite investigation is needed.

Soil material is used to cover compacted solid waste in an area 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 wind erosion.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock or the water table to permit revegetation. The soil material used as the 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.

Water Management

Soil properties and site features affect design and maintenance of pond reservoir areas; embankments, dikes, and levees; and aquifer-fed excavated ponds.

Pond reservoir areas hold water behind a dam or embankment. Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. Soils are a source of material for embankment fill. It is assumed that soil layers will be uniformly mixed and compacted during construction. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

The properties that affect the ability of the natural soil to support an embankment may extend beyond the depth of observation. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, salts, or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, permeability of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the number of large stones affect the ease of excavation.

Other water management considerations involve drainage, irrigation, terraces and diversions, and grassed waterways.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, or sulphur.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock or to a cemented pan. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to control erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind erosion or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

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Glossary

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.

Alluvial fan. The fanlike deposit of a stream where it issues from a gorge upon a plain or of a tributary stream near or at its junction with its main stream.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Animal unit month (AUM). The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

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. In this survey, the capacity is expressed in inches for a 60-inch profile or to a limiting layer.

Backslope. The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bisequum. Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Canopy. The leafy crown of trees or shrubs. (See Crown.)

Canyon. A long, deep, narrow, very steep sided valley with high, precipitous walls in an area of high local relief.

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.

Catena. A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

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 material. Soil material that has, by volume, 15 to 35 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 channer.

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.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

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 textured soil. Sand or loamy sand.

Cobble (or cobblestone). A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Colluvium. Soil material or 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 establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil or miscellaneous areas 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 or miscellaneous areas are somewhat similar in all areas.

Concretions. Cemented bodies with crude internal symmetry organized around a point, a line, or a plane. They typically take the form of concentric layers visible to the naked eye. Calcium carbonate, iron oxide, and manganese oxide are common compounds making up concretions. If formed in place, concretions of iron oxide or manganese oxide are generally considered a type of redoximorphic concentration.

Conglomerate. A coarse grained, clastic rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Consistence, soil. Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the "Soil Survey Manual."

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 and 40 or 80 inches.

Corrosion. Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Crown. The upper part of a tree or shrub, including the living branches and their foliage.

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 grazing land for a prescribed period.

Depth, soil. Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

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 wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the "Soil Survey Manual."

Drainage, surface. Runoff, or surface flow of water, from an area.

Draw. A small stream valley that generally is more open and has broader bottom land than a ravine or gulch.

Duff. A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

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.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Ephemeral stream. A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.
Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.
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 pavement. A layer of gravel or stones that remains on the surface after fine particles are removed by sheet or rill erosion.

Escarpment. A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Synonym: scarp.

Extrusive rock. Igneous rock derived from deep-seated molten matter (magma) emplaced on the earth's surface.

Fan terrace. A relict alluvial fan, no longer a site of active deposition, incised by younger and lower alluvial surfaces.

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.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

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, or clay.

Flaggy soil material. Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone. A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Fluvial. Of or pertaining to rivers; produced by river action, as a fluvial plain.

Foothill. A steeply sloping upland that has relief of as much as 1,000 feet (300 meters) and fringes a mountain range or high-plateau escarpment.

Footslope. The position that forms the inner, gently inclined surface at the base of a hillslope. In profile, footslopes are commonly concave. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb. Any herbaceous plant not a grass or a sedge.

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.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Ground water. Water filling all the unblocked pores of the 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.

Hard bedrock. Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head out. To form a flower head.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

Hill. A natural elevation of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline; hillsides generally have slopes of more than 15 percent. The distinction between a hill and a mountain is arbitrary and is dependent on local usage.

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 uppercase letter represents the major horizons. Numbers or lowercase 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.

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, aluminum, or some combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A 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.

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 overlying soil material. 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, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties are depth to a seasonal high water table, the infiltration rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock. Rock formed by solidification from a molten or partially molten state. Major varieties include plutonic and volcanic rock. Examples are andesite, basalt, and granite.

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 capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

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

Intermittent stream. A stream, or reach of a stream, that flows for prolonged periods only when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Knoll. A small, low, rounded hill rising above adjacent landforms.

Landslide. The rapid downhill movement of a mass of soil and loose rock, generally when wet or saturated. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones (*in tables*). Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

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.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. The soil is not strong enough to support loads.

Marl. An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal amounts.

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. Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, or 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.

Mountain. A natural elevation of the land surface, rising more than 1,000 feet above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range.

Munsell notation. A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value of 6.6 to 7.3. (*See Reaction, soil.*)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low	less than 0.5 percent
Low	0.5 to 1.0 percent
Moderately low	1.0 to 2.0 percent
Moderate	2.0 to 4.0 percent
High	4.0 to 8.0 percent
Very high	more than 8.0 percent

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

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 movement of water through the soil.

Permeability. The quality of the soil that enables water or air to move through the profile. The rate at which a saturated soil transmits water is accepted as a measure of this quality. In soil physics, the rate is referred to as "saturated hydraulic conductivity," which is defined in the "Soil Survey Manual." In line with conventional usage in the engineering profession and with traditional usage in published soil surveys, this rate of flow continues to be expressed as "permeability." Terms describing permeability, measured in inches per hour, are as follows:

Extremely slow	0.0 to 0.01 inch
Very slow	0.01 to 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, such as slope, stoniness, and flooding.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, 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.

Plateau. An extensive upland mass with relatively flat summit area that is considerably elevated (more than 100 meters) above adjacent lowlands and separated from them on one or more sides by escarpments.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

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.

Potential plant community. See Climax vegetation.

Potential rooting depth (effective rooting depth). Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

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.

Range condition. The present composition of the plant community on a range site in relation to the potential natural plant community for that site. Range condition is expressed as excellent, good, fair, or poor on the basis of how much the present plant community has departed from the potential.

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.

Range site. An area of rangeland where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. A range site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other range sites in kind or proportion of species or total production.

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 degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid	less than 3.5
Extremely acid	3.5 to 4.4
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Moderately acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Slightly 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 generally is a few inches deep and not wide enough to be an obstacle to farm machinery.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

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-sized particles.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saprolite. Unconsolidated residual material underlying the soil and grading to hard bedrock below.

Saturation. Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

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.

Sequum. A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. 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.

Shoulder. The position that forms the uppermost inclined surface near the top of a hillslope. It is a transition from backslope to summit. The surface is dominantly convex in profile and erosional in origin.

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.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

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.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

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 in 100 feet of horizontal distance. In this survey, the following slope classes are recognized:

Nearly level	0 to 3 percent
Gently sloping or undulating	3 to 7 percent
Strongly sloping or rolling	7 to 15 percent
Moderately steep or hilly	15 to 25 percent
Steep	25 to 55 percent
Very steep	55 percent and higher

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Small stones (in tables). Rock fragments less than 3 inches (7.6 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soft bedrock. Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

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, in millimeters, of separates recognized in the United States are as follows:

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, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally, it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

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 grain* (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. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summit. The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

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."

Surface soil. The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus. Fragments of rock and other soil material accumulated by gravity at the foot of cliffs or steep slopes.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

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."

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope. The position that forms the gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

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.

Upland. Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Water bars. Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

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 a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow. The uprooting and tipping over of trees by the wind.

Tables

Table 1.--Classification of the Soils

Soil name	Classification
Blancoverde	Fine-loamy, mixed (calcareous), thermic Ustic Torriorthents
Pagesprings	Loamy-skeletal, carbonatic, thermic Lithic Ustic Haplocalcids
Penthouse	Fine, mixed, thermic Ustic Calciargids
Stronghold	Coarse-loamy, mixed, thermic Ustic Haplocalcids
Tombstone	Loamy-skeletal, mixed, thermic Ustic Haplocalcids

Table 2.--Acreage and Proportionate Extent of the Soils

Map symbol	Map unit name	Acres	Percent
528	Pagesprings-Blancoverde complex, 3 to 60 percent slopes	115	14.4
538	Tombstone-Stronghold complex, 2 to 10 percent slopes	459	57.3
541	Penthouse-Tombstone complex, 2 to 25 percent slopes	227	28.3
	Total	801	100.0

Corrected Acreage
(these figures are for NPS-owned land only)

Map symbol	Acres	Percent
528	9.3	16.1
538	9.7	16.8
541	38.7	67.1
total	57.7	100.0

Table 3.--Engineering Index Properties

(Absence of an entry indicates that the data were not estimated.)

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag-ments > 10 inches	Frag-ments 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plas-ticity index
	In				Pct	Pct					Pct	
528:												
Pagesprings--	0-1	Very gravelly loam.	GC, GC-GM	A-1, A-2	0	10-15	35-50	30-45	25-40	20-35	25-30	5-10
	1-5	Very cobbly silt loam.	ML, CL-ML	A-3, A-1, A-4	5-10	20-35	40-50	35-45	30-40	25-35	25-30	NP-10
	5-7	Very cobbly loam.	ML, CL	A-1, A-4, A-3	5-10	20-35	40-50	35-45	30-40	25-35	25-30	NP-10
	7	Bedrock-------	---	---	---	---	---	---	---	---	---	---
Blancoverde--	0-3	Very stony loam.	GC, GC-GM, GP-GC	A-1, A-2	20-30	5-10	20-50	30-45	10-40	5-35	25-30	5-10
	3-10	Very cobbly silt loam.	SC-SM, GC-GM, GM	A-2, A-4	0-10	40-50	50-75	45-70	35-70	25-65	20-25	NP-5
	10-30	Loam-----------	ML, CL-ML	A-4	0	0	90-95	85-90	70-85	50-70	20-25	NP-5
	30-50	Loam-----------	ML, CL, CL-ML	A-4	0	0	90-100	85-100	75-100	60-80	25-35	5-10
	50-60	Loam-----------	CL, ML, CL-ML	A-4	0	0	90-100	85-100	75-100	60-80	25-35	5-10
538:												
Tombstone----	0-4	Very gravelly sandy loam.	SC-SM, GC-GM	A-1	0	10-15	55-60	30-45	25-40	15-20	25-30	NP-5
	4-20	Very gravelly sandy loam.	GC-GM, GP-GC, GP-GM	A-1	0	0-25	35-55	30-45	15-35	10-20	25-30	NP-5
	20-40	Extremely gravelly coarse sandy loam.	GP-GC, GP-GM	A-1	0	0-15	20-40	15-25	5-20	5-10	25-30	NP
	40-60	Very gravelly loamy coarse sand.	GP-GM, GP	A-1	0	0	35-55	30-45	15-25	0-10	15-20	NP
Stronghold---	0-3	Very gravelly fine sandy loam.	GC-GM, GP-GC, GP-GM	A-1	0	0-10	35-50	30-45	20-40	10-25	25-30	5-10
	3-25	Loam----------	CL-ML, ML, SC-SM, SM	A-2, A-4	0	0	90-100	85-100	60-95	35-75	20-30	5-10
	25-60	Loam----------	CL-ML, SM, ML, SC-SM	A-2, A-4	0	0	90-100	85-100	60-95	35-75	20-30	5-10
541:												
Penthouse----	0-2	Fine sandy loam.	CL-ML, SC, SC-SM	A-4	0	0	90-100	85-100	60-85	35-55	25-30	5-10
	2-26	Sandy clay----	SC, CL	A-6	0	0	95-100	90-100	75-95	40-60	35-40	15-20
	26-60	Sandy loam----	SC-SM	A-2, A-4	0	0	90-100	85-100	50-70	25-40	20-30	5-10

Table 3.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag- ments > 10 inches	Frag- ments 3-10 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plas- ticity index
	In				Pct	Pct					Pct	
541:												
Tombstone----	0-2	Very gravelly sandy loam.	GC-GM, GP-GC, GP-GM	A-1	0	0-10	40-55	35-45	20-35	10-20	25-30	5-10
	2-18	Very gravelly sandy loam.	GP-GM, GC-GM, GP-GC	A-1	0	0-10	45-55	35-45	25-35	10-20	25-30	5-10
	18-45	Extremely gravelly sandy loam.	GC-GM, GP-GC, GP-GM	A-1	0	0-15	25-35	10-25	10-20	5-15	20-25	NP-5
	45-60	Very gravelly loamy coarse sand.	GP, GP-GC, SP, GP-GM	A-1	0	0-10	40-55	35-45	15-25	0-10	15-20	NP

Table 4.--Physical and Chemical Properties of the Soils

(Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" apply only to the surface layer.)

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea-bility	Available water capacity	Linear extensi-bility	Soil reaction	Erosion factors Kw	Erosion factors T	Wind erodi-bility group
	In	Pct	g/cc	In/hr	In/in	Pct	pH			
528:										
Pagesprings-----	0-1	18-27	1.35-1.45	0.6-2.0	0.04-0.10	0.0-2.9	7.9-8.4	0.10	1	6
	1-5	18-27	1.35-1.45	0.6-2.0	0.01-0.12	0.0-2.9	7.9-8.4	0.05		
	5-7	18-27	1.35-1.45	0.6-2.0	0.01-0.12	0.0-2.9	7.9-8.4	0.05		
	7	---	---	---	---	---	---	----		
Blancoverde-----	0-3	18-27	1.25-1.55	0.6-2.0	0.02-0.09	0.0-2.9	7.9-8.4	0.05	1	6
	3-10	15-20	1.25-1.55	0.6-2.0	0.05-0.13	0.0-2.9	7.9-8.4	0.10		
	10-30	15-20	1.65-1.75	0.2-6.0	0.11-0.17	0.0-2.9	7.9-8.4	0.28		
	30-50	18-25	1.65-1.75	0.06-0.2	0.15-0.21	0.0-2.9	7.9-8.4	0.32		
	50-60	18-25	1.65-1.75	0.06-0.2	0.15-0.21	0.0-2.9	7.9-8.4	0.32		
538:										
Tombstone--------	0-4	15-20	1.35-1.55	2.0-6.0	0.04-0.08	0.0-2.9	7.9-8.4	0.05	4	6
	4-20	15-20	1.35-1.55	2.0-6.0	0.03-0.08	0.0-2.9	7.9-8.4	0.05		
	20-40	15-20	1.35-1.75	2.0-6.0	0.01-0.06	0.0-2.9	7.9-8.4	0.02		
	40-60	5-10	1.55-1.65	6.0-20	0.02-0.05	0.0-2.9	7.9-8.4	0.02		
Stronghold-------	1-3	12-15	1.25-1.55	2.0-6.0	0.03-0.08	0.0-2.9	7.9-8.4	0.05	5	6
	3-25	12-18	1.25-1.55	2.0-6.0	0.11-0.18	0.0-2.9	7.9-8.4	0.28		
	25-60	12-18	1.25-1.55	0.2-0.6	0.11-0.18	0.0-2.9	7.9-8.4	0.28		
541:										
Penthouse-------	0-2	15-20	1.25-1.55	2.0-6.0	0.07-0.15	0.0-2.9	7.4-8.4	0.17	3	3
	2-26	15-40	1.55-1.65	0.06-0.2	0.11-0.17	3.0-5.9	7.4-8.4	0.15		
	26-60	10-20	1.35-1.55	2.0-6.0	0.07-0.13	0.0-2.9	7.4-8.4	0.15		
Tombstone-------	0-2	15-20	1.35-1.55	2.0-6.0	0.03-0.08	0.0-2.9	7.9-8.4	0.05	3	6
	2-18	15-20	1.35-1.55	2.0-6.0	0.04-0.08	0.0-2.9	7.9-8.4	0.05		
	18-45	10-15	1.35-1.55	2.0-6.0	0.02-0.06	0.0-2.9	7.9-8.4	0.02		
	45-60	5-10	1.55-1.65	6.0-20	0.02-0.05	0.0-2.9	7.9-8.4	0.02		

Table 5.--Soil Features

(See text for definitions of terms used in this table. Absence of an entry indicates that the feature is not a concern or that data were not estimated.)

Map symbol and soil name	Restrictive layer				Risk of corrosion	
	Kind	Depth to top	Thickness	Hardness	Uncoated steel	Concrete
		In	In			
528:						
Pagesprings	Bedrock (lithic)	7-18	24-55	Indurated	High	Low.
Blancoverde	Dense material	40-60	16-60	Moderately cemented.	High	Low.
538:						
Tombstone	---	---	---	---	High	Low.
Stronghold	---	---	---	---	High	Low.
541:						
Penthouse	---	---	---	---	High	Low.
Tombstone	---	---	---	---	High	Low.

Table 6.--Rangeland Productivity and Characteristic Plant Communities

(The abbreviation "p.z." means precipitation zone.)

Map symbol and soil name	Ecological site	Total production: Kind of year	Total production: Dry weight	Characteristic vegetation	Composition
			Lb/acre		Pct
528:					
Pagesprings	Limestone Upland, 12-16" p.z.	Favorable	850	Bastardsage	5
		Normal	600	Black grama	10
		Unfavorable	450	Bush muhly	10
				Creosotebush	20
				Fourwing saltbush	10
				Littleleaf ratany	10
				Other perennial grasses	5
				Other shrubs	10
				Winterfat	5
Blancoverde	Limy Slopes, 12-16" p.z.	Favorable	900	Bastardsage	5
		Normal	650	Black grama	15
		Unfavorable	500	Bush muhly	10
				Fourwing saltbush	5
				Littleleaf ratany	5
				Mesquite	15
				Mimosa	10
				Other perennial grasses	5
				Other shrubs	10
538:					
Tombstone	Limy Slopes, 12-16" p.z.	Favorable	900	Bastardsage	5
		Normal	650	Black grama	15
		Unfavorable	500	Bush muhly	10
				Fourwing saltbush	5
				Littleleaf ratany	5
				Mesquite	15
				Mimosa	10
				Other perennial grasses	5
				Other shrubs	10
Stronghold	Limy Slopes, 12-16" p.z.	Favorable	900	Bastardsage	5
		Normal	650	Black grama	15
		Unfavorable	500	Bush muhly	10
				Fourwing saltbush	5
				Littleleaf ratany	5
				Mesquite	15
				Mimosa	10
				Other perennial grasses	5
				Other shrubs	10
541:					
Penthouse	Clay Loam Upland, 12-16" p.z.	Favorable	1,100	Indian ricegrass	5
		Normal	950	Bastardsage	5
		Unfavorable	750	Black grama	15
				Bush muhly	10
				Littleleaf ratany	5
				Mesquite	15
				Other perennial grasses	5
				Other shrubs	10

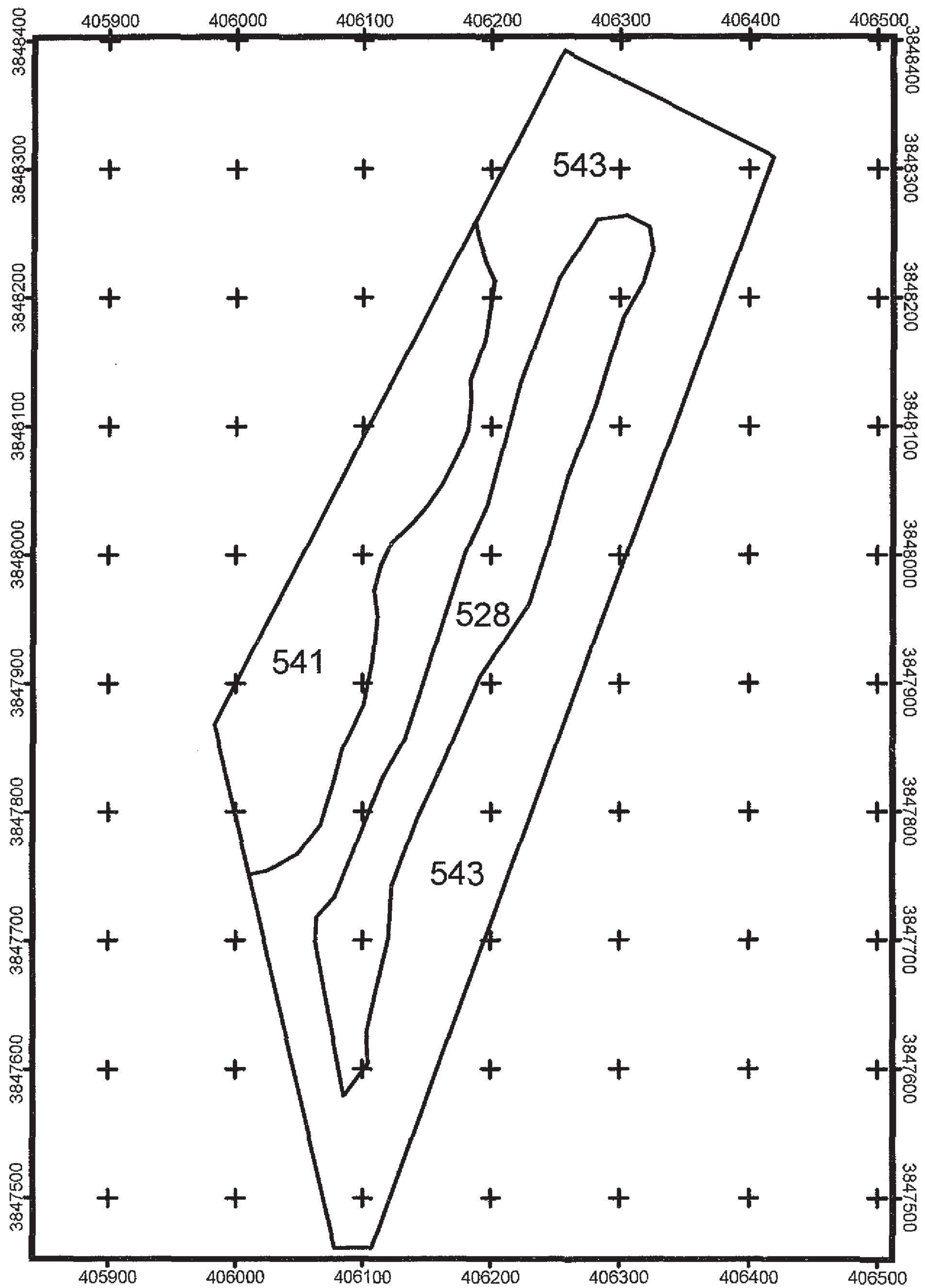
Table 6.--Rangeland Productivity and Characteristic Plant Communities--Continued

Map symbol and soil name	Ecological site	Total production: Kind of year	Total production: Dry weight	Characteristic vegetation	Composition
			Lb/acre		Pct
541:					
Tombstone----------	Limy Slopes, 12-16" p.z.	Favorable	900	Bastardsage------------------	5
		Normal	650	Black grama------------------	15
		Unfavorable	500	Bush muhly-------------------	10
				Fourwing saltbush------------	5
				Littleleaf ratany------------	5
				Mesquite---------------------	15
				Mimosa-----------------------	10
				Other perennial grasses------	5
				Other shrubs-----------------	10

Table 7.--Recreational Development

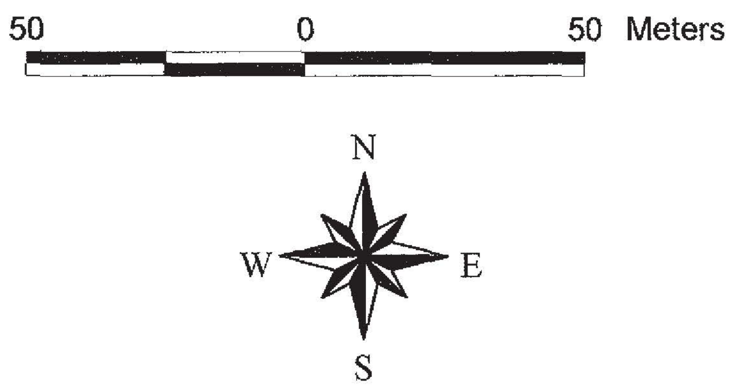
Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
528:					
Pagesprings	Severe: small stones, depth to rock.	Severe: small stones, depth to rock.	Severe: slope, small stones, depth to rock.	Severe: small stones.	Severe: small stones, depth to rock, droughty.
Blancoverde	Severe: slope, small stones.	Severe: slope, small stones.	Severe: large stones, slope, small stones.	Severe: slope, small stones.	Severe: slope, small stones.
538:					
Tombstone	Moderate: small stones.	Moderate: small stones.	Severe: slope, small stones.	Slight	Severe: droughty.
Stronghold	Severe: small stones.	Severe: small stones.	Severe: slope, small stones.	Severe: small stones.	Severe: small stones.
541:					
Penthouse	Slight	Slight	Severe: slope.	Slight	Moderate: droughty.
Tombstone	Severe: slope, small stones.	Severe: slope, small stones.	Severe: slope, small stones.	Moderate: slope.	Severe: slope, small stones, droughty.

Tuzigoot National Monument Soils Map

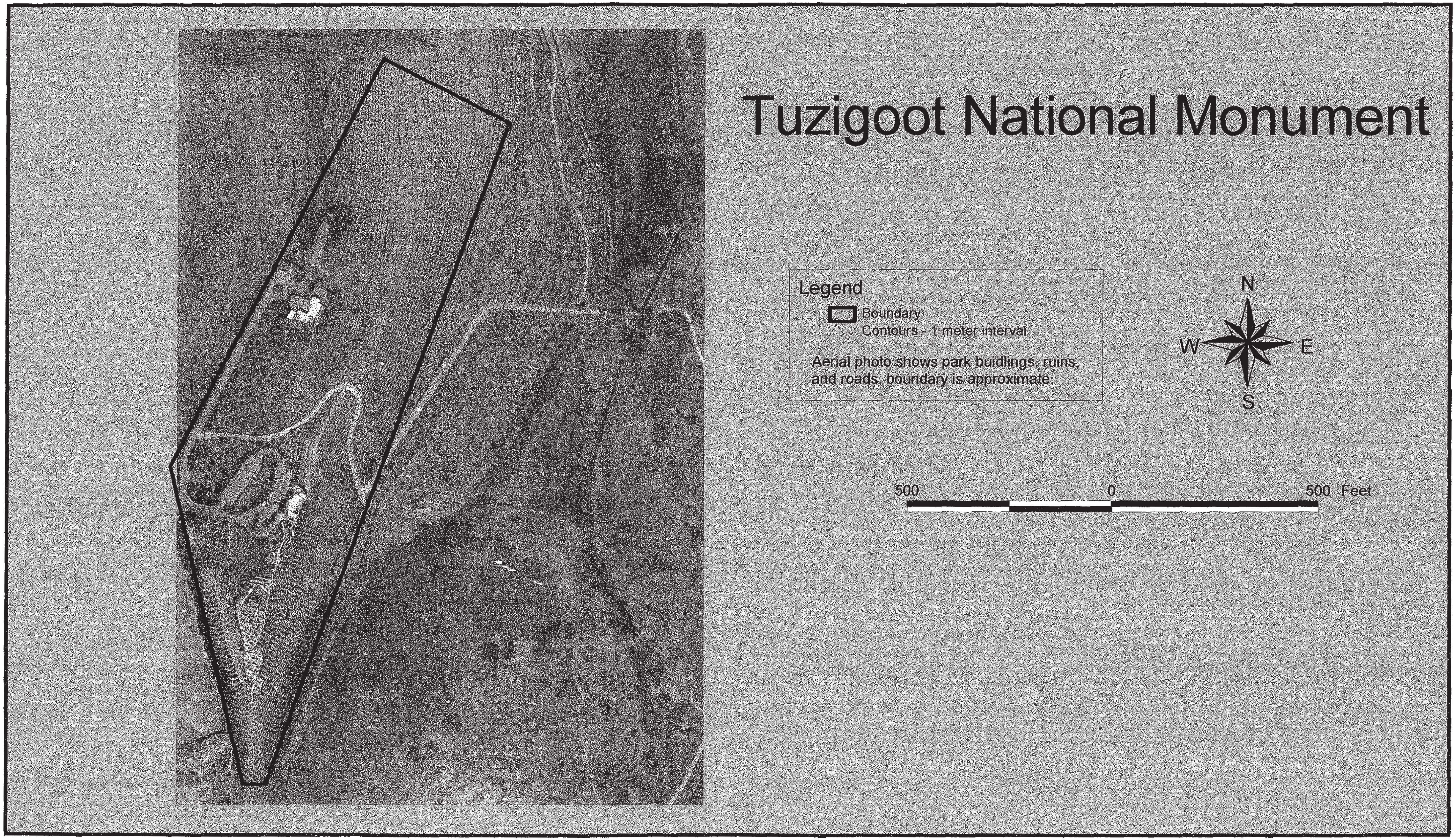


Soil Legend

528 - Pagesprings-Blancoverde complex, 3 to 60 percent slopes
541 - Tombstone-Stronghold complex, 2 to 10 percent slopes
543 - Penthouse-Tombstone, 2 to 25 percent slopes



This soils survey map was produced by USDA-NRCS based on aerial photography. The digital map was produced by the NPS at a scale of 1:6000.


Tuzigoot National Monument
Legend
Boundary
Contours - 1 meter interval
Aerial photo shows park buidlings, ruins, and roads, boundary is approximate.
N
W
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