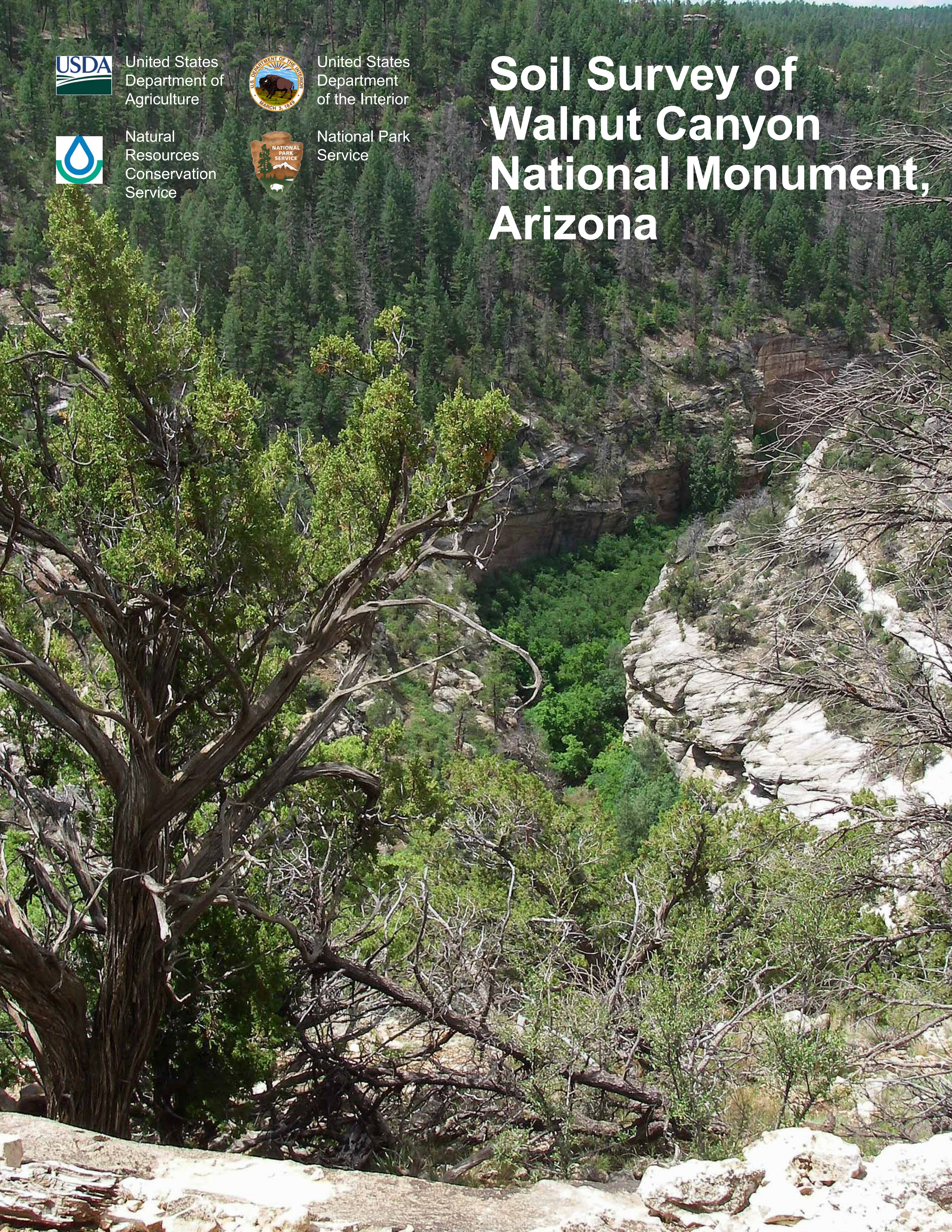
United States Department of Agriculture

Natural Resources Conservation Service

United States Department of the Interior

National Park Service

Soil Survey of Walnut Canyon National Monument, Arizona



How To Use This Soil Survey

General Soil Map

The general soil map, which is a color map, shows the survey area divided into groups of associated soils called general soil map units. This map is useful in planning the use and management of large areas.

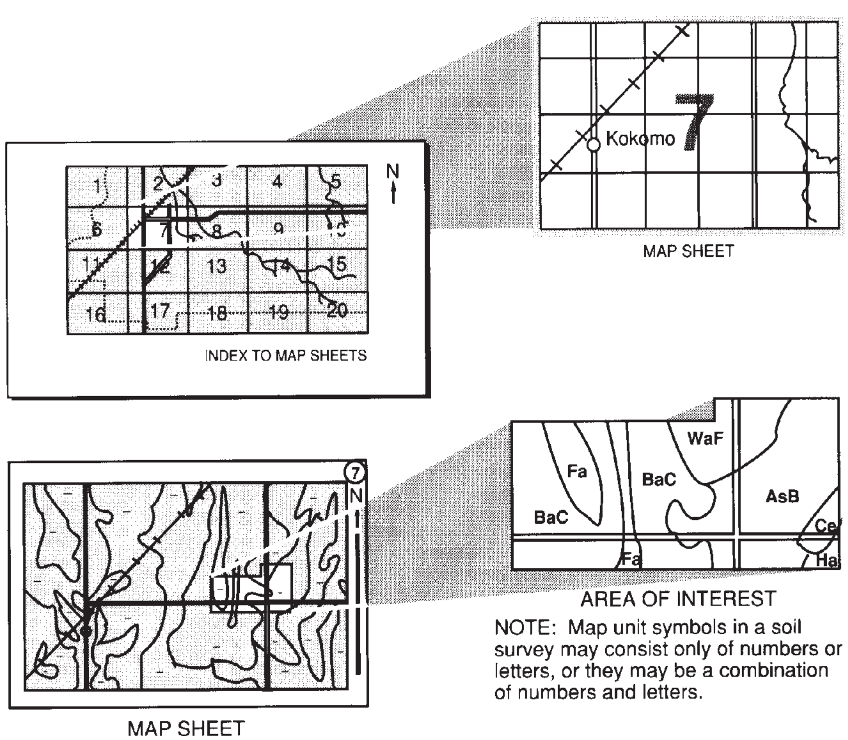
Detailed Soil Map

The detailed soil map can be useful in planning the use and management of small areas.

To find information about your area of interest, locate that area on the **Index to Map Sheets**. Note the number of the map sheet and go to that sheet.

Locate your area of interest on the map sheet. Note the map unit symbols that are in that area. Go to the **Contents**, which lists the map units by symbol and name and shows the page where each map unit is described.

The **Contents** shows which table has data on a specific land use for each detailed soil map unit. Also see the **Contents** for sections of this publication that may address your specific needs.



National Cooperative Soil Survey

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in 2011. Soil names and descriptions were approved in 2011. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 2011. This survey was made cooperatively by the Natural Resources Conservation Service and the National Park Service.

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

Literature Citation

The correct citation for this survey is as follows:

United States Department of Agriculture, Natural Resources Conservation Service, and United States Department of the Interior, National Park Service. 2015. Soil survey of Walnut Canyon National Monument, Arizona. (Accessible online at: http://soils.usda.gov/survey/printed_surveys/)

Cover Caption

Walnut Canyon as seen from beneath the south rim overlooking the canyon floor inside the park. Map unit 33 (Cosnino-Rock outcrop complex) is on the slopes across the canyon. Map unit 36 (Oxyaquic Ustifluvents) is on the canyon floor. The canyon has been carved out by Walnut Creek as the uplift of the Colorado Plateau has progressed over the last 5 million years. The cut exposed the Toroweap Formation and the Coconino Sandstone. In this photo, the Coconino Sandstone is the rock formation with steep slopes in the lower portion of the canyon cliffs. The Toroweap Formation has more moderately sloping exposures that form blocky joints with weathering. Fragments will eventually break off the Toroweap Formation and fall to the canyon toeslopes, adding to colluvial deposits near the canyon floor. In this narrow upper part of the canyon, this colluvium tends to be removed more quickly by episodes of storms, while in the wider, lower part, rock fragments collect at the base of canyon walls.

Additional information about the Nation's natural resources is available online from the Natural Resources Conservation Service at http://www.nrcs.usda.gov/.

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Contents

Issued 2015

Foreword

This soil survey was developed in conjunction with the National Park Service's Soil Inventory and Monitoring Program and is intended to serve as the official source document for soils occurring within Walnut Canyon National Monument, Arizona.

This soil survey contains information that affects current and future land use planning in the park. It contains predictions of soil behavior for selected land uses. The survey highlights soil limitations, actions needed to overcome the limitations, and the impact of selected land uses on the environment. It is designed to meet the needs of the National Park Service and its partners to better understand the properties of the soils in the park and the effects of these properties on various natural ecological characteristics. This knowledge can help the National Park Service and its partners to understand, protect, and enhance the environment.

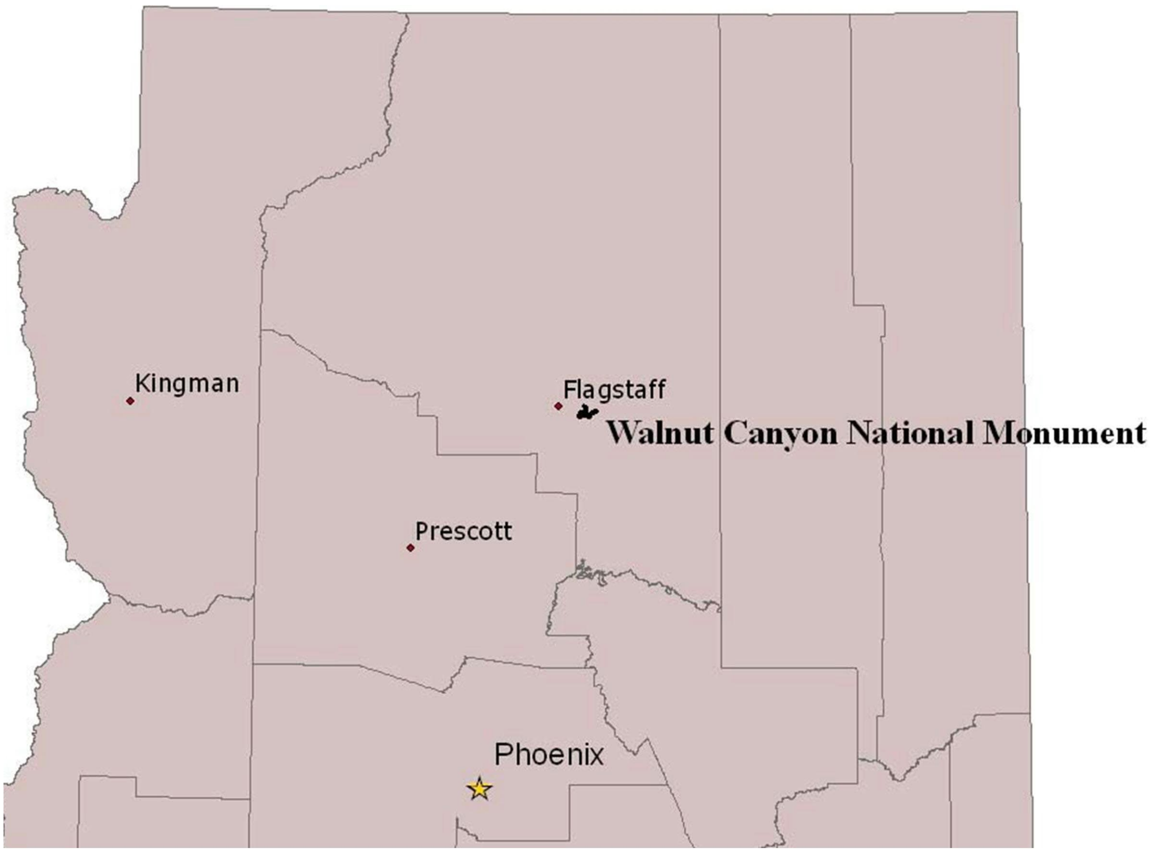
Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. The information in this report is intended to identify soil properties that are used in making various land use or land treatment decisions. Statements made in this report are intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. The location of each map unit is shown on the detailed soil map. Each soil in the survey area is described, and information on specific uses is given. Help in using this publication and additional information are available at the local office of the Natural Resources Conservation Service or the Cooperative Extension Service.

Help in using this publication and additional information are available at the local office of the Natural Resources Conservation Service or Cooperative Extension Service or at the National Park Service's Natural Resources Program Center.

Keisha Tatum
State Conservationist
Natural Resources Conservation Service



Location of Walnut Canyon National Monument in Arizona.

Soil Survey of Walnut Canyon National Monument, Arizona

By James M. Harrigan, Natural Resources Conservation Service

Fieldwork by Michael W. Burney, James M. Harrigan, and Harry A. Hosler, Natural Resources Conservation Service

Ecological site assessment by Jennifer M. Puttere, Natural Resources Conservation Service

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

Walnut Canyon National Monument lies within the State of Arizona. It was established by President Woodrow Wilson on November 30, 1915, to preserve and protect Walnut Canyon and the surrounding lands, including the cliff dwellings (figs. 1 and 2). Sometime during the 12th century, the Sinagua built the cliff dwellings that survive to this day, although many of the artifacts were removed after the railroad was completed in the 1880s. The park consists of approximately 3,579 acres. A major portion of the monument borders Coconino National Forest (see Walnut Canyon National Monument 3D Map).

The monument is accessible by vehicle. Interstate 40 runs near the northern edge of the park, near the city of Flagstaff. Walnut Canyon Road enters the park from the north and continues to the Visitor Center, where it ends.

The Island Trail was constructed for visitors to observe the cliff dwellings and the various natural surroundings. A second trail, the Rim Trail, connects two canyon overlooks.

Descriptions, names, and delineations of soils in the survey do not fully agree with some of the soil maps for adjacent soil survey areas. The differences are the result of mapping intensity, the availability of more recent technology for soil mapping, modifications in series concepts, or extent of soils within the survey.

General Nature of the Park

This section discusses the physiography, major land resource areas, and climate of Walnut Canyon National Monument.

Physiography

Walnut Canyon National Monument lies within the Colorado Plateau between two volcanic fields. To the north of the canyon is the San Francisco Volcanic Field, which is a hot spot of recent activity. The Mormon Volcanic Field, to the south, is generally older, has smaller and lower features, and has had no recent activity. The volcanic

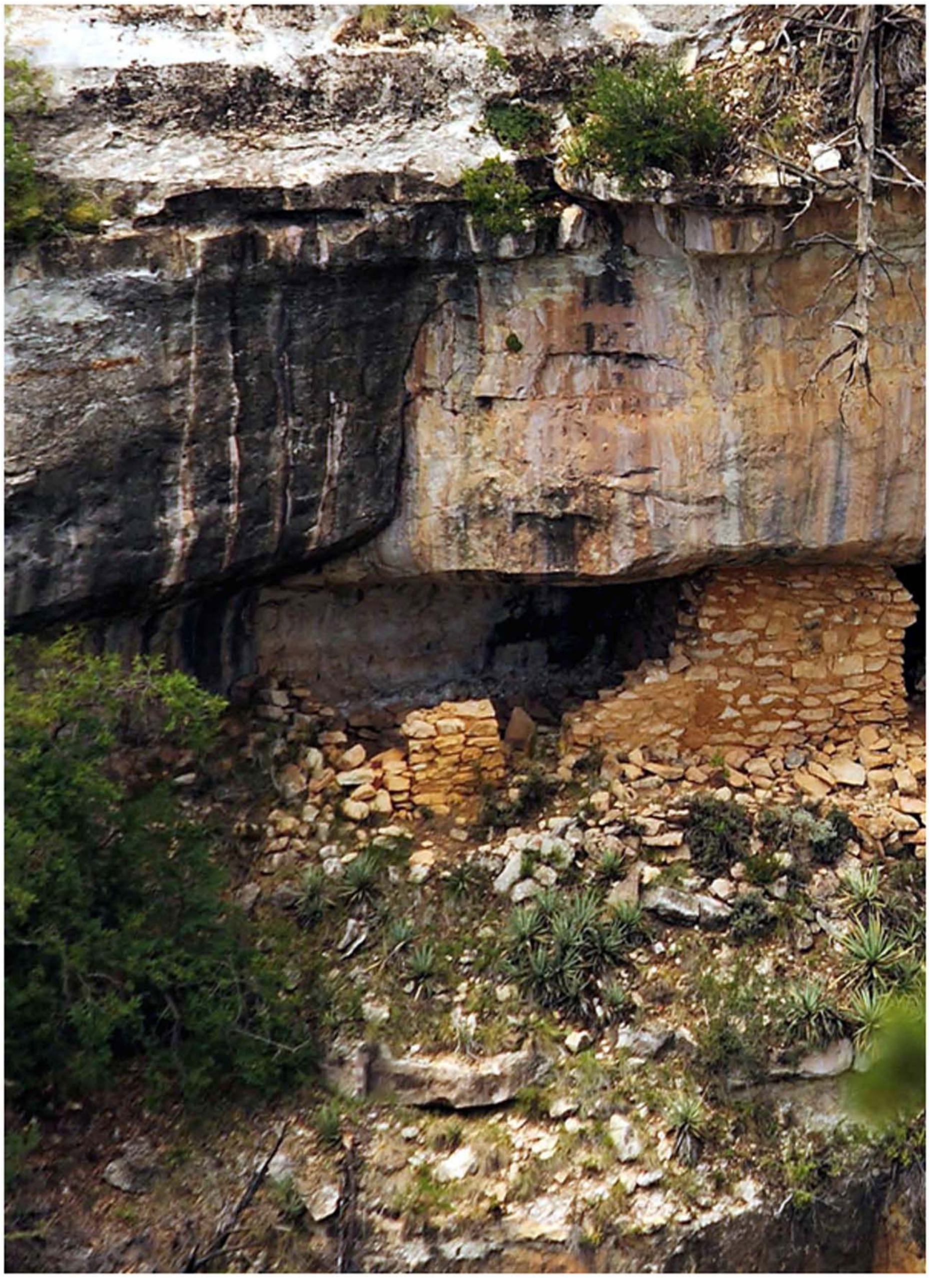


Figure 1.—View of a cliff dwelling. These dwellings once housed members of the Sinagua culture. They were made from shallow caves eroded out of limestone cliffs by water and wind.

fields are on the shoulder of the larger Colorado Plateau, which forms a large basin to the north. In this basin, sedimentary formations have been slowly eroding for more than 5 million years (See Walnut Canyon National Monument 3D Map).

Major Land Resource Areas

Walnut Canyon National Monument is split between two major land resource areas (MLRAs): MLRA 35—Colorado Plateau and MLRA 39—Arizona and New Mexico Mountains (figs. 3 and 4). MLRAs are large geographic areas identified by similarities in temperature, precipitation, physiography, and management. Within each MLRA are smaller land resource units (LRUs) which are defined by how precipitation, temperature, timing of moisture, and elevation pertain to soils and vegetation management.

MLRA 35—Colorado Plateau

MLRA 35 is in the Colorado Plateaus Province of the Intermontane Plateaus. It is defined by a large structurally uplifted plateau that has been cut down by rivers. This large plateau stretches from northern Arizona into southern Utah and western New Mexico and includes the entire Navajo Nation, Grand Canyon National Park, Canyon Lands National Park, and the Grand Staircase Escalante National Monument. The dominant geology is shale, sandstone, limestone, and volcanic rocks. Annual precipitation ranges from less than 5 inches to 30 inches; most of the area receives 6 to 10 inches annually. Most precipitation is received as intense thunderstorms during the monsoon season (July through September). May and June are the driest months. About three-fourths of the area is rangeland used for grazing, and less than 1 percent is irrigated cropland. The MLRA 35 portion of Walnut Canyon National Monument is in land resource unit 35.7, which is dominated by pinyon-juniper woodland and receives 14 to 18 inches of precipitation annually.

MLRA 39—Arizona and New Mexico Mountains

MLRA 39 is also in the Colorado Plateaus Province of the Intermontane Plateaus. It is characterized by volcanic fields and gently dipping sedimentary rocks that eroded

Figure 2.—The bottom of Walnut Canyon beneath the forest has a lush covering of vegetation. The flower pictured is western white clematis.

MLRA	Elevation (feet)	Average precipitation (inches)	Soil temperature regime	Soil moisture regime
35.7	5,000-7,000	14-18	mesic	aridic ustic
39.1	7,000-12,500	18-22	frigid	typic ustic

Figure 3.—Summary of major land resource areas in Walnut Canyon National Monument.

into plateaus, valleys, and deep canyons. This MRLA stretches through central Arizona to western New Mexico and includes the White Mountains and San Francisco Peaks. The dominant geology is limestone, volcanic rocks, and granite. Annual precipitation ranges from 9 to 43 inches; most of the area receives 15 to 30 inches annually. Most precipitation is received as intense thunderstorms during the monsoon season (July through September), and the rest occurs as snowfall in December through February. Most of the MLRA is forested and managed for timber production. The MLRA 39 portion of Walnut Canyon National Monument is in land resource unit 39.1, which is dominated by ponderosa pine and Douglas fir and receives 18 to 22 inches of precipitation annually.

Climate

The climate of the park is highly variable. There is often snow cover in winter, which may be as thick as 100 inches. Monsoonal rain patterns typically begin in July, when brief heavy rains and thunderstorms may occur on a nearly daily basis.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Walnut Canyon National Monument, Arizona, in the period 1910 to 2013. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on the length of the growing season.

In winter, the average temperature is 2.3 degrees C and the average daily minimum temperature is -6.0 degrees C. The lowest temperature on record, which occurred at Walnut Canyon on January 1, 2011, was -24 degrees C. In summer, the average temperature is 20.0 degrees C and the average daily maximum temperature is 28.6 degrees C. The highest recorded temperature, which occurred at Walnut Canyon on multiple days, was 38 degrees C.

Growing degree days are shown in table 1. They are equivalent to “heat units.” During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (10 degrees C). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

The average annual total precipitation is 46.20 centimeters. Of this, 26.2 centimeters, or about 57 percent, usually falls in April through October. The growing season for most crops falls within this period. The heaviest 1-day rainfall during the period of record was 10.29 centimeters, which occurred at Walnut Canyon National Monument on August 15, 1987. Most thunderstorms occur between July and September.

The average seasonal snowfall is 162.1 centimeters. The greatest snow depth at any one time during the period of record was 137 centimeters, recorded on December 20, 1967. On an average, 91 days per year have at least 2.54 centimeters (1 inch) of snow on the ground. The heaviest 1-day snowfall on record was 61 centimeters inches, recorded on December 13, 1967.

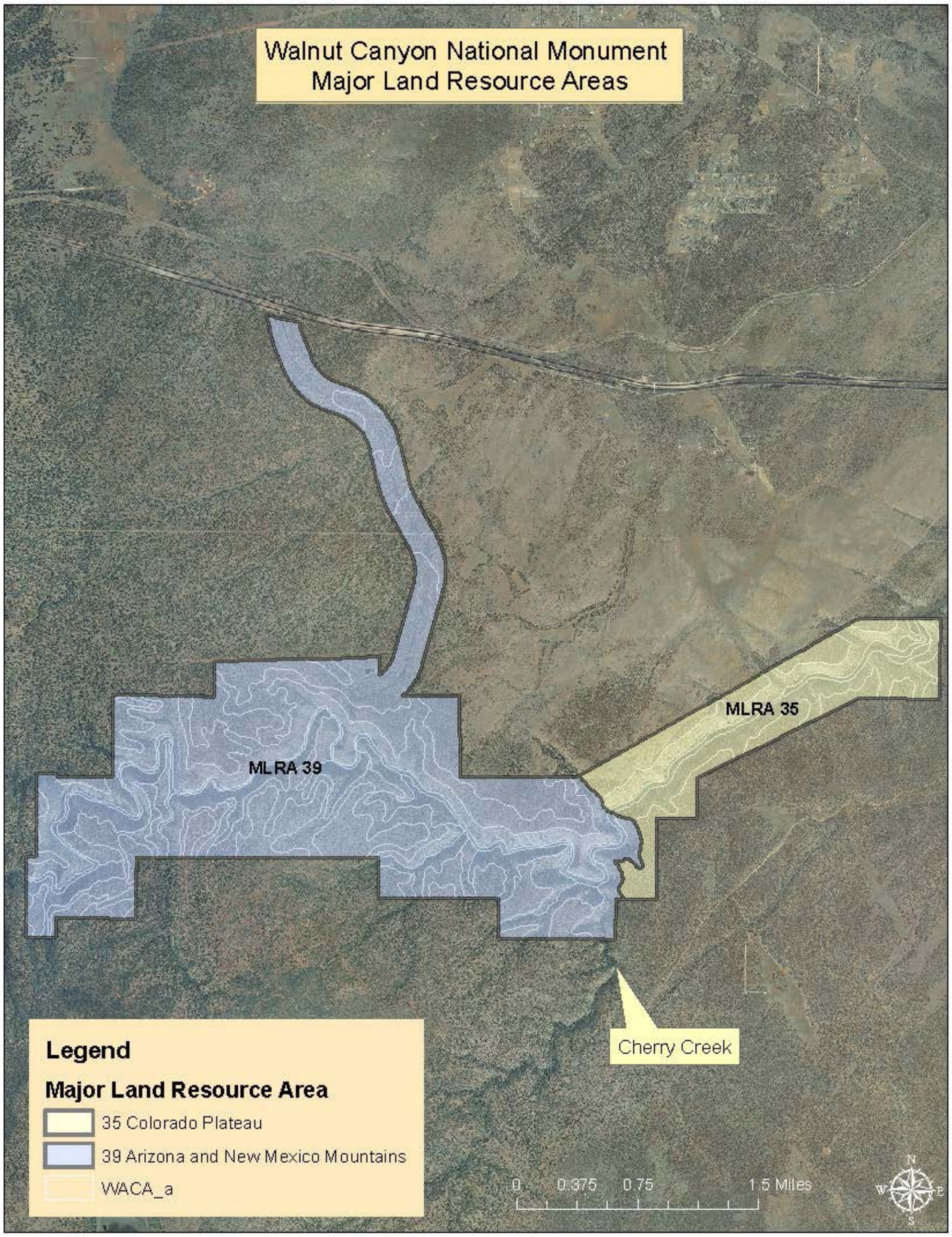


Figure 4—Map showing the split between MLRA 35 and MLRA 39 in Walnut Canyon National Monument. MLRA 35 has lower amounts of precipitation and warmer temperatures, which support juniper and pinyon pine as the dominant species. MLRA 39 has higher amounts of precipitation and colder temperatures (due to local topography), which support cold-tolerant ponderosa pine and Douglas fir as the dominant species.

How This Survey Was Made

This survey was made in conjunction with the National Park Service's Soil Inventory and Monitoring Program to provide information about the soils and miscellaneous areas in Walnut Canyon National Monument. A scoping meeting was held in 2010 with park staff to identify their soil resource information needs and to relate these needs into the development of the final products. Of particular importance to park staff was information regarding the relationship of soil types and plant communities to climatic regimes and landforms in the park. Following the meeting, additional interviews were conducted to identify other particular geographic areas of interest and concern.

During the soil survey, relationships between ecological sites and soil components were observed and noted, and soil-site correlation concepts were established to help in designing the map units. Soil and plant specialists tested the concepts during mapping and collected field documentation at numerous points across the landscape.

Information in this report 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 vegetation; and the kinds of bedrock. Scientists excavated small pits to study soil profiles. A soil profile is the vertical sequence of natural layers, or horizons, in a soil. The profile extends from the surface down through stable and unstable horizons into bedrock (commonly limestone in this park).

Soils and miscellaneous areas in the survey area are in an orderly pattern related to the topography, climate, vegetation, and geology 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 and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept or model of how they formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area 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, the soil scientist must determine the boundary between soil map units. Use of remotely sensed data greatly improves the soil scientist's ability detect changes in the soil. When available, data such as Landsat imagery is extensively used in soil mapping. The manipulation of the spectral bands on this imagery can enhance certain properties, such as basic minerals or vegetation types, when compared with visible light imagery. Since soil scientists can observe only a limited number of soil profiles, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship and the use of remotely sensed data, are sufficient to verify predictions of the kinds of soil in an area and to determine the soil 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. The soil profile reflects the activities of the five soil-forming factors. A succession of layers or horizons form, extending from the surface down to the unweathered parent material. The horizons differ in one or more properties, for example, thickness, color, texture, structure, consistence, porosity, and reaction (pH).

Describing Soil Profiles

Soil profiles consist commonly of five major horizons, designated as O, A, E, B, and C horizons. O horizons consist of decomposing organic materials. An example of an O horizon comprised of decomposing pine needles is in the Chilson soil in map unit 31. A horizons are mineral horizons that have an organic matter content that is higher than that of underlying horizons but lower than that of overlying O horizons. The A horizon may be the surface layer if there is no O horizon. The E horizon is the zone of maximum leaching of materials. E horizons commonly are found in wetter climates or wetter soil conditions on certain landscapes and may overlie a B horizon (a zone of accumulation). C horizons are in the bottom part of a soil profile and are most related to the parent material.

The B horizon lies directly below the A horizon. In some soils it may have not developed, while in other soils it may be very developed. This horizon varies in color, and color plays an important part in distinguishing B horizons. The B horizon is the horizon of maximum accumulation of dissolved or suspended materials, for example, iron, clay, or calcium carbonate. It can be an altered horizon whose structure is distinct from that of the A horizon but show little evidence of clay translocation or accumulation. An example of a B horizon in which calcium carbonate has accumulated and concentrated is a Bk horizon. A B horizon that contains a significant amount of clay accumulation is called a Bt horizon. Subsurface horizons that show little evidence of accumulation, but have been altered in some way by the soil-forming processes, are Bw horizons. Cosnino, Kydestea, and Whiskey soils have these horizons. The C horizon is relatively unchanged by the soil-forming processes. Oxyaquic Ustifluvents in map unit 36 and Lithic Ustorthents in map unit 35 have mainly C horizons. An R layer underlies most of the soils in the survey area and is generally limestone or calcareous sandstone. Chilson, Cosnino, and Kydestea soils have this layer.

After describing the soils in the survey area and determining their properties, 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. Classes are used as a basis for comparison to classify soils systematically (see table 30). Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

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

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can 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 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.

General Soil Map Units

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

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

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

1—Chilson-Wilcoxson complex

Shallow and moderately deep, gently sloping, well drained soils that formed from residuum in an aridic ustic moisture regime

Map Unit Setting

Ecological site association: Limestone/Sandstone Upland 18-22” p.z.
Dominant vegetation: Ponderosa pine, blue grama, and Gambel oak
Landscape: Colorado Plateau
Landform setting: Structural benches
Elevation: 6,600 to 6,890 feet (2,011 to 2,100 meters)
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Slope range: 2 to 8 percent

Map Unit Composition

Extent of the map unit in the survey area: 21.6 percent
Extent of the components in the map unit:
- Chilson and similar soils: 55 percent
- Wilcoxson and similar soils: 40 percent
- Minor components: Rock outcrop—5 percent

Major Component Descriptions

Chilson
Depth class: Shallow
Drainage class: Well drained
Geomorphic position: Structural benches
Parent material: Residuum from limestone

Slope: 2 to 8 percent
Ecological site ID: F039XA139AZ

Wilcoxson
Depth class: Moderately deep
Drainage class: Well drained
Geomorphic position: Structural benches
Parent material: Residuum from limestone or sandstone
Slope: 2 to 8 percent
Ecological site ID: F039XA139AZ

2—Cosnino-Rock outcrop-Lithic Ustorthents association

Very shallow, moderately sloping to steep, well drained soils that formed from residuum in an aridic ustic moisture regime

Map Unit Setting

Ecological site association: Limestone/Sandstone Upland 18-22” p.z.
Dominant vegetation: Ponderosa pine, blue grama, and Douglas fir
Landscape: Colorado Plateau
Landform setting: Canyons
Elevation: 6,400 to 6,840 feet (1,950 to 2,084 meters)
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Slope range: 5 to 70 percent

Map Unit Composition

Extent of the map unit in the survey area: 56.0 percent
Extent of the components in the map unit:
    Cosnino and similar soils: 44 percent
    Rock outcrop: 28 percent
    Lithic Ustorthents and similar soils: 26 percent
    Minor components: Loamy, Lithic Haplustolls—2 percent;

Major Component Descriptions

Cosnino
Depth class: Shallow
Drainage class: Well drained
Geomorphic position: Canyons
Parent material: Residuum from limestone
Slope: 5 to 70 percent
Ecological site ID: F039XA139AZ

Rock outcrop
Parent material: Limestone

Lithic Haplustolls
Depth class: Shallow
Drainage class: Well drained
Geomorphic position: Canyons
Parent material: Residuum from limestone or sandstone
Slope: 25 to 75 percent
Ecological site ID: F039XA139AZ

3—Oxyaquic Ustifluvents consociation

Very deep, level to gently sloping, well drained soils that formed from alluvium in an aridic ustic moisture regime

Map Unit Setting

Ecological site association: Canyon Bottom (Riparian) 18-22” p.z.
Dominant vegetation: Redosier dogwood, Woods’ rose, and western white clematis
Landscape: Colorado Plateau
Landform setting: Flood-plain steps
Elevation: 6,280 to 6,550 feet (1,914 to 1,996 meters)
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Slope range: 2 to 6 percent

Map Unit Composition

Extent of the map unit in the survey area: 2.6 percent
Extent of the components in the map unit:
Oxyaquic Ustifluvents and similar soils: 85 percent
Minor components: Oxyaquic Haplustolls—15 percent

Major Component Description

Oxyaquic Ustifluvents
Depth class: Very deep
Drainage class: Somewhat excessively drained
Geomorphic position: Stream terraces
Parent material: Mixed alluvium
Slope: 2 to 6 percent
Ecological site ID: R039XA140AZ

4—Kydestea-Rock outcrop association

Shallow, moderately sloping to steep, well drained soils that formed from residuum in an ustic aridic moisture regime

Map Unit Setting

Ecological site association: Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z.
Dominant vegetation: Oneseed juniper, blue grama, and cliffrose
Landscape: Colorado Plateau
Landform setting: Canyons
Elevation: 6,240 to 6,658 feet (1,902 to 2,029 meters)
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Slope range: 3 to 50 percent

Map Unit Composition

Extent of the map unit in the survey area: 17.9 percent
Extent of the components in the map unit:
Kydestea and similar soils: 60 percent
Rock outcrop: 35 percent
Minor components: Aridic Lithic Haplustepts—5 percent

Major Component Descriptions

Kydestea
Depth class: Shallow
Drainage class: Well drained
Geomorphic position: Canyons
Parent material: Residuum and colluvium derived from limestone
Slope: 3 to 50 percent
Ecological site ID: R035XG723AZ

Rock outcrop
Parent material: Limestone

5—Whiskey-Vosburg association

Very deep, nearly level to gently sloping, well drained soils that formed from alluvium in an ustic aridic moisture regime

Map Unit Setting

Ecological site association: Semi-Riparian Canyon Bottom 14-18” p.z.
Dominant vegetation: Blue grama, oneseed juniper, and rubber rabbitbrush
Landscape: Colorado Plateau
Landform setting: Stream terraces and terraces
Elevation: 6,110 to 6,280 feet (1,862 to 1,914 meters)
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Slope range: 1 to 8 percent

Map Unit Composition

Extent of the map unit in the survey area: 1.9 percent
Extent of the components in the map unit:
- Whiskey and similar soils: 69 percent
- Vosburg and similar soils: 23 percent
- Minor components: Ustifluvents—8 percent

Major Component Descriptions

Whiskey
Depth class: Very deep
Drainage class: Well drained
Geomorphic position: Stream terraces
Parent material: Mixed alluvium
Slope: 2 to 8 percent
Ecological site ID: R035XG724AZ

Vosburg
Depth class: Very deep
Drainage class: Well drained
Geomorphic position: Terraces
Parent material: Mixed alluvium
Slope: 1 to 5 percent
Ecological site ID: R035XG724AZ

Detailed Soil Map Units

The map units delineated on the detailed soil map in this survey represent the soils or miscellaneous areas in the park. 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 minor components that belong to taxonomic classes other than those of the major soils.

Most minor 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, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. 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 maps. The contrasting components are mentioned in the map unit descriptions. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components 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 maps 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 the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. The soils of a given 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, Whiskey loam, 2 to 8 percent slopes, is a phase of the Whiskey series. The map unit descriptions include a full pedon description for each major soil component.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are 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 map. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Chilson-Wilcoxson complex, 2 to 8 percent slopes, very rocky, is an example.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. The Rock outcrop part of Cosnino-Rock outcrop complex, 5 to 25 percent slopes, is an example.

Table 4 lists each map unit in the park, its major components, and the percentage of each major component in the unit. Table 5 gives the acreage, number of hectares, and proportionate extent of each map unit. Table 6 identifies the major map unit components in the survey area, the map unit(s) in which each occurs, the component kind, and correlated ecological sites. Other tables give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils or miscellaneous areas.

31—Chilson-Wilcoxson complex, 2 to 8 percent slopes, very rocky

Map Unit Setting

Major land resource area: 39—Arizona and New Mexico Mountains
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Landform(s): Structural benches (figs. 5 and 6)
Elevation: 6,000 to 7,500 feet (1,829 to 2,286 meters)
Mean annual precipitation: 18 to 22 inches (457 to 559 millimeters)
Mean annual air temperature: 42 to 46 degrees F (3.9 to 7.2 degrees C)
Mean annual soil temperature: 44 to 48 degrees F (5.0 to 8.3 degrees C)
Frost-free period: 100 to 120 days

Map Unit Composition

Chilson and similar soils: 55 percent
Wilcoxson and similar soils: 40 percent
Minor components: Rock outcrop—5 percent

Description of the Chilson Soil

Taxonomic classification: Clayey, mixed, superactive, frigid Lithic Argiustolls
Taxon kind: Series
Geomorphic position: Areas near summits of hills away from canyons
Parent material: Colluvium and/or residuum weathered from limestone
Elevation: 6,000 to 7,500 feet (1,829 to 2,286 meters)
Slope: 2 to 8 percent
Depth to restrictive feature(s): 6 to 19 inches to lithic bedrock
Drainage class: Well drained
K_{sat} *of solum:* 0.06 inch to 1.98 inches per hour (0.42 micrometer to 14.00 micrometers per second)
K_{sat} *of restrictive layer:* 0.00 to 0.57 inch per hour (0.00 to 4.00 micrometers per second)
Available water capacity (total inches): 1.9 (very low)

Figure 5.—An area of the Chilson soil in Chilson-Wilcoxson complex, 2 to 8 percent slopes, rocky.

Figure 6.—An area of the Wilcoxson soil in Chilson-Wilcoxson complex, 2 to 8 percent slopes, rocky.

Figure 7.—Surface of Chilson loam.

Shrink-swell potential: About 4.5 LEP (moderate)
Flooding hazard: None
Ponding hazard: None
Runoff class: Very high
Hydrologic group: D
Ecological site name: Limestone/Sandstone Upland 18-22” p.z.
Ecological site number: F039XA139AZ
Present vegetation: Ponderosa pine, Gambel oak, alligator juniper, blue grama, Canadian wildrye, muttongrass, Rocky Mountain juniper, Utah juniper, buckwheat, Junegrass, squirreltail, forbs, and annuals
Land capability (nonirrigated): 5c
Surface cover (percent): (fig. 7)

Canopy plant cover	10
Woody debris	0
Bare soil	0
Rock fragments	0

Typical Pedon (figs. 8 and 9)

Location by Universal Transverse Mercator System: Zone 12N, 3892232 Northing, 452654 Easting

Oe—0 to 1 inch (0 to 3 centimeters); very dark brown (10YR 2/2) moderately decomposed plant material, black (10YR 2/1) moist; massive; many very fine roots throughout; very strongly acid, pH 5.0; abrupt smooth boundary.

A—1 to 4 inches (3 to 10 centimeters); brown (7.5YR 4/3) loam, dark brown (7.5YR 3/2) moist; 16 percent clay; weak thick platy structure parting to weak fine

Figure 8.—Profile of Chilson soil. Scale is in centimeters.

subangular blocky; slightly hard, friable, moderately sticky, slightly plastic; many very fine and fine roots; many fine and common medium dendritic tubular pores; few organic stains; 5 percent gravel; noneffervescent; neutral, pH 7.2; clear smooth boundary.

Bt—4 to 15 inches (10 to 38 centimeters); reddish brown (5YR 4/4 and 4/3) clay, dark reddish brown (5YR 3/4 and 3/3) moist; 42 percent clay; strong fine and medium subangular blocky structure; moderately hard, firm, very sticky, very plastic; common very fine, fine, and medium roots; common fine dendritic tubular pores; few organoargillans and common distinct clay films on all faces of peds; 10 percent gravel; noneffervescent; slightly alkaline, pH 7.4; abrupt wavy boundary.

R—15 inches (38 centimeters); unfractured, unweathered bedrock of the Kaibab or Moenkopi Formation.

Figure 9.—Box sample of Chilson typical pedon.

Range in Characteristics

Rock fragments in the control section: 2 to 10 percent gravel
Clay content of particle-size control section: 40 to 45 percent
Mollic epipedon: At a depth of 1 to 15 inches (3 to 38 centimeters) (A and Bt horizons)
Argillic horizon: At a depth of 4 to 15 inches (10 to 38 centimeters) (Bt horizon)

A horizon:
Hue—5YR or 7.5YR
Value—3 or 4 dry; 2.5 or 3 moist
Chroma—1 to 4, dry or moist
Texture—loam
Clay content—14 to 18 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—2 to 10 percent gravel
Reaction: Neutral or slightly alkaline

Bt horizon:
Hue—5YR or 7.5YR
Value—3 or 4, dry or moist
Chroma—2.5 to 4, dry or moist
Texture—clay
Clay content—40 to 45 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—2 to 10 percent gravel
Reaction—neutral or slightly alkaline

Figure 10.—Surface of Wilcoxson loam.

Description of the Wilcoxson Soil

Taxonomic classification: Fine, mixed, superactive, frigid Typic Argiustolls
Taxon kind: Series
Geomorphic position: More stable areas near summits of hills away from canyons
Parent material: Colluvium and/or residuum weathered from limestone
Elevation: 6,000 to 7,500 feet (1,829 to 2,286 meters)
Slope: 2 to 8 percent
Depth to restrictive feature(s): 22 to 32 inches to lithic bedrock
Drainage class: Well drained
K_{sat} *of solum:* 0.20 inch to 1.98 inches per hour (1.40 to 14.00 micrometers per second)
K_{sat} *of restrictive layer:* 0.00 to 0.57 inch per hour (0.00 to 4.00 micrometers per second)
Available water capacity (total inches): 3.4 (low)
Shrink-swell potential: About 4.5 LEP (moderate)
Flooding hazard: None
Ponding hazard: None
Runoff class: High
Hydrologic group: C
Ecological site name: Limestone/Sandstone Upland 18-22” p.z.
Ecological site number: F039XA139AZ
Present vegetation: Ponderosa pine, Gambel oak, alligator juniper, blue grama, Canadian wildrye, muttongrass, Rocky Mountain juniper, Utah juniper, buckwheat, Junegrass, squirreltail, forbs, and annuals
Land capability (nonirrigated): 5c
Surface cover (percent): (fig. 10)

Figure 11.—Profile of Wilcoxson soil. Scale is in centimeters.

Canopy plant cover	10
Woody debris	0
Bare soil	0
Rock fragments	0

Typical Pedon (figs. 11 and 12)

Location by Universal Transverse Mercator System: Zone 12N, 3892254 Northing, 452604 Easting

A—0 to 4 inches (0 to 10 centimeters); brown (7.5YR 4/3) loam, dark brown (7.5YR 3/3) moist; 18 percent clay; moderate thin platy structure parting to weak fine granular; slightly hard, friable, slightly sticky, slightly plastic; many very fine and

Figure 12.—Box sample of Wilcoxson typical pedon.

fine roots; many fine irregular pores; 5 percent gravel; noneffervescent; neutral, pH 7.0; clear smooth boundary.

BA—4 to 9 inches (10 to 23 centimeters); reddish brown (5YR 4/3) sandy clay loam, dark reddish brown (5YR 3/3) moist; 21 percent clay; moderate fine subangular blocky structure; moderately hard, firm, moderately sticky, moderately plastic; many very fine, fine, and medium roots; many fine tubular pores; 5 percent gravel; noneffervescent; slightly alkaline, pH 7.4; clear smooth boundary.

Bt—9 to 17 inches (23 to 43 centimeters); reddish brown (5YR 4/3) clay loam, dark reddish brown (5YR 3/3) moist; 38 percent clay; strong medium and fine subangular blocky structure; hard, very firm, very sticky, very plastic; common very fine and many fine, medium, and coarse roots; many fine and common medium tubular pores; common prominent clay films on all faces of peds; 10 percent gravel; very slightly effervescent, 2 percent calcium carbonate equivalent; slightly alkaline, pH 7.8; clear smooth boundary.

2Btk—17 to 26 inches (43 to 66 centimeters); brown (7.5YR 4/4) very gravelly sandy clay, dark brown (7.5YR 3/4) moist; 35 percent clay; strong fine subangular blocky structure; moderately hard, firm, very sticky, very plastic; few very fine and fine and many medium roots; many fine and few medium tubular pores; few distinct clay films on all faces of peds; 1 percent fine masses of oxidized iron; carbonate coats around rock fragments; 45 percent gravel; strongly effervescent, 5 percent calcium carbonate equivalent; moderately alkaline, pH 8.2; abrupt wavy boundary.

2R—26 inches (66 centimeters); unfractured, unweathered limestone of the Kaibab Formation.

Range in Characteristics

Rock fragments in the control section: 2 to 35 percent gravel
Clay content of particle-size control section: 35 to 39 percent
Mollic epipedon: At a depth of 0 to 17 inches (0 to 43 centimeters) (A, BA, and Bt horizons)
Argillic horizon: At a depth of 9 to 26 inches (23 to 66 centimeters) (Bt and 2Btk horizons)

A horizon:
Hue—5YR or 7.5YR
Value—3 or 4 dry; 2.5 or 3 moist
Chroma—1 to 4, dry or moist
Texture—loam
Clay content—16 to 20 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—2 to 10 percent gravel
Reaction—neutral or slightly alkaline

BA horizon:
Hue—5YR or 7.5YR
Value—3 or 4 dry; 2.5 or 3 moist
Chroma—1 to 4, dry or moist
Texture—sandy clay loam
Clay content—18 to 25 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—2 to 10 percent gravel
Reaction—neutral or slightly alkaline

Bt horizon:
Hue—5YR or 7.5YR
Value—3 or 4, dry or moist
Chroma—2.5 to 4, dry or moist
Texture—clay loam
Clay content—35 to 39 percent
Calcium carbonate equivalent—0 to 4 percent
Rock fragments—2 to 10 percent gravel
Reaction—neutral or slightly alkaline

2Btk horizon:
Hue—5YR or 7.5YR
Value—3 or 4, dry or moist
Chroma—2.5 to 4, dry or moist
Texture—sandy clay
Clay content—35 to 39 percent
Calcium carbonate equivalent—0 to 10 percent
Rock fragments—35 to 55 percent gravel
Reaction—neutral to moderately alkaline

32—Cosnino-Rock outcrop complex, 5 to 25 percent slopes

Map Unit Setting

Major land resource area: 39—Arizona and New Mexico Mountains
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Landform(s): Canyons and rims (figs. 13 and 14)
Elevation: 6,000 to 7,500 feet (1,829 to 2,286 meters)
Mean annual precipitation: 18 to 22 inches (457 to 559 millimeters)
Mean annual air temperature: 42 to 46 degrees F (5.5 to 7.7 degrees C)
Mean annual soil temperature: 41 to 47 degrees F (6.6 to 8.8 degrees C)
Frost-free period: 100 to 120 days

Map Unit Composition

Cosnino and similar soils: 80 percent
Rock outcrop: 20 percent

Description of the Cosnino Soil

Taxonomic classification: Loamy-skeletal, mixed, superactive, frigid Lithic Haplustolls
Taxon kind: Series
Geomorphic position: Shoulder slopes along canyon rims
Parent material: Colluvium and/or residuum weathered from limestone

Figure 13.—An area of the Cosnino soil in Cosnino-Rock outcrop complex, 5 to 25 percent slopes.

Figure 14.—An area of Rock outcrop in Cosnino-Rock outcrop complex, 5 to 25 percent slopes.

Elevation: 6,000 to 7,500 feet (1,829 to 2,286 meters)
Slope: 5 to 25 percent
Depth to restrictive feature(s): 4 to 15 inches to lithic bedrock
Drainage class: Somewhat excessively drained
K_{sat} *of solum:* 1.98 to 5.95 inches per hour (14.00 to 42.00 micrometers per second)
K_{sat} *of restrictive layer:* 0.00 to 0.57 inch per hour (0.00 to 4.00 micrometers per second)
Available water capacity (total inches): 0.5 (very low)
Shrink-swell potential: About 1.5 LEP (low)
Flooding hazard: None
Ponding hazard: None
Runoff class: Very high
Hydrologic group: D
Ecological site name: Limestone/Sandstone Upland 18-22” p.z.
Ecological site number: F039XA139AZ
Present vegetation: Blue grama, twoneedle pinyon, needle and thread, western wheatgrass, alligator juniper, alderleaf mountain mahogany, cliffrose, Gambel oak, broom snakeweed, Canadian wildrye, Louisiana sagewort, penstemon, ponderosa pine, Rocky Mountain juniper, squirreltail, Utah juniper, cactus, forbs, and annuals
Land capability (nonirrigated): 5c
Surface cover (percent): (fig. 15)

Canopy plant cover	10
Woody debris	0
Bare soil	0
Rock fragments	0

Figure 15.—Surface of Cosnino channery sandy loam.

Typical Pedon (figs. 16 and 17)

Location by Universal Transverse Mercator System: Zone 12N, 3891898 Northing, 452163 Easting

A—0 to 2 inches (0 to 5 centimeters); reddish brown (5YR 4/3) channery sandy loam, dark reddish brown (5YR 3/3) moist; 16 percent clay; weak fine granular structure; soft, friable, slightly sticky, slightly plastic; many very fine roots; many very fine and common fine tubular pores; 5 percent flagstones and 20 percent channers; noneffervescent; slightly alkaline, pH 7.6; clear smooth boundary.

Bw—2 to 8 inches (5 to 20 centimeters); reddish brown (5YR 4/3) very stony sandy loam, dark reddish brown (5YR 3/3) moist; 12 percent clay; moderate fine subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many very fine and fine roots; many fine and few medium tubular pores; 10 percent flagstones, 20 percent channers, and 25 percent flagstones; noneffervescent; slightly alkaline, pH 7.8; abrupt wavy boundary.

R—8 inches (20 centimeters); unfractured, unweathered limestone of the Kaibab Formation.

Range in Characteristics

Rock fragments in the control section: 35 to 70 percent channers, flagstones, and stones

Clay content of particle-size control section: 10 to 18 percent

Mollic epipedon: At a depth of 0 to 8 inches (0 to 20 centimeters) (A and Bw horizons)

A horizon:

Hue—5YR or 7.5YR

Value—3 or 4 dry; 2.5 or 3 moist

Figure 16.—Profile of Cosnino soil. Scale is in centimeters.

Chroma—1 to 4, dry or moist
Texture—sandy loam
Clay content—12 to 18 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—15 to 30 percent channers and flagstones
Reaction—slightly alkaline

Bw horizon:
Hue—5YR or 7.5YR
Value—3 or 4, dry or moist
Chroma—2.5 to 4, dry or moist
Texture—loam or sandy loam

Figure 17.—Box sample of Cosnino typical pedon.

Clay content—10 to 16 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—35 to 70 percent channers, flagstones, and stones
Reaction—slightly alkaline

Description of the Rock Outcrop

This component consists of flat or rolling exposures of the Kaibab Formation. Areas are typically barren but may have sparse vegetation growing in cracks and crevices or in layers of eolian, alluvial, or colluvial material.

33—Cosnino-Rock outcrop complex, 25 to 70 percent slopes

Map Unit Setting

Major land resource area: 39—Arizona and New Mexico Mountains
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Landform(s): Canyons and canyon walls (figs. 18 and 19)
Elevation: 6,000 to 7,500 feet (1,828 to 2,286 meters)
Mean annual precipitation: 18 to 22 inches (457 to 559 millimeters)
Mean annual air temperature: 42 to 46 degrees F (5.5 to 7.7 degrees C)
Mean annual soil temperature: 44 to 48 degrees F (6.6 to 8.8 degrees C)
Frost-free period: 100 to 120 days

Map Unit Composition

Cosnino and similar soils: 50 percent
Rock outcrop: 40 percent
Minor components: Loamy Lithic Haplustolls—10 percent

Description of the Cosnino Soil

Taxonomic classification: Loamy-skeletal, mixed, superactive, frigid Lithic Haplustolls
Taxon kind: Series

Figure 18.—An area of the Cosnino soil in Cosnino-Rock outcrop complex, 25 to 70 percent slopes.

Figure 19.—An area of Rock outcrop in Cosnino-Rock outcrop complex, 25 to 70 percent slopes.

Figure 20.—Surface of Cosnino flaggy sandy loam.

Geomorphic position: Predominantly north aspects of canyon side slopes in limestone
Parent material: Colluvium and/or residuum weathered from limestone
Elevation: 6,000 to 7,500 feet (1,828 to 2,286 meters)
Slope: 25 to 70 percent
Depth to restrictive feature(s): 4 to 20 inches to lithic bedrock
Drainage class: Somewhat excessively drained
K_{sat} *of solum:* 1.98 to 5.95 inches per hour (14.00 to 42.00 micrometers per second)
K_{sat} *of restrictive layer:* 0.00 to 0.57 inch per hour (0.00 to 4.00 micrometers per second)
Available water capacity (total inches): 1.1 (very low)
Shrink-swell potential: About 1.5 LEP (low)
Flooding hazard: None
Ponding hazard: None
Runoff class: Very high
Hydrologic group: D
Ecological site name: Limestone/Sandstone Upland 18-22” p.z.
Ecological site number: F039XA139AZ
Present vegetation: Douglas fir, ponderosa pine, and Gambel oak
Land capability (nonirrigated): 8c
Surface cover (percent): (fig. 20)

Canopy plant cover	10
Woody debris	0
Bare soil	0
Rock fragments	0

Figure 21.—Profile of Cosnino soil. Scale is in centimeters.

Typical Pedon (figs. 21 and 22)

Location by Universal Transverse Mercator System: Zone 12N, 3891375 Northing, 452137 Easting

Oi—0 to 2 inches (0 to 5 centimeters); very dark brown (10YR 2/2) slightly decomposed plant material, black (10YR 2/1) moist; many very fine and fine roots; abrupt smooth boundary.

A—2 to 6 inches (5 to 15 centimeters); very dark grayish brown (10YR 3/2) flaggy sandy loam, very dark brown (10YR 2/2) moist; 14 percent clay; weak fine granular structure parting to single grain; soft, very friable, slightly sticky, slightly plastic; many very fine, fine, and medium roots; many very fine tubular pores; 5 percent

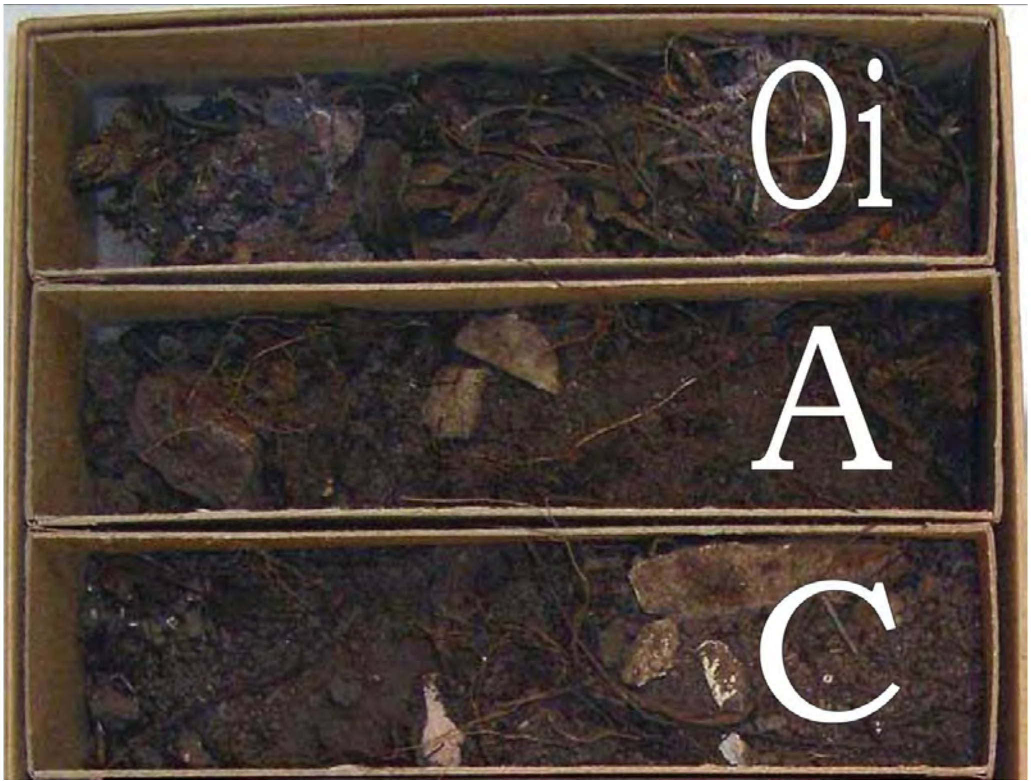


Figure 22.—Box sample of Cosnino typical pedon.

stones, 10 percent flagstones, and 15 percent channers; noneffervescent; slightly alkaline, pH 7.8; clear smooth boundary.

C—6 to 16 inches (15 to 41 centimeters); very dark grayish brown (10YR 3/2) very stony sandy loam, very dark brown (10YR 2/2) moist; 16 percent clay; massive parting to single grain; slightly hard, friable, slightly sticky, slightly plastic; many very fine, fine, and medium roots; many very fine irregular pores; 15 percent channers and 25 percent flagstones; slightly effervescent, 4 percent calcium carbonate equivalent; moderately alkaline, pH 8.0; abrupt wavy boundary.

R—16 inches (41 centimeters); unfractured, unweathered limestone of the Kaibab Formation.

Range in Characteristics

Rock fragments in the control section: 35 to 50 percent channers, flagstones, and stones
Clay content of particle-size control section: 12 to 18 percent
Mollic epipedon: At a depth of 0 to 16 inches (0 to 41 centimeters) (A and C horizons)

A horizon:
Hue—7.5YR or 10YR
Value—3 or 4 dry; 2 or 3 moist
Chroma—2 or 3, dry or moist
Texture—sandy loam
Clay content—12 to 18 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—15 to 30 percent channers, flagstones, and stones
Reaction—slightly alkaline or moderately alkaline

Figure 23.—An area of the Kydestea soil in Kydestea-Rock outcrop complex, 3 to 25 percent slopes.

C horizon:
Hue—7.5YR or 10YR
Value—2 to 4, dry or moist
Chroma—2 or 3, dry or moist
Texture—sandy loam
Clay content—14 to 18 percent
Calcium carbonate equivalent—0 to 4 percent
Rock fragments—25 to 50 percent channers, flagstones, and stones
Reaction—moderately alkaline

Description of the Rock Outcrop

This component consists of steep exposures of the Kaibab or Toroweap Formation or very steep exposures of the Coconino Sandstone. Areas are typically barren but may have sparse vegetation growing in cracks and crevices or in layers of eolian, alluvial, or colluvial material.

34—Kydestea-Rock outcrop complex, 3 to 25 percent slopes

Map Unit Setting

Major land resource area: 35—Colorado Plateau
Land resource unit: 35-7 Colorado Plateau-Woodland-Grassland
Landform(s): Canyons and rims (figs. 23 and 24)
Elevation: 6,000 to 7,000 feet (1,829 to 2,134 meters)
Mean annual precipitation: 14 to 18 inches (356 to 457 millimeters)

Mean annual air temperature: 46 to 50 degrees F (8.0 to 10.0 degrees C)
Mean annual soil temperature: 48 to 52 degrees F (9.1 to 11.1 degrees C)
Frost-free period: 120 to 180 days

Map Unit Composition

Kydestea and similar soils: 80 percent
Rock outcrop: 20 percent

Description of the Kydestea Soil

Taxonomic classification: Loamy-skeletal, mixed, superactive, calcareous, mesic Aridic Lithic Ustorthents
Taxon kind: Series
Geomorphic position: Shoulder slopes along the canyon rims
Parent material: Colluvium and/or residuum weathered from limestone
Elevation: 6,000 to 7,000 feet (1,829 to 2,134 meters)
Slope: 3 to 25 percent
Depth to restrictive feature(s): 4 to 15 inches to lithic bedrock
Drainage class: Well drained
K_{sat} *of solum:* 0.57 inch to 1.98 inches per hour (4.00 to 14.00 micrometers per second)
K_{sat} *of restrictive layer:* 0.00 to 0.57 inch per hour (0.00 to 4.00 micrometers per second)
Available water capacity (total inches): 0.9 (very low)
Shrink-swell potential: About 4.5 LEP (moderate)
Flooding hazard: None

Figure 24.—An area of Rock outcrop in Kydestea-Rock outcrop complex, 3 to 25 percent slopes.

Figure 25.—Surface of Kydestea very flaggy loam.

Ponding hazard: None
Runoff class: Very high
Hydrologic group: D
Ecological site name: Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z.
Ecological site number: R035XG723AZ
Present vegetation: Blue grama, oneseed juniper, cliffrose, Fremont’s mahonia, twoneedle pinyon, broom snakeweed, Utah juniper, and fernbush
Land capability (nonirrigated): 8c
Surface cover (percent): (fig. 25)

Canopy plant cover	10
Woody debris	0
Bare soil	0
Rock fragments	0

Typical Pedon (figs. 26 and 27)

Location by Universal Transverse Mercator System: Zone 12N, 3892457 Northing, 459127 Easting

A—0 to 3 inches (0 to 8 centimeters); brown (10YR 4/3) very flaggy loam, very dark grayish brown (10YR 3/2) moist; 18 percent clay; strong fine granular structure; soft, friable, moderately sticky, slightly plastic; many very fine and common fine roots; few fine tubular pores; 5 percent stones, 15 percent flagstones, and 20 percent channers; slightly effervescent, 2 percent calcium carbonate equivalent; moderately alkaline, pH 8.0; clear smooth boundary.

Bw—3 to 9 inches (8 to 23 centimeters); brown (7.5YR 4/3) very stony loam, dark brown (7.5YR 3/4 and 3/3) moist; 20 percent clay; moderate fine subangular blocky structure; slightly hard, friable, moderately sticky, moderately plastic;

Figure 26.—Profile of Kydestea soil. Scale is in centimeters.

many very fine and common fine and medium roots; common fine tubular pores; 15 percent stones, 15 percent flagstones, and 15 percent channers; strongly effervescent, 5 percent calcium carbonate equivalent; moderately alkaline, pH 8.2; abrupt wavy boundary.

R—9 inches (23 centimeters); unfractured, unweathered limestone of the Kaibab Formation.

Range in Characteristics

Rock fragments in the control section: 35 to 55 percent channers, flagstones, and stones

Clay content of particle-size control section: 18 to 24 percent

Figure 27.—Box sample of Kydestea typical pedon.

A horizon:
Hue—7.5YR or 10YR
Value—4 or 5 dry; 3 or 4 moist
Chroma—2 to 4, dry or moist
Texture—loam
Clay content—16 to 24 percent
Calcium carbonate equivalent—0 to 5 percent
Rock fragments—35 to 55 percent channers, flagstones, and stones
Reaction—moderately alkaline

Bw horizon:
Hue—7.5YR or 10YR
Value—4 to 6 dry; 3 or 4 moist
Chroma—3 or 4, dry or moist
Texture—loam
Clay content—18 to 24 percent
Calcium carbonate equivalent—0 to 5 percent
Rock fragments—35 to 55 percent channers, flagstones, and stones
Reaction—moderately alkaline

Description of the Rock Outcrop

This component consists of flat or rolling exposures of the Kaibab Formation. Areas are typically barren but may have sparse vegetation growing in cracks and crevices or in layers of eolian, alluvial, or colluvial material.

35—Lithic Ustorthents-Rock outcrop complex, 25 to 70 percent slopes

Map Unit Setting

Major land resource area: 39—Arizona and New Mexico Mountains
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Landform(s): Canyons and canyon walls (figs. 28 and 29)

Figure 28.—An area of the Lithic Ustorthents in Lithic Ustorthents-Rock outcrop complex, 25 to 70 percent slopes.

Figure 29.—An area of Rock outcrop in Lithic Ustorthents-Rock outcrop complex, 25 to 70 percent slopes.

Elevation: 6,000 to 7,500 feet (1,829 to 2,286 meters)
Mean annual precipitation: 18 to 22 inches (457 to 559 millimeters)
Mean annual air temperature: 42 to 46 degrees F (5.5 to 7.7 degrees C)
Mean annual soil temperature: 44 to 48 degrees F (6.6 to 8.8 degrees C)
Frost-free period: 100 to 120 days

Map Unit Composition

Lithic Ustorthents and similar soils: 70 percent
Rock outcrop: 30 percent

Description of the Lithic Ustorthents

Note: Lithic Ustorthents have soil properties that vary beyond family class limits.

Taxonomic classification: Loamy-skeletal, mixed, superactive, calcareous, frigid Lithic Ustorthents
Taxon kind: Taxon above family
Geomorphic position: Predominantly south aspects of canyon side slopes in limestone
Parent material: Colluvium and/or residuum weathered from limestone
Elevation: 6,000 to 7,500 feet (1,829 to 2,286 meters)
Slope: 25 to 70 percent
Depth to restrictive feature(s): 4 to 18 inches to lithic bedrock
Drainage class: Well drained
K_{sat} *of solum:* 0.57 inch to 5.95 inches per hour (4.00 to 42.00 micrometers per second)
K_{sat} *of restrictive layer:* 0.00 to 0.57 inch per hour (0.00 to 4.00 micrometers per second)
Available water capacity (total inches): 1.0 (very low)
Shrink-swell potential: About 4.5 LEP (moderate)
Flooding hazard: None
Ponding hazard: None
Runoff class: Very high
Hydrologic group: D
Ecological site name: Limestone/Sandstone Upland 18-22” p.z.
Ecological site number: F039XA139AZ
Present vegetation: Twoneedle pinyon, Rocky Mountain juniper, blue grama, Utah juniper, mountain mahogany, muttongrass, squirreltail, banana yucca, broom snakeweed, fleabane, and Indian paintbrush
Land capability (nonirrigated): 8c
Surface cover (percent): (fig. 30)

Canopy plant cover	10
Woody debris	0
Bare soil	0
Rock fragments	0

Typical Pedon (figs. 31 and 32)

Location by Universal Transverse Mercator System: Zone 12N, 3891715 Northing, 452105 Easting

A—0 to 4 inches (0 to 10 centimeters); brown (10YR 4/3) flaggy sandy loam; 15 percent clay; weak thick platy structure parting to weak fine granular; soft, very friable, slightly sticky, slightly plastic; many very fine, fine, and few coarse roots; few fine irregular pores; 5 percent stones, 10 percent channers, and 15 percent flagstones; slightly effervescent, 5 percent calcium carbonate equivalent; moderately alkaline, pH 8.0; clear smooth boundary.

Figure 30.—Surface of Lithic Ustorthents, flaggy sandy loam.

C—4 to 11 inches (10 to 28 centimeters); yellowish brown (10YR 5/4) very stony sandy clay loam, dark brown (10YR 3/3) moist; 22 percent clay; massive; soft, friable, moderately sticky, moderately plastic; many fine and medium and few coarse roots; many fine and few medium tubular pores; 10 percent channers, 20 percent stones, and 20 percent flagstones; strongly effervescent; moderately alkaline, pH 8.0; abrupt wavy boundary.

R—11 inches (28 centimeters); unfractured, unweathered limestone of the Kaibab Formation.

Range in Characteristics

Rock fragments in the control section: 35 to 55 percent channers, flagstones, and stones

Clay content of particle-size control section: 18 to 25 percent

A horizon:

Hue—7.5YR or 10YR
Value—4 or 5 dry; 3 or 4 moist
Chroma—3 or 4, dry or moist
Texture—sandy loam
Clay content—12 to 18 percent
Calcium carbonate equivalent—0 to 5 percent
Rock fragments—15 to 30 percent channers, flagstones, and stones
Reaction—moderately alkaline

C horizon:

Value—4 to 6 dry; 3 or 4 moist
Chroma—3 or 4, dry or moist

Figure 31.—Profile of Lithic Ustorthents. Scale is in centimeters.

Texture—sandy clay loam
Clay content—18 to 25 percent
Calcium carbonate equivalent—0 to 10 percent
Rock fragments—35 to 55 percent channers, flagstones, and stones
Reaction—moderately alkaline

Description of the Rock Outcrop

This component consists of steep exposures of the Kaibab or Toroweap Formation or very steep exposures of the Coconino Sandstone. Areas are typically barren but may have sparse vegetation growing in cracks and crevices or in layers of eolian, alluvial, or colluvial material.

Figure 32.—Box sample of Lithic Ustorthents typical pedon.

36—Oxyaquic Ustifluvents, 2 to 6 percent slopes

Map Unit Setting

Major land resource area: 39—Arizona and New Mexico Mountains
Land resource unit: 39-1 Mogollon Plateau-Coniferous Forest
Landform(s): Flood-plain steps (fig. 33)
Elevation: 5,500 to 7,000 feet (1,676 to 2,134 meters)
Mean annual precipitation: 18 to 22 inches (457 to 559 millimeters)
Mean annual air temperature: 42 to 46 degrees F (5.5 to 7.7 degrees C)
Mean annual soil temperature: 44 to 48 degrees F (6.6 to 8.8 degrees C)
Frost-free period: 100 to 120 days

Map Unit Composition

Oxyaquic Ustifluvents and similar soils: 85 percent
Minor components: Oxyaquic Haplustolls—15 percent

Description of the Oxyaquic Ustifluvents

Note: Oxyaquic Ustifluvents have soil properties that vary beyond family class limits.

Taxonomic classification: Oxyaquic Ustifluvents
Taxon kind: Taxon above family
Geomorphic position: Canyon bottoms of flood-plain steps
Parent material: Alluvium derived from limestone, sandstone, and shale
Elevation: 5,500 to 7,000 feet (1,676 to 2,134 meters)
Slope: 2 to 6 percent
Drainage class: Somewhat excessively drained
K_{sat} *of solum:* 1.98 to 99.92 inches per hour (14.00 to 705.00 micrometers per second)
Available water capacity (total inches): 2.7 (low)
Shrink-swell potential: About 1.5 LEP (low)
Flooding hazard: Occasional
Ponding hazard: None
Seasonal water table (minimum depth): About 35 to 39 inches

Figure 33.—An area of Oxyaquic Ustifluvents, 2 to 6 percent slopes.

Runoff class: Negligible
Hydrologic group: A
Ecological site name: Canyon Bottom (Riparian) 18-22” p.z.
Ecological site number: R039XA140AZ
Present vegetation: Canyon grape, New Mexico locust, Woods’ rose, snowberry, western white clematis, boxelder, chokecherry, redosier dogwood, sideoats grama, and yarrow
Land capability (nonirrigated): 5c
Surface cover (percent): (fig. 34)

Canopy plant cover	10
Woody debris	0
Bare soil	0
Rock fragments	0

Typical Pedon (fig. 35)

Location by Universal Transverse Mercator System: Zone 12N, 3891484 Northing, 452044 Easting

A—0 to 8 inches (0 to 20 centimeters); dark brown (7.5YR 3/2) extremely cobbly loamy sand, black (7.5YR 2.5/1) moist; 5 percent clay; weak fine granular structure; loose, nonsticky, nonplastic; many very fine and fine and common medium roots; many fine tubular pores; 10 percent stones, 20 percent cobbles, and 40 percent gravel; noneffervescent; slightly alkaline, pH 7.4; gradual smooth boundary.

C1—8 to 37 inches (20 to 94 centimeters); 50 percent brown (7.5YR 4/2) and 50 percent dark brown (7.5YR 3/2) extremely stony coarse sand, black (7.5YR 2.5/1) moist; 3 percent clay; single grain; loose, nonsticky, nonplastic; many very fine, fine, and medium and few coarse roots; many fine tubular pores; 15 percent

Figure 34.—Surface of Oxyaquic Ustifluvents, extremely cobbly loamy sand.

Figure 35.—Box sample of Oxyaquic Ustifluvents typical pedon.

cobbles, 20 percent stones, and 30 percent gravel; noneffervescent; slightly alkaline, pH 7.6; clear smooth boundary.

C2—37 to 60 inches (94 to 152 centimeters); dark brown (7.5YR 3/2) very stony sandy loam, very dark brown (7.5YR 2.5/2) moist; 14 percent clay; massive; soft, very friable, slightly sticky, slightly plastic; many very fine, fine, and medium roots; many fine tubular pores; 1 percent fine masses of oxidized iron and 5 percent medium iron-manganese concretions; 5 percent cobbles, 10 percent stones, and 20 percent gravel; noneffervescent; slightly alkaline, pH 7.4.

Range in Characteristics

Rock fragments in the control section: 25 to 75 percent gravel, cobbles, and stones
Clay content of particle-size control section: 1 to 16 percent
Depth to redoximorphic features: More than 30 inches (76 centimeters) (C1 and C2 horizons)

A horizon:
Hue—7.5YR or 10YR
Value—2 or 3, dry or moist
Chroma—1 to 3, dry or moist
Texture—loamy sand
Clay content—2 to 8 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—60 to 75 percent gravel, cobbles, and stones
Reaction—neutral or slightly alkaline

C1 horizon:
Hue—7.5YR or 10YR
Value—2.5 to 4 dry; 2 or 3 moist
Chroma—1 to 3, dry or moist
Texture—coarse sand
Clay content—1 to 6 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—60 to 75 percent gravel, cobbles, and stones
Reaction—neutral or slightly alkaline

C2 horizon:
Hue—7.5YR or 10YR
Value—2.5 or 3 dry; 2 or 3 moist
Chroma—2 or 3, dry or moist
Texture—sandy loam
Clay content—12 to 16 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—25 to 50 percent gravel, cobbles, and stones
Reaction—neutral or slightly alkaline

37—Rock outcrop-Kydestea complex, 25 to 60 percent slopes

Map Unit Setting

Major land resource area: 35—Colorado Plateau
Land resource unit: 35-7 Colorado Plateau-Woodland-Grassland
Landform(s): Canyons and canyon walls (figs. 36 and 37)
Elevation: 6,290 to 6,600 feet (1,918 to 2,012 meters)

Figure 36.—An area of Rock outcrop in Rock outcrop-Kydestea complex, 25 to 60 percent slopes.

Figure 37.—An area of the Kydestea soil in Rock outcrop-Kydestea complex, 25 to 60 percent slopes.

Mean annual precipitation: 14 to 18 inches (356 to 457 millimeters)
Mean annual air temperature: 46 to 50 degrees F (8.0 to 10.0 degrees C)
Mean annual soil temperature: 48 to 52 degrees F (9.1 to 11.1 degrees C)
Frost-free period: 120 to 180 days

Map Unit Composition

Rock outcrop: 50 percent
Kydestea and similar soils: 40 percent
Minor components: Coarse-loamy Aridic Lithic Haplustepts—10 percent

Description of the Rock Outcrop

This component consists of steep cliffs of the Kaibab or Toroweap Formation. Areas are typically barren but may have sparse vegetation growing in cracks and crevices or in layers of eolian, alluvial, or colluvial material.

Description of the Kydestea Soil

Taxonomic classification: Loamy-skeletal, mixed, superactive, calcareous, mesic Aridic Lithic Ustorthents
Taxon kind: Series
Geomorphic position: Canyon side slopes in limestone
Parent material: Colluvium and/or residuum weathered from limestone
Elevation: 6,290 to 6,600 feet (1,918 to 2,012 meters)
Slope: 25 to 50 percent
Depth to restrictive feature(s): 14 to 20 inches to lithic bedrock
Drainage class: Well drained
K_{sat} *of solum:* 0.57 inch to 1.98 inches per hour (4.00 to 14.00 micrometers per second)
K_{sat} *of restrictive layer:* 0.00 to 0.60 inch per hour (0.00 to 4.23 micrometers per second)
Available water capacity (total inches): 1.4 (very low)
Shrink-swell potential: About 4.5 LEP (moderate)
Flooding hazard: None
Ponding hazard: None
Runoff class: Very high
Hydrologic group: D
Ecological site name: Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z.
Ecological site number: R035XG723AZ
Present vegetation: Cliffrose, blue grama, muttongrass, oneseed juniper, and twoneedle pinyon
Land capability (nonirrigated): 6c
Surface cover (percent): (fig. 38)

Canopy plant cover	10
Woody debris	0
Bare soil	0
Rock fragments	0

Typical Pedon (figs. 39 and 40)

Location by Universal Transverse Mercator System: Zone 12N, 3892693 Northing, 459063 Easting

A—0 to 3 inches (0 to 8 centimeters); very dark gray (7.5YR 3/1) very flaggy loam, black (7.5YR 2.5/1) moist; 19 percent clay; moderate medium granular structure; soft, very friable, moderately sticky, slightly plastic; common medium and few coarse roots; many very fine and fine interstitial pores; 5 percent stones, 20

Figure 38.—Surface of Kydestea very flaggy loam.

percent channers, and 25 percent flagstones; very slightly effervescent, 1 percent calcium carbonate equivalent; slightly alkaline, pH 7.6; abrupt smooth boundary.

C—3 to 17 inches (8 to 43 centimeters); brown (7.5YR 4/2) very flaggy loam, dark brown (7.5YR 3/2) moist; 24 percent clay; weak medium subangular blocky structure; slightly hard, friable, moderately sticky, moderately plastic; common medium and few coarse roots; common very fine and fine interstitial pores; 5 percent stones, 20 percent channers, and 25 percent flagstones; slightly effervescent, 5 percent calcium carbonate equivalent; slightly alkaline, pH 7.4; abrupt wavy boundary.

R—17 inches (43 centimeters); unfractured, unweathered limestone of the Kaibab Formation.

Range in Characteristics

Rock fragments in the control section: 35 to 60 percent channers, flagstones, and stones

Clay content of particle-size control section: 18 to 26 percent

A horizon:

Hue—7.5YR or 10YR
Value—3 or 4 dry; 2.5 to 4 moist
Chroma—1 to 4, dry or moist
Texture—loam
Clay content—15 to 26 percent
Calcium carbonate equivalent—0 to 2 percent

Figure 39.—Profile of Kydestea soil. Scale is in centimeters.

Rock fragments—35 to 60 percent channers, flagstones, and stones
Reaction—slightly alkaline

C horizon:
Hue—7.5YR or 10YR
Value—4 to 6 dry; 3 or 4 moist
Chroma—2 to 4, dry or moist
Texture—loam
Clay content—15 to 26 percent
Calcium carbonate equivalent—2 to 10 percent
Rock fragments—35 to 60 percent channers, flagstones, and stones
Reaction—slightly alkaline

Figure 40.—Box sample of Kydestea typical pedon.

38—Whiskey loam, 2 to 8 percent slopes

Map Unit Setting

Major land resource area: 35—Colorado Plateau
Land resource unit: 35-7 Colorado Plateau-Woodland-Grassland
Landform(s): Stream terraces (fig. 41)
Elevation: 6,200 to 6,270 feet (1,891 to 1,910 meters)
Mean annual precipitation: 14 to 18 inches (356 to 457 millimeters)
Mean annual air temperature: 46 to 50 degrees F (8.0 to 10.0 degrees C)
Mean annual soil temperature: 48 to 52 degrees F (9.1 to 11.1 degrees C)
Frost-free period: 120 to 180 days

Map Unit Composition

Whiskey and similar soils: 90 percent
Minor components: Ustifluvents—10 percent

Description of the Whiskey Soil

Taxonomic classification: Fine-loamy, mixed, superactive, mesic Pachic Haplustolls
Taxon kind: Series
Geomorphic position: Canyon bottoms on stream terraces
Parent material: Alluvium derived from limestone, sandstone, and shale
Elevation: 6,200 to 6,270 feet (1,891 to 1,910 meters)
Slope: 2 to 8 percent
Drainage class: Well drained
K_{sat} of solum: 0.57 inch to 1.98 inches per hour (4.00 to 14.00 micrometers per second)
Available water capacity (total inches): 7.4 (high)
Shrink-swell potential: About 4.5 LEP (moderate)
Flooding hazard: Rare
Ponding hazard: None
Runoff class: Medium
Hydrologic group: B
Ecological site name: Semi-Riparian Canyon Bottom 14-18” p.z.
Ecological site number: R035XG724AZ

Figure 41.—An area of the Whiskey soil (foreground) in Whiskey loam, 2 to 8 percent slopes.

Present vegetation: Blue grama, rubber rabbitbrush, oneseed juniper, cottonwood, ponderosa pine, twoneedle pinyon, winterfat, aster, sand dropseed, and western wheatgrass

Land capability (nonirrigated): 6c

Surface cover (percent): (fig. 42)

Canopy plant cover	10 percent
Woody debris	0 percent
Bare soil	0 percent
Rock fragments	0 percent

Typical Pedon (figs. 43 and 44)

Location by Universal Transverse Mercator System: Zone 12N, 3892903 Northing, 459062 Easting

A—0 to 2 inches (0 to 5 centimeters); brown (10YR 4/3) loam, very dark grayish brown (10YR 3/2) moist; 18 percent clay; weak thin platy and moderate fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; many very fine and common medium roots; common very fine and fine dendritic tubular pores; very slightly effervescent, 1 percent calcium carbonate equivalent; slightly alkaline, pH 7.4; abrupt smooth boundary.

AB—2 to 15 inches (5 to 38 centimeters); brown (10YR 4/3) loam, very dark grayish brown (10YR 3/2) moist; 20 percent clay; weak medium angular blocky structure and massive; slightly hard, friable, slightly sticky, slightly plastic; many very fine and common medium roots; common very fine and fine dendritic tubular pores; slightly effervescent, 3 percent calcium carbonate equivalent; slightly alkaline, pH 7.4; gradual smooth boundary.

Figure 42.—Surface of Whiskey loam.

Bw—15 to 34 inches (38 to 86 centimeters); brown (10YR 4/3) fine sandy loam, very dark grayish brown (10YR 3/2) moist; 18 percent clay; weak fine subangular blocky and weak medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; common very fine and fine roots; common very fine and fine dendritic tubular pores; slightly effervescent, 5 percent calcium carbonate equivalent; slightly alkaline, pH 7.6; gradual smooth boundary.

Ck—34 to 60 inches (86 to 152 centimeters); brown (10YR 4/3) loam, dark brown (10YR 3/3) moist; 22 percent clay; massive; moderately hard, firm, moderately sticky, slightly plastic; few very fine and fine roots; common very fine dendritic tubular pores; common fine carbonate masses; strongly effervescent, 12 percent calcium carbonate equivalent; slightly alkaline, pH 7.8.

Range in Characteristics

Rock fragments in the control section: 0 to 15 percent gravel
Clay content of particle-size control section: 18 to 25 percent
Mollic epipedon: At a depth of 0 to 34 inches (0 to 86 centimeters) (A, AB, and Bw horizons)

A horizon:
Hue—10YR or 7.5YR
Value—4 dry; 3 moist
Chroma—3 dry; 2 moist
Texture—loam
Clay content—12 to 25 percent
Calcium carbonate equivalent—0 to 2 percent
Rock fragments—0 to 15 percent gravel
Reaction—slightly alkaline

Figure 43.—Profile of Whiskey soil. Scale is in inches.

AB horizon:

Hue—10YR or 7.5YR
Value—4 dry; 3 moist
Chroma—3 dry; 2 moist
Texture—loam or fine sandy loam
Clay content—12 to 25 percent
Calcium carbonate equivalent—2 to 5 percent
Rock fragments—0 to 15 percent gravel
Reaction—slightly alkaline or moderately alkaline

Figure 44.—Box sample of Whiskey typical pedon.

Bw horizon:
Hue—10YR or 7.5YR
Value—4 dry; 3 moist
Chroma—3 dry; 2 moist
Texture—loam or fine sandy loam
Clay content—12 to 25 percent
Calcium carbonate equivalent—2 to 10 percent
Rock fragments—0 to 15 percent gravel
Reaction—slightly alkaline or moderately alkaline

Ck horizon:
Hue—10YR or 7.5YR
Value—4 dry; 3 moist
Chroma—3, dry or moist
Texture—loam or fine sandy loam
Clay content—12 to 25 percent
Calcium carbonate equivalent—10 to 15 percent
Rock fragments—0 to 15 percent gravel
Reaction—slightly alkaline or moderately alkaline

Figure 45.—An area of Vosburg sandy loam, 1 to 5 percent slopes.

39—Vosburg sandy loam, 1 to 5 percent slopes

Map Unit Setting

Major land resource area: 35—Colorado Plateau
Land resource unit: 35-7 Colorado Plateau-Woodland-Grassland
Landform(s): Terraces (fig. 45)
Elevation: 5,500 to 7,000 feet (1,676 to 2,134 meters)
Mean annual precipitation: 14 to 18 inches (356 to 457 millimeters)
Mean annual air temperature: 46 to 50 degrees F (8.0 to 10.0 degrees C)
Mean annual soil temperature: 48 to 52 degrees F (9.1 to 11.1 degrees C)
Frost-free period: 120 to 180 days

Map Unit Composition

Vosburg and similar soils: 100 percent

Description of the Vosburg Soil

Taxonomic classification: Fine-loamy, mixed, superactive, mesic Pachic Argiustolls
Taxon kind: Series
Geomorphic position: More stable areas of older terrace deposits near canyon side slopes
Parent material: Alluvium derived from limestone, sandstone, and shale
Elevation: 5,500 to 7,000 feet (1,676 to 2,134 meters)
Slope: 1 to 5 percent
Drainage class: Well drained
K_{sat} *of solum:* 0.57 inch to 5.95 inches per hour (4.00 to 42.00 micrometers per second)

Available water capacity (total inches): 7.9 (high)
Shrink-swell potential: About 4.5 LEP (moderate)
Flooding hazard: Rare
Ponding hazard: None
Runoff class: Low
Hydrologic group: B
Ecological site name: Semi-Riparian Canyon Bottom 14-18” p.z.
Ecological site number: R035XG724AZ
Present vegetation: Blue grama, rabbitbrush, western wheatgrass, winterfat, fleabane, and globemallow
Land capability (nonirrigated): 6c
Surface cover (percent): (fig. 46)

Canopy plant cover	10
Woody debris	0
Bare soil	0
Rock fragments	0

Typical Pedon (figs. 47 and 48)

Location by Universal Transverse Mercator System: Zone 12N, 3892797 Northing, 459101 Easting

A—0 to 4 inches (0 to 10 centimeters); brown (10YR 4/3) sandy loam, very dark brown (10YR 2/2) moist; 14 percent clay; moderate thick platy structure parting to weak fine granular; soft, very friable, nonsticky, nonplastic; many very fine and common fine roots; many very fine irregular pores; 1 percent fine masses of oxidized iron;

Figure 46.—Surface of Vosburg sandy loam.

Figure 47.—Profile of Vosburg soil. Scale is in centimeters.

2 percent gravel; slightly effervescent, 4 percent calcium carbonate equivalent; moderately alkaline, pH 8.0; clear smooth boundary.

BA—4 to 12 inches (10 to 30 centimeters); dark grayish brown (10YR 4/2) and brown (10YR 4/3) sandy loam, very dark brown (10YR 2/2) moist; 16 percent clay; weak fine subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; many very fine and fine roots; many very fine and fine and common medium irregular pores; 1 percent fine masses of oxidized iron; 2 percent gravel; slightly effervescent, 4 percent calcium carbonate equivalent; slightly alkaline, pH 7.8; gradual smooth boundary.

Bk—12 to 21 inches (30 to 53 centimeters); brown (10YR 5/3 and 4/3) sandy loam, dark brown (7.5YR 3/2) moist; 18 percent clay; weak fine subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many very fine and fine roots; many very fine and fine and common medium irregular pores; common

Figure 48.—Box sample of Vosburg typical pedon.

carbonate masses; 2 percent gravel; slightly effervescent, 9 percent calcium carbonate equivalent; slightly alkaline, pH 7.8; clear smooth boundary.

Btk—21 to 32 inches (53 to 81 centimeters); brown (7.5YR 4/2) loam, very dark brown (7.5YR 2.5/2) moist; 22 percent clay; moderate medium subangular blocky and moderate fine subangular blocky structure; moderately hard, friable, moderately sticky, moderately plastic; many very fine and common fine roots; common very fine and many fine irregular pores; few distinct clay films on surfaces along root channels; 1 percent fine masses of oxidized iron; common carbonate masses; 2 percent gravel; slightly effervescent, 9 percent calcium carbonate equivalent; moderately alkaline, pH 8.2; gradual smooth boundary.

BCk—32 to 60 inches (81 to 152 centimeters); brown (7.5YR 4/3) loam, dark brown (7.5YR 3/2) moist; 24 percent clay; weak fine subangular blocky structure; slightly hard, friable, moderately sticky, moderately plastic; common very fine and fine roots; common very fine and many fine irregular pores; 1 percent fine masses of oxidized iron; many carbonate filaments; 2 percent gravel; strongly effervescent, 1 percent calcium carbonate equivalent; moderately alkaline, pH 8.2.

Range in Characteristics

Rock fragments in the control section: 0 to 5 percent gravel
Clay content of particle-size control section: 18 to 26 percent
Mollic epipedon: At a depth of 0 to 32 inches (0 to 81 centimeters) (A, BA, Bk, and Btk horizons)
Argillic horizon: At a depth of 21 to 32 inches (53 to 81 cm) (Btk horizon)

A horizon:
Hue—10YR or 7.5YR
Value—4 dry; 2 moist
Chroma—3 dry; 2 moist
Texture—sandy loam
Clay content—12 to 16 percent
Calcium carbonate equivalent—0 to 4 percent
Rock fragments—0 to 5 percent gravel
Reaction—slightly alkaline or moderately alkaline

BA horizon:
Hue—10YR or 7.5YR
Value—4 dry; 2 moist
Chroma—2 or 3 dry; 2 moist
Texture—sandy loam
Clay content—12 to 18 percent
Calcium carbonate equivalent—0 to 4 percent
Rock fragments—0 to 5 percent gravel
Reaction—slightly alkaline or moderately alkaline

Bk horizon:
Hue—10YR or 7.5YR
Value—4 or 5 dry; 3 moist
Chroma—3 dry; 2 moist
Texture—sandy loam or loam
Clay content—16 to 22 percent
Calcium carbonate equivalent—5 to 25 percent
Rock fragments—0 to 5 percent gravel
Reaction—slightly alkaline or moderately alkaline

Btk horizon:
Hue—10YR or 7.5YR
Value—4 dry; 2.5 or 3 moist
Chroma—2 or 3, dry or moist
Texture—sandy loam or loam
Clay content—18 to 26 percent
Calcium carbonate equivalent—5 to 25 percent
Rock fragments—0 to 5 percent gravel
Reaction—slightly alkaline or moderately alkaline

BCk horizon:
Hue—10YR or 7.5YR
Value—4 dry; 3 moist

Chroma—2 or 3, dry or moist
Texture—loam
Clay content—18 to 26 percent
Calcium carbonate equivalent—5 to 25 percent
Rock fragments—0 to 5 percent gravel
Reaction—slightly alkaline or moderately alkaline

Ecological Sites

Jennifer M. Putterre, ecological site inventory specialist, Natural Resources Conservation Service, prepared this section.

An ecological site is the product of all the environmental factors responsible for its development. It has characteristic soils that have developed over time throughout the soil development process; a characteristic hydrology, particularly infiltration and runoff, that has developed over time; and a characteristic plant community (kind and amount of vegetation). The hydrology of the site is influenced by development of the soil and plant community. The vegetation, soils, and hydrology are all interrelated. Each is influenced by the others and influences the development of the others. The plant community on an ecological site is typified by an association of species that differs from that of other ecological sites in the kind and/or proportion of species or in total production.

The ecological sites for Walnut Canyon National Monument are a mix of forest and range sites with riparian and relict riparian sites occurring at the bottom of the water-carved limestone cliffs (figs. 49 and 50). The hydrology at Walnut Canyon has been significantly altered, and this has affected the vegetation. The altered conditions are likely reversible if water were allowed to flow seasonally into the canyon.

An ecological site description is a document that contains details about the characteristic soils, plant community, different ecological states and transitions that are expected, and site interpretations. For full ecological site descriptions that include a state and transition model, refer to the Natural Resources Conservation Service Ecological Site and Information System: https://esis.sc.egov.usda.gov. You may also refer to the "Ecological Site Description Report for Walnut Canyon National Monument" (USDI-NPS, 2008). The ecological sites in Walnut Canyon National Monument are briefly described in this section.

Ecological site name	Dominant vegetation	Map units
Typic Ustic MLRA 39:		
Limestone/Sandstone Upland 18-22” p.z.	ponderosa pine	31, 32, 33, 35
Canyon Bottom (Riparian) 18-22” p.z.	riparian	36
Aridic Ustic MLRA 35:		
Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z.	oneseed juniper	34, 37
Semi-Riparian Canyon Bottom 14-18” p.z.	upland grass/shrubland	38, 39

Figure 49.—Ecological sites in Walnut Canyon National Monument and their associated map units.

Ecological site name	Ecological site number	MLRA	LRU/CRA	Moisture regime
Limestone/Sandstone Upland 18-22” p.z.	F039XA139AZ	39	39.1	typic ustic
Canyon Bottom (Riparian) 18-22” p.z.	R039XA140AZ	39	39.1	typic ustic
Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z.	R035XG723AZ	35	35.7	aridic ustic
Semi-Riparian Canyon Bottom 14-18” p.z.	R035XG724AZ	35	35.7	aridic ustic

Figure 50.—Ecological site names and numbers for Walnut Canyon National Monument.

Definition of Table Headers and Discussion of Data

Table 7—Ecological Site-Soil Correlation

This table lists the map unit symbol, soil component name, and component percent with the ecological site name, ecological site type (forestland or rangeland), and ecological site ID (ecological site number).

Table 8—Climate, Landscape, Landform, Parent Material, and Ecological Site

This table displays information about climate, landscape, landform, parent material, and ecological site for each soil in the map units.

Percent of the map unit is the extent of the named soil in the map unit.

Slope is 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. The table shows the low and high range of slope for the named component or soil.

Elevation is the height of an object or area on the earth's surface in reference to a fixed reference point, such as mean sea level. The typical low and high range of elevation is displayed for each soil.

MAP is the mean annual precipitation for areas of the soil in the map unit.

Landscape refers to the broad shape of the earth in the area where the soil occurs. Examples are a valley and a mountain.

Landform is a specific shape of the earth in the area where a soil typically occurs. Examples are a mountain summit and a valley bottom.

Parent material is the material in which soils formed. Examples are the underlying geological material (including bedrock), a surficial deposit (such as volcanic ash), and organic material. Soils inherit their chemical and physical properties from the parent material.

Ecological site and number is the ecological site name and unique reference number that are correlated to the named soil in the map unit.

Table 9—Rangeland and Forest Understory Productivity with Existing Plant Communities

Table 9 lists the map unit symbol and each component's name and percent of map unit alongside the ecological site name and number; the total production of vegetation in favorable, normal, and unfavorable years; the characteristic vegetation (common names); and the average species composition by annual production (percent of total annual air-dry weight). Species composition for forestland ecological sites is listed under the forest column and pertains to annual production, up to 13 feet in height. Species composition for rangeland ecological sites is listed under the range column.

Total production is the amount of vegetation that can be expected to grow annually on well managed rangeland or forest understory and support the potential natural plant community. 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 provide substantially better growing conditions 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 percentage 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. These production amounts can be used to calculate carrying capacities and stocking rates for the management of domestic or wild animals, or to determine fuel-loading in preparation of prescribed burning plans or fire modeling.

Existing vegetation includes the grasses, forbs, shrubs, and trees in the plant community at the time of the survey. The amount that can be used as forage depends on the kinds of grazing animals and on the grazing season.

Composition gives the typical percentage of the total annual production for the dominant species of the existing vegetation.

Table 10—Canopy Cover

This table gives the canopy cover for the plant species associated with the map unit components. Canopy cover is determined by crown perimeter-vertical projection by species. Because this cover can overlap in layers by species, total cover can be greater than 100 percent.

Tables 11 and 12—Index of Common and Scientific Plant Names and Plant Symbols

These tables show the common plants in the survey area and their associated scientific name and plant symbol. The plants are sorted by common name in table 11 and by plant symbol in table 12.

General Information

Walnut Canyon National Monument has been divided at Cherry Creek into two different soil and temperature regimes. To the west is MLRA 39.1, which is considered colder and wetter. To the east of Cherry Creek is MLRA 35.7, which is considered hotter and drier (see figure 4 in the introduction). The section “Major Land Resource Areas” in the introduction provides more information.

The ecological site that occurs at the base of the canyon demonstrates the changes in hydrology that have been occurring due to changes in water use outside of the park. The riparian site is split into two moisture and temperature regimes; the remaining riparian area is only still riparian due to the nature of the underlying limestone; the limestone leaches water into the narrow canyon. The drier relict half of the riparian area is not supplied with water by the limestone walls and has become more like an upland site.

Forest and Treed Rangeland Sites

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

The vegetation of Walnut Canyon National Monument is dominated at the west end by coniferous forests and at the east end by open parkland and open pinyon-juniper rangeland (see table 7). The monument has the same geologic parent material throughout. The soils differ in the amount of moisture they receive. The west end of the park receives 18 to 22 inches of rainfall per year and is in a colder temperature regime. The east end is slightly lower in elevation, receives 10 to 14 inches of rainfall per year, and is in a warmer, drier temperature regime. The combination of lower elevations and the reduced rainfall results in a drier vegetation type.

Range management requires a knowledge of the kinds of soil and of the potential natural plant community. It also requires an evaluation of the present range similarity index and rangeland trend. Range similarity index is determined by comparing the present plant community with the potential natural plant community on a particular rangeland ecological site. The more closely the existing community resembles the potential community, the higher the range similarity index. Rangeland trend is defined as the direction of change in an existing plant community relative to the potential natural plant community. Further information about the range similarity index and rangeland trend is available in chapter 4 of the “National Range and Pasture Handbook” (http://www.ftw.nrcs.usda.gov/glti/NRPH.html).

The objective in range management is to control grazing so that the plants growing on a site are about the same in kind and amount as the potential natural plant community for that site. Such management generally results in the optimum production of vegetation, control of undesirable brush species, conservation of water, and control of erosion. Sometimes, however, an area with a range similarity index somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

Riparian Sites

Two ecological sites in Walnut Canyon National Monument are riparian or semi-riparian (also termed relict riparian). They are connected to each other geographically and historically. The two sites have diverged due to changes in hydrology.

Historically, Walnut Creek flowed through Walnut Canyon as an ephemeral stream. In 1940 and 1941, Upper Lake Mary dam was constructed upstream as a drinking water reservoir for the city of Flagstaff, Arizona. This changed the hydrology of the area.

Before the construction of the dam, riparian vegetation in the canyon bottom was maintained and scoured periodically by flooding from Walnut Creek. Currently, the vegetation is maintained by seepage and runoff from the steep canyon walls. Since the building of Upper Lake Mary dam, the channel is no longer periodically scoured and the riparian vegetation has flourished unchecked. The vegetation on these sites is dominated by riparian species, such as chokecherry, western white clematis, snowberry, canyon grape, and meadowrue (see table 9).

In the areas upstream from Upper Lake Mary dam, the vegetation has become either semi-riparian or almost fully upland. The semi-riparian indicators are limited to a few boxelders (*Acer negundo*) and scattered shrubs. The majority of the upland vegetation is blue grama (*Bouteloua gracilis*) and other upland species. There is now only occasional flooding in the area when sufficient rainfall or snowmelt causes an overflow at Lake Mary (Brian, 1992).

Both riparian/semi-riparian ecological sites occur in a riparian or a relict riparian corridor in the same stream channel. The area to the east, however, is warmer and drier and considered an open relict flood plain and stream terrace while the area to the west is colder and wetter and has the relict stream channel maintained by seepage from outside the deep limestone canyon walls.

Figure 51.—Limestone/Sandstone Upland 18-22" p.z. (F039XA139AZ). The reference site for this ecological site has a dominant overstory of ponderosa pine (*Pinus ponderosa*).

Map unit	General location	Landform	Model	State	Phase
31	west end	structural bench	1	1	1.1
32	west end	structural bench	2	1	1.1
33	west end	canyon	3	1	1.1
33	west end	canyon	2	1	1.1

Figure 52.—Summary of soil map units in Walnut Canyon National Monument that occur in ecological site Limestone/Sandstone Upland 18-22" p.z (F039XA139AZ). The model, state, and phase columns refer to the included state and transition model.

Descriptions of Forest Ecological Sites

F039XA139AZ—Limestone/Sandstone Upland 18-22" p.z.

This ecological site occurs on canyon escarpments and structural benches on the west end of the park (figs. 51 and 52). The soils are very shallow to moderately deep to limestone bedrock and are well drained. Surface layers include loam, gravelly sandy loam, and cobbly sandy loam. Subsurface layers are loamy. Available water capacity is moderate. This ecological site is at elevations between 6,263 and 6,912 feet (1,909 and 2,107 meters) on mainly north aspects. Slopes range from 5 to 70 percent.

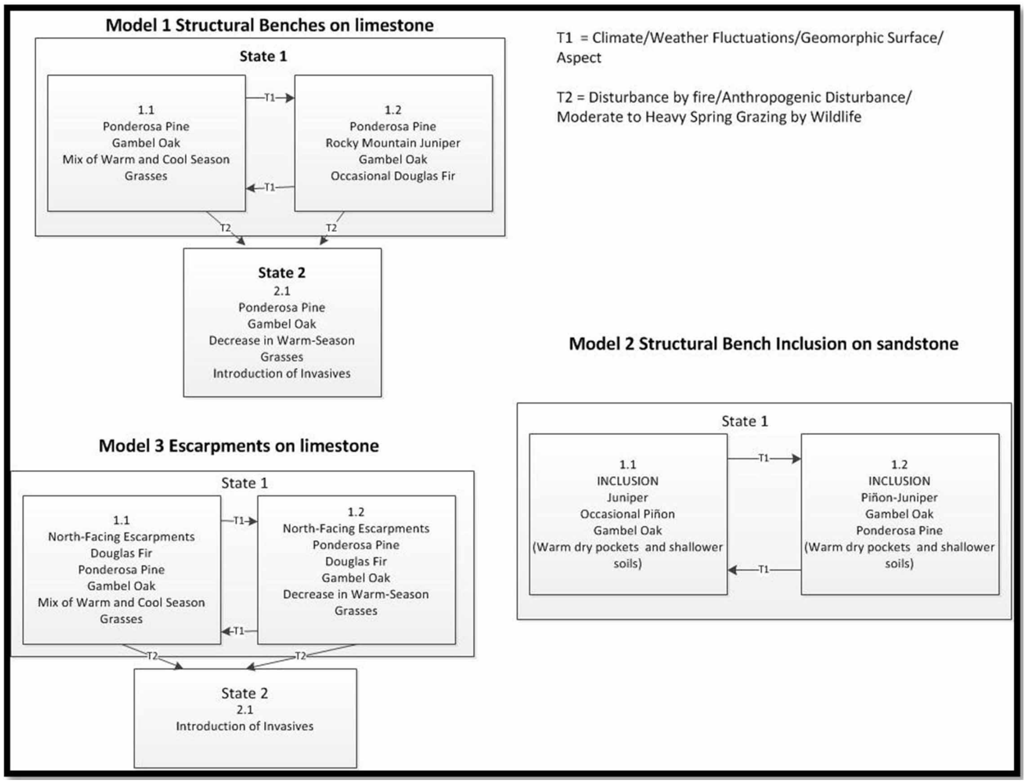


Figure 53.—State and transition model for Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ). There are many processes occurring on this ecological site. The site is a mixture of forest types, water downcutting the limestone and creating escarpments, and warm pockets of sandstone parent material which allow mesic species to exist in a frigid environment. At the scale mapped, these sites are so intermixed that it is not practical to separate them for interpretations.

Mean annual precipitation ranges from 18 to 22 inches (457 to 559 millimeters), and mean annual temperature is between 39 and 45 degrees F (3.9 and 7.2 degrees C). This site occurs on limestone benches. The dominant overstory is ponderosa pine (*Pinus ponderosa*). The site includes park-like open areas which are a mix of native warm- and cool-season grasses and areas of heavily forested snags. The understory is a mix of warm- and cool-season grasses and various shrubs and forbs. This site also contains warm phases of pinyon-juniper which occurs intermittently throughout the site (model 2, state 1, phase 1.2) See the state and transition model (fig. 53).

Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ), model 1, state 1, phase 1.2 occurs on structural benches on limestone (fig. 54). This phase occurs near the edges of north-facing escarpments and on steep escarpments of north-facing slopes in Walnut Canyon. Away from the edge of the canyon on less steep slopes, the extent of Douglas fir begins to decline and ponderosa pine begins to dominate (this occurs in state 1, phase 1.1).

Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ), model 1, state 2, phase 2.1 is a typical site where pioneering invasives may be found (fig. 55). These sites are dominated by ponderosa pine (*Pinus ponderosa*) with understories of Gambel oak (*Quercus gambelii*) and a mixture of warm- and cool-season grasses. When there

Figure 54.—Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ), model 1, state 1, phase 1.2. This view shows ponderosa pine (*Pinus ponderosa*) and Gambel oak (*Quercus gambelii*) with a warm-season grass understory.

are droughty conditions combined with downed material, such as trees, pine needles, litter, and other detritus, invasive plants such as Dalmatian toadflax (*Linaria* spp.) and locoweed (*Oxytropis* spp.) begin colonizing these sites. Other disturbances, such as severe fire and insect damage, may also contribute to an accelerated colonization by non-native species.

Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ) pinyon-juniper inclusion site, model 2, state 1, phase 1.2 occurs on structural benches on sandstone (fig. 56). It is considered an inclusion within a larger ecological site due to its limited acreage. It occupies warm pockets within forest of ponderosa pine and is important to wildlife. Because areas of this phase remain warmer, plants begin growing earlier in spring.

Figure 55.—Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ), model 1, state 2, phase 2.1.

Figure 56.—Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ) pinyon-juniper inclusion site, model 2, state 1, phase 1.2.

Figure 57.—View of north-facing slopes from the south-facing slope of Walnut Canyon. The north-facing slopes are in Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ), model 3, state 1, phases 1.1 and 1.2. This view shows mostly phase 1.1 with Douglas fir (*Pseudotsuga menziesii*) as the dominant species. Phase 1.2 occurs a short distance from the edge of the escarpment.

Map unit	General location	Landform	Model	State	Phase
34	east end	canyon	1	2	1.1
37	east end	cliff	1	2	1.1

Figure 58.—Summary of soil map units in Walnut Canyon National Monument that occur in ecological site Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z. (R035XG723AZ). The model, state, and phase columns refer to the included state and transition model.

This phase also is dominated by juniper (*Juniperus* spp.) with some twoneedle pinyon (*Pinus edulis*).

Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ), model 3, state 1, phases 1.1 and 1.2 are on the north-facing slopes of Walnut Canyon (fig. 57). In phase 1.1, Douglas fir (*Pseudotsuga menziesii*) is the dominant species. In phase 1.2, numbers of Douglas fir decrease and numbers of ponderosa pine increase.

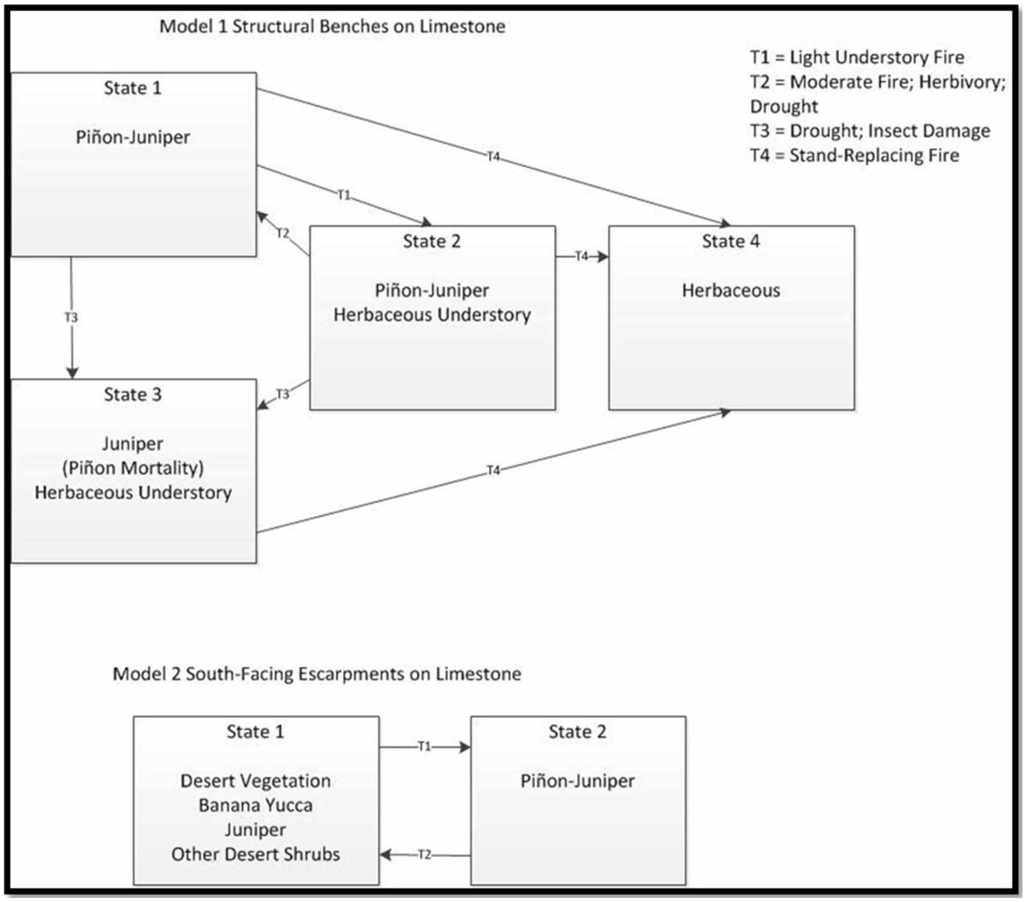


Figure 59.—State and transition model for Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z. (R035XG723AZ).

Descriptions of Rangeland Ecological Sites

R035XG723AZ—Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z.

This ecological site has two different models which are close in proximity and difficult to separate at the scale mapped. The two models are related in that they reflect similar moisture and temperature regimes and similar soils, but they occur on different geomorphological surfaces.

This site occurs on canyon escarpments and structural benches on the east end of the park (fig. 58). The soils are very shallow to moderately deep to limestone bedrock and are well drained. Surface layers include gravelly sandy loam and stony loam. Subsurface layers are loamy. Available water capacity is moderate. This ecological site is at elevations between 6,220 and 6,658 feet (1,895 and 2,029 meters) on mainly south aspects. Slopes range from 3 to 25 percent.

Mean annual precipitation ranges from 14 to 18 inches (356 to 347 millimeters), and mean annual temperature is between 45 and 50 degrees F (8 and 10 degrees C). See state and transition model (fig. 59).

Figure 60.—Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z. (R035XG723AZ), model 1, state 3.

Note: Model 1, state 1 does not currently occur in the park. Because there is a high mortality rate for twoneedle pinyon, this state has been relegated to “historical” at this time. There are areas within the park that appear to have nearly 100 percent mortality rate for twoneedle pinyon.

Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z. (R035XG723AZ), model 1, state 3 occurs on the east end of Walnut Canyon National Monument (fig. 60). It has high pinyon mortality due to drought and bark beetle infestation.

Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z. (R035XG723AZ), model 2, state 1 is identified by south-facing slopes on limestone with xerophytic vegetation (fig. 61). It is located directly across the forested north-facing slopes of Walnut Canyon.

Figure 61.—Limestone/Sandstone Upland (Pinyon-Juniper) 14-18" p.z. (R035XG723AZ), model 2, state 1.

Figure 62.—Canyon Bottom (Riparian) 18-22” p.z. (R039XA140AZ). This site is in the narrow riparian corridor at the bottom of Walnut Canyon. While Walnut Creek rarely flows, the limestone sides of the canyon trap moisture and allow riparian vegetation to flourish.

Map unit	General location	Landform	Model	State	Phase
36	west end	flood-plain step	1	1	1.1

Figure 63.—Summary of soil map units in Walnut Canyon National Monument that occur in ecological site Canyon Bottom (Riparian) 18-22” p.z. (R039XA140AZ). The model, state, and phase columns refer to the included state and transition model.

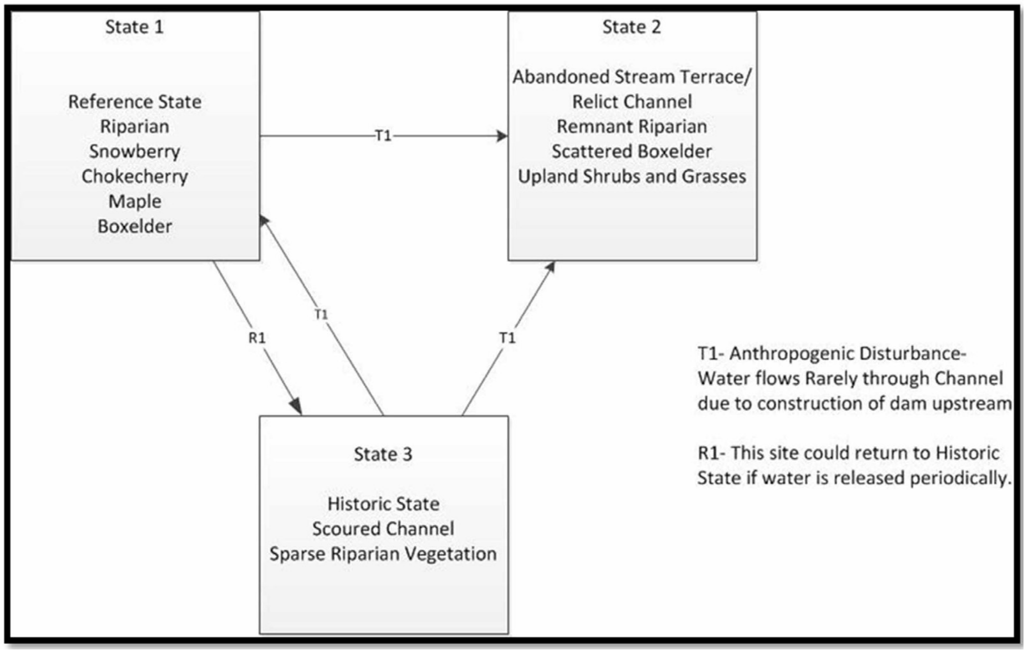


Figure 64.—State and transition model for Canyon Bottom (Riparian) 18-22” p.z. (R039XA140AZ). The same ecological site and state and transition model are used for ecological site Semi-Riparian Canyon Bottom 14-18” p.z. (R035XG724AZ). The historic Walnut Creek ran through the park and through two different moisture and temperature regimes.

R039XA140AZ—Canyon Bottom (Riparian) 18-22” p.z.

This ecological site occurs on stream bottoms at the west end of the park (figs. 62 and 63). The soils are shallow to very deep to limestone bedrock and are somewhat poorly drained to somewhat excessively drained. Surface layers include loam, gravelly sandy loam, and cobbly loamy sand. Subsurface layers are loamy. Available water capacity is high. This ecological site is at elevations between 6,260 and 6,422 feet (1,908 to 2,107 meters) on mainly north aspects. Slopes range from 2 to 6 percent.

Mean annual precipitation ranges from 18 to 22 inches (457 to 559 millimeters), and mean annual temperature is between 39 and 45 degrees F (3.9 and 7.2 degrees C). See state and transition model (fig. 64).

Figure 65.—Semi-Riparian Canyon Bottom 14-18” p.z. (R035XG724AZ) (relict riparian canyon bottom). This is the dry site of Canyon Bottom (Riparian) 18-22” p.z. (R039XA140AZ). This site is in a channel (lower position) and on a stream terrace (upper position). The channel occasionally floods, and there remain a very few relict riparian species on the site. The stream terrace, although it was abandoned earlier than the channel, has similar vegetation due to the lack of running water.

Map unit	General location	Landform	Model	State	Phase
38	east end	stream terrace	1	2	1.1
39	east end	terrace	1	2	1.1

Figure 66.—Summary of soil map units in Walnut Canyon National Monument that occur in ecological site Semi-Riparian Canyon Bottom 14-18” p.z. (R035XG724AZ). The model, state, and phase columns refer to the state and transition model.

R035XG724AZ—Semi-Riparian Canyon Bottom 14-18” p.z.

This ecological site occurs on stream terraces at the east end of the park (figs. 65 and 66). The soils are very deep and well drained. Surface layers include loam, gravelly sandy loam, and cobbly sandy loam. Subsurface layers are loamy. Available water capacity is moderate. This ecological site is at elevations between 6,205 to 6,260 feet (1,891 to 1,908 meters) on all aspects. Slopes range from 2 to 6 percent.

Mean annual precipitation ranges from 14 to 18 inches (356 to 457 millimeters), and mean annual temperature is between 45 and 50 degrees F (8 and 10 degrees C). This ecological site has the same state and transition model as Canyon Bottom (Riparian) 18-22” p.z. (R039XA140AZ). See figure 64.

Summary

Limestone/Sandstone Upland 18-22” p.z. (F039XA139AZ) consists of three parts: structural benches on limestone (model 1), structural benches on sandstone (model 2), and escarpments on limestone (model 3). See figure 53. These sites are all intermingled with each other and all interconnected.

Canyon Bottom (Riparian) 18-22” p.z. (R039XA140AZ) is a riparian site which connects to Semi-Riparian Canyon Bottom 14-18” p.z. (R035XG724AZ) at the two ends of the park. Walnut Creek, which no longer flows, was the main source of water for the canyon. Riparian vegetation on the canyon bottom continues to grow within the steep canyon walls due to seepage. At the other end of the stream channel, on the semi-riparian site, the vegetation has become mainly upland species.

Limestone/Sandstone Upland (Pinyon-Juniper) 14-18” p.z. (R035XG723AZ) is an upland site on the east end of the park. This site has extensive damage of and high mortality rates for twoneedle pinyon due to drought and insect damage. The site supports oneseed juniper with some herbaceous understory. The south-facing escarpments of this site are populated with desert vegetation, such as banana yucca and shrubby oneseed juniper. These escarpments of Walnut Canyon across from the north-facing escarpments are populated with ponderosa pine and Douglas fir.

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 in predicting soil behavior.

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

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

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

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

Interpretive Ratings

The interpretive tables in this survey rate the soils in the survey area for various uses. Many of the tables identify the limitations that affect specified uses and indicate the severity of those limitations. The ratings in these tables are both verbal and numerical.

Rating Class Terms

Rating classes are expressed in the tables in terms that indicate the extent to which the soils are limited by all of the soil features that affect a specified use or in terms that indicate the suitability of the soils for the use. Thus, the tables may show limitation classes or suitability classes. Terms for the limitation classes are *not limited, somewhat limited,* and *very limited*. The suitability ratings are expressed as *well suited, moderately suited, poorly suited,* and *unsuited* or as *good, fair,* and *poor*.

Numerical Ratings

Numerical ratings in the tables indicate the relative severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.00 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use and the point at which the soil feature is not a limitation. The limitations appear in order from the most limiting to the least limiting. Thus, if more than one limitation is identified, the most severe limitation is listed first and the least severe one is listed last.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of 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 forestland, or for engineering purposes.

In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit (USDA-SCS, 1961).

Capability classes, the broadest groups, are designated by the numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class 1 soils have slight limitations that restrict their use.

Class 2 soils have moderate limitations that restrict the choice of plants or that require moderate conservation practices.

Class 3 soils have severe limitations that restrict the choice of plants or that require special conservation practices, or both.

Class 4 soils have very severe limitations that restrict the choice of plants or that require very careful management, or both.

Class 5 soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 6 soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.

Class 8 soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.

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, 2e. 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,* used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by *w, s,* or *c* because the soils in class 5 are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, forestland, wildlife habitat, or recreation.

Capability units are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, 2e-4 and 3e-6. These units are not given in all soil surveys.

The capability classification of map units in this survey area is given in table 13 and in the section "Detailed Soil Map Units."

Prime Farmland

Prime farmland is one of several kinds of important farmland defined by the U.S. Department of Agriculture. It is of major importance in meeting the Nation's short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It could be cultivated land, pastureland, forestland, or other land, but it is not urban or built-up land or water areas. The soil qualities, growing season, and moisture supply are those needed for the soil to economically produce sustained high yields of crops when proper management, including water management, and acceptable farming methods are applied. In general, prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, an acceptable salt and sodium content, and few or no rocks. It is permeable to water and air. It is not excessively erodible or saturated with water for long periods, and it either is not frequently flooded during the growing season or is protected from flooding. Slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Natural Resources Conservation Service.

There are no areas in Walnut Canyon National Monument that meet the soil requirements for prime farmland.

Hydric Soils

There are no hydric soils in the survey area. This section is provided for informational purposes.

The three essential characteristics of wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology (Cowardin and others, 1979; U.S. Army Corps of Engineers, 1987; National Research Council, 1995; Tiner, 1985). Criteria for all of the characteristics must be met for areas to be identified as wetlands. Undrained hydric soils that have natural vegetation should support a dominant population of ecological wetland plant species. Hydric soils that have been converted to other uses should be capable of being restored to wetlands. Onsite investigation is recommended to determine the hydric soils on a specific site (National Research Council, 1995; USDA-NRCS, 2010).

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in “Soil Taxonomy” (Soil Survey Staff, 1999) and “Keys to Soil Taxonomy” (Soil Survey Staff, 2010) and in the “Soil Survey Manual” (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in “Field Indicators of Hydric Soils in the United States” (USDA-NRCS, 2010).

Hydric soils are identified by examining and describing the soil to a depth of about 20 inches. This depth may be greater if determination of an appropriate indicator so requires. It is always recommended that soils be excavated and described to the depth necessary for an understanding of the redoximorphic processes. Then, using the completed soil descriptions, soil scientists can compare the soil features required by each indicator and specify which indicators have been matched with the conditions observed in the soil. The soil can be identified as a hydric soil if at least one of the approved indicators is present.

Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform.

Land Management

In table 14, parts I through IV, interpretive ratings are given for various aspects of land management. The ratings are both verbal and numerical.

Some rating class terms indicate the degree to which the soils are suited to a specified land management practice. *Well suited* indicates that the soil has features that are favorable for the specified practice and has no limitations. Good performance can be expected, and little or no maintenance is needed. *Moderately suited* indicates that the soil has features that are moderately favorable for the specified practice. One or more soil properties are less than desirable, and fair performance can be expected. Some maintenance is needed. *Poorly suited* indicates that the soil has one or more properties that are unfavorable for the specified practice. Overcoming the unfavorable properties requires special design, extra maintenance, and costly alteration. *Unsuited* indicates that the expected performance of the soil is unacceptable for the specified practice or that extreme measures are needed to overcome the undesirable soil properties.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified land management practice (1.00) and the point at which the soil feature is not a limitation (0.00).

Rating class terms for *fire damage* and *seedling mortality* are expressed as low, moderate, and high. Where these terms are used, the numerical ratings indicate gradations between the point at which the potential for fire damage or seedling mortality is highest (1.00) and the point at which the potential is lowest (0.00).

Rating class terms for *hazard of erosion* are expressed as slight, moderate, severe, and very severe. Where these terms are used, the numerical ratings indicate gradations between the point at which the potential for erosion is highest (1.00) and the point at which the potential is lowest (0.00).

The paragraphs that follow indicate the soil properties considered in rating the soils for land management practices.

Planting and Harvesting

Ratings in the columns *suitability for hand planting* and *suitability for mechanical planting* are based on slope, depth to a restrictive layer, content of sand, plasticity index, rock fragments on or below the surface, depth to a water table, and ponding. The soils are described as well suited, moderately suited, poorly suited, or unsuited to these methods of planting. It is assumed that necessary site preparation is completed before seedlings are planted.

Ratings in the column *suitability for use of harvesting equipment* indicate the suitability of the soils for harvesting with heavy equipment. It assumes the use of standard rubber-tired skidders and bulldozers for ground-based harvesting and transport. It considers the off-road transport or harvest of logs and/or wood products by ground-based wheeled or tracked equipment. Activities that disturb from 35 to 75 percent of the surface area with rutting, puddling, or displacement up to a depth of 18 inches are considered. Year-round water tables and year-round ponding are unfavorable. Ratings do not assess non-soil obstacles, such as slash, or frozen or snow-covered soils.

Hazard of Erosion and Suitability for Roads

Ratings in the column *hazard of erosion* are based on slope and on soil erodibility factor K. The soil loss is caused by sheet or rill erosion in areas where 50 to 75 percent of the surface has been exposed by different kinds of disturbance. The hazard is described as slight, moderate, severe, or very severe. A rating of *slight* indicates that erosion is unlikely under ordinary climatic conditions; *moderate* indicates that some erosion is likely and that erosion-control measures may be needed; *severe* indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and *very severe* indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical.

Ratings in the column *hazard of erosion on roads and trails* are based on the soil erodibility factor K, slope, and content of rock fragments. The ratings apply to unsurfaced roads and trails. The hazard is described as slight, moderate, or severe. A rating of *slight* indicates that little or no erosion is likely; *moderate* indicates that some erosion is likely, that the roads or trails may require occasional maintenance, and that simple erosion-control measures are needed; and *severe* indicates that significant erosion is expected, that the roads or trails require frequent maintenance, and that costly erosion-control measures are needed.

Ratings in the column *suitability for roads (natural surface)* are based on slope, rock fragments on the surface, plasticity index, content of sand, the Unified classification, depth to a water table, ponding, flooding, and the hazard of soil slippage. The ratings indicate the suitability for using the natural surface of the soil for roads. The soils are described as well suited, moderately suited, or poorly suited to this use.

Site Preparation

Ratings in the column *suitability for mechanical site preparation (deep)* are based on slope, depth to a restrictive layer, rock fragments on or below the surface, depth to a water table, and ponding. The soils are described as well suited, poorly suited, or unsuited to this management activity. The part of the soil from the surface to a depth of about 3 feet is considered in the ratings.

Ratings in the column *suitability for mechanical site preparation (surface)* are based on slope, depth to a restrictive layer, plasticity index, rock fragments on or below the surface, depth to a water table, and ponding. The soils are described as well suited, poorly suited, or unsuited to this management activity. The part of the soil from the surface to a depth of about 1 foot is considered in the ratings.

Site Restoration

Ratings in the column *potential for damage to soil by fire* are based on texture of the surface layer, content of rock fragments and organic matter in the surface layer, thickness of the surface layer, and slope. The soils are described as having a low, moderate, or high potential for this kind of damage. The ratings indicate an evaluation of the potential impact of prescribed fires or wildfires that are intense enough to remove the duff layer and consume organic matter in the surface layer.

Ratings in the column *potential for seedling mortality* are based on flooding, ponding, depth to a water table, content of lime, reaction, salinity, available water capacity, soil moisture regime, soil temperature regime, aspect, and slope. The soils are described as having a low, moderate, or high potential for seedling mortality.

Recreation

The soils of the park are rated in table 15, parts I and II, according to limitations that affect their suitability for recreation. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the recreational uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The ratings in the table 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.

The information in table 15 can be supplemented by other information in this survey, for example, interpretations for building site development, construction materials, and water management.

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 ratings are based on the soil properties that affect the ease of developing camp areas and the performance of the areas after development. Slope, stoniness, and depth to bedrock or a cemented pan are the main concerns affecting the development of camp areas. The soil properties that affect the performance of the areas after development are those that influence trafficability and promote the growth of vegetation, especially in heavily used areas. For good trafficability, the surface of camp areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, permeability, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, permeability, and toxic substances in the soil.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The ratings are based on the soil properties that affect the ease of developing picnic areas and that influence trafficability and the growth of vegetation after development. Slope and stoniness are the main concerns affecting the development of picnic areas. For good trafficability, the surface of picnic areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, permeability, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, permeability, and toxic substances in the soil.

Foot traffic and equestrian trails for hiking and horseback riding should require little or no slope modification through cutting and filling. The ratings are based on the soil properties that affect trafficability and erodibility. These properties are stoniness, depth to a water table, ponding, flooding, slope, and texture of the surface layer.

Mountain bike and off-road vehicle trails require little or no site preparation. They are not covered with surfacing material or vegetation. Considerable compaction of the soil material is likely. The ratings are based on the soil properties that influence erodibility, trafficability, dustiness, and the ease of revegetation. These properties are stoniness, depth to a water table, ponding, slope, flooding, and texture of the surface layer.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. Ratings are given for building site development, sanitary facilities, construction materials, and water management. The ratings are based on observed performance of the soils and on the data in the tables described under the heading “Soil Properties.”

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 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 ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about particle-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 7 feet of the surface, soil wetness, depth to a water table, ponding, 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, commercial, industrial, and recreational uses; 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.

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

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

Dwellings and Small Commercial Buildings

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. Table 16 shows the degree and kind of soil limitations that affect dwellings and small commercial buildings.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Dwellings are single-family houses of three stories or less. For dwellings without basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. For dwellings with basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of about 7 feet. The ratings for dwellings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility. Compressibility is inferred from the Unified classification. The properties that affect the ease and amount of excavation include depth to a water table, ponding, flooding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Small commercial buildings are structures that are less than three stories high and do not have basements. The foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. The ratings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility (which is inferred from the Unified classification). The properties that affect the ease and amount of excavation include flooding, depth to a water table, ponding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Roads and Streets, Shallow Excavations, and Landscaping

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. Table 17 shows the degree and kind of soil limitations that affect local roads and streets, shallow excavations, and landscaping.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material (concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), the potential for frost action, depth to a water table, and ponding.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.

Landscaping requires soils on which turf, trees, and shrubs can be established and maintained. Irrigation is not considered in the ratings. The ratings are based on the soil properties that affect plant growth and trafficability after vegetation is established. The properties that affect plant growth are reaction; depth to a water table; ponding; depth to bedrock or a cemented pan; the available water capacity in the upper 40 inches; the content of salts, sodium, or calcium carbonate; and sulfidic materials. The properties that affect trafficability are flooding, depth to a water table, ponding, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer.

Sewage Disposal

Table 18 shows the degree and kind of soil limitations that affect septic tank absorption fields and sewage lagoons. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches or between a depth of 24 inches and a restrictive layer is evaluated. The ratings are based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. Saturated hydraulic conductivity (K_{sat}), depth to a water table, ponding, depth to bedrock or a cemented pan, and flooding affect absorption of the effluent. Stones and boulders, ice, and bedrock or a cemented pan interfere with installation. Subsidence interferes with installation and maintenance. Excessive slope may cause lateral seepage and surfacing of the effluent in downslope areas.

Some soils are underlain by loose sand and gravel or fractured bedrock at a depth of less than 4 feet below the distribution lines. In these soils the absorption field may not adequately filter the effluent, particularly when the system is new. As a result, the ground water may become contaminated.

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. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Considered in the ratings are slope, saturated hydraulic conductivity (K_{sat}), depth to a water table, ponding, depth to bedrock or a cemented pan, flooding, large stones, and content of organic matter.

Saturated hydraulic conductivity (K_{sat}) is a critical property affecting the suitability for sewage lagoons. Most porous soils eventually become sealed when they are used as sites for sewage lagoons. Until sealing occurs, however, the hazard of pollution is severe. Soils that have a K_{sat} rate of more than 14 micrometers per second are too porous for the proper functioning of sewage lagoons. In these soils, seepage of the effluent can result in contamination of the ground water. Ground-water contamination is also a hazard if fractured bedrock is within a depth of 40 inches, if the water table is high enough to raise the level of sewage in the lagoon, or if floodwater overtops the lagoon.

A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor. If the lagoon is to be uniformly deep throughout, the slope must be gentle enough and the soil material must be thick enough over bedrock or a cemented pan to make land smoothing practical.

Source of Gravel and Sand

Table 19 gives information about the soils as potential sources of gravel and sand. Normal compaction, minor processing, and other standard construction practices are assumed.

Gravel and *sand* are natural aggregates suitable for commercial use with a minimum of processing. They are used in many kinds of construction. Specifications for each use vary widely. Only the likelihood of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material. The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the Unified classification of the soil), the thickness of suitable material, and the content of rock fragments. If the bottom layer of the soil contains sand or gravel, the soil is considered a likely source regardless of thickness. The assumption is that the sand or gravel layer below the depth of observation exceeds the minimum thickness. The ratings are for the whole soil, from the surface to a depth of about 6 feet.

The soils are rated *good, fair,* or *poor* as potential sources of sand and gravel. A rating of *good* or *fair* means that the source material is likely to be in or below the soil. The bottom layer and the thickest layer of the soils are assigned numerical ratings. These ratings indicate the likelihood that the layer is a source of sand or gravel. The number 0.00 indicates that the layer is a poor source. The number 1.00 indicates that the layer is a good source. A number between 0.00 and 1.00 indicates the degree to which the layer is a likely source.

Source of Reclamation Material, Roadfill, and Topsoil

Table 20 gives information about the soils as potential sources of reclamation material, roadfill, and topsoil. Normal compaction, minor processing, and other standard construction practices are assumed.

The soils are rated *good, fair,* or *poor* as potential sources of reclamation material, roadfill, and topsoil. The features that limit the soils as sources of these materials are specified in the table. Numerical ratings between 0.00 and 0.99 are given after the specified features. These numbers indicate the degree to which the features limit the soils as sources of topsoil, reclamation material, or roadfill. The lower the number, the greater the limitation.

Reclamation material is used in areas that have been drastically disturbed by surface mining or similar activities. When these areas are reclaimed, layers of soil material or unconsolidated geological material, or both, are replaced in a vertical sequence. The reconstructed soil favors plant growth. The ratings in the table do not apply to quarries and other mined areas that require an offsite source of reconstruction material. The ratings are based on the soil properties that affect erosion and stability of the surface and the productive potential of the reconstructed soil. These properties include the content of sodium, salts, and calcium carbonate; reaction; available water capacity; erodibility; texture; content of rock fragments; and content of organic matter and other features that affect fertility.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments. The ratings are for the whole soil, from the surface to a depth of about 5 feet. It is assumed that soil layers will be mixed when the soil material is excavated and spread.

The ratings are based on the amount of suitable material and on soil properties that affect the ease of excavation and the performance of the material after it is in place. The thickness of the suitable material is a major consideration. The ease of excavation is affected by large stones, depth to a water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the AASHTO classification of the soil) and linear extensibility (shrink-swell potential).

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area. The ratings are based on the soil properties that affect plant growth; the ease of excavating, loading, and spreading the material; and reclamation of the borrow area. Toxic substances, soil reaction, and the properties that are inferred from soil texture, such as available water capacity and fertility, affect plant growth. The ease of excavating, loading, and spreading is affected by rock fragments, slope, depth to a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, depth to a water table, rock fragments, depth to bedrock or a cemented pan, and toxic material.

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

Ponds and Embankments

Table 21 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas; embankments, dikes, and levees; and aquifer-fed excavated ponds. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the saturated hydraulic conductivity (K_{sat}) of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

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. Embankments that have zoned construction (core and shell) are not considered. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. 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, or 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, K_{sat} of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey.

Soil properties are ascertained by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine particle-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 are shown in tables. They include engineering properties, physical and chemical properties, and pertinent soil and water features.

Engineering Properties

Table 22 gives the engineering classifications and the range of engineering properties for the layers of each soil in the park.

Depth to the upper and lower boundaries of each layer is indicated.

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 15 percent or more, an appropriate modifier is added, for example, “gravelly.”

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

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

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 particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

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

Rock fragments larger than 250 millimeters in diameter and 70 to 250 millimeters 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.

Physical Soil Properties

Table 23 shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the park. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

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

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (K_{sat}), 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 $^1/_3$- or $^1/_{10}$-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each 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 linear extensibility, 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. Depending on soil texture, a bulk density of more than 1.4 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 (K_{sat}) refers to the ability of a soil to transmit water or air. The term "permeability," as used in soil surveys, indicates saturated hydraulic conductivity (K_{sat}). The estimates in the table indicate the rate of water movement, in inches per hour, 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 soil layer. The capacity varies, depending on soil properties that affect retention of water. 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.

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

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

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

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter in a soil can be maintained by returning crop residue to the soil. Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion Properties

Table 24 shows estimates of some erosion factors that affect a soil's potential for different uses. These estimates are given for each layer of every soil for K factors and are given as one rating for the entire soil for the T factor, the wind erodibility group, and the wind erodibility index. Values are reported for each soil in the park. Estimates are based on field observations and on test data for these and similar soils.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Soil erosion factors Kw and Kf quantify soil detachment by runoff and raindrop impact. These erosion factors are indexes used to predict the long-term average soil loss from sheet and rill erosion under crop systems and conservation techniques. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and 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 and on soil structure and K_{sat}. 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.

The procedure for determining the Kf factor is outlined in Agriculture Handbook 703, “Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE),” USDA, Agricultural Research Service, 1997.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments. In horizons where total rock fragments are 15 percent or more, by volume, the Kw factor is always less than the Kf factor.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size. Soil horizons that do not have rock fragments are assigned equal Kw and Kf factors.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/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 susceptibility to wind erosion in cultivated areas. 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 described in the “National Soil Survey Handbook.”

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Total Soil Carbon

Table 25 gives estimates of total soil carbon. Soil carbon occurs as organic and inorganic carbon.

Soil organic carbon (SOC) is carbon (C) in soil that originated from a biological source, such as plants, animals, or micro-organisms. SOC is found in both organic and mineral soil layers. The term “soil organic carbon” refers only to the carbon occurring in soil organic matter (SOM). Soil organic carbon makes up about one-half the weight of soil organic matter. The rest of SOM is mostly oxygen, nitrogen, and hydrogen.

Soil inorganic carbon (SIC) is carbon found in soil carbonates, typically as calcium carbonate layers in the soil or as clay-sized fractions throughout the soil. Carbonates in soils are most common in areas where evaporation rates exceed precipitation, as is the case in most desert environments. Typically, the carbonates accumulated from carbonatic dust or from solution during periods of wetter climates. Soil inorganic carbon also occurs in soils that formed in marl in all regions of the country.

The SOC and SIC contents are reported in kilograms per square meter to a depth of 2 meters or to a representative depth of either hard bedrock or a cemented horizon. The SOC and SIC values are on a whole soil basis, corrected for rock fragments.

SOC can be an indicator of overall soil fertility and soil quality that affects ecosystem function. SOM is the main reservoir for most plant nutrients, such as phosphorus and nitrogen. Managing for SOC by managing for SOM increases the content of these elements and improves soil resiliency.

Soil organic matter binds soil particles together and thus increases soil porosity and water infiltration and allows better root penetration and waterflow into the soil. Greater inflow of water reduces the hazard of erosion and the rate of surface water runoff.

Greater SOC levels improve not only soil quality but also the quality of air and water. Soil acts as a filter and improves water quality. Fertile soils that support plant life remove carbon dioxide (CO_2) from the atmosphere and increase oxygen levels through photosynthesis. Maintaining the level of soil organic carbon reduces C release into the atmosphere and thus can lessen the effects of global warming.

SIC influences the types of plants that will grow. High SIC levels are commonly associated with a higher soil pH, which limits the types of plants that will thrive.

Like SOM, soil carbonates, the source of SIC, also bind soil particles together. They fill voids in the soil and thus can reduce soil porosity. Compacted soil carbonates may restrict root penetration and waterflow into the soil.

Soil Features

Table 26 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 restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness of the restrictive layer, which significantly affects the ease of excavation. *Depth to top* is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

Potential for frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (K_{sat}), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that corrodes 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 or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete 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.

Water Features

Table 27 gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

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 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.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. Table 27 indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

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

Chemical Soil Properties

Table 28 shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the park. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable 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. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Soil reaction is a measure of acidity or alkalinity. The pH of each soil 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.

Calcium carbonate equivalent is the percent of carbonates, by weight, in the fraction of the soil less than 2 millimeters in size. The availability of plant nutrients is influenced by the amount of carbonates in the soil. Incorporating nitrogen fertilizer into calcareous soils helps to prevent nitrite accumulation and ammonium-N volatilization.

Gypsum is expressed as a percent, by weight, of hydrated calcium sulfates in the fraction of the soil less than 20 millimeters in size. Gypsum is partially soluble in water. Soils that have a high content of gypsum may collapse if the gypsum is removed by percolating water.

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

Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity (K_{sat}) and aeration, and a general degradation of soil structure.

Formation and Classification of the Soils

Soils within most of Walnut Canyon National Monument, like those of many canyons on the Colorado Plateau, are shallow (less than 20 to 50 centimeters to bedrock). Because these areas have been regionally uplifted, erosive soil environments predominate. Soil is transported along slopes and fluvial channels as quickly as it weathers from rock. In a few significant places, the soils are not shallow (see table 26). More soil accumulates in narrow canyon bottoms and in isolated areas away from canyon rims that are protected from soil erosion.

This lack of soil stability corresponds to weak development within the soil profile. The stability and, in turn, the level of development in the soils in these canyon environments can be directly linked to the landform, specifically the position on the landform. The type and age of geologic material underlying and weathering into soil also have a major impact on soil development and stability. This relationship between landform, geologic material, and soil development is very evident throughout Walnut Canyon National Monument. A review of these landforms, geologic formations, and soil-forming processes is helpful in understanding how the various soils of the park are very similar in depth but very different in stability, physical and chemical characteristics, and level of development.

General Overview

Landforms

Walnut Canyon National Monument has four major landforms: structural benches, canyon rims, canyon walls, and terrace and flood-plain steps (fig. 67) (see Walnut Canyon National Monument 3D Landforms and Soil Types). The top of the canyons consist of structural benches. Structural benches are stable, low-sloping, bedrock-

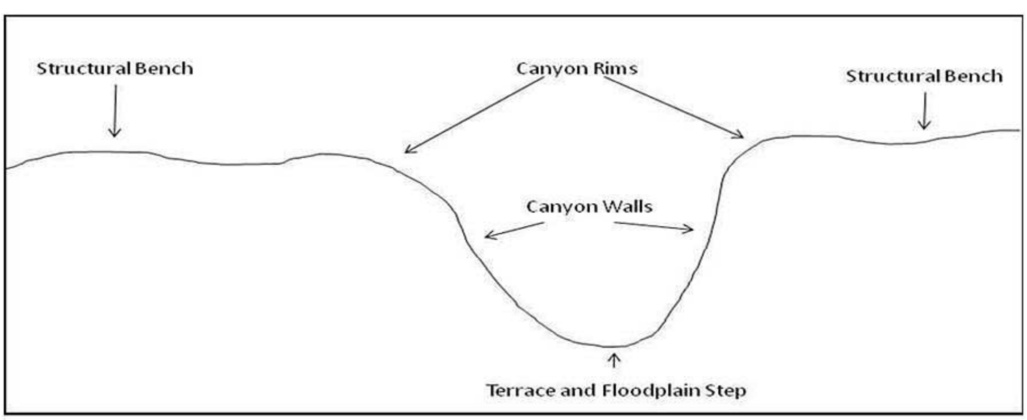


Figure 67.—Diagram depicting the four major landforms in Walnut Canyon National Monument and their general location in the canyon.

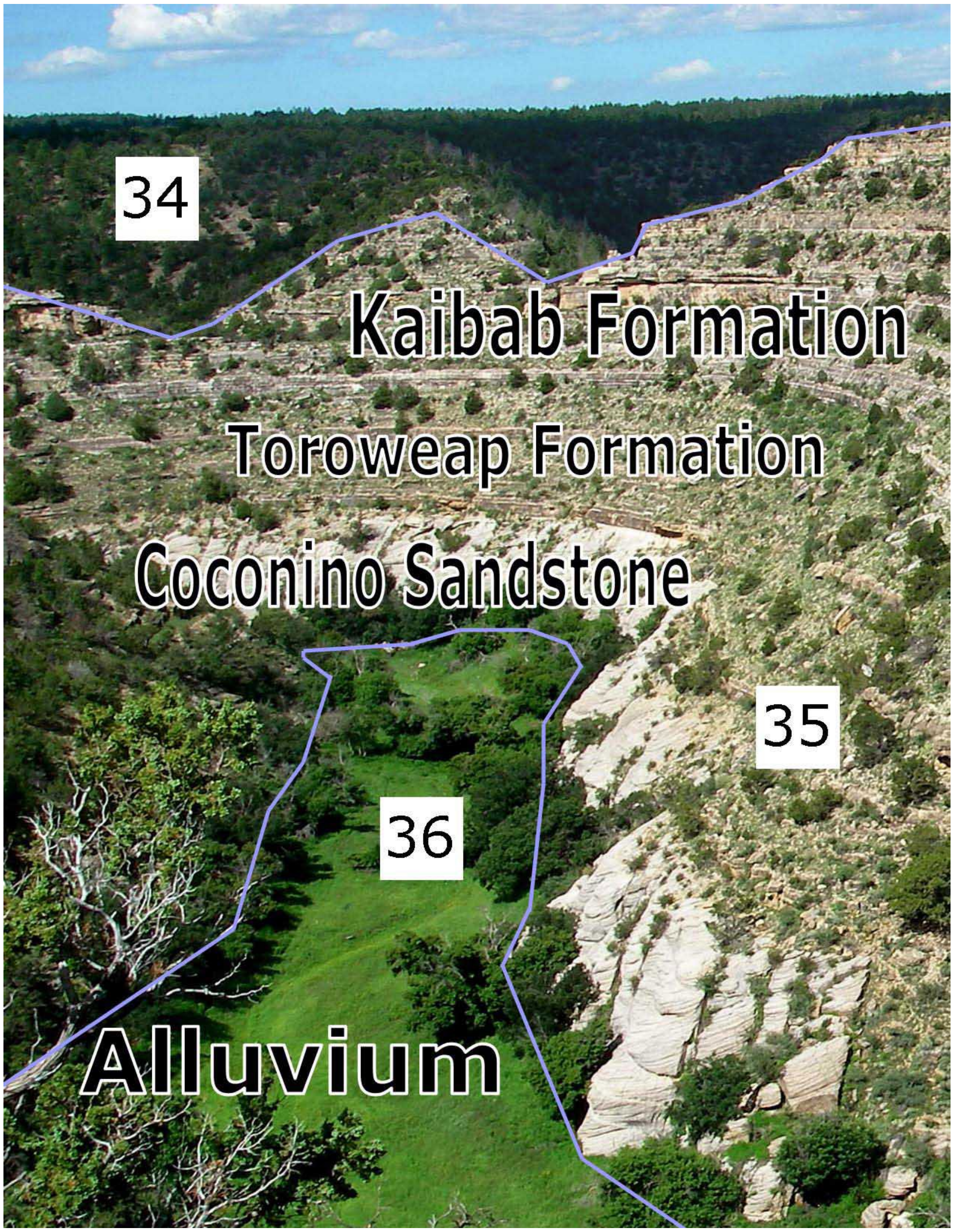


Figure 68.—Geologic profile of Walnut Canyon. Geologic formations are labeled in black. Soil map units are labeled and delineated in lavender. Map unit 36 is Oxyaquic Ustifluvents. Map unit 35 is Lithic Ustorthents-Rock outcrop complex. Map unit 34 is Kydestea-Rock outcrop complex.

controlled surfaces that commonly have shallow to moderately deep, well developed soils. These soils are typically more productive than those on neighboring steep slopes along the canyon edges. At the moderately sloping edges of the canyon are canyon rims, which have slopes of generally less than 25 percent. Canyon rims have soils that are younger and less developed than those on the structural benches. Along the steep edges consisting of exposed bedrock are canyon walls. Canyon walls are dominated by very shallow soils with high percentages of rock fragments and slopes of more than 35 percent. The canyon floors consist of terrace and flood-plain steps. Terraces and flood-plain steps have young, deep soils with little development and very

Figure 69.—The Coconino Sandstone in the western portion of Walnut Canyon. Walnut Creek cuts into steep cliffs of sandstone cross-beds. Because of steep slopes and noncohesive grains, there is almost no residuum associated with this formation.

gentle slopes. These different landforms and their underlying geologic formations are important in explaining the formation of the soils of Walnut Canyon National Monument (see table 8).

Geologic Formations

Walnut Canyon National Monument has three sedimentary rock formations (fig. 68). Deposition ranges from Permian periods (275 million years ago to about 250 million years ago) to the Triassic (USDI-NPS, 2008; Chronic and Chronic, 2004). Much of the Triassic formations have since been removed by erosion. Listed from oldest to youngest, or from the bottom of the canyon to the top, the formations are:

Coconino Sandstone.—This formation has yellowish tan to brown, resistant cross-beds of eolian sandstone with fine to medium, well sorted grains and calcium carbonate cementation (fig. 69). It also has minor inclusions of coarse sandstone, red siltstone, and limestone (USGS, 2006a).

Toroweap Formation.—This formation has white to tan, resistant cross-beds of marine sandstone and limestone with fine to medium grains and calcium carbonate cementation (fig. 70). It also has minor inclusions of gypsiferous siltstone and sandy siltstone and interbeds of gypsum (USGS, 2006c).

Kaibab Formation.—This formation has white to light gray or tan, resistant massive beds of limestone and dolomite with fine to medium sandy or silty grains and calcium carbonate cementation (fig. 71). It also has minor inclusions of thin layers of shaly siltstone and sandstone, gypsifereous siltstone, fossilferous chert nodules, and calcite (USGS, 2006b).

Figure 70.—The Toroweap Formation is in the central portion of Walnut Canyon. This formation resembles the Kaibab Formation in many ways but is generally more sandy.

In addition, isolated patches of the Moenkopi Formation occur as soil residuum above the Kaibab Formation.

The Kaibab Formation and the lower Toroweap Formation fracture and dissolve into underground passageways where cavernous water flows downward to the Coconino Sandstone. The porous sandstone from the Coconino Sandstone forms an aquifer, which recharges seeps at the bottoms of canyon walls (USDI-NPS, 2008).

Walnut Canyon, like many of the canyons in the region, formed during the gradual uplifting of the Colorado Plateau over the last 5 million years. The canyon itself formed from the simultaneous uplift of sedimentary blocks and the downcutting of Walnut Creek.

The development of the canyon as a landform was also influenced by faulting. Fault movement causes openings in the rock for water, which encourages development of solution openings in blocks of carbonate sedimentary formations. The Anderson Mesa Fault and the Lake Mary Fault are normal faults in the area that strike perpendicular to the flow of Walnut Canyon. Minor faulting can be seen from the Visitor Center.

The soils associated with structural benches and canyon rims have residuum as the dominant parent material. The more stable soils on structural benches contain weathered material from both the Moenkopi and Kaibab Formations, while the more erosive canyon rims contain residuum weathered from the Kaibab Formation. Although the soils associated with these two landforms are both shallow, they are very different in development and have very different physical and chemical characteristics.

The structural benches have two named soils—Chilson and Wilcoxson—mapped in a complex, specifically map unit 31 (see Walnut Canyon National Monument 3D Landforms and Soil Types). A mapped complex is one that contains two or more soils that cannot be differentiated from each other at the mapping scale but that are different enough in physical or chemical characteristics to have different soil classification. Chilson and Wilcoxson soils contain weathered material from the Moenkopi Formation, a mudstone with a higher percent of clay-sized particles than the Kaibab Formation. Soil stability is increased by parent material containing clay minerals. Clay minerals, by possessing a surface charge, help the soil to adhere to itself. The surface charge of clay minerals not only helps clay minerals to aggregate and resist erosion on gentle slopes but also helps the clay to adhere to water. The presence of water in the soil helps plants grow, increases organic material, and allows roots to further stabilize the soil. These clay minerals, over time and under stable conditions, can accumulate below the surface in an argillic horizon.

Both Chilson and Wilcoxson soils have argillic horizons, labeled as Bt in the soil profile. They developed these horizons over time while remaining stable on the gently sloped structural benches above the canyon rims. Though old enough to have an argillic horizon, both soils are not deep but rather shallow to moderately deep. Chilson soils have hard bedrock at a depth of about 15 inches (38 centimeters), and Wilcoxson soils have hard bedrock at a depth of about 26 inches (66 centimeters) (see table 8, column for parent material). This is because the parent material of the soils is residuum. These two soils do not gain additional inputs from other sources like the soils at the canyon bottom with alluvium. Instead, everything in the soil has weathered in place. Though considered developed for soils that are shallow to moderately deep, these soils are still limited to ponderosa pine and some Douglas fir on north-facing slopes because of the depth to bedrock. These structural benches with the associated argillic soils are very common across the Colorado Plateau.

The canyon rims also have soils that are shallow to a hard bedrock contact, but these soils are much different than those on structural benches (see Walnut Canyon National Monument 3D Landforms and Soil Types). The two soils associated with

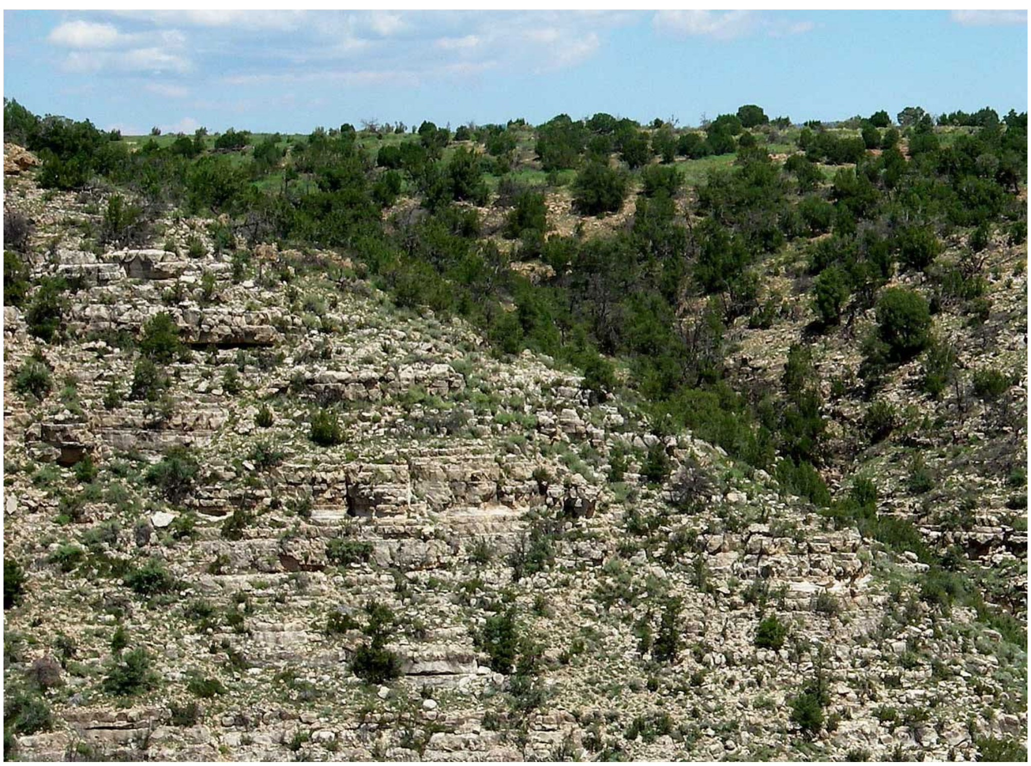


Figure 71.—The Kaibab Formation in the eastern portion of Walnut Canyon. This formation consists predominantly of limestone with minor inclusions of dolostone and limey sandstone. Residuum from the Kaibab Formation tends to have a high content of clays because of the carbonate clays in the parent material.

these landforms are Kydestea and Cosnino. The Cosnino series is new and was conceptualized inside Walnut Canyon National Monument. Both Kydestea and Cosnino soils are very shallow, about 8 inches (20 centimeters), to hard bedrock. Both soils formed in Kaibab Formation residuum and are on an erosive surface. Because of the erosive nature of the canyon rims, finer materials in these areas are removed downslope by wind, water, or gravity. As the finer material erodes from the larger, gravel, cobbles, and stones are left, which create a soil with a high concentration of rock fragments. The soils with a high content of rock fragments, or a loamy-skeletal family particle-size classification, were not stable enough to have broken down to clay-sized particles, like Chilson and Wilcoxson soils located upslope (see table 22).

Kydestea and Cosnino soils are mapped with Rock outcrop in map units 34 and 32, respectively. These areas of Rock outcrop are part of the Kaibab Formation. Along canyon faces, the downcutting by Walnut Creek will continue to expose more limestone beds, which will be susceptible to sliding from gravity. These canyon rim soils are naturally too erosive to have any real recognizable soil development for clay particles but do show some slight evidence of calcium carbonate accumulation. Though not enough to develop a calcic horizon, the soils are leaching and accumulating slight amounts of calcium carbonate through the profile. Kydestea and Cosnino soils do not consistently support the pinyon and juniper plant community typical of the surrounding areas.

Relationships between Soil, Water, Geology, and Archaeology

The interrelationships of soil, water, and rock formations are connected with the initial settlement of Walnut Canyon and, later, the establishment of the monument. Walnut Canyon National Monument was established to preserve and display the overhanging cliff dwellings. The structures were homes to the Sinagua people between 1150 and 1300 AD (fig. 72). Walnut Canyon lies near a natural route of travel that connected farmed areas east of the San Francisco Peaks with the lower canyons to the southwest. Early farmers grew corn, squash, and beans in the soils above the canyon rim using water collected from bedrock depressions on the canyon floor or water caught from seeps and drainages along the canyon walls.

Cliff dwellings were constructed on resistant limestone ledges within the softer sandstone interbeds of the Kaibab Formation. Hand-constructed outside walls, built from imported clay and local limestone rocks, provided protection from winds and rains. South- and east-facing cliff sides are exposed to more sunlight and its warmth. Deeper caverns formed naturally by water flowing through cracks within the soluble limestone and minor dolomite formation (Thybony, 1996).

Factors of Soil Formation

Soils form a special covering of earth’s surface that provides a place for minerals, water, organic matter, and air to mingle. The matrices of these together provide an environment for sustaining plants, animals, and microorganisms. Soils are products of various natural and/or human-influenced processes (fig. 73). Soils can vary in chemical composition, mineral structure, granular surface charges, compaction, soil structure, and more, all of which affect soil character and soil qualities (such as water infiltration rates, soil erodibility, and available water-holding capacity). Soils differ in their appearance, productivity, and management requirements due to more fundamental complex chemical and physical properties that result from the interaction of the five soil-forming factors. These factors are interdependent, and few generalizations can be made regarding any one factor unless the effects of the other factors are known. The term pedogenesis is often used to connote the processes of soil formation.

Figure 72.—Construction of cliff dwellings showing the use of local limestone carbonate rocks and imported clays for cementation.

The soil-forming factors are parent material, climate, organisms, time, and relief or topography. *Parent material* is the source material in which soils formed. Soils are influenced by the texture and structure of the parent material and its mineralogical and chemical composition. *Climate* is predominantly the temperature and kind and amount of precipitation. Climate is also the seasonal distribution of temperature and precipitation. *Organisms* are the plants and other organisms living in and on the soil, including humans. *Time* refers to how long the soil-forming factors have been operating on a particular landscape. *Relief* or *topography* is the shape and elevation of the landscape. It affects internal and external soil properties, such as soil drainage, aeration, susceptibility to erosion, and the soil's exposure to the sun and wind (Jenny, 1941).

The influence of each of the soil-forming factors varies. Soils may differ significantly from place to place in a survey or soils may differ within very short distances as a result of complex interactions among the five factors. Conversely, surveys may have consistent stretches of one type of soil in areas where soil-forming factors are uniform. The soil-forming factors in relationship to the soils of Walnut Canyon National Monument are discussed in the following paragraphs.

Parent Material

Parent material is the newly unconsolidated material from which soil develops. Parent materials can be divided into origin classes. Parent material origin is the type of bedrock from which the parent material is derived. In Walnut Canyon National Monument, the origin is predominantly sedimentary material from geologic formations. That of alluvial soils on the canyon bottoms is mixed igneous and sedimentary rocks.

Figure 73.—Formation of soils in Walnut Canyon can sometimes be the result of violent phenomena. Lightning has caused a tree to be thrown from the soil. Fallen trees decompose into organic matter, creating an A horizon rich in humus. A variety of plants, bacteria, and fungus will contribute to the decomposition. Organic matter will add biomass and nutrients to the soil while stabilizing the crust and moderating the temperature.

Parent materials can also be divided into kind classes. Parent material kind is the term used to describe the general physical, chemical, and mineralogical composition of the material, whether mineral or organic, from which soil develops. Parent material may have formed without major transportation or sorting of grains, as is the case of parent material formed from geologic formations. This parent material kind is residuum. Other kinds of parent materials may have collected by transport processes. They include alluvium, colluvium, and eolian deposits. In alluvium, the major gathering force is water. In colluvium, the gathering force is gravity. In eolian deposits, the major gathering force is wind. In all parent materials, any combination of forces may apply. In Walnut Canyon National Monument, the most common parent material kind is residuum, although alluvium collects at canyon bottoms and colluvium collects at the bases of the canyon walls (see table 8).

Residuum

Residuum consists of unconsolidated, weathered, or partly weathered mineral material that accumulates by the weathering and disintegration of bedrock in place. It is the most common kind of parent material in the park. Because residuum is closely related to its parent material and the local geology, an example of residuum is useful when describing the relationship between geologic formations and parent material.

In and around the Colorado Plateau, the residuum is commonly controlled by structural geology and tectonic forces. The uplift of bedrock increases the amount of erosion due to increased gravitational potentials. The forces responsible for the uplift are related to tectonics. Although uplift and tectonics are generally not considered one of the forces that determine parent material kind, uplift makes soils prone to movement by erosion and, because of their exposure, causes rocks to become prone to weathering. Because of the extreme erosional potential, soils that formed in residuum tend to be shallow and very shallow, especially near and along the canyon rim. The constant removal of soil material from the region leads to immature, unstable soils that do not have strong pedogenic development. These young, immature soils are greatly influenced by the geologic formations from which they have evolved.

Alluvium and Colluvium

Quaternary deposits within the monument are limited to alluvial stream deposits along Walnut Creek and Cherry Creek and colluvial talus at interbed slope breaks on canyon walls and at canyon wall bases. Alluvial deposits may have an influence of volcanic ash and debris. In one small isolated area, very deep lacustrine deposits have formed behind a man-made dam.

Alluvium is unconsolidated clastic material, including gravel, sand, silt, clay, and various mixtures deposited by water in comparatively recent geologic time. Colluvium is a loose incoherent mass of soil or rock fragments deposited on side slopes or at the base of slopes by mass movement due to gravitational forces in combination with rainwash, sheetwash, or slow, continuous downslope creep.

Alluvial landforms identified in the park are stream terraces and flood-plain steps (see Walnut Canyon National Monument 3D Landforms and Soil Types). The stream terraces are higher upslope and represent the old stream channel after the water level has dropped or meandered to the other side of the canyon. The stream terraces no longer receive much flooding because the water level in the canyon is controlled through man-made structures upstream. The flood-plain steps are downslope and along the current channel. They still flood occasionally, even with the control structures.

Soils associated with the terrace landforms are Vosburg and Whiskey. Whiskey soils are very deep, loamy soils with a high organic matter content. They are closer to the existing channel and are younger than the upslope Vosburg soils. Vosburg soils are also very deep with a high organic matter content but have an argillic horizon, like the soils on structural benches. An argillic horizon is the result of the stream cutting deeper and deeper into the limestone bedrock to the point where the old part of the channel becomes abandoned and the soils become stable and do not flood, allowing materials to accumulate in the soil profile (fig. 74). Because Vosburg soils have this horizon, they are slightly more productive on the canyon floor than the downslope Whiskey soils that have a better water-holding capacity due to a higher clay content.

The soils associated with flood-plain steps are mapped to the subgroup level of classification and not to a family level or series. This is because the stream channel has high variability and soil material is actively deposited through alluvial forces. These soils are named Oxyaquic Ustifluvents. The Oxyaquic designation indicates the frequency of flooding on the flood-plain step. The Ustifluvents designation indicates the alluvial deposition of the soils as related to landform position. Oxyaquic Ustifluvents are the wettest soils in the park and the most susceptible to flooding (see table 27).

Colluvial soils are associated with canyon walls. In the park, the canyon walls are dominated by exposed rock outcrop. In sections at the bottom of canyon walls, soil and fragments accumulate. These areas, like the canyon rims, are mapped as Kydesta and Cosnino soils (fig. 75). The soils associated with canyon walls, however, are much steeper and have even higher concentrations of rock fragments. Like the soils on canyon rims, these soils are unstable and undeveloped and support pinyon and juniper plant communities (see table 14, part II, column for hazard of erosion).

Figure 74.—Thick soil beds have accumulated behind an early dam in the east-central portion of the park. The hydrology of the canyon has been modified by humans. The soil in the foreground has weathered from colluvial deposits near the bottom of the cliff face.

Organisms

Jennifer M. Puttere, ecological site inventory specialist, Natural Resources Conservation Service, prepared this section.

Biotic factors include organisms living both on the soil surface (such as plants and animals) and under the soil surface (such as nematodes, springtails, soil bacteria, and soil fungus) (figs. 76 and 77). Many different interrelated events develop and alter the soil surface. Large herbivores walk on the surface, compacting the soil, and selectively browse plants. Insects such as grasshoppers defoliate and create litter; plants grow roots and anchor the soil; wildfires create nutrient-rich ash; and soil microbes thrive where roots have penetrated the soil (rhizosphere).

Biological Soil Crusts and Vascular Plants

Biological soil crusts occur in almost all drylands worldwide, are one of the most important soil-stabilizing organisms in the deserts of the world, and have the ability to stabilize soil against erosive forces (Bowker et al., 2007). Cyanobacteria exude polysaccharides that contribute to soil aggregate formation. Lichens and mosses also contribute to soil stabilization by penetrating the soil surface with hairlike growths, called rhizines, that bind them to the soil surface (Jimenez Aguilar et. al., 2009). In Walnut Canyon National Monument, Bowker et. al. (2007) found that the park had the potential for biological soil crusts but that there was actually very little, perhaps due to recent fires or flooding.

Vascular plants stabilize the soil surface, distribute nutrients, and contribute organic matter to the soil. Plants also have an influence on soil properties, such as soil structure. Plants can promote soil aggregation in various ways, including root penetration, modification of the soil water regime, creating networks of roots in the soil profile, increasing microbial activity in the rhizosphere, and increasing soil carbon input through roots and litter (Angers and Caron, 1998). Soil microbial communities are the primary drivers of nutrient cycling in the rhizosphere (Williams et al., 2012). Microbial activity directly influences plant productivity and diversity by influencing plant growth and development, plant competition, and nutrient and water intake (Kennedy and Stubbs, 2006).

Forest trees in the pine family (*Pinaceae*), such as ponderosa pine (*Pinus ponderosa*), contribute to soil development and stability through a symbiotic relationship between their roots and a soil fungus, specifically ectomycorrhizal fungi (Smith et al., 2005). Tree roots contribute to the mobilization of nutrients through chemical activity in the rhizosphere (Attiwill and Adams, 1993).

The level of microbial activity in the soil can alter the soil's classification, health, and productivity. Mollisols are soils that have high concentrations of organic matter in and just below the surface (see table 23). This high concentration of organic matter results in better soil structure and a higher water-holding capacity and improves soil health overall. The organic matter is also food for soil microorganisms. On the more stable structural benches, the incorporation of organic matter from forest trees helps to create the dark surface colors of Chilson and Wilcoxson soils, which both classify as Mollisols (see table 29). The canyon floor terraces also accumulate organic matter through alluvial inputs. Both Whiskey and Vosburg soils have thick (more than 40 centimeters) accumulations of organic matter in the profile. This high concentration of organic

Figure 75.—Display of differences in colluvium (above) along the base of cliffs and alluvium (below) on the canyon floor. The colluvial soils tend to be sloping, rocky, and sandy. In this photo, the colluvial soil is the Kydestea soil in map unit 37 (Rock outcrop-Kydestea complex, 25 to 60 percent slopes). The alluvial soil is the Whiskey soil in map unit 38 (Whiskey loam, 2 to 8 percent slopes).

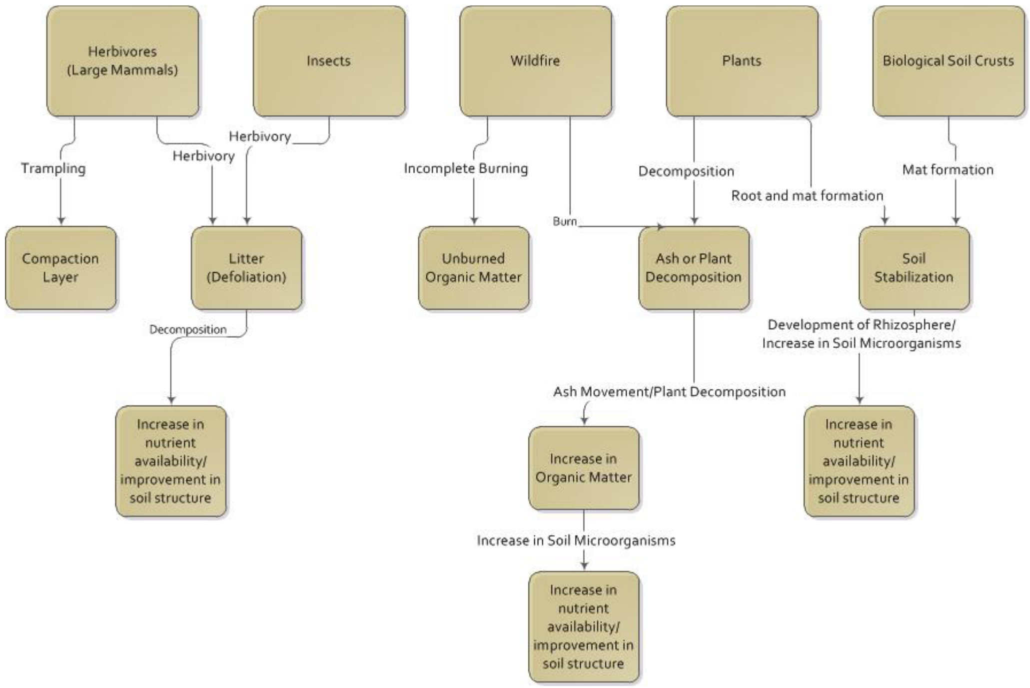


Figure 76.—A flow chart summarizing interrelationships of biotic processes in soil-forming factors.

matter improves soil health, increases soil stability, and increases soil productivity for farming. These areas, especially on structural benches, are where the native Sinagua people had farms.

Large Mammals

In Walnut Canyon, North American elk (*Cervus elaphus*) and other herbivorous grazing animals, such as mule deer (*Odocoileus hemionus*), are known to improve the palatability of forage by increasing the nitrogen content of above-ground biomass, as long as their populations remain at low to moderate densities (Stewart et al., 2006). Conversely, large mammals can reduce nutrient cycling by uprooting and trampling plants. They can also contribute to the compaction of soils, which slows the cycling processes (Belovsky and Slade, 2000). Large herbivorous mammals can affect the mineralization rate by selectively browsing more palatable plants and leaving less palatable and less decomposable plants (McNaughton et al., 1997). Insects can have similar effects on soil nutrients but not cause compaction. They create litter by choosing to feed on plants that are more easily decomposed (Belovsky and Slade, 2000).

Wildfire and Organisms

Wildfire affects the cycling of soil and plant nutrients by converting all or part of organic matter and detritus into organic ash and other combustion products (Boerner, 1982). Some nutrients may be lost to the atmosphere or remain incompletely burned (Boerner, 1982). Frequent fires on the same site can damage soil fertility and alter nutrient cycling (Williams et al., 2012). The suppression of natural wildfire, however, allows trees to grow in high densities, resulting in an altered ecosystem function and a high risk of severe wildfire (Whicker et al., 2008).

Figure 77.—Walnut Canyon serves as a refuge for wildlife, especially for several birds.

Figure 78.—The San Francisco Mountain rises over the more arid east end of Walnut Canyon. The growth of trees is more limited in height and mass in this area. Pinyon and juniper use the moisture between cracks in canyon walls.

Figure 79.—Moisture on a north aspect allows larger Douglas fir to grow across the canyon at the west end of the park.

Climate

The climate of Walnut Canyon National Monument tends to be consistent with Mogollon Rim climates (figs. 78 and 79). Weather can change quickly at any time of the year. In spring, strong, gusty winds occur on the rim and in the canyon. June is the driest month of the year. Summers are moderately warm and have a monsoonal rain pattern; afternoon thunderstorms occur from July to September. The average daily maximum temperature in July is 87 degrees F. Rainfall peaks in August, which has an average of 2.7 inches. Fall tends to be dry and cool. Winters are cold and commonly have deep accumulations of snow. The average daily minimum temperature in January is 19 degrees F. The average annual snowfall is 54.6 inches. Average annual precipitation is 18.1 inches (see the "Climate" section in the introduction for more information).

Young soils in an erosive environment, such as Kydestea soils and Lithic Torriorthents occurring on the canyon walls of Walnut Creek, are dominated by particles weathered from rock formations and rock fragments. Colluvium moves down the canyon escarpment and is replaced by material weathering out of rocks. Two processes related to the park's climate account for much of the rock weathering: 1) frost shattering from freeze-thaw processes and 2) exfoliation and spalling of rock from forest fires.

The physical processes of freeze-thaw disintegration occur because rock and water/ice coexist at various temperatures that change. As temperature decreases, water expands while rock contracts, and vice versa as temperature increases. The force and movement created by freezing water are always into the rock. Water/ice can exist on surfaces and within pores in various amounts. Rock surfaces may be large or small, dry or saturated. Pores can also be dry or saturated. The amount of shattering can also be related to the tensile strength of the rock. In addition, freezing and thawing rates and overall intensity affect frost shattering (Matsuoka, 1991; Ritter et al., 1995).

Vertical displacement of rocks or soil due to the freeze-thaw cycle is called frost heaving. Repeated frost heaving forces larger particles to move toward the surface. The freeze-thaw cycle plays a direct role in the destruction of soil aggregates (Hillel, 1998) (see table 26, column on potential for frost action).

Forest fires also contribute to the disintegration of rocks. Rocks respond to heat by exfoliation and spalling. Spalling (or spalliation) is the flaking of a rock from impact or internal stress. Exfoliation is the surface-parallel fracture process that often leads to disintegration into concentric pieces. The degree and form of weathering differ by rock type. Spalling has been induced in tests where rocks have been exposed to high temperatures and combinations of thermal stress and pore pressures (Zhang et al., 2011).

Wildfire and Climate

Wildfires are an important natural part of the regional climate of the park and can impact soil formation. Wildfire events can create a number of swift and intense impacts, especially for forest soils. A single wildfire can cause immediate conditions for severe soil erosion and accelerated water runoff.

During wildfires, plant organic matter is combusted. With the loss of organic matter, the soil loses stability. Subsequent movement of soil after wildfires poses safety hazards and is associated with great damage to property. Removal of surface organic matter affects soil temperatures. This is significant in Walnut Canyon where soils experience seasonal freeze-thaw cycles. Organic matter benefits soil in many ways, including increasing moisture retention, moderating temperature and pH, and increasing biomass and nutrient availability (Miller and Gardiner, 1998).

While some fires may remove only the litter layer, more intense fires may also remove both the litter layer and the root biomass immediately below the soil surface, which can result in very severe erosion. Furthermore, fire can greatly reduce infiltration rates and increase runoff rates under some conditions (DeBano, 1981; Toy et al., 2002). Severe erosion occurs on some soils because vaporization and readsorption of stable organic substances during a burn make the soil hydrophobic (DeBano et al., 1970; Morgan, 2005). The potential for soil erosion following fires increases as fire temperatures increase. Furthermore, revegetation after fires with extreme temperatures can take four times as long. Where possible, the intensity of the fire, such as in controlled burns, should be managed to avoid loosening surface cover and the underlying organic material. Revegetation is a standard erosion-control practice following fire.

Landforms can influence the spread of fire. Fires occur more frequently in upslope areas and less frequently along streams. The influence of fires on landforms is less clear. Fire affects landscape development because it has an important influence on the rate of erosion (Swanson, 1981).

Topography

Topography, or relief, is characterized by the length, shape, aspect, and degree of surface slope. It influences soil formation by affecting moisture distribution, runoff, and erosion (figs. 80 and 81). For example, soils on steeper slopes have faster runoff rates and less soil moisture than those on gentler slopes. These conditions increase the erosion potential (Hendricks, 1985). More runoff on steeper slopes can lead to soils that lack development and have shallow depths. Soils on moderate and gentle slopes can retain more moisture and thus be more developed.

The topography of Walnut Canyon is the result of surface water erosion that cut into the limestone geology. Situated in the Coconino Plateau and part of the Colorado Plateau, Walnut Canyon is a deep ravine that formed over time similarly to the Grand

Figure 80.—Area of Kydestea soil. Kydestea soils formed on erosive Colorado Plateau topography unprotected from naturally occurring erosion. Although soil material has been removed, exposing the Kaibab Formation, some young undeveloped soil has collected between the rocks.

Canyon. Walnut Canyon's geologic material is mostly limestone from the Kaibab and Toroweap Formations. An exposed view of the upper canyon walls shows limestone ledges and slopes with thick and thin layers of both silty limestone/dolomite and limy shaly siltstone, respectively (Chronic and Chronic, 2004). A closer look at Walnut Canyon and the equally exposed yet lower-situated canyon walls reveals cross-bedded sandstone. In general, the topography of Walnut Canyon has been influenced by water eroding soil to shallow depths and eroding the bedrock formations to a deeper canyon wall.

The importance of relief in soil formation is very evident in Walnut Canyon (see Walnut Canyon National Monument 3D Landforms and Soil Types). The canyon top is comprised of stable structural benches that have more developed soils and higher vegetative production, as evident on Chilson and Wilcoxson soils in map unit 31. The nearer the canyon rim, the steeper the soils and the more exposed the shallow bedrock (due to increased erosion by wind and water). This is evident on Cosnino and Kydestea soils in map units 32 and 34. Further down the canyon walls the bedrock dominates soil formation on steeper slopes, as evident in map units 33 and 37. Near the bottom of canyon walls, slope may decrease due to the occurrence of colluvial material (specifically fallen piles of rock and soil). The canyon floor has more gently sloped terraces and reworked deep alluvial soils, as evident in map units 36, 38, and 39.

Aspect also affects soil formation. South-facing slopes are much hotter and drier than north-facing slopes due to more direct sun exposure. The south-facing slopes in Walnut Canyon are dominated by very shallow soils, such as the Kydestea soil in map units 34 and 37. The greater sun exposure dries out the soil quicker, leaving less water for plants and soil microbes and thus a less productive and developed soil. The north-facing slopes are cooler and wetter. They are dominated by Douglas fir and ponderosa pine. The forest soils retain water and snow longer, creating a better environment for soil microbes and plants (see table 9). Soils on the north-facing slopes also have a mollic epipedon (a deep layer of organic material at the surface). They include the Cosnino soil in map unit 33.

Time

The soil-forming factors of parent material, climate, organisms, and topography are influenced by time. In Walnut Canyon National Monument, because of the predominance of erosional surfaces, soil development is evident only in areas away from the rim where stability is limited only by the resistance of limestone and sandstone.

Soils in areas away from the rim have had enough time and stability to develop horizonation. Soils above and away from canyon rims increase in depth and develop argillic horizons and mollic epipedons.

An argillic horizon is a visible horizon that has a significantly higher percentage of phyllosilicate clay than the overlying soil. Argillic horizons show evidence of clay illuviation. In Walnut Canyon, Chilson and Wilcoxson soils have argillic horizons. Wilcoxson soils formed on structural benches on the tops of Walnut Canyon, where they have been stable long enough to allow the finer clay particles to translocate down

Figure 81.—Area of Wilcoxson soil. Wilcoxson soils formed from isolated residuum of the red Moenkopi Formation that rests stratigraphically above the Kaibab Formation. Although most of the Moenkopi Formation in Walnut Canyon National Monument has been removed through alluvial and eolian forces, this area is circumstantially protected from erosion. The red soil material and level slope indicate increasing stability and the possibility for further soil development, including argillic horizonation.

Figure 82.—Indian paintbrush and other flowers growing in decaying wood will contribute to organic matter accumulation on the soil surface.

through the soil profile. An argillic horizon forms below the surface but may appear at the surface if overlying soil material has been removed by erosion. Argillic horizons are significant because they represent a barrier to water, nutrients, and organisms (Buol et al., 2011). These argillic soils on the canyon tops, because they had a higher water-holding capacity and available nutrients, were historically farmed by the Sinaqua people.

An argillic horizon also is important because it allows moisture to gather in a zone where it can easily be collected by plant roots. Where moisture infiltrates downward by gravity and capillary forces, it may continue to migrate downward past the rooting zone of plants, sometimes in a short amount of time. This is particularly true for sandy soils because most common quartz grains do not have a surface which will adhere water and retain moisture. When clay argillans aggregate into an argillic horizon they provide a surface for water adsorption and hence moisture retention (see table 23).

A mollic epipedon is the surface horizon that is visibly enriched with organic matter. This enrichment causes the darkening of a mineral soil. There are several processes related to the formation of a mollic horizon. Roots extend down into the profile from the surface and eventually die and decompose in the soil. Earthworms, ants, and other organisms rework the soil surface and subsurface layers, moving organic material in the process. Organic matter and mineral matter move through voids between peds. Some of the organic matter decomposes quickly to form more stable residues while more resistant lignins collect in the profile.

A mollic epipedon is also important to plants for several reasons. Organic matter enriches the soil and improves soil health in several ways (fig. 82). It retains moisture, provides nutrients and biomass, reduces temperature extremes, and moderates pH, which can affect nutrient availability. A mollic epipedon may provide the right environment for the germination of seeds that were distributed on the soil surface.

Mollic epipedons typically form in two ways: 1) from additions of organic matter from surrounding vegetation or 2) from the accumulation of organic matter by the alluvial process. Soils in Walnut Canyon National Monument have both forms of mollic epipedons. In Vosburg and Whiskey soils, thick organic epipedons formed as organic matter was deposited through the alluvial process. Both soils are on the lower terraces of Walnut Creek; however, Vosburg soils are higher on a terrace where they had enough stability and time to also develop an argillic horizon. In contrast, Chilson and Cosnino soils have shallower mollic epipedons that formed as organic matter was deposited by vegetation in areas shallow to bedrock along the canyon rims.

Finally, given time, soils may develop a favorable depth for plants and animals. Very shallow soils may not offer enough space for some plants to establish roots and gain adequate mechanical support. Shallow soils are more subject to erosion and inadequate drainage. More water is stored in a deep soil and, during drought, moisture is removed more slowly from a deep soil than a shallow soil (Tromp-van Meerveld and McDonnell, 2006).

If there is adequate time, the right combination of the other four soil-forming factors, and a measure of appropriate care and management, a unique forest habitat is created. Such a forest habitat surrounds Walnut Canyon and is visible from the Visitor Center. More critical, remote locales occur beyond the canyon rim in protected spaces. In the future, much of Walnut Canyon will likely have further rock weathering and transport of soil due to the forces of water and gravity. Walnut Canyon is the site of a naturally erosional environment. It will continue to erode slowly and naturally as long as there is a healthy plant cover and stabilizing organic matter is protected from unnaturally hot wildfires.

Classification of the Soils

Soils are named and classified on the basis of physical and chemical properties in their horizons (layers). Color, texture, structure, and other properties of the soil to a depth of 2 meters are used to key the soil into a classification system. This system helps people to use soil information and also provides a common language for scientists.

Soils and their horizons differ from one another, depending on how and when they formed. Soil scientists use the five soil-forming factors to help predict where different soils may occur. The degree and expression of the soil horizons reflect the extent of interaction of the soil-forming factors with one or more of the soil-forming processes (Simonson, 1959).

When mapping soils, a soil scientist looks for areas with similar soil-forming factors to find similar soils. The properties of the soils are described. Soils with the same kind of properties are given taxonomic names. Soils are classified, mapped, and interpreted on the basis of various kinds of soil horizons and their arrangement. The distribution of soil orders corresponds with the general patterns of the soil-forming factors within the park.

The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1999 and 2010). 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. The categories are defined in the following paragraphs.

ORDER. Soil taxonomy at the highest hierarchical level identifies 12 soil orders. The names for the orders and taxonomic soil properties relate to Greek, Latin, or other root words that reveal something about the soil. 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 Mollisol.

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. Sixty-four suborders are recognized at the next level of classification. The last syllable in the name of a suborder indicates the order. An example is Ustoll (*Ust,* indicating an ustic soil moisture regime, plus *oll,* from Mollisol).

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; type of saturation; and base status. There are about 300 great groups. 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 Haplustoll (*Hapl,* meaning minimal horizonation, plus *ustoll,* the suborder of the Mollisols that has an ustic moisture regime).

SUBGROUP. There are more than 2,400 subgroups. Each great group has a typic subgroup. The typic subgroup is the central concept of the great group; it is not necessarily the most extensive. Other subgroups are intergrades or extragrades. 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 taxonomic class. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Lithic* identifies the subgroup that has hard bedrock at a depth of less than 20 inches (50 centimeters). An example is Lithic Haplustolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties for family placement are those of horizons below a traditional agronomic plow depth. Among the properties and characteristics considered are particle-size class, mineralogy class, cation-exchange activity class, soil temperature regime, soil depth, and reaction class. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is loamy-skeletal, mixed, superactive, frigid Lithic Haplustolls.

SERIES. The soil series is the lowest category in the soil classification system. The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile.

An example is the Cosnino series, which is classified as a loamy-skeletal, mixed, superactive, frigid Lithic Haplustoll. The Cosnino series is unique to Walnut Canyon National Monument and was named after an old town located near the soil type location.

Most parks are mapped to the series level. The names of soil series are selected by the soil scientists during the course of mapping. The series names are commonly geographic place names or are coined. Because of access limitations and soil variability, soils in some remote areas are classified at the great group or subgroup level.

Table 29 indicates the order, suborder, great group, subgroup, and family of the soil series in the park. Table 30 displays the classification as a key sorted by order.

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Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the “National Soil Survey Handbook” (available in local offices of the Natural Resources Conservation Service or on the Internet).

`a`a lava. Hawaiian term for basaltic lava having a rough, jagged, clinkery surface and a vesicular interior.

`a`a lava flow. Basaltic lava flow dominated by `a`a lava that has a characteristically rough, jagged, clinkery surface.

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.

Alkali (sodic) soil. A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial fan. A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium. Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Aquic conditions. Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon. A subsoil horizon characterized by an accumulation of illuvial clay.

Ash (volcanic). Unconsolidated, pyroclastic material less than 2 mm in all dimensions. Commonly called “volcanic ash.”

Ash flow. (Note: This term is not preferred; see Pyroclastic flow and Pyroclastic surge.) A highly heated mixture of volcanic gases and ash, traveling down the flank of a volcano or along the surface of the ground; produced by the explosive disintegration of viscous lava in a volcanic crater, or by the explosive emission of gas-charged ash from a fissure or group of fissures. The solid materials contained in a typical ash flow are generally unsorted and ordinarily include volcanic dust, pumice, scoria, and blocks in addition to ash. Also called pyroclastic flow.

Aspect. The direction toward which a slope faces. Also called slope aspect.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

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.

Badland. A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

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.

Base slope (geomorphology). A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

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

Bedrock-controlled topography. A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock

Block field. A thin accumulation of typically angular stone blocks that has only coarse fragments in the upper part and overlies solid or weathered bedrock, colluvium, or alluvium where there is not a cliff or ledge above as an apparent source. Block fields occur on high mountain slopes above the tree-line or in polar or paleo-periglacial regions. They are most extensive along slopes parallel to the contour; and they generally occur on slopes of less than 5 percent.

Block glide (mass movement). A slow type of landslide in which largely intact units (blocks) of rock or soil slide downslope along a relatively planar surface, such as a bedding plane, without any significant distortion of the original mass; a type of translational rock slide.

Block lava. Lava having a surface of angular blocks that is similar to \`a\`a lava but has fragments that are larger and more regular in shape, somewhat smoother, and less vesicular. Compare to \`a\`a lava, pahoehoe lava, and pillow lava.

Block lava flow. A lava flow dominated by block lava. Compare to \`a\`a lava flow and pahoehoe lava flow.

Bottom land. An informal term loosely applied to various portions of a flood plain.

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

Bouldery. Refers to a soil containing boulders in numbers that interfere with or prevent tillage.

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

Caldera. A large, more or less circular depression, which was formed by explosion and/or collapse and which surrounds a volcanic vent or vents. Its diameter is many times greater than that of the included vent or vents.

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

Canyon. A long, deep, narrow 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-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.

Cinder cone. A conical hill formed by the accumulation of cinders and other pyroclastics, typically basaltic or andesitic in composition. Slopes generally exceed 20 percent.

Cinders. Uncemented vitric, vesicular, pyroclastic material that is more than 2.0 millimeters long in at least one dimension and has an apparent specific gravity (including vesicles) of more than 1.0 and less than 2.0.

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.

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.

Cobbly soil material. Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility). See Linear extensibility.

Colluvium. Unconsolidated, unsorted earth material that is transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Common resource area. See Land resource units and Major land resource areas.

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. See Redoximorphic features.

Conglomerate. A coarse grained, clastic sedimentary 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 (geomorphology). A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations). 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.

Dense layer (in tables). A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Densic materials. Materials that are relatively unaltered and have a noncemented rupture-resistance class. The bulk density or the organization is such that roots cannot enter, except in cracks. These are mostly earthy materials, such as till, volcanic mudflows, and some mechanically compacted materials, such as mine spoils. Some noncemented rocks can be densic materials if they are dense or resistant enough to keep roots from entering, except in cracks.

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.

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.

Drainageway. A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Dune. A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand). It is either barren and capable of movement from place to place or is covered and stabilized with vegetation but still retaining its characteristic shape.

Earthy fill. See Mine spoil.

Ecological site. An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological 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 ecological sites in kind and/or proportion of species or in total production.

Eolian deposit. Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

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 (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion surface. A land surface shaped by the action of erosion, especially by running water.

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. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Extrusive. Term used for igneous rocks and sediments derived from deep-seated molten matter (magma), deposited and cooled on the earth's surface. Examples are lava flows and tephra deposits.

Fan remnant. A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

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.

Fill slope. A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil. Sandy clay, silty clay, or clay.

Fissure vent. An opening in the earth's surface of a volcanic conduit in the form of a crack or fissure rather than a localized crater; a roughly linear crack or area along which lava, generally mafic and of low viscosity, wells up to the surface, usually without any explosive activity. The results include an extensive lava plateau, such as the Columbia River Plateau.

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

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

Flood-plain step. An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. Flood-plain steps may occur individually or as a series of steps.

Fluvial. Of or pertaining to rivers or streams; produced by stream or river action.

Foothills. A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope. The concave surface at the base of a hillslope. 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.

Forest cover. All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type. A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

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 small channel with steep sides caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. 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 slope (geomorphology). A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hill. A generic term for an elevated area 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. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope. A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

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:

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.

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.

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.

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.

Interfluve (geomorphology). A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream. A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Iron depletions. See Redoximorphic features.

K_{sat}. Saturated hydraulic conductivity. (See Permeability.)

Lacustrine deposit. Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Land resource units (LRUs). The basic units from which major land resource areas (MLRAs) are determined. LRUs are created by subdividing MLRAs according to resource concerns, soil groups, hydrologic units, topography, other landscape features, and considerations affecting land use and soil and water conservation treatment. Also referred to as common resource areas (CRAs).

Landslide. A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. 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.

Lava. A general term for a molten extrusive; also the rock solidified from it.

Lava channel. See Lava trench.

Lava field. An area covered primarily by lava flows whose terrain can be rough and broken or relatively smooth; it can include vent structures (e.g., small cinder cones and spatter cones), surface flow structures (e.g., pressure ridges and tumuli) and small, intermittent areas covered with pyroclastics.

Lava flow. A solidified body of rock formed from the lateral, surficial outpouring of molten lava from a vent or fissure. It is commonly lobate in form. Compare to `a`a lava flow, lava flow unit, and pahoehoe lava flow.

Lava flow unit. A separate, distinct lobe of lava that issues from the main body of a lava flow; a specific outpouring of lava a few centimeters to several meters thick and of variable lateral extent that forms a subdivision within a single flow. A series of overlapping lava flow units comprise a single lava flow. Also called flow unit.

Lava plain. A broad area of nearly level land that can be localized but is commonly hundreds of square kilometers in extent and that is covered by a relatively thin succession of primarily basaltic lava flows resulting from fissure eruptions.

Lava plateau. A broad elevated tableland or flat-topped highland that may be localized but commonly is many hundreds or thousands of square kilometers in extent and that is underlain by a thick succession of basaltic lavaflows resulting from fissure eruptions (e.g., the Columbia River Plateau).

Lava trench. A natural surface channel in a lava flow that never had a roof and was formed by the surficial draining of molten lava rather than by erosion from running water. Also called lava channel.

Lava tube. A natural, hollow tunnel beneath the surface of a solidified lava flow through which the lava flow was fed. The tunnel was left empty when the molten lava drained out.

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

Ledge. A narrow shelf or projection of rock, much longer than wide, formed on a rock wall or cliff face,

Linear extensibility. Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. 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. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

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

Mafic rock. A general term for igneous rock composed chiefly of one or more ferromagnesian, dark-colored minerals; also said of those minerals.

Major land resource areas (MLRAs). These are geographically associated land resource units (LRUs). Identification of these large areas is important in statewide agricultural planning as well as in interstate, regional, and national planning.

Marl. An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also in more saline environments.

Mass movement. A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses. See Redoximorphic features.

Mawae (colloquial Hawaiian term). A natural surface channel that commonly occurs near the middle of an \`a\`a lava flow and that formed by the surficial draining of molten lava rather than by erosion from running water; a type of lava trench.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mesa. A broad, nearly flat-topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock. Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth’s crust. Nearly all such rocks are crystalline.

Mine spoil. An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

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. A kind of map unit 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.

Mottling, soil. Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Mountain. A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) 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.

Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Mudstone. A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

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.)

Nodules. See Redoximorphic features.

Nose slope (geomorphology). A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

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

Pahoehoe lava. Basaltic lava that has a characteristically smooth, billowy or rope-like surface and vesicular interior.

Pahoehoe lava flow. A basaltic lava flow that has a characteristically smooth, billowy or rope-like surface.

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 downward 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:

Impermeable	less than 0.0015 inch
Very slow	0.0015 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

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

Phase, soil. A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Pillow lava. A general term for lava displaying pillow structure (discontinuous, close-fitting, bun-shaped, or ellipsoidal masses generally less than 1 meter in diameter). Pillow lava is considered to have formed in a subaqueous environment. Such lava is typically basaltic or andesitic.

Pillow lava flow. A lava flow or body displaying pillow structure and considered to have formed in a subaqueous environment; typically basaltic or andesitic in composition. Compare to block lava flow and pahoehoe lava flow.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology). A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower-lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

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.

Pore linings. See Redoximorphic features.

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.

Proper grazing use. Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproductive capacity of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

Pumice (soil science). Rock fragments that are 2 millimeters in diameter or coherent rock layers (pumice flow) composed of light-colored, vesicular, glassy rock commonly having the composition of rhyolite. The material commonly has a specific gravity of less than 1.0 and is thereby sufficiently buoyant to float on water.

Pumice (geology). Rock fragments or coherent rock layers (pumice flow) composed of light-colored, vesicular, glassy rock commonly having the composition of rhyolite. The material commonly has a specific gravity of less than 1.0 and is thereby sufficiently buoyant to float on water. There are no size restrictions.

Pyroclastic. Pertaining to clastic rock particles produced by explosive, aerial ejection from a volcanic vent. Such materials may accumulate on land or under water. Compare to volcaniclastic.

Pyroclastic flow. A fast-moving current of pyroclastic material, usually very hot, composed of a mixture of gasses and a variety of pyroclastic particles (such as ash, pumice, scoria, and lava fragments). It is produced by the explosive disintegration of viscous lava in a volcanic crater or by the explosive emission of gas-charged ash from a fissure and tends to follow topographic lows (e.g., valleys) as it moves. This term is used in a more general sense than ash flow.

Pyroclastic surge. A low-density, dilute, turbulent pyroclastic flow, usually very hot, composed of a generally unsorted mixture of gases, ash, pumice, and dense rock fragments that travels across the ground at high speeds and is less constrained by topography than a pyroclastic flow. There are several types of pyroclastic surges, including base surge and ash-cloud surge.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed as 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

Red beds. Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations. See Redoximorphic features.

Redoximorphic depletions. See Redoximorphic features.

Redoximorphic features. Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:

   A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*

   B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*

   C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.

2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:

   A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*

   B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).

3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix. See Redoximorphic features.

Relief. The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material). Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Riser. The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, step-like landforms, such as successive stream terraces.

Road cut. A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

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

Rock varnish. A thin, dark, shiny film or coating, composed of iron oxide accompanied by traces of manganese oxide and silica, that formed on the surfaces of pebbles, boulders, and other rock fragments. It commonly occurs on rock outcrops in arid regions. It is thought to be caused by exudation of mineralized solutions from within and deposition by evaporation on the surface.

Rocky. A term used in the phase name of a soil map unit to indicate areas that have between 0.01 and 10 percent rock outcrop.

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.

Saturated hydraulic conductivity (K_{sat}). See Permeability.

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.

Scarp. An escarpment, cliff, or steep slope of some extent along the margin of a plateau, mesa, terrace, or structural bench. A scarp may be of any height.

Scarp slope. The relatively steeper face of a cuesta, facing in a direction opposite to the dip of the strata.

Scoria (soil science). Vesicular rock fragments that are more than 2 millimeters in size in at least one dimension and have a specific gravity of more than 2.0, or a cindery crust of such material on the surface of andesitic or basaltic lava. The vesicular nature is due to the escape of volcanic gases before solidification. It is typically heavier, darker, and more crystalline than pumice.

Scoria (geology). Vesicular rock fragments that have a specific gravity of more than 2.0 or a cindery crust of such material on the surface of andesitic or basaltic lava. There are no size restrictions. The vesicular nature is due to the escape of volcanic gases before solidification. It is typically heavier, darker, and more crystalline than pumice.

Scree. A collective term for an accumulation of coarse rock debris or a sheet of coarse debris mantling a slope. Scree is not synonymous with talus as scree includes loose, coarse fragments on slopes without cliffs.

Scree slope. A portion of a hillside or mountain slope mantled by scree and lacking an up-slope rockfall source (i.e., cliff). Compare to scree and talus.

Sedimentary rock. A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

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 that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

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 convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell (in tables). 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.

Side slope (geomorphology). A geomorphic component of hills consisting of the laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

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. An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Slickensides (pedogenic). Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slick rock. A barren, highly smoothed and subrounded bedrock pavement with considerable, irregular topography sculpted primarily by wind in an arid climate; a type of rock outcrop common on the top of massive sandstone bedrock (e.g., the Navajo, Windgate, and Kayenta Formations), especially on summits of ridges and near the leading edge of plateaus, mesas, and cuestas.

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.

Slope alluvium. Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Sodic (alkali) soil. A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodium adsorption ratio (SAR). A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

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 and by the passage 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.

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.

Stream terrace. One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

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."

Talus. Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terrace (geomorphology). A step-like surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

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.”

Toeslope. 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.

Tread. The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff. A generic term for any consolidated or cemented deposit that is 50 percent volcanic ash (less than 2 millimeters in size). Various types of tuff are distinguished by composition: acidic tuff is predominantly composed of acidic particles and basic tuff is predominantly composed of basic particles.

Upland. An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace.

Volcanic breccia. A volcaniclastic rock composed mostly of angular rock fragments larger than 2 millimeters. This term is not synonymous with pyroclastic breccia as volcanic breccia forms in different ways.

Volcanic cone. A conical hill of lava and/or pyroclastics that is built up around a volcanic vent.

Volcanic dome. A steep-sided, rounded extrusion of highly viscous lava squeezed out from a volcano and forming a dome-shaped or bulbous mass of congealed lava above and around the volcanic vent.

Volcanic field. A more or less well defined area that is covered with volcanic rocks of much more diverse lithology and distribution than a lava field or that is so modified by age and erosion that its original topographic configuration, composition, and extent are uncertain.

Volcaniclastic. Pertaining to the entire spectrum of fragmental materials with a preponderance of clasts of volcanic origin. The term includes not only pyroclastic materials but also epiclastic deposits derived from volcanic source areas by normal processes of mass movement and stream erosion. Examples are welded tuff and volcanic breccia.

Weathering. All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth’s surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered 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.

Tables

Table 1.—Temperature and Precipitation

(Recorded in the period 1910-2013 at Walnut Canyon National Monument, Arizona)

Month	Temperature (degrees C)						Precipitation (centimeters)				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 may have: Maximum higher than--	2 years in 10 may have: Minimum lower than--	Average number of growing degree days*	Average	2 years in 10 may have: Less than--	2 years in 10 may have: More than--	Average number of days with 0.254 inch or more	Average snow-fall
January--	7.3	-7.2	0.1	16	-20	0	4.24	0.91	7.95	4	27.9
February-	8.2	-5.7	1.3	18	-18	0	3.89	0.97	6.22	4	27.4
March----	13.3	-2.3	5.5	22	-12	13	4.29	1.19	6.96	4	29.0
April----	16.6	0.4	8.5	26	-6	49	2.51	0.74	3.91	3	10.4
May------	22.3	5.1	13.7	32	-4	239	1.60	0.18	2.44	2	1.5
June-----	27.9	9.4	18.7	35	2	468	1.07	0.00	1.37	1	0.0
July-----	30.6	13.9	22.2	37	8	683	6.07	3.18	8.69	6	0.0
August---	28.0	12.5	20.2	33	7	572	7.01	2.95	9.32	6	0.0
September	25.4	7.8	16.6	32	0	358	4.37	0.97	7.67	4	0.0
October--	19.2	1.1	10.2	27	-6	87	3.33	0.81	5.11	3	3.0
November-	12.9	-2.8	5.1	23	-12	10	3.26	1.04	4.75	3	11.2
December-	7.2	-7.1	0.1	18	-18	0	4.27	1.07	8.43	3	28.2
Yearly:											
Average-	18.3	2.1	10.6	---	---	---	---				
Extreme-	---	---	---	37	-21	---	---				
Total---	---	---	---	---	---	2,479	46.20	37.97	56.95	43	162.1

* A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (10 degrees C).

Table 2.—Freeze Dates in Spring and Fall

(Recorded in the period 1969-2013 at Walnut Canyon National Monument, Arizona)

Probability	Temperature (degrees C)		
	-4 or lower	-2 or lower	0 or lower
Last freezing temperature in spring:			
1 year in 10 later than--	May 4	May 12	June 1
2 years in 10 later than--	May 3	May 11	May 30
5 years in 10 later than--	Apr. 20	May 4	May 25
First freezing temperature in fall:			
1 year in 10 earlier than--	Nov. 19	Nov. 12	Oct. 29
2 years in 10 earlier than--	Oct. 26	Oct. 8	Sept. 23
5 years in 10 earlier than--	Oct. 30	Oct. 12	Oct. 6

Table 3.—Growing Season

(Recorded in the period 1969-2013 at Walnut Canyon National Monument, Arizona)

Probability	Daily minimum temperature during growing season (degrees C)		
	-4 or higher	-2 or higher	0 or higher
	Days	Days	Days
9 years in 10	240	224	205
8 years in 10	179	153	124
5 years in 10	194	166	132
2 years in 10	213	179	155
1 year in 10	175	300	167

Table 4.—Soil Legend

Map unit symbol and map unit name	Components in map unit	Percent of map unit
31:		
Chilson-Wilcoxson complex, 2 to 8 percent slopes, very rocky	Chilson	55
	Wilcoxson	40
32:		
Cosnino-Rock outcrop complex, 5 to 25 percent slopes	Cosnino	80
	Rock outcrop	20
33:		
Cosnino-Rock outcrop complex, 25 to 70 percent slopes	Cosnino	50
	Rock outcrop	40
34:		
Kydestea-Rock outcrop complex, 3 to 25 percent slopes	Kydestea	80
	Rock outcrop	20
35:		
Lithic Ustorthents-Rock outcrop complex, 25 to 70 percent slopes	Lithic Ustorthents	70
	Rock outcrop	30
36:		
Oxyaquic Ustifluvents, 2 to 6 percent slopes	Oxyaquic Ustifluvents	85
37:		
Rock outcrop-Kydestea complex, 25 to 60 percent slopes	Rock outcrop	50
	Kydestea	40
38:		
Whiskey loam, 2 to 8 percent slopes	Whiskey	90
39:		
Vosburg sandy loam, 1 to 5 percent slopes	Vosburg	100

Table 5.—Acres, Hectares, and Proportionate Extent of the Map Units

Map symbol	Map unit name	Acres	Hectares	Percent
31	Chilson-Wilcoxson complex, 2 to 8 percent slopes, very rocky	769	311	21.6
32	Cosnino-Rock outcrop complex, 5 to 25 percent slopes	866	351	24.3
33	Cosnino-Rock outcrop complex, 25 to 70 percent slopes	390	158	10.9
34	Kydestea-Rock outcrop complex, 3 to 25 percent slopes	318	129	8.9
35	Lithic Ustorthents-Rock outcrop complex, 25 to 70 percent slopes	740	300	20.8
36	Oxyaquic Ustifluvents, 2 to 6 percent slopes	94	38	2.6
37	Rock outcrop-Kydestea complex, 25 to 60 percent slopes	322	130	9.0
38	Whiskey loam, 2 to 8 percent slopes	51	21	1.4
39	Vosburg sandy loam, 1 to 5 percent slopes	15	6	0.4
	Total	3,566	1,444	100

Table 6.—Component, Map Unit Symbol, and Ecosite ID

(This report displays major components and their associated map units and ecosite IDs)

Component name	Map unit symbol	Component kind	Ecosite ID
Chilson	31	series	F039XA139AZ
Cosnino	32	series	F039XA139AZ
	33	series	F039XA139AZ
Kydestea	34	series	R035XG723AZ
	37	series	R035XG723AZ
Lithic Ustorthents	35	taxon above family	F039XA139AZ
Oxyaquic Ustifluvents	36	taxon above family	R039XA140AZ
Vosburg	39	series	R035XG724AZ
Whiskey	38	series	R035XG724AZ
Wilcoxson	31	series	F039XA139AZ

Table 7.—Ecological Site-Soil Correlation

(Only soils and miscellaneous land types with correlated ecological sites are shown)

Map unit symbol, soil component name, and and percent of map unit	Ecological site name	Ecological site type	Ecological site ID
31:			
55%-Chilson	Limestone/Sandstone Upland 18-22″ p.z.	Forestland	F039XA139AZ
40%-Wilcoxson	Limestone/Sandstone Upland 18-22″ p.z.	Forestland	F039XA139AZ
32:			
80%-Cosnino	Limestone/Sandstone Upland 18-22″ p.z.	Forestland	F039XA139AZ
33:			
50%-Cosnino	Limestone/Sandstone Upland 18-22″ p.z.	Forestland	F039XA139AZ
34:			
80%-Kydestea	Limestone/Sandstone Upland (Pinyon-Juniper) 14-18″ p.z.	Rangeland	R035XG723AZ
35:			
70%-Lithic Ustorthents	Limestone/Sandstone Upland 18-22″ p.z.	Forestland	F039XA139AZ
36:			
85%-Oxyaquic Ustifluvents	Canyon Bottom (Riparian) 18-22″ p.z.	Rangeland	R039XA140AZ
37:			
40%-Kydestea	Limestone/Sandstone Upland (Pinyon-Juniper) 14-18″ p.z.	Rangeland	R035XG723AZ
38:			
90%-Whiskey	Semi-Riparian Canyon Bottom 14-18″ p.z.	Rangeland	R035XG724AZ
39:			
100%-Vosburg	Semi-Riparian Canyon Bottom 14-18″ p.z.	Rangeland	R035XG724AZ

Table 8.—Climate, Landscape, Landform, Parent Material, and Ecological Site

(Miscellaneous nonsoil components are not displayed in this report. Component percents may not add up to 100. MAP is the mean annual precipitation)

Map unit symbol and soil name	Percent of map unit	Slope	Elevation	MAP	Landscape	Landform	Parent material	Ecological site name and number
		Pct	Ft	In				
1:								
Chilson	55	2-8	6000-7500	18-22	Canyonlands	Structural bench	Colluvium and/or residuum weathered from limestone	Limestone/Sandstone Upland 18-22″ p.z., F039XA139AZ
Wilcoxson	40	2-8	6000-7500	18-22	Canyonlands	Structural bench	Colluvium and/or residuum weathered from limestone	Limestone/Sandstone Upland 18-22″ p.z., F039XA139AZ
32:								
Cosnino	80	5-25	6000-7500	18-22	Canyonlands	Canyon rim	Colluvium and/or residuum weathered from limestone	Limestone/Sandstone Upland 18-22″ p.z., F039XA139AZ
33:								
Cosnino	50	25-70	5998-7500	18-22	Canyonlands	Canyon wall	Colluvium and/or residuum weathered from limestone	Limestone/Sandstone Upland 18-22″ p.z., F039XA139AZ
34:								
Kydestea	80	3-25	6000-7000	14-18	Canyonlands	Canyon rim	Colluvium and/or residuum weathered from limestone	Limestone/Sandstone Upland (Pinyon-Juniper) 14-18″ p.z., R035XG723AZ
35:								
Lithic Ustorthents	70	25-70	6000-7500	18-22	Canyonlands	Canyon wall	Colluvium and/or residuum weathered from limestone	Limestone/Sandstone Upland 18-22″ p.z., F039XA139AZ
36:								
Oxyaquic Ustifluvents	85	2-6	5500-7000	18-22	Canyonlands	Flood-plain step	Alluvium derived from limestone, sandstone, and shale	Canyon Bottom (Riparian) 18-22″ p.z., R039XA140AZ
37:								
Kydestea	40	25-50	6293-6601	14-18	Canyonlands	Canyon wall	Colluvium derived from limestone and/or residuum weathered from limestone	Limestone/Sandstone Upland (Pinyon-Juniper) 14-18″ p.z., R035XG723AZ

Table 8.—Climate, Landscape, Landform, Parent Material, and Ecological Site—Continued

Map unit symbol and soil name	Percent of map unit	Slope	Elevation	MAP	Landscape	Landform	Parent material	Ecological site name and number
		Pct	Ft	In				
38:								
Whiskey------------	90	2-8	6204-6266	14-18	Canyonlands	Stream terrace	Alluvium derived from limestone, sandstone, and shale	Semi-Riparian Canyon Bottom 14-18″ p.z., R035XG724AZ
39:								
Vosburg------------	100	1-5	5500-7000	14-18	Canyonlands	Terrace	Alluvium derived from limestone, sandstone, and shale	Semi-Riparian Canyon Bottom 14-18″ p.z., R035XG724AZ

Table 9.—Rangeland and Forest Understory Productivity with Existing Plant Communities

(Absence of a composition percent indicates trace amounts of that species)

Map symbol and soil name	Ecological site name and ID	Total production: Kind of year	Total production: Dry weight	Existing vegetation	Composition: Forest	Composition: Range
			Lb/acre		Pct	Pct
31:						
Chilson	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	Favorable	800	ponderosa pine	30	
		Normal	623	Gambel oak	20	
		Unfavorable	450	alligator juniper	10	
				Forb, annual	10	
				blue grama	5	
				Canadian wildrye	5	
				muttongrass	5	
				Rocky Mountain juniper	5	
				Utah juniper	5	
				buckwheat		
				Junegrass		
				squirreltail		
Wilcoxson	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	Favorable	350	ponderosa pine	30	
		Normal	219	Gambel oak	20	
		Unfavorable	100	alligator juniper	10	
				Forb, annual	10	
				blue grama	5	
				Canadian wildrye	5	
				muttongrass	5	
				Rocky Mountain juniper	5	
				Utah juniper	5	
				buckwheat		
				Junegrass		
				squirreltail		
32:						
Cosnino	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	Favorable	500	blue grama	35	
		Normal	345	Forb, annual	17	
		Unfavorable	200	twoneedle pinyon	12	
				needle and thread	10	
				western wheatgrass	6	
				alligator juniper	5	
				alderleaf mountain mahogany	2	
				cliffrose	2	
				Gambel oak	2	
				broom snakeweed	1	
				Canadian wildrye	1	
				Louisiana sagewort	1	
				other shrubs	1	
				penstemon	1	
				ponderosa pine	1	
				Rocky Mountain juniper	1	
				squirreltail	1	
				Utah juniper	1	
				cactus		
33:						
Cosnino	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	Favorable	850	Douglas fir	40	
		Normal	602	ponderosa pine	30	
		Unfavorable	400	Gambel oak	20	

Table 9.—Rangeland and Forest Understory Productivity with Existing Plant Communities—Continued

Map symbol and soil name	Ecological site name and ID	Total production: Kind of year	Total production: Dry weight	Existing vegetation	Composition: Forest	Composition: Range
			Lb/acre		Pct	Pct
34:						
Kydestea-------	Limestone/Sandstone Upland (Pinyon-Juniper 14-18″ p.z. (R035XG723AZ)	Favorable	200	blue grama		30
		Normal	97	oneseed juniper		30
		Unfavorable	50	cliffrose		10
				Fremont’s mahonia		10
				twoneedle pinyon		10
				broom snakeweed		5
				Utah juniper		5
				fernbush		
35:						
Lithic Ustorthents---	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	Favorable	1,250	twoneedle pinyon	30	
		Normal	1,164	Rocky Mountain juniper	20	
		Unfavorable	800	blue grama	10	
				other shrubs	10	
				Utah juniper	10	
				mountain mahogany	5	
				muttongrass	5	
				squirreltail	5	
				banana yucca		
				broom snakeweed		
				fleabane		
				Indian paintbrush		
36:						
Oxyaquic Ustifluvents--	Canyon Bottom (Riparian) 18-22″ p.z. (R039XA140AZ)	Favorable	800	canyon grape		30
		Normal	436	New Mexico locust		15
		Unfavorable	300	Woods’ rose		15
				snowberry		10
				western white clematis		10
				boxelder		5
				chokecherry		5
				redosier dogwood		5
				sideoats grama		5
				yarrow		
37:						
Kydestea-------	Limestone/Sandstone Upland (Pinyon-Juniper) 14-18″ p.z. (R035XG723AZ)	Favorable	1,300	cliffrose		40
		Normal	1,171	blue grama		20
		Unfavorable	800	muttongrass		20
				oneseed juniper		10
				twoneedle pinyon		10
38:						
Whiskey--------	Semi-Riparian Canyon Bottom 14-18″ p.z. (R035XG724AZ)	Favorable	1,250	blue grama		20
		Normal	976	rubber rabbitbrush		15
		Unfavorable	700	oneseed juniper		10
				cottonwood		5
				ponderosa pine		5
				twoneedle pinyon		5
				winterfat		5
				aster		
				sand dropseed		
				western wheatgrass		

Table 9.—Rangeland and Forest Understory Productivity with Existing Plant Communities—Continued

Map symbol and soil name	Ecological site name and ID	Total production: Kind of year	Total production: Dry weight	Existing vegetation	Composition: Forest	Composition: Range
			Lb/acre		Pct	Pct
39:						
Vosburg--------	Semi-Riparian Canyon Bottom 14-18” p.z. (R035XG724AZ)	Favorable	1,500	blue grama		40
		Normal	1,216	rabbitbrush		20
		Unfavorable	725	western wheatgrass		20
				winterfat		10
				fleabane		5
				globemallow		5

Table 10.—Canopy Cover

(This report gives the canopy cover for the plant species associated with the map unit soil components. Only soils and miscellaneous land types with correlated ecological sites are shown. Canopy cover is determined by crown perimeter-vertical projection by species. Because this cover can overlap in layers by species, total cover can be greater than 100 percent. Plants listed with no percent canopy cover are less than 1 percent cover)

Map unit symbol, soil name, and percent of map unit	Ecological site	Characteristic vegetation	Canopy cover
			Pct
31:			
Chilson - 55%	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	ponderosa pine	16
		blue grama	12
		Utah juniper	12
		hairy grama	5
		Gambel oak	3
		Canadian wildrye	2
		Junegrass	2
		muttongrass	2
Wilcoxson - 40%	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	ponderosa pine	20
		mutton bluegrass	4
		alligator juniper	2
		blue grama	2
		Canadian wildrye	2
32:			
Cosnino - 80%	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	ponderosa pine	42
		blue grama	40
		bottlebrush squirreltail	4
		needleandthread	4
		twoneedle pinyon	4
33:			
Cosnino - 50%	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	ponderosa pine	14
		Gambel oak	12
		Douglas fir	10
34:			
Kydestea - 80%	Limestone/Sandstone Upland (Pinyon-Juniper) 14-18″ p.z. (R035XG723AZ)	oneseed juniper	16
		twoneedle pinyon	16
		broom snakeweed	8
		blue grama	6
		bottlebrush squirreltail	2
		cliffrose	2
		fernbush	2
		threeawn	2
35:			
Lithic Ustorthents - 70%	Limestone/Sandstone Upland 18-22″ p.z. (F039XA139AZ)	twoneedle pinyon	16
		Utah juniper	14
		muttongrass	6
		blue grama	2
		bottlebrush squirreltail	2
		broom snakeweed	2
36:			
Oxyaquic Ustifluvents - 85%	Canyon Bottom (Riparian) 18-22″ p.z. (R039XA140AZ)	redosier dogwood	28
		Woods’ rose	16
		canyon grape	12
		New Mexico locust	12
		snowberry	8

Table 10.—Canopy Cover—Continued

Map unit symbol, soil name, and percent of map unit	Ecological site	Characteristic vegetation	Canopy cover
			Pct
37:			
Kydestea - 40%	Limestone/Sandstone Upland (Pinyon-Juniper) 14-18″ p.z. (R035XG723AZ)	oneseed juniper	16
		twoneedle pinyon	16
		broom snakeweed	8
		blue grama	6
		bottlebrush squirreltail	2
		cliffrose	2
		fernbush	2
		threeawn	2
38:			
Whiskey - 90%	Semi-Riparian Canyon Bottom 14-18″ p.z. (R035XG724AZ)	blue grama	42
		oneseed juniper	20
		rabbitbrush	4
39:			
Vosburg - 100%	Semi-Riparian Canyon Bottom 14-18″ p.z. (R035XG724AZ)	blue grama	28
		Canada wildrye	22
		rabbitbrush	12
		western wheatgrass	4

Table 11.—Index of Common and Scientific Plant Names and Plant Symbols
Sorted by Common Name

(Plants displayed occur within the National Soils Information System (NASIS) plant tables used for the soil survey area. The scientific and common names are referenced at the USDA PLANTS database: plants.usda.gov)

Local common name	Scientific name	Plant symbol
alderleaf mountain mahogany	Cercocarpus montanus	CEMO2
alligator juniper	Juniperus deppeana	JUDE2
aster	Aster	ASTER
banana yucca	Yucca baccata	YUBA
blue grama	Bouteloua gracilis	BOGR2
boxelder	Acer negundo	ACNE2
broom snakeweed	Gutierrezia sarothrae	GUSA2
buckwheat	Eriogonum	ERIOG
cactus	Opuntia	OPUNT
Canadian wildrye	x Elyleymus hirtiflorus	ELHI4
canyon grape	Vitis arizonica	VIAR2
chokecherry	Prunus virginiana	PRVI
cliffrose	Cowania mexicana var. stansburiana	COMES
cottonwood	Populus	POPUL
Douglas fir	Pseudotsuga menziesii	PSME
fernbush	Chamaebatiaria millefolium	CHMI2
fleabane	Erigeron	ERIGE2
Forb, annual		2FA
Fremont’s mahonia	Mahonia fremontii	MAFR3
Gambel oak	Quercus gambelii	QUGA
globemallow	Sphaeralcea	SPHAE
Indian paintbrush	Castilleja	CASTI2
Junegrass	Koeleria	KOELE
Louisiana sagewort	Artemisia ludoviciana	ARLU
mountain mahogany	Cercocarpus	CERCO
muttongrass	Poa fendleriana	POFE
needle and thread	Hesperostipa comata	HECO26
New Mexico locust	Robinia neomexicana	RONE
oneseed juniper	Juniperus monosperma	JUMO
other shrubs		2SHRUB
penstemon	Penstemon	PENST
ponderosa pine	Pinus ponderosa	PIPO
rabbitbrush	Chrysothamnus	CHRYS9
redosier dogwood	Cornus sericea	COSE16
Rocky Mountain juniper	Juniperus scopulorum	JUSC2
rubber rabbitbrush	Ericameria nauseosa	ERNA10
sand dropseed	Sporobolus cryptandrus	SPCR
sideoats grama	Bouteloua curtipendula	BOCU
snowberry	Symphoricarpos	SYMPH
squirreltail	Elymus elymoides	ELEL5
twoneedle pinyon	Pinus edulis	PIED
Utah juniper	Juniperus osteosperma	JUOS
western wheatgrass	Pascopyrum smithii	PASM
western white clematis	Clematis ligusticifolia	CLLI2
winterfat	Krascheninnikovia lanata	KRLA2
Woods’ rose	Rosa woodsii	ROWO
yarrow	Achillea	ACHIL

Table 12.—Index of Common and Scientific Plant Names and Plant Symbols
Sorted by Plant Symbol

(Plants displayed occur within the National Soils Information System (NASIS) plant tables used for the soil survey area. The scientific and common names are referenced at the USDA PLANTS database: plants.usda.gov)

Local common name	Scientific name	Plant symbol
Forb, annual		2FA
other shrubs		2SHRUB
yarrow	Achillea	ACHIL
boxelder	Acer negundo	ACNE2
Louisiana sagewort	Artemisia ludoviciana	ARLU
aster	Aster	ASTER
sideoats grama	Bouteloua curtipendula	BOCU
blue grama	Bouteloua gracilis	BOGR2
Indian paintbrush	Castilleja	CASTI2
alderleaf mountain mahogany	Cercocarpus montanus	CEMO2
mountain mahogany	Cercocarpus	CERCO
fernbush	Chamaebatiaria millefolium	CHMI2
rabbitbrush	Chrysothamnus	CHRYS9
western white clematis	Clematis ligusticifolia	CLLI2
cliffrose	Cowania mexicana var. stansburiana	COMES
redosier dogwood	Cornus sericea	COSE16
squirreltail	Elymus elymoides	ELEL5
Canadian wildrye	x Elyleymus hirtiflorus	ELHI4
fleabane	Erigeron	ERIGE2
buckwheat	Eriogonum	ERIOG
rubber rabbitbrush	Ericameria nauseosa	ERNA10
broom snakeweed	Gutierrezia sarothrae	GUSA2
needle and thread	Hesperostipa comata	HECO26
alligator juniper	Juniperus deppeana	JUDE2
oneseed juniper	Juniperus monosperma	JUMO
Utah juniper	Juniperus osteosperma	JUOS
Rocky Mountain juniper	Juniperus scopulorum	JUSC2
Junegrass	Koeleria	KOELE
winterfat	Krascheninnikovia lanata	KRLA2
Fremont’s mahonia	Mahonia fremontii	MAFR3
cactus	Opuntia	OPUNT
western wheatgrass	Pascopyrum smithii	PASM
penstemon	Penstemon	PENST
twoneedle pinyon	Pinus edulis	PIED
ponderosa pine	Pinus ponderosa	PIPO
muttongrass	Poa fendleriana	POFE
cottonwood	Populus	POPUL
chokecherry	Prunus virginiana	PRVI
Douglas fir	Pseudotsuga menziesii	PSME
Gambel oak	Quercus gambelii	QUGA
New Mexico locust	Robinia neomexicana	RONE
Woods’ rose	Rosa woodsii	ROWO
sand dropseed	Sporobolus cryptandrus	SPCR
globemallow	Sphaeralcea	SPHAE
snowberry	Symphoricarpos	SYMPH
canyon grape	Vitis arizonica	VIAR2
banana yucca	Yucca baccata	YUBA

Table 13.—Land Capability Classification

(Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. Only the soils suitable for cultivation are listed. The classification is for nonirrigated areas)

Map unit symbol and component name	Land capability
31:	
Chilson	5c
Wilcoxson	5c
32:	
Cosnino	5c
33:	
Cosnino	8c
34:	
Kydestea	8c
35:	
Lithic Ustorthents	8c
36:	
Oxyaquic Ustifluvents	5c
37:	
Kydestea	6c
38:	
Whiskey	6c
39:	
Vosburg	6c

Table 14.—Land Management, Part I (Planting and Harvesting)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and component name	Pct. of map unit	Suitability for hand planting		Suitability for mechanical planting		Suitability for use of harvesting equipment	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
31:							
Chilson	55	Moderately suited		Poorly suited		Moderately suited	
		Stickiness; high plasticity index	0.50	Rock fragments	0.75	Low strength	0.50
		Rock fragments	0.50	Stickiness; high plasticity index	0.50	Dusty	0.08
Wilcoxson	40	Moderately suited		Poorly suited		Moderately suited	
		Stickiness; high plasticity index	0.50	Rock fragments	0.75	Low strength	0.50
		Rock fragments	0.50	Stickiness; high plasticity index	0.50	Dusty	0.05
32:							
Cosnino	80	Unsuited		Unsuited		Well suited	
		Restrictive layer	1.00	Restrictive layer	1.00	Dusty	0.01
		Rock fragments	0.50	Rock fragments	0.75		
				Slope	0.50		
Rock outcrop	20	Not rated		Not rated		Not rated	
33:							
Cosnino	50	Moderately suited		Unsuited		Poorly suited	
		Rock fragments	0.50	Slope	1.00	Slope	1.00
		Slope	0.50	Rock fragments	0.75	Rock fragments	0.50
						Dusty	0.01
Rock outcrop	40	Not rated		Not rated		Not rated	
34:							
Kydestea	80	Unsuited		Unsuited		Moderately suited	
		Restrictive layer	1.00	Restrictive layer	1.00	Slope	0.50
		Rock fragments	0.50	Rock fragments	0.75	Dusty	0.22
				Slope	0.75		
Rock outcrop	20	Not rated		Not rated		Not rated	
35:							
Lithic Ustorthents	70	Unsuited		Unsuited		Poorly suited	
		Restrictive layer	1.00	Slope	1.00	Slope	1.00
		Rock fragments	0.75	Rock fragments	1.00	Rock fragments	0.50
		Slope	0.50	Restrictive layer	1.00	Dusty	0.02
Rock outcrop	30	Not rated		Not rated		Not rated	
36:							
Oxyaquic Ustifluvents	85	Moderately suited		Poorly suited		Moderately suited	
		Rock fragments	0.50	Rock fragments	0.75	Sandiness	0.50
		Sandiness	0.50	Sandiness	0.50	Rock fragments	0.50

Table 14.—Land Management, Part I (Planting and Harvesting)—Continued

Map unit symbol and component name	Pct. of map unit	Suitability for hand planting: Rating class and limiting features	Value	Suitability for mechanical planting: Rating class and limiting features	Value	Suitability for use of harvesting equipment: Rating class and limiting features	Value
37:							
Rock outcrop	50	Not rated		Not rated		Not rated	
Kydestea	40	Poorly suited		Unsuited		Moderately suited	
		Rock fragments	0.75	Slope	1.00	Slope	0.50
		Slope	0.50	Rock fragments	1.00	Rock fragments	0.50
						Dusty	0.20
38:							
Whiskey	90	Well suited		Moderately suited		Moderately suited	
				Slope	0.50	Low strength	0.50
						Dusty	0.15
39:							
Vosburg	100	Well suited		Well suited		Well suited	
						Dusty	0.03

Table 14.—Land Management, Part II (Hazard of Erosion and Suitability for Roads)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and component name	Pct. of map unit	Hazard of erosion: Rating class and limiting features	Hazard of erosion: Value	Hazard of erosion on roads and trails: Rating class and limiting features	Hazard of erosion on roads and trails: Value	Suitability for roads (natural surface): Rating class and limiting features	Suitability for roads (natural surface): Value
31:							
Chilson-------------	55	Slight		Moderate		Moderately suited	
				Slope/erodibility	0.50	Low strength	0.50
						Dusty	0.08
Wilcoxson-----------	40	Slight		Moderate		Moderately suited	
				Slope/erodibility	0.50	Low strength	0.50
						Dusty	0.05
32:							
Cosnino-------------	80	Slight		Moderate		Moderately suited	
				Slope/erodibility	0.50	Slope	0.50
						Dusty	0.01
Rock outcrop--------	20	Not rated		Not rated		Not rated	
33:							
Cosnino-------------	50	Very severe		Severe		Poorly suited	
		Slope/erodibility	0.95	Slope/erodibility	0.95	Slope	1.00
						Rock fragments	0.50
						Dusty	0.01
Rock outcrop--------	40	Not rated		Not rated		Not rated	
34:							
Kydestea------------	80	Moderate		Severe		Poorly suited	
		Slope/erodibility	0.50	Slope/erodibility	0.95	Slope	1.00
						Dusty	0.22
Rock outcrop--------	20	Not rated		Not rated		Not rated	
35:							
Lithic Ustorthents--	70	Severe		Severe		Poorly suited	
		Slope/erodibility	0.75	Slope/erodibility	0.95	Slope	1.00
						Rock fragments	0.50
						Dusty	0.02
Rock outcrop--------	30	Not rated		Not rated		Not rated	
36:							
Oxyaquic Ustifluvents-------	85	Slight		Slight		Moderately suited	
						Sandiness	0.50
						Flooding	0.50
						Rock fragments	0.50
37:							
Rock outcrop--------	50	Not rated		Not rated		Not rated	
Kydestea------------	40	Moderate		Severe		Poorly suited	
		Slope/erodibility	0.50	Slope/erodibility	0.95	Slope	1.00
						Rock fragments	0.50
						Dusty	0.20

Table 14.—Land Management, Part II (Hazard of Erosion and Suitability for Roads)—Continued

Map unit symbol and component name	Pct. of map unit	Hazard of erosion: Rating class and limiting features	Hazard of erosion: Value	Hazard of erosion on roads and trails: Rating class and limiting features	Hazard of erosion on roads and trails: Value	Suitability for roads (natural surface): Rating class and limiting features	Suitability for roads (natural surface): Value
38:							
Whiskey	90	Slight		Moderate		Moderately suited	
				Slope/erodibility	0.50	Low strength	0.50
						Slope	0.50
						Dusty	0.15
39:							
Vosburg	100	Slight		Slight		Well suited	
						Dusty	0.03

Table 14.—Land Management, Part III (Site Preparation)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Suitability for mechanical site preparation (deep): Rating class and limiting features	Value	Suitability for mechanical site preparation (surface): Rating class and limiting features	Value
31:					
Chilson	55	Unsuited		Poorly suited	
		Restrictive layer	1.00	Stickiness; high plasticity index	0.50
Wilcoxson	40	Poorly suited		Well suited	
		Restrictive layer	0.50		
32:					
Cosnino	80	Unsuited		Unsuited	
		Restrictive layer	1.00	Restrictive layer	1.00
				Rock fragments	0.50
33:					
Cosnino	50	Unsuited		Unsuited	
		Restrictive layer	1.00	Slope	1.00
		Slope	1.00	Rock fragments	0.50
34:					
Kydestea	80	Unsuited		Unsuited	
		Restrictive layer	1.00	Restrictive layer	1.00
		Slope	0.50	Slope	0.50
				Rock fragments	0.50
35:					
Lithic Ustorthents	70	Unsuited		Unsuited	
		Restrictive layer	1.00	Slope	1.00
		Slope	1.00	Restrictive layer	1.00
				Rock fragments	0.50
36:					
Oxyaquic Ustifluvents	85	Well suited		Poorly suited	
				Rock fragments	0.50
37:					
Kydestea	40	Unsuited		Poorly suited	
		Restrictive layer	1.00	Slope	0.50
		Slope	0.50	Rock fragments	0.50
38:					
Whiskey	90	Well suited		Well suited	
39:					
Vosburg	100	Well suited		Well suited	

Table 14.—Land Management, Part IV (Site Restoration)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Potential for damage to soil by fire: Rating class and limiting features	Value	Potential for seedling mortality: Rating class and limiting features	Value
31:					
Chilson	55	Low		High	
				Available water	1.00
Wilcoxson	40	Low		Moderate	
				Available water	0.50
32:					
Cosnino	80	Low		High	
				Available water	1.00
33:					
Cosnino	50	Low		Moderate	
				Available water	0.50
34:					
Kydestea	80	Low		Moderate	
				Available water	0.50
				Soil reaction	0.50
35:					
Lithic Ustorthents	70	Low		High	
				Available water	1.00
				Soil reaction	0.50
36:					
Oxyaquic Ustifluvents	85	Moderate		High	
		Texture/rock fragments	0.50	Available water	1.00
37:					
Kydestea	40	Low		Moderate	
				Available water	0.50
38:					
Whiskey	90	Low		Moderate	
				Available water	0.50
39:					
Vosburg	100	Low		Moderate	
				Available water	0.50

Table 15.—Recreation, Part I (Camp and Picnic Areas)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Camp areas: Rating class and limiting features	Camp areas: Value	Picnic areas: Rating class and limiting features	Picnic areas: Value
31:					
Chilson	55	Somewhat limited		Somewhat limited	
		Dusty		Dusty	
Wilcoxson	40	Somewhat limited		Somewhat limited	
		Dusty	0.05	Dusty	0.05
32:					
Cosnino	80	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to bedrock	1.00
		Dusty	0.01	Dusty	0.01
33:					
Cosnino	50	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00
		Large stones content	0.04	Large stones content	0.04
		Dusty	0.01	Dusty	0.01
34:					
Kydestea	80	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to bedrock	1.00
		Slope	1.00	Slope	1.00
		Large stones content	0.23	Large stones content	0.23
		Dusty	0.22	Dusty	0.22
35:					
Lithic Ustorthents	70	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00
		Dusty	0.02	Dusty	0.02
		Large stones content	0.01	Large stones content	0.01
36:					
Oxyaquic Ustifluvents	85	Very limited		Somewhat limited	
		Flooding	1.00	Gravel content	0.97
		Gravel content	0.97	Too sandy	0.36
		Too sandy	0.36	Large stones content	0.05
		Large stones content	0.05		
37:					
Kydestea	40	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00
		Dusty	0.20	Dusty	0.20
		Large stones content	0.16	Large stones content	0.16
		Gravel content	0.01	Gravel content	0.01

Table 15.—Recreation, Part I (Camp and Picnic Areas)—Continued

Map unit symbol and soil name	Pct. of map unit	Camp areas: Rating class and limiting features	Camp areas: Value	Picnic areas: Rating class and limiting features	Picnic areas: Value
38:					
Whiskey	90	Very limited		Somewhat limited	
		Flooding	1.00	Dusty	0.15
		Dusty	0.15		
39:					
Vosburg	100	Very limited		Somewhat limited	
		Flooding	1.00	Dusty	0.03
		Dusty	0.03		

Table 15.—Recreation, Part II (Trail Management)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Foot traffic and equestrian trails: Rating class and limiting features	Value	Mountain bike and off-road vehicle trails: Rating class and limiting features	Value
31:					
Chilson	55	Somewhat limited		Somewhat limited	
		Dusty	0.05	Dusty	0.05
Wilcoxson	40	Somewhat limited		Somewhat limited	
		Dusty	0.05	Dusty	0.05
32:					
Cosnino	80	Somewhat limited		Somewhat limited	
		Dusty	0.01	Dusty	0.01
33:					
Cosnino	50	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Large stones content	0.04	Large stones content	0.04
		Dusty	0.01	Dusty	0.01
34:					
Kydestea	80	Somewhat limited		Somewhat limited	
		Slope	0.68	Large stones content	0.23
		Large stones content	0.23	Dusty	0.22
		Dusty	0.22		
35:					
Lithic Ustorthents	70	Very limited		Somewhat limited	
		Slope	1.00	Slope	0.96
		Dusty	0.02	Dusty	0.02
		Large stones content	0.01	Large stones content	0.01
36:					
Oxyaquic Ustifluvents	85	Somewhat limited		Somewhat limited	
		Too sandy	0.36	Too sandy	0.36
		Large stones content	0.05	Large stones content	0.05
37:					
Kydestea	40	Very limited		Somewhat limited	
		Slope	1.00	Slope	0.78
		Dusty	0.20	Dusty	0.20
		Large stones content	0.16	Large stones content	0.16
38:					
Whiskey	90	Somewhat limited		Somewhat limited	
		Dusty	0.15	Dusty	0.15
39:					
Vosburg	100	Somewhat limited		Somewhat limited	
		Dusty	0.03	Dusty	0.03

Table 16.—Dwellings and Small Commercial Buildings

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and component name	Pct. of map unit	Dwellings without basements		Dwellings with basements		Small commercial buildings	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
31:							
Chilson	55	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
Wilcoxson	40	Somewhat limited		Very limited		Somewhat limited	
		Depth to hard bedrock	0.79	Depth to hard bedrock	1.00	Depth to hard bedrock	0.79
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
32:							
Cosnino	80	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Large stones	0.97	Large stones	0.97	Slope	1.00
						Large stones	0.97
Rock outcrop	20	Not rated		Not rated		Not rated	
33:							
Cosnino	50	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Large stones	0.37	Large stones	0.37	Large stones	0.37
Rock outcrop	40	Not rated		Not rated		Not rated	
34:							
Kydestea	80	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
		Large stones	0.99	Large stones	0.99	Large stones	0.99
Rock outcrop	20	Not rated		Not rated		Not rated	
35:							
Lithic Ustorthents	70	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Large stones	0.96	Large stones	0.96	Large stones	0.96
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
Rock outcrop	30	Not rated		Not rated		Not rated	

Table 16.—Dwellings and Small Commercial Buildings—Continued

Map unit symbol and component name	Pct. of map unit	Dwellings without basements: Rating class and limiting features	Value	Dwellings with basements: Rating class and limiting features	Value	Small commercial buildings: Rating class and limiting features	Value
36:							
Oxyaquic Ustifluvents	85	Very limited		Very limited		Very limited	
		Flooding	1.00	Flooding	1.00	Flooding	1.00
		Large stones	0.50	Depth to saturated zone	0.94	Large stones	0.50
				Large stones	0.50		
37:							
Rock outcrop	50	Not rated		Not rated		Not rated	
Kydestea	40	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Large stones	0.76	Large stones	0.76	Large stones	0.76
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
38:							
Whiskey	90	Very limited		Very limited		Very limited	
		Flooding	1.00	Flooding	1.00	Flooding	1.00
						Slope	0.88
39:							
Vosburg	100	Very limited		Very limited		Very limited	
		Flooding	1.00	Flooding	1.00	Flooding	1.00
		Shrink-swell	0.03	Shrink-swell	0.15	Shrink-swell	0.03

Table 17.—Roads and Streets, Shallow Excavations, and Landscaping

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and component name	Pct. of map unit	Local roads and streets		Shallow excavations		Landscaping	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
31:							
Chilson	55	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to bedrock	1.00
		Low strength	1.00	Dusty	0.08	Droughty	1.00
		Shrink-swell	0.50	Unstable excavation walls	0.01	Dusty	0.08
Wilcoxson	40	Somewhat limited		Very limited		Somewhat limited	
		Depth to hard bedrock	0.79	Depth to hard bedrock	1.00	Depth to bedrock	0.80
		Shrink-swell	0.50	Dusty	0.05	Droughty	0.17
				Unstable excavation walls	0.01	Dusty	0.05
32:							
Cosnino	80	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to bedrock	1.00
		Large stones	0.97	Large stones	0.97	Droughty	1.00
		Frost action	0.50	Unstable excavation walls	0.01	Large stones content	0.79
				Dusty	0.01	Dusty	0.01
Rock outcrop	20	Not rated		Not rated		Not rated	
33:							
Cosnino	50	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to bedrock	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
		Frost action	0.50	Large stones	0.37	Droughty	1.00
		Large stones	0.37	Unstable excavation walls	0.01	Large stones content	1.00
				Dusty	0.01	Dusty	0.01
Rock outcrop	40	Not rated		Not rated		Not rated	
34:							
Kydestea	80	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to bedrock	1.00
		Slope	1.00	Slope	1.00	Droughty	1.00
		Large stones	0.99	Large stones	0.99	Large stones content	1.00
		Frost action	0.50	Dusty	0.22	Slope	1.00
				Unstable excavation walls	0.01	Dusty	0.22
Rock outcrop	20	Not rated		Not rated		Not rated	

Table 17.—Roads and Streets, Shallow Excavations, and Landscaping—Continued

Map unit symbol and component name	Pct. of map unit	Local roads and streets: Rating class and limiting features	Value	Shallow excavations: Rating class and limiting features	Value	Landscaping: Rating class and limiting features	Value
35:							
Lithic Ustorthents--	70	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to bedrock	1.00
						Slope	1.00
		Slope	1.00	Slope	1.00	Droughty	1.00
		Large stones	0.96	Large stones	0.96	Large stones content	1.00
		Frost action	0.50	Dusty	0.02		
		Shrink-swell	0.50	Unstable excavation walls	0.01	Dusty	0.02
Rock outcrop--------	30	Not rated		Not rated		Not rated	
36:							
Oxyaquic Ustifluvents-------	85	Very limited		Somewhat limited		Very limited	
		Flooding	1.00	Depth to saturated zone	0.94	Droughty	1.00
		Large stones	0.50	Flooding	0.60	Large stones content	1.00
				Large stones	0.50	Gravel content	0.97
				Unstable excavation walls	0.02	Flooding	0.60
37:							
Rock outcrop--------	50	Not rated		Not rated		Not rated	
Kydestea------------	40	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to bedrock	1.00
						Slope	1.00
		Slope	1.00	Slope	1.00	Droughty	1.00
		Large stones	0.76	Large stones	0.76	Large stones content	1.00
		Frost action	0.50	Dusty	0.20		
		Shrink-swell	0.50	Unstable excavation walls	0.01	Dusty	0.20
38:							
Whiskey-------------	90	Somewhat limited		Somewhat limited		Somewhat limited	
		Frost action	0.50	Dusty	0.15	Dusty	0.15
		Flooding	0.40	Unstable excavation walls	0.01		
39:							
Vosburg-------------	100	Somewhat limited		Somewhat limited		Somewhat limited	
		Low strength	0.78	Dusty	0.03	Dusty	0.03
		Frost action	0.50	Unstable excavation walls	0.01		
		Flooding	0.40				
		Shrink-swell	0.03				

Table 18.—Sewage Disposal

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and component name	Pct. of map unit	Septic tank absorption fields: Rating class and limiting features	Value	Sewage lagoons: Rating class and limiting features	Value
31:					
Chilson	55	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
				Slope	0.32
Wilcoxson	40	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slow water movement	1.00	Slope	0.08
32:					
Cosnino	80	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Seepage, bottom layer	1.00	Slope	1.00
		Large stones	0.97	Large stones	1.00
Rock outcrop	20	Not rated		Not rated	
33:					
Cosnino	50	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Slope	1.00
		Seepage, bottom layer	1.00	Seepage	1.00
		Large stones	0.37	Large stones	1.00
Rock outcrop	40	Not rated		Not rated	
34:					
Kydestea	80	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Large stones	1.00
		Large stones	0.99	Slope	1.00
Rock outcrop	20	Not rated		Not rated	
35:					
Lithic Ustorthents	70	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Slope	1.00
		Large stones	0.96	Large stones	1.00
Rock outcrop	30	Not rated		Not rated	

Table 18.—Sewage Disposal—Continued

Map unit symbol and component name	Pct. of map unit	Septic tank absorption fields		Sewage lagoons	
		Rating class and limiting features	Value	Rating class and limiting features	Value
36:					
Oxyaquic Ustifluvents	85	Very limited		Very limited	
		Flooding	1.00	Flooding	1.00
		Depth to saturated zone	1.00	Seepage	1.00
		Seepage, bottom layer	1.00	Depth to saturated zone	1.00
		Large stones	0.50	Large stones	1.00
				Slope	0.08
37:					
Rock outcrop	50	Not rated		Not rated	
Kydestea	40	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Slope	1.00
		Large stones	0.76	Large stones	1.00
			0.76	Seepage	0.50
38:					
Whiskey	90	Somewhat limited		Very limited	
		Slow water movement	0.50	Slope	1.00
		Flooding	0.40	Seepage	0.50
				Flooding	0.40
39:					
Vosburg	100	Somewhat limited		Very limited	
		Slow water movement	0.50	Seepage	1.00
		Flooding	0.40	Flooding	0.40
				Slope	0.08

Table 19.—Source of Gravel and Sand

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The ratings given for the thickest layer are for the thickest layer above and excluding the bottom layer. The numbers in the value columns range from 0.00 to 0.99. The greater the value, the greater the likelihood that the bottom layer or thickest layer of the soil is a source of sand or gravel. See text for further explanation of ratings in this table)

Map unit symbol and component name	Pct. of map unit	Gravel source: Rating class and limiting features	Gravel source: Value	Sand source: Rating class and limiting features	Sand source: Value
31:					
Chilson	55	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Wilcoxson	40	Fair		Poor	
		Thickest layer	0.00	Bottom layer	0.00
		Bottom layer	0.25	Thickest layer	0.00
32:					
Cosnino	80	Poor		Fair	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.09
Rock outcrop	20	Not rated		Not rated	
33:					
Cosnino	50	Poor		Fair	
		Bottom layer	0.00	Bottom layer	0.03
		Thickest layer	0.00	Thickest layer	0.09
Rock outcrop	40	Not rated		Not rated	
34:					
Kydestea	80	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Rock outcrop	20	Not rated		Not rated	
35:					
Lithic Ustorthents	70	Poor		Fair	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.07
Rock outcrop	30	Not rated		Not rated	
36:					
Oxyaquic Ustifluvents	85	Fair		Fair	
		Bottom layer	0.00	Bottom layer	0.03
		Thickest layer	0.13	Thickest layer	0.22
37:					
Rock outcrop	50	Not rated		Not rated	
Kydestea	40	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00

Table 19.—Source of Gravel and Sand—Continued

Map unit symbol and component name	Pct. of map unit	Gravel source: Rating class and limiting features	Gravel source: Value	Sand source: Rating class and limiting features	Sand source: Value
38:					
Whiskey	90	Poor		Fair	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.01
39:					
Vosburg	100	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00

Table 20.—Source of Reclamation Material, Roadfill, and Topsoil

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.00 to 0.99. The smaller the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and component name	Pct. of map unit	Source of reclamation material: Rating class and limiting features	Value	Roadfill source: Rating class and limiting features	Value	Topsoil source: Rating class and limiting features	Value
31:							
Chilson	55	Poor		Poor		Poor	
		Droughty	0.00	Depth to bedrock	0.00	Depth to bedrock	0.00
		Depth to bedrock	0.00	Low strength	0.00	Too clayey	0.15
		Too clayey	0.21	Shrink-swell	0.87	Exchange capacity	0.85
Wilcoxson	40	Fair		Poor		Poor	
		Droughty	0.04	Depth to bedrock	0.00	Rock fragments	0.00
		Depth to bedrock	0.21	Shrink-swell	0.87	Depth to bedrock	0.21
		Low content of organic matter	0.68			Too clayey	0.77
32:							
Cosnino	80	Poor		Poor		Poor	
		Droughty	0.00	Depth to bedrock	0.00	Depth to bedrock	0.00
		Depth to bedrock	0.00	High gypsum content	0.00	Rock fragments	0.05
		Stone content	0.00			Exchange capacity	0.19
				Stones	0.00		
Rock outcrop	20	Not rated		Not rated		Not rated	
33:							
Cosnino	50	Poor		Poor		Poor	
		Stone content	0.00	Depth to bedrock	0.00	Depth to bedrock	0.00
		Droughty	0.00	Slope	0.00	Slope	0.00
		Depth to bedrock	0.00	Stones	0.00	Exchange capacity	0.46
Rock outcrop	40	Not rated		Not rated		Not rated	
34:							
Kydestea	80	Poor		Poor		Poor	
		Stone content	0.00	Depth to bedrock	0.00	Depth to bedrock	0.00
		Droughty	0.00	Stones	0.00	Slope	0.00
		Depth to bedrock	0.00	Slope	0.32	Rock fragments	0.11
Rock outcrop	20	Not rated		Not rated		Not rated	
35:							
Lithic Ustorthents	70	Poor		Poor		Poor	
		Stone content	0.00	Depth to bedrock	0.00	Depth to bedrock	0.00
		Droughty	0.00	Slope	0.00	Slope	0.00
		Depth to bedrock	0.00	Stones	0.00	Rock fragments	0.03
Rock outcrop	30	Not rated		Not rated		Not rated	
36:							
Oxyaquic Ustifluvents	85	Poor		Poor		Poor	
		Too sandy	0.00	Stones	0.00	Rock fragments	0.00
		Droughty	0.00	Cobble content	0.97	Too sandy	0.00
		Stone content	0.00			Exchange capacity	0.24

Table 20.—Source of Reclamation Material, Roadfill, and Topsoil—Continued

Map unit symbol and component name	Pct. of map unit	Source of reclamation material: Rating class and limiting features	Value	Roadfill source: Rating class and limiting features	Value	Topsoil source: Rating class and limiting features	Value
37:							
Rock outcrop	50	Not rated		Not rated		Not rated	
Kydestea	40	Poor		Poor		Poor	
		Droughty	0.00	Depth to bedrock	0.00	Depth to bedrock	0.00
		Depth to bedrock	0.00	Slope	0.00	Slope	0.00
		Low content of organic matter	0.18	Cobble content	0.05	Rock fragments	0.00
38:							
Whiskey	90	Fair		Poor		Good	
		Low content of organic matter	0.18	Low strength	0.00		
		Water erosion	0.90				
39:							
Vosburg	100	Fair		Poor		Good	
		Low content of organic matter	0.18	Low strength	0.00		
				Shrink-swell	0.96		
		Water erosion	0.99				

Table 21.—Ponds and Embankments

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and component name	Pct. of map unit	Pond reservoir areas: Rating class and limiting features	Value	Embankments, dikes, and levees: Rating class and limiting features	Value	Aquifer-fed excavated ponds: Rating class and limiting features	Value
31:							
Chilson	55	Very limited		Very limited		Very limited	
		Depth to bedrock	1.00	Thin layer	1.00	Depth to water	1.00
		Slope	0.08	Hard to pack	0.50		
		Seepage	0.01	Dusty	0.08		
Wilcoxson	40	Somewhat limited		Somewhat limited		Very limited	
		Depth to bedrock	0.95	Thin layer	0.95	Depth to water	1.00
		Seepage	0.03	Dusty	0.05		
32:							
Cosnino	80	Very limited		Very limited		Very limited	
		Depth to bedrock	1.00	Thin layer	1.00	Depth to water	1.00
		Slope	1.00	Large stones	0.97		
				Dusty	0.01		
Rock outcrop	20	Not rated		Not rated		Not rated	
33:							
Cosnino	50	Very limited		Very limited		Very limited	
		Slope	1.00	Thin layer	1.00	Depth to water	1.00
		Depth to bedrock	1.00	Large stones	0.37		
		Seepage	0.01	Dusty	0.01		
Rock outcrop	40	Not rated		Not rated		Not rated	
34:							
Kydestea	80	Very limited		Very limited		Very limited	
		Depth to bedrock	1.00	Thin layer	1.00	Depth to water	1.00
		Slope	1.00	Large stones	0.99		
				Dusty	0.22		
Rock outcrop	20	Not rated		Not rated		Not rated	
35:							
Lithic Ustorthents	70	Very limited		Very limited		Very limited	
		Slope	1.00	Thin layer	1.00	Depth to water	1.00
		Depth to bedrock	1.00	Large stones	0.96		
		Seepage	0.01	Dusty	0.02		
Rock outcrop	30	Not rated		Not rated		Not rated	
36:							
Oxyaquic Ustifluvents	85	Very limited		Very limited		Very limited	
		Seepage	1.00	Seepage	1.00	Unstable excavation walls	1.00
				Large stones	0.50	Large stones	0.50
				Depth to saturated zone	0.37	Depth to saturated zone	0.29

Table 21.—Ponds and Embankments—Continued

Map unit symbol and component name	Pct. of map unit	Pond reservoir areas		Embankments, dikes, and levees		Aquifer-fed excavated ponds	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
37:							
Rock outcrop--------	50	Not rated		Not rated		Not rated	
Kydestea------------	40	Very limited		Very limited		Very limited	
		Slope	1.00	Thin layer	1.00	Depth to water	1.00
		Depth to bedrock	1.00	Large stones	0.76		
				Dusty	0.20		
38:							
Whiskey-------------	90	Somewhat limited		Somewhat limited		Very limited	
		Slope	0.92	Piping	0.50	Depth to water	1.00
		Seepage	0.70	Dusty	0.15		
39:							
Vosburg-------------	100	Very limited		Somewhat limited		Very limited	
		Seepage	1.00	Dusty	0.03	Depth to water	1.00

Table 22.—Engineering Properties

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

Map unit symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >250 mm	Fragments: 70-250 mm	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	Cm				Pct	Pct					Pct	
31:												
Chilson---------	0-3	Moderately decomposed plant material			0	0	100	100	100	100	---	---
	3-10	Loam	CL	A-4	0	0	85-97	84-97	72-87	51-63	25-35	10-15
	10-38	Clay	CH	A-7-6	0	0	84-96	83-96	76-93	61-76	49-55	25-35
	38-63	Bedrock	---	---	---	---	---	---	---	---	---	---
Wilcoxson-------	0-10	Loam	CL	A-6	0	0	85-95	80-95	70-90	50-65	30-35	10-15
	10-23	Sandy clay loam	SC	A-6	0	0	85-95	80-95	70-90	35-50	30-40	10-20
	23-43	Clay loam	CL	A-7-6	0	0	80-95	80-95	70-90	60-70	45-50	25-30
	43-66	Very gravelly sandy clay	GC	A-2-7	0	0	30-50	30-50	25-45	15-30	45-50	25-30
	66-91	Bedrock	---	---	---	---	---	---	---	---	---	---
32:												
Cosnino---------	0-5	Channery sandy loam	SC	A-2-4	0-12	12-31	72-86	72-86	53-68	26-37	25-50	5-15
	5-20	Extremely stony loam, very stony sandy loam	SC-SM	A-2-4	18-50	14-24	53-82	52-81	39-65	19-34	20-30	5-10
	20-45	Bedrock	---	---	---	---	---	---	---	---	---	---
33:												
Cosnino---------	0-5	Slightly decomposed plant material	PT	A-8	0	0	---	---	---	---	---	---
	5-15	Flaggy sandy loam	SC	A-2-4	9-27	11-20	84-95	83-95	62-77	31-41	25-35	5-15
	15-41	Very stony sandy loam, very stony loam	SC	A-2-4	22-39	7-15	79-84	78-84	59-67	30-36	25-30	10-15
	41-66	Bedrock	---	---	---	---	---	---	---	---	---	---
34:												
Kydestea--------	0-8	Very flaggy loam	SC	A-6	4-27	16-30	61-78	60-78	52-73	37-54	30-40	10-15
	8-23	Very stony loam	CL	A-6	24-40	14-24	70-85	69-85	60-79	43-58	30-35	10-15
	23-48	Bedrock	---	---	---	---	---	---	---	---	---	---
35:												
Lithic Ustorthents----	0-10	Flaggy sandy loam	SC	A-2-4	9-27	11-20	84-95	83-95	62-76	31-41	25-35	5-15
	10-28	Very stony sandy loam, very stony sandy clay loam	SC	A-2-6	20-30	20-30	65-90	60-90	50-80	25-45	30-40	10-20
	28-53	Bedrock	---	---	---	---	---	---	---	---	---	---

Table 22.—Engineering Properties—Continued

Map unit symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >250 mm	Fragments: 70-250 mm	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	Cm				Pct	Pct					Pct	
36:												
Oxyaquic Ustifluvents---	0-20	Extremely cobbly loamy sand	GW-GM	A-1-a	6-22	13-27	27-42	24-39	19-32	7-13	0-25	NP-5
	20-94	Extremely stony coarse sand	GP-GM	A-1-a	5-25	5-25	30-65	25-65	10-30	3-10	0-20	NP-3
	94-152	Stony sandy loam, very stony sandy loam	SC	A-1-a	5-25	5-20	50-75	45-75	35-60	20-30	25-30	5-10
37:												
Kydestea--------	0-8	Very flaggy loam	SC	A-2-6	5-33	8-31	62-82	62-82	52-78	36-57	28-41	10-18
	8-43	Very stony sandy loam, very flaggy loam	SC	A-2-6	0-31	9-37	56-87	25-69	20-63	13-45	26-39	10-18
	43-68	Bedrock	---	---	---	---	---	---	---	---	---	---
38:												
Whiskey---------	0-5	Loam	ML	A-6	0	0	84-100	68-100	63-100	43-76	29-45	7-17
	5-38	Fine sandy loam, loam	CL	A-6	0	0	85-100	70-100	63-100	42-74	27-42	7-17
	38-86	Fine sandy loam, loam	CL	A-6	0	0	85-100	70-100	58-97	33-60	27-42	7-17
	86-152	Fine sandy loam, loam	CL	A-6	0	0	84-100	68-100	60-100	40-72	24-38	7-18
39:												
Vosburg---------	0-10	Sandy loam	SC	A-4	0	0	91-100	91-100	68-79	34-41	25-36	5-10
	10-30	Sandy loam	SC	A-4	0	0	90-100	90-100	70-80	35-45	25-37	5-15
	30-53	Loam, sandy loam	SC	A-6	0	0	90-100	90-100	70-80	35-45	25-35	10-15
	53-81	Sandy loam, loam	CL	A-6	0	0	90-100	90-100	80-95	55-70	30-40	10-20
	81-152	Loam	CL	A-6	0	0	90-100	90-100	75-90	55-70	30-40	15-20

Table 23.—Physical Soil Properties

(Sand, silt, and clay values are shown either as a range or as a representative value. Absence of an entry indicates that data were not estimated)

Map unit symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Permeability (Ksat)	Available water capacity	Shrink-swell potential	Organic matter
	In	Pct	Pct	Pct	g/cc	In/hr	In/in	Pct	Pct
31:									
Chilson---------	0-1	0	0	0-0	0.25-0.75	2.3-20.0	0.04-0.08	---	2.0-8.0
	1-4	44	40	14-18	1.25-1.40	0.6-2.0	0.12-0.17	0.0-2.9	1.5-2.5
	4-15	28	30	40-45	1.15-1.30	0.1-0.2	0.13-0.14	3.0-5.9	0.5-0.8
	15-25	---	---	---	---	0.0-0.6	---	---	---
Wilcoxson-------	0-4	43	39	16-20	1.25-1.40	0.6-2.0	0.12-0.17	0.0-2.9	1.5-2.5
	4-9	61	18	18-25	1.25-1.40	0.6-2.0	0.13-0.17	3.0-5.9	1.0-2.0
	9-17	31	31	35-39	1.20-1.35	0.2-0.6	0.15-0.19	3.0-5.9	0.5-0.8
	17-26	53	12	35-39	1.25-1.40	0.2-0.6	0.07-0.10	3.0-5.9	0.5-0.8
	26-36	---	---	---	---	0.0-0.6	---	---	---
32:									
Cosnino---------	0-2	65	19	12-18	1.35-1.50	2.0-5.9	0.06-0.10	0.0-29.0	1.5-2.5
	2-8	68	20	10-16	1.35-1.50	2.0-5.9	0.04-0.07	0.0-2.9	0.5-0.8
	8-18	---	---	---	---	0.0-0.6	---	---	---
33:									
Cosnino---------	0-2	0	0	0-0	0.25-0.75	5.9-99.9	0.00-0.04	---	65-95
	2-6	67	19	12-18	1.35-1.50	2.0-5.9	0.06-0.09	0.0-2.9	1.5-2.5
	6-16	65	19	14-18	1.35-1.50	2.0-5.9	0.05-0.09	0.0-2.9	0.5-0.8
	16-26	---	---	---	---	0.0-0.6	---	---	---
34:									
Kydestea--------	0-3	43	39	16-24	1.25-1.40	0.6-2.0	0.08-0.11	3.0-5.9	1.5-2.5
	3-9	42	38	18-24	1.25-1.40	0.6-2.0	0.08-0.11	3.0-5.9	0.5-0.8
	9-19	---	---	---	---	0.0-0.6	---	---	---
35:									
Lithic Ustorthents----	0-4	66	19	12-18	1.35-1.50	2.0-5.9	0.06-0.10	0.0-2.9	1.5-2.5
	4-11	60	18	18-25	1.25-1.40	0.6-2.0	0.08-0.10	3.0-5.9	0.5-0.8
	11-21	---	---	---	---	0.0-0.6	---	---	---
36:									
Oxyaquic Ustifluvents---	0-8	78	16	2-8	1.45-1.60	5.9-20.0	0.03-0.04	0.0-2.9	1.5-2.5
	8-37	91	6	1-6	1.45-1.60	20.0-99.9	0.02-0.04	0.0-2.9	0.5-0.8
	37-60	67	19	12-16	1.35-1.50	2.0-5.9	0.06-0.09	0.0-2.9	0.5-0.8
37:									
Kydestea--------	0-3	45	36	15-26	1.25-1.40	0.6-2.0	0.07-0.10	3.0-5.9	0.8-1.5
	3-17	45	31	15-26	1.25-1.40	0.6-2.0	0.07-0.10	3.0-5.9	0.1-0.6
	17-27	---	---	---	---	0.0-0.6	---	---	---

Table 23.—Physical Soil Properties—Continued

Map unit symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Permeability (Ksat)	Available water capacity	Shrink-swell potential	Organic matter
	In	Pct	Pct	Pct	g/cc	In/hr	In/in	Pct	Pct
38:									
Whiskey---------	0-2	50	32	12-25	1.25-1.40	0.6-2.0	0.13-0.18	3.0-5.9	2.5-4.0
	2-15	50	30	12-25	1.35-1.50	0.6-2.0	0.08-0.15	0.0-2.9	2.5-3.5
	15-34	55	27	12-25	1.35-1.50	0.6-2.0	0.08-0.15	0.0-2.9	2.5-3.5
	34-60	50	28	12-25	1.25-1.40	0.6-2.0	0.13-0.18	3.0-5.9	0.1-0.6
39:									
Vosburg---------	0-4	67	19	12-16	1.35-1.50	2.0-5.9	0.08-0.13	0.0-2.9	2.5-4.0
	4-12	65	19	12-18	1.35-1.50	2.0-5.9	0.08-0.13	0.0-2.9	2.5-4.0
	12-21	67	15	16-22	1.35-1.50	2.0-5.9	0.08-0.13	0.0-2.9	0.1-0.6
	21-32	41	37	18-26	1.25-1.40	0.6-2.0	0.13-0.18	3.0-5.9	0.1-0.6
	32-60	39	37	18-26	1.25-1.40	0.6-2.0	0.13-0.18	3.0-5.9	0.1-0.6

Table 24.—Erosion Properties

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

Map unit symbol and component name	Depth (cm)	Erosion factors Kw	Kf	T	Wind erodi-bility group	Wind erodi-bility index
31:						
Chilson	0-3	---	---	1	5	56
	3-10	.43	.43			
	10-38	.28	.28			
	38-63	---	---			
Wilcoxson	0-10	.32	.32	2	5	56
	10-23	.24	.24			
	23-43	.28	.28			
	43-66	.05	.17			
	66-91	---	---			
32:						
Cosnino	0-5	.10	.17	1	5	56
	5-20	.05	.28			
	20-45	---	---			
Rock outcrop.						
33:						
Cosnino	0-5	---	---	1	5	56
	5-15	.05	.15			
	15-41	.10	.28			
	41-66	---	---			
Rock outcrop.						
34:						
Kydestea	0-8	.10	.32	1	7	38
	8-23	.15	.37			
	23-48	---	---			
Rock outcrop.						
35:						
Lithic Ustorthents	0-10	.10	.17	1	5	56
	10-28	.10	.28			
	28-53	---	---			
Rock outcrop.						
36:						
Oxyaquic Ustifluvents	0-20	.02	.15	5	6	48
	20-94	.02	.02			
	94-152	.10	.24			
37:						
Rock outcrop.						
Kydestea	0-8	.10	.37	1	7	38
	8-43	.10	.37			
	43-68	---	---			
38:						
Whiskey	0-5	.32	.32	5	5	56
	5-38	.37	.37			
	38-86	.28	.28			
	86-152	.43	.43			

Table 24.—Erosion Properties—Continued

Map unit symbol and component name	Depth (cm)	Erosion factors: Kw	Erosion factors: Kf	Erosion factors: T	Wind erodi-bility group	Wind erodi-bility index
39:						
Vosburg	0-10	.15	.15	5	3	86
	10-30	.24	.24			
	30-53	.20	.20			
	53-81	.37	.37			
	81-152	.37	.37			

Table 25.—Total Soil Carbon

(This table displays soil organic carbon (SOC) and soil inorganic carbon (SIC) in kilograms per square meter to a depth of 2 meters or to the representative top depth of any kind of bedrock or any cemented soil horizon. SOC and SIC are reported on a volumetric whole soil basis, corrected for representative rock fragments indicated in the database. SOC is converted from horizon soil organic matter of the fraction of the soil less than 2 mm in diameter. If soil organic matter indicated in the database is NULL, SOC is assumed to be zero. SIC is converted from horizon calcium carbonate content fraction of the soil less than 2 mm in diameter. If horizon calcium carbonate indicated in the database is NULL, SIC is assumed to be zero. A weighted average of all horizons is used in the calculations. Only major components of a map unit are displayed in this table)

Map unit symbol, component name, and component percent	SOC	SIC
	kg/m^2	kg/m^2
31:		
Chilson (55%)	2	0
Wilcoxson (40%)	4	2
32:		
Cosnino (80%)	1	0
Rock outcrop (20%)	0	0
33:		
Cosnino (50%)	10	2
Rock outcrop (40%)	0	0
34:		
Kydestea (80%)	1	1
Rock outcrop (20%)	0	0
35:		
Lithic Ustorthents (70%)	2	2
Rock outcrop (30%)	0	0
36:		
Oxyaquic Ustifluvents (85%)	4	0
37:		
Rock outcrop (50%)	0	0
Kydestea (40%)	1	1
38:		
Whiskey (90%)	23	19
39:		
Vosburg (100%)	10	21

Table 26.—Soil Features

(See text for definitions of terms used in this table. Absence of an entry indicates that data were not estimated)

Map unit symbol and soil name	Restrictive layer			Potential for frost action	Risk of corrosion	
	Kind	Depth to top	Hardness		Uncoated steel	Concrete
		Cm				
31:						
Chilson	Lithic bedrock	15-48	Indurated	Low	High	Low
Wilcoxson	Lithic bedrock	56-81	Indurated	Low	Moderate	Low
32:						
Cosnino	Lithic bedrock	10-38	Indurated	Moderate	Moderate	Low
33:						
Cosnino	Lithic bedrock	10-41	Indurated	Moderate	Moderate	Low
34:						
Kydestea	Lithic bedrock	10-38	Indurated	Moderate	Moderate	Low
35:						
Lithic Ustorthents	Lithic bedrock	10-46	Indurated	Moderate	Moderate	Low
36:						
Oxyaquic Ustifluvents	---	---	---	Moderate	Moderate	Low
37:						
Kydestea	Lithic bedrock	35-45	Indurated	Moderate	Moderate	Low
38:						
Whiskey	---	---	---	Moderate	Moderate	Low
39:						
Vosburg	---	---	---	Moderate	Moderate	Low

Table 27.—Water Features

(See text for definitions of terms used in this table. Estimates of the frequency of ponding and flooding apply to the whole year rather than to individual months. Absence of an entry indicates that the feature is not a concern or that data were not estimated)

Map unit symbol and soil name	Hydrologic group	Months	Water table: Upper limit	Water table: Lower limit	Ponding: Surface water depth	Ponding: Duration	Ponding: Frequency	Flooding: Duration	Flooding: Frequency
			Cm	Cm	Cm				
31:									
Chilson	D								
		Jan-Dec	---	---	---	---	None	---	None
Wilcoxson	C								
		Jan-Dec	---	---	---	---	None	---	None
32:									
Cosnino	D								
		Jan-Dec	---	---	---	---	None	---	None
33:									
Cosnino	D								
		Jan-Dec	---	---	---	---	None	---	None
34:									
Kydestea	D								
		Jan-Dec	---	---	---	---	None	---	None
35:									
Lithic Ustorthents	D								
		Jan-Dec	---	---	---	---	None	---	None
36:									
Oxyaquic Ustifluvents	A								
		January	94	---	---	---	None	---	None
		February	94	---	---	---	None	---	None
		Mar-May	---	---	---	---	None	---	None
		June	---	---	---	---	None	Very brief	Occasional
		July	---	---	---	---	None	Very brief	Occasional
		August	---	---	---	---	None	Very brief	Occasional
		Sep-Nov	---	---	---	---	None	---	None
		December	94	---	---	---	None	---	None
37:									
Kydestea	D								
		Jan-Dec	---	---	---	---	None	---	None

Table 27.—Water Features—Continued

Map unit symbol and soil name	Hydrologic group	Months	Water table: Upper limit	Water table: Lower limit	Ponding: Surface water depth	Ponding: Duration	Ponding: Frequency	Flooding: Duration	Flooding: Frequency
			Cm	Cm	Cm				
38:									
Whiskey	B								
		Jan-May	---	---	---	---	None	---	None
		June	---	---	---	---	None	Brief	Rare
		July	---	---	---	---	None	Brief	Rare
		August	---	---	---	---	None	Brief	Rare
		Sep-Dec	---	---	---	---	None	---	None
39:									
Vosburg	B								
		Jan-May	---	---	---	---	None	---	None
		June	---	---	---	---	None	Very brief	Rare
		July	---	---	---	---	None	Very brief	Rare
		August	---	---	---	---	None	Very brief	Rare
		Sep-Dec	---	---	---	---	None	---	None

Table 28.—Chemical Soil Properties

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

Map unit symbol and soil name	Depth	Cation-exchange capacity	Soil reaction	Calcium carbon-ate	Gypsum	Salinity	Sodium adsorp-tion ratio
	Cm	meq/100 g	pH	Pct	Pct	mmhos/cm	
31:							
Chilson	0-3	12.0-16.0	6.6-7.8	0-2	0-2	0.0-2.0	0-2
	3-10	12.0-16.0	6.6-7.8	0-2	0-2	0.0-2.0	0-2
	10-38	30.0-34.0	6.6-7.8	0-2	0-2	0.0-2.0	0-2
	38-63	---	---	---	---	---	---
Wilcoxson	0-10	14.0-17.0	6.6-7.8	0-2	0-2	0.0-2.0	0-2
	10-23	15.0-21.0	6.6-7.8	0-2	0-2	0.0-2.0	0-2
	23-43	27.0-30.0	6.6-7.8	0-4	0-2	0.0-2.0	0-2
	43-66	26.0-30.0	7.4-8.4	0-10	0-2	0.0-2.0	0-2
	66-91	---	---	---	---	---	---
32:							
Cosnino	0-5	11.0-16.0	7.4-7.8	0-2	0-2	0.0-2.0	0-2
	5-20	9.0-14.0	7.4-7.8	0-2	0-2	0.0-2.0	0-2
	20-45	---	---	---	---	---	---
33:							
Cosnino	0-5	11.0-16.0	7.4-8.4	0-2	0-2	0.0-2.0	0-2
	5-15	11.0-16.0	7.4-8.4	0-2	0-2	0.0-2.0	0-2
	15-41	12.0-15.0	7.9-8.4	0-4	0-2	0.0-2.0	0-2
	41-66	---	---	---	---	---	---
34:							
Kydestea	0-8	14.0-20.0	7.9-8.4	0-5	0-2	0.0-2.0	0-2
	8-23	15.0-19.0	7.9-8.4	0-5	0-2	0.0-2.0	0-2
	23-48	---	---	---	---	---	---
35:							
Lithic Ustorthents	0-10	11.0-16.0	7.9-8.4	0-5	0-2	0.0-2.0	0-2
	10-28	15.0-20.0	7.9-8.4	0-10	0-2	0.0-2.0	0-2
	28-53	---	---	---	---	---	---
36:							
Oxyaquic Ustifluvents	0-20	2.0-8.0	6.6-7.8	0-2	0-2	0.0-2.0	0-2
	20-94	1.0-6.0	6.6-7.8	0-2	0-2	0.0-2.0	0-2
	94-152	10.0-14.0	6.6-7.8	0-2	0-2	0.0-2.0	0-2
37:							
Kydestea	0-8	12.7-21.4	7.4-7.8	0-2	0-2	0.0-2.0	0-2
	8-43	11.7-20.6	7.4-7.8	2-10	0-2	0.0-2.0	0-2
	43-68	---	---	---	---	---	---
38:							
Whiskey	0-5	10.9-21.4	7.4-7.8	0-2	0-2	0.0-2.0	0-2
	5-38	10.9-21.3	7.4-8.4	2-5	0-2	0.0-2.0	0-2
	38-86	10.9-21.3	7.4-8.4	2-10	0-2	0.0-2.0	0-2
	86-152	9.6-19.9	7.4-8.4	10-15	0-2	0.0-2.0	0-2
39:							
Vosburg	0-10	10.0-14.0	7.4-8.4	0-4	0-2	0.0-2.0	0-2
	10-30	10.0-15.0	7.4-8.4	0-4	0-2	0.0-2.0	0-2
	30-53	12.0-18.0	7.4-8.4	5-25	0-2	0.0-2.0	0-2
	53-81	14.0-21.0	7.4-8.4	5-25	0-2	0.0-2.0	0-2
	81-152	14.0-21.0	7.4-8.4	5-25	0-2	0.0-2.0	0-2

Table 29.—Taxonomic Classification of the Soils

Soil name	Family or higher taxonomic class
Chilson	Clayey, mixed, superactive, frigid Lithic Argiustolls
Cosnino	Loamy-skeletal, mixed, superactive, frigid Lithic Haplustolls
Kydestea	Loamy-skeletal, mixed, superactive, calcareous, mesic Aridic Lithic Ustorthents
Lithic Ustorthents	Loamy-skeletal, mixed, superactive, calcareous, frigid Lithic Ustorthents
Oxyaquic Ustifluvents	Oxyaquic Ustifluvents
Vosburg	Fine-loamy, mixed, superactive, mesic Pachic Argiustolls
Whiskey	Fine-loamy, mixed, superactive, mesic Pachic Haplustolls
Wilcoxson	Fine, mixed, superactive, frigid Typic Argiustolls

Table 30.—Soil Classification Key

(An asterisk in the first column indicates a taxadjunct to the series. See text for a description of those characteristics that are outside the range of the series)

ORDER
   Suborder
      Great Group
         Subgroup
            Series or Higher Category

ENTISOLS
   Fluvents
      Ustifluvents
         Oxyaquic Ustifluvents
            Oxyaquic Ustifluvents---------Oxyaquic Ustifluvents
   Orthents
      Ustorthents
         Lithic Ustorthents
            Lithic Ustorthents------------Loamy-skeletal, mixed, superactive, calcareous, frigid Lithic Ustorthents
         Aridic Lithic Ustorthents
            Kydestea----------------------Loamy-skeletal, mixed, superactive, calcareous, mesic Aridic Lithic Ustorthents

MOLLISOLS
   Ustolls
      Argiustolls
         Typic Argiustolls
            Wilcoxson---------------------Fine, mixed, superactive, frigid Typic Argiustolls
         Lithic Argiustolls
            Chilson-----------------------Clayey, mixed, superactive, frigid Lithic Argiustolls
         Pachic Argiustolls
            Vosburg-----------------------Fine-loamy, mixed, superactive, mesic Pachic Argiustolls
      Haplustolls
         Lithic Haplustolls
            Cosnino-----------------------Loamy-skeletal, mixed, superactive, frigid Lithic Haplustolls
         Pachic Haplustolls
            Whiskey-----------------------Fine-loamy, mixed, superactive, mesic Pachic Haplustolls

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