USDA United States Department of Agriculture

Natural Resources Conservation Service

In cooperation with United States Department of the Interior, Bureau of Indian Affairs; the Arizona Agricultural Experiment Station; and the Hualapai and Havasupai Tribes

Soil Survey of Hualapai-Havasupai Area, Arizona,

Parts of Coconino, Mohave, and Yavapai Counties

How to Use This Soil Survey

General Soil Map

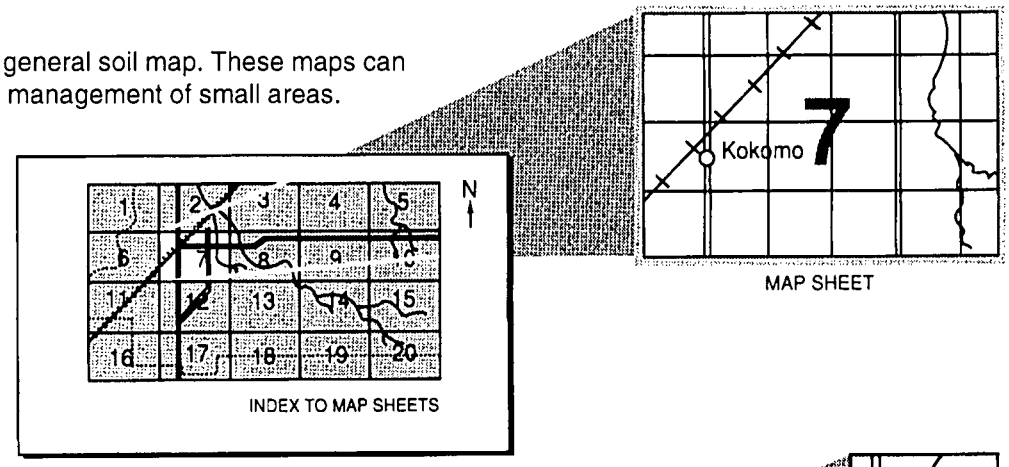
The general soil map, which is the color map preceding the detailed soil maps, shows the survey area divided into groups of associated soils called general soil map units. This map is useful in planning the use and management of large areas.

To find information about your area of interest, locate that area on the map, identify the name of the map unit in the area on the color-coded map legend, then refer to the section **General Soil Map Units** for a general description of the soils in your area.

Detailed Soil Maps

The detailed soil maps follow the general soil map. These maps 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**, which precedes the soil maps. Note the number of the map sheet and turn to that sheet.

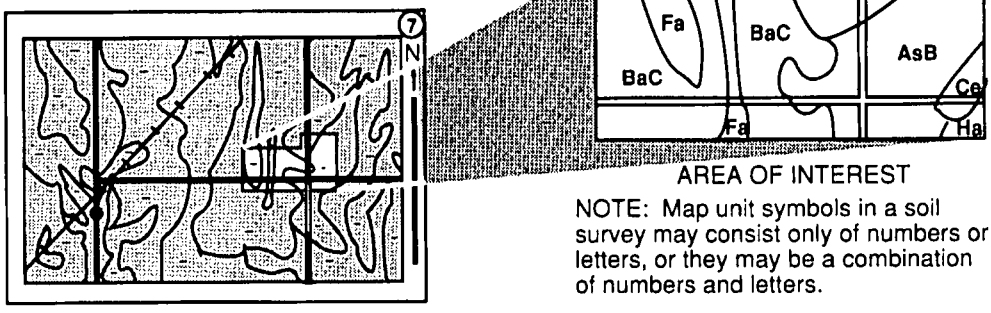


INDEX TO MAP SHEETS

MAP SHEET

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

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



MAP SHEET

AREA OF INTEREST

NOTE: Map unit symbols in a soil survey may consist only of numbers or letters, or they may be a combination of numbers and letters.

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 (formerly the Soil Conservation Service) has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in 1992. Soil names and descriptions were approved in 1993. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1992. This survey was made cooperatively by the Natural Resources Conservation Service and the Arizona Agricultural Experiment Station. It is part of the technical assistance furnished to the Big Sandy and Coconino Natural Resource Conservation Districts.

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

All programs and services of the Natural Resources Conservation Service are offered on a nondiscriminatory basis, without regard to race, color, national origin, religion, sex, age, marital status, or handicap.

Cover: View from the Aubrey Cliffs near Granite Park in the Grand Canyon.

Contents

Issued 1999

Summary of Tables

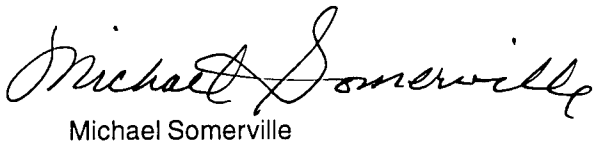
Foreword

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

This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. 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. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Natural Resources Conservation Service or the Cooperative Extension Service.



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State Conservationist
Natural Resources Conservation Service

Soil Survey of Hualapai-Havasupai Area, Arizona,

Parts of Coconino, Mohave, and Yavapai Counties

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United States Department of Agriculture, Natural Resources Conservation Service,
in cooperation with
the Arizona Agricultural Experiment Station; the United States Department of the
Interior, Bureau of Indian Affairs; and the Hualapai and Havasupai Tribes

General Nature of the Survey Area

Physiography

The Hualapai-Havasupai soil survey area covers 1,180,540 acres in northwestern Arizona (fig. 1). It consists of two Indian reservations administered by the United States Department of the Interior, Bureau of Indian Affairs (BIA). The Hualapai Indian Reservation is 992,463 acres in size. It is mostly in Coconino and Mohave Counties, but a small area near the southeastern boundary is in Yavapai County (fig. 2). The Havasupai Indian Reservation is 188,077 acres in size. It is entirely in Coconino County. The Hualapai Reservation is a broad, irregular U-shaped area that follows the course of the Colorado River channel. Each wing of the "U" extends nearly 50 miles. The overall width is approximately 60 miles. The Havasupai Reservation branches off the eastern wing and adjoins the Grand Canyon National Park to the northeast.

The Hualapai and Havasupai Indian Reservations are in the southwestern section of the Colorado Plateau. This area is subdivided into two irregular plateaus, the Hualapai Plateau and the western part of the Coconino Plateau (fig. 3). The Hualapai Plateau has an average elevation of 5,000 feet. It is bounded on the west by the Grand Wash Cliffs, which separate the Colorado Plateau from the Basin and Range province (Twenter, 1962). The Hurricane Fault in Peach Springs Canyon separates the eastern margin of the Hualapai Plateau from the Coconino Plateau. The Coconino Plateau has an average elevation of 6,500 feet.

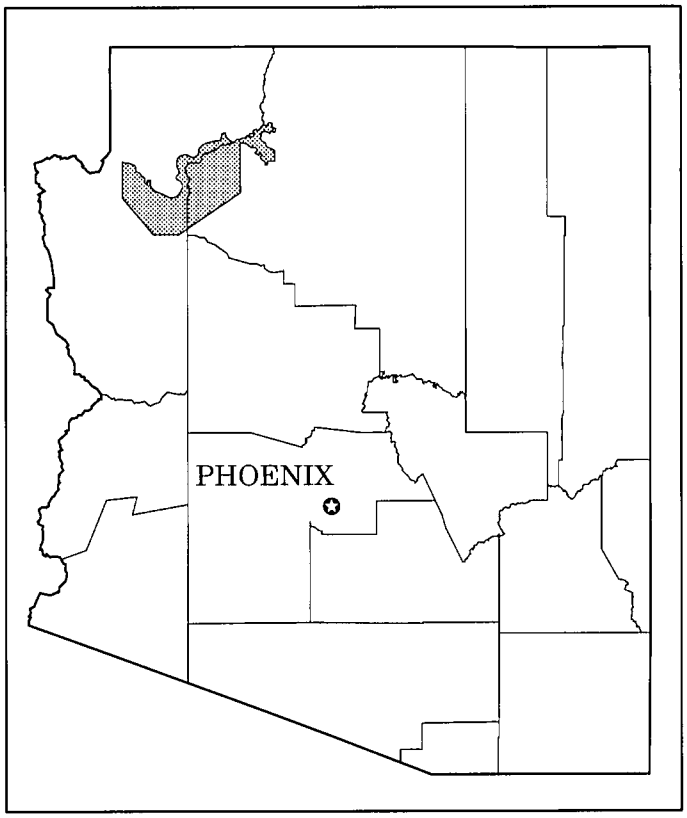

Figure 1.—Location of the Hualapai-Havasupai area in Arizona.

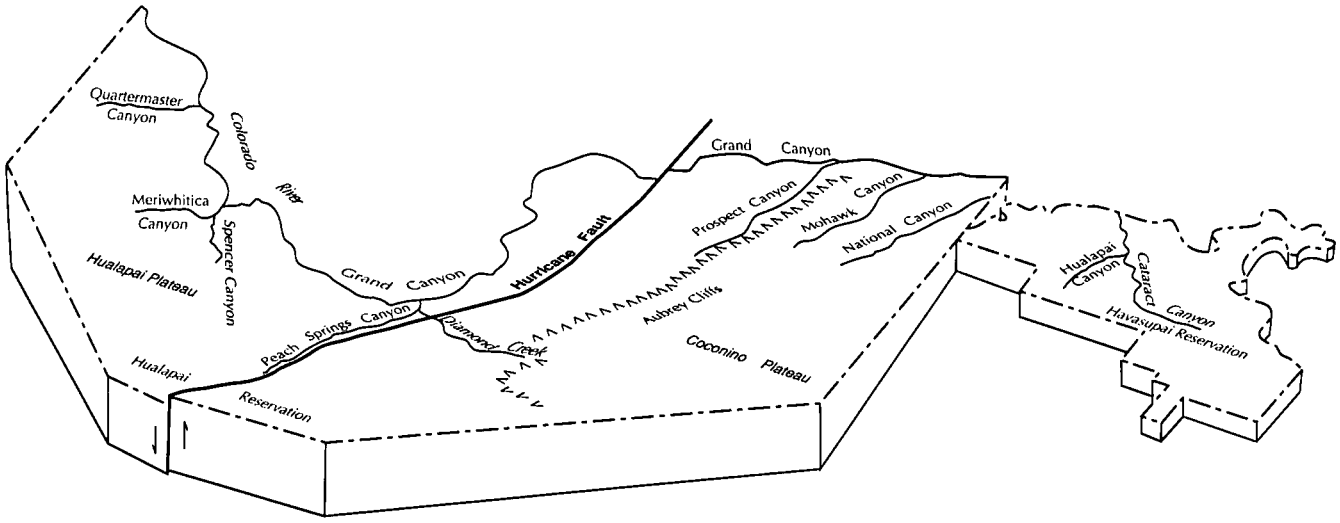

Figure 2.—Planar view of the Hualapai-Havasupai area.

The plateaus are broken to the north by steep, rugged canyons that merge with the Grand Canyon and the deeply entrenched Colorado River. Ephemeral drainages that flow to the northeast are in Quartermaster, Meriwhitica, Peach Springs, Prospect, Mohawk, and National Canyons. Spencer, Diamond, and Havasu Creeks drain to the northwest and have a perennial flow from springs. Havasu Creek flows through Cataract Canyon below its confluence with Hualapai Canyon.

The southern upland areas in the survey area are situated on the gently undulating terrain of the Hualapai and Coconino Plateaus. They are underlain by nearly horizontal Paleozoic sedimentary rocks with an average regional dip of 1 degree northeast.

The highest elevation in the survey area is about 7,392 feet at Manzanita. Manzanita is about 7 miles west of Thorton Lookout, near the western edge of the Coconino Plateau on the Aubrey Cliffs. The lowest elevation in the survey area is 1,157 feet at the Colorado River near Lake Mead.

History and Development

The Hualapai and Havasupai Indians are members of the Yuman-speaking tribes, collectively known as "Pai." Their aboriginal lands covered over 5 million acres of diverse topography in northwestern Arizona. The area, inhabited since the 12th century, was utilized by 13 hunting and gathering bands, whose subsistence lifestyle centered on seasonal movement to locations with abundant plant and animal resources (McGuire, 1987). Agriculture was common along the perennial streams and near springs in canyon walls.

The first direct contact with Anglos occurred in 1776, during the expedition of Franciscan missionary Francisco Garces. Another 70 years passed before exploration and survey parties from the United States reached the area after the territory was transferred from Mexico to the United States (McGuire, 1987). The geographic distribution of the Pai bands led to the misconception of the people as two different tribes—the "Hwala'pay," or Pine Tree People, and the "Havasuw`apa," or Blue Green Water People.

The killing of a Hualapai leader by Anglos in 1866 led to the Hualapai War of 1866-1869 (Dobyns and Euler, 1960). The defeated Hualapais were marched to the Colorado Indian Reservation for internment. The eastern bands of the Havasupais escaped the encampment due to their isolation in the steep canyon and continued their aboriginal hunting and gathering lifestyle.

In 1883, the Hualapai Indian Reservation was established for the survivors of the western Hualapai bands. The reservation encompassed approximately 900,000 acres of the Hualapais' original land. Anglo colonization and heavy cattle grazing during the brief absence of the Hualapais prevented a return to native subsistence activities. Employment was sought in nearby railroad towns or with ranchers and miners. During the Depression, many of the Hualapais returned to the reservation to work with the Civilian Conservation Corps and remained to raise cattle after the program ended. In 1960, half of the 702 Hualapais on the tribal rolls lived permanently in Peach Springs (McGuire, 1987).

In 1882, only 518 acres were set aside to establish the Havasupai Reservation near Supai Village in Havasu Canyon (Dobyns and Euler, 1960). During the 1880's, mining exploration in Cataract Canyon and the development of Grand Canyon tourism greatly diminished the Havasupai subsistence lifestyle. Wage labor was sought outside the village, and many Havasupais were employed at Grand Canyon Village. In 1939, Tribal

governments were established under the Indian Reorganization Act (Marshal, 1971). The Havasupai Reservation was expanded in 1975 to more than 188,000 acres, returning part of the traditional lands on the Colorado Plateau to the tribe. An additional 95,300 acres of the Grand Canyon National Park are presently reserved as traditional "Havasupai Use Lands."

The Hualapai population currently totals 2,200. Nearly half of this total is under the age of 16. Tribal enterprises include cattle ranching, wildlife hunting permits, commercial timber harvest, and Colorado River raft operations. Education is another important source of employment. However, only 28 percent of the potential labor force is employed locally on the reservation (Watahomigie, 1988).

The only current settlement on the Hualapai Reservation is the town of Peach Springs. It is located on old Highway 66 along the Santa Fe Railroad about 120 miles west of Flagstaff and 50 miles east of Kingman. Peach Springs has a grade school, a post office, a general store, two gas stations, a tribal office complex, and a U.S. Indian Health Service clinic (Watahomigie, 1988).

Currently, the population of the Havasupai Tribe is about 500. The main tribal enterprise is tourism. The tribe operates a tourist office, a lodge, campgrounds, a cafe, and a grocery store. The reservation has over 20,000 visitors each year and is famous for its turquoise-colored perennial stream and waterfalls below the village. Major sources of employment are tourism, education, clerical work, and construction. The unemployment rate in 1987 was 38 percent (Ariz. Dept. of Commerce, 1988).

The only current settlement on the Havasupai Reservation is the village of Supai in Havasu Canyon. It is accessible only by foot, horse, or helicopter. The trail from Hualapai Hilltop (Panya Point) to Supai is 8 miles long. The trailhead is reached by BIA Route 18, which branches north from Highway 66 east of Peach Springs. Supplies and building materials must be packed by horse, mule train, or chartered helicopter. The U.S. Postal Service transports mail to and from the village by packhorse train. Supai has an elementary school, post office, tribal office and community building, and Indian Health Service clinic.

Natural Resources

Natural resources in the survey area include soil, water, wildlife, minerals and geologic materials, timber products, grazeable woodland, and rangeland. Conservation and utilization of these related resources are tied to soil properties that affect use and management.

Mineral resources include uranium, vanadium, and copper and small areas of gypsum (McKee, 1977). Uranium is found in solution collapsed breccia pipes within the Redwall Limestone in the northeastern part of the survey area. Copper bearing minerals are also associated with the breccia pipes (Billingsley). Copper was once mined at the Ridenour mine west of Prospect Valley.

Local deposits of Tertiary and Quaternary age gravel provide a source of sand and gravel for road material. Other geologic materials include limestone, sandstone, and travertine (McKee, 1977). Limestone is quarried from the Redwall Formation in the southeastern corner of the survey area. Flagstone is quarried from small sandstone deposits near the southwest boundary of the Hualapai Reservation.

Water is a limited resource within the Hualapai and Havasupai Reservations. Sources of surface water are the Colorado River, water entrenched in the Grand Canyon,

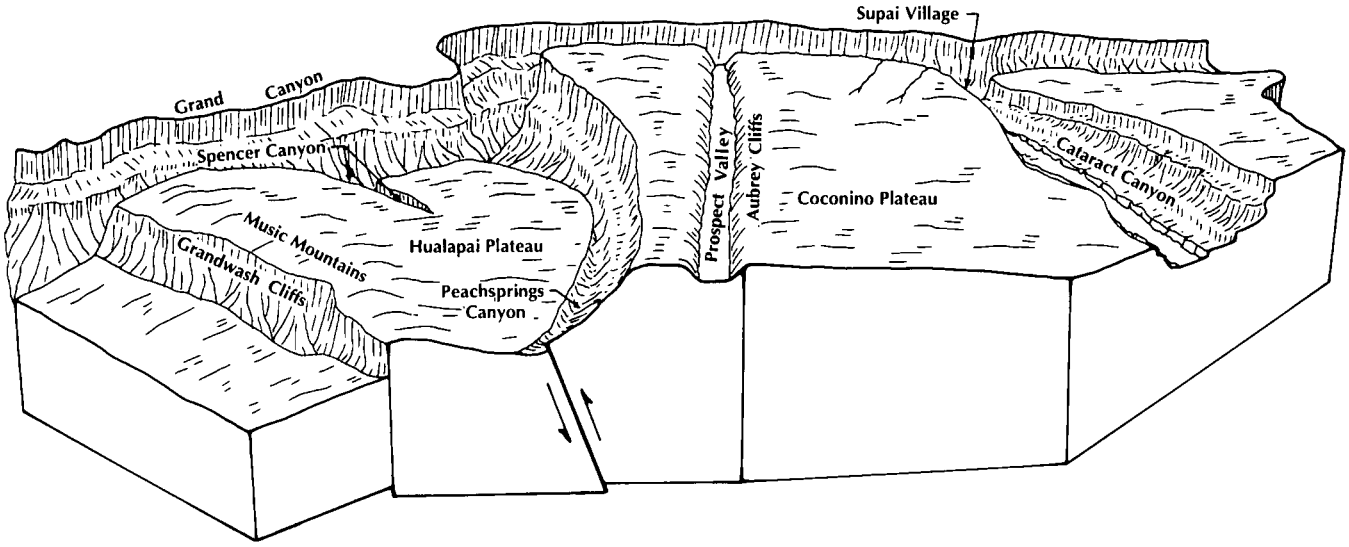

Figure 3.—Cross-sectional view of the physiography of the survey area.

and springs located in deep tributary canyons. Significant flows originate from Warm, Diamond, Spencer, Meriwhitica, and Quartermaster Springs on the Hualapai Reservation and Havasu, Topocoba, Bachathaiva, and High Wall Springs on the Havasupai Reservation. The inaccessible locations of several of these springs limit use for water development. Potential groundwater supplies are limited to aquifers in the Muav Limestone, Coconino Sandstone, and Tertiary alluvial deposits (Twenter, 1962). Nearly all of the developed water is used for livestock. It is either supplied to troughs and drinkers by networks of pipeline from wells and water catchments, or it is impounded in earthen stock tanks. Domestic water in Peach Springs is piped from a well near Truxton. Havasu Creek flows through Supai Village, providing a perennial water source for irrigation and domestic use.

The major land uses of the survey area are livestock grazing and timber production. Secondary uses are wildlife habitat and recreation. Small areas of cropland are utilized near Supai Village, where water is abundant for irrigation.

Climate

Table 1 gives data on temperature and precipitation for the survey area as recorded at Supai in the period 1957 to 1987 and at Seligman (outside the survey area) in the period 1905 to 1993. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature at Supai is 48 degrees F and the average daily minimum temperature is 33 degrees. The lowest temperature on record is -4 degrees in January, 1979. In summer, the average temperature is 79 degrees and the average daily maximum temperature is 96 degrees. The highest recorded temperature is 112 degrees in June, 1981.

In winter the average temperature at Seligman is 39 degrees F and the average daily minimum temperature is 23 degrees. The lowest temperature on record, which occurred at Seligman is -17 degrees F in December, 1931. In summer, the average temperature is 67 degrees and the average daily maximum temperature is 86 degrees. The highest recorded temperature at Seligman is 104 degrees in July, 1932.

The total annual precipitation at Supai is 8.5 inches. Of this, 4.3 inches, or 50 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 1.5 inches. Thunderstorms occur mostly from July through September.

The total annual precipitation at Seligman is 11 inches. Of this, 6 inches, or 55 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 2 inches. Thunderstorms occur mostly July through September.

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 (40 degrees F). 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.

Major Land Resource Units

Major land resource areas (MLRAs) are geographically associated units that have a particular pattern of soils, climate, water resources, and land use (USDA, Handb. 296, 1981). Identification of MLRAs is important in statewide agricultural planning and has value in interstate, regional, and national planning. The MLRAs consist of at least several thousand acres, although much smaller areas of a characteristic MLRA may occur in a localized area. The MLRAs have broad ranges of elevation, precipitation, location of occurrence, and other characteristics. At the state and local level, MLRAs are usually subdivided into Major Land Resource Units (MLRUs) for more detailed inventory and planning purposes. The MLRUs that occur within the Hualapai-Havasupai soil survey area have a more narrow range of characteristics, such as elevation, precipitation, and temperature, than is characteristic for an MLRA on a regional basis. The general soil map at the back of this soil survey shows the distribution of MLRUs in the survey area.

The Hualapai-Havasupai soil survey area consists of five MLRUs (fig. 4). From the bottom of the Grand Canyon to an elevation of about 4,500 feet is the Grand Canyon Desert Shrub (MLRU 30-2AZ). The Colorado Plateau Mixed Grass Plains (MLRU 35-1AZ) and the Grand Canyon Woodland-Shrub (MLRU 39-3AZ) are at elevations ranging from about 4,500 to 6,600 feet and are the most widespread of the MLRUs in the survey area. The Colorado Plateau Sagebrush-Grassland (MLRU 35-3AZ) occupies an area dominantly within the Havasupai Reservation. The Mogollon Plateau Coniferous Forest (MLRU 39-1AZ) occurs only in the highest parts of the survey area near the Aubrey Cliffs and near Thorton Lookout. These MLRUs are described in the following paragraphs.

MLRU 30-2AZ—Grand Canyon Desert Shrub. The Grand Canyon Desert Shrub resource unit is primarily in canyons and on dissected plateaus in the survey area (fig. 5). Elevations are dominantly 2,000 to 5,000 feet. The most prominent feature in the unit is the Grand Canyon.

The climate is arid and warm. Annual precipitation ranges from about 8 to 12 inches at the higher elevations.

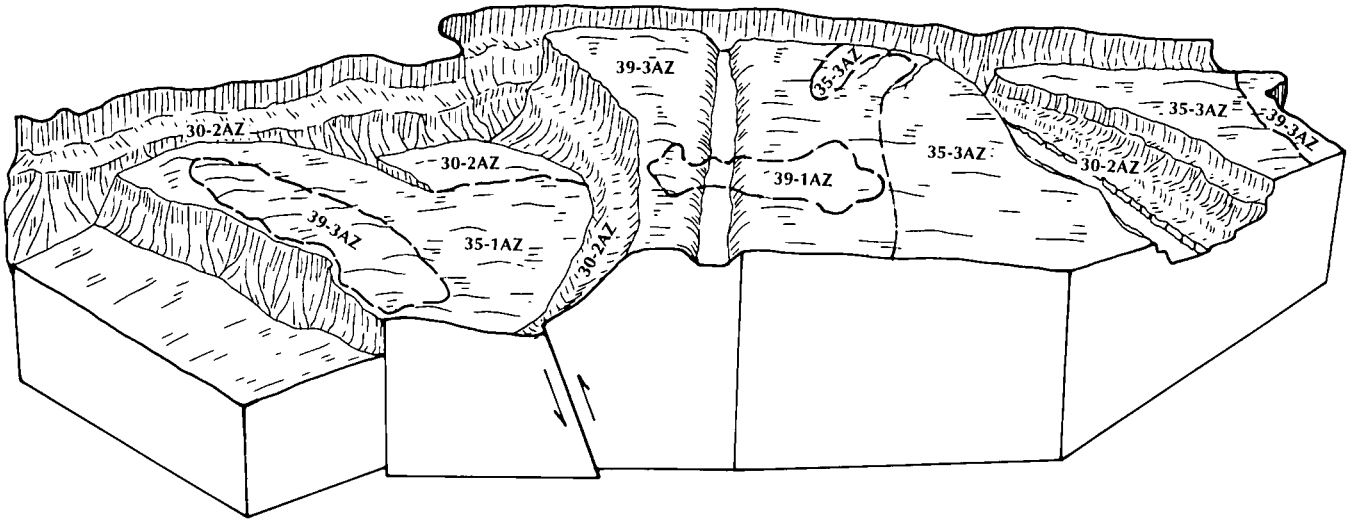

Figure 4.—Generalized diagram of the major land resource units in the survey area.

The average air temperature ranges from 57 to 68 degrees F. The average frost-free period ranges from 130 to 220 days.

The plant communities in the upland areas are dominated by blackbrush but also include minor amounts of creosotebush, ratany, yucca, white bursage, winterfat, and various cactus species. Dominant grasses on upland soils include big galleta, bush muhly, Indian ricegrass, desert needlegrass, dropseeds, and perennial threeawns. Bottomland soils are dominated by big galleta, bush muhly, Indian ricegrass, perennial threeawns, dropseeds, Mexican bladdersage, white burrobrush, and buckhorn cholla. Wet periods, particularly during the spring months, produce large quantities of annual vegetation that are important to wildlife. The vegetation consists of annual grasses and forbs such as lupine, desert Indianwheat, primrose, sixweeks grama, and sixweeks fescue.

This unit is used dominantly for recreational purposes. On the reservations, camping, hiking, hunting, fishing, and boating are popular. This area is also used for rangeland and wildlife habitat and for limited livestock grazing. Major management concerns include inadequate livestock watering facilities, the abundance of shrubby species, and steep slopes.

This MLRU makes up about 29 percent of the survey area and is subdivided into 2 map units on the general soil map. Soils that occur in this MLRU in the survey area include highly variable Torriorthents; very shallow and shallow Splanod and Hindu soils; and very deep Arizo, Lostman, Naha, Nickel family, and Cowan family soils. Rock outcrop is also a major component.

MLRU 35-1AZ—Colorado Plateau Mixed Grass Plains. This MLRU is mainly undulating to hilly plains with an occasional deeply incised, steep-sided drainageway (fig. 6). Elevations range from about 4,000 to 7,200 feet. No perennial streams are in the area. Ground water is usually deep and often of poor quality.

Precipitation ranges from 10 to 18 inches per year. Fifty percent of it occurs from October to May as snow or rain. The snow occurs during December, January, and February. The mean annual air temperature ranges from 50 to 55 degrees F. The frost-free period ranges from 130 to 180 days.

The upland soils are dominated by needlegrasses, Indian ricegrass, galleta, and blue grama. Important shrubs are fourwing saltbush, blackbrush, winterfat, and Bigelow sagebrush. Some scattered open savannahs exist on shallow soils and are dominated by Utah juniper and Stansbury cliffrose.

This unit is primarily used for livestock grazing. In some areas overgrazing has resulted in the deterioration of range quality and in wind and water erosion. Gully erosion is a problem in some of the drainageways.

This MLRU makes up approximately 26 percent of the survey area. It is subdivided into 4 map units on the general soil map. Many of the soils in this area, such as Curhollow, Winona, and Meriwhitica soils, are shallow to limestone bedrock. The Rolie soils are very shallow and shallow to a calcium carbonate cemented hardpan. The Peachsprings and Poley soils are very deep and occur on fan terraces.

MLRU 35-3A—Colorado Plateau Sagebrush-Grassland. This unit is characterized by rolling hills and plateaus. Elevations range from 4,600 to 6,100 feet. Precipitation ranges from 10 to 12 inches per year. Sixty percent of the precipitation falls as snow or rain during the

Figure 5.—An area of Arizo soils in Peach Springs Canyon in MLRU 30-2AZ. The canyon escarpments are rock outcrop and shallow to very deep Torriorthents.

winter months. The remainder falls as rain from June through September. May and June are typically dry. The average annual air temperature ranges from 52 to 56 degrees F. Winters are cold, and summers are warm. The frost-free period ranges from 135 to 175 days.

Indian ricegrass, needleandthread, and western wheatgrass are the dominant cool season grasses in this unit. Galleta, black grama, blue grama, and sand dropseed are the major warm season grasses. Winterfat, fourwing saltbush, and Wyoming big sagebrush are the most important shrubs.

This MLRU is used dominantly for livestock grazing. The unpredictable rainfall creates management concerns for livestock operators. Pastures frequently do not receive enough rainfall to produce the normal amount of feed. Stock tanks are often dry. Water catchments are being used to harvest rainfall. Wells are very deep and widely scattered. Springs are also scarce. Irrigated water has not been developed, and no perennial streams exist in the unit.

Overgrazing is a management concern that results in increased densities of sagebrush. Serious gully erosion occurs in some areas. The shallow soils and the high content of rock fragments make reseeding difficult. The shallow depth to bedrock increases the hazard of erosion.

This MLRU makes up only 9 percent of the survey area. Most of the soils in this unit are very shallow and shallow to limestone bedrock. The most common soils are Winona, Curhollow, and Puertecito soils.

MLRU 39-3AZ—Grand Canyon Woodland-Shrub. Elevations range from 4,500 to 6,600 feet. Undulating plateaus and small mesas are the characteristic topography. The mean annual precipitation ranges from about 14 to 18 inches. Sixty-five percent of the precipitation occurs from October through May. Snow occurs from November through mid-April. The remainder of the precipitation falls as rain during June through September, often during thunderstorms. The mean annual

temperature ranges from 49 to 55 degrees F. The average frost-free period ranges from 120 to 175 days.

Approximately 80 percent of this unit has a cover of Utah juniper and Colorado pinyon or singleleaf pinyon. Important understory plants include turbinella oak, desert ceanothus, Stansbury cliffrose, Wyoming big sagebrush, mountain big sagebrush, true mountain mahogany, and fourwing saltbush. The major grasses include muttongrass, bottlebrush squirreltail, blue grama, and sideoats grama. Banana yucca, running pricklypear, and Fremont barberry are present in minor amounts.

This MLRU provides firewood, posts, wildlife habitat for big game species, and pinyon nuts. The understory plants provide some grazing for livestock. About 20 percent of the unit is shrub-grassland that has usable forage for grazing. Water is scarce throughout the area. Stock tanks often fill with snow melt but may go dry if summer rains do not refill them. This unit has no perennial streams, and springs are scarce. Wells are deep and widely scattered.

This MLRU makes up approximately 32 percent of the survey area. It is subdivided into 4 map units on the general soil map. The majority of the soils and map units in the survey area are in this MLRU. The soils range from very shallow to very deep and have a variety of parent materials.

MLRU 39-1AZ—Mogollon Plateau Coniferous Forest. This MLRU consists of undulating to mountainous topography that has scattered areas of steep, low hills. Elevation in this survey area ranges from about 6,200 to 7,900 feet. The mean annual precipitation ranges from about 18 to more than 20 inches. Approximately 65 percent of the precipitation falls as snow. Snow cover may remain on the ground from November through April. The mean annual temperature ranges from 45 to 54 degrees F. The frost-free period ranges from 120 to 150 days.

The dominant vegetation in this MLRU is ponderosa pine (fig. 7). Another important tree species is Gambel oak. Important understory grasses and shrubs include Arizona fescue, sheep fescue, mountain muhly, prairie junegrass, muttongrass, pine dropseed, dryland sedges, Wyoming big

Figure 6.—Blackbrush and yucca in MLRU 35-1AZ. The foreground is the Curhollow soil in an area of Curhollow-Rolie-Meriwhitica association, 1 to 35 percent slopes. The background shows plateaus and mesas typical of the area.

Figure 7.—Ponderosa pine in an area of Turkeytrack gravelly loam, 1 to 6 percent slopes, in MLRU 39-1AZ.

sagebrush, and mountain big sagebrush.

This MLRU is used for commercial timber cutting. It is also used for recreational purposes, such as hiking, camping, fishing, and hunting. Additionally, this unit provides grazing for livestock during the summer months.

This MLRU makes up only about 4 percent of the survey area. The majority of the soils in this unit in the survey area are high in clay and range from very shallow to very deep. The major soils are Pinntank, Pocomate, and Theecan soils. The minor soils are Retsover and Turkeytrack soils on mesas and Pinespring and Sponiker soils in draws and on stream terraces.

Geologic History

The northern edge of the survey area contains an extensive geologic record expressed within the deeply entrenched Grand Canyon. The Grand Canyon is unique, not only because of its scenic beauty but also because it is the most complete and well preserved stratigraphic column in the world. From the bottom of the canyon to the top, the different layers of rock represent the history of the earth from about 2 billion years ago to the present day. Figure 8 shows a complete stratigraphic section of the Grand Canyon on the northern edge of the survey area.

The first rocks on the earth's surface formed about 4 billion years ago in the Precambrian Period. At this time, the continents were merely thin crusts of rock floating on a magma ocean. Eventually, when the earth cooled and moisture condensed, the rock began to weather. The first eroded sediments were formed into rock about 2 billion years ago as the result of heat and pressure over time. The hardened sediments were uplifted, tilted, and exposed to further heat and pressure. These altered, or metamorphic, rocks of Precambrian age are exposed in the bottom of the Grand Canyon and lower Peach Springs Canyon. These rocks are called the Vishnu Group and consist of schist and gneiss with granitic intrusions.

About 600 to 500 million years ago, the Precambrian age continents were covered by shallow seas. Sediments deposited during advancement and recession of the Cambrian age seas formed the Tapeats Sandstone, Bright Angel Shale, and the Muav Limestone formations of the Tonto Group. These rocks can be seen in the lower reaches of Peach Springs Canyon.

There are no rocks in the Grand Canyon formed during the Ordovician Period (500 to 400 million years ago) or the Silurian Period (440 to 400 million years ago). One theory is that the area was no longer under water and no sediments were deposited or the deposited sediments were eroded away. The lack of sediment deposition is called a hiatus and is an unconformity in the stratigraphic column (Collier, 1980).

About 400 million years ago this area was again invaded by shallow seas. Devonian age sediments, which formed the Temple Butte Limestone, were deposited. Following the Devonian Period, a hiatus in deposition occurred for about 150 million years. Then about 350 to 325 million years ago, this area was submerged again during the Mississippian Period. Fossils indicate that this area was a shallow, warm, tropical sea. Calcium carbonate and other sediments deposited in this area formed the Redwall Limestone that consistently forms massive, vertical cliffs 500 to 800 feet high about midway up the canyon wall. The cliff face is usually stained red by iron oxide material washed down from the red beds of the overlying Supai Group.

During the Pennsylvanian and early Permian Periods, 325 to 300 million years ago, four formations of the Supai Group were deposited in a low, swampy environment of continental, shoreline, and shallow marine origin. A broad variety of lithologies including sandstone, mudstone, conglomerate, and limestone occur in this group and contain a large amount of iron oxide, which imparts a tan to bright red color that is characteristic of these formations. The four formations, in ascending order, are the Watahomigi, the Manakacha, the Wescogame, and the Esplanade Sandstone Formations. The Esplanade Sandstone Formation forms a broad flat terrace, called a structural bench, that is located midway up the canyon (Harris and Tuttle, 1983).

In ascending order, the Hermit Shale, Coconino Sandstone, Toroweap Formation, and Kaibab Limestone were all deposited during the Permian Period, 280 to 240 million years ago (Nations and Stump, 1981). The Hermit Shale was deposited in a low, swampy environment and is composed of red sloping, erodible siltstones. The Coconino Sandstone formed from desert sand dunes. It exhibits strong crossbedding in tan and buff vertical cliffs below the canyon rim. The overlying Toroweap Formation consists of sloping beds of sandstone, limestone, and gypsum. It marks the advance and recession of a western sea. The uppermost Kaibab Limestone was deposited by the return of this western sea. Its tan cliffs and ledges comprise the uppermost layer of the Grand Canyon rock sequence. The Kaibab Limestone underlies much of the surface of the Coconino Plateau in the eastern parts of the survey area.

Additional rock formations were deposited in the Grand Canyon area during the Triassic, Jurassic, and Cretaceous Periods (240 to 63 million years ago). However, these layers have been eroded from the surface. It is estimated that more than 4,000 feet of material has been removed as a result of extensive erosion since Cretaceous time (Breed and Roat, 1974). In the western part of the survey area, the Pennsylvanian and Permian rocks have also been removed, exposing the Redwall Limestone and Muav Limestone as surface rock on the Hualapai Plateau.

The entire region was uplifted with very little deformation during Miocene time (20 million years ago). The survey area is located on a large part of this uplifted crust known as the Colorado Plateau.

During the last several million years the Colorado River and its tributaries have been cutting into the underlying rock, forming the presently entrenched Grand Canyon. The ancestral Colorado River may have flowed in its present course as far as the eastern end of the Grand Canyon, and then it either continued southeastward along the present course of the Little Colorado River or it crossed the Kaibab Plateau along its present course.

The uplifting of the Colorado Plateau caused cracks in

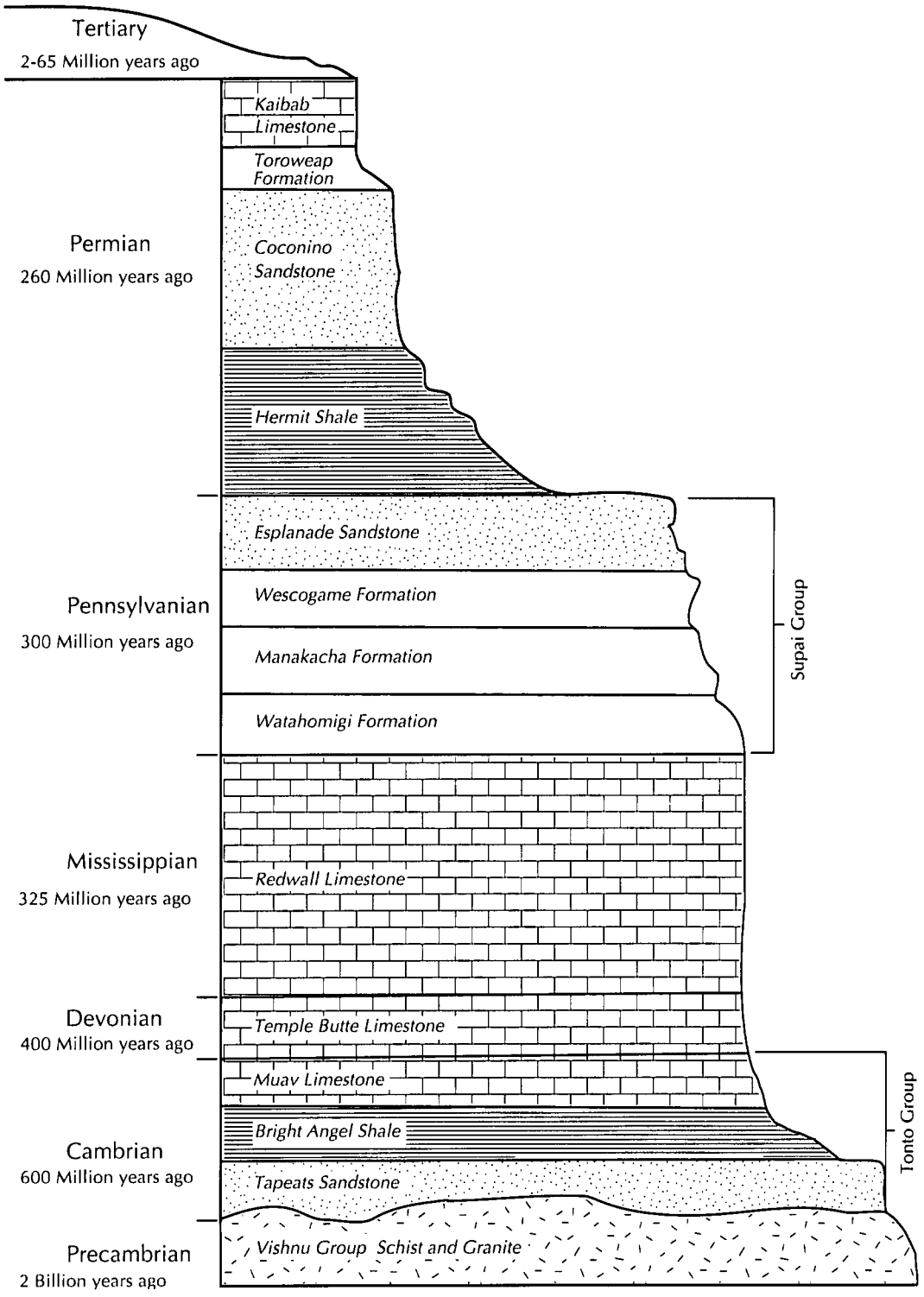

Figure 8.—Stratigraphic column of the Grand Canyon exhibiting the major geologic formations in the survey area.

the earth's crust that produced conditions conducive to volcanism all over the southwestern United States. Volcanism began about 3 million years ago with a few cinder cones in the northeastern part of the Hualapai Reservation and extensive lava flows in the western part.

Important Tertiary age formations are alluvial in origin. They include the Music Mountain Conglomerate, the Willow Springs Formation, the Buck and Doe

Conglomerate, and the Frazier Well Gravels. These formations occur mostly in the southern and western parts of the Hualapai Reservation (Young, 1966).

The most recent sedimentary deposits in the survey area are Quaternary in age and range from recently deposited sediments to sediments that are about 2 million years old. These deposits include alluvium in stream terraces, flood plains, alluvial fans, and fan terraces.

How This Survey Was Made

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

The soils and miscellaneous areas in the survey area are in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils 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 the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil 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, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. 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 and for engineering tests. Soil scientists interpret the data from these analyses and tests 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. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

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

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

The descriptions, names, and delineations of the soils in this survey area do not fully agree with those of the soils in adjacent survey areas. Differences are the result of a better knowledge of soils, modifications in series concepts, or variations in the intensity of mapping or in the extent of the soils in the survey areas.

Map Unit Composition

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

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

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

Formation of the Soils

Processes of Soil Formation

Soils are dynamic, natural bodies on the earth's surface that are capable of supporting terrestrial plants. They are composed of mineral and organic constituents, as well as dilute solutions, gaseous mixtures, and micro-organisms. Soils are dynamic in that they exist as the result of a combination of processes occurring in the environment and they respond to changes in the environment. Some responses are immediate, such as water content and micro-organism activity after a rain. Some responses take a great deal of time to be detectable, such as the development of soil morphology.

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

Some soils may have horizons that are not pedogenic. Such horizons in a soil profile may have differing physical and chemical characteristics. They have not formed as the result of pedogenic processes but are the result of geologic processes such as flooding or landslides. Nonpedogenic soil horizons usually indicate a young soil. Well developed pedogenic soil horizons usually indicate an old soil. In areas of active deposition, such as flood plains, a soil that is old enough to have developed pedogenic soil horizons may be buried by a younger sediment. These soils are called buried soils or paleosols.

Factors of Soil Formation

There are five environmental factors that affect soil formation. These factors are parent material, climate, living organisms, topography, and time. Tremendous diversity exists in soil morphology as a result of unique combinations of these factors. Soil horizons are constantly forming or changing in response to these environmental factors over time. All of the factors are related, and no individual factor can completely determine a soil property. The factors are discussed in the following sections.

Parent Material

Parent material is the mineral and organic material in which soils form. It can be derived in place from weathered bedrock or transported by wind, water, or gravity. The influence of parent material is accounted for in soil taxonomy by mineralogy and particle size classes. Criteria for each class is defined in Soil Taxonomy (USDA, 1975).

Residuum is the unconsolidated mineral material that accumulates in place as bedrock disintegrates. The kind of rock from which the residuum has been weathered greatly determines the properties and characteristics of a soil formed in it. Residuum derived from sandstone usually has large amounts of sand. Parent materials derived from shale have large amounts of clay and low amounts of sand. Many types of shale may contain large amounts of sodium, gypsum, or sulphur bearing minerals. These parent materials can cause many problems for all kinds of soil uses. Basalt rocks usually form soils that have large amounts of clay. Limestone rocks form residuum that has variable amounts of clay depending on the composition of the rock.

Alluvium is unconsolidated sediment deposited by water. It includes deposits made by rivers, creeks, and

intermittent streams and materials at the base of mountains forming alluvial fans, fan terraces, and bajadas.

Colluvium is material transported by gravity. Materials sloughed downhill as the result of landslides are one example of colluvium. On steep mountain slopes, materials may slowly creep downhill even if abundant vegetation exists. Occasionally, trees may even bend downslope as the result of soil creep.

Eolian materials are materials transported by wind. In the survey area, eolian deposits are very thin and commonly overlie other parent materials in many locations.

Most of the map units in the survey area contain soils formed in alluvium on stream terraces, flood plains, alluvial fans, and fan terraces. Most of the soils on stream terraces and flood plains are very deep, but many of the soils on fan terraces and plateaus are shallow or moderately deep to an indurated, calcium carbonate cemented hardpan or bedrock. Examples of soils formed in alluvium on fan terraces are Havasupai and Milkweed soils. Examples of soils formed in alluvium on stream terraces and flood plains are Cowan family, Jacques, Arizo, Lostman, and Naha soils. Natank soils are an example of a plateau soil derived from local alluvium.

Parent material can influence the development of soil horizons. Several map units in the survey area are comprised of soils formed in residuum. It is postulated that the variable porosity of the Kaibab Limestone is related to the presence or absence of argillic horizons (zones of secondary clay accumulation) in the survey area. In areas where the limestone has been leached of calcium carbonate, a porous crystal framework that is conducive to clay illuviation results. In areas where the limestone is more compacted, the nonporous bedrock inhibits the removal of calcium carbonate, which in turn retards the development of argillic horizons (Levine and Hendricks, 1989). Examples of soils formed in the Kaibab Limestone are Yumtheska and Pinntank soils. Soils formed in the Redwall Limestone are Curhollow and Meriwhitica soils.

A few of the soils in the survey area formed in residuum derived from volcanic rock. These are Prieta, Wyva, Luzena, and Thunderbird soils. Wukoki and Lomaki soils formed in volcanic cinders and are very deep. Some map units consist of soils formed in colluvium derived from formations exposed on steep canyon walls. Examples of these soils are Tovar and Hermshale soils.

Climate

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

Climate is used to classify soils based on the temperature and moisture regime in which they occur. A soil temperature regime is based on the mean annual temperature of the soil at a depth of 50 centimeters. If bedrock or another hard layer occurs at a depth of less than 50 centimeters, the temperature used is the average at the top of the bedrock or hard layer. The average annual soil temperature in the survey area is about 2 degrees warmer than the average annual air temperature. For example, a mesic soil temperature regime means that the mean annual soil temperature is not lower than 8 degrees C or higher than 15 degrees C.

Soil moisture regimes are based on the amount of time that the soil profile is moist and the time of year that rainfall occurs. Generally, if the soil is dry most of the year, the soil has an aridic moisture regime. If the soil is frequently moist in most years and the rainfall occurs mostly during the growing season, the soil has an ustic moisture regime. If the soil is frequently moist and the precipitation occurs in the winter when plant growth is minimal, the soil has a xeric moisture regime. Intergrades are allowed, such as aridic-xeric or ustic-aridic. These are defined in Soil Taxonomy. The mean soil temperature and the amount of precipitation is given for each soil and each map unit in the detailed descriptions.

The present climate of the Hualapai and Havasupai Reservations is semi-arid. The variation in precipitation and temperature is directly related to differences in elevation.

The warmest and driest areas are in the canyon bottoms. They have a mean annual precipitation of 8 to 12 inches and a mean annual soil temperature of 60 to 70 degrees F. Elevations are typically less than 5,000 feet. The soil climate class in the canyons is aridic and thermic. Examples of soils in this climate class are Nickel family, Splanod, and Arizo soils.

Precipitation increases and temperature decreases on the higher surfaces of the Hualapai and Coconino Plateaus. At elevations of about 5,100 to 6,100 feet, precipitation ranges from 10 to 14 inches and average annual soil temperature is commonly 54 to 58 degrees F. Soils in this region have ustic-aridic moisture regimes and mesic temperature regimes. Examples are Winona, Tusayan, Curhollow, and Puertecito soils.

At elevations of about 4,000 to 7,200 feet, precipitation increases and soil temperature decreases slightly.

Precipitation ranges from to 14 to 18 inches, and soil temperature ranges from 48 to 58 degrees F. Soil climate is classified as aridic-ustic and mesic. Examples are Bleumont, Natank, and Frazwell soils.

The highest elevations, 6,200 to more than 7,900 feet, receive an average of 18 to 20 inches of precipitation per year and have mean annual soil temperatures of 45 to 54 degrees F. These soils have ustic moisture regimes and mesic temperature regimes. Examples are Theecan and Pinntank soils.

Past climate has also played a major role in the formation of soils in the survey area. Paleosols that developed during wetter periods occur as both relict and buried features. Examples of these soils are Bleumont and Milkweed soils, which have highly developed pedogenic horizons of clay and lime accumulation.

Living Organisms

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

Plants are the major influence of living organisms on soil formation. They provide a source of organic matter, create pores and channels with roots, protect soil from erosion, and influence physical and chemical soil properties with their decomposed residue. Distinct plant communities are found at every elevation in the survey area due to differences in moisture, temperature, and kind of soil.

In the aridic thermic soils of the canyons, vegetation consists dominantly of desert shrubs, cacti, and grasses. Biomass production is low and soils are typically light colored and low in organic matter content. Examples are Arizo, Lostman, and Naha soils. Small areas of riparian communities exist along water sources, which have water tables that are within reach of roots.

The ustic-aridic mesic soils of the plateaus dominantly support grasslands. Fibrous root systems add organic matter to the soil as they decompose, darkening the soil color significantly. Juniper and pinyon woodlands that are low in production occur on shallow, rocky soils. The deep tap roots work through fractures in the underlying bedrock. Examples of such soils are Plaintank, Winona, Barx, Curhollow, and Poley soils.

At the higher elevations, pinyon-juniper woodlands and grasslands with sagebrush occur on aridic-ustic mesic soils. The sagebrush and grass vegetation add significant amounts of organic matter to the soil. In some soils mollic epipedons may have formed. These surface soil horizons have large amounts of organic matter and very dark colors. Examples of soils with mollic epipedons are Frazwell and Yumtheska soils.

Ponderosa pine forest grows in the highest elevations on ustic mesic soils. Mollic epipedons are common in level and concave landscape positions. Layers of clay accumulation in the subsoil called argillic horizons are well developed and often underlie a thin eluvial horizon. Acidic pine litter influences leaching processes and soil reaction. Organic acids have leached the upper subsoils of calcium carbonate even though they developed in limestone parent material. Examples are Pinntank and Retsover soils.

Topography

Topography influences soil development through its effect upon water movement and stability of soil material. Steep slopes increase surface water runoff and water erosion. Soils on steep and very steep slopes are often unstable, and water erosion occurs faster than the processes of soil development. Wind erosion is also significant in the survey area. Soils on steep slopes are commonly shallow and have poorly developed soil horizons. Many of these soils occur on canyon walls and escarpments. Examples are Metuck, Meriwhitica, and Hindu soils. Some of the soils on the very steep canyon walls are so variable that it is not possible to classify them into a specific series. They are called Torriorthents or Ustorthents, depending on their soil moisture regime.

Soils on the lesser slopes tend to be more stable and develop distinct soil horizons over time. Surface runoff collects in level to concave areas from adjoining uplands, where organic matter and sediments accumulate. In these areas of alluvial deposition, the surface horizons are somewhat thicker and higher in organic matter and may form mollic epipedons. For example, Frazwell soils are very deep soils that occur in slightly concave positions. They have a thick dark surface layer that is rich in organic matter and is derived from adjacent slopes. Natank soils are another example of stability. They have developed a strong horizon of clay accumulation over long periods of time.

Time

Time as a soil forming factor refers to the duration that a parent material has been in place and influenced by the other soil forming factors. Generally, the older and more stable a soil is, the more developed the morphology will be. For example, unprotected soils on steep slopes and soils

in active flood plains are unstable and subject to erosion. Therefore, they are generally young soils. They have few, if any, pedogenic soil horizons.

Examples of very young soils are Arizo soils and Cowan family soils. They do not have pedogenic soil horizons. They have different layers in their soil profiles, but the layers are the result of geologic deposition. These soils occur in very active and unstable environments such as flood plains and alluvial fans. In these areas erosion and deposition occur so frequently that time is insufficient for the soil forming factors to form pedogenic soil horizons.

Bleumont soils are an example of a very old soil. These soils formed in alluvium on fan terraces. They have horizons that are high in clay and calcium carbonate. These layers formed as the result of pedogenic processes over long periods of time.

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

General Soil Map Units

The general soil map at the back of this publication shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit on the general soil map is a unique natural landscape. Typically, it consists of one or more major soils and some minor soils or miscellaneous areas. It is named for the major soils or miscellaneous areas. The soils or miscellaneous areas making up one 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 or miscellaneous areas can be identified on the map. Likewise, areas that are not suitable can be identified.

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

Warm, Arid Soils in Canyons and on Mesa Rims

This group consists of two map units. It makes up about 29 percent of the survey area. The vegetation in most areas is desert shrubs and blackbrush. This group is in MLRU 30-2AZ (Grand Canyon Desert Shrub). Elevation is 2,000 to 5,000 feet. Mean average soil temperature is 59 to 70 degrees F, and mean annual precipitation is 8 to 12 inches.

1. Rock outcrop-Torriorthents-Splanod

Very shallow to very deep, excessively drained to well drained, nearly level to very steep, variable textured and gravelly loamy soils; on canyon escarpments, mesas, and structural benches (fig. 9)

Setting

Location: The Grand Canyon of the Colorado River and the major canyon tributaries
Landform: Canyon escarpments, structural benches
Flooding: Minor soils are subject to occasional brief flooding
Slope range: 2 to 120 percent
Elevation: 2,000 to 5,000 feet
Mean annual precipitation: 8 to 12 inches
Mean annual soil temperature: 59 to 62 degrees F
Frost-free period: 130 to 200 days
Major Land Resource Unit: 30-2AZ (Grand Canyon Desert Shrub)
Vegetation: Blackbrush, desert needlegrass, black grama, Indian ricegrass, bush muhly
Wildlife: Desert bighorn sheep, kit fox, Gambel's quail, willow flycatcher, canyon wren

Composition

Percent of the survey area: 22
Rock outcrop—60 percent
Torriorthents—25 percent
Splanod and similar soils—10 percent
Minor soils—5 percent

Soil Properties and Qualities

Torriorthents

Landform: Canyon escarpments
Slope range: 35 to 120 percent
Parent material: Colluvium and residuum derived from sedimentary rocks
Textural class: Variable
Depth class: Very shallow to very deep
Drainage class: Excessively drained to well drained
Runoff: Very rapid
Permeability: Moderate to rapid

Splanod

Landform: Mesas or structural benches
Slope range: 2 to 15 percent
Parent material: Residuum and colluvium derived from sandstone
Textural class: Gravelly loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Potential rooting depth: 6 to 20 inches
Runoff: Medium to rapid
Permeability: Moderate

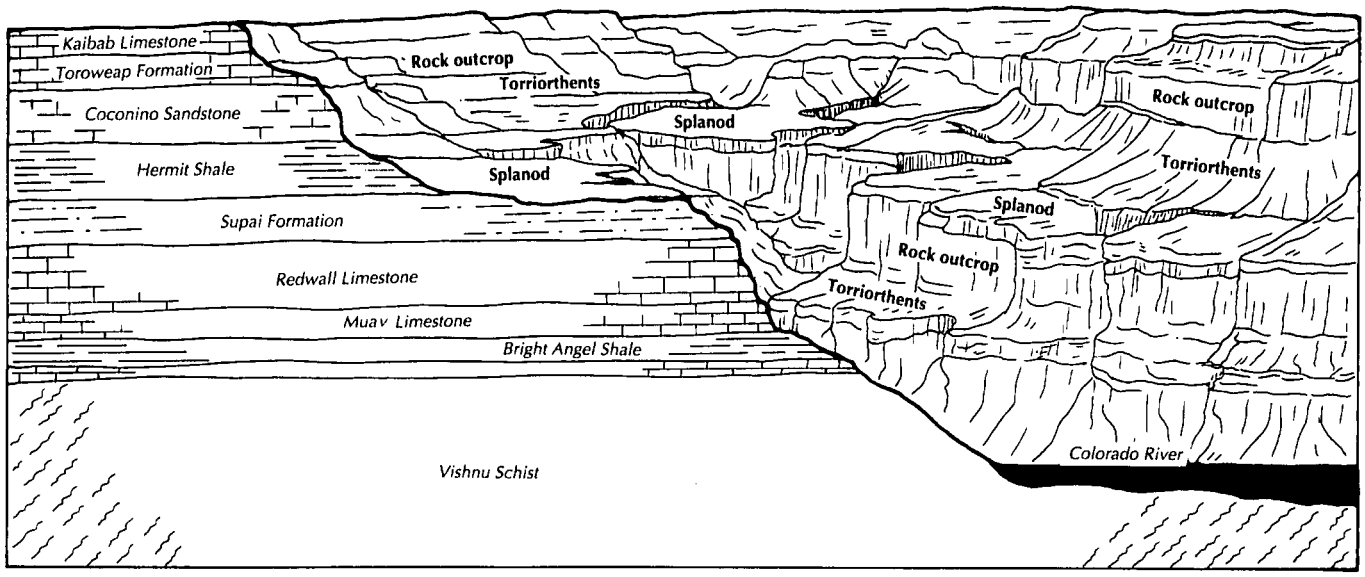

Figure 9.—Typical pattern of soils and parent material in the Rock outcrop-Torriorthents-Splanod general soil map unit in the Grand Canyon. Splanod soils are on the structural bench known as the Esplanade, on the uppermost member.

Minor soils

- Very deep, very cobbly sandy Arizo soils on flood plains that are subject to rare flooding
- Very deep, gravelly loamy Lostman soils on stream terraces
- Very deep, sandy Cowan family soils and sandy over loamy Naha soils on flood plains that are subject to occasional brief flooding
- Moderately deep to a hardpan, cobbly loamy Harrisburg soils on stream terraces that are subject to rare flooding
- Very deep, loamy Lostman family soils on stream terraces that are subject to rare flooding
- Very deep, cindery, Wukoki and Lomaki soils on cinder cones

Use and Management

Major uses: Wildlife habitat and recreation
Major management factors: Extremely steep slopes, inaccesible areas, shallow depth to rock

2. Hindu-Rock outcrop-Nickel family

Very shallow to very deep, well drained, nearly level to steep, very gravelly loamy and extremely gravelly loamy soils; on hills, mesas, and fan terraces

Setting

Location: Bordering major canyons and in ancient alluvial deposits of tributaries to the Grand Canyon
Landform: Hills, mesas, and fan terraces
Flooding: Minor soils are subject to occasional flooding
Slope range: 2 to 45 percent
Elevation: 3,700 to 4,800 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 60 to 70 degrees F
Frost-free period: 175 to 220 days
Major Land Resource Unit: 30-2AZ (Grand Canyon Desert Shrub)
Vegetation: Blackbrush, banana yucca, black grama
Wildlife: Desert bighorn sheep, kit fox, Gambel's quail, willow flycatcher, canyon wren

Composition

Percent of the survey area: 7
Hindu soils—55 percent
Rock outcrop—20 percent
Nickel family—15 percent
Minor soils—10 percent

Soil Properties and Qualities

Hindu

Landform: Hills and mesas
Slope range: 5 to 45 percent
Parent material: Residuum and colluvium derived from calcareous sedimentary rock
Textural class: Very gravelly loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Runoff: Rapid to very rapid
Permeability: Moderate

Nickel family

Landform: Fan terraces
Slope range: 2 to 35 percent
Parent material: Mixed alluvium
Textural class: Extremely gravelly loamy
Depth class: Very deep
Drainage class: Well drained
Runoff: Medium to rapid
Permeability: Moderate

Minor soils

- Very deep, very gravelly sandy Arizo soils on flood plains that are subject to occasional brief flooding

Use and Management

Major use: Rangeland
Major management factors: High content of rock fragments, steep slopes, droughtiness, shallow depth to rock

Cool, semi-arid soils in canyons and on plateaus and hills

This group consists of four map units. It makes up about 26 percent of the survey area. The vegetation in most areas is grass and desert shrubs. Scattered pinyon and juniper occur at the higher elevations. This group is in MLRU 35-1AZ (Colorado Plateau Mixed Grass Plains). Elevation is 4,000 to 7,200 feet. Mean annual soil temperature is 48 to 58 degrees F, and mean annual precipitation is 10 to 18 inches.

3. Curhollow-Rolie-Meriwhitica

Very shallow and shallow, well drained, nearly level to steep, extremely cobbly loamy and cobbly loamy soils; on hills, mesas, fan terraces, and plateaus

Setting

Location: Hualapai Plateau, north and east of the Music Mountains
Landform: Mesas, fan terraces, and plateaus
Slope range: 1 to 35 percent
Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 55 to 58 degrees F
Frost-free period: 135 to 175 days
Major Land Resource Unit: 35-1AZ (Colorado Plateau Mixed Grass Plains)
Vegetation: Blackbrush, black grama, Stansbury cliffrose
Wildlife: Pronghorn antelope, golden eagle, red-tailed hawk

Composition

Percent of the survey area: 7
Curhollow soils—35 percent
Rolie soils—20 percent
Meriwhitica—15 percent
Minor soils—30 percent

Soil Properties and Qualities

Curhollow

Landform: Mesas and plateaus
Slope range: 1 to 25 percent
Parent material: Colluvium and residuum derived from limestone
Textural class: Extremely cobbly loamy
Depth class: Shallow
Drainage class: Well drained
Runoff: Medium to very rapid
Permeability: Moderate

Rolie

Landform: Fan terraces
Slope range: 1 to 15 percent
Parent material: Limestone alluvium
Textural class: Cobbly loamy
Depth class: Very shallow and shallow to a hardpan
Drainage class: Well drained
Runoff: Medium to rapid
Permeability: Moderate

Meriwhitica

Landform: Mesas and plateaus
Slope range: 1 to 35 percent
Parent material: Limestone residuum
Textural class: Extremely cobbly loamy
Depth class: Very shallow
Drainage class: Well drained
Runoff: Medium to very rapid
Permeability: Moderate

Minor soils

- Moderately deep, gravelly loamy Sazi soils on mesas
- Shallow, extremely cobbly clayey Prieta soils on mesas
- Very deep, very gravelly loamy Saemo soils on fan terraces

Use and Management

Major use: Rangeland
Major management factors: Shallow depth to calcium carbonate cemented hardpan or bedrock, extremely cobbly and extremely gravelly surface layers, steep slopes

4. Rolie-Poley-Peachsprings

Very shallow to very deep, well drained, nearly level to moderately steep, gravelly loamy and clayey soils; on fan terraces

Setting

Location: Southern and eastern parts of the Hualapai Reservation
Landform: Fan terraces
Flooding: None
Slope range: 1 to 20 percent
Elevation: 4,300 to 6,100 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 53 to 58 degrees F
Frost-free period: 135 to 175 days
Major Land Resource Unit: 35-1AZ (Colorado Plateau Mixed Grass Plains)
Vegetation: Blue grama, bottlebrush squirreltail, fourwing saltbush
Wildlife: Pronghorn antelope, coyote, red-tailed hawk, golden eagle

Composition

Percent of the survey area: 10
Rolie and similar soils—35 percent
Poley and similar soils—30 percent
Peachsprings and similar soils—15 percent
Minor soils—20 percent

Soil Properties and Qualities

Rolie

Landform: Fan terraces
Slope range: 1 to 20 percent
Parent material: Limestone alluvium
Textural class: Gravelly loamy
Depth class: Very shallow and shallow to a hard pan
Drainage class: Well drained
Runoff: Medium to very rapid
Permeability: Moderate

Poley

Landform: Fan terraces
Slope range: 1 to 8 percent
Parent material: Limestone and sandstone alluvium
Textural class: Clayey
Depth class: Very deep
Drainage class: Well drained
Runoff: Medium
Permeability: Slow

Peachsprings

Landform: Fan terraces
Slope range: 2 to 15 percent
Parent material: Mixed alluvium
Textural class: Gravelly loamy
Depth class: Very deep
Drainage class: Well drained
Runoff: Medium
Permeability: Moderately slow

Minor soils

- Very deep, gravelly loamy Dean soils on fan terraces
- Shallow to a hardpan, extremely gravelly loamy Havasupai soils on fan terraces

Use and Management

Major use: Rangeland
Major management factors: Rolie—shallow calcium carbonate cemented hardpan; Poley—high shrink-swell potential; Peachsprings—high content of calcium carbonate

5. Rizno-Ustorthents-Rock outcrop

Very shallow to very deep, well drained, nearly level to very steep, loamy and variable textured soils; on canyon escarpments and structural benches (fig. 10)

Setting

Location: Along the Colorado River and tributaries and on steep escarpments on sides of canyons
Landform: Canyon escarpments and structural benches
Flooding: None
Slope range: 2 to 90 percent
Elevation: 4,000 to 7,200 feet
Mean annual precipitation: 10 to 18 inches
Mean annual soil temperature: 48 to 58 degrees F
Frost-free period: 120 to 180 days
Major Land Resource Unit: 35-1AZ (Colorado Plateau Mixed Grass Plains)
Vegetation: Black grama, blackbrush, desert needlegrass, Utah juniper, singleleaf pinyon
Wildlife: Desert bighorn sheep, coyote, Gambel's quail

Composition

Percent of the survey area: 6
Rizno soils—25 percent
Ustorthents soils—25 percent
Rock outcrop—20 percent
Minor soils—30 percent

Soil Properties and Qualities

Rizno

Landform: Structural benches
Slope range: 2 to 15 percent

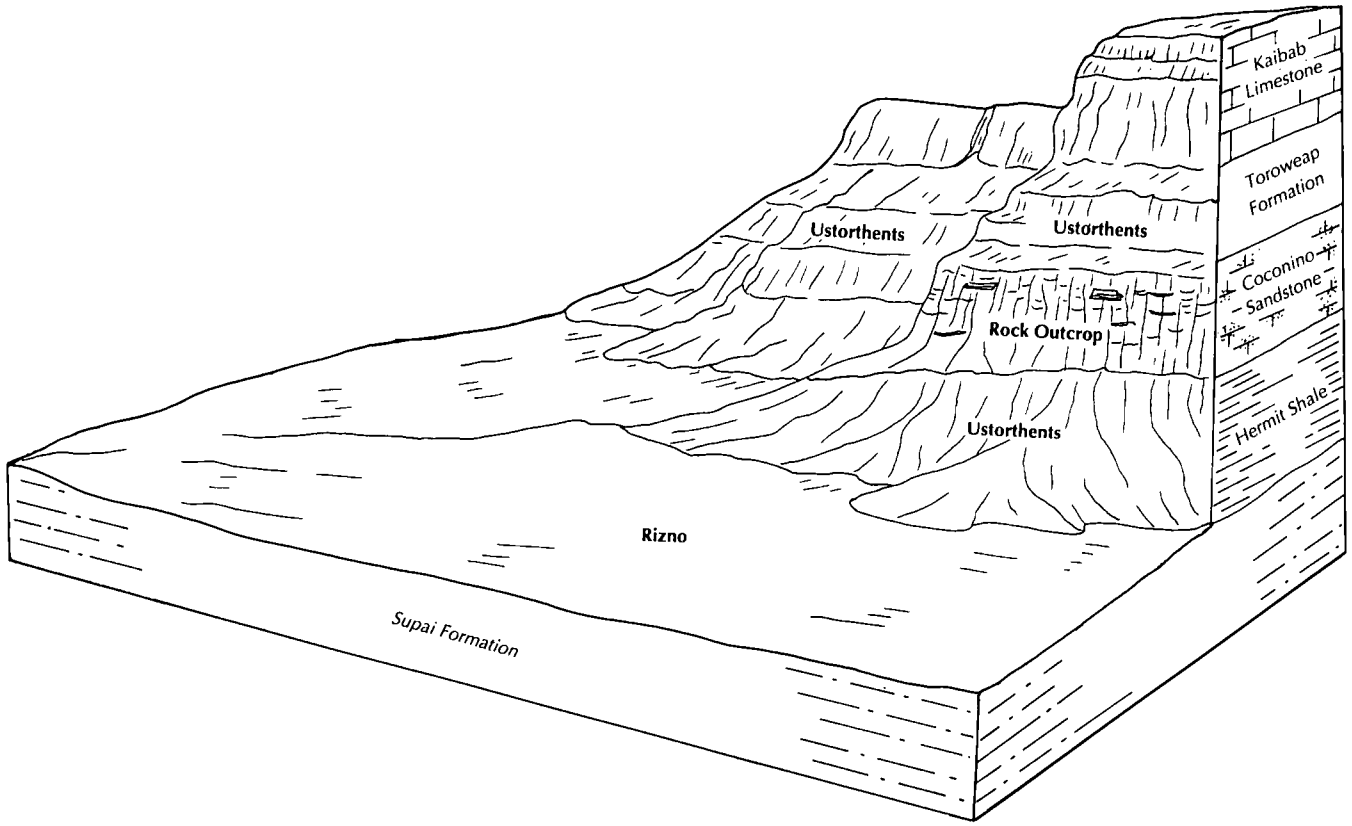

Figure 10.—Typical pattern of soils and parent material in the Rizno-Ustorthents-Rock outcrop general soil map unit. This unit occurs at the highest elevations of the Grand Canyon and its major tributaries.

Parent material: Eolian deposits and alluvium and residuum derived from sandstone
Textural class: Loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Runoff: Medium to rapid
Flooding: None
Permeability: Moderately rapid

Ustorthents

Landform: Canyon escarpments
Slope range: 35 to 90 percent
Parent material: Alluvium, residuum, and colluvium derived from sedimentary rock
Textural class: Variable
Depth class: Very shallow to very deep
Drainage class: Well drained
Runoff: Very rapid
Permeability: Moderate to rapid

Minor soils

- Shallow, extremely gravelly loamy Winona soils on hills

Use and Management

Major uses: Rangeland and wildlife habitat
Major management factors: Steep slopes, high content of rock fragments, droughtiness, inaccesibility

6. Winona-Curhollow

Very shallow and shallow, well drained, nearly level to very steep, very cobbly loamy soils; on hills

Setting

Location: Southern parts of the Hualapai Reservation
Landform: Hills
Flooding: Minor soils are subject to rare flooding
Slope range: 1 to 55 percent
Elevation: 5,100 to 6,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days
Major Land Resource Unit: 35-1AZ (Colorado Plateau Mixed Grass Plains)

Vegetation: Blue grama, Stansbury cliffrose, Colorado pinyon, Utah juniper
Wildlife: Mule deer, gray fox, red-tailed hawk

Composition

Percent of the survey area: 3
Winona soils—60 percent
Curhollow soils—25 percent
Minor soils—15 percent

Soil Properties and Qualities

Winona

Landform: Hills
Slope range: 1 to 55 percent
Parent material: Limestone residuum and colluvium
Textural class: Very cobbly loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Runoff: Medium to very rapid
Permeability: Moderate

Curhollow

Landform: Hills
Slope range: 1 to 8 percent
Parent material: Limestone residuum and colluvium
Textural class: Very cobbly loamy
Depth class: Shallow to a hardpan
Drainage class: Well drained
Runoff: Medium
Permeability: Moderate

Minor soils

- Very deep, loamy Quagwa soils in draws that are subject to rare flooding
- Shallow, very gravelly loamy Wyva family soils on hills
- Shallow to a hardpan, extremely cobbly loamy Plaintank soils on fan terraces
- Very deep, gravelly loamy and loamy Barx soils on fan terraces
- Shallow to a hardpan, gravelly loamy Havasupai soils on fan terraces
- Very deep, gravelly loamy Milok soils on fan terraces
- Shallow to a hardpan, gravelly loamy Pastern soils on fan terraces

Use and Management

Major use: Woodland
Major management factors: Low production of juniper-pinyon woodland, shallow depth to rock, droughtiness, high content of rock fragments

Cool, semi-arid soils with winter dominant moisture on plateaus and mesas

This group consists of only one map unit. It makes up about 9 percent of the survey area. The vegetation in most areas is Wyoming big sagebrush and grasses. This group is in MLRU 35-3AZ (Colorado Plateau Sagebrush-Grassland). Elevation is 5,100 to 6,100 feet. Mean annual soil temperature is 54 to 57 degrees F, and mean annual precipitation is 10 to 12 inches. Approximately 60 percent of the annual precipitation occurs during winter months.

7. Winona-Curhollow-Puertecito

Very shallow and shallow, well drained, nearly level to very steep, extremely gravelly loamy, very cobbly loamy, and very gravelly loamy soils; on plateaus, mesas, and hills (fig. 11)

Setting

Location: Mesas of the Havasupai Indian Reservation in the northeast part of the survey area
Landform: Plateaus, mesas, and hills
Flooding: None
Slope range: 1 to 55 percent
Elevation: 5,100 to 6,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days
Major Land Resource Unit: 35-3AZ (Colorado Plateau Sagebrush-Grassland)
Vegetation: Blue grama, Wyoming big sagebrush, muttongrass
Wildlife: Pronghorn antelope, coyote, red-tailed hawk, golden eagle

Composition

Percent of the survey area: 9
Winona and similar soils—35 percent
Curhollow and similar soils—30 percent
Puertecito and similar soils—15 percent
Minor soils—20 percent

Soil Properties and Qualities

Winona

Landform: Hills
Slope range: 15 to 55 percent
Parent material: Colluvium derived from limestone
Textural class: Extremely gravelly loamy
Depth class: Very shallow and shallow
Drainage class: Well drained

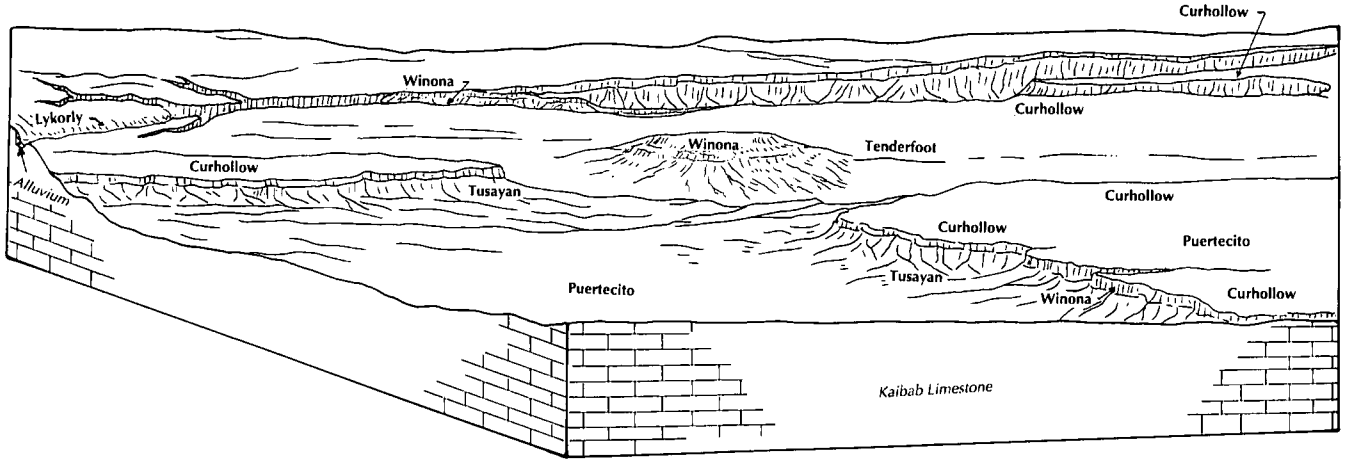

Figure 11.—Typical pattern of soils and parent material in the Winona-Curhollow-Puertecito general soil map unit.

Runoff: Very rapid
Permeability: Moderate

Curhollow

Landform: Plateaus and mesas
Slope range: 1 to 12 percent
Parent material: Colluvium derived from limestone
Textural class: Very cobbly loamy
Depth class: Shallow to a hardpan
Drainage class: Well drained
Runoff: Medium to rapid
Permeability: Moderate

Puertecito

Landform: Plateaus and mesas
Slope range: 1 to 12 percent
Parent material: Residuum and colluvium derived from limestone
Textural class: Very gravelly loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Runoff: Medium
Permeability: Moderately slow

Minor soils

- Moderately deep, very gravelly loamy Tusayan soils on hills
- Shallow to a hardpan, extremely cobbly loamy Tenderfoot soils on mesas
- Very deep, loamy Lykorly soils in drainageways
- Rock outcrop on ledges and escarpments

Use and Management

Major use: Rangeland
Major management factors: Very shallow and shallow depth to rock or hardpan, high content of rock fragments, steep slopes of Winona soils

Cool, dry-subhumid soils on plateaus and mesas

This group consists of four map units. It makes up about 32 percent of the survey area. The vegetation in most areas is pinyon and juniper woodland that has an understory of sagebrush and grasses. This group is in MLRU 39-3AZ (Grand Canyon Woodland-Shrub). Elevation is 4,500 to 6,600 feet. Mean annual soil temperature is 51 to 57 degrees F, and mean annual precipitation is 14 to 18 inches.

8. Wodomont-Milkweed-Luzena

Very shallow and shallow, well drained, nearly level to steep, extremely gravelly loamy, very gravelly loamy, and gravelly clayey soils; on hills, mesas, and fan terraces

Setting

Location: Western parts of the Hualapai Reservation
Landform: Hills, mesas, and fan terraces
Flooding: None
Slope range: 2 to 40 percent
Elevation: 4,600 to 5,500
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 57 degrees F
Frost-free period: 120 to 160 days
Major Land Resource Unit: 39-3AZ (Grand Canyon Woodland-Shrub)
Vegetation: Utah juniper, singleleaf pinyon, desert ceanothus, turbinella oak
Wildlife: Mule deer, elk, mountain lion, wild turkey

Composition

Percent of the survey area: 8
Wodomont soils—40 percent

Milkweed and similar soils—15 percent
Luzena and similar soils—15 percent
Minor soils—30 percent

Soil Properties and Qualities

Wodomont

Landform: Hills
Slope range: 5 to 40 percent
Parent material: Limestone residuum
Textural class: Extremely cobbly loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Runoff: Rapid to very rapid
Permeability: Moderate

Milkweed

Landform: Fan terraces
Slope range: 2 to 20 percent
Parent material: Alluvium derived from sedimentary and igneous rocks
Textural class: Very gravelly loamy
Depth class: Shallow to hardpan
Drainage class: Well drained
Runoff: Medium to rapid
Permeability: Moderate

Luzena

Landform: Hills and mesas
Slope range: 3 to 20 percent
Parent material: Basalt or rhyolite residuum and alluvium
Textural class: Gravelly clayey
Depth class: Shallow
Drainage class: Well drained
Runoff: Medium to very rapid
Permeability: Slow

Minor soils

- Very shallow and shallow, extremely flaggy clayey Grandwash soils on hills
- Moderately deep, cobbly clayey Thunderbird soils on hills and mesas
- Very deep, loamy Lykorly soils in draws and on stream terraces
- Very deep, clayey Disterheff soils in draws and on stream terraces and fan terraces
- Shallow and moderately deep, clayey Toqui and Tovar soils on plateaus
- Deep to a hardpan, gravelly loamy Buckndoe soils on fan terraces
- Moderately deep to a hardpan, loamy Quartermaster soils on fan terraces

Use and Management

Major use: Woodland

Major managment factors: Shallow depth to rock, steep slopes, very cobbly surface horizons; Luzena—high shrink-swell potential

9. Deama-Toqui

Very shallow and shallow, well drained, nearly level to very steep, very cobbly loamy and gravelly clayey soils; on mesas and canyon escarpments (fig. 12)

Setting

Location: Along the edges of the Coconino Plateau, near the Aubrey cliffs, Mohawk Canyon, National Canyon, and the Great Thumb Mesa
Landform: Mesas and canyon escarpments
Flooding: None
Slope range: 2 to 55 percent
Elevation: 5,000 to 6,600 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 120 to 160 days
Major Land Resource Unit: 39-3AZ (Grand Canyon Woodland-Shrub)
Vegetation: Utah juniper, Colorado pinyon, Stansbury cliffrose, Wyoming big sagebrush, muttongrass
Wildlife: Mule deer, mountain lion, gray fox, wild turkey, elk

Composition

Percent of the survey area: 10
Deama and similar soils—45 percent
Toqui and similar soils—35 percent
Minor soils—20 percent

Soil Properties and Qualities

Deama

Landform: Canyon escarpments
Slope range: 25 to 55 percent
Parent material: Limestone alluvium, colluvium, and residuum
Textural class: Very cobbly loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Runoff: Very rapid
Permeability: Moderate

Toqui

Landform: Mesas
Slope range: 2 to 30 percent
Parent material: Limestone residuum
Textural class: Gravelly clayey
Depth class: Shallow
Drainage class: Well drained

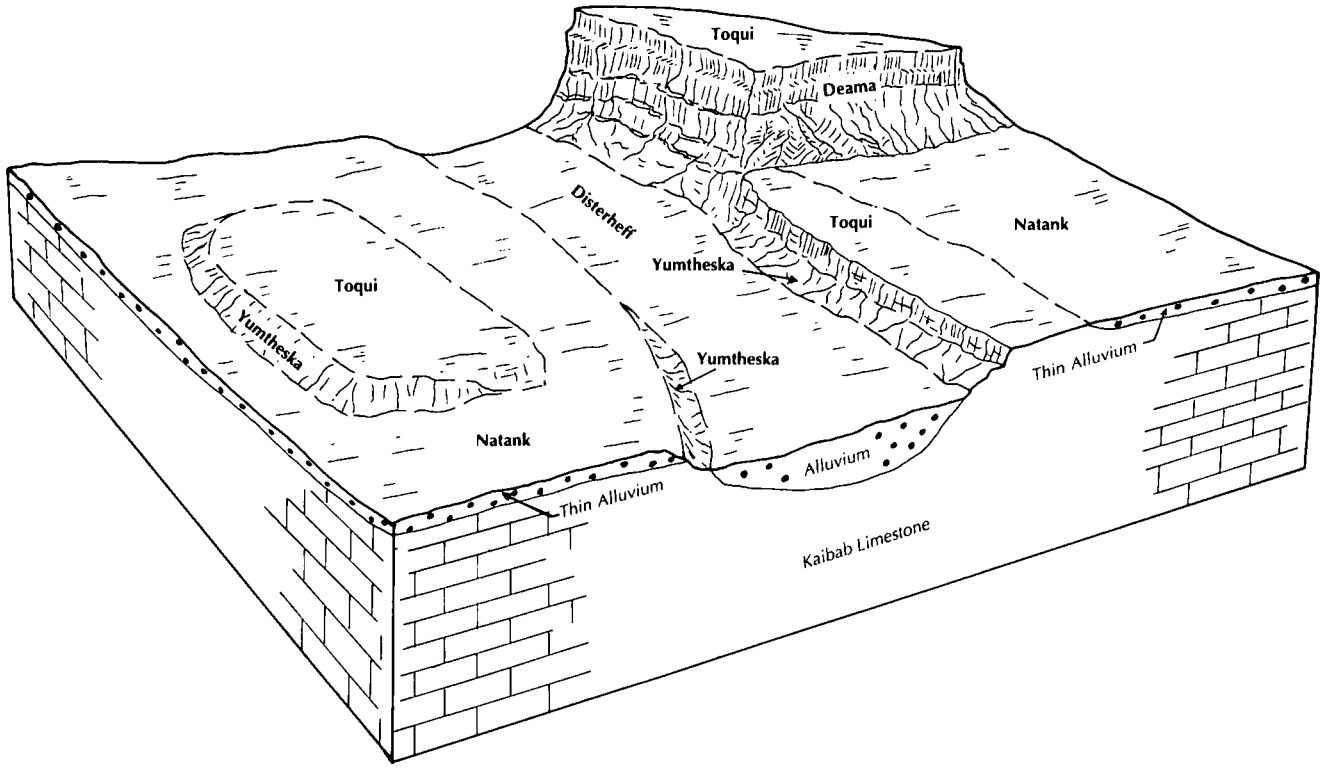

Figure 12.—Typical pattern of soils and parent material in the Deama-Toqui and Natank-Disterheff-Yumtheska general soil map units. The landscape is controlled by the underlying limestone, and soil components vary mainly in depth to rock and slope.

Runoff: Medium to very rapid
Permeability: Slow

Minor soils

- Very shallow and shallow, extremely cobbly loamy Wodomont soils on hills
- Shallow, extremely cobbly loamy Topocopa soils on plateaus and mesas
- Moderately deep, clayey Tovar soils on mesas
- Very shallow and shallow, very cobbly loamy Yumtheska soils on mesas

Use and Management

Major uses: Woodland and wildlife habitat
Major managment factors: Steep slopes, very shallow to shallow depth to rock, high rock fragment content

10. Metuck-Bleumont

Very shallow to very deep, well drained, nearly level to very steep, very channery loamy and clayey soils; on fan terraces and canyon escarpments

Setting

Location: Southeastern parts of the Hualapai Reservation, between Blue Mountain and the Tower of Babylon, along Robbers Roost Canyon near Frazier Well
Landform: Fan terraces and canyon escarpments
Flooding: Minor soils are subject to rare flooding
Slope range: 2 to 60 percent
Elevation: 4,500 to 5,900 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 120 to 170 days
Major Land Resource Unit: 39-3AZ (Grand Canyon Woodland-Shrub)
Vegetation: Colorado pinyon, Utah juniper, blue grama, turbinella oak, desert ceanothus
Wildlife: Elk, mule deer, wild turkey, red-tailed hawk

Composition

Percent of the survey area: 6
Metuck and similar soils—45 percent
Bleumont and similar soils—30 percent
Minor soils—25 percent

Soil Properties and Qualities

Metuck
Landform: Canyon escarpments
Slope range: 15 to 60 percent

Parent material: Calcareous sandstone residuum
Textural class: Very channery loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Runoff: Very rapid
Permeability: Moderate

Bleumont

Landform: Fan terraces
Slope range: 2 to 20 percent
Parent material: Alluvium derived from igneous and sedimentary rocks
Textural class: Clayey
Depth class: Very deep
Drainage class: Well drained
Runoff: Medium to rapid
Permeability: Slow

Minor soils

- Moderately deep, gravelly loamy Coconino soils on plateaus and mesas
- Moderately deep, flaggy clayey Tovar soils on structural benches
- Deep, clayey Hermshale soils on fan terraces
- Very deep, clayey Disterheff soils on fan terraces
- Very deep, loamy Frazwell and Jacques soils in draws and on stream terraces that are subject to rare flooding
- Very shallow and shallow, very gravelly loamy Wodomont soils on plateaus and mesas
- Very deep, loamy Hidvalle soils in draws

Use and Management

Major use: Woodland
Major management factors: Metuck—shallow depth to rock, high content of rock fragments, steep slopes; Bleumont—high content of cobbles on surface

11. Natank-Disterheff-Yumtheska

Very shallow to very deep, well drained, nearly level to steep, clayey and very cobbly loamy soils; on plateaus, fan terraces, and stream terraces (fig. 12)

Setting

Location: Coconino Plateau in the northeastern part of the survey area
Landform: On plateaus, fan terraces, and stream terraces
Flooding: Minor soils are subject to rare flooding
Slope range: 1 to 35 percent
Elevation: 5,600 to 6,600 feet
Mean annual precipitation: 14 to 18 inches
Mean annual soil temperature: 51 to 56 degrees F
Frost-free period: 130 to 160 days
Major Land Resource Unit: 39-3AZ (Grand Canyon Woodland-Shrub)
Vegetation: Utah juniper, Colorado pinyon, muttongrass, blue grama, and Wyoming big sagebrush
Wildlife: Mule deer, elk, wild turkey

Composition

Percent of the survey area: 8
Natank and similar soils—40 percent
Disterheff and similar soils—30 percent
Yumtheska and similar soils—15 percent
Minor soils—15 percent

Soil Properties and Qualities

Natank

Landform: Plateaus
Slope range: 2 to 15 percent
Parent material: Alluvium derived from calcareous sandstone
Textural class: Clayey
Depth class: Moderately deep
Drainage class: Well drained
Runoff: Medium
Permeability: Slow

Disterheff

Landform: Fan terraces and stream terraces
Slope range: 2 to 8 percent
Parent material: Alluvium derived from limestone and sandstone
Textural class: Clayey
Depth class: Very deep
Drainage class: Well drained
Runoff: Medium
Permeability: Slow

Yumtheska

Landform: Plateaus
Slope range: 3 to 35 percent
Parent material: Limestone residuum and alluvium
Textural class: Very cobbly loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Runoff: Medium to very rapid
Permeability: Moderate

Minor soils

- Very deep, loamy Lykorly soils on stream terraces
- Very deep, clayey Albers soils that are subject to rare flooding
- Very deep, very gravelly loamy Mextank soils on fan terraces

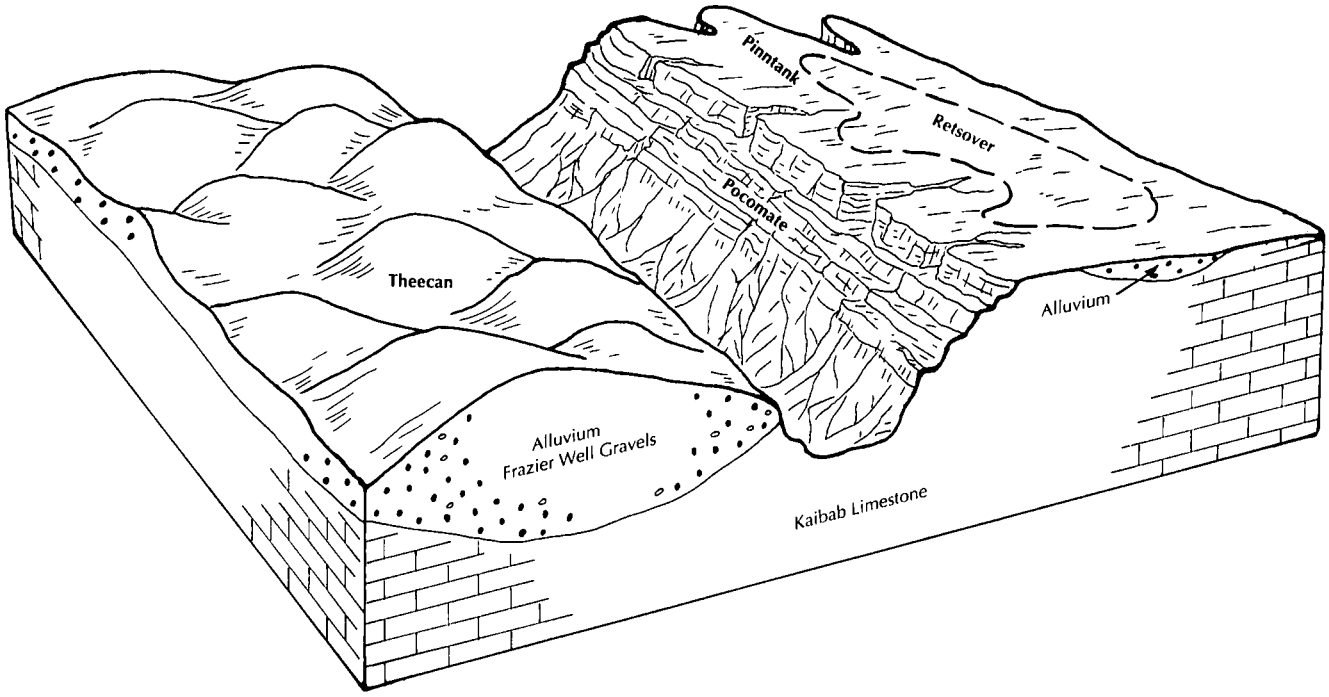

Figure 13.—Typical pattern of soils and parent material in the Pinntank-Pocomate-Theecan general soil map unit. Parts of the Coconino Plateau in the survey area are overlain by deep, alluvial deposits that have been uplifted and eroded into dissected hills. Theecan soils are derived from these deposits.

Use and Management

Major use: Woodland
Major management factors: Steep slopes; Natank and Disterheff—high shrink-swell potential, slow permeability; Yumtheska—high content of rock fragments

Very cool, subhumid soils on plateaus and in canyons

This group contains only one map unit. It makes up about 4 percent of the entire survey area. The vegetation in most areas is Ponderosa pine with a grass and shrub understory. This group is in MLRU 39-1AZ (Mogollon Plateau Coniferous Forest). Elevation is 6,200 to 7,900 feet. Mean annual soil temperature is 47 to 56 degrees F, and mean annual precipitation is 18 to 20 inches.

12. Pinntank-Pocomate-Theecan

Very shallow to very deep, well drained, nearly level to very steep, clayey and extremely cobbly loamy soils; on plateaus, hills, fan terraces, mesas, and escarpments (fig. 13)

Setting

Location: Bordering the Aubrey Cliffs and near Thorton Lookout at the western edge of the Coconino Plateau
Landform: Plateaus, mesas, hills, fan terraces, and escarpments
Flooding: Minor soils are subject to rare flooding
Slope range: 1 to 55 percent
Elevation: 6,200 to 7,900 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 47 to 56 degrees F
Frost-free period: 120 to 150 days
Major Land Resource Unit: 39-1AZ (Mogollon Plateau Coniferous Forest)
Vegetation: Ponderosa pine, Gambel oak, mountain big sagebrush, bottlebrush squirreltail, muttongrass, blue grama
Wildlife: Elk, wild turkey, mule deer, Abert's squirrel

Composition

Percent of the survey area: 4
Pinntank and similar soils—40 percent
Pocomate and similar soils—30 percent
Theecan and similar soils—15 percent
Minor soils—15 percent

Soil Properties and Qualities

Pinntank

Landform: Mesas and plateaus
Slope range: 1 to 15 percent

Parent material: Residuum derived from sedimentary rocks
Textural class: Clayey
Depth class: Moderately deep
Drainage class: Well drained
Runoff: Medium
Permeability: Slow

Pocomate

Landform: Hills and escarpments
Slope range: 15 to 55 percent
Parent material: Residuum and colluvium derived from limestone
Textural class: Extremely cobbly loamy
Depth class: Very shallow and shallow
Drainage class: Well drained
Runoff: Rapid to very rapid
Permeability: Moderately slow

Theecan

Landform: Fan terraces
Slope range: 2 to 35 percent
Parent material: Mixed alluvium
Textural class: Clayey
Depth class: Very deep
Drainage class: Well drained
Runoff: Medium to very rapid
Permeability: Slow

Minor soils

- Deep, clayey Retsover soils on mesas
- Very deep, gravelly clayey Turkeytrack soils on stream terraces and fan terraces
- Very deep, clayey Sponiker and Pinespring soils in draws and on stream terraces that are subject to rare flooding

Use and Management

Major use: Woodland
Major management factors: Pinntank and Theecan—high clay content, high shrink-swell potential; Pocomate—shallow depth to rock, steep slopes, high content of rock fragments

Detailed Soil Map Units

The map units delineated on the detailed soil maps at the back of this survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this section, along with the maps, 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. More information about each map unit is given under the heading "Use and Management of the Soils."

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

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

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

Soils of one series can differ in texture of the surface layer or of the underlying material. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into soil phases. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Sponiker loam, 1 to 4 percent slopes, is a phase of the Sponiker series.

Most map units in this survey area are made up of two or more major soils or miscellaneous areas. These map units are complexes or associations.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Toqui-Yumtheska complex, 2 to 30 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated soil uses in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Topocoba-Wodomont association, 2 to 15 percent slopes, is an example.

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

This survey includes *miscellaneous areas.* Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example. Miscellaneous areas are shown on the soil maps. Some that are too small to be shown are identified by a special symbol on the soil maps.

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

1—Albers silty clay loam, 0 to 3 percent slopes

Setting

Landform: Stream terraces
Flooding: Rare
Elevation: 6,000 to 6,600 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days

Composition

Albers soil and similar inclusions: 90 percent
Contrasting inclusions: 10 percent

Typical Profile

0 to 1 inch—dark brown silty clay loam
1 to 29 inches—dark brown clay
29 to 60 inches—calcareous brown and dark brown clay

Soil Properties and Qualities

Parent material: Alluvium derived from sedimentary rock
Depth class: Very deep
Drainage class: Well drained
Permeability: Very slow
Available water capacity: High
Potential rooting depth: More than 60 inches
Runoff: Slow with occasional ponding
Hazard of water erosion: Slight
Hazard of wind erosion: Moderate
Shrink-swell potential: Very high
Content of calcium carbonate: None in the upper 29 inches and less than 15 percent in the lower subsoil
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Very deep soils that have a lower content of clay than the Albers soil (Disterheff and Lykorly soils)

Similar inclusions:
• Soils that have a surface texture of loam or clay loam

Use and Management

Rangeland

Dominant vegetation:
• Potential plant community—western wheatgrass, bottlebrush squirreltail, blue grama, Wyoming big sagebrush, fourwing saltbush
• Present plant community—bottlebrush squirreltail, blue grama, Wyoming big sagebrush, green rabbitbrush
Major management factors: Very slow permeability, very high shrink-swell potential, occasional ponding (fig. 14)
General management considerations:
• Continuous, intensive year-round grazing commonly results in a deteriorated plant community that has low forage value.
• If shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.
• Range seeding may be needed if quantities of the more desirable forage plants have decreased.
• Suitability for range seeding is fair because of soil-related factors.
Suitable management practices:
• Vary the season of grazing and the period of rest during successive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• Manage the brush in areas where unpalatable brushy plants have increased significantly.
• Control brush by using approved methods.
• Seed the range if the plant cover is not sufficient to protect the soil from erosion.
• Seed suitable plants, such as plants that meet the seasonal requirements of both livestock and wildlife and plants that tolerate shrinking and swelling of the soil.
• Seed late in the fall for best results.
• After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
• This unit supports vegetation that provides important habitat for mule deer.
• This unit provides important wintering areas for elk and wild turkey.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing practices to preserve forage for wildlife.
• Avoid nest trees when gathering firewood.
• Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Range site: Clay Upland, 13-17" p.z.

2—Arizo-Lostman complex, 1 to 5 percent slopes

Setting

Landform: Arizo—flood plains; Lostman—stream terraces
Flooding: Arizo—rare; Lostman—none
Slope range: 1 to 5 percent
Elevation: 3,000 to 4,400 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 60 to 70 degrees F
Frost-free period: 200 to 230 days

Composition

Arizo soil and similar inclusions: 50 percent
Lostman soil and similar inclusions: 35 percent
Contrasting inclusions: 15 percent

Figure 14.—Ponding in an area of Albers silty clay loam, 0 to 3 percent slopes.

Typical Profile

Arizo

0 to 2 inches—yellowish brown extremely gravelly loamy sand
2 to 9 inches—brown very gravelly loamy sand
9 to 23 inches—brown extremely gravelly coarse sand
23 to 48 inches—brown extremely cobbly coarse sand
48 to 60 inches—brown very gravelly coarse sand

Lostman

0 to 3 inches—yellowish brown very gravelly sandy loam
3 to 35 inches—brown gravelly fine sandy loam
35 to 49 inches—light brown gravelly fine sandy loam
49 to 61 inches—yellowish brown extremely gravelly sandy loam

Soil Properties and Qualities

Arizo

Parent material: Mixed alluvium
Depth class: Very deep
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: Very low
Potential rooting depth: 60 or more inches
Runoff: Very slow to slow
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Corrosivity: Steel (uncoated)—high; concrete—low

Lostman

Parent material: Mixed alluvium
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: Moderate
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 5 to 10 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Riverwash and commonly flooded soils in incised drainageways

Similar inclusions:
- Loamy soils on stream terraces
- Soils that have mean annual soil temperatures that are higher than those of the Arizo and Lostman soils in the lowest elevations

Use and Management

Rangeland

Dominant vegetation on the Arizo soil:
- Potential plant community—bush muhly, sand dropseed, spike dropseed, black grama, catclaw acacia, banana yucca, Anderson wolfberry
- Present plant community—bush muhly, black grama, spike dropseed, sand dropseed, rayless goldenhead, banana yucca, broom snakeweed

Dominant vegetation on the Lostman soil:
- Potential plant community—bush muhly, black grama, sand dropseed, spike dropseed, fourwing saltbush, Mexican bladdersage, catclaw acacia
- Present plant community—bush muhly, black grama, spike dropseed, buckhorn cholla, fourwing saltbush, Nevada Mormon tea

Major management factors: Arizo—very low water-holding capacity, excessively drained, high content of rock fragments on the surface and in the subsoil, rare flooding

General management considerations on the Arizo and Lostman soils:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Suitability for seeding is poor because of soil-related and climatic factors.

Suitable management practices on the Arizo and Lostman soils:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Provide periodic rest during spring in alternate years.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, willow flycatcher, coyote, common raven, kit fox, canyon wren, violet-green swallow, ringtail, Mohave rattlesnake, leopard frog, spadefoot toad, Gambel's quail, kangaroo rat

General management considerations:
- This unit is an important watering area for desert bighorn sheep and other animals. Water occurs as ephemeral flows from summer storms and collects in pools.
- Small mammals are important prey for many species, especially raptors, and their population fluctuates widely with environmental conditions.
- This unit supports diverse riparian vegetation providing migration corridors for neotropical migratory birds.
- The Colorado River corridor supports a diverse avian community including waterfowl and shorebirds.
- The willow flycatcher is a candidate for endangered species status.

Suitable management practices:
- Develop water facilities for wildlife.
- Designate camping areas to preserve riparian habitat.
- Plant trees to control erosion and to improve the diversity of vegetation.
- Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: VIIs, nonirrigated
Major Land Resource Unit: 30-2AZ—Grand Canyon Desert Shrub
Range site: Arizo soil—Sandy Terrace, 9-12" p.z.; Lostman soil—Sandy Loam Terrace, 9-12" p.z.

3—Arizo-Riverwash complex, 1 to 3 percent slopes

Setting

Landform: Flood plains
Flooding: Arizo—rare to occasional; Riverwash—frequent
Duration of flooding: Brief
Slope range: 1 to 3 percent
Elevation: 2,200 to 3,800 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 60 to 70 degrees F
Frost-free period: 200 to 230 days

Composition

Arizo soil and similar inclusions: 55 percent
Riverwash: 35 percent
Contrasting inclusions: 10 percent

Typical Profile

Arizo

0 to 2 inches—brown very gravelly sand
2 to 8 inches—brown gravelly loamy coarse sand
8 to 21 inches—brown very cobbly coarse sand
21 to 60 inches—light brown very gravelly coarse sand

Riverwash consists of deep, stratified, extremely gravelly sandy material in active channels that are devoid of vegetation.

Soil Properties and Qualities

Arizo

Parent material: Mixed alluvium
Depth class: Very deep
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: Very low
Potential rooting depth: 60 or more inches
Runoff: Very slow
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Deep very gravelly sandy soils that have a zone of secondary calcium carbonate accumulation at a depth of more than 25 inches
- Wet soils near permanent streams and springs

Similar inclusions:
- Arizo soils that have extremely stony surface layers
- Arizo soils that have slightly steeper slopes on alluvial fans
- Soils that have a mean annual soil temperature that is higher than that of the Arizo soil at the lower elevations

Use and Management

Rangeland

Dominant vegetation on the Arizo soil:
- Potential plant community—bush muhly, mesa dropseed, spike dropseed, black grama, sand dropseed, catclaw acacia, burrobrush
- Present plant community—bush muhly, black grama, mesa dropseed, sand dropseed, catclaw acacia, burrobrush, wooly bursage

Major management factors: Flooding, high content of rock fragments, very low available water capacity
General management considerations on the Arizo-Riverwash soils:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Suitability for seeding is poor because of soil-related and climatic factors.

Suitable management practices on the Arizo soil and the Riverwash:
- Vary the season of grazing and the period of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, willow flycatcher, coyote, common raven, kit fox, canyon wren, violet-green swallow, ringtail, Mohave rattlesnake, leopard frog, spadefoot toad, Gambel's quail, kangaroo rat
General management considerations:
- This unit is an important watering area for desert bighorn sheep and other animals. Water occurs as ephemeral flows from summer storms and collects in pools.
- Small mammals are important prey for many species, especially raptors, and their population fluctuates widely with environmental conditions.
- This unit supports diverse riparian vegetation providing migration corridors for neotropical migratory birds.
- The Colorado River corridor supports a diverse avian community including waterfowl and shorebirds.
- The willow flycatcher is a candidate for endangered species status.

Suitable management practices:
- Develop water facilities for wildlife.
- Designate camping areas to preserve riparian habitat.
- Plant trees to control erosion and to improve the diversity of vegetation.
- Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: Arizo—VIIw, nonirrigated
Major Land Resource Unit: 30-2AZ—Grand Canyon Desert Shrub
Range site: Arizo—Sandy Bottom, 9-12" p.z.

4—Barx fine sandy loam, 1 to 6 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Elevation: 5,900 to 6,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days

Composition

Barx soil and similar inclusions: 85 percent
Contrasting inclusions: 15 percent

Typical Profile

0 to 1 inch—reddish brown fine sandy loam
1 to 11 inches—reddish brown sandy clay loam
11 to 17 inches—light reddish brown sandy clay loam

17 to 28 inches—light reddish brown limy clay loam
28 to 46 inches—yellowish red limy loam
46 to 60 inches—yellowish red fine sandy loam

Soil Properties and Qualities

Parent material: Thin eolian deposits overlying alluvium derived from sandstone and limestone
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: High to very high
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Moderately high
Shrink-swell potential: Moderate
Content of calcium carbonate: 15 to 40 percent in the lower subsoil
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Very deep, clayey soils on stream terraces (Poley soils)
- Moderately deep, loamy soils
- Soils that have layers of clay at a depth of more than 20 inches

Similar inclusions:
- Soils that have gravel in the substrata
- Soils that have stratified very fine sandy loam at a depth of more than 30 inches
- Soils that have surface textures of very fine sandy loam or loam

Use and Management

Rangeland

Dominant vegetation:
- Potential plant community—Indian ricegrass, bottlebrush squirreltail, blue grama, black grama, fourwing saltbush
- Present plant community—blue grama, ring muhly, Greene rabbitbrush, gray horsebrush, broom snakeweed

Major management factors: Hazard of wind erosion, moderate shrink-swell potential, high content of calcium carbonate in the subsoil
General management considerations:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- If shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.
- Suitability for seeding is fair because of soil-related factors.

Suitable management practices:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Manage the brush in areas where unpalatable brushy plants have increased significantly.
- Control the brush by using approved methods.
- Seed the range if the plant cover is not sufficient to protect the soil from erosion.
- After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals that frequent this unit are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIe, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Loamy Upland, 9-13" p.z.

5—Bleumont-Frazwell association, 2 to 20 percent slopes

Setting

Landform: Fan terraces and draws
Landscape position: Bleumont—side slopes and summits of fan terraces; Frazwell—draws
Flooding: Bleumont—none; Frazwell—rare (runoff from adjacent slopes)
Slope range: Bleumont—2 to 20 percent; Frazwell—2 to 6 percent
Elevation: 5,500 to 5,900 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F

Frost-free period: 120 to 160 days

Composition

Bleumont soil and similar inclusions: 60 percent
Frazwell soil and similar inclusions: 25 percent
Contrasting inclusions: 15 percent

Typical Profile

Bleumont

0 to 2 inches—brown extremely cobbly fine sandy loam
2 to 4 inches—dark brown very gravelly sandy clay loam
4 to 12 inches—yellowish red clay
12 to 21 inches—yellowish red and very dark brown sandy clay
21 to 34 inches—yellowish red and very pale brown very cobbly sandy clay
34 to 62 inches—reddish yellow and pink extremely cobbly sandy clay loam

Frazwell

0 to 3 inches—dark brown sandy loam
3 to 17 inches—very dark grayish brown sandy clay loam
17 to 40 inches—very dark grayish brown sandy clay and gravelly sandy clay loam
40 to 45 inches—brown very gravelly loamy coarse sand
45 to 62 inches—yellowish red sandy clay loam

Soil Properties and Qualities

Bleumont

Parent material: Alluvium derived from metamorphic and igneous rock of the Frazier Well Gravels Formation
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Moderate
Potential rooting depth: 60 or more inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: High
Content of calcium carbonate: 20 to 35 percent below a depth of 34 inches
Corrosivity: Steel (uncoated)—high; concrete—low

Frazwell

Parent material: Alluvium derived from sedimentary and igneous rock of the Frazier Well Gravels Formation
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium or rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Moderately high
Shrink-swell potential: Moderate
Content of calcium carbonate: None in the upper part of the profile, 0 to 10 percent below a depth of 40 inches
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Very deep, moderately coarse textured soils in draws and on foot slopes of hills

Similar inclusions:
- Soils that have a higher content of rock fragments in the subsoil than the Bleumont and Frazwell soils
- Soils that have a higher content of clay in the surface layers than the Bleumont and Frazwell soils

Use and Management

Woodland

Dominant overstory vegetation on the Bleumont soil: Colorado pinyon—45 percent; Utah juniper—55 percent
Overstory production:
- Fuelwood—8 to 10 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—60 to 70 per acre
- Christmas trees—40 to 50 per acre
- Ornamental trees—40 to 50 per acre

Dominant understory vegetation on the Bleumont soil: Turbinella oak, blue grama, muttongrass, banana yucca, desert ceanothus, running pricklypear, crimson hedgehog cactus
Major management factors on the Bleumont soil: High content of rock fragments in the surface layers, high shrink-swell potential
General management considerations:
- Wood products can be harvested when the canopy cover exceeds 35 percent.
- In areas where the density of the canopy is less than about 35 percent, the understory produces plants suitable for grazing.
- Maintaining the understory vegetation is essential in controlling erosion.
- Suitability for range seeding is poor because of soil-related factors.

Suitable management practices:
- Use conventional methods in harvesting.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.

• Control the time and amount of use by livestock.

Rangeland

Dominant vegetation on the Frazwell soil:
• Potential plant community—blue grama, needleandthread, bottlebrush squirreltail, Utah juniper, fourwing saltbush, shrubby buckwheat
• Present plant community—blue grama, Fendler threeawn, Utah juniper, Fremont barberry, Whipple cholla, shrubby buckwheat
Major management factors on the Frazwell soil: Hazard of wind erosion, rare hazard of flooding
General management considerations:
• Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
• Suitability for seeding is good.
• Range seeding may be needed if quantities of the more desirable forage plants have decreased.
Suitable management practices:
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.
• Seed the range if the plant cover is not sufficient to protect the soil from erosion.
• After seeding, defer grazing until young plants are well established.
• Seed late in fall for best results.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
• This unit supports vegetation that provides important habitat for mule deer.
• This unit provides important wintering areas for elk and wild turkey.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing practices to preserve forage for wildlife.
• Avoid nest trees when gathering firewood.
• Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: Bleumont—VIs, nonirrigated; Frazwell—VIe, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Bleumont—Cobbly Sandy Clay, 13-17" p.z.
Range site: Frazwell—Loamy Upland, 13-17" p.z.

6—Cowan family-Naha complex, 0 to 3 percent slopes

Setting

Landform: Flood plains
Flooding: Occasional
Duration of flooding: Brief
Slope range: 0 to 3 percent
Elevation: 3,100 to 4,200 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 59 to 64 degrees F
Frost-free period: 180 to 200 days

Composition

Cowan family and similar inclusions: 55 percent
Naha soil and similar inclusions: 30 percent
Contrasting inclusions: 15 percent

Typical Profile

Cowan family

0 to 13 inches—yellowish red very fine sandy loam
13 to 35 inches—reddish yellow fine sand
35 to 60 inches—yellowish red very fine sandy loam

Naha

0 to 4 inches—reddish brown loamy fine sand
4 to 9 inches—yellowish red fine sandy loam
9 to 13 inches—reddish yellow loamy fine sand
13 to 21 inches—light reddish brown sand
21 to 29 inches—mixed reddish yellow, yellowish red, and reddish brown silt loam
29 to 38 inches—reddish brown very fine sandy loam
38 to 64 inches—reddish yellow and yellowish red stratified fine sand, sand, and loamy fine sand

Soil Properties and Qualities

Cowan family

Parent material: Alluvium derived from sandy sedimentary rock
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately rapid

Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Very slow
Hazard of water erosion: Moderate
Hazard of wind erosion: Moderately high
Shrink-swell potential: Low
Content of calcium carbonate: Calcareous throughout, averaging 5 to 15 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Naha

Parent material: Stratified alluvium derived from sedimentary rock
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: Moderate
Potential rooting depth: 60 or more inches
Runoff: Slow to medium
Hazard of water erosion: Slight
Hazard of wind erosion: High
Shrink-swell potential: Low
Content of calcium carbonate: Calcareous throughout, averaging 5 to 10 percent
Salinity: Ec—8-16 mmhos below a depth of 20 inches
Sodicity: SAR 6-10 below a depth of 20 inches
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Very gravelly soils
- Soils that are somewhat poorly drained and have a water table within a depth of 4 feet
- Riverwash
- Soils that have gravelly surfaces

Similar inclusions:
- Soils that have surface textures that are slightly coarser or finer than those of the Cowan family and Naha soils
- Soils that have slopes that are slightly steeper than those of the Cowan family and Naha soils

Use and Management

Cropland

This unit is used for irrigated and dryland subsistence farming near the village of Supai.
Major management factors: Cowan family—well suited to irrigated crops; Naha soil—soil blowing, moderate salinity, sodium content of subsoil
General management considerations:
- Stubble and other crop residue can reduce soil blowing in spring.
- Fields should be kept small in size to reduce unsheltered distance from wind.
- Over-irrigation can result in perched water tables or increased levels of salt and sodium. Apply only enough water to meet the needs of the crop.

Rangeland

Dominant vegetation on the Cowan family soil:
- Potential plant community—big galleta, bush muhly, Indian ricegrass, fourwing saltbush
- Present plant community—cheatgrass, sand dropseed, annual grama, fourwing saltbush, running pricklypear

Dominant vegetation on the Naha soil:
- Potential plant community—big galleta, bush muhly, Indian ricegrass, fourwing saltbush
- Present plant community—cheatgrass, sand dropseed, annual grama, fourwing saltbush, running pricklypear

Major management factors: Hazard of wind and water erosion, flood hazard
Major management factors on the Naha soil: Moderate salinity and sodicity below a depth of 20 inches
General management considerations on the Cowan family-Naha soils:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Suitability for seeding is poor because of soil-related and climatic factors.

Suitable management practices on the Cowan family-Naha soils:
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Vary the season of grazing and the periods of rest during successive years.
- Control the time and amount of use by livestock.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, willow flycatcher, coyote, common raven, kit fox, canyon wren, violet-green swallow, ringtail, Mohave rattlesnake, leopard frog, spadefoot toad, Gambel's quail, kangaroo rat
General management considerations:
- This unit is an important watering area for desert bighorn sheep and other animals. Water occurs as ephermeral flows from summer storms and collects in pools.
- Small mammals are important prey for many species, especially raptors, and their population fluctuates widely with environmental conditions.
- This unit supports diverse riparian vegetation providing migration corridors for neotropical migratory birds.
- The Colorado River corridor supports a diverse avian community including waterfowl and shorebirds.

• The willow flycatcher is a candidate for endangered species status.
Suitable management practices:
• Develop water facilities for wildlife.
• Designate camping areas to preserve riparian habitat.
• Plant trees to control erosion and to improve the diversity of vegetation.
• Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: Cowan family—VIIe, nonirrigated, IIIe, irrigated; Naha—VIIe, nonirrigated, IIe, irrigated
Major Land Resource Unit: 30-2AZ—Grand Canyon Desert Shrub
Range site: Loamy Bottom, 9-12" p.z.

7—Curhollow-Puertecito complex, 1 to 12 percent slopes

Setting

Landform: Plateaus and mesas
Flooding: None
Slope range: 1 to 12 percent
Elevation: 5,700 to 6,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days

Composition

Curhollow soil and similar inclusions: 55 percent
Puertecito soil and similar inclusions: 30 percent
Contrasting inclusions: 15 percent

Typical Profile

Curhollow

0 to 1 inch—yellowish brown very gravelly loam
1 to 4 inches—dark yellowish brown gravelly loam
4 to 11 inches—dark brown very cobbly loam
11 to 20 inches—indurated, calcium carbonate cemented hardpan
20 inches—limestone bedrock

Puertecito

0 to 2 inches—yellowish brown very gravelly loam
2 to 13 inches—brown very gravelly clay loam and very gravelly loam
13 inches—cherty limestone

Soil Properties and Qualities

Curhollow

Parent material: Alluvium derived from limestone
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 15 to 35 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Puertecito

Parent material: Alluvium and colluvium derived from the Kaibab Limestone Formation
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: Very low
Potential rooting depth: 8 to 20 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Slight
Shrink-swell potential: Moderate
Content of calcium carbonate: 8 to 15 percent above the hardpan
Corrosivity: Steel (uncoated)—moderate; concrete—low

Inclusions

Contrasting inclusions:
• Deep loamy soils (Lykorly soils) in drainageways
• Shallow soils that have fewer rock fragments on the surface or in the subsoil than the Curhollow and Puertecito soils
• Deep clayey soils (Disterheff soils) in drainageways
• Rock outcrop on ledges and eroded shoulders on hills

Similar inclusions:
• Moderately deep soils overlying limestone in concave to planar positions
• Soils that have a hardpan at a depth of 20 to 40 inches
• Puertecito soils that have a very cobbly or extremely cobbly surface texture
• Soils less than 8 inches deep to bedrock or a hardpan

Use and Management

Rangeland

Dominant vegetation on the Curhollow soil:
• Potential plant community—needleandthread,

muttongrass, blue grama, bottlebrush squirreltail, Wyoming big sagebrush
• Present plant community—blue grama, bottlebrush squirreltail, Wyoming big sagebrush, broom snakeweed
Dominant vegetation on the Puertecito soil:
• Potential plant community—needleandthread, muttongrass, blue grama, bottlebrush squirreltail, Wyoming big sagebrush
• Present plant community—blue grama, bottlebrush squirreltail, Wyoming big sagebrush, broom snakeweed
Major management factors: High content of rock fragments on surface, shallow depth to bedrock or an indurated hardpan, very low available water capacity
General management considerations on the Curhollow and Puertecito soils:
• Continuous intensive year-round grazing commonly results in a deteriorated plant community that has low forage value.
• If the shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.
• Suitability for seeding is poor because of soil-related factors.
Suitable management practices on the Curhollow and Puertecito soils:
• Vary the season of grazing and the period of rest during successive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Manage the brush in areas where unpalatable brushy plants have increased significantly.
• Control brush by using approved methods.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
• This unit supports vegetation that provides important habitat for pronghorn antelope.
• The small mammals that frequent this unit are important prey for raptors and other species.
• Small mammal populations fluctuate widely with environmental conditions.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing practices to preserve forage for wildlife.
• Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
• Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 35-3AZ—Colorado Plateau Sagebrush-Grassland
Range site: Shallow Loamy, 9-13" p.z.

8—Curhollow-Rolie-Meriwhitica association, 1 to 35 percent slopes

Setting

Landform: Hills, mesas, and plateaus
Landscape position: Curhollow—toe slopes of mesas and plateaus; Rolie—fan terraces on plateaus; Meriwhitica—summits and side slopes of hills, mesas, and plateaus
Flooding: None
Slope range: Curhollow—1 to 25 percent; Rolie—1 to 15 percent; Meriwhitica—1 to 35 percent
Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 55 to 58 degrees F
Frost-free period: 135 to 175 days

Composition

Curhollow soil and similar inclusions: 40 percent
Rolie soil and similar inclusions: 25 percent
Meriwhitica soil and similar inclusions: 20 percent
Contrasting inclusions: 15 percent

Typical Profile

Curhollow

0 to 2 inches—brown extremely gravelly loam
2 to 8 inches—yellowish brown very gravelly loam
8 to 14 inches—yellowish brown, limy extremely cobbly loam
14 to 20 inches—indurated calcium carbonate cemented hardpan
20 inches—limestone

Rolie

0 to 1 inch—yellowish brown very gravelly loam
1 to 4 inches—dark yellowish brown gravelly loam
4 to 9 inches—yellowish brown cobbly loam
9 to 15 inches—fractured, calcium carbonate cemented hardpan
15 to 60 inches—indurated hardpan

Meriwhitica

0 to 3 inches—pale brown extremely cobbly loam
3 to 8 inches—yellowish brown extremely cobbly loam
8 inches—limestone

Soil Properties and Qualities

Curhollow

Parent material: Alluvium and residuum derived from limestone
Depth class: Shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 20 to 35 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Rolie

Parent material: Alluvium derived from limestone
Depth class: Shallow and very shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 15 to 25 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Meriwhitica

Parent material: Residuum derived from limestone
Depth class: Very shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 3 to 10 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 15 to 35 percent above the bedrock
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Moderately deep loamy soils
- Rock outcrop
- Small areas of steeper slopes adjoining major canyons

Similar inclusions:
- Soils that have extremely gravelly or extremely cobbly fine sandy loam or loam surface textures

Use and Management

Rangeland

Dominant vegetation on the Curhollow soil:
- Potential plant community—blackbrush, black grama, slim tridens, bottlebrush squirreltail, fourwing saltbush
- Present plant community—blackbrush, banana yucca, black grama, slim tridens, red brome, bottlebrush squirreltail

Dominant vegetation on the Rolie soil:
- Potential plant community—needleandthread, black grama, blue grama, bottlebrush squirreltail, fourwing saltbush, winterfat
- Present plant community—black grama, cheatgrass, needleandthread, blue grama, fourwing saltbush, winterfat

Dominant vegetation on the Meriwhitica soil:
- Potential plant community—blackbrush, Utah agave, Stansbury cliffrose, sideoats grama, black grama, slim tridens
- Present plant community—blackbrush, Utah agave, Stansbury cliffrose, sideoats grama, slim tridens, black grama

Major management factors: Curhollow and Rolie—shallow depth to calcium carbonate cemented hardpan, high content of calcium carbonate, very low available water capacity; Meriwhitica—shallow depth to rock, high content of rock fragments (fig. 15)

General management considerations on the Curhollow, Rolie, and Meriwhitica soils:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Suitability for seeding is poor because of droughtiness, shallow soils, high content of rock fragments, and content of calcium carbonate.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.

Suitable management practices on the Curhollow, Rolie, and Meriwhitica soils:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit

Figure 15.—Rock fragments on the surface of the Meriwhitica soil severely limit activities, such as reseeding.

fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon

General management considerations:

- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals that frequent this unit are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable mangement practices:

- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated

Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains

Range site: Curhollow—Limestone Upland, 9-13" p.z.; Rolie—Limy Upland (Shallow), 9-13" p.z.; Meriwhitica—Limestone Hills, 9-13" p.z.

9—Curhollow-Tenderfoot complex, 1 to 8 percent slopes

Setting

Landform: Plateaus and mesas

Landscape position: Curhollow—convex shoulders and summits of gently sloping plateaus and mesas; Tenderfoot—slightly concave foot slopes

Flooding: None

Slope range: 1 to 8 percent

Elevation: 5,700 to 6,100 feet

Mean annual precipitation: 10 to 12 inches

Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days

Composition

Curhollow soil and similar inclusions: 65 percent
Tenderfoot soil and similar inclusions: 30 percent
Contrasting inclusions: 5 percent

Typical Profile

Curhollow

0 to 2 inches—brown extremely gravelly loam
2 to 9 inches—light brown very gravelly loam
9 to 13 inches—light brown extremely gravelly limy loam
13 to 22 inches—indurated calcium carbonate cemented hardpan
22 inches—limestone

Tenderfoot

0 to 3 inches—reddish brown very gravelly loam
3 to 9 inches—yellowish red clay loam
9 to 17 inches—reddish brown extremely cobbly clay loam
17 to 23 inches—indurated, calcium carbonate cemented hardpan
23 inches—limestone

Soil Properties and Qualities

Curhollow

Parent material: Alluvium and residuum derived from limestone
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 15 to 40 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Tenderfoot

Parent material: Alluvium derived from cherty limestone
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Content of calcium carbonate: 5 to 30 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Deep loamy soils in narrow drainageways

Similar inclusions:
- Shallow soils directly overlying limestone bedrock
- Shallow soils that have less gravel or cobbles on the surface or in the subsoil than the Curhollow and Tenderfoot soils
- Very shallow soils that are less than 10 inches deep
- Moderately deep soils overlying a hardpan at a depth of 20 to 40 inches

Use and Management

Rangeland

Dominant vegetation on the Curhollow soil:
- Potential plant community—Indian ricegrass, needleandthread, bottlebrush squirreltail, blue grama, Wyoming big sagebrush, green Mormon tea
- Present plant community—blue grama, bottlebrush squirreltail, Wyoming big sagebrush, broom snakeweed, green Mormon tea

Dominant vegetation on the Tenderfoot soil:
- Potential plant community—Indian ricegrass, needleandthread, bottlebrush squirreltail, blue grama, Wyoming big sagebrush, green Mormon tea
- Present plant community—blue grama, bottlebrush squirreltail, Wyoming big sagebrush, broom snakeweed, green Mormon tea

Major management factors: Gravel on the surface, shallow depth to hardpan and underlying bedrock, very low available water capacity, moderate content of calcium carbonate

General management considerations on the Curhollow and Tenderfoot soils:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low forage value.
- If shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Curhollow and Tenderfoot soils:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

• Manage the brush in areas where unpalatable brushy plants have increased significantly.
• Control brush by using approved methods.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
• This unit supports vegetation that provides important habitat for pronghorn antelope.
• The small mammals that frequent this unit are important prey for raptors and other species.
• Small mammal populations fluctuate widely with environmental conditions.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing practices to preserve forage for wildlife.
• Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
• Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 35-3AZ—Colorado Plateau Sagebrush-Grassland
Range site: Shallow Loamy, 9-13" p.z.

10—Deama-Rock outcrop complex, 25 to 55 percent slopes

Setting

Landform: Canyon escarpments
Flooding: None
Slope range: 25 to 55 percent
Elevation: 5,000 to 6,400 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 120 to 160 days

Composition

Deama soil and similar inclusions: 70 percent
Rock outcrop: 20 percent
Contrasting inclusions: 10 percent

Typical Profile

Deama

0 to 1 inch—brown extremely cobbly loam
1 to 14 inches—dark brown and brown limy very cobbly loam
14 inches—hard limestone

Rock outcrop consists of steep ledges of the Kaibab Formation or the Toroweap Formation

Soil Properties and Qualities

Deama

Parent material: Alluvium, colluvium, and residuum derived from limestone
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 7 to 20 inches
Runoff: Very rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Potential frost action: Moderate
Content of calcium carbonate: Averages more than 40 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Rock outcrop consists of escarpments of limestone.

Inclusions

Contrasting inclusions:
• Deep, loamy, calcareous soils in drainageways

Similar inclusions:
• Shallow soils that have a lower content of calcium carbonate (Yumtheska soils)
• Moderately deep soils on foot slopes
• Soils that have very stony or very gravelly surface layers

Use and Management

Woodland

Dominant overstory vegetation: Utah juniper—40 percent; Colorado pinyon—60 percent
Overstory production:
• Fuelwood—7 to 9 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
• Posts—20 to 30 per acre
• Christmas trees—10 to 15 per acre
• Ornamental trees—20 to 30 per acre
Dominant understory vegetation: Muttongrass, blue grama, bottlebrush squirreltail, turbinella oak, Stansbury cliffrose, green Mormon tea, Wyoming big sagebrush
Major management factors: Steep slopes, shallow depth to bedrock, high content of rock fragments, very low available water capacity, high content of calcium carbonate, hazard of water erosion

General management considerations:
- Wood products can be harvested when the canopy cover exceeds 35 percent.
- In areas where the density of the canopy is less than about 35 percent, the understory produces plants suitable for grazing.
- Maintaining the understory vegetation is essential in controlling erosion.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accessible forage on the ridgetops and in the valleys before they graze the side slopes.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices:
- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on very steep slopes.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay

General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.
- The Rock outcrop supports no vegetation but is important for nest sites, resting cover, hunting perches, escape routes, and dens for wildlife.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIIe, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Limestone Slopes, 13-17" p.z.

11—Disterheff gravelly fine sandy loam, cool, 1 to 8 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Elevation: 5,700 to 5,850 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 51 to 54 degrees F
Frost-free period: 130 to 160 days

Composition

Disterheff soil and similar inclusions: 75 percent
Contrasting inclusions: 25 percent

Typical Profile

0 to 1 inch—light brown gravelly fine sandy loam
1 to 3 inches—light yellowish brown loam
3 to 9 inches—dark brown clay loam
9 to 23 inches—reddish brown clay
23 to 31 inches—yellowish red limy clay
31 to 38 inches—pink, limy very gravelly clay
38 to 64 inches—yellowish red and pink, limy clay loam

Soil Properties and Qualities

Parent material: Alluvium derived from sedimentary and igneous rock
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Content of calcium carbonate: 10 to 40 percent in the lower subsoil
Hazard of water erosion: Slight
Hazard of wind erosion: Moderate
Shrink-swell potential: Very high
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Very deep loamy soils in swales (Barx soils)
- Very deep silty soils in draws (Hidvalle soils)
- Moderately deep soils over a calcium carbonate cemented hardpan

Similar inclusions:
- Disterheff soils that have very gravelly surface layers
- Disterheff soils that have very fine sandy loam surface textures

Use and Management

Woodland

Dominant overstory vegetation: Utah juniper—90 percent; Colorado pinyon—10 percent
Overstory production:
- Fuelwood—8 to 10 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—80 to 100 per acre
- Christmas trees—5 to 10 per acre
- Ornamental trees—5 to 10 per acre

Dominant understory vegetation: Blue grama, bottlebrush squirreltail, broom snakeweed, Fremont barberry, banana yucca
Major management factors: Very high shrink-swell potential, slow permeability, high content of calcium carbonate
General management considerations:
- Wood products can be harvested when the canopy cover exceeds 35 percent.
- In areas where the density of the canopy is less than about 40 percent, the understory vegetation is essential in preventing erosion.
- Range seeding may be necessary if quantities of the more desirable forage plants have decreased.
- Suitability for range seeding is good.
- If shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.

Suitable management practices:
- Use conventional methods in harvesting.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the period of rest during successive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Seed disturbed areas to adapted grasses by drilling in order to increase forage production.
- Prepare the site adequately in order to seed understory plants successfully.
- Seed late in the fall for best results. After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Clay Loam Upland (Gravelly), 13-17" p.z.

12—Disterheff gravelly loam, 1 to 4 percent slopes

Setting

Landform: Fan terraces and stream terraces
Flooding: None
Elevation: 6,000 to 6,500 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days

Composition

Disterheff soil and similar inclusions: 85 percent
Contrasting inclusions: 15 percent

Typical Profile

0 to 1 inch—brown gravelly loam
1 to 3 inches—brown loam
3 to 11 inches—dark brown and reddish brown clay loam
11 to 24 inches—reddish brown clay
24 to 60 inches—pinkish white limy clay loam

Soil Properties and Qualities

Parent material: Alluvium derived from sedimentary rock
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Moderate
Shrink-swell potential: Very high
Content of calcium carbonate: 10 to 40 percent in the lower subsoil
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Soils that have a higher content of clay and a higher shrink-swell potential than the Disterheff soil (Albers soils)
- Soils that have a lower content of clay than the Disterheff soil (Lykorly soils)

Similar inclusions:
- Soils that have a higher content of clay and gravel in the surface layer than the Disterheff soil
- Soils that have a higher organic content and darker surface colors than the Disterheff soil
- Soils that have calcium carbonate accumulations at a depth of 30 inches or more

Use and Management

Rangeland

Dominant vegetation:
- Potential plant community—western wheatgrass, blue grama, muttongrass, prairie junegrass, Wyoming big sagebrush
- Present plant community—western wheatgrass, blue grama, muttongrass, bottlebrush squirreltail, Wyoming big sagebrush

Major management factors: Slow permeability, very high shrink-swell potential, high content of calcium carbonate

General management considerations:
- Continuous intensive year-round grazing commonly results in a deteriorated plant community that has low forage value.
- Range seeding may be needed if quantities of the more desirable forage plants have decreased.
- Suitability for range seeding is fair because of soil-related factors.

Suitable management practices:
- Vary the season of grazing and the period of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Seed the range if the plant cover is not sufficient to protect the soil from erosion.
- Seed suitable plants, such as plants that meet the seasonal requirements of both livestock and wildlife and plants that tolerate shrinking and swelling of the soil.
- Seed late in the fall for best results.
- After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay

General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Range site: Clay Loam Upland, 13-17" p.z.

13—Frazwell-Jacques complex, 1 to 3 percent slopes

Setting

Landform: Draws and stream terraces
Flooding: Rare
Slope range: 1 to 3 percent
Elevation: 5,800 to 6,000 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 130 to 160 days

Composition

Frazwell soil and similar inclusions: 65 percent
Jacques soil and similar inclusions: 25 percent
Contrasting inclusions: 10 percent

Typical Profile

Frazwell

0 to 2 inches—brown loam
2 to 11 inches—dark brown clay loam
11 to 41 inches—dark brown and brown sandy clay loam
41 to 72 inches—reddish yellow stratified coarse sand and loamy sand
72 to 80 inches—brown sandy clay loam

Jacques

0 to 1 inch—brown fine sandy loam
1 to 9 inches—brown sandy clay loam
9 to 34 inches—brown clay

34 to 52 inches—brown stratified sandy clay loam and clay loam
52 to 59 inches—brown sandy loam
59 to 65 inches—brown cobbly fine sandy loam

Soil Properties and Qualities

Frazwell

Parent material: Alluvium derived from sedimentary and igneous rock of the Frazier Well Gravels Formation
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Moderate
Hazard of wind erosion: Slight
Shrink-swell potential: Moderate
Corrosivity: Steel (uncoated)—high; concrete—low

Jacques

Parent material: Mixed alluvium derived from the Frazier Well Gravels Formation
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Moderately high
Shrink-swell potential: Moderate
Corrosivity: Steel (uncoated)—high; concrete—low
Contrasting inclusions:
- Riverwash in incised channels
- Soils that have a lower content of clay than the Frazwell and Jacques soils

Similar inclusions:
- Soils that have dark surface horizons that are thinner or thicker than those of the Frazwell and Jacques soils

Use and Management

Rangeland

Dominant vegetation on the Frazwell soil:
- Potential plant community—blue grama, bottlebrush squirreltail, western wheatgrass, mountain big sagebrush
- Present plant community—blue grama, bottlebrush squirreltail, Fendler threeawn, mountain big sagebrush, broom snakeweed

Dominant vegetation on the Jacques soil:
- Potential plant community—western wheatgrass, blue grama, bottlebrush squirreltail, mountain big sagebrush, broom snakeweed
- Present plant community—bottlebrush squirreltail, blue grama, cheatgrass, mountain big sagebrush, Fremont barberry, Utah juniper

Major management factors: Jacques—hazard of wind erosion, slow permeability
General management considerations:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- If shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.
- Suitability for seeding is good.

Suitable management practices:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Manage the brush in areas where unpalatable brushy plants have increased significantly.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.
- Seed the range if the plant cover is not sufficient to protect the soil from erosion.
- After seeding, defer grazing until young plants are well established.
- Seed late in the fall for best results.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: Frazwell—VIs, nonirrigated; Jacques—VIe, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Range site: Frazwell—Loamy Upland, 13-17" p.z.; Jacques—Clay Loam Upland, 13-17" p.z.

14—Grandwash extremely flaggy sandy loam, 2 to 25 percent slopes

Setting

Landform: Hills
Flooding: None
Elevation: 4,700 to 5,000 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 130 to 165 days

Composition

Grandwash soil and similar inclusions: 85 percent
Contrasting inclusions: 15 percent

Typical Profile

0 to 1 inch—reddish brown extremely flaggy sandy loam
1 to 2 inches—reddish brown and dark reddish brown channery fine sandy loam
2 to 12 inches—reddish brown extremely flaggy clay
12 inches—thin bedded, fine grained, red sandstone

Soil Properties and Qualities

Parent material: Residuum and colluvium derived from sandstone
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Slow
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Very gravelly deep loamy soils (Buckndoe soils) that have a high content of calcium carbonate on fan terraces
- Rock outcrop

Similar inclusions:
- Soils that have extremely channery fine sandy loam surfaces
- Soils that have extremely stony sandy loam surfaces

Use and Management

Woodland

Dominant overstory vegetation: Utah juniper—60 percent; singleleaf pinyon—40 percent
Overstory production:
- Fuelwood—5 to 7 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—55 to 65 per acre
- Christmas trees—40 to 50 per acre
- Ornamental trees—40 to 50 per acre

Dominant understory vegetation: Turbinella oak, desert ceanothus, shrubby buckwheat, banana yucca, Stansbury cliffrose, bottlebrush squirreltail
Major management factors: Shallow depth to rock, high content of rock fragments, steep slopes
General management considerations:
- Wood products can be harvested when the canopy cover exceeds 30 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces some plants suitable for grazing.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Suitability for seeding is poor because of soil-related factors.
- People who are gathering firewood need to avoid nest trees.

Suitable management practices:
- Use conventional methods in harvesting.
- Leave the larger trees to provide shade for seedlings, pinyon nut production, and wildlife habitat.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on very steep slopes.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Sandstone Upland, 13-17" p.z.

15—Havasupai very gravelly loam, 1 to 8 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Elevation: 5,200 to 5,700 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days

Composition

Havasupai soil and similar inclusions: 85 percent
Contrasting inclusions: 15 percent

Typical Profile

0 to 2 inches—brown very gravelly loam
2 to 7 inches—yellowish brown gravelly loam
7 to 14 inches—light brown very gravelly sandy clay loam
14 to 33 inches—indurated, calcium carbonate cemented hardpan
33 to 60 inches—reddish brown extremely gravelly sand, weakly cemented with calcium carbonate

Soil Properties and Qualities

Parent material: Mixed alluvium derived from sedimentary and igneous rock
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 25 to 45 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Deep, loamy soils

Similar inclusions:
- Soils that have a hardpan at a depth of 20 to 40 inches
- Soils that are less than 10 inches deep
- Soils that have a higher content of gravel on the surface than the Havasupai soil
- Soils that have very gravelly fine sandy loam surfaces

Use and Management

Rangeland

Dominant vegetation:
- Potential plant community—black grama, sideoats grama, blue grama, needleandthread, fourwing saltbush, winterfat
- Present plant community—blue grama, bottlebrush squirreltail, needleandthread, broom snakeweed, winterfat, Fremont barberry

Major management factors: Shallow to hardpan, high gravel content, very low available water capacity, high content of calcium carbonate
General management considerations:
- Continuous, intensive year-round grazing commonly results in a deteriorated plant community that has low forage value.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices:
- Vary the season of grazing and the period of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals that frequent this unit are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated

Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Limy Upland (Shallow), 9-13" p.z.

16—Hermshale extremely flaggy fine sandy loam, 15 to 35 percent slopes

Setting

Landform: Fan terraces
Landscape position: Foot slopes and toe slopes at the base of escarpments
Flooding: None
Elevation: 5,900 to 6,200 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 58 degrees F
Frost-free period: 140 to 160 days

Composition

Hermshale soil and similar inclusions: 75 percent
Contrasting inclusions: 25 percent

Typical Profile

0 to 2 inches—brown extremely flaggy fine sandy loam
2 to 7 inches—reddish brown channery loam
7 to 15 inches—reddish brown very gravelly clay loam
15 to 23 inches—yellowish red clay
23 to 43 inches—yellowish red, white, and pink channery clay and very channery clay
43 inches—sandstone

Soil Properties and Qualities

Parent material: Alluvium and colluvium derived from sandstone, siltsone, and shale of the Hermit Shale Formation
Depth class: Deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 40 to 60 inches
Runoff: Rapid or very rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Very high
Corrosivity: Steel (uncoated)—high; concrete—low;

Inclusions

Contrasting inclusions:
- Moderately deep, fine soils (Tovar soils)
- Deep, loamy soils in drainageways (Lykorly and Frazwell soils)
- Deep, fine soils in drainageways (Disterheff soils)

Similar inclusions:
- Soils that have very stony surface textures
- Soils that are on the steeper slopes

Use and Management

Woodland

Dominant overstory vegetation: Utah juniper—60 percent; Colorado pinyon—40 percent
Overstory production:
- Fuelwood—10 to 12 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—70 to 80 per acre
- Christmas trees—20 to 25 per acre
- Ornamental trees—40 to 50 per acre

Dominant understory vegetation: Turbinella oak, running pricklypear, banana yucca, blue grama, bottlebrush squirreltail
Major management factors: Steep slopes, hazard of water erosion on the steep slopes, high content of rock fragments on the surface, slow permeability, very high shrink-swell potential
General management considerations:
- Wood products can be harvested when the canopy cover exceeds 35 percent and slope is less than 25 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Maintaining the understory vegetation is essential in controlling erosion.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accessible forage on the ridge tops and in the valleys before they graze the steep side slopes.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices:
- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on steep slopes.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous

hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
• This unit supports vegetation that provides important habitat for mule deer.
• This unit provides important wintering areas for elk and wild turkey.
Suitable mangement practices:
• Develop water facilities for wildlife.
• Use proper grazing practices to preserve forage for wildlife.
• Avoid nest trees when gathering firewood.
• Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Sandstone Upland, 13-17" p.z.

17—Hidvalle very fine sandy loam, 1 to 6 percent slopes

Setting

Landform: Draws
Flooding: None
Elevation: 5,300 to 5,900 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days

Composition

Hidvalle soil and similar inclusions: 90 percent
Contrasting inclusions: 10 percent

Typical Profile

0 to 2 inches—reddish brown very fine sandy loam
2 to 18 inches—reddish brown very fine sandy loam
18 to 60 inches—reddish brown very fine sandy loam

Soil Properties and Qualities

Parent material: Alluvium and eolian deposits derived from sandstone and shale of the Supai Formation
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderate
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Moderately high
Shrink-swell potential: Low
Content of calcium carbonate: 0 to 10 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Moderately deep, loamy soils

Similar inclusions:
• Soils that have a content of clay that is slightly higher than that of the Hidvalle soil
• Soils that have gravelly substrata
• Soils that have fine sandy loam surfaces

Use and Management

Rangeland

Dominant vegetation:
• Potential plant community—needleandthread, Indian ricegrass, blue grama, black grama, fourwing saltbush, winterfat
• Present plant community—blue grama, ring muhly, broom snakeweed, fourwing saltbush, winterfat, Fremont barberry
Major management factors: Hazard of wind and water erosion, low bearing strength, piping
General management considerations:
• Continuous, intensive year-round grazing results in a deteriorated plant community that has low forage value.
• Suitability for seeding is fair.
Suitable management practices:
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• Seed the range if the plant cover is not sufficient to protect the soil from erosion.
• After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
• This unit supports vegetation that provides important habitat for mule deer.
• This unit provides important wintering areas for elk and wild turkey.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing practices to preserve forage for wildlife.

- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIe, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Range site: Sandy Loam Upland, 13-17" p.z.

18—Hindu-Rock outcrop complex, 5 to 45 percent slopes

Setting

Landform: Hills and mesas
Landscape position: Shoulders and back slopes
Flooding: None
Slope range: 5 to 45 percent
Elevation: 4,000 to 4,800 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 60 to 70 degrees F
Frost-free period: 175 to 220 days

Composition

Hindu soil and similar inclusions: 60 percent
Rock outcrop: 20 percent
Contrasting inclusions: 20 percent

Typical Profile

Hindu

0 to 3 inches—light brown extremely cobbly loam
3 to 9 inches—light brown very gravelly loam
9 inches—gray limestone

Rock outcrop consists of exposures of dominantly Redwall Limestone

Soil Properties and Qualities

Hindu

Parent material: Residuum and colluvium derived from calcareous sedimentary rock
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: Very low
Potential rooting depth: Dominantly 3 to 10 inches but ranges to 19 inches
Runoff: Rapid or very rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: Averages 10 to 35 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Moderately deep, gravelly soils
- Deep, loamy soils in drainageways

Similar inclusions:
- Shallow, gravelly soils overlying a calcium carbonate cemented hardpan
- Soils that have a lower content of rock fragments in the subsoil than the Hindu soil
- Soils that have less slope on the top edges of mesas
- Shallow soils that have accumulations of clay or calcium carbonate in the subsoil
- Soils on the steeper slopes near confluences of major canyons

Use and Management

Rangeland

Dominant vegetation on the Hindu soil:
- Potential plant community—blackbrush, mariola, banana yucca, Nevada Mormon tea, Utah agave, black grama, slim tridens, bush muhly
- Present plant community—blackbrush, mariola banana yucca, Nevada Mormon tea, Utah agave, black grama, red brome, slim tridens, bush muhly

Major management factors: Shallow depth to rock, high content of rock fragments, steep slopes, very low available water capacity, hazard of water erosion on steep slopes

General management considerations on the Hindu soil and Rock outcrop:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Suitability for seeding is poor, because of shallow soils, rock content, droughtiness, and steep slopes.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accessible forage on the ridgetops and in the valleys before they graze the side slopes.
- Areas of Hindu soils located within the Grand Canyon are inaccessible to livestock.

Suitable management practices on the Hindu soil and Rock outcrop:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, golden eagle, peregrine falcon, canyon wren, violet-green swallow, ringtail, chuckawalla
General management considerations:
• These areas provide important nest sites for many species of birds and provide escape routes for bighorn sheep.
• The Rock outcrop supports no vegetation but is important for nest sites, resting cover, hunting perches, escape routes, and dens.
Suitable management practices:
• Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: Hindu—VIIs, nonirrigated
Major Land Resource Unit: 30-2AZ—Grand Canyon Desert Shrub
Range site: Hindu—Limestone Hills, 9-12" p.z.

19—Lostman family-Harrisburg complex, 1 to 5 percent slopes

Setting

Landform: Stream terraces
Flooding: Rare, very brief runoff from adjacent slopes
Slope range: 1 to 5 percent
Elevation: 3,800 to 4,200 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 59 to 62 degrees F
Frost-free period: 180 to 200 days

Composition

Lostman family and similar inclusions: 50 percent
Harrisburg soil and similar inclusions: 45 percent
Contrasting inclusions: 5 percent

Typical Profile

Lostman family

0 to 2 inches—brown very fine sandy loam
2 to 27 inches—light brown very fine sandy loam
27 to 37 inches—light brown silt loam
37 to 53 inches—light brown very fine sandy loam
53 to 60 inches—light brown very gravelly fine sandy loam

Harrisburg

0 to 27 inches—light brown very fine sandy loam
27 to 34 inches—light brown cobbly very fine sandy loam
34 to 42 inches—pinkish white extremely cobbly very fine sandy loam, strongly calcium carbonate cemented
42 inches—indurated, calcium carbonate cemented hardpan

Soil Properties and Qualities

Lostman family

Parent material: Alluvium derived from limestone and sandstone
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Moderately high
Shrink-swell potential: Low
Corrosivity: Steel (uncoated)—high; concrete—low

Harrisburg

Parent material: Alluvium derived from limestone and sandstone
Depth class: Moderately deep to a hardpan
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: Moderate
Potential rooting depth: 20 to 40 inches
Runoff: Medium or rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Moderately high
Shrink-swell potential: Low
Calcium carbonate equivalent: 15 to 30 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Soils containing more than 35 percent rock fragments

Similar inclusions:
• Soils that have a surface layer of fine sandy loam

Use and Management

Rangeland

Dominant vegetation on the Lostman family soil:
• Potential plant community—big galleta, sand dropseed, black grama, fourwing saltbush, Anderson wolfberry
• Present plant community—big galleta, sand dropseed, cheatgrass, fourwing saltbush, Anderson wolfberry
Dominant vegetation on the Harrisburg soil:
• Potential plant community—big galleta, black grama, sand dropseed, fourwing saltbush, Anderson wolfberry, Nevada Mormon tea

• Present plant community—big galleta, sand dropseed, bush muhly, cheatgrass, fourwing saltbush, Nevada Mormon tea, Anderson wolfberry
Major management factors: Hazard of wind and water erosion
General management considerations on these soils:
• Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
• Suitability for seeding is poor, because of low precipitation and hot temperatures.
• Water is scarce.
Suitable management practices on these soils:
• Vary the season of grazing and the periods of rest during succesive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• To use the site, develop water facilities for livestock.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, willow flycatcher, coyote, common raven, kit fox, canyon wren, violet-green swallow, ringtail, Mohave rattlesnake, leopard frog, spadefoot toad, Gambel's quail, kangaroo rat
General management considerations:
• This unit is an important watering area for desert bighorn sheep and other animals. Water occurs as ephermeral flows from summer storms and collects in pools.
• Small mammals are important prey for many species, especially raptors, and their population fluctuates widely with environmental conditions.
• These areas support diverse riparian vegetation providing migration corridors for neotropical migratory birds.
• The Colorado River corridor supports a diverse avian community including waterfowl and shorebirds.
• The willow flycatcher is a candidate for endangered species status.
Suitable management practices:
• Develop water facilities for wildlife.
• Designate camping areas to preserve riparian habitat.
• Plant trees to control erosion and to improve the diversity of vegetation.
• Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: VIIe, nonirrigated
Major Land Resource Unit: 30-2AZ—Grand Canyon Desert Shrub
Range site: Limy Fan, 9-12" p.z.

20—Luzena-Thunderbird complex, 3 to 20 percent slopes

Setting

Landform: Hills and mesas
Flooding: None
Slope range: 3 to 20 percent
Elevation: 4,900 to 5,400 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 57 degrees F
Frost-free period: 120 to 160 days

Composition

Luzena soil and similar inclusions: 45 percent
Thunderbird soil and similar inclusions: 30 percent
Contrasting inclusions: 25 percent

Typical Profile

Luzena

0 to 2 inches—brown extremely cobbly sandy loam
2 to 12 inches—brown gravelly clay loam
12 to 17 inches—fractured and weathered rhyolite
17 inches—hard rhyolite

Thunderbird

0 to 2 inches—dark brown very cobbly fine sandy loam
2 to 6 inches—dark brown cobbly loam
6 to 11 inches—dark brown clay loam
11 to 24 inches—brown cobbly clay
24 inches—rhyolite, widely fractured and weathered in the upper 2 to 3 inches

Soil Properties and Qualities

Luzena

Parent material: Alluvium and residuum derived from basalt or rhyolite
Depth class: Shallow
Drainage class: Well drained
Permeability: Slow
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: High
Corrosivity: Steel (uncoated)—high; concrete—low

Thunderbird

Parent material: Residuum and alluvium derived from basalt or rhyolite
Depth class: Moderately deep

Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: High
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Rock outcrop
- Very shallow soils that have a lower content of clay than the Luzena and Thunderbird soils
- Shallow soils that have a higher content of rock fragments in the subsoil than the Luzena and Thunderbird soils

Similar inclusions:
- Soils that have a higher or lower content of rock fragments on the surface than the Luzena and Thunderbird soils
- Soils that are on the steeper slopes on edges of mesas
- Soils that have extremely gravelly or extremely cobbly sandy loam or loam surface textures
- Soils over volcanic tuff and breccia
- Soils that have less organic matter and lighter colored surface horizons than the Luzena and Thunderbird soils

Use and Management

Woodland

Dominant overstory vegetation on the Luzena soil: Utah juniper—90 percent; singleleaf pinyon—10 percent
Overstory production on the Luzena soil:
- Fuelwood—6 to 8 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—70 to 80 per acre
- Christmas trees—20 to 30 per acre
- Ornamental trees—20 to 30 per acre

Dominant understory vegetation on the Luzena soil: Muttongrass, bottlebrush squirreltail, prairie junegrass, sideoats grama, Stansbury cliffrose, turbinella oak, banana yucca.
Dominant overstory vegetation on the Thunderbird soil: Utah juniper—90 percent; singleleaf pinyon—10 percent
Overstory production:
- Fuelwood—8 to 10 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—60 to 70 per acre
- Christmas trees—0 to 2 per acre
- Ornamental trees—0 to 2 per acre

Dominant understory vegetation on the Thunderbird soil: Blue grama, bottlebrush squirreltail, Stansbury cliffrose, turbinella oak, broom snakeweed, desert ceanothus, mountain big sagebrush.
Major management factors: Shallow depth to rock, high shrink-swell potential, high content of rock fragments on surface, slow permeability
General management considerations on the Luzena and Thunderbird soils:
- Wood products can be harvested when the canopy cover exceeds 35 percent.
- Leave larger trees for pinyon nut production and wildlife habitat.
- In areas where the density of the canopy is less than about 35 percent, the understory produces plants suitable for grazing.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accessible forage on the ridge tops and in the valleys before they graze the side slopes.
- Suitability for seeding is poor because of soil-related factors.
- People who are gathering firewood need to avoid nest trees.

Suitable management practices on the Luzena and Thunderbird soils:
- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on very steep slopes.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.

• Avoid nest trees when gathering firewood.
• Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Basalt Upland, 13-17" p.z.

21—Lykorly gravelly loam, 1 to 4 percent slopes

Setting

Landform: Stream terraces
Flooding: None
Elevation: 6,000 to 6,500 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days

Composition

Lykorly soil and similar inclusions: 85 percent
Contrasting inclusions: 15 percent

Typical Profile

0 to 1 inch—light brown gravelly loam
1 to 2 inches—light yellowish brown loam
2 to 4 inches—dark yellowish brown loam
4 to 25 inches—dark yellowish brown and brown clay loam
25 to 44 inches—brown loam
44 to 60 inches—yellowish red clay

Soil Properties and Qualities

Parent material: Alluvium derived from limestone and sandstone
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Slight
Shrink-swell potential: Moderate
Content of calcium carbonate: Less than 15 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Soils that have a higher content of clay than the Lykorly soil (Albers and Disterheff soils)
• Soils that have a higher organic content and darker surface colors than the Lykorly soil

Similar inclusions:
• Soils that have fine sandy loam surface layers
• Soils that have red clay layers slightly above a depth of 40 inches
• Soils that have a higher content of silt in the subsoil than the Lykorly soil

Use and Management

Rangeland

Dominant vegetation:
• Potential plant community—western wheatgrass, muttongrass, blue grama, bottlebrush squirreltail, fourwing saltbush, Wyoming big sagebrush
• Present plant community—bottlebrush squirreltail, blue grama, muttongrass, Wyoming big sagebrush, broom snakeweed
Major management factors: Slow permeability
General management considerations:
• Continuous, intensive, year-round grazing commonly results in a deteriorated plant community that has low forage value.
• If shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.
• Range seeding may be needed if quantities of the more desirable forage plants have decreased.
• Suitability for range seeding is good.
Suitable management practices:
• Vary the season of grazing and the period of rest during consecutive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• Manage the brush in areas where unpalatable brushy plants have increased significantly.
• Control brush by using approved methods.
• Seed the range if the plant cover is not sufficient to protect the soil from erosion.
• Seed suitable plants that meet the seasonal requirements of both livestock and wildlife.
• Seed late in the fall for best results.
• After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay

General management considerations:
- These soils support vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing practices to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Range site: Loamy Upland, 13-17" p.z.

22—Lykorly silt loam, moist, 1 to 5 percent slopes

Setting

Landform: Stream terraces
Flooding: None
Elevation: 5,400 to 5,800 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days

Composition

Lykorly soil and similar inclusions: 75 percent
Contrasting inclusions: 25 percent

Typical Profile

0 to 2 inches—brown silt loam
2 to 10 inches—brown loam
10 to 38 inches—brown with pinkish white silt loam
38 to 60 inches—brown loam and silt loam

Soil Properties and Qualities

Parent material: Alluvium derived from limestone and sandstone
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Moderate
Shrink-swell potential: Moderate
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Rock outcrop
- Shallow, loamy to clayey soils overlying sedimentary rock
- Moderately deep loamy soils overlying sedimentary rock

Similar inclusions:
- Soils that have a gravelly surface layer
- Soils that have layers of gravel at a depth of 30 inches or more

Use and Management

Woodland

Dominant overstory vegetation: Utah juniper—70 percent; singleleaf pinyon—30 percent
Overstory production:
- Fuelwood—10 to 12 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—100 to 120 per acre
- Christmas trees—10 to 20 per acre
- Ornamental trees—10 to 20 per acre

Dominant understory vegetation: Muttongrass, blue grama, bottlebrush squirreltail, turbinella oak, mountain big sagebrush, Fremont barberry, broom snakeweed
Major management factors: Hazard of water erosion, low bearing strength, piping
General management considerations:
- Wood products can be harvested when the canopy cover exceeds 30 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Range seeding may be needed if quantities of the more desirable forage plants have decreased.
- Suitability for seeding grass is good.
- If shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.

Suitable management practices:
- Use conventional methods in harvesting.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during succesive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Seed disturbed areas to adapted grasses by drilling in order to increase forage production.
- Prepare the site adequately in order to seed understory plants successfully.
- Seed late in the fall for best results.
- After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
• This unit supports vegetation that provides important habitat for mule deer.
• This unit provides important wintering areas for elk and wild turkey.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing practices to preserve forage for wildlife.
• Avoid nest trees when gathering firewood.
• Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIe, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Loamy Upland (Limy), 13-17" p.z.

23—Metuck-Rock outcrop complex, 15 to 60 percent slopes

Setting

Landform: Canyon escarpments
Flooding: None
Slope range: 15 to 60 percent
Elevation: 4,500 to 5,800 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 170 days

Composition

Metuck soil and similar inclusions: 60 percent
Rock outcrop: 30 percent
Contrasting inclusions: 10 percent

Typical Profile

Metuck

0 to 1 inch—reddish brown extremely channery fine sandy loam
1 to 8 inches—reddish brown very channery fine sandy loam
8 to 10 inches—light reddish brown very channery very fine sandy loam
10 to 12 inches—fractured, weathered sandstone
12 inches—calcareous sandstone

Rock outcrop consists of thin-bedded sandstone ledges of the Supai Formation

Soil Properties and Qualities

Metuck

Parent material: Residuum derived from calcareous sandstone of the Supai Formation
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: Dominantly less than 10 inches but ranges from 3 to 17 inches
Runoff: Very rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: Averages 15 to 30 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Soils that are moderately deep

Similar inclusions:
• Soils that have more rock fragments in the subsoil than the Metuck soil
• Shallow soils that have horizons of clay or calcium carbonate accumulations

Use and Management

Woodland

Dominant overstory vegetation on the Metuck soils: Colorado pinyon—60 percent; Utah juniper—40 percent
Overstory production:
• Fuelwood—6 to 8 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
• Posts—15 to 30 per acre
• Christmas trees—15 to 30 per acre
• Ornamental trees—20 to 25 per acre
Dominant understory vegetation on the Metuck soil: Bigelow sagebrush, desert ceanothus, spiny greasebush, turbinella oak, true mountain mahogany, Indian ricegrass, crested needlegrass, sideoats grama
Major management factors: Hazard of water erosion, shallow depth to rock, high content of rock fragments, steep slopes
General management considerations on the Metuck soil:
• Wood products can be harvested when the canopy cover exceeds 30 percent and when the slope is less than 35 percent.
• In areas where the density of the canopy is less than

about 30 percent, the understory produces plants suitable for grazing.
• Maintaining the understory vegetation is essential in controlling erosion.
• Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
• Livestock prefer to graze the easily accessible forage on the ridge tops and in the valleys before they graze the side slopes.
• Suitability for range seeding is poor because of soil-related factors.
Suitable management practices on the Metuck soil:
• Use conventional methods in harvesting.
• Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on steep slopes.
• Leave some of the larger trees to provide shade for seedlings.
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
• This unit supports vegetation that provides important habitat for mule deer.
• This unit provides important wintering areas for elk and wild turkey.
• The Rock outcrop supports no vegetation but is important for nest sites, resting cover, hunting perches, escape routes, and dens.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing practices to preserve forage for wildlife.
• Avoid nest trees when gathering firewood.
• Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIIe, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Metuck soil—Sandstone Slopes, 13-17" p.z.

24—Mextank-Lykorly-Disterheff complex, 2 to 20 percent slopes

Setting

Landform: Fan terraces
Landscape position: Mextank—shoulders and back slopes; Disterheff and Lykorly—summits and foot slopes
Flooding: None
Slope range: Mextank—5 to 20 percent; Disterheff and Lykorly—2 to 6 percent
Elevation: 5,600 to 6,000 feet
Mean annual precipitation: 16 to 18 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 140 to 160 days

Composition

Mextank soil and similar inclusions: 45 percent
Lykorly soil and similar inclusions: 25 percent
Disterheff soil and similar inclusions: 25 percent
Contrasting inclusions: 5 percent

Typical Profile

Mextank

0 to 1 inch—brown extremely gravelly fine sandy loam
1 to 14 inches—brown very gravelly fine sandy loam and loam
14 to 27 inches—brown very cobbly loam
27 to 50 inches—brown very gravelly loam and sandy clay loam
50 to 60 inches—light brown extremely gravelly coarse sandy loam

Lykorly

0 to 1 inch—brown extremely gravelly loam
1 to 39 inches—brown loam and clay loam
39 to 65 inches—light brown and pink, calcareous loam

Disterheff

0 to 1 inch—brown extremely gravelly loam
1 to 3 inches—dark brown loam
3 to 9 inches—reddish brown clay loam
9 to 22 inches—reddish brown gravelly clay
22 to 37 inches—reddish brown clay loam
37 to 60 inches—reddish brown, calcareous clay loam

Soil Properties and Qualities

Mextank

Parent material: Colluvium derived from limestone and sandstone
Depth class: Very deep
Drainage class: Well drained

Permeability: Moderate
Available water capacity: Low
Potential rooting depth: 60 or more inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 5 to 30 percent
Corrosivity: Steel (uncoated)—moderate; concrete—low

Lykorly

Parent material: Alluvium derived from limestone and sandstone
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Slow to medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Corrosivity: Steel (uncoated)—high; concrete—low

Disterheff

Parent material: Alluvium derived from limestone and sandstone
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: High
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Very high
Content of calcium carbonate: 10 to 50 percent in the lower subsoil
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Shallow, clayey soils overlying cemented hardpans on fan terraces
- Riverwash

Similar inclusions:
- Soils that have a content of rock fragments that is more than 35 percent and that have lighter colored surface horizons than the Mextank, Lykorly, and Disterheff soils
- Clayey soils that have soil surfaces that are darker than those of the Mextank, Lykorly, and Disterheff soils

Use and Management

Woodland

Dominant overstory vegetation on the Mextank soil: Utah juniper—50 percent; Colorado pinyon—50 percent
Overstory production:
- Fuelwood—10 to 14 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—100 to 110 per acre
- Christmas trees—20 to 25 per acre
- Ornamental trees—20 to 25 per acre

Dominant understory vegetation on the Mextank soil: Bottlebrush squirreltail, blue grama, muttongrass, turbinella oak, Wyoming big sagebrush, Wright birdbeak
Dominant overstory vegetation on the Lykorly soil: Utah juniper—50 percent; Colorado pinyon—50 percent
Overstory production:
- Fuelwood—9 to 11 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—50 to 60 per acre
- Christmas trees—30 to 40 per acre
- Ornamental trees—50 to 60 per acre

Dominant understory vegetation on the Lykorly soil: Muttongrass, blue grama, bottlebrush squirreltail, Wyoming big sagebrush, Stansbury cliffrose, turbinella oak
Dominant overstory vegetation on the Disterheff soil: Utah juniper—50 percent; Colorado pinyon—50 percent
Overstory production:
- Fuelwood—10 to 12 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—60 to 80 per acre
- Christmas trees—30 to 40 per acre
- Ornamental trees—40 to 50 per acre

Dominant understory vegetation on the Disterheff soil: Muttongrass, bottlebrush squirreltail, blue grama, mountain big sagebrush, Wyoming big sagebrush, Stansbury cliffrose, broom snakeweed
Major management factors: Mextank—high content of rock fragments on the surface, moderately steep slopes; Lykorly—high content of rock frgaments on the surface; Disterheff—very high shrink-swell potential, slow permeability, high content of rock fragments on the surface
General management considerations on these soils:
- Wood products can be harvested when the canopy cover exceeds 30 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Suitability for seeding grass is fair because of soil-related factors.

Suitable management practices on these soils:
- Use conventional methods in harvesting.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during succesive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Seed disturbed areas to adapted grasses by drilling and broadcasting in order to increase forage production.
- Prepare the site adequately in order to seed understory plants successfully.
- Seed late in the fall for best results.
- After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Loamy Upland (Gravelly), 13-17" p.z.

25—Milkweed-Quartermaster-Buckndoe complex, 2 to 20 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Slope range: Milkweed and Buckndoe—2 to 20 percent; Quartermaster—2 to 12 percent
Elevation: 4,600 to 5,500 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 120 to 160 days

Composition

Milkweed soil and similar inclusions: 50 percent
Quartermaster soil and similar inclusions: 30 percent
Buckndoe soil and similar inclusions: 15 percent
Contrasting inclusions: 5 percent

Typical Profile

Milkweed

0 to 2 inches—dark yellowish brown extremely gravelly loam
2 to 11 inches—brown and dark yellowish brown very gravelly loam
11 to 28 inches—fractured, calcium carbonate cemented hardpan
28 to 60 inches—indurated, calcium carbonate cemented hardpan

Quartermaster

0 to 2 inches—yellowish brown extremely gravelly sandy loam
2 to 19 inches—yellowish brown loam
19 to 26 inches—yellowish brown cobbly loam
26 inches—indurated, calcium carbonate cemented hardpan

Buckndoe

0 to 2 inches—yellowish brown very gravelly sandy loam
2 to 5 inches—yellowish brown gravelly sandy loam
5 to 10 inches—yellowish brown gravelly loam
10 to 16 inches—yellowish brown gravelly fine sandy loam
16 to 26 inches—brown very cobbly fine sandy loam
26 to 42 inches—pinkish white very cobbly fine sandy loam
42 to 60 inches—extremely hard, calcium carbonate cemented hardpan

Soil Properties and Qualities

Milkweed

Parent material: Alluvium derived from sedimentary and igneous rock
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight

Shrink-swell potential: Low
Potential frost action: Moderate
Content of calcium carbonate: Averages 30 to 40 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Quartermaster

Parent material: Alluvium derived from limestone and basalt
Depth class: Moderately deep to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Potential frost action: Moderate
Content of calcium carbonate: 15 to 40 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Buckndoe

Parent material: Alluvium derived from sedimentary and igneous rock
Depth class: Deep to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Low
Potential rooting depth: 40 to 59 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Slight
Shrink-swell potential: Low
Potential frost action: Moderate
Content of calcium carbonate: Averages 20 to 40 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Shallow, very gravelly loamy soils overlying bedrock (Wodomont soils)
- Soils in areas on steeper slopes
- Very deep, fine soils in drainageways (Lykorly soils)

Similar inclusions:
- Soils that have less rock fragments than the Milkweed, Quartermaster, and Buckndoe soils
- Moderately deep, very gravelly soils
- Soils that are less than 10 inches thick over a hardpan
- Very deep soils overlying a hardpan at a depth of more than 60 inches

Use and Management

Woodland

Dominant overstory vegetation on the Milkweed soil: Utah juniper—70 percent; singleleaf pinyon—30 percent
Overstory production:
- Fuelwood—9 to 11 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—100 to 110 per acre
- Christmas trees—20 to 25 per acre
- Ornamental trees—20 to 25 per acre

Dominant understory vegetation on the Milkweed soil: Bottlebrush squirreltail, blue grama, broom snakeweed, turbinella oak, desert ceanothus, Stansbury cliffrose, Fremont barberry
Dominant overstory vegetation on the Quartermaster soil: Utah juniper—90 percent; singleleaf pinyon—10 percent
Overstory production:
- Fuelwood—9 to 11 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—100 to 110 per acre
- Christmas trees—5 to 10 per acre
- Ornamental trees—5 to 10 per acre

Dominant understory vegetation on the Quartermaster soil: Blue grama, Indian ricegrass, bottlebrush squirreltail, Fendler threeawn, broom snakeweed, Fremont barberry
Dominant overstory vegetation on the Buckndoe soil: Utah juniper—70 percent; singleleaf pinyon—30 percent
Overstory production:
- Fuelwood—10 to 12 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—80 to 100 per acre
- Christmas trees—30 to 40 per acre
- Ornamental trees—30 to 40 per acre

Dominant understory vegetation on the Buckndoe soil: Bottlebrush squirreltail, blue grama, desert ceanothus, mountain big sagebrush, turbinella oak, broom snakeweed, Fremont barberry
Major management factors: Shallow depth to a pan, high content of rock fragments, high content of calcium carbonate
General management considerations on the Milkweed, Quartermaster, and Buckndoe soils:
- Wood products can be harvested when the canopy cover exceeds 30 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Suitability for seeding grass is good for the Buckndoe soil and poor for the Milkweed soil because of soil-related factors.

Suitable management practices on the Milkweed, Quartermaster, and Buckndoe soils:
- Use conventional methods in harvesting.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Seed disturbed areas to adapted grasses by drilling and broadcasting in order to increase forage production.
- Prepare the site adequately in order to seed understory plants successfully.
- Seed late in the fall for best results.
- After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Milkweed—Shallow Loam (Gravelly), 13-17" p.z.; Quartermaster—Shallow Loam (Gravelly), 13-17" p.z.; Buckndoe—Loamy Upland (Limy), 13-17" p.z.

26—Milok-Pastern complex, 4 to 12 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Elevation: 4,300 to 4,600 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 53 to 56 degrees F
Frost-free period: 150 to 165 days

Composition

Milok soil and similar inclusions: 55 percent
Pastern soil and similar inclusions: 35 percent
Contrasting inclusions: 10 percent

Typical Profile

Milok

0 to 2 inches—brown gravelly sandy loam
2 to 25 inches—brown and pale brown gravelly sandy loam
25 to 37 inches—very pale brown gravelly loam
37 to 60 inches—light brown loam

Pastern

0 to 2 inches—brown gravelly sandy loam
2 to 11 inches—yellowish brown and brown gravelly loam
11 to 21 inches—indurated, calcium carbonate cemented hardpan
21 to 60 inches—yellowish brown extremely gravelly sandy loam

Soil Properties and Qualities

Milok

Parent material: Limestone alluvium
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Moderate
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Slight
Shrink-swell potential: Low
Content of calcium carbonate: Averages 10 to 25 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Pastern

Parent material: Limestone alluvium
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Moderate
Shrink-swell potential: Low
Content of calcium carbonate: 5 to 25 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Soils that are shallow or moderately deep over bedrock
- Deep silt loam soils in drainageways
- Soils that are deep over bedrock

Similar inclusions:
- Shallow and very deep soils that have more than 35 percent rock fragments in the profile
- Soils that do not have a zone of calcium carbonate accumulation
- Soils moderately deep to a hardpan
- Shallow and very deep soils that have more than 40 percent calcium carbonate equivalent in the profile
- Soils that have a clay increase in the profile

Use and Management

Rangeland

Dominant vegetation on the Milok and Pastern soils:
- Potential plant community—fourwing saltbush, winterfat, blue grama, sand dropseed, Indian ricegrass, black grama
- Present plant community—broom snakeweed, blue grama, black grama, threeawn

Major management factors: Pastern—shallow depth to a hardpan, very low available water capacity

General management considerations on the Milok and Pastern soils:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Range seeding may be needed if quantities of the more desirable forage plants have decreased.
- Suitability for seeding is fair on the Peachsprings soil and poor on the Pastern soil because of soil-related factors.

Suitable management practices on the Milok and Pastern soils:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.
- Seed the range if the plant cover is not sufficient to protect the soil from erosion.
- After seeding, defer grazing until young plants are well established.
- Seed late in fall for best results.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, thirteen-lined ground squirrel, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon

General management considerations:
- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals that frequent this unit are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Milok—Limy Upland, 9-13" p.z.; Pastern—Limy Upland (Shallow), 9-13" p.z.

27—Natank-Disterheff-Yumtheska complex, 2 to 35 percent slopes

Setting

Landform: Plateaus and stream terraces
Landscape position: Natank—summits; Disterheff—stream terraces on plateaus; Yumtheska—back slopes and shoulders
Flooding: None
Slope range: Natank—2 to 15 percent; Disterheff—2 to 8 percent; Yumtheska—3 to 35 percent
Elevation: 6,200 to 6,600 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days

Composition

Natank soil and similar inclusions: 40 percent
Disterheff soil and similar inclusions: 30 percent
Yumtheska soil and similar inclusions: 15 percent
Contrasting inclusions: 15 percent

Typical Profile

Natank

0 to 2 inches—brown extremely gravelly loam
2 to 4 inches—brown clay loam
4 to 22 inches—reddish brown clay

22 to 30 inches—reddish yellow loam
30 inches—calcareous sandstone

Disterheff

0 to 2 inches—brown very gravelly loam
2 to 4 inches—brown clay loam
4 to 23 inches—reddish brown clay
23 to 39 inches—pink limy gravelly clay loam
39 to 60 inches—pink clay loam

Yumtheska

0 to 1 inch—brown very cobbly loam
1 to 10 inches—dark brown very cobbly loam
10 to 14 inches—grayish brown very cobbly loam
14 inches—limestone

Soil Properties and Qualities

Natank

Parent material: Alluvium and residuum derived from calcareous sandstone and limestone
Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink swell potential: High
Content of calcium carbonate: None in the upper part; variable in the lower subsoil, commonly averaging 15 to 40 percent above the bedrock
Corrosivity: Steel (uncoated)—high; concrete—low

Disterheff

Parent material: Alluvium derived from sedimentary rock
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Very high
Content of calcium carbonate: 15 to 40 percent in the lower subsoil
Corrosivity: Steel (uncoated)—high; concrete—low

Yumtheska

Parent material: Alluvium and residuum derived from limestone
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 7 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 15 to 40 percent above bedrock
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Deep, loamy soils on narrow stream terraces (Lykorly soils)
- Shallow, clayey soils (Toqui soils)
- Rock outcrop on escarpments and ledges

Similar inclusions:
- Shallow soils that have a higher content of calcium carbonate than the Natank, Disterheff, and Yumtheska soils (Deama soils)
- Shallow soils that have lighter colors than the Natank, Disterheff, and Yumtheska soils
- Soils that have less calcium carbonate or less clay than the Disterheff or Natank soil

Use and Management

Woodland

Dominant overstory vegetation on the Natank soil: Utah juniper—55 percent; Colorado pinyon—45 percent
Overstory production:
- Fuelwood—9 to 11 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—60 to 70 per acre
- Christmas trees—20 to 30 per acre
- Ornamental trees—20 to 30 per acre

Dominant understory vegetation on the Natank soil: Muttongrass, blue grama, prairie junegrass, Stansbury cliffrose, Wyoming big sagebrush
Dominant overstory vegetation on the Yumtheska soil: Colorado pinyon—60 percent; Utah juniper—40 percent
Overstory production:
- Fuelwood—4 to 6 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—40 to 50 per acre
- Christmas trees—20 to 30 per acre
- Ornamental trees—20 to 30 per acre

Dominant understory vegetation on the Yumtheska soil: Muttongrass, blue grama, Stansbury cliffrose, Wyoming big sagebrush, bottlebrush squirreltail
Major management factors: Natank—high shrink-swell potential, large amounts of rock fragments on the

surface; Disterheff—very high shrink-swell potential; Yumtheska—shallow depth to bedrock, very low available water-holding capacity, steep slopes, hazard of water erosion on steep slopes

General management considerations on the Natank and Yumtheska soils:

- Wood products can be harvested when the canopy cover exceeds 33 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accessible forage on the ridge tops and in the valleys before they graze the side slopes.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Natank and Yumtheska soils:

- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on very steep slopes.
- Leave some of the larger trees to provide shade for seedlings.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Vary the season of grazing and the periods of rest during successive years.
- Control the time and amount of use by livestock.

Rangeland

Dominant vegetation on the Disterheff soil:

- Potential plant community—western wheatgrass, muttongrass, blue grama, prairie junegrass, bottlebrush squirreltail, Wyoming big sagebrush
- Present plant community—muttongrass, blue grama, prairie junegrass, bottlebrush squirreltail, Wyoming big sagebrush

Major management factors: Disterheff—high shrink-swell potential, slow permeability, large amounts of gravel on the surface

Suitable management practices on the Disterheff soil:

- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of livestock use.
- Seed the range if the plant cover is not sufficient to protect the soil from erosion.
- Seed suitable plants, such as plants that meet the seasonal requirments of both livestock and wildlife and plants that tolerate shrinking and swelling of the soil.
- Seed late in the fall for best results.
- After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay

General management considerations:

- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:

- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Natank—Clay Loam Upland (Gravelly), 13-17" p.z.; Yumtheska—Limestone Slopes, 13-17" p.z.
Range site: Disterheff—Clay Loam Upland, 13-17" p.z.

28—Nickel family extremely gravelly sandy loam, 2 to 35 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Elevation: 3,700 to 4,200 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 60 to 70 degrees F
Frost-free period: 180 to 220 days

Composition

Nickel family and similar inclusions: 80 percent
Contrasting inclusions: 20 percent

Typical Profile

0 to 2 inches—dark yellowish brown extremely gravelly sandy loam
2 to 5 inches—brown extremely gravelly fine sandy loam
5 to 12 inches—pinkish white, limy, very gravelly fine sandy loam

12 to 41 inches—pinkish white, limy, extremely gravelly sandy clay loam
41 to 60 inches—pink, limy, very gravelly sandy loam

Soil Properties and Qualities

Parent material: Mixed alluvium
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Low
Potential rooting depth: 60 or more inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: Averages 15 to 35 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Shallow soils that have a content of rock fragments that is more than 35 percent (Hindu soils)
- Moderately deep soils that have a content of rock fragments that is more than 35 percent
- Rock outcrop
- Soils that do not have coarse fragments

Similar inclusions:
- Soils that have extremely cobbly or extremely stony sandy loam or fine sandy loam surface textures
- Deep, red soils that do not have zones of calcium carbonate accumulation

Use and Management

Rangeland

Dominant vegetation:
- Potential plant community—blackbrush, slim tridens, black grama, sideoats grama, banana yucca, Nevada Mormon tea, canotia
- Present plant community—blackbrush, slim tridens, red brome, black grama, banana yucca, Nevada Mormon tea, canotia

Major management factors: High content of rock fragments, steep slopes, high content of calcium carbonate, hazard of water erosion on steep slopes
General management considerations:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Suitability for seeding is poor because of droughtiness, steep slopes, shallow soils, and high contents of rock fragments and lime.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accessible forage on the ridgetops and in the valleys before they graze the side slopes.

Suitable management practices:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, coyote, common raven, kit fox, golden eagle, Gambel's quail, kangaroo rat
General management considerations:
- These are important foraging areas for desert bighorn sheep and other animals.
- Small mammals are important prey for many species. Their population fluctuates widely with environmental conditions.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: VIIs, nonirrigated
Major Land Resource Unit: 30-2AZ—Grand Canyon Desert Shrub
Range site: Gravelly Sandy Loam Hills, 9-12" p.z.

29—Peachsprings-Havasupai complex, 2 to 35 percent slopes

Setting

Landform: Fan terraces
Landscape position: Peachsprings—summits and foot slopes; Havasupai—shoulders and side slopes
Flooding: None
Slope range: Peachsprings—2 to 15 percent; Havasupai—2 to 35 percent
Elevation: 4,300 to 5,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days

Composition

Peachsprings soil and similar inclusions: 75 percent

Havasupai soil and similar inclusions: 20 percent
Contrasting inclusions: 5 percent

Typical Profile

Peachsprings

0 to 3 inches—brown extremely gravelly coarse sandy loam
3 to 8 inches—brown gravelly sandy loam
8 to 21 inches—light brown, gravelly sandy clay loam
21 to 32 inches—pink gravelly clay loam
32 to 43 inches—light reddish brown and light brown fine sandy loam
43 to 64 inches—light reddish brown and light brown sandy loam

Havasupai

0 to 2 inches—brown extremely gravelly sandy loam
2 to 7 inches—brown very gravelly fine sandy loam
7 to 15 inches—yellowish brown and white, calcareous extremely gravelly sandy loam
15 to 25 inches—indurated, calcium carbonate cemented hardpan
25 to 60 inches—pink and reddish yellow extremely gravelly coarse sand, weakly calcium carbonate cemented

Soil Properties and Qualities

Peachsprings

Parent material: Mixed alluvium derived from sedimentary and igneous rock
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: Moderate
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Content of calcium carbonate: Averages 25 to 35 percent in the control section
Corrosivity: Steel (uncoated)—high; concrete—low

Havasupai

Parent material: Mixed alluvium derived from sedimentary and igneous rock
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: Averages 25 to 45 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Deep, loamy and fine soils that do not have calcium carbonate accumulations (Poley soils)

Similar inclusions:
• Soils that have less rock fragments on the surface than the Peachsprings and Havasupai soils
• Loamy soils overlying calcium carbonate cemented hardpans at a depth of 20 to 40 inches
• Soils that have very gravelly to extremely gravelly sandy loam to loam surface textures
• Soils that have less fragments in the subsoil (Pastern soils) than the Peachsprings and Havasupai soils

Use and Management

Rangeland

Dominant vegetation on the Peachsprings soil:
• Potential plant community—needleandthread, black grama, blue grama, Indian ricegrass, winterfat, fourwing saltbush
• Present plant community—fourwing saltbush, black grama, needleandthread, banana yucca, broom snakeweed, Utah juniper
Dominant vegetation on the Havasupai soil:
• Potential plant community—needleandthread, black grama, blue grama, sideoats grama, winterfat, fourwing saltbush, Utah juniper
• Present plant community—black grama, blue grama, needleandthread, broom snakeweed, banana yucca, Utah juniper
Major management factors: Peachsprings—high content of calcium carbonate, extremely gravelly surfaces; Havasupai—shallow depth to hardpan, hazard of water erosion on steep slopes
General management considerations on the Peachsprings and Havasupai soils:
• Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
• Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments or both.
• Range seeding may be needed if quantities of the more desirable forage plants have decreased.
• Suitability for seeding is fair on the Peachsprings soil and poor on the Havasupai soil because of soil-related factors.
Suitable management practices on the Peachsprings and Havasupai soils:
• Vary the season of grazing and the periods of rest during successive years.

• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.
• Seed the range if the plant cover is not sufficient to protect the soil from erosion.
• After seeding, defer grazing until young plants are well established.
• Seed late in fall for best results.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
• This unit supports vegetation that provides important habitat for pronghorn antelope.
• The small mammals in these areas are important prey for raptors and other species.
• Small mammal populations fluctuate widely with environmental conditions.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
• Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Peachsprings—Limy Upland, 9-13" p.z.; Havasupai—Limy Upland, (Shallow), 9-13" p.z.

30—Pinntank fine sandy loam, 1 to 8 percent slopes

Setting

Landform: Plateaus and mesas
Flooding: None
Elevation: 6,800 to 7,400 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 47 to 51 degrees F
Frost-free period: 120 to 150 days

Composition

Pinntank soil and similar inclusions: 65 percent
Contrasting inclusions: 35 percent

Typical Profile

0.5 to 0 inch—slightly decomposed pine needles and leaf litter
0 to 8 inches—dark brown and brown fine sandy loam
8 to 33 inches—red clay
33 to 39 inches—soft, weathered sandstone
39 inches—sandstone

Soil Properties and Qualities

Parent material: Residuum derived from sedimentary rock
Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Moderately high
Shrink-swell potential: High
Corrosivity: Steel (uncoated)—moderate; concrete—low

Inclusions

Contrasting inclusions:
• Moderately deep soils near mesa edges that have more than 35 percent rock fragments
• Rock outcrop
• Soils less than 20 inches deep over sandstone

Similar inclusions:
• Pinntank soils that have gravelly surface textures
• Small areas of soils on steeper slopes

Use and Management

Timberland

Dominant overstory vegetation: Ponderosa pine—100 percent
Overstory production:
• Average site index—60 (Minor)
• Estimated average annual production per acre (commercial)—3,000 board feet (Scribner rule) of timber from a stand of trees 100 years old
Dominant understory vegetation: Bottlebrush squirreltail, blue grama, Ross sedge, hairy goldaster, redroot buckwheat, Gambel oak
Major management factors: Hazard of wind erosion, very high shrink-swell potential, moderately deep to bedrock
General management considerations:
• Snowpack and spring thaw limit the use of equipment and restrict access.

• Careless use of wheeled and tracked equipment disturbs the protective layer of duff.
• Adequately designed road drainage reduces the hazard of erosion.
• Maintaining the understory vegetation is essential in controlling erosion.
• If seed trees are in the stand, reforestation occurs naturally in cutover areas.
• Carefully managed reforestation reduces competition from undesirable understory plants.
• Machine planting may be practical in nearly level and dry areas.
• Plant competition delays natural regeneration, but does not prevent the eventual development of a fully stocked, normal stand of trees.
• Trees are subject to windthrow when the soil is excessively wet and winds are strong.
• In areas where the density of the canopy cover is less than about 50 percent, the understory produces plants suitable for grazing.
• Suitability for a grass seeding after logging is good.
Suitable management practices:
• To reduce compaction, use suitable methods of harvest, lay out skid trails in advance, and harvest when the soil is least susceptible to compaction.
• Limit the use of equipment when the soil is wet.
• Reduce the hazard of erosion by avoiding excessive disturbance on the soil; seeding roads and landings; and constructing water bars to protect roads and landings.
• Leave some of the larger trees to provide shade for seedlings.
• Mulch around seedlings to retain moisture in summer.
• Seed disturbed areas to adapted grasses by broadcasting or drilling in order to increase forage production.
• Prepare the site adequately in order to seed understory plants successfully.
• Seed late in fall for best results. After seeding, defer grazing until grasses and tree seedlings are well established.

Wildlife

Wildlife observed in areas of this unit: Elk, mule deer, black bear, mountain lion, bobcat, wild turkey, Abert's squirrel, golden eagle, short-eared owl, white-breasted nuthatch, western tanager
General management considerations:
• This unit supports vegetation that provides important summer foraging areas for elk and wild turkey.
• Gambel oak is an important food and cover tree for a variety of species.
• The northern goshawk and the endangered Mexican spotted owl may exist in these areas.
• These areas provide important roosting and perching sites for golden eagles.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Grazing and timber harvesting should be delayed until July 1 in elk calving areas.
• Seed mixture for revegetation should be suitable for wildlife species.
• Leave snags for wildlife habitat when harvesting timber.

Interpretive Groups

Land capability classification: VIe, nonirrigated
Major Land Resource Unit: 39-1AZ—Mogollon Plateau Coniferous Forest
Woodland site: Sandy Loam Upland, 17-20" p.z.

31—Pinntank-Pocomate-Retsover complex, 1 to 30 percent slopes

Setting

Landform: Mesas, escarpments, and plateaus
Landscape position: Pinntank—summits and shoulders; Pocomate—escarpments; Retsover—summits
Flooding: None
Slope: Pinntank and Retsover soils—1 to 15 percent; Pocomate soils—15 to 30 percent
Elevation: 6,600 to 7,400 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 47 to 51 degrees F
Frost-free period: 120 to 150 days

Composition

Pinntank soil and similar inclusions: 50 percent
Pocomate soil and similar inclusions: 20 percent
Retsover soil and similar inclusions: 20 percent
Contrasting inclusions: 10 percent

Typical Profile

Pinntank

1 to 0 inch—slightly decomposed pine litter
0 to 2 inches—brown loam
2 to 7 inches—dark brown clay loam
7 to 24 inches—reddish brown and yellowish red clay
24 inches—cherty limestone

Pocomate

2 to 0 inches—recent and slightly decomposed pine litter
0 to 3 inches—dark brown extremely cobbly loam
3 to 8 inches—dark brown extremely cobbly clay loam
8 inches—limestone

Retsover

2 to 0 inches—recent and slightly decomposed pine and leaf litter
0 to 1 inch—dark brown gravelly loam
1 to 3 inches—brown loam
3 to 9 inches—dark brown clay loam
9 to 34 inches—reddish brown clay
34 to 44 inches—yellowish red and reddish yellow very cobbly clay
44 inches—limestone

Soil Properties and Qualities

Pinntank

Parent material: Residuum derived from sedimentary rock
Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Slight
Shrink-swell potential: Very high
Corrosivity: Steel (uncoated)—moderate; concrete—low

Pocomate

Parent material: Limestone residuum and colluvium
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: Very low
Potential rooting depth: 8 to 20 inches
Runoff: Rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Corrosivity: Steel (uncoated)—high; concrete—low

Retsover

Parent material: Limestone residuum and local alluvium
Depth class: Deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Moderate
Potential rooting depth: 40 to 60 inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Slight
Shrink-swell potential: Very high
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Rock outcrop
- Soils that have more than 35 percent rock fragments throughout the subsoil

Similar inclusions:
- Shallow to deep soils overlying limestone
- Pocomate soils in small areas of steeper slopes
- Soils that have a lower content of clay in the upper subsoil than the Pinntank, Pocomate, and Retsover soils

Use and Management

Timberland

Dominant overstory vegetation on the Pinntank soil: Ponderosa pine—100 percent
Overstory production:
- Average site index—60 (Minor)
- Estimated average annual production per acre (commercial)—3,300 board feet (Scribner rule) of timber from a stand of trees 100 years old

Dominant understory vegetation on the Pinntank soil: Bottlebrush squirreltail, Ross sedge, blue grama, Gambel oak, broom snakeweed, redroot buckwheat
Dominant overstory vegetation on the Pocomate soil: Ponderosa pine—100 percent
Overstory production:
- Average site index—62 (Minor)
- Estimated average annual production per acre (commercial)—4,600 board feet (Scribner rule) of timber from a stand of trees 100 years old

Dominant understory vegetation on the Pocomate soil: Bottlebrush squirreltail, Ross sedge, prairie junegrass, muttongrass, Gambel oak, Rocky Mountain juniper, New Mexico locust
Dominant overstory vegetation on the Retsover soil: Ponderosa pine—100 percent
Overstory production:
- Average site index—61 (Minor)
- Estimated average annual production per acre (commercial)—3,000 board feet (Scribner rule) of timber from a stand of trees 100 years old

Dominant understory vegetation on the Retsover soil: Bottlebrush squirreltail, Ross sedge, blue grama, muttongrass, Gambel oak, mountain big sagebrush
Major management factors: Shallow Pinntank—depth to limestone, slow permability, very high shrink-swell potential; Pocomate—shallow depth to limestone, large amounts of cobbles on surface, steep slopes; Retsover—slow permeability, very high shrink-swell potential

General management considerations on the Pinntank, Pocomate, and Retsover soils:
- Snowpack and spring thaw limit the use of equipment and restrict access.
- Using wheeled and tracked equipment in harvesting timber is difficult because of the slope on the Pocomate soils.
- Disturbing the soil excesssively in harvesting timber and building roads increases the loss of soil, which in turn leaves a greater amount of rock fragments on the surface.
- When wet, unsurfaced roads and skid trails are muddy. They may be impassable during rainy periods.
- Logging roads require suitable surfacing for year-round use.
- Adequately designed road drainage reduces the hazard of erosion.
- Steep yarding paths, skid trails and firebreaks are subject to rilling and gullying. A plant cover or water bars are needed.
- Maintaining the understory vegetation is essential in controlling erosion.
- Rock outcrops cause breakage of timber and hinder yarding.
- If seed trees are in the stand, reforestation occurs naturally in cutover areas.
- Carefully managed reforestation reduces competition from undesirable understory plants.
- Tree seedlings have a poor rate of survival on Pocomate soils because of shallowness.
- Machine planting may be practical in nearly level areas of the Pinntank and Retsover soils.
- Seedling mortality may be high in summer because of the lack of adequate soil moisture.
- Droughtiness of the surface layer increases seedling mortality, especially on south and southwest facing slopes.
- Plant competition delays natural revegetation, but does not prevent the eventual development of a fully stocked, normal stand of trees.
- Trees are subject to windthrow when soils are excessively wet and winds are strong.
- In areas where the density of the canopy is less than about 50 percent, the understory produces plants suitable for grazing.
- Uniform distribution of grazing is difficult because of the slope, lack of permanent water development, or both.
- Livestock prefer to graze the easily accessible forage on the ridgetops and in the valleys before they graze the side slopes.
- Suitability for a grass seeding after logging is good on the Pinntank and Retsover soils.

Suitable management practices on the Pinntank, Pocomate, and Retsover soils:
- Use suitable methods of harvest, lay out skid trails in advance, and harvest when the soil is least susceptible to erosion.
- Limit the use of equipment on steep slopes.
- Reduce the hazard of erosion by avoiding excessive disturbance on the soil; seeding roads, cutbanks, and landings; installing water bars and culverts; constructing water bars to protect roads and landings; and seeding cuts and fills.
- Leave some of the larger trees to provide shade for seedlings.
- Improve stands by thinning before trees reach commercial size and by selective cutting of mature trees.
- Seed disturbed areas to adapted grasses by broadcasting in order to increase forage production.
- Prepare the site adequately in order to seed understory plants successfully.
- Seed late in fall for best results. After seeding, defer grazing until grasses and tree seedlings are well established.

Wildlife

Wildlife observed in areas of this unit: Elk, mule deer, black bear, mountain lion, bobcat, wild turkey, Abert's squirrel, golden eagle, short-eared owl, white-breasted nuthatch, western tanager

General management considerations:
- This unit supports vegetation that provides important summer foraging areas for elk and wild turkey.
- Gambel oak is an important food and cover tree for a variety of species.
- The northern goshawk and the endangered Mexican spotted owl may exist in these areas.
- These areas provide important roosting and perching sites for golden eagles.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Grazing and timber harvesting should be delayed until July 1 in elk calving areas.
- Seed mixture for revegetation should be suitable for wildlife species.
- Leave snags for wildlife habitat when harvesting timber.

Interpretive Groups

Land capability classification: VIs, nonirrigated

Major Land Resource Unit: 39-1AZ—Mogollon Plateau Coniferous Forest

Woodland site: Pinntank—Clay Loam Upland, 17-20" p.z.; Pocomate—Limestone Slopes, 17-20" p.z.; Retsover—Clay Loam Upland, 17-20" p.z.

32—Plaintank-Barx complex, 1 to 5 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Slope range: 1 to 5 percent
Elevation: 4,600 to 5,000 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days

Composition

Plaintank soil and similar inclusions: 45 percent
Barx soil and similar inclusions: 40 percent
Contrasting inclusions: 15 percent

Typical Profile

Plaintank

0 to 2 inches—yellowish brown extremely gravelly loam
2 to 12 inches—yellowish brown gravelly loam
12 to 17 inches—yellowish brown extremely cobbly loam
17 to 36 inches—indurated, calcium carbonate cemented hardpan
36 to 46 inches—pink very gravelly sandy loam, moderately cemented with calcium carbonate
46 to 60 inches—brown very gravelly sandy loam

Barx

0 to 2 inches—brown gravelly loam
2 to 12 inches—reddish brown clay loam
12 to 26 inches—pink and pinkish white clay loam
26 to 47 inches—pink and white limy gravelly loam
47 to 60 inches—yellowish red fine sandy loam

Soil Properties and Qualities

Plaintank

Parent material: Alluvium derived dominantly from sedimentary and igneous rock
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Content of calcium carbonate: 10 to 30 percent above the pan
Corrosivity: Steel (uncoated)—high; concrete—low

Barx

Parent material: Alluvium derived from sandstone and limestone, with eolian influence in some areas
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: High to very high
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Moderate
Shrink-swell potential: Moderate
Content of calcium carbonate: 15 to 40 percent in the lower subsoil, averages less than 40 percent in the control section
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Very deep, fine-textured soils (Poley soils) in swales and drainageways

Similar inclusions:
- Moderately deep soils over a hardpan
- Barx-like soils that have clay layers below a depth of 30 inches
- Soils that have a rock content that is higher than that of the Plaintank and Barx soils
- Soils that have very gravelly to extremely gravelly sandy loam or very fine sandy loam surface textures

Use and Management

Rangeland

Dominant vegetation on the Plaintank soil:
- Potential plant community—blue grama, needleandthread, bottlebrush squirreltail, fourwing saltbush, winterfat
- Present plant community—blue grama, bottlebrush squirreltail, needleandthread, winterfat

Dominant vegetation on the Barx soil:
- Potential plant community—Indian ricegrass, bottlebrush squirreltail, blue grama, black grama, fourwing saltbush
- Present plant community—blue grama, needleandthread, ring muhly, winterfat, broom snakeweed

Major Management Factors: Plaintank—shallow depth to a hardpan, very low available water capacity, large amounts of gravel on the surface

General management considerations on the Plaintank and Barx soils:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Range seeding may be needed if quantities of the more desirable forage plants have decreased.

- Suitability for seeding is fair on the Barx soil.
- Suitability for seeding on the Plaintank soil is poor because of shallow depth to pan, droughtiness, and surface gravel content.
- The Barx component of this unit is intricately mixed with the shallow Plaintank component.
- Larger areas of the Barx soil are delineated in a separate mapping unit.
- Seeding may be more practical in these larger areas of the Barx soil.

Suitable management practices on the Plaintank and Barx soils:

- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Seed the range if the plant cover is not sufficient to protect the soil from erosion.
- After seeding, defer grazing until young plants are well established.
- Seed late in fall for best results.

Cropland

- The Barx soil is potentially suited to the production of irrigated crops.
- If the Barx soil is used for cropland, irrigation is needed for optimum production.
- Furrow, border, corrugation, or sprinkler irrigation is suited to this soil.
- If furrow or corrugation systems are used, runs should be on the contour or across the slopes.
- Tillage should also be on the contour or across the slopes to minimize water erosion.
- Maintaining crop residue on or near the surface reduces runoff and soil blowing and helps to maintain soil tilth and organic matter content.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon

General management considerations:

- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals in these areas are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:

- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: Plaintank—VIs, nonirrigated; Barx—VIs, nonirrigated, IIIe, irrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Plaintank—Limy Upland (Shallow), 9-13" p.z.; Barx—Loamy Upland, 9-13" p.z.

33—Pocomate-Rock outcrop complex, 15 to 55 percent slopes

Setting

Landform: Hills and escarpments
Flooding: None
Elevation: 6,600 to 7,900 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 47 to 51 degrees F
Frost-free period: 120 to 150 days

Composition

Pocomate soil and similar inclusions: 55 percent
Rock outcrop: 35 percent
Contrasting inclusions: 10 percent

Typical Profile

Pocomate

0.25 to 0 inch—slightly decomposed pine and leaf litter
0 to 3 inches—dark brown extremely cobbly loam
3 to 8 inches—dark brown very gravelly clay loam
8 to 13 inches—brown extremely cobbly clay loam
13 inches—limestone
Rock outcrop consists of steep ledges of Kaibab Limestone Formation or Toroweep Formation

Soil Properties and Qualities

Pocomate

Parent material: Limestone residuum and colluvium
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: Very low
Potential rooting depth: 8 to 20 inches
Runoff: Very rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Very slight

Shrink-swell potential: Low
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Moderately deep, very gravelly soils on steep slopes
- Deep, very gravelly soils on foot slopes

Similar inclusions:
- Soils that have very gravelly loam surfaces
- Soils that have very cobbly sandy loam surfaces
- Small areas of steeper or less steep slopes

Use and Management

Timberland

Dominant overstory vegetation on the Pocomate soil: Ponderosa pine—100 percent
Overstory production:
- Average site index—58 (Minor)
- Estimated average annual production per acre (commercial)—3,000 board feet (Scribner rule) of timber from a stand of trees 100 years old

Dominant understory vegetation on the Pocomate soil: Ross sedge, muttongrass, blue grama, bottlebrush squirreltail, mountain big sagebrush, broom snakeweed, Gambel oak
Major management factors: Steep slopes, large amounts of cobbles on surface, shallow depth to limestone bedrock
General management considerations:
- Snowpack and spring thaw limit the use of equipment and restrict access.
- Using wheeled and tracked equipment in harvesting timber is difficult because of the steep slope.
- Careless use of wheeled and tracked equipment disturbs the protective layer of duff.
- Disturbing the soil excessively in harvesting timber and building roads increases the loss of soil, which in turn leaves a greater amount of rock fragments on the surface.
- Logging roads require suitable surfacing or year-round use.
- Adequately designed road drainage reduces the hazard of erosion.
- Steep yarding paths, skid trails, and firebreaks are subject to rilling and gullying, a plant cover or water bars are needed.
- Maintaining the understory vegetation is essential in controlling erosion.
- Rock outcrops cause breakage of timber and hinder yarding.
- If seed trees are in the stand, reforestation occurs naturally in cutover areas.
- Carefully managed reforestation reduces competition from undesirable understory plants.
- Tree seedlings have a poor rate of survival because of shallow rock and rock ragments.
- Seedling mortality may be high in summer because of the lack of adequate soil moisture.
- Droughtiness of the surface layer increases seedling mortality; especially on south and southwest facing slopes.
- Plant competition delays natural regeneration; but does not prevent the eventual development of a fully stocked, normal stand of trees.
- Trees are subject to windthrow when the soil is excessively wet and the winds are strong.
- In areas where the density of the canopy is less than about 50 percent, the understory produces plants suitable for grazing.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accesible forage on the ridgetops and in the valleys before they graze the side slopes.
- Suitability for a grass seeding after logging is fair.

Suitable management practices:
- To reduce compaction, use suitable methods of harvest, lay out skid trails in advance, and harvest when the soil is least susceptible to compaction.
- Limit the use of equipment on steep slopes.
- Reduce the hazard of erosion by avoiding excessive disturbance on the soil; seeding roads, cutbanks, and landings; installing water bars and culverts; and seeding cuts and fills.
- Leave some of the larger trees to provide shade for seedlings.
- Improve stands by thinning before trees reach commercial size and by selective cutting of mature trees.
- Seed disturbed areas to adapted grasses by broadcasting in order to increase forage production.
- Prepare the site adequately in order to seed understory plants successfully.
- Seed late in fall for best results. After seeding, defer grazing until grasses and tree seedlings are well established.

Wildlife

Wildlife observed in areas of this unit: Elk, mule deer, black bear, mountain lion, bobcat, wild turkey, Abert's squirrel, golden eagle, short-eared owl, white-breasted nuthatch, western tanager
General management considerations:
- This unit supports vegetation that provides important summer foraging areas for elk and wild turkey.
- Gambel oak is an important food and cover tree for a variety of species.
- The northern goshawk and the endangered Mexican spotted owl may exist in these areas.

• These areas provide important roosting and perching sites for golden eagles.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Grazing and timber harvesting should be delayed until July 1 in elk calving areas.
• Seed mixture for revegetation should be suitable for wildlife species.
• Leave snags for wildlife habitat when harvesting timber.

Interpretive Groups

Land capability classification: Pocomate—VIIe, nonirrigated
Major Land Resource Unit: 39-1AZ—Mogollon Plateau Coniferous Forest
Woodland site: Pocomate—Limestone Slopes, 17-20" p.z.

34—Poley loam, 1 to 5 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Elevation: 5,500 to 6,000 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 135 to 175 days

Composition

Poley soil and similar inclusions: 85 percent
Contrasting inclusions: 15 percent

Typical Profile

0 to 1 inch—brown loam
1 to 3 inches—light yellowish brown loam
3 to 14 inches—reddish brown clay loam
14 to 27 inches—reddish brown clay
27 to 60 inches—white clay loam

Soil Properties and Qualities

Parent material: Alluvium derived from limestone and sandstone
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Slight
Shrink-swell potential: Moderate
Content of calcium carbonate: 15 to 40 percent in lower subsoil
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Shallow soils overlying a hardpan
• Calcareous soils that are 20 to 40 inches deep over a hardpan
• Soils that have less clay in the subsoil than the Poley soil

Similar inclusions:
• Soils that have calcium carbonate accumulations within a depth of 20 inches
• Soils that have gravelly surface layers
• Soils that have sandy loam or clay loam surface textures

Use and Management

Rangeland

Dominant vegetation:
• Potential plant community—blue grama, black grama, bottlebrush squirreltail, sand dropseed, fourwing saltbush
• Present plant community—blue grama, bottlebrush squirreltail, ring muhly, Greene rabbitbrush, broom snakeweed, fourwing saltbush
Major management factors: Slow permeability, high shrink-swell potential, high content of calcium carbonate in the lower subsoil
General management considerations:
• Continuous, intensive year-round grazing commonly results in a deteriorated plant community that has low forage value.
• Range seeding may be needed if quantities of the more desirable forage plants have decreased.
• Suitability for range seeding is fair because of soil-related factors.
Suitable management practices:
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• Seed the range if the plant cover is not sufficient to protect the soil from erosion.
• Seed suitable plants, such as plants that meet the seasonal requirements of both livestock and wildlife.
• Seed late in the fall for best results.
• After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit

fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon

General management considerations:

- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals in these areas are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:

- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Clay Loam Upland, 9-13" p.z.

35—Poley-Rolie complex, 1 to 8 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Slope range: 1 to 8 percent
Elevation: 4,700 to 6,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 56 to 58 degrees F
Frost-free period: 135 to 175 days

Composition

Poley soil and similar inclusions: 45 percent
Rolie soil and similar inclusions: 40 percent
Contrasting inclusions: 15 percent

Typical Profile

Poley

0 to 1 inch—brown gravelly loam
1 to 4 inches—reddish brown clay loam
4 to 21 inches—reddish brown clay
21 to 25 inches—white and reddish brown clay
25 to 60 inches—white and brown clay loam

Rolie

0 to 1 inch—yellowish brown very gravelly loam
1 to 4 inches—dark yellowish brown gravelly loam
4 to 9 inches—dark yellowish brown cobbly loam
9 to 15 inches—fractured, calcium carbonate cemented hardpan
15 to 60 inches—indurated, calcium carbonate cemented hardpan

Soil Properties and Qualities

Poley

Parent material: Alluvium derived from limestone and sandstone
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Slight
Shrink-swell potential: Moderate
Content of calcium carbonate: 15 to 40 percent in the lower subsoil
Corrosivity: Steel (uncoated)—high; concrete—low

Rolie

Parent material: Alluvium derived from limestone
Depth class: Very shallow and shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: Averages 10 to 30 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:

- Very deep soils that have a lower content of clay in the subsoil than the Poley and Rolie soils
- Soils that are 20 to 40 inches deep over a hardpan

Similar inclusions:

- Deep, clayey soils that have calcium carbonate accumulations within a depth of 20 inches
- Shallow soils overlying a hardpan that have a higher content of coarse fragments on the surface or in the subsoil than the Poley and Rolie soils
- Deep, clayey soils that do not have calcium carbonate accumulations within a depth of 40 inches

Use and Management

Rangeland

Dominant vegetation on the Poley soil:
• Potential plant community—blue grama, black grama, bottlebrush squirreltail, sand dropseed, fourwing saltbush
• Present plant community—blue grama, bottlebrush squirreltail, ring muhly, Greene rabbitbrush, broom snakeweed, fourwing saltbush
Dominant vegetation on the Rolie soil:
• Potential plant community—blue grama, needleandthread, bottlebrush squirreltail, fourwing saltbush, winterfat
• Present plant community—blue grama, bottlebrush squirreltail, ring muhly, needleandthread, Greene rabbitbrush, fourwing saltbush, Fremont barberry
Major management factors: Poley—slow permeability; Rolie—large amounts of gravel on the surface, shallow depth to hardpan
General management considerations on the Poley and Rolie soils:
• Continuous, intensive year-round grazing commonly results in a deteriorated plant community that has low forage value.
• On the Poley soil, range seeding may be needed if quantities of the more desirable forage plants have decreased.
• Suitability for range seeding is fair on the Poley soil and poor on the Rolie soil because of soil-related factors.
Suitable management practices on the Poley and Rolie soils:
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• Seed the range if the plant cover is not sufficient to protect the soil from erosion on the Poley soil.
• Seed suitable plants, such as plants that meet the seasonal requirements of both livestock and wildlife.
• Seed late in the fall for best results.
• After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
• This unit supports vegetation that provides important habitat for pronghorn antelope.
• The small mammals in these areas are important prey for raptors and other species.
• Small mammal populations fluctuate widely with environmental conditions.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
• Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Poley—Clay Loam Upland, 9-13" p.z.; Rolie—Limy Upland (Shallow), 9-13" p.z.

36—Prieta-Rock outcrop complex, 2 to 35 percent slopes

Setting

Landform: Mesas
Flooding: None
Slope range: 2 to 35 percent
Elevation: 5,400 to 5,800 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days

Composition

Prieta soil and similar inclusions: 75 percent
Rock outcrop: 15 percent
Contrasting inclusions: 10 percent

Typical Profile

Prieta

0 to 1 inch—brown extremely cobbly loam
1 to 7 inches—brown very cobbly clay loam
7 to 17 inches—dark brown extremely cobbly clay
17 inches—basalt

Rock outcrop consists of fractured basalt flows that cap mesas and hills

Soil Properties and Qualities

Prieta

Parent material: Basalt residuum
Depth class: Shallow
Drainage class: Well drained
Permeability: Slow
Available water capacity: Very low

Potential rooting depth: 10 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Deep, clayey soils that have more than 35 percent rock fragments

Similar inclusions:
• Moderately deep soils overlying basalt bedrock
• Shallow soils that have a lower content of rock fragments than the Prieta soil

Use and Management

Rangeland

Dominant vegetation on the Prieta soil:
• Potential plant community—blackbrush, sideoats grama, bottlebrush squirreltail, muttongrass, Stansbury cliffrose, Utah juniper
• Present plant community—blackbrush, sideoats grama, bottlebrush squirreltail, green Mormon tea, Stansbury cliffrose, Utah juniper
Major management factors: Shallow depth to rock, extremely cobbly surface, very low available water capacity, hazard of water erosion on steep slopes
General management considerations:
• Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
• Suitability for seeding is poor because of the shallow soil depth, slope, and rock fragments.
• Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
• Livestock prefer to graze the easily accessible forage on the ridgetops and in the valleys before they graze the side slopes.
Suitable management practices:
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Reduce hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the soil surface.
• Control the time and amount of use by livestock.
• Provide periodic rest during spring in alternate years.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
• This unit supports vegetation that provides important habitat for pronghorn antelope.
• The small mammals that frequent this unit are important prey for raptors and other species.
• Small mammal populations fluctuate widely with environmental conditions.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
• Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: Prieta—VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Prieta—Basalt Hills (Cobbly), 9-13" p.z.

37—Quagwa silt loam, 1 to 3 percent slopes

Setting

Landform: Draws
Flooding: None to rare
Elevation: 5,100 to 5,900 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days

Composition

Quagwa soil and similar inclusions: 85 percent
Contrasting inclusions: 15 percent

Typical Profile

0 to 2 inches—light brown silt loam
2 to 14 inches—brown silt loam
14 to 30 inches—dark brown silt loam
30 to 50 inches—dark brown clay loam
50 to 62 inches—strong brown loam

Soil Properties and Qualities

Parent material: Alluvium derived from limestone
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderate
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium

Hazard of water erosion: Moderate
Hazard of wind erosion: Moderate
Shrink-swell potential: Moderate
Content of calcium carbonate: 2 to 14 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Soils that have gravelly and cobbly substrata
- Moderately deep to deep soils overlying hardpans
- Very deep, fine textured soils

Similar inclusions:
- Soils that have a higher content of calcium carbonate in the subsoil than the Quagwa soil
- Soils that have gravelly loam or gravelly silt loam surfaces

Use and Management

Rangeland

Dominant vegetation:
- Potential plant community—blue grama, black grama, galleta, Indian ricegrass, bottlebrush squirreltail, fourwing saltbush, winterfat
- Present plant community—blue grama, sand dropseed, burrograss, broom snakeweed, fourwing saltbush

Major management factors: Low bearing strength, piping

Cropland

- If this soil is used as cropland, irrigation is necessary for maximum production.
- All tillage should be on the contour or across the slope to minimize water erosion.
- Diversions and grassed waterways may be needed in existing channels.
- Crusting of the surface, soil compaction, and soil blowing can be reduced by returning crop residue to the soil and by using minimum tillage.

General management considerations:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Suitability for seeding is fair because of soil-related factors.
- Range seeding may be needed if quantities of the more desirable forage plants have decreased.

Suitable management practices:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, and properly distributing salt licks.
- Use proper stocking rates.
- Control the time and amount of use by livestock.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.
- Seed the range if the plant cover is not sufficient to protect the soil from erosion.
- After seeding, defer grazing until young plants are well established.
- Seed late in fall for best results.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon

General management considerations:
- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals in this unit are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: IIIe, irrigated; VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Loamy Upland, 9-13" p.z.

38—Rizno-Rock outcrop complex, 2 to 15 percent slopes

Setting

Landform: Structural benches on the Esplanade in the Grand Canyon
Flooding: None
Slope range: 2 to 15 percent
Elevation: 4,000 to 5,500 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 56 to 58 degrees F
Frost-free period: 140 to 180 days

Composition

Rizno soil and similar inclusions: 65 percent

Rock outcrop: 25 percent
Contrasting inclusions: 10 percent

Typical Profile

Rizno

0 to 8 inches—yellowish red fine sandy loam
8 inches—red thin bedded sandstone
Rock outcrop consists of Esplanade sandstone of the Supai Formation

Soil Properties and Qualities

Rizno

Parent material: Alluvium, eolian deposits, and residuum derived from sandstone
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: Very low
Potential rooting depth: 4 to 10 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Moderately high
Shrink-swell potential: Low
Content of calcium carbonate: 5 to 15 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Soils that are more than 20 inches deep
- Soils that have zones of calcium carbonate accumulation in the subsoil
- Rock outcrop

Similar inclusions:
- Soils that have surface textures of gravelly or very channery loamy fine sand to very fine sandy loam
- Soils that have more rock fragments in the subsoil than the Rizno soil
- Soils that are leached of calcium carbonate

Use and Management

Rangeland

Dominant vegetation on the Rizno soil:
- Potential plant community—black grama, galleta, bottlebrush squirreltail, blackbrush, turbinella oak, singleleaf pinyon, Utah juniper
- Present plant community—black grama, blackbrush, broom snakeweed, singleleaf pinyon, Utah juniper

Major management factors: Shallow depth to rock, hazard of wind erosion, very low available water capacity
General management considerations on the Rizno soil and Rock outcrop:
- This map unit is commonly located in inaccessible areas on the Esplanade below the rim of the Grand Canyon.
- It is best suited to wildlife habitat and recreational uses.
- If used as rangeland, continuous intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Suitability for seeding is poor because of shallow depth to rock, droughtiness, and hazard of soil blowing.

Suitable management practices on the Rizno soil and Rock outcrop:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, coyote, common raven, kit fox, golden eagle, Gambel's quail, kangaroo rat
General management considerations:
- This unit provides important foraging areas for desert bighorn sheep and other animals.
- Small mammals are important prey for many species, and their popoulation fluctuates widely with environmental conditions.
- The Rock outcrop supports no vegetation but is important for nest sites, resting cover, hunting perches, escape routes, and dens.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: Rizno—VIe, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Rizno—Shallow Sandy Loam, 9-13" p.z.

39—Rock outcrop-Torriorthents complex, 35 to 120 percent slopes

Setting

Landform: Canyon escarpments
Flooding: None
Slope range: 35 to 120 percent
Elevation: 2,000 to 5,000 feet
Mean annual precipitation: 8 to 12 inches

Mean annual soil temperature: 59 to 62 degrees F
Frost-free period: 130 to 170 days

Composition

Rock outcrop: 60 percent
Torriorthents and similar inclusions: 30 percent
Contrasting inclusions: 10 percent

Typical Profile

Rock outcrop consists of extremely steep to vertical escarpments of sedimentary rock exposed below the rim of the Grand Canyon and its major tributaries. Formations range from the Vishnu Schist to the Kaibab Limestone.

Torriorthents are variable in depth, color, and texture. No single profile typifies this soil group, but a commonly observed soil profile is:
0 to 6 inches—brown extremely gravelly loam
6 to 13 inches—light brown very gravelly loam
13 to 30 inches—pinkish gray extremely gravelly loam
30 to 46 inches—light brown very gravelly loam
46 to 60 inches—light brown very channery loam

Soil Properties and Qualities

Torriorthents

Parent material: Colluvium and residuum derived from sedimentary rock
Depth class: Very shallow to very deep
Drainage class: Excessively drained to well drained
Permeability: Moderate to rapid
Available water capacity: Low to moderate
Potential rooting depth: 4 to 60 or more inches
Runoff: Very rapid
Hazard of water erosion: Very severe
Hazard of wind erosion: Very slight to slight
Shrink-swell potential: Low
Content of calcium carbonate: Variable, but at least slightly calcareous throughout the profile
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Rubbleland
- Shallow to moderately deep, basalt derived soils
- Soils that have a content of clay that is higher or lower than that of the Torriorthents
- Steep slopes that are capped by basalt, tuff, or breccia

Similar inclusions:
- Shallow to deep soils on the more gentle slopes, usually having a zone of calcium carbonate accumulation
- Shallow to deep soils that do not have calcium carbonate
- Warmer soils at lower elevations

Use and Management

Major management factors: Steep slope, shallow depth to bedrock, inaccessibility of area
Major plants in the upper zone: Blackbrush, canotia, catclaw acacia, flattop buckwheat, slim tridens
Major plants in the lower zone: Ocotillo, white brittlebush, bush muhly, big galleta
General management considerations on the Torriorthents:
- Use of this unit is limited by very steep slopes and inaccessibility. This unit is best suited for wildlife habitat and limited recreation because of its scenic qualities.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, golden eagle, peregrine falcon, canyon wren, violet-green swallow, ringtail, chuckawalla
General management considerations:
- This unit provides important nest sites for many species of birds and provides escape routes for bighorn sheep.
- The Rock outcrop supports no vegetation but is important for nest sites, resting cover, hunting perches, escape routes, and dens.

Suitable management practices:
- Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: Torriorthents—VIIIe, nonirrigated
Major Land Resource Unit: 30-2AZ—Grand Canyon Desert Shrub

40—Rolie-Dean complex, 2 to 20 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Slope range: 2 to 20 percent
Elevation: 4,500 to 5,200 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 53 to 57 degrees F
Frost-free period: 135 to 175 days

Composition

Rolie soil and similar inclusions: 60 percent
Dean soil and similar inclusions: 25 percent
Contrasting inclusions: 15 percent

Typical Profile

Rolie

0 to 1 inch—yellowish brown very gravelly loam

1 to 9 inches—dark yellowish brown gravelly loam and cobbly loam
9 to 15 inches—fractured, calcium carbonate cemented hardpan
15 to 60 inches—indurated, calcium carbonate cemented hardpan

Dean

0 to 2 inches—brown extremely gravelly loam
2 to 16 inches—yellowish brown gravelly loam
16 to 21 inches—yellowish brown very gravelly loam
21 to 28 inches—yellowish brown gravelly loam
28 to 60 inches—light brown and pinkish white, limy gravelly loam

Soil Properties and Qualities

Rolie

Parent material: Alluvium derived from limestone of the Willow Springs Formation
Depth class: Shallow and very shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: Averages 15 to 30 percent above hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Dean

Parent material: Mixed alluvium derived from the Willow Springs Formation
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Moderate
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Content of calcium carbonate: Averages 40 to 60 percent at a depth of 10 to 40 inches
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Very deep, loamy soils (Quagwa soils) that do not have zones of calcium carbonate accumulation in drainageways
- Very deep, fine textured soils (Poley soils) on foot slopes and stream terraces
- Shallow soils overlying a silica cemented hardpan

Similar inclusions:
- Soils that have a higher content of rock fragments in the subsoil than the Rolie and Dean soils
- Moderately deep soils that have a calcium carbonate cemented hardpan at a depth of 20 to 40 inches
- Soils that have fewer rock fragments or a lower content of sand in the surface layer than the Rolie and Dean soils

Use and Management

Woodland

Dominant overstory vegetation on the Rolie soil: Utah juniper—90 percent; singleleaf pinyon—10 percent
Overstory production:
- Fuelwood—4 to 6 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—25 to 30 per acre
- Christmas trees—0 to 2 per acre
- Ornamental trees—0 to 2 per acre

Dominant understory vegetation on the Rolie soil: Present plant community—black grama, blue grama, Fendler threeawn, needleandthread, banana yucca, broom snakeweed
Dominant overstory vegetation on the Dean soil: Utah juniper—90 percent; singleleaf pinyon—10 percent
Overstory production:
- Fuelwood—6 to 8 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—20 to 30 per acre
- Christmas trees—0 to 2 per acre
- Ornamental trees—0 to 2 per acre

Dominant understory vegetation on the Dean soil: Present plant community—blue grama, needleandthread, black grama, Fendler threeawn, broom snakeweed, fourwing saltbush, winterfat
Major management factors: Rolie—shallow depth to hardpan, very low available water capacity, large amount of gravel on the surface; Dean—large amount of gravel on the surface, large amount of calcium carbonate throughout the profile
General management considerations on the Rolie and Dean soils:
- Wood products can be harvested when the canopy cover exceeds 30 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Rolie and Dean soils:
- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on very steep slopes.
- Leave some of the larger trees to provide shade for seedlings, pinyon nut production, and wildlife habitat.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Avoid nest trees when gathering firewood.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, thirteen-lined ground squirrel, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals in this unit are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Woodland site: Rolie—Shallow Limy Upland, 9-13" p.z.; Dean—Limy Upland (Gravelly), 9-13" p.z.

41—Saemo extremely gravelly sandy loam, 2 to 45 percent slopes

Setting

Landform: Fan terraces
Flooding: None
Elevation: 4,000 to 4,800 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days

Composition

Saemo soil and similar inclusions: 75 percent
Contrasting inclusions: 25 percent

Typical Profile

0 to 2 inches—brown extremely gravelly sandy loam
2 to 16 inches—dark brown very gravelly sandy clay loam
16 to 26 inches—strong brown very gravelly coarse sandy loam
26 to 34 inches—strong brown extremely cobbly loamy coarse sand
34 to 60 inches—strong brown extremely cobbly coarse sand

Soil Properties and Qualities

Parent material: Mixed alluvium
Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: Low
Potential rooting depth: 60 or more inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Content of calcium carbonate: 0 to 10 percent in the lower subsoil and the substratum
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Fine and coarse textured soils that have a lower content of rock fragments than the Saemo soil

Similar inclusions:
- Soils that have limy subsoils
- Soils that have a surface layer of extremely cobbly sandy loam

Use and Management

Woodland

Dominant overstory vegetation: Utah juniper—50 percent; singleleaf pinyon—50 percent
Overstory production:
- Fuelwood—4 to 8 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—20 to 30 per acre
- Christmas trees—6 to 10 per acre
- Ornamental trees—6 to 10 per acre

Dominant understory vegetation: Black grama, sideoats grama, desert needlegrass, blue grama, desert

ceanothus, turbinella oak, banana yucca
Major management factors: Large amounts of rock fragments on the surface and in the profile, steep slopes, hazard of water erosion on steep slopes
General management considerations:
• Wood products can be harvested when the canopy cover exceeds 25 percent.
• In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
• Uniform distribution of grazing is difficult because of the slopes, the lack of permanent water developments, or both.
• Suitability for range seeding is poor because of soil-related factors.
Suitable management practices:
• Use conventional methods in harvesting.
• Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on very steep slopes.
• Leave some of the larger trees to provide shade for seedlings.
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• Seed disturbed areas to adapted grasses by broadcasting in order to increase forage production.
• Prepare the site adequately in order to seed understory plants successfully.
• Seed late in the fall for best results.
• After seeding, defer grazing until young plants are well established.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, thirteen-lined ground squirrel, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
• This unit supports vegetation that provides important habitat for pronghorn antelope.
• The small mammals that frequent this unit are important prey for raptors and other species.
• Small mammal populations fluctuate widely with environmental conditions.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
• Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Woodland site: Sandy Loam (Gravelly), 9-13" p.z.

42—Sazi very gravelly fine sandy loam, 1 to 5 percent slopes

Setting

Landform: Mesas
Landscape position: Swales and depressions
Flooding: None
Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 10 to 11 inches
Mean annual soil temperature: 55 to 58 degrees F
Frost-free period: 140 to 170 days

Composition

Sazi soil and similar inclusions: 75 percent
Contrasting inclusions: 25 percent

Typical Profile

0 to 2 inches—light brown very gravelly fine sandy loam
2 to 10 inches—light brown fine sandy loam
10 to 19 inches—light brown gravelly fine sandy loam
19 to 25 inches—light brown fine sandy loam
25 to 32 inches—fractured, weathered sandstone
32 inches—calcareous sandstone

Soil Properties and Qualities

Parent material: Alluvium and eolian deposits derived from sandstone and limestone
Depth class: Moderately deep
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 10 to 25 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Shallow soils overlying bedrock at a depth of 10 to 20 inches
• Soils that are more than 40 inches deep

Use and Management

Rangeland

Dominant vegetation:
• Potential plant community—black grama, needleandthread, blue grama, fourwing saltbush, winterfat
• Present plant community—black grama, blue grama, cheatgrass, fourwing saltbush, winterfat
Major management factors: Low available water capacity
General management considerations:
• Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
• Suitability for seeding is fair, because of soil-related and climatic factors.
• Range seeding may be needed if amounts of the more desirable forage plants have decreased.
Suitable management practices:
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.
• Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.
• Seed the range if the plant cover is not sufficient to protect the soil from erosion.
• After seeding, defer grazing until young plants are well established.
• Seed late in fall for best results.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
• This unit supports vegetation that provides important habitat for pronghorn antelope.
• The small mammals that frequent this unit are important prey for raptors and other species.
• Small mammal populations fluctuate widely with environmental conditions.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
• Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: Sazi—VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Sazi—Limy Upland, 9-13" p.z.

43—Splanod-Rock outcrop complex, 2 to 15 percent slopes

Setting

Landform: Mesas or major structural benches in the Grand Canyon (the Esplanade)
Flooding: None
Slope range: 2 to 15 percent
Elevation: 4,000 to 4,800 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 59 to 62 degrees F
Frost-free period: 180 to 200 days

Composition

Splanod soil and similar inclusions: 40 percent
Rock outcrop: 40 percent
Contrasting inclusions: 20 percent

Typical Profile

Splanod

0 to 1 inch—red very gravelly fine sandy loam
1 to 7 inches—red gravelly sandy clay loam
7 inches—sandstone

Rock outcrop consists of exposed areas of thinly bedded sandstone from the Supai Formation, commonly the Esplanade member.

Soil Properties and Qualities

Splanod

Parent material: Residuum and alluvium derived from sandstone of the Supai Formation
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Slight
Shrink-swell potential: Moderate
Content of calcium carbonate: 0 to 35 percent disseminated calcium carbonate
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Soils that have bedrock that is more than 20 inches deep
- Soils that have steeper slopes near canyon escarpments
- Soils that have very cobbly or very stony surfaces at the foot slopes of escarpments
- Soils that have more than 35 percent rock fragments in the subsoil

Similar inclusions:
- Shallow soils that have only traces of rock fragments
- Shallow soils overlying soft sandstone or shale
- Shallow soils that have thin calcium carbonate accumulations or calcium carbonate cemented layers above the bedrock
- Soils that have loamy fine sand or very fine sandy loam surface textures

Use and Management

Rangeland

Dominant vegetation on the Splanod soil:
- Potential plant community—needleandthread, Indian ricegrass, black grama, sand dropseed, blackbrush, Utah mortonia, fourwing saltbush, broom snakeweed
- Present plant community—black grama, needleandthread, Indian ricegrass, cheatgrass, blackbrush, broom snakeweed, fourwing saltbush, Utah mortonia

Major management factors: Very shallow depth to rock, large amounts of rock fragments on the surface, very low available water capacity

General management considerations on the Splanod soil:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Suitability for seeding is poor because of soil-related and climatic factors.

Suitable management practices on the Splanod soil:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, coyote, common raven, kit fox, golden eagle, Gambel's quail, kangaroo rat

General management considerations:
- This unit provides important foraging areas for desert bighorn sheep and other animals.
- Small mammals are important prey for many species, and their population fluctuates widely with environmental conditions.
- The Rock outcrop supports no vegetation but is important for nest sites, resting cover, hunting perches, escape routes, and dens.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: Splanod—VIIs, nonirrigated
Major Land Resource Unit: 30-2AZ—Grand Canyon Desert Shrub
Range site: Splanod—Sandstone Upland, 9-12" p.z.

44—Sponiker loam, 1 to 4 percent slopes

Setting

Landform: Draws and stream terraces
Flooding: Rare, very brief runoff from adjacent slopes
Ponding: Soils may be saturated after snowmelt in early spring
Slope range: 1 to 4 percent
Elevation: 6,500 to 6,700 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 47 to 51 degrees F
Frost-free period: 120 to 150 days

Composition

Sponiker soil and similar inclusions: 90 percent
Contrasting inclusions: 10 percent

Typical Profile

0 to 3 inches—dark brown loam
3 to 8 inches—dark brown clay loam
8 to 31 inches—dark brown silty clay loam
31 to 62 inches—brown clay loam

Soil Properties and Qualities

Sponiker

Parent material: Alluvium derived dominantly from sedimentary rock
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: High
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Moderate
Hazard of wind erosion: Slight
Shrink-swell potential: High

Corrosivity: Steel (uncoated)—moderate; concrete—low

Inclusions

Contrasting inclusions:
- Very deep soils that have a content of clay that is lower than that of the Sponiker soil
- Very deep soils that have gravelly substrata (Turkeytrack soils)

Similar inclusions:
- Soils that have gravelly surface textures
- Soils that have thinner, dark surface layers

Use and Management

Rangeland

Dominant vegetation:
- Potential plant community—western wheatgrass, blue grama, bottlebrush squirreltail, muttongrass, mountain big sagebrush, rushlike rubber rabbitbrush
- Present plant community—mountain big sagebrush, rushlike rubber rabbitbrush, bottlebrush squirreltail, blue grama, western wheatgrass

Major management factors: High shrink-swell potential, slow permeability

General management considerations:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low forage value.
- Suitability for seeding is good.
- If shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.
- Range seeding may be needed if quantities of the more desirable forage plants have decreased.

Suitable management practices:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Manage the brush in areas where unpalatable brushy plants have increased significantly.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.
- Seed the range if the plant cover is not sufficient to protect the soil from erosion. After seeding, defer grazing until young plants are well established.
- Seed late in fall for best results.

Wildlife

Wildlife observed in areas of this unit: Elk, mule deer, black bear, mountain lion, bobcat, wild turkey, Abert's squirrel, golden eagle, short-eared owl, white-breasted nuthatch, western tanager

General management considerations:
- This unit supports vegetation that provides important summer foraging areas for elk and wild turkey.
- Gambel oak is an important food and cover tree for a variety of species.
- The northern goshawk and the endangered Mexican spotted owl may exist in areas of this unit.
- This unit provides important roosting and perching sites for golden eagles.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Grazing and timber harvesting should be delayed until July 1st in elk calving areas.
- Seed mixture for revegetation should be suitable for wildlife species.
- Leave snags for wildlife habitat when harvesting timber.

Interpretive Groups

Land capability classification: Sponiker—VIs, nonirrigated
Major Land Resource Unit: 39-1AZ—Mogollon Plateau Coniferous Forest
Range site: Sponiker—Loamy Upland, 17-20" p.z.

45—Theecan-Pinespring association, 2 to 35 percent slopes

Setting

Landform: Fan terraces and stream terraces
Landscape position: Theecan—side slopes and summits; Pinespring—draws and foot slopes
Flooding: Theecan—none; Pinespring—rare, brief runoff from adjacent slopes
Slope range: Theecan—2 to 35 percent; Pinespring—2 to 5 percent
Elevation: 6,200 to 6,800 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 120 to 150 days

Composition

Theecan soil and similar inclusions: 45 percent
Pinespring soil and similar inclusions: 25 percent
Contrasting inclusions: 30 percent

Typical Profile

Theecan

0 to 2 inches—brown very cobbly sandy loam
2 to 5 inches—dark brown sandy clay loam

5 to 40 inches—dark brown, strong brown, and yellowish red sandy clay and clay
40 to 58 inches—yellowish red and strong brown extremely gravelly loamy coarse sand
58 to 65 inches—yellowish red and strong brown sandy clay loam

Pinespring

0 to 2 inches—brown sandy loam
2 to 14 inches—brown sandy clay loam
14 to 33 inches—dark brown clay loam
33 to 44 inches—brown sandy clay
44 to 60 inches—brown sandy clay loam

Soil Properties and Qualities

Theecan

Parent material: Mixed alluvium derived from Frazier Well Gravels Formation
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Very high
Potential rooting depth: 60 or more inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Slight
Shrink-swell potential: Very high
Corrosivity: Steel (uncoated)—high; concrete—low

Pinespring

Parent material: Mixed alluvium derived from Frazier Well Gravels Formation
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Moderate
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Moderately high
Shrink-swell potential: High
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Moderately coarse soils that have a lower content of clay in draws
- Riverwash in drainageways
- Shallow, loamy soils overlying cemented conglomerate on ridges and summits

Similar inclusions:
- Very deep, loamy soils in draws

Use and Management

Timberland

Dominant overstory vegetation on the Theecan soil: Ponderosa pine—100 percent
Overstory production:
- Average site index—64 (Minor)
- Estimated average annual production per acre (commercial)—5,000 board feet (Scribner rule) of timber from a stand of trees 100 years old

Dominant understory vegetation on the Theecan soil: Bottlebrush squirreltail, Ross sedge, blue grama, Gambel oak, turbinella oak, desert ceanothus
Dominant overstory vegetation on the Pinespring soil: Ponderosa pine—100 percent
Overstory production:
- Average site index—58 (Minor)
- Estimated average annual production per acre (commercial)—3,600 board feet (Scribner rule) of timber from a stand of trees 100 years old

Dominant understory vegetation on the Pinespring soil: Bottlebrush squirreltail, Ross sedge, blue grama, muttongrass, Gambel oak, mountain big sagebrush, turbinella oak
Major management factors: Theecan—hazard of water erosion on steep slopes, very high shrink-swell potential, slow permeability, large amounts of cobbles on the surface, steep slopes; Pinespring—hazard of wind erosion, slow permeability, high shrink-swell potential
General management considerations on the Theecan and Pinespring soils:
- Snowpack and spring thaw limits the use of equipment and restricts access.
- Using wheeled and tracked equipment in harvesting timber is difficult because of the slope on the Theecan soil.
- Disturbing the soil excessively in harvesting timber and building roads increases the loss of soil, which in turn leaves a greater amount of rock fragments on the surface.
- When wet, unsurfaced roads and skid trails are muddy. They may be impassable during rainy periods.
- Logging roads require suitable surfacing for year-round use.
- Adequately designed road drainage reduces the hazard of erosion.
- Steep yarding paths, skid trails, and firebreaks are subject to rilling and gullying. A plant cover or water bars are needed.
- Maintaining the understory vegetation is essential in controlling erosion.
- If seed trees are in the stand, reforestation occurs naturally in cutover areas.
- Carefully managed reforestation reduces competition from undesirable understory plants.

• Machine planting may be practical on the Pinespring soils.
• Seedling mortality may be high in summer because of the lack of adequate soil moisture.
• Droughtiness of the surface layer increases seedling mortality, especially on south and southwest facing slopes.
• Plant competition delays natural regeneration, but does not prevent the eventual development of a fully stocked, normal stand of trees.
• In areas where the density of the canopy is less than about 50 percent, the understory produces plants suitable for grazing.
• Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
• Livestock prefer to graze the easily accesible forage on the ridgetops and in the valleys before they graze the side slopes.
• Suitability for a grass seeding after logging is good on the Pinespring soil.
Suitable management practices:
• Use suitable methods of harvest, lay out skid trails in advance, and harvest when the soil is least susceptible to compaction.
• Limit the use of equipment on steep slopes.
• Reduce the hazard of erosion by avoiding excessive disturbance on the soil; seeding roads, cutbanks, and landings; installing water bars and culverts; constructing water bars to protect roads and landings; and seeding cuts and fills.
• Leave some of the larger trees to provide shade for seedlings.
• Improve stands by thinning before trees reach commercial size and by selective cutting of mature trees.
• Seed disturbed areas to adapted grasses by broadcasting in order to increase forage production.
• Prepare the site adequately in order to seed understory plants successfully.
• Seed late in fall for best results. After seeding, defer grazing until grasses and tree seedlings are well established.

Wildlife

Wildlife observed in areas of this unit: Elk, mule deer, black bear, mountain lion, bobcat, wild turkey, Abert's squirrel, golden eagle, short-eared owl, white-breasted nuthatch, western tanager
General management considerations:
• This unit supports vegetation that provides important summer foraging areas for elk and wild turkey.
• Gambel oak is an important food and cover tree for a variety of species.
• The northern goshawk and the endangered Mexican spotted owl may exist in these areas.
• This unit provides important roosting and perching sites for golden eagles.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Delay grazing and timber harvesting until July 1st in elk calving areas.
• Seed mixture for revegetation should be suitable for wildlife species.
• Leave snags for wildlife habitat when harvesting timber.

Interpretive Groups

Land capability classification: Theecan—VIs, nonirrigated; Pinespring—VIe, nonirrigated
Major Land Resource Unit: 39-1AZ—Mogollon Plateau Coniferous Forest
Woodland site: Theecan—Cobbly Sandy Clay, 17-20" p.z.; Pinespring—Loamy Terrace 17-20" p.z.

46—Topocoba-Wodomont association, 2 to 15 percent slopes

Setting

Landform: Plateaus and mesas
Flooding: None
Slope range: Topocoba soil—2 to 8 percent; Wodomont soil—5 to 15 percent
Elevation: 5,800 to 6,200 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 130 to 160 days

Composition

Topocoba soil and similar inclusions: 45 percent
Wodomont soil and similar inclusions: 40 percent
Contrasting inclusions: 15 percent

Typical Profile

Topocoba

0 to 1 inch—brown gravelly very fine sandy loam
1 to 6 inches—reddish brown gravelly sandy clay loam
6 to 12 inches—reddish brown extremely cobbly sandy clay loam
12 to 17 inches—reddish brown extremely cobbly sandy clay loam
17 to 22 inches—indurated calcium carbonate cemented hardpan
22 inches—limestone

Wodomont

0 to 12 inches—brown extremely cobbly loam

12 to 15 inches—light brown very gravelly loam
15 inches—fractured limestone

Soil Properties and Qualities

Topocoba

Parent material: Alluvium derived from limestone and sandstone
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Slight
Shrink-swell potential: Moderate
Content of calcium carbonate: 10 to 30 percent in the subsoil above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Wodomont

Parent material: Colluvium and residuum derived from limestone
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 20 to 40 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Shallow soils that have a high content of clay
- Soils that are more than 20 inches deep
- Rock outcrop
- Soils that have steeper slopes than the Topocoba and Wodomont soils

Similar inclusions:
- Shallow soils that have a content of rock fragments that is less than 35 percent
- Soils that have a higher organic matter content than the Topocoba and Wodomont soils
- Soils that have a higher content of calcium carbonate than the Topocoba and Wodomont soils (Deama soils)
- Topocoba-like soils that have a lower content of clay

Use and Management

Rangeland

Dominant vegetation on the Topocoba soil:
- Potential plant community—muttongrass, Indian ricegrass, blue grama, bottlebrush squirreltail, Wyoming big sagebrush, fourwing saltbush
- Present plant community—blue grama, bottlebrush squirreltail, Wyoming big sagebrush, broom snakeweed

Major management factors: Large amounts of rock fragments on the surface and in the subsoil, shallow depth to hardpan, very low available water capacity
General management considerations on the Topocoba soil:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low forage value.
- If shrubs are managed to create open areas, a good stand of desirable grasses and forbs can be produced.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Topocoba soil:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Manage the brush in areas where unpalatable brushy plants have increased significantly.
- Control the brush by using chemicals or fire.

Woodland

Dominant overstory vegetation on Wodomont soil: Colorado pinyon—50 percent; Utah juniper—50 percent
Overstory production:
- Fuelwood—6 to 8 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—70 to 80 per acre
- Christmas trees—10 to 15 per acre
- Ornamental trees—10 to 15 per acre

Dominant understory vegetation on the Wodomont soil: Wyoming big sagebrush, green Mormon tea, banana yucca, blue grama, bottlebrush squirreltail, needleandthread
Major management factors: Shallow depth to bedrock, large amount of cobbles on the surface, very low available water capacity
General management considerations on the Wodomont soil:
- Harvest wood products when the canopy cover exceeds 35 percent.
- In areas where the density of the canopy is less than

about 35 percent, the understory produces plants suitable for grazing.
• Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
• Suitability for seeding is poor because of soil-related factors.
Suitable management practices on the Wodomont soil:
• Use conventional methods in harvesting.
• Reduce the hazard of erosion by avoiding excessive disturbances on the soil and by avoiding harvesting on very steep slopes.
• Leave some of the larger trees to provide shade for seedlings.
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating watering facilities, and using proper stocking rates.
• Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
• This unit supports vegetation that provides important habitat for mule deer.
• This unit provides important wintering areas for elk and wild turkey.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Avoid nest trees when gathering firewood.
• Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Range site: Topocoba—Shallow Loamy, 13-17" p.z.
Woodland site: Wodomont—Limestone Slopes, 13-17" p.z.

47—Toqui-Tovar-Rock outcrop complex, 1 to 15 percent slopes

Setting

Landform: Plateaus
Flooding: None
Slope range: 1 to 15 percent
Elevation: 5,000 to 5,800 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 140 to 160 days

Composition

Toqui soil and similar inclusions: 30 percent
Tovar soil and similar inclusions: 30 percent
Rock outcrop: 20 percent
Contrasting inclusions: 20 percent

Typical Profile

Toqui

0.0 to 0.5 inch—brown extremely cherty very fine sandy loam
0.5 inch to 2.0 inches—brown loam
2 to 5 inches—dark brown loam
5 to 11 inches—reddish brown cobbly clay
11 to 18 inches—yellowish red clay
18 inches—limestone

Tovar

0 to 1 inch—brown extremely cherty very fine sandy loam
1 to 3 inches—dark yellowish brown loam
3 to 8 inches—reddish brown gravelly clay loam
8 to 19 inches—dark reddish brown clay
19 to 28 inches—yellowish red very cobbly clay
28 inches—limestone

Rock outcrop consists of thin bedded, gray limestone from the Muav Formation.

Soil Properties and Qualities

Toqui

Parent material: Alluvium and residuum derived from Muav limestone
Depth class: Shallow
Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 10 to 20 inches
Runoff: Slow to medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: High
Content of calcium carbonate: 5 to 15 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Tovar

Parent material: Residuum derived from Muav limestone
Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Slow to medium

Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Very high
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Shallow soils that have a content of rock fragments that is more than 35 percent
- Moderately deep soils that have a content of rock fragments that is more than 35 percent

Similar inclusions:
- Soils that have steeper slopes than the Toqui and Tovar soils
- Soils that have calcium carbonate accumulations at lithic contact

Use and Management

Woodland

Dominant overstory vegetation on the Toqui soil: Utah juniper—85 percent; singleleaf pinyon—15 percent
Overstory production:
- Fuelwood—9 to 11 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—70 to 80 per acre
- Christmas trees—10 to 15 per acre
- Ornamental trees—10 to 15 per acre

Dominant understory vegetation on the Toqui soil: Stansbury cliffrose, turbinella oak, banana yucca, running pricklypear, bottlebrush squirreltail, muttongrass, sideoats grama
Dominant overstory vegetation on the Tovar soil: Utah juniper—65 percent; singleleaf pinyon—35 percent
Overstory production:
- Fuelwood—8 to 10 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—70 to 80 per acre
- Christmas trees—8 to 10 per acre
- Ornamental trees—8 to 10 per acre

Dominant understory vegetation on the Tovar soil: Turbinella oak, Stansbury cliffrose, pointleaf manzanita, muttongrass, and sideoats grama
Major management factors: High content of gravel on the surface, high shrink-swell potential, slow permeability, shallow depth to bedrock; Tovar—very high shrink-swell potential
General management considerations on the Toqui and Tovar soils and the Rock outcrop:
- Wood products can be harvested when canopy cover exceeds 35 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Maintaining the understory vegetation is essential in controlling erosion.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Toqui and Tovar soils and the Rock outcrop:
- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on steep slopes.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during succesive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: Toqui—VIs, nonirrigated; Tovar—VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Toqui—Shallow Loam (Gravelly), 13-17" p.z.; Tovar—Shallow Loam (Gravelly), 13-17" p.z.

48—Toqui-Yumtheska complex, 2 to 30 percent slopes

Setting

Landform: Mesas
Landscape position: Toqui—summits and shoulders; Yumtheska—side slopes and escarpments

Flooding: None
Slope range: Toqui—2 to 15 percent; Yumtheska—2 to 30 percent
Elevation: 6,200 to 6,600 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 140 to 160 days

Composition

Toqui soil and similar inclusions: 50 percent
Yumtheska soil and similar inclusions: 35 percent
Contrasting inclusions: 15 percent

Typical Profile

Toqui

0 to 2 inches—brown very gravelly loam
2 to 17 inches—reddish brown gravelly clay
17 to 20 inches—fractured cherty limestone
20 inches—cherty limestone

Yumtheska

0 to 2 inches—brown extremely cobbly loam
2 to 17 inches—brown very cobbly loam
17 inches—limestone

Soil Properties and Qualities

Toqui

Parent material: Alluvium and residuum derived from limestone
Depth class: Shallow
Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 10 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: High
Content of calcium carbonate: 5 to 25 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Yumtheska

Parent material: Alluvium and residuum derived from limestone
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 7 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 15 to 40 percent as disseminated lime and pendants on rock fragments
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Moderately deep, clayey soils (Natank soils)
- Very deep, clayey soils (Disterheff soils)

Similar inclusions:
- Shallow soils that have a higher content of calcium carbonate than the Toqui and Yumtheska soils (Deama soils)
- Yumtheska-like soils that have lighter colors
- Toqui-like soils that have a very flaggy surface and that have flagstones in the subsoil

Use and Management

Woodland

Dominant overstory vegetation on the Toqui soil: Utah juniper—55 percent; Colorado Pinyon—45 percent
Overstory production:
- Fuelwood—9 to 11 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—60 to 70 per acre
- Christmas trees—10 to 15 per acre
- Ornamental trees—10 to 15 per acre

Dominant understory vegetation on the Toqui soil: Present plant community—muttongrass, blue grama, prairie junegrass, Wyoming big sagebrush, Stansbury cliffrose
Dominant overstory vegetation on the Yumtheska soil: Colorado pinyon—60 percent; Utah juniper—40 percent
Overstory production:
- Fuelwood—4 to 6 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—10 to 20 per acre
- Christmas trees—10 to 20 per acre
- Ornamental trees—10 to 20 per acre

Dominant understory vegetation on the Yumtheska soil: Present plant community—muttongrass, bottlebrush squirreltail, Stansbury cliffrose, Fremont barberry, Wyoming big sagebrush
Major management factors: Toqui and Yumtheska—Large amounts of rock fragments on the surface and in the profile, shallow depth to bedrock; Toqui—high shrink-swell potential, slow permeability
General management considerations on the Toqui and Yumtheska soils:
- Wood products can be harvested when canopy cover exceeds 30 percent.
- In areas where the density of the canopy is less than

about 30 percent, the understory produces plants suitable for grazing.
• Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
• Livestock prefer to graze the easily accessible forage on the ridgetops and in the valleys before they graze the side slopes.
• Suitability for seeding is poor because of soil-related factors.
Suitable management practices on the Toqui and Yumtheska soils:
• Use conventional methods in harvesting.
• Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on very steep slopes.
• Leave some of the larger trees to provide shade for seedlings.
• Vary the season of grazing and the periods of rest during excessive years.
• Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
• This unit supports vegetation that provides important habitat for mule deer.
• This unit provides important wintering areas for elk and wild turkey.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Avoid nest trees when gathering firewood.
• Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Toqui—Clay Loam Upland (Gravelly), 13-17" p.z.; Yumtheska—Limestone Slopes, 13-17" p.z.

49—Tovar extremely flaggy fine sandy loam, 2 to 25 percent slopes

Setting

Landform: Structural benches
Flooding: None
Elevation: 5,900 to 6,100 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 140 to 160 days

Composition

Tovar soil and similar inclusions: 85 percent
Contrasting inclusions: 15 percent

Typical Profile

0 to 1 inch—brown extremely flaggy fine sandy loam
1 to 2 inches—pale brown very fine sandy loam
2 to 10 inches—reddish brown extremely flaggy clay loam
10 to 29 inches—yellowish red and reddish brown channery clay and flaggy clay
29 inches—red sandstone

Soil Properties and Qualities

Parent material: Residuum, alluvium, and colluvium derived from sandstone of the Supai Formation
Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: Very high
Content of calcium carbonate: None in the upper part and 0 to 10 percent in the lower subsoil
Corrosivity: Steel (uncoated)—moderate; concrete—low

Inclusions

Contrasting inclusions:
• Deep, moderately fine textured soils in swales (Lykorly and Frazwell soils)
• Deep, fine soils in swales
• Soils that are less than 20 inches deep

Similar inclusions:
• Soils that have very stony surface textures
• Soils that have gravelly or fine sandy loam surface textures
• Soils that are more than 40 inches deep over bedrock

Use and Management

Woodland

Dominant overstory vegetation: Utah juniper—60 percent; Colorado pinyon—40 percent
Overstory production:
• Fuelwood—9 to 10 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot

- Posts—90 to 100 per acre
- Christmas trees—60 to 75 per acre
- Ornamental trees—60 to 75 per acre

Dominant understory vegetation: Blue grama, bottlebrush squirreltail, sideoats grama, banana yucca, running pricklypear, narrowleaf yucca
Major management factors: Depth to bedrock, large amounts of flagstone on the surface, very high shrink-swell potential, slow permeability
General management considerations:
- Wood products can be harvested when canopy cover exceeds 35 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Maintaining the understory vegetation is essential in controlling erosion.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices:
- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on steep slopes.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Sandstone Upland, 13-17" p.z.

50—Tovar very fine sandy loam, 1 to 10 percent slopes

Setting

Landform: Plateaus and mesas
Flooding: None
Elevation: 6,200 to 6,600 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 140 to 160 days

Composition

Tovar soil and similar inclusions: 75 percent
Contrasting inclusions: 25 percent

Typical Profile

0 to 2 inches—brown very fine sandy loam
2 to 8 inches—dark brown loam
8 to 35 inches—reddish brown clay
35 inches—red sandstone

Soil Properties and Qualities

Parent material: Alluvium and residuum derived from sandstone
Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Medium
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Moderately high
Shrink-swell potential: Very high
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Shallow, loamy soils overlying sandstone
- Shallow, clayey soils overlying sandstone

Similar inclusions:
- Clayey soils that are more than 40 inches deep
- Soils that have a thicker surface horizon than the Tovar soil

Use and Management

Woodland

Dominant overstory vegetation: Utah juniper—50 percent; Colorado pinyon—50 percent

Overstory production:
• Fuelwood—12 to 15 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
• Posts—90 to 200 per acre
• Christmas trees—30 to 40 per acre
• Ornamental trees—30 to 40 per acre
Dominant understory vegetation: Muttongrass, prairie junegrass, bottlebrush squirreltail, Wyoming big sagebrush, Gambel oak, Stansbury cliffrose
Major management factors: Hazard of wind and water erosion, depth to bedrock, very high shrink-swell potential, slow permeability
General management considerations:
• Wood products can be harvested when canopy cover exceeds 35 percent.
• In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
• Maintaining the understory vegetation is essential in controlling erosion.
• Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
• Suitability for seeding is poor because of soil-related factors.
Suitable management practices:
• Use conventional methods in harvesting.
• Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on steep slopes.
• Leave some of the larger trees to provide shade for seedlings.
• Vary the season of grazing and the periods of rest during successive years.
• Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
• Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
• This unit supports vegetation that provides important habitat for mule deer.
• This unit provides important wintering areas for elk and wild turkey.
Suitable management practices:
• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Avoid nest trees when gathering firewood.
• Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIe, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Clay Loam Upland (Gravelly), 13-17" p.z.

51—Turkeytrack gravelly loam, 1 to 6 percent slopes

Setting

Landform: Fan terraces and stream terraces
Flooding: None
Elevation: 6,500 to 6,900 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 48 to 52 degrees F
Frost-free period: 120 to 150 days

Composition

Turkeytrack soil and similar inclusions: 90 percent
Contrasting inclusions: 10 percent

Typical Profile

0.5 to 0 inch—slightly decomposed pine litter
0 to 2 inches—light brown and brown gravelly loam
2 to 9 inches—brown loam
9 to 16 inches—reddish brown cobbly clay
16 to 45 inches—reddish brown and yellowish red gravelly clay
45 to 62 inches—yellowish red and pinkish white very cobbly sandy clay

Soil Properties and Qualities

Parent material: Alluvium derived dominantly from igneous and sedimentary rock
Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Available water capacity: Moderate
Potential rooting depth: 60 or more inches
Runoff: Medium
Hazard of erosion by water: Slight
Hazard of erosion by wind: Very slight
Shrink-swell potential: Very high
Content of calcium carbonate: 1 to 15 percent below a depth of 45 inches
Corrosivity: Steel (uncoated)—moderate; concrete—low

Inclusions

Contrasting inclusions:
• Fine textured soils overlying bedrock at a depth of less than 60 inches

Similar inclusions:
- Soils that have gravelly or cobbly surface textures
- Soils on the steeper slopes
- Soils that have thick surfaces that are high in organic matter in draws (Frazwell soils)

Use and Management

Timberland

Dominant overstory vegetation on the Turkeytrack soil: Ponderosa pine—100 percent
Overstory production:
- Average site index—63 (Minor)
- Estimated average annual production per acre (commercial)—3,400 board feet (Scribner rule) of timber from a stand of trees 100 years old

Dominant understory vegetation: Mountain big sagebrush, blue grama, bottlebrush squirreltail, redroot buckwheat
Major management factors: Very high shrink-swell potential, slow permeability
General management considerations:
- Snowpack and spring thaw limits the use of equipment and restricts access.
- Careless use of wheeled and tracked equipment disturbs the protective layer of duff.
- Heavy equipment and the conventional method of harvesting timber are likely to compact the soil if it is wet.
- When wet, unsurfaced roads and skid trails are muddy. They may be impassable during rainy periods.
- Logging roads require suitable surfacing for year-round use.
- Adequately designed road drainage reduces the hazard of erosion.
- Maintaining the understory vegetation is essential for controlling erosion.
- If seed trees are in the stand, reforestation occurs naturally in cutover areas.
- Carefully managed reforestation reduces competition from undesirable understory plants.
- Machine planting may be practical in nearly level areas.
- Machine planting is practical in dry areas.
- Seedling mortality may be high in summer because of the lack of adequate soil moisture.
- Seedlings planted in the less fertile part of the soil profile show poor growth and vigor.
- Plant competition delays natural regeneration but does not prevent the eventual development of a fully stocked, normal stand of trees.
- In areas where the density of the canopy is less than about 50 percent, the understory produces plants suitable for grazing.
- Suitability for grass seeding after logging is good.

Suitable management practices:
- Reduce compaction by using suitable methods of harvest, laying out skid trails in advance, and harvesting when the soil is least susceptible to compaction.
- Limit the use of equipment when the soil is wet.
- Reduce the hazard of erosion by avoiding excessive disturbance on the soil, seeding roads and landings, and constructing water bars to protect roads and landings.
- Leave some of the larger trees to provide shade for seedlings.
- Mulch around seedlings to retain moisture in summer.
- Improve stands by thinning before trees grow to commercial size and by selective cutting of mature trees.
- Seed disturbed areas to adapted grasses by broadcasting or drilling in order to increase forage production.
- Prepare the site adequately in order to seed understory plants successfully.
- Seed late in fall for best results. After seeding, defer grazing until grasses and tree seedlings are well established.

Wildlife

Wildlife observed in areas of this unit: Elk, mule deer, black bear, mountain lion, bobcat, wild turkey, Abert's squirrel, golden eagle, short-eared owl, white-breasted nuthatch, western tanager
General management considerations:
- This unit supports vegetation that provides important summer foraging areas for elk and wild turkey.
- Gambel oak is an important food and cover tree for a variety of species.
- The northern goshawk and the endangered Mexican spotted owl may exist in these areas.
- This unit provides important roosting and perching sites for golden eagles.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Delay grazing and timber harvesting until July 1 in elk calving areas.
- Use seed mixture for revegetation that is suitable for wildlife species.
- Leave snags for wildlife habitat when harvesting timber.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-1AZ—Mogollon Plateau Coniferous Forest
Woodland site: Loamy Terrace, 17-20" p.z.

52—Ustorthents-Rock outcrop complex, 35 to 90 percent slopes

Setting

Landform: Canyon escarpments
Flooding: None
Elevation: 6,000 to 7,200 feet
Mean annual precipitation: 14 to 18 inches
Mean annual soil temperature: 48 to 56 degrees F
Frost-free period: 120 to 160 days

Composition

Ustorthents and similar inclusions: 60 percent
Rock outcrop: 30 percent
Contrasting inclusions: 10 percent

Typical Profile

Ustorthents are variable in depth, color, and texture. No single profile typifies this group, but a commonly observed soil profile is:
0 to 1 inch—light brown extremely flaggy fine sandy loam
1 to 18 inches—light brown channery and flaggy fine sandy loam
18 inches—sandstone

Rock outcrop consists of very steep escarpments of the Hermit Shale Formation, Coconino Sandstone Formation, Toroweap Formation, or the Kaibab Limestone Formation.

Soil Properties and Qualities

Ustorthents

Parent material: Residuum, colluvium, and alluvium derived from sedimentary rock
Depth class: Very shallow to very deep
Drainage class: Well drained
Permeability: Moderate to rapid
Available water capacity: Low to high
Potential rooting depth: 8 to 60 or more inches
Runoff: Very rapid
Hazard of water erosion: Severe to very severe
Hazard of wind erosion: Moderate to very slight
Shrink-swell potential: Low to high
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
• Shallow soils that have dark surface layers and developed subsoils (Pocomate soils)
• Deep, clayey soils that have extremely flaggy surfaces and subsoils on foot slopes

Similar inclusions:
• Soils on slopes that are less steep or more steep than those of the Ustorthents
• Variable soils on north slopes that have cooler temperatures and more effective precipitation than the Ustorthents

Use and Management

Rangeland

Dominant vegetation on the Ustorthents soil:
• Potential plant community—sideoats grama, desert needlegrass, muttongrass, prairie junegrass, bottlebrush squirreltail, turbinella oak, Utah juniper, Colorado pinyon, shrubby buckwheat
• Present plant community—sideoats grama, desert needlegrass, muttongrass, prairie junegrass, blue grama, turbinella oak, Utah juniper, Colorado pinyon, shrubby buckwheat
Major management factors: Hazard of water erosion, very steep slopes, large amounts of rock fragments on the surface and in the soil
General management considerations:
• Use of this unit is limited by very steep slopes and inaccessibility. This scenic unit is best suited to wildlife habitat and limited recreational use.

Wildlife

Wildlife observed in areas of this unit: Desert bighorn sheep, golden eagle, peregrine falcon, canyon wren, violet-green swallow, ringtail, chuckawalla
General management considerations:
• This unit provides important nest sites for many species of birds and provides escape routes for bighorn sheep.
• The Rock outcrop supports no vegetation but is important for nest sites, resting cover, hunting perches, escape routes, and dens.
Suitable management practices:
• Manage feral horses and burros to benefit bighorn sheep.

Interpretive Groups

Land capability classification: Ustorthents—VIIe, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Range site: Ustorthents—Breaks, 13-17" p.z.

53—Winona-Curhollow complex, 1 to 12 percent slopes

Setting

Landform: Mesas and plateaus
Landscape position: Winona—back slopes; Curhollow—

nearly level to slightly concave foot slopes and summits
Flooding: None
Slope range: Winona—1 to 12 percent; Curhollow—1 to 8 percent
Elevation: 5,200 to 5,500 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days

Composition

Winona soil and similar inclusions: 60 percent
Curhollow soil and similar inclusions: 25 percent
Contrasting inclusions: 15 percent

Typical Profile

Winona

0 to 1 inch—brown extremely cobbly loam
1 to 5 inches—dark brown very cobbly loam
5 to 17 inches—brown limy very cobbly loam
17 inches—limestone

Curhollow

0 to 2 inches—dark brown very gravelly loam
2 to 8 inches—brown very cobbly loam
8 to 14 inches—light brown limy very cobbly loam
14 to 28 inches—fractured, indurated, calcium carbonate cemented hardpan
28 inches—limestone

Soil Properties and Qualities

Winona

Parent material: Limestone residuum
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Medium or rapid
Hazard of water erosion: Slight to moderate
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 40 to 60 percent in the control section
Corrosivity: Steel (uncoated)—high; concrete—low

Curhollow

Parent material: Alluvium and residuum derived from limestone
Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 10 to 20 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 15 to 35 percent above the hardpan
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Rock outcrop
- Moderately deep to very deep loamy soils in draws
- Very deep soils on foot slopes that have a content of rock fragments that is more than 35 percent

Similar inclusions:
- Soils that are less than 7 inches deep
- Soils that have a lower content of organic matter than the Winona and Curhollow soils
- Soils that have more stones on the surface than the Winona and Curhollow soils
- Soils that have slopes that are steeper than those of the Winona and Curhollow soils
- Soils that have shallow hardpans overlying gravelly alluvium (Havasupai soils)

Use and Management

Woodland

Dominant overstory vegetation on the Winona soil: Utah juniper—85 percent; Colorado pinyon—15 percent
Overstory production:
- Fuelwood—4 to 6 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—15 to 20 per acre
- Christmas trees—5 to 10 per acre
- Ornamental trees—10 to 15 per acre

Dominant understory vegetation on the Winona soil: Blue grama, sand dropseed, bottlebrush squirreltail, Stansbury cliffrose
Dominant overstory vegetation on the Curhollow soil: Utah juniper—85 percent; Colorado pinyon—15 percent
Overstory production:
- Fuelwood—4 to 6 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—15 to 20 per acre
- Christmas trees—5 to 10 per acre
- Ornamental trees—10 to 15 per acre

Dominant understory vegetation on the Curhollow soil: Blue grama, sand dropseed, bottlebrush squirreltail, Stansbury cliffrose

Major management factors: Shallow depth to rock or hardpan, high content of calcium carbonate, very low available water capacity, large amounts of rock fragments on the surface and in the soil

General management considerations on the Winona and Curhollow soils:

- Wood products can be harvested when canopy cover exceeds 25 percent.
- In areas where the density of the canopy is less than about 25 percent, the understory produces plants suitable for grazing.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Winona and Curhollow soils:

- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil while harvesting.
- Vary the season of grazing and the periods of rest during successive years.
- Leave some of the larger trees to provide shade for seedlings.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay

General management considerations:

- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:

- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Woodland site: Shallow Loam (Cobbly), 9-13" p.z.

54—Winona-Rock outcrop complex, 15 to 55 percent slopes

Setting

Landform: Hills
Flooding: None
Slope range: 15 to 55 percent
Elevation: 5,100 to 5,500 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days

Composition

Winona soil and similar inclusions: 60 percent
Rock outcrop: 30 percent
Contrasting inclusions: 10 percent

Typical Profile

Winona

0 to 1 inch—light yellowish brown limy very stony loam
1 to 5 inches—light yellowish brown limy very gravelly silt loam
5 to 17 inches—light yellowish brown and yellowish brown limy extremely stony silt loam
17 inches—limestone

Rock outcrop consists dominantly of steep outcrops of dolomitic limestone.

Soil Properties and Qualities

Winona

Parent material: Limestone colluvium
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Very rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: More than 40 percent in the control section
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:

- Moderately deep to deep soils that have a high content of calcium carbonates on foot slopes and near drainageways

Similar inclusions:

- Soils that are less than 6 inches deep over rock

- Shallow soils that have a layer of secondary calcium carbonate accumulation
- Soils that have a calcium carbonate cemented hardpan within a depth of 20 inches
- Soils that have a lower content of calcium carbonate than the Winona soil
- Soils that have a higher content of organic matter than the Winona soil

Use and Management

Rangeland

Dominant vegetation on the Winona soil:
- Potential plant community—blue grama, bottlebrush squirreltail, sideoats grama, Stansbury cliffrose, Fremont barberry, Utah juniper
- Present plant community—blue grama, bottlebrush squirreltail, red brome, sand dropseed, Stansbury cliffrose, broom snakeweed, Utah juniper

Major management factors: Hazard of water erosion, shallow depth to rock, very steep slopes, large amounts of rock fragments on the surface and in the subsoil, high content of calcium carbonate

General management considerations on the Winona soil:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low value as forage.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accessible forage on the ridgetops and in the valleys before they graze the side slopes.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Winona soil:
- Vary the season of grazing and the periods of rest during successive years.
- Control the time and amount of use by livestock.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon

General management considerations:
- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals that frequent this unit are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.
- The Rock outcrop supports no vegetation but is important for nest sites, resting cover, hunting perches, escape routes, and dens.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: Winona—VIIe, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Range site: Winona—Breaks, 9-13" p.z.

55—Winona-Rock outcrop-Tusayan complex, 15 to 55 percent slopes

Setting

Landform: Hills
Landscape position: Winona—steep shoulders, back slopes, and rocky ledges; Tusayan—foot slopes
Flooding: None
Slope range: Winona—15 to 55 percent; Tusayan—15 to 35 percent
Elevation: 5,600 to 6,000 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days

Composition

Winona soil and similar inclusions: 50 percent
Rock outcrop: 25 percent
Tusayan soil and similar inclusions: 20 percent
Contrasting inclusions: 5 percent

Typical Profile

Winona

0 to 2 inches—brown extremely gravelly loam
2 to 10 inches—brown extremely gravelly loam
10 to 17 inches—very pale brown extremely gravelly loam
17 inches—widely fractured limestone, thickly coated with calcium carbonate

Rock outcrop consists of ledges of Kaibab Limestone Formation or the Toroweap Formation.

Tusayan

0 to 4 inches—brown extremely gravelly fine sandy loam
4 to 13 inches—yellowish brown limy, very gravelly loam

13 to 22 inches—light yellowish brown, limy, very gravelly loam
22 to 29 inches—highly fractured, calcium carbonate coated limestone
29 inches—limestone

Soil Properties and Qualities

Winona

Parent material: Alluvium, colluvium, and residuum derived from limestone
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Very rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 40 to 60 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Tusayan

Parent material: Alluvium derived from limestone
Depth class: Moderately deep
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 20 to 40 inches
Runoff: Rapid to very rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: Averages more than 40 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Deep soils in drainageways that have a content of rock fragments that is more than 35 percent
- Soils that have gypsum on hillslope shoulders

Similar inclusions:
- Soils that have gentler slopes or steeper slopes than the Winona and Tusayan soils and the Rock outcrop
- Soils that do not have discrete zones of calcium carbonate accumulation on steeper slopes
- Soils that are less than 8 inches deep
- Soils that have redder colors than the Winona and Tusayan soils
- Soils that have a slightly lower content of calcium carbonate than the Winona and Tusayan soils

Use and Management

Rangeland

Dominant vegetation on the Winona soil:
- Potential plant community—muttongrass, blue grama, bottlebrush squirreltail, Wyoming big sagebrush, green Mormontea
- Present plant community—muttongrass, blue grama, bottlebrush squirreltail, Wyoming big sagebrush, broom snakeweed, Stansbury cliffrose, green Mormontea

Dominant vegetation on the Tusayan soil:
- Potential plant community—needleandthread, black grama, blue grama, fourwing saltbush, winterfat
- Present plant community—blue grama, black grama, needleandthread, fourwing saltbush, broom snakeweed

Major management factors: Large amounts of rock fragments on the surface, steep slope, shallow depth to bedrock, high content of calcium carbonate

General management considerations on the Winona and Tusayan soils:
- Continuous, intensive year-round grazing results in a deteriorated plant community that has low forage value.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Winona and Tusayan soils:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of grazing by livestock.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon

General management considerations:
- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals that frequent this unit are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: Winona—VIIe, nonirrigated; Tusayan—VIs, nonirrigated
Major Land Resource Unit: 35-3AZ—Colorado Plateau Sagebrush-Grassland
Range site: Winona—Limestone Hills, 9-13" p.z.; Tusayan—Limy Slopes, 9-13" p.z.

56—Wodomont-Coconino complex, 2 to 15 percent slopes

Setting

Landform: Plateaus and mesas
Landscape position: Wodomont—ridges, summits, and back slopes; Coconino—foot slopes and back slopes
Flooding: None
Slope range: 2 to 15 percent
Elevation: 5,300 to 5,800 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days

Composition

Wodomont soil and similar inclusions: 55 percent
Coconino soil and similar inclusions: 30 percent
Contrasting inclusions: 15 percent

Typical Profile

Wodomont

0 to 2 inches—brown extremely channery very fine sandy loam
2 to 5 inches—reddish brown very gravelly very fine sandy loam
5 to 12 inches—reddish brown very gravelly very fine sandy loam
12 to 19 inches—highly fractured, thin bedded, calcareous sandstone
19 inches—calcareous sandstone

Coconino

0 to 2 inches—reddish brown extremely channery very fine sandy loam
2 to 6 inches—reddish brown channery loam
6 to 13 inches—light reddish brown gravelly loam
13 to 26 inches—light reddish brown and pink limy gravelly loam
26 inches—calcareous sandy shale

Soil Properties and Qualities

Wodomont

Parent material: Residuum and colluvium derived from interbedded calcareous sandstone, limestone, and siltstone of the Supai Formation
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Rapid
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 20 to 30 percent
Corrosivity: Steel (uncoated)—high; concrete—low
Potential frost action: Moderate

Coconino

Parent material: Colluvium and residuum derived from calcareous sandstone, limestone, and siltstone of the Supai Formation
Depth class: Moderately deep
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Low
Potential rooting depth: 20 to 40 inches
Runoff: Medium
Hazard of water erosion: Slight
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: Calcareous throughout, with 15 to 25 percent in the control section
Corrosivity: Steel (uncoated)—high; concrete—low
Potential frost action: Moderate

Inclusions

Contrasting inclusions:
- Rock outcrop
- Shallow soils overlying soft bedrock
- Soils that are less than 6 inches deep
- Deep, loamy soils
- Shallow to moderately deep, clayey soils

Similar inclusions:
- Wodomont and Coconino soils on the steeper slopes

Use and Management

Woodland

Dominant overstory vegetation on the Wodomont soil: Utah juniper—60 percent; Colorado pinyon—40 percent
Overstory production:
- Fuelwood—6 to 7 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—20 to 40 per acre
- Christmas trees—15 to 20 per acre
- Ornamental trees—15 to 20 per acre

Dominant understory vegetation on the Wodomont soil: Blue grama, Fendler threeawn, black grama, broom snakeweed, Fremont barberry, banana yucca, green Mormontea
Dominant overstory vegetation on the Coconino soil: Utah juniper—65 percent; Colorado Pinyon—35 percent
Overstory production:
- Fuelwood—8 to 10 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—70 to 80 per acre
- Christmas trees—20 to 30 per acre
- Ornamental trees—20 to 30 per acre

Dominant understory vegetation on the Coconino soil: Blue grama, muttongrass, Indian ricegrass, green Mormontea, broom snakeweed, Fremont barberry, running pricklypear
Major management factors: Shallow depth to rock, large amounts of rock fragments on the surface and in the soil
General management considerations on the Wodomont and Coconino soils:
- Harvest wood products when canopy cover exceeds 30 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Wodomont and Coconino soils:
- Use conventional methods in wood harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbances of the soil while harvesting.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Sandstone Upland, 13-17" p.z.

57—Wodomont-Rock outcrop complex, 5 to 40 percent slopes

Setting

Landform: Hills
Flooding: None
Slope range: 5 to 40 percent
Elevation: 4,600 to 5,400 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 140 to 160 days

Composition

Wodomont soil and similar inclusions: 70 percent
Rock outcrop: 20 percent
Contrasting inclusions: 10 percent

Typical Profile

Wodomont

0 to 2 inches—brown extremely cobbly loam
2 to 7 inches—dark brown very cobbly loam
7 to 11 inches—brown extremely cobbly loam
11 inches—limestone

Rock outcrop consists of thin bedded, gray limestone from the Muav Formation or the Redwall Formation.

Soil Properties and Qualities

Wodomont

Parent material: Residuum derived from the Muav Formation, Redwall Limestone Formation, or the Supai Formation
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 6 to 20 inches
Runoff: Rapid and very rapid

Hazard of water erosion: Slight to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Content of calcium carbonate: 20 to 40 percent
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Very deep, moderately fine textured soils (Lykorly soils)
- Deep soils that have a content of rock fragments that is more than 35 percent (Buckndoe soils)

Similar inclusions:
- Soils that are less than 6 inches deep
- Soils that have extremely gravelly surface textures
- Soils that have very stony or cobbly surface textures

Use and Management

Woodland

Dominant overstory vegetation on the Wodomont soil: Utah juniper—65 percent; singleleaf pinyon—35 percent
Overstory production:
- Fuelwood—7 to 8 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—30 to 40 per acre
- Christmas trees—10 to 15 per acre
- Ornamental trees—10 to 15 per acre

Dominant understory vegetation on Wodomont soil: Turbinella oak, Stansbury cliffrose, desert ceanothus, muttongrass, sideoats grama, needleandthread, blue grama
Major management factors: Shallow depth to rock, steep slopes, hazard of water erosion on steep slopes, large amounts of rock fragments on the surface and in the soil
General management considerations on the Wodomont soils:
- Wood products can be harvested when canopy cover exceeds 35 percent and slope is less than 25 percent.
- In areas where the density of the canopy is less than about 30 percent, the understory produces plants suitable for grazing.
- Maintaining the understory vegetation is essential in controlling erosion.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accessible forage on the ridgetops and in the valleys before they graze the side slopes.
- Suitability for seeding is poor because of soil-related factors.

Suitable management practices on the Wodomont soils:
- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding excessive disturbance of the soil and by avoiding harvesting on steep slopes.
- Leave some of the larger trees to provide shade for seedlings.
- Vary the season of grazing and periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Mule deer, elk, wild turkey, coyote, gray fox, mountain lion, ferruginous hawk, red-tailed hawk, flammulated owl, lazuli bunting, Steller's jay, pinyon jay
General management considerations:
- This unit supports vegetation that provides important habitat for mule deer.
- This unit provides important wintering areas for elk and wild turkey.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Avoid nest trees when gathering firewood.
- Manage vegetation in order to provide adequate thermal cover for wintering big game species.

Interpretive Groups

Land capability classification: Wodomont—VIs, nonirrigated
Major Land Resource Unit: 39-3AZ—Grand Canyon Woodland-Shrub
Woodland site: Wodomont—Shallow Loam (Gravelly), 13-17" p.z.

58—Wukoki-Lomaki complex, 15 to 50 percent slopes

Setting

Landform: Cinder cones
Flooding: None
Slope range: 15 to 50 percent
Elevation: 5,500 to 5,800 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 150 to 165 days

Composition

Wukoki soil and similar inclusions: 45 percent
Lomaki soil and similar inclusions: 40 percent
Contrasting inclusions: 15 percent

Typical Profile

Wukoki

0 to 3 inches—yellowish brown extremely gravelly loam
3 to 10 inches—light yellowish brown extremely gravelly loam
10 to 60 inches—black cinders

Lomaki

0 to 30 inches—yellowish brown extremely gravelly loam
30 to 60 inches—black cinders

Soil Properties and Qualities

Wukoki

Parent material: Alluvium and colluvium derived from scoriaceous basalt and pyroclastics
Depth class: Very deep
Drainage class: Somewhat excessively drained
Permeability: Moderate
Available water capacity: Very low
Potential rooting depth: 60 inches or more
Runoff: Rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Corrosivity: Steel (uncoated)—high; concrete—low
Parent material: Alluvium and colluvium derived from scoriaceous basalt and pyroclastics
Depth class: Very deep
Drainage class: Somewhat excessively drained
Permeability: Moderate
Available water capacity: Low
Potential rooting depth: 60 inches or more
Runoff: Rapid
Hazard of water erosion: Moderate to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Low
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Soils that have slopes of more than 50 percent
- Soils that are deeper than 40 inches to cinders and that are usually on fan terraces
- Soils that are shallow to bedrock and that usually have slopes of more than 45 percent

Similar inclusions:
- Soils that have slopes of less than 15 percent

Use and Management

Rangeland

Dominant vegetation on the Wukoki soil:
- Potential plant community—needleandthread, Wyoming big sagebrush, sideoats grama, black grama
- Present plant community—snakeweed, rabbitbrush, cheatgrass

Dominant vegetation on the Lomaki soil:
- Potential plant community—sideoats grama, black grama, needleandthread, Wyoming big sagebrush
- Present plant community—blue grama, rabbitbrush, big sagebrush, snakeweed

Major management factors: Very low available water capacity, steep slope, hazard of water erosion

General management considerations on the Wukoki and Lomaki soils:
- Water developments are generally lacking on this unit.
- Low productivity and steep slopes limit management alternatives.
- Livestock grazing should be managed to protect the soil from excessive erosion because of the severe hazard of erosion.
- Trails and walkways can be constructed in places to encourage livestock to graze in areas where access is limited.

Suitable management practices on the Wukoki and Lomaki soils:
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating watering facilities, properly distributing salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.
- Reduce the hazard of erosion by avoiding overgrazing, maintaining adequate plant cover, and accumulating organic litter on the surface.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon

General management considerations:
- This unit supports vegetation that provides important habitat for pronghorn antelope.
- The small mammals that frequent this unit are important prey for raptors and other species.
- Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:
- Develop water facilities for wildlife.
- Use proper grazing of vegetation to preserve forage for wildlife.
- Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
- Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: VIIe, nonirrigated
Major Land Resource Unit: 35-3AZ—Colorado Plateau Sagebrush-Grassland
Range site: Cinder Hills, 9-13" p.z.

59—Wyva family-Rock outcrop complex, 5 to 35 percent slopes

Setting

Landform: Hills
Flooding: None
Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days

Composition

Wyva family and similar inclusions: 60 percent
Rock outcrop: 25 percent
Contrasting inclusions: 15 percent

Typical Profile

Wyva family

0 to 2 inches—reddish brown extremely gravelly sandy loam
2 to 9 inches—reddish brown very gravelly clay loam
9 inches—basalt

Rock outcrop consists of basalt exposures that cap hills.

Soil Properties and Qualities

Wyva family

Parent material: Basalt residuum
Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: Very low
Potential rooting depth: 5 to 20 inches
Runoff: Medium to very rapid
Hazard of water erosion: Slight to severe
Hazard of wind erosion: Very slight
Shrink-swell potential: Moderate
Corrosivity: Steel (uncoated)—high; concrete—low

Inclusions

Contrasting inclusions:
- Very deep, moderately fine textured soils on stream terraces in drainageways
- Soils that are more than 20 inches deep over basalt, a calcium carbonate cemented hardpan, or a silica cemented hardpan

Similar inclusions:
- Soils that have a content of clay that is slightly higher or slightly lower than that of the Wyva family
- Soils that have darker surface colors than the Wyva family

Use and Management

Woodland

Dominant overstory vegetation on the Wyva family soil: Utah juniper—95 percent; singleleaf pinyon—5 percent
Overstory production:
- Fuelwood—3 to 5 cords per acre in a stand of trees that averages 5 inches in diameter at a height of 1 foot
- Posts—1 to 5 per acre
- Christmas trees—0 to 2 per acre
- Ornamental trees—0 to 2 per acre

Dominant understory vegetation on the Wyva family soil: Present plant community—sideoats grama, galleta, blue grama, slim tridens, banana yucca, Apache plume, green Mormontea, broom snakeweed
Major management factors: Hazard of water erosion on steep slopes, shallow depth to rock, very low available water capacity
General management considerations:
- Wood products can be harvested when canopy cover exceeds 25 percent.
- In areas where the density of the canopy is less than about 25 percent, the understory produces plants suitable for grazing.
- Uniform distribution of grazing is difficult because of the slope, the lack of permanent water developments, or both.
- Livestock prefer to graze the easily accesible forage areas.
- Suitability for range seeding is poor because of soil-related factors.

Suitable management practices:
- Use conventional methods in harvesting.
- Reduce the hazard of erosion by avoiding harvesting on steep slopes and excessive disturbance of the soil.
- Vary the season of grazing and the periods of rest during successive years.
- Promote uniform grazing by fencing, properly locating salt licks, and using proper stocking rates.
- Control the time and amount of use by livestock.

Wildlife

Wildlife observed in areas of this unit: Pronghorn antelope, coyote, black-tailed jackrabbit, badger, prairie dog, kit fox, red-tailed hawk, American kestrel, northern shrike, golden eagle, sage thrasher, rufous-sided towhee, prairie falcon
General management considerations:
- This unit supports vegetation that provides important habitat for pronghorn antelope.

• The small mammals that frequent this unit are important prey for raptors and other species.
• Small mammal populations fluctuate widely with environmental conditions.

Suitable management practices:

• Develop water facilities for wildlife.
• Use proper grazing of vegetation to preserve forage for wildlife.
• Manage vegetation to provide adequate height of cover to reduce predation in pronghorn antelope fawning areas.
• Manage feral horses to benefit pronghorn antelope.

Interpretive Groups

Land capability classification: Wyva—VIs, nonirrigated
Major Land Resource Unit: 35-1AZ—Colorado Plateau Mixed Grass Plains
Woodland site: Wyva—Basalt Hills, 9-13" p.z.

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 woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreational facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

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

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

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

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 take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes (USDA, 1961).

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

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

Class I soils have few limitations that restrict their use.

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

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

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

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

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

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

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

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example IIe. 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 I there are no subclasses because the soils of

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

The capability classification of each map unit is given in the section "Detailed Soil Map Units."

Cropland

Michael Vasquez, assistant professor of anthropology, Northern Arizona University, prepared this section.

Cropland in the survey area includes approximately 70 acres of feed, vegetable, and orchard crops. Also, 60 acres of cropland is predominantly fallow. All of the acreage used for crop production is in Havasupai Canyon within a short distance of the village of Supai. The dominant soils used for crop production are Cowan family and Naha soils. All crop production is for subsistence purposes. Based on agricultural permit data, there are 43 families engaged in crop production.

Agricultural activity among the Havasupai has declined considerably during the last 50 years. Current acreage devoted to crop production includes 60 irrigated acres and approximately 10 acres that are dry farmed. The Havasupai Tribe has experienced four major floods in the past 4 years that have caused extensive damage to the irrigation system and agricultural fields. As a result, irrigated acreage fell from 125 acres to its present level. The major crops grown are alfalfa, corn, apricots, peaches, melons, and squash and limited amounts of other fruits and vegetables. As of 1993, there were 40 acres devoted to alfalfa, 10 to 20 acres of orchards, and 10 acres of corn, melons, squash, and other vegetable crops. The majority of farming activities involves garden plots of 1 acre or less.

Rangeland

Harmon S. Hodgkinson, area range conservationist, Natural Resources Conservation Service, prepared this section.

Approximately 56 percent of the land in the survey area is rangeland. Most of the range is utilized year-round. Cattle are the most common livestock. Cow-calf operations on the Hualapai Reservation are conducted by five grazing associations that were established in 1957 (Watahomigie, 1983). The size of the five grazing areas ranges from 174,000 acres to 230,000 acres (including grazeable woodland). These grazing areas are divided by fences. Livestock watering facilities have been developed using storage tanks and an extensive distribution of pipelines and troughs. Grazing system plans have been developed by the associations. As the plans are currently being implemented, plants are being properly grazed. These plans include deferring grazing during the green growth period at least once every 3 years, allowing the plants to maintain a healthy condition.

On the Havasupai Reservation, the tribal members have two large grazing districts that are divided by Cataract Canyon. The area west of Cataract Canyon (Long Mesa, Tenderfoot Mesa, and Panya Point) is grazed year-round by horses. Most of these horses are used by tribal members to ride and transport supplies to Supai Village. The area east of Cataract Canyon is used by both horses and cow-calves year-round. The Havasupai Tribe has recently formed a grazing association that manages the grazing resource. Range and livestock management practices, such as water developments, proper grazing use, and grazing systems, are currently being planned or implemented.

The main goal of rangeland management should be to use the native forage plants at an intensity that will maintain or improve the quantity and quality of the vegetation for soil protection and forage production. This goal can be achieved by using a proper grazing system. Most native herbaceous forage plants remain vigorous and produce good leaf growth if at least 50 percent of the annual production by weight remains at the end of the growing season. To meet this objective, implementation of a grazing system is necessary. The animals should be moved to another area when grazing has reached the desired level.

Overgrazing depletes native plants, leaving only the least desirable and poorest quality plants. The range can be improved by seeding suited species and controlling undesirable brush. This is especially true in areas that receive 10 or more inches of precipitation per year.

Some range sites are better suited to seeding than others. The Loamy Upland, Sandy Loam Upland, and Clay Loam Upland sites have the best potential for reseeding under poor conditions. The soils in these range sites have the fewest limitations for seeding. A firm, weed-free seedbed must be prepared to allow for maximum moisture at the shallow depth of seed placement. A suitable drill that has depth-band regulators or methods applied to firm the seedbed are very important for establishing seedlings. Late fall is the best time to seed. The seed will be dormant until germination in the spring, taking advantage of winter and spring moisture.

There are areas on the Loamy Upland, Sandy Loam Upland, and Clay Loam Upland sites where brush species such as Wyoming big sagebrush, broom snakeweed, and rubber rabbitbrush have increased beyond the percentage desired in the native potential plant community. Methods of control may be applied to the brush to bring the percentage to a tolerable level. This will provide space for

the more desirable plants to grow and provide cover to protect the soil from erosion.

Range that is best suited to brush management is in areas that have desirable understory species that will respond to the water and nutrients the brush will no longer use. These areas are usually in fair condition. If no understory species exist, seeding will be necessary after brush management.

Many methods are used to manage brush, such as burning, rotobeating, plowing, and using biological and chemical controls. Some brush species are killed by certain methods while others flourish. The right method must be matched with the particular species for best results. Long-term improvement programs and good range management result in a balanced native plant community that stabilizes the soil resources.

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

Table 5 shows, for each soil that supports rangeland vegetation suitable for grazing, the range site; the total annual production of vegetation in favorable, normal, and unfavorable years; the characteristic vegetation; and the average percentage of each species. An explanation of the column headings in table 5 follows.

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

Total production is the amount of vegetation that can be expected to grow annually on well managed rangeland that is supporting 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 and the temperatures make growing conditions substantially better than average. In a normal year, growing conditions are about average. In an unfavorable year, growing conditions are well below average, generally because of low available soil moisture.

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

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

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 condition. Range condition is determined by comparing the present plant community with the potential natural plant community on a particular range site. The more closely the existing community resembles the potential community, the better the range condition. Range condition is an ecological rating only.

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, a range condition somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

Woodland and Timberland

Harmon S. Hodgkinson, area range conservationist, Natural Resources Conservation Service, and Charlie Murphy and Tom Walquist, foresters, Hualapai Tribe, prepared this section.

Approximately 40 percent of the survey area is woodland, and 4 percent is timberland. Steep slopes, rocky terrain, and shallow soils typify the topography of much of these areas. However, the soils produce good quality wood products if properly managed.

The Ponderosa pine forest occurs in the 18- to 20-inch precipitation zone, which makes growth slow and production low. Common understory species are Utah juniper, twoleaf pinyon, and Gambel oak. A main management goal of this timberland type should be to selectively harvest mature trees on a sustained yield basis and thin young stands to maximize wood growth. On the Hualapai Reservation, selective harvest of mature Ponderosa pine is conducted by commercial loggers. It generates labor and revenue for the tribe. The logs are sold to mills in Ash Fork, Williams, and Winslow. Wildlife

habitat, livestock grazing, surface and ground water quality, natural beauty, and recreational considerations need to be a part of the timberland management plan.

In the 14- to 18-inch precipitation zone, singleleaf pinyon, twoleaf pinyon, and Utah juniper dominate. The pinyon-juniper woodland provides wood products and a resource for wildlife and livestock grazing. Fuelwood from pinyons and junipers is harvested by Hualapai tribal members for both personal and commercial uses. Also, "cedar" posts from the Utah juniper are cut by the Hualapais for personal use. Pinyon nuts are gathered in the fall during good nut producing years. Management goals should allow for the harvest of wood products while protecting the soil from erosion and maintaining the understory for grazing uses.

Major management concerns on both timberlands and woodlands are steep slopes and rocky soils. Steep, rocky slopes restrict equipment use and indicate to the forest manager a need to choose the proper equipment. Harvesting methods and woodland improvement practices on these slopes are more costly than on gentle slopes. Erosion can occur on all soils but is worse on steep slopes. Special precautions are needed to control erosion and protect water quality in areas where the soil is exposed along roads, skid trails, and loading areas. Soils that have slopes of more than 35 percent should receive special attention during the development and implementation of woodland plans. Some practices that will aid in the use and management of timberland and woodland are seeding of disturbed areas, installation of cross drains on roads, proper grazing of the understory, disposal of slash in a way that helps prevent erosion, and site preparation for reforestation after harvesting. Tribal foresters manage the woodland and timberland of the Hualapai Reservation and provide guidance to harvesters, improvement crews, and all other users.

The Havasupai Tribe uses its woodland resources on a limited basis because of the distance from Supai Village to the pinyon-juniper area on the Coconino Plateau. When tribal members work the livestock and camp out of the canyon, "on top," fuelwood is gathered. Pinyon nuts are gathered on a limited basis in the fall.

Woodland and Timberland Management and Productivity

Table 6 can be used by woodland owners or forest managers in planning the use of soils for wood crops. Only those soils suitable for wood crops are listed. The table lists the ordination symbol for each soil. Soils assigned the same ordination symbol require the same general management and have about the same potential productivity.

The first part of the *ordination symbol*, a number, indicates the potential productivity of the soils for an indicator tree species. The number indicates the volume, in cubic meters per hectare per year, which the indicator species can produce. The number 0 or 1 indicates low potential productivity; 2 or 3, moderate; 4 or 5, moderately high; 6 to 8, high; 9 to 11, very high; and 12 to 39, extremely high. The second part of the symbol, a letter, indicates the major kind of soil limitation. The letter *R* indicates steep slopes; *X*, stoniness or rockiness; *D*, restricted rooting depth; *C*, clay in the upper part of the soil; *S*, sandy texture; and *F*, a high content of rock fragments in the soil. The letter *A* indicates that limitations or restrictions are insignificant. If a soil has more than one limitation, the priority is as follows: R, X, D, C, S, and F.

In table 6, *slight, moderate,* and *severe* indicate the degree of the major soil limitations to be considered in management.

Erosion hazard is the probability that damage will occur as a result of site preparation and cutting where the soil is exposed along roads, skid trails, and fire lanes and in log-handling areas. Forests that have been burned or overgrazed are also subject to erosion. Ratings of the erosion hazard are based on the percent of the slope. A rating of *slight* indicates that no particular prevention measures are needed under ordinary conditions. A rating of *moderate* indicates that erosion-control measures are needed in certain silvicultural activities. A rating of *severe* indicates that special precautions are needed to control erosion in most silvicultural activities.

Equipment limitation reflects the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland timberland management or harvesting. The chief characteristics and conditions considered in the ratings are slope, stones on the surface, rock outcrops, soil wetness, and texture of the surface layer. A rating of *slight* indicates that under normal conditions the kind of equipment or season of use is not significantly restricted by soil factors. Soil wetness can restrict equipment use, but the wet period does not exceed 1 month. A rating of *moderate* indicates that equipment use is moderately restricted because of one or more soil factors. If the soil is wet, the wetness restricts equipment use for a period of 1 to 3 months. A rating of *severe* indicates that equipment use is severely restricted either as to the kind of equipment that can be used or the season of use. If the soil is wet, the wetness restricts equipment use for more than 3 months.

Seedling mortality refers to the death of naturally occurring or planted tree seedlings, as influenced by the kinds of soil, soil wetness, or topographic conditions. The factors used in rating the soils for seedling mortality are texture of the surface layer, depth to a seasonal high water table and the length of the period when the water table is high, rock fragments in the surface layer, effective rooting

depth, and slope aspect. A rating of *slight* indicates that seedling mortality is not likely to be a problem under normal conditions. Expected mortality is less than 25 percent. A rating of *moderate* indicates that some problems from seedling mortality can be expected. Extra precautions are advisable. Expected mortality is 25 to 50 percent. A rating of *severe* indicates that seedling mortality is a serious problem. Extra precautions are important. Replanting may be necessary. Expected mortality is more than 50 percent.

Windthrow hazard is the likelihood that trees will be uprooted by the wind because the soil is not deep enough for adequate root anchorage. The main restrictions that affect rooting are a seasonal high water table and the depth to bedrock, a fragipan, or other limiting layers. A rating of *slight* indicates that under normal conditions no trees are blown down by the wind. Strong winds may damage trees, but they do not uproot them. A rating of *moderate* indicates that some trees can be blown down during periods when the soil is wet and winds are moderate or strong. A rating of *severe* indicates that many trees can be blown down during these periods.

Plant competition ratings indicate the degree to which undesirable species are expected to invade and grow when openings are made in the tree canopy. The main factors that affect plant competition are the depth to the water table and the available water capacity. A rating of *slight* indicates that competition from undesirable plants is not likely to prevent natural regeneration or suppress the more desirable species. Planted seedlings can become established without undue competition. A rating of *moderate* indicates that competition may delay the establishment of desirable species. Competition may hamper stand development, but it will not prevent the eventual development of fully stocked stands. A rating of *severe* indicates that competition can be expected to prevent regeneration unless precautionary measures are applied.

The *potential productivity* of merchantable or *common trees* on a soil is expressed as a *site index* and as a *productivity class*. The site index is the average height, in feet, that dominant and codominant trees of a given species attain in a specified number of years. The site index applies to fully stocked, even-aged, unmanaged stands. In areas of pinyon-juniper woodland, the site index is determined by basal area. The productivity class is the yield in cubic meters per hectare per year calculated at the age of culmination of mean annual increment for fully stocked natural stands. Commonly grown trees are those that woodland managers generally favor in intermediate or improvement cuttings. They are selected on the basis of growth rate, quality, value, and marketability.

The first species listed under *common trees* for a soil is the indicator species for that soil. It is the most common species on the soil and is the one that determines the ordination class.

Trees to plant are those that are suitable for commercial wood production.

Woodland and Timberland Understory Vegetation

Understory vegetation consists of grasses, forbs, shrubs, and other plants. If well managed, some woodland can produce enough understory vegetation to support grazing of livestock or wildlife, or both, without damage to the trees.

The quantity and quality of understory vegetation vary with the kind of soil, the age and kind of trees in the canopy, the density of the canopy, and the depth and condition of the litter. The density of the canopy determines the amount of light that understory plants receive.

Table 7 shows, for each soil suitable for woodland and timberland, the potential for producing understory vegetation. The total production of understory vegetation includes the herbaceous plants and the leaves, twigs, and fruit of woody plants up to a height of 4.5 feet. It is expressed in pounds per acre of air-dry vegetation in favorable, normal, and unfavorable years. In a favorable year, soil moisture is above average during the optimum part of the growing season; in a normal year, soil moisture is average; and in an unfavorable year, it is below average.

Table 7 also lists the common names of the characteristic vegetation on each soil and the *composition*, by percentage, of air-dry weight, of each kind of plant. The table shows the kind and percentage of understory plants expected under a canopy density that is most nearly typical of woodland and timberland in which the production of wood crops is highest.

Recreation

The soils of the survey area are rated in table 8 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the

height, duration, intensity, and frequency of flooding is essential.

In table 8, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or a combination of these measures.

The information in table 8 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 10 and interpretations for dwellings without basements and for local roads and streets in table 9.

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

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

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

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

Wildlife Habitat

David W. Seery and Marcus Miller, biologists, Natural Resources Conservation Service, prepared this section.

There are five main types of wildlife habitat in the survey area. These habitats are described in the following paragraphs.

Rock Outcrop and Escarpments

These areas are found in abundance in the survey area along the Grand Canyon and its major tributaries. They do not support vegetation but are important for many species of birds as resting perches and nesting sites. The ledges are used by desert bighorn sheep as travel paths and escape routes. Foxes, bobcats, and cougars use overhangs and caves as dens for raising their young.

Valleys and Canyons

Valleys and canyons are numerous and large in this survey area. Most contain a variety of vegetation suitable for many different animals. Desert bighorn sheep and mule deer use these areas as travel corridors. Eagles and hawks catch uplifting currents in the canyons. Several wide open valleys contain grasslands that support pronghorn antelope. Many of the canyon bottoms support riparian trees, such as cottonwood, willow, ash, and California redbud. These trees indicate the location of springs on the canyon walls.

Mesas and Plateaus

Mesas and plateaus support forests of ponderosa pine, pinyon pine, juniper, and Gambel oak. Elk and mule deer use the forests extensively for food, cover, and water. Wild turkeys roost in favorite trees throughout the forest. An occasional black bear feeds on the acorns, as do the numerous Abert's squirrels.

Rivers and Streams

A few rivers and streams dissect the landscape. The most notable, of course, is the famous Colorado River within the Grand Canyon on the north boundary of the survey area. Several species of endangered native fish are found in the Colorado River. Some springs also have unique fish in them. Streams such as Diamond Creek and Spencer Creek contain important water for wildlife. The vegetation along these stream courses provides an oasis for various species in this otherwise arid region.

Breaks

Breaks are the steep, broken lands on the edges of mesas and mountains. They are highly eroded with many ridges and gullies. Vegetation grows on breaks, but not in large amounts. However, many different kinds of plants and the physical diversity of the terrain attract wildlife. Deer can hide in the breaks and feed on the weeds and browse species. A fox must run only a short distance to be out of danger. Scattered trees grow in many of these areas and serve as hunting perches for hawks.

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 estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. 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 grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 or 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

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

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

Building Site Development

Table 9 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

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

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

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel,

crushed rock, or stabilized soil material; and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, potential for frost action, and depth to a high water table affect the traffic-supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 40 inches, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Sanitary Facilities

Table 10 shows the degree and kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 10 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

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

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

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

Table 10 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

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

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

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

The ratings in table 10 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of

landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

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

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

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

Construction Materials

Table 11 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a *probable* or *improbable* source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

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

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

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

Sand and *gravel* 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. In table 11, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

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

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

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

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

Soils rated *good* have friable loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are

naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

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

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

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

Water Management

Table 12 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 and for embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect irrigation, terraces and diversions, and grassed waterways.

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 permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

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. 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 about 5 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.

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

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

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

Soil Properties

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

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

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

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

Engineering Index Properties

Table 13 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

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

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

Classification of the soils is determined according to the Unified soil classification system *(ASTM, 1993)* and the system adopted by the American Association of State Highway and Transportation Officials *(AASHTO, 1986)*.

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. 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 grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

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

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

The estimates of grain-size distribution are generally rounded to the nearest 5 percent. Thus, if the ranges of

gradation extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is omitted in the table.

Physical and Chemical Properties

Table 14 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

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

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

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

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

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

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

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

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

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

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

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

the more susceptible the soil is to sheet and rill erosion by water.

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

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

1. Coarse sands, sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are very highly erodible, and vegetation is difficult to establish.
2. Loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, and sapric soil material. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion are used.
3. Coarse sandy loams, sandy loams, fine sandy loams, and very fine sandy loams. These soils are moderately highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

4L. Calcareous loams, silt loams, clay loams, and silty clay loams. These soils are moderately erodible. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, noncalcareous clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion are used.
5. Noncalcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.
6. Noncalcareous loams and silt loams that are more than 20 percent clay and noncalcareous clay loams that are less than 35 percent clay. These soils are slightly erodible. Crops can be grown if ordinary measures to control wind erosion are used.
7. Silts, noncalcareous silty clay loams that are less than 35 percent clay, and fibric soil material. These soils are slightly erodible. Crops can be grown if ordinary measures to control wind erosion are used.
8. Soils that are subject to only a slight hazard of wind erosion because of coarse fragments on the surface or because of surface wetness.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In table 14, 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 or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

Soil and Water Features

Table 15 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

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

The four hydrologic soil groups are:

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

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

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

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

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

Table 15 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *occasional* that it occurs, on the average, once or less in 2 years; and *frequent* that it occurs, on the average, more than once in 2 years. Duration is expressed as *very brief* if less than 2 days,

brief if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months.

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.

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

A *cemented pan* is a cemented or indurated subsurface layer within a depth of 5 feet. Such a pan causes difficulty in excavation. Pans are classified as thin or thick. A thin pan is less than 3 inches thick if continuously indurated or less than 18 inches thick if discontinuous or fractured. Excavations can be made by trenching machines, backhoes, or small rippers. A thick pan is more than 3 inches thick if continuously indurated or more than 18 inches thick if discontinuous or fractured. Such a pan is so thick or massive that blasting or special equipment is needed in excavation.

Potential 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, permeability, 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 mainly to pavements and other rigid structures. Soils that have a frost heave rating of low are rarely susceptible to the formation of ice lenses. Soils that have a rating of moderate are susceptible to the formation of ice crystals resulting in frost heave and subsequent loss of soil strength.

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

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

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

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories *(USDA, 1975)*. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 16 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

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

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Ustalf (*Ust*, meaning burnt or dry climate, plus *Alf*, from Alfisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Paleustalfs (*Pale*, meaning old development, plus *ustalf*, the suborder of the Alfisols that has an ustic moisture regime).

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

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine, montmorillonitic, mesic Aridic Paleustalfs.

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

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. Characteristics of the soil and the material in which it formed are identified for each series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the "Soil Survey Manual" (USDA, 1981). Many of the technical terms used in the descriptions are defined in "Soil Taxonomy" (USDA, 1975). Unless otherwise stated, matrix colors in the descriptions are for dry soil. Following the pedon description is the range of important characteristics of the soils in the series.

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

Albers Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Very slow
Landform: Stream terraces
Parent material: Alluvium derived from sedimentary rocks
Slope range: 0 to 3 percent
Elevation: 6,000 to 6,600 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days

Classification: Fine, montmorillonitic, mesic Aridic Haplusterts

Typical Pedon

Albers silty clay loam, 0 to 3 percent slopes, about 1,200 feet south and 2,400 feet east of the northwest corner of sec. 28, T. 29 N., R. 7 W.

A—0 to 1 inch; dark brown (10YR 3/3) silty clay loam, dark brown (10YR 3/3) moist; weak thick platy structure; hard, firm, sticky and plastic; many very fine roots; many very fine vesicular pores; noneffervescent; neutral (pH 6.7); clear smooth boundary.

Bss1—1 to 6 inches; dark brown (10YR 3/3) clay, very dark grayish brown (10YR 3/2) moist; weak coarse prismatic structure parting to weak medium subangular blocky; hard, very firm, very sticky and very plastic; many very fine roots; few very fine tubular pores; many intersecting slickensides; noneffervescent; neutral (pH 6.8); clear smooth boundary.

Bss2—6 to 29 inches; dark brown (10YR 3/3) clay, very dark grayish brown (10YR 3/2) moist; weak coarse prismatic structure parting to weak medium angular blocky; very hard, very firm, very sticky and very plastic; common very fine roots; few very fine tubular pores; many intersecting slickensides; noneffervescent; neutral (pH 7.2); gradual smooth boundary.

Bss3—29 to 36 inches; dark brown (10YR 3/3) clay, very dark grayish brown (10YR 3/2) moist; weak coarse prismatic structure parting to weak medium angular blocky; very hard, very firm, very sticky and very plastic; common very fine roots; few very fine tubular pores; common intersecting slickensides; slightly effervescent; slightly alkaline (pH 7.4); clear smooth boundary.

Bss4—36 to 44 inches; brown (10YR 4/3) clay, dark brown (10YR 3/3) moist; weak coarse prismatic structure parting to weak medium angular blocky; very hard, very firm, very sticky and very plastic; few very fine roots; few very fine tubular pores; few intersecting slickensides; slightly effervescent; slightly alkaline (pH 7.4); clear smooth boundary.

2Bk1—44 to 53 inches; brown (10YR 4/3 and 7.5YR 5/4) clay, dark brown (10YR 3/3 and 7.5YR 4/4) moist; weak medium subangular blocky structure; very hard, very firm, very sticky and very plastic; few very fine roots; few very fine tubular pores; 2 percent gravel; few fine soft calcium carbonate masses and thin coatings on rock fragments; strongly effervescent, 2 percent calcium carbonate equivalent; slightly alkaline (pH 7.4); clear smooth boundary.

2Bk2—53 to 60 inches; brown (7.5YR 5/4) clay, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; very hard, very firm, very sticky and very plastic; few fine roots; few fine tubular pores; 10 percent gravel; common fine soft calcium carbonate masses and thin coatings on rock fragments; violently effervescent, 7 percent calcium carbonate equivalent; slightly alkaline (pH 7.5).

Range in Characteristics

Content of calcium carbonate: Less than 15 percent at a depth of 29 inches or more; noneffervescent within a depth of 29 inches

Content of rock fragments: Less than 5 percent

Cracking: Deep, wide cracks are common when soil is dry

Slickensides: Common to many intersecting slickensides in the Bss horizon

Bss horizon:

Reaction—neutral to slightly alkaline

2Bk horizon:

Does not occur in some pedons

Arizo Series

Depth class: Very deep

Drainage class: Excessively drained

Permeability: Very rapid

Landform: Flood plains

Parent material: Alluvium derived from mixed rock sources

Slope range: 1 to 5 percent

Elevation: 2,200 to 4,400 feet

Mean annual precipitation: 10 to 12 inches

Mean annual soil temperature: 60 to 70 degrees F

Frost-free period: 200 to 230 days

Classification: Sandy-skeletal, mixed, thermic Typic Torriorthents

Typical Pedon

Arizo very gravelly sand, in an area of Arizo-Riverwash complex, 1 to 3 percent slopes; about 400 feet south and 2,200 feet east of the northwest corner of sec. 33, T. 26 N., R. 11 W.

A—0 to 2 inches; brown (10YR 5/3) very gravelly sand, dark brown (10YR 4/3) moist; weak medium platy structure parting to weak fine subangular blocky; soft, very friable, nonsticky and nonplastic; many very fine roots; common very fine interstitial pores; 35 percent gravel, 5 percent cobble; strongly effervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

C1—2 to 8 inches; brown (7.5YR 5/4) gravelly loamy coarse sand, dark brown (7.5YR 4/4) moist; massive; loose, nonsticky and nonplastic; many very fine roots and few medium roots; common very fine interstitial pores; 15 percent gravel, 5 percent cobble; slightly

effervescent; moderately alkaline (pH 8.2); abrupt wavy boundary.
C2—8 to 21 inches; brown (7.5YR 5/4) very cobbly coarse sand, dark brown (7.5YR 4/4) moist; single grained; loose, nonsticky and nonplastic; common very fine roots and few medium roots; common fine interstitial pores; 20 percent gravel, 15 percent cobble, 5 percent stones; slightly effervescent; moderately alkaline (pH 8.2); clear wavy boundary.
C3—21 to 34 inches; light brown (7.5YR 6/4) very gravelly coarse sand, dark brown (7.5YR 4/4) moist; single grained; loose, nonsticky and nonplastic; common very fine roots and few medium roots; common very fine tubular pores; 30 percent gravel, 15 percent cobble; slightly effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.
C4—34 to 60 inches; light brown (7.5YR 6/4) very gravelly coarse sand, dark brown (7.5YR 4/4) moist; massive; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; few very fine interstitial pores; 50 percent gravel, 2 percent cobble; strongly effervescent; moderately alkaline (pH 8.0).

Range in Characteristics

Content of rock fragments in the control section: 40 to 80 percent

A horizon:
Texture—very gravelly sand, extremely gravelly loamy sand

C horizon:
Texture—highly stratified, gravelly to extremely cobbly loamy coarse sand, sand, coarse sand
Reaction—slightly alkaline or moderately alkaline

Barx Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Landform: Fan terraces
Parent material: Alluvium derived dominantly from sandstone and limestone, with eolian influences in some areas
Slope range: 1 to 6 percent
Elevation: 4,600 to 6,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days
Classification: Fine-loamy, mixed, mesic Ustollic Haplargids

Typical Pedon

Barx gravelly loam, in an area of Plaintank-Barx complex, 1 to 5 percent slopes; about 2,250 feet south and 650 feet west of the northeast corner of sec. 10, T. 26 N., R. 12 W.

A—0 to 2 inches; brown (7.5YR 5/4) gravelly loam, dark brown (7.5YR 4/4) moist; weak thin platy structure parting to weak fine granular; soft, very friable, slightly sticky and slightly plastic; common very fine roots; few very fine tubular pores and common very fine irregular pores; 15 percent gravel; slightly effervescent; slightly alkaline (pH 7.6); abrupt wavy boundary.
Btk1—2 to 12 inches; reddish brown (5YR 4/4) clay loam, dark reddish brown (5YR 3/4) moist; strong medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many very fine roots and common fine roots; common fine and very fine tubular pores; common faint clay films lining pores and few faint clay films on faces of peds; 10 percent gravel; few fine soft calcium carbonate masses and thin coatings on rock fragments; slightly effervescent matrix with violently effervescent concentrations; slightly alkaline (pH 7.7); clear wavy boundary.
Btk2—12 to 26 inches; pink (5YR 7/4) and pinkish white (5YR 8/2) clay loam, light reddish brown (5YR 6/4) and pink (5YR 7/4) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; few very fine roots; few very fine tubular pores; 8 percent gravel; few faint clay films on ped faces; many medium and coarse soft calcium carbonate masses and common thin coatings on rock fragments; violently effervescent; slightly alkaline (pH 7.8); clear wavy boundary.
Bk1—26 to 47 inches; pink (5YR 7/3) and white (5YR 8/1) gravelly loam, light reddish brown (5YR 6/3) and pinkish white (5YR 8/2) moist; massive; slightly hard to hard, friable, slightly sticky and plastic; few very fine roots; few very fine tubular pores; 20 percent gravel; many coarse soft calcium carbonate masses and concretions, and many thin coatings on rock fragments; violently effervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.
2Bk2—47 to 60 inches; yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; strong medium angular blocky structure; very hard, very firm, nonsticky and plastic; common thin calcium carbonate coatings on faces of peds; strongly effervescent; moderately alkaline (pH 8.2).

Range in Characteristics

Calcium carbonate equivalent: 15 to 40 percent in calcic horizons
Content of rock fragments: Less than 15 percent
Depth to calcic horizon: 14 to 30 inches

A horizon:
Texture—gravelly loam, fine sandy loam

B horizon:
Texture—loam, clay loam, sandy clay loam

2Bk horizon:
Does not occur in some pedons

Bleumont Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Landform: Fan terraces
Parent material: Alluvium derived dominantly from igneous and metamorphic rocks (Frazier Well Gravels Formation)
Slope range: 2 to 20 percent
Elevation: 5,500 to 5,900 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 120 to 160 days
Classification: Fine, montmorillonitic, mesic Aridic Paleustalfs

Typical Pedon

Bleumont extremely cobbly fine sandy loam (fig. 16), in an area of Bleumont-Frazwell association, 2 to 20 percent slopes; about 1,650 feet east and 950 feet north of the southwest corner of sec. 19, T. 26 N., R. 8 W.

A—0 to 2 inches; brown (10YR 4/3) extremely cobbly fine sandy loam, very dark brown (10YR 2/3) moist; weak thin platy structure parting to moderate fine granular; soft, very friable, nonsticky and nonplastic; few very fine roots; common very fine irregular pores; 35 percent gravel, 25 percent cobble, 5 percent stones; noneffervescent; slightly alkaline (pH 7.5); abrupt smooth boundary.

AB—2 to 4 inches; dark brown (10YR 3/3) very gravelly sandy clay loam, very dark brown (10YR 2/2) moist; weak medium subangular structure; soft, very friable, slightly sticky and slightly plastic; common very fine roots and few fine roots; common very fine tubular pores; 35 percent gravel; noneffervescent; slightly alkaline (pH 7.5); abrupt smooth boundary.

Bt—4 to 12 inches; yellowish red (5YR 5/6) clay, yellowish red (5YR 4/6) moist; moderate coarse subangular blocky structure; hard, firm, very sticky and very plastic; common very fine roots and few fine and medium roots; few very fine tubular pores; few faint clay films lining pores and common distinct clay films on faces of peds; noneffervescent; slightly alkaline (pH 7.7); abrupt wavy boundary.

Btk1—12 to 21 inches; variegated yellowish red (5YR 4/6 and 5/6) and very dark brown (10YR 3/3) sandy clay, yellowish red (5YR 4/6), strong brown (7.5YR 4/6), and dark brown (10YR 3/3) moist; strong coarse prismatic structure; hard, firm, sticky and plastic; few fine, medium, and coarse roots; few very fine tubular pores; many distinct clay films lining pores and on faces of peds; few thin soft calcium carbonate filaments; noneffervescent matrix with slightly effervescent concentrations; slightly alkaline (pH 7.8); abrupt wavy boundary.

2Btk2—21 to 34 inches; variegated yellowish red (5YR 4/6 and 5/6) and very pale brown (10YR 8/3) very cobbly sandy clay, yellowish red (5YR 4/6) and reddish yellow (7.5YR 7/6) moist; moderate coarse subangular blocky structure; very hard, firm, sticky and plastic; few very fine roots; few very fine tubular pores; 25 percent gravel, 30 percent cobble; common faint clay films on faces of peds; common medium and coarse soft calcium carbonate masses and many thin coatings under rock fragments; noneffervescent matrix with violently effervescent concentrations; slightly alkaline (pH 7.8); abrupt wavy boundary.

2Btk3—34 to 62 inches; variegated reddish yellow and pink (7.5YR 6/8, 7/4, and 8/4) extremely cobbly sandy clay loam, reddish yellow (7.5YR 5/6 and 7/6) moist; massive; hard, firm, slightly sticky and slightly plastic; few very fine roots; few very fine tubular pores; 10 percent gravel, 35 percent cobble, 10 percent stones, 10 percent boulders; few faint clay films lining pores and on faces of peds; weakly cemented with calcium carbonate; violently effervescent; moderately alkaline (pH 8.0).

Range in Characteristics

Content of rock fragments in the surface lag layer: 65 to 85 percent
Content of rock fragments in the control section: 10 to 35 percent
Depth to calcic horizon: 20 to 40 inches

Bt horizon:
Content of clay—35 to 55 percent

Btk horizon:
Calcium carbonate equivalent—2 to 20 percent

2Btk3 horizon:
Calcium carbonate equivalent—20 to 35 percent

Buckndoe Series

Depth class: Deep to a hardpan
Drainage class: Well drained
Permeability: Moderate
Landform: Fan terraces
Parent material: Alluvium derived from sedimentary and igneous rocks

Slope range: 2 to 20 percent
Elevation: 4,600 to 5,500 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 120 to 160 days
Classification: Loamy-skeletal, mixed, mesic Calciorthidic Ustochrepts

Typical Pedon

Buckndoe very gravelly sandy loam, in an area of Milkweed-Quartermaster-Buckndoe complex, 2 to 20 percent slopes; about 2,350 feet east and 1,500 feet north of the southwest corner of sec. 13, T. 26 N., R. 14 W.

A—0 to 2 inches; yellowish brown (10YR 5/4) very gravelly sandy loam, dark brown (10YR 4/3) moist; weak medium platy structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; few very fine roots; common very fine irregular pores; 55 percent gravel; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Bw1—2 to 5 inches; yellowish brown (10YR 5/4) gravelly sandy loam, dark brown (10YR 4/3) moist; weak thick platy structure parting to weak medium subangular blocky; soft, very friable, nonsticky and nonplastic; common very fine roots; few very fine and fine tubular pores; 30 percent gravel; violently effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Bw2—5 to 10 inches; yellowish brown (10YR 5/4) gravelly loam, dark yellowish brown (10YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots and few fine and medium roots; common very fine and few fine tubular pores; 20 percent gravel; violently effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Bk1—10 to 16 inches; yellowish brown (10YR 5/4) gravelly fine sandy loam, dark yellowish brown (10YR 3/4) moist; weak medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine and fine roots and few coarse roots; common very fine and fine tubular pores; 20 percent gravel; few thin calcium carbonate coatings under rock fragments; violently effervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

Bk2—16 to 26 inches; brown (10YR 5/3) very cobbly fine sandy loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine roots, few medium roots, and few coarse roots; common very fine tubular pores; 30 percent gravel, 20 percent cobble; common thin calcium carbonate coatings on faces of peds and rock fragments, few coarse soft calcium carbonate masses and concretions; violently effervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

Bk3—26 to 42 inches; pinkish white (7.5YR 8/2) very cobbly fine sandy loam, light brown (7.5YR 6/4) moist; massive; hard, friable, slightly sticky and slightly plastic; few very fine roots and few fine roots; few very fine tubular pores; 30 percent gravel, 30 percent cobble; common thick calcium carbonate coatings on rock fragments; moderately cemented with calcium carbonate; violently effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

Bkm—42 to 60 inches; indurated, laminar capped, calcium carbonate cemented hardpan.

Range in Characteristics

Depth to calcic horizon: 16 to 26 inches
Depth to a hardpan: 40 to 59 inches
Content of calcium carbonate: 20 to 40 percent above the hardpan
Content of rock fragments in the subsoil: 35 to 60 percent gravel and cobble

Bw horizon:
Texture—very gravelly, extremely gravelly, very cobbly, extremely cobbly loam, fine sandy loam, sandy loam

Coconino Series

Depth class: Moderately deep
Drainage class: Well drained
Permeability: Moderate
Landform: Plateaus and mesas
Parent material: Colluvium and residuum derived from calcareous sandstone, limestone, and siltstone of the Supai Formation
Slope range: 2 to 15 percent
Elevation: 5,300 to 5,800 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days
Classification: Fine-loamy, mixed, mesic Calciorthidic Ustochrepts

Typical Pedon

Coconino extremely channery very fine sandy loam, in an area of Wodomont-Coconino complex, 2 to 15 percent slopes; about 2,200 feet east and 2,500 feet north of the southwest corner of sec. 24, T. 26 N., R. 10 W.

A—0 to 2 inches; reddish brown (5YR 5/3) extremely channery very fine sandy loam, reddish brown (5YR 4/3) moist; weak medium platy structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; common very fine roots; common very fine

irregular pores; 65 percent channers, 15 percent cobble, 5 percent stones; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.
Bw1—2 to 6 inches; reddish brown (5YR 5/4) channery loam, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; soft, very friable, nonsticky and slightly plastic; many very fine roots; common very fine tubular pores; 15 percent channers, 15 percent gravel; violently effervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.
Bw2—6 to 13 inches; light reddish brown (2.5YR 6/4) gravelly loam, reddish brown (2.5YR 4/4) moist; moderate fine subangular blocky structure; slightly hard, very friable, nonsticky and slightly plastic; many very fine and few medium roots; common very fine tubular pores; 15 percent gravel, 10 percent cobble; violently effervescent; slightly alkaline (pH 7.8); clear wavy boundary.
Bk—13 to 26 inches; light reddish brown (2.5YR 6/4) and pink (5YR 7/3) gravelly loam, reddish brown (2.5YR 4/4 and 5YR 5/4) moist; moderate coarse subangular blocky structure; slightly hard, friable, slightly sticky and plastic; many very fine roots and common coarse roots; common very fine tubular pores; 15 percent gravel; common fine soft calcium carbonate masses and thin coatings on faces of peds; violently effervescent, 20 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); abrupt wavy boundary.
Cr—26 inches; calcareous sandy shale.

Range in Characteristics

Content of calcium carbonate in the control section: 15 to 25 percent
Reaction: Slightly alkaline or moderately alkaline
Depth to soft bedrock: 20 to 40 inches

B horizon:
Texture—gravelly very fine sandy loam, loam, sandy clay loam

Cowan Family

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately rapid
Landform: Flood plains
Parent material: Alluvium derived from sandy sedimentary rocks
Slope range: 0 to 3 percent
Elevation: 3,100 to 4,200 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 59 to 64 degrees F
Frost-free period: 180 to 200 days
Classification: Sandy, mixed, thermic Typic Torrifluvents

Typical Pedon

Cowan family very fine sandy loam, in an area of Cowan family-Naha complex, 0 to 3 percent slopes; about 2,200 feet east and 1,000 feet north of the projected southwest corner of sec. 15, T. 33 N., R. 4 W.

Ap1—0 to 3 inches; yellowish red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) moist; moderate thick platy structure; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; few very fine irregular pores; strongly effervescent; slightly alkaline (pH 7.7); clear smooth boundary.
Ap2—3 to 13 inches; yellowish red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; common very fine roots; common very fine tubular pores; strongly effervescent; slightly alkaline (pH 7.7); abrupt smooth boundary.
C1—13 to 35 inches; reddish yellow (5YR 6/6) fine sand, yellowish red (5YR 5/6) moist; massive; loose, nonsticky and nonplastic; few very fine roots; few very fine tubular pores; strongly effervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.
C2—35 to 60 inches; yellowish red (5YR 5/6) very fine sandy loam, reddish brown (5YR 4/6) moist; massive; loose, nonsticky and nonplastic; few very fine roots; few very fine tubular pores; strongly effervescent; slightly alkaline (pH 7.8).

Range in Characteristics

A horizon:
Reaction—slightly alkaline or moderately alkaline

C horizon:
Texture—highly variable and stratified, dominantly fine sand and very fine sandy loam that has thin strata of loamy fine sand, loamy very fine sand, or silt loam
Reaction—slightly alkaline or moderately alkaline
Calcium carbonate equivalent—5 to 15 percent

Curhollow Series

Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Landform: Mesas, hills, and plateaus
Parent material: Alluvium and residuum derived dominantly from limestone
Slope range: 1 to 25 percent
Elevation: 4,600 to 6,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days

Classification: Loamy-skeletal, mixed, mesic, shallow Ustollic Paleorthids

Typical Pedon

Curhollow very gravelly loam, in an area of Curhollow-Puertecito complex, 1 to 12 percent slopes; about 1,950 feet north and 2,300 feet west of the southeast corner of sec. 21, T. 30 N., R. 6 W.

A—0 to 1 inch; yellowish brown (10YR 5/4) very gravelly loam, dark brown (10YR 4/3) moist; weak thick platy structure; soft, very friable, nonsticky and nonplastic; many very fine roots; common very fine vesicular pores; 50 percent gravel; noneffervescent; slightly alkaline (pH 7.4); clear smooth boundary.

Bkl—1 to 4 inches; dark yellowish brown (10YR 4/4) gravelly loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular pores; many very fine soft calcium carbonate masses and thin coatings on rock fragments; 15 percent gravel; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Bk2—4 to 11 inches; dark brown (10YR 4/3) very cobbly loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; few very fine tubular pores; 25 percent gravel, 30 percent cobble; common thick calcium carbonate pendants under rock fragments; violently effervescent; slightly alkaline (pH 7.6); abrupt smooth boundary.

Bkm—11 to 20 inches; indurated, calcium carbonate cemented hardpan; few very fine roots in widely spaced fractures; violently effervescent; abrupt smooth boundary.

R—20 inches; limestone.

Range in Characteristics

Depth to a hardpan: 10 to 20 inches
Depth to bedrock: 16 to 40 inches

Bk horizon:
Texture—gravelly loam, very gravelly loam, very cobbly loam, extremely cobbly loam, extremely gravelly loam
Content of clay—20 to 30 percent
Reaction—slightly alkaline or moderately alkaline

Deama Series

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Landform: Canyon escarpments
Parent material: Alluvium, colluvium, and residuum derived dominantly from limestone
Slope range: 25 to 55 percent
Elevation: 5,000 to 6,400 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 120 to 160 days
Classification: Loamy-skeletal, carbonatic, mesic Lithic Calciustolls

Typical Pedon

Deama extremely cobbly loam, in an area of Deama-Rock outcrop complex, 25 to 55 percent slopes; about 2,000 feet west and 1,100 feet south of the northeast corner of sec. 26, T. 31 N., R. 6 W.

A—0 to 1 inch; brown (10YR 5/3) extremely cobbly loam, dark brown (10YR 4/3) moist; weak fine granular structure; soft, very friable, nonsticky and slightly plastic; many very fine roots; many very fine vesicular pores and common fine tubular pores; 30 percent gravel, 35 percent cobble, 5 percent stones; violently effervescent, 31 percent calcium carbonate equivalent; moderately alkaline (pH 7.9); clear smooth boundary.

Bk1—1 to 6 inches; dark brown (10YR 4/3) very cobbly loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular pores; 25 percent gravel, 25 percent cobble, 5 percent stones; violently effervescent, 42 percent calcium carbonate equivalent; moderately alkaline (pH 7.9); gradual smooth boundary.

Bk2—6 to 14 inches; brown (10YR 5/3) very cobbly loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many fine roots; common fine tubular pores; 30 percent gravel, 20 percent cobble, 5 percent stones; violently effervescent, 44 percent calcium carbonate equivalent; moderately alkaline (pH 7.9); abrupt smooth boundary.

R—14 inches; limestone.

Range in Characteristics

Depth to limestone: 7 to 20 inches
Content of rock fragments in the control section: 50 to 70 percent
Content of clay: 18 to 25 percent
Content of calcium carbonate: 40 to 60 percent

Dean Series

Depth class: Very deep
Drainage class: Well drained

Permeability: Moderate
Landform: Fan terraces
Parent material: Mixed alluvium dominantly derived from the Willow Springs Formation
Slope range: 2 to 20 percent
Elevation: 4,500 to 5,200 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 53 to 57 degrees F
Frost-free period: 135 to 175 days
Classification: Fine-loamy, carbonatic, mesic Ustollic Calciorthids

Typical Pedon

Dean extremely gravelly loam, in an area of Rolie-Dean complex, 2 to 20 percent slopes; about 1,500 feet west and 1,850 feet south of the northeast corner of sec. 18, T. 26 N., R. 12 W.

A—0 to 2 inches; brown (10YR 5/3) extremely gravelly loam, dark brown (10YR 3/3) moist; weak medium platy structure parting to weak fine granular; soft, very friable, slightly sticky and slightly plastic; common very fine roots; many very fine irregular pores; 85 percent gravel; violently effervescent; slightly alkaline (pH 7.7); abrupt smooth boundary.

Bw—2 to 6 inches; yellowish brown (10YR 5/4) gravelly loam, dark yellowish brown (10YR 4/3) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and plastic; many very fine roots and few fine roots; few very fine tubular pores; 25 percent gravel; violently effervescent; slightly alkaline (pH 7.7); clear smooth boundary.

Bk1—6 to 16 inches; yellowish brown (10YR 5/4) gravelly loam, dark yellowish brown (10YR 5/3) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and plastic; common very fine and fine roots and few medium and coarse roots; common very fine tubular pores; 25 percent gravel; common fine soft calcium carbonate masses and thin coatings under rock fragments; violently effervescent, 36 percent calcium carbonate equivalent; slightly alkaline (pH 7.7); clear wavy boundary.

Bk2—16 to 21 inches; yellowish brown (10YR 5/4) very gravelly loam, dark yellowish brown (10YR 4/4) moist; weak medium subangular blocky structure; slightly hard, very friable, slightly sticky and plastic; many very fine roots, common fine and medium roots, and few coarse roots; common very fine tubular pores; 30 percent gravel, 5 percent cobbles; few thin calcium carbonate coatings on faces of peds and common thin pendants under rock fragments; violently effervescent, 39 percent calcium carbonate equivalent; slightly alkaline (pH 7.7); abrupt wavy boundary.

Bk3—21 to 28 inches; yellowish brown (10YR 5/4) gravelly loam, dark yellowish brown (10YR 4/4) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and plastic; common very fine and fine roots; common very fine tubular pores; 25 percent gravel; common fine soft calcium carbonate masses and thin coatings and pendants on rock fragments; violently effervescent, 40 percent calcium carbonate equivalent; slightly alkaline (pH 7.7); abrupt wavy boundary.

2Bk4—28 to 60 inches; light brown (7.5YR 6/4) and pinkish white (5YR 8/2) gravelly loam, brown (7.5YR 5/3) and pinkish white (5YR 8/2) moist; massive; hard, friable, slightly sticky and plastic; common very fine roots; few very fine tubular pores; 25 percent gravel and hardpan fragments; weakly cemented with calcium carbonate; violently effervescent, 62 percent calcium carbonate equivalent; moderately alkaline (pH 7.9).

Range in Characteristics

Depth to calcic horizon: 6 to 20 inches
Average content of calcium carbonate in the control section: 40 to 60 percent

B horizon:
Texture—gravelly fine sandy loam, loam
Content of clay—15 to 30 percent, averaging more than 18 percent

Disterheff Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Landform: Fan terraces and stream terraces on plateaus
Parent material: Alluvium derived dominantly from sedimentary and igneous rocks
Slope range: 1 to 8 percent
Elevation: 5,600 to 6,600 feet
Mean annual precipitation: 14 to 18 inches
Mean annual soil temperature: 51 to 56 degrees F
Frost-free period: 130 to 160 days
Classification: Fine, montmorillonitic, mesic Vertic Haplustalfs

Typical Pedon

Disterheff gravelly loam, 1 to 4 percent slopes (fig. 17), about 750 feet west and 2,000 feet north of the southeast corner of sec. 7, T. 29 N., R. 6 W.

A—0 to 1 inch; brown (7.5YR 5/4) gravelly loam, dark brown (7.5YR 4/4) moist; weak thick platy structure; soft, very friable, nonsticky and nonplastic; many very fine roots; many fine vesicular pores; 20 percent gravel; noneffervescent; neutral (pH 6.7); abrupt smooth boundary.

E—1 to 3 inches; brown (10YR 5/3) loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many fine vesicular pores; noneffervescent; slightly acid (pH 6.5); abrupt smooth boundary.

Bt1—3 to 6 inches; dark brown (7.5YR 4/4) clay loam, dark brown (7.5YR 3/4) moist; weak medium subangular blocky structure; hard, firm, sticky and plastic; common very fine roots; common fine tubular pores; few faint clay films lining pores and bridging sand grains; noneffervescent; neutral (pH 6.9); clear smooth boundary.

Bt2—6 to 11 inches; reddish brown (5YR 4/4) clay loam, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocky structure; hard, very firm, sticky and very plastic; common very fine roots; common fine tubular pores; 5 percent gravel; common faint clay films lining pores and on faces of peds; noneffervescent; slightly acid (ph 6.5); clear smooth boundary.

Bt3—11 to 21 inches; reddish brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; moderate medium prismatic structure parting to moderate medium subangular blocky; very hard, very firm, very sticky and very plastic; many very fine roots; few fine tubular pores; 3 percent gravel; common faint clay films bridging sand grains; many pressure faces; noneffervescent; neutral (pH 7.1); clear smooth boundary.

Btk—21 to 24 inches; reddish brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; moderate medium prismatic structure parting to moderate medium subangular blocky; very hard, very firm, very sticky and very plastic; few very fine roots; few fine tubular pores; 3 percent gravel; common faint clay films bridging sand grains; many pressure faces; common fine soft calcium carbonate masses; slightly effervescent; slightly alkaline (pH 7.5); abrupt smooth boundary.

Bk—24 to 60 inches; pinkish white (5YR 8/2) clay loam, reddish yellow (5YR 6/6) moist; massive; hard, firm, slightly sticky and plastic; few fine roots; few fine tubular pores; 10 percent gravel; many soft calcium carbonate masses and thin coatings on rock fragments; violently effervescent, 40 percent calcium carbonate equivalent; slightly alkaline (pH 7.7).

Range in Characteristics

A horizon:
Texture—very gravelly loam, gravelly fine sandy loam, gravelly loam

E horizon:
Does not occur in some pedons

Bt horizon:
Texture—clay loam, clay

Btk horizon:
Texture—clay loam, clay
Reaction—neutral to slightly alkaline
Content of calcium carbonate—10 to 15 percent

Bk horizon:
Texture—loam or clay loam
Content of calcium carbonate—10 to 40 percent
Reaction—slightly alkaline or moderately alkaline

Frazwell Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Landform: Stream terraces and draws
Parent material: Alluvium derived dominantly from sedimentary and igneous rocks of the Frazier Well Gravels Formation
Slope range: 1 to 6 percent
Elevation: 5,500 to 6,000 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 120 to 160 days
Classification: Fine-loamy, mixed, mesic Cumulic Haplustolls

Typical Pedon

Frazwell sandy loam, in an area of Bleumont-Frazwell association, 2 to 20 percent slopes; about 250 feet east and 2,500 feet north of the southwest corner of sec. 19, T. 26 N., R. 8 W.

A—0 to 3 inches; dark brown (10YR 3/3) sandy loam, very dark brown (10YR 2/3) moist; weak thick platy structure parting to weak medium granular; soft, very friable, slightly sticky and nonplastic; many very fine roots; many very fine irregular pores; noneffervescent; slightly alkaline (pH 7.5); abrupt smooth boundary.

Bw1—3 to 12 inches; very dark grayish brown (10YR 3/2) sandy clay loam, very dark brown (10YR 2/2) moist; weak coarse prismatic structure parting to moderate medium subangular blocky; slightly hard, very friable, slightly sticky and plastic; many very fine roots and few fine roots; common very fine and few fine tubular pores; few faint clay films lining pores and bridging sand grains; noneffervescent; slightly alkaline (pH 7.7); abrupt smooth boundary.

Bw2—12 to 17 inches; very dark grayish brown (10YR 3/2) sandy clay loam, very dark brown (10YR 2/2) moist; moderate medium subangular blocky structure; hard, friable, sticky and plastic; common very fine roots and

few fine and medium roots; common very fine tubular pores; few faint clay films lining pores and on faces of peds; noneffervescent; slightly alkaline (pH 7.7); abrupt smooth boundary.

Bw3—17 to 29 inches; very dark grayish brown (10YR 3/2) sandy clay, very dark brown (10YR 2/2) moist; moderate coarse subangular blocky structure; very hard, firm, sticky and plastic; common very fine roots and few fine roots; few very fine and fine tubular pores; few faint clay films bridging sand grains and on faces of peds; noneffervescent; slightly alkaline (pH 7.7); clear wavy boundary.

Bw4—29 to 40 inches; very dark grayish brown (10YR 3/2) gravelly sandy clay loam, very dark brown (10YR 2/2) moist; weak medium subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; common very fine roots; common very fine and fine tubular pores; 20 percent gravel; few faint clay films bridging sand grains and on faces of peds; noneffervescent; slightly alkaline (pH 7.7); abrupt wavy boundary.

2Ab—40 to 45 inches; brown (7.5YR 5/4) very gravelly loamy coarse sand, dark brown (7.5YR 4/4) moist; weak coarse granular structure; slightly hard, very friable, nonsticky and nonplastic; common very fine roots; common very fine irregular pores; 45 percent gravel, 10 percent cobble; noneffervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

2Btb—45 to 62 inches; yellowish red (5YR 5/8) sandy clay loam, yellowish red (5YR 4/6) moist; weak coarse subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few very fine roots; few very fine irregular pores; 5 percent gravel; few faint clay films bridging sand grains and on faces of peds; noneffervescent; slightly alkaline (pH 7.8).

Range in Characteristics

Average content of rock fragments of the surface horizon: less than 10 percent gravel
Depth to a buried argillic horizon: 34 to 60 inches or more
Calcium carbonate equivalent—0 to 10 percent below a depth of 40 inches

A horizon:
Thickness of a mollic epipedon—20 to 45 inches

Bw horizon:
Content of clay—20 to 35 percent, ranging to 40 percent in the lower part

Grandwash Series

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Slow
Landform: Hills
Parent material: Colluvium and residuum derived from sandstone
Slope range: 2 to 25 percent
Elevation: 4,700 to 5,000 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 130 to 165 days
Classification: Clayey-skeletal, mixed, mesic Lithic Haplustalfs

Typical Pedon

Grandwash extremely flaggy sandy loam, 2 to 25 percent slopes, about 2,200 feet south and 100 feet west of the northeast corner of sec. 24, T. 25 N., R. 13 W.

A—0 to 1 inch; reddish brown (5YR 4/4) extremely flaggy sandy loam, dark reddish brown (5YR 3/3) moist; moderate fine granular structure; soft, very friable, nonsticky and nonplastic; many very fine irregular pores; 35 percent channers, 40 percent flagstones, 15 percent stones; noneffervescent; neutral (pH 7.0); abrupt smooth boundary.

E—1 to 2 inches; reddish brown (5YR 5/3) and dark reddish brown (5YR 3/3) channery fine sandy loam, dark reddish brown (5YR 3/3) moist; moderate thick platy structure; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine irregular pores and few fine tubular pores; 25 percent channers, 5 percent flagstones; noneffervescent; neutral (pH 7.0); abrupt smooth boundary.

Bt1—2 to 7 inches; reddish brown (5YR 4/4) extremely flaggy clay, dark reddish brown (2.5YR 3/4) moist; moderate medium subangular blocky structure; hard, firm, sticky and plastic; common fine roots; common fine tubular pores; 30 percent channers, 35 percent flagstones, 5 percent stones; few faint clay films lining pores and on faces of peds; noneffervescent; neutral (pH 7.2); clear wavy boundary.

Bt2—7 to 12 inches; reddish brown (2.5YR 4/4) and dusky red (2.5YR 3/2) extremely flaggy clay, dark red (2.5YR 3/6) moist; moderate coarse subangular blocky structure; hard, firm, very sticky and very plastic; many fine roots and few coarse roots; few fine tubular pores; 20 percent channers, 45 percent flagstones, 10 percent stones; few faint clay films lining pores and on faces of peds; noneffervescent; neutral (pH 7.2); abrupt wavy boundary.

2R—12 inches; thin bedded, fine grained sandstone.

Range in Characteristics

Depth to bedrock: 6 to 20 inches
Content of rock fragments on the surface: 70 to 95 percent
Average content of rock fragments in the control section: 50 to 85 percent; more than half of the fragments are more than 3 inches in diameter, including 10 to 25

percent flagstones that are more than 10 inches in diameter

E horizon (if it occurs):
Texture—fine sandy loam, sandy loam, loam

B horizon:
Texture—extremely flaggy clay, clay loam

Harrisburg Series

Depth class: Moderately deep to a hardpan
Drainage class: Well drained
Permeability: Moderately rapid
Landform: Stream terraces
Parent material: Alluvium derived from limestone and sandstone
Slope range: 1 to 5 percent
Elevation: 3,800 to 4,200 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 59 to 62 degrees F
Frost-free period: 180 to 200 days
Classification: Coarse-loamy, mixed, thermic Typic Paleorthids

Typical Pedon

Harrisburg very fine sandy loam, in an area of Lostman family-Harrisburg complex, 1 to 5 percent slopes; about 1,200 feet west and 400 feet north of the southeast corner of sec. 1, T. 32 N., R. 8 W.

A—0 to 2 inches; light brown (7.5YR 6/3) very fine sandy loam, dark brown (7.5YR 4/3) moist; weak medium platy structure parting to moderate fine granular; soft, very friable, nonsticky and nonplastic; common very fine roots; common very fine irregular pores; violently effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw1—2 to 17 inches; light brown (7.5YR 6/4) very fine sandy loam, dark brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; common fine tubular pores; few thin calcium carbonate coatings in root channels and on rock fragments; violently effervescent; moderately alkaline (pH 8.4); clear smooth boundary.

Bk1—17 to 27 inches; light brown (7.5YR 6/4) very fine sandy loam, dark brown (7.5YR 4/4) moist; weak coarse prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; common very fine and fine tubular pores; few thin calcium carbonate coatings in root channels and on rock fragments; violently effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

Bk2—27 to 34 inches; light brown (7.5YR 6/4) cobbly very fine sandy loam, dark brown (7.5YR 4/4) moist; slightly hard, friable, slightly sticky and slightly plastic; few very fine and fine roots; few very fine and common fine tubular pores; 5 percent gravel, 20 percent cobbles; few faint calcium carbonate coatings lining pores and on faces of peds; many moderately thick calcium carbonate pendants on rock fragments; violently effervescent; strongly alkaline (pH 8.6); abrupt wavy boundary.

2Bkm1—34 to 42 inches; pinkish white (7.5YR 8/2) extremely cobbly very fine sandy loam, light brown (7.5YR 6/4) moist; massive; hard, firm, slightly sticky and nonplastic; 15 percent gravel, 50 percent cobbles; strongly calcium carbonate cemented; violently effervescent; strongly alkaline (pH 8.6); abrupt wavy boundary.

2Bkm2—42 inches; indurated, laminar capped, calcium carbonate cemented hardpan.

Range in Characteristics

Depth to a petrocalcic horizon: 20 to 40 inches
Average content of rock fragments in the control section: Less than 15 percent
Texture in the control section: Very fine sandy loam, loam, or fine sandy loam

Havasupai Series

Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Landform: Fan terraces
Parent material: Mixed alluvium derived from sedimentary and igneous rocks
Slope range: 1 to 35 percent
Elevation: 4,300 to 5,700 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days
Classification: Loamy-skeletal, mixed, mesic, shallow Ustollic Paleorthids

Typical Pedon

Havasupai very gravelly loam, 1 to 8 percent slopes, about 2,400 feet west and 1,400 feet south of the northeast corner of sec. 4, T. 25 N., R. 9 W.

A—0 to 2 inches; brown (7.5YR 5/2) very gravelly loam, dark brown (7.5YR 3/2) moist; weak fine subangular blocky structure parting to weak fine granular; soft, very friable, nonsticky and slightly plastic; many very fine roots; many very fine irregular pores; 55 percent gravel; strongly effervescent, 16 percent calcium

carbonate equivalent; slightly alkaline (pH 7.5); abrupt smooth boundary.

Bk1—2 to 7 inches; yellowish brown (10YR 5/4) gravelly loam, dark yellowish brown (10YR 3/4) moist; weak fine subangular blocky structure; slightly hard, very friable, nonsticky and slightly plastic; many very fine roots; common very fine tubular pores; 20 percent gravel, 5 percent cobble; few thin calcium carbonate coatings under rock fragments; strongly effervescent, 14 percent calcium carbonate equivalent; slightly alkaline (pH 7.4); clear wavy boundary.

Bk2—7 to 14 inches; light brown (7.5YR 6/4) very gravelly sandy clay loam, brown (7.5YR 5/4) moist; weak fine subangular blocky structure; hard, friable, nonsticky and slightly plastic; common very fine roots; few very fine tubular pores; 30 percent gravel, 10 percent cobble; common thin calcium carbonate coatings on rock fragments; violently effervescent, 45 percent calcium carbonate equivalent; slightly alkaline (pH 7.5); abrupt wavy boundary.

Bkm—14 to 33 inches; indurated, laminar capped, calcium carbonate cemented hardpan; abrupt wavy boundary.

2Bk—33 to 60 inches; reddish brown (5YR 5/4) extremely gravelly sand, reddish brown (5YR 4/4) moist; massive; very hard, friable, nonsticky and nonplastic; 80 percent gravel, 5 percent cobble; many thick calcium carbonate coatings and pendants on rock fragments; weak to strong discontinuous calcium carbonate cementation; violently effervescent.

Range in Characteristics

Depth to petrocalcic horizon: 10 to 20 inches

A horizon:

Texture—extremely gravelly sandy loam, very gravelly loam

Bk horizon:

Texture—gravelly, very gravelly, extremely gravelly, very cobbly sandy loam, fine sandy loam, loam, or sandy clay loam

Reaction—slightly alkaline or moderately alkaline

2Bk horizon:

Texture—weakly cemented, extremely gravelly coarse sand to sandy loam

Hermshale Series

Depth class: Deep
Drainage class: Well drained
Permeability: Slow
Landform: Fan terraces
Parent material: Alluvium and colluvium derived from sandstone, siltstone, and shale of the Hermit Shale Formation
Slope range: 15 to 35 percent
Elevation: 5,900 to 6,200 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 58 degrees F
Frost-free period: 140 to 160 days
Classification: Fine, montmorillonitic, mesic Vertic Haplustalfs

Typical Pedon

Hermshale extremely flaggy fine sandy loam, 15 to 35 percent slopes, about 600 feet south and 1,300 feet west of the northeast corner of sec. 8, T. 26 N., R. 8 W.

A—0 to 2 inches; brown (7.5YR 4/4) extremely flaggy fine sandy loam, dark brown (7.5YR 3/4) moist; moderate thick platy structure; slightly hard, very friable, nonsticky and slightly plastic; many very fine roots; many very fine irregular pores; 35 percent channers, 25 percent flagstones, 10 percent stones; noneffervescent; slightly alkaline (pH 7.6); abrupt smooth boundary.

Bt1—2 to 7 inches; reddish brown (5YR 4/4) channery loam, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots and common fine roots; few very fine and fine tubular pores; 15 percent channers and gravel, 5 percent cobble; few faint clay films in pores; noneffervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

Bt2—7 to 15 inches; reddish brown (5YR 4/4) very gravelly clay loam, reddish brown (5YR 4/4) moist; weak medium prismatic structure parting to strong medium subangular blocky; very hard, firm, sticky and very plastic; common very fine and fine roots and few medium and coarse roots; few very fine tubular pores; 30 percent gravel, 5 percent cobble; few faint clay films lining pores and on faces of peds; many pressure faces; noneffervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

Bt3—15 to 23 inches; yellowish red (5YR 4/6) clay, yellowish red (5YR 4/6) moist; strong coarse prismatic structure; very hard, very firm, very sticky and very plastic; few very fine to coarse roots; few very fine and fine tubular pores; 5 percent gravel; few faint clay films lining pores and on faces of peds; many pressure faces; noneffervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

Btk1—23 to 38 inches; yellowish red (5YR 4/6) and white (5YR 8/1) channery clay, yellowish red (5YR 4/6) and pink (5YR 7/4) moist; moderate coarse prismatic

structure; very hard, very firm, very sticky and very plastic; few very fine to medium roots; few very fine tubular pores; 25 percent channers, 5 percent cobbles; few faint clay films on faces of peds; few pressure faces; few thin soft calcium carbonate masses and few thin coatings on rock fragments; noneffervescent matrix with violently effervescent calcium carbonate concentrations; slightly alkaline (pH 7.8); abrupt wavy boundary.

Btk2—38 to 43 inches; yellowish red (5YR 4/6) with pink (5YR 7/4) very channery clay, yellowish red (5YR 4/6) with reddish yellow (5YR 6/6) moist; strong medium subangular blocky structure; very hard, very firm, very sticky and very plastic; few very fine roots; few very fine tubular pores; 45 percent channers; few faint clay films lining pores and on faces of peds; common pressure faces; many medium and coarse soft calcium carbonate masses and common thin coatings on rock fragments; noneffervescent matrix with violently effervescent calcium carbonate concentrations; moderately alkaline (pH 8.0); abrupt wavy boundary.

R—43 inches; sandstone.

Range in Characteristics

Depth to bedrock: 40 to 60 inches

Content of rock fragments in the control section: Less than 35 percent

Content of clay in the control section: 35 to 50 percent

Bt horizon:

Texture—clay, very gravelly clay loam, channery loam, sandy clay loam, clay loam, sandy clay

Content of clay—35 to 50 percent

Btk horizon:

Texture—channery clay, very channery clay, sandy clay

Calcium carbonate equivalent—less than 15 percent

A Bw horizon occurs below the A horizon in some pedons.

Hidvalle Series

Depth class: Very deep

Drainage class: Well drained

Permeability: Moderate

Landform: Draws

Parent material: Alluvium and eolian deposits derived dominantly from sandstone and shale of the Supai Formation

Slope range: 1 to 6 percent

Elevation: 5,300 to 5,900 feet

Mean annual precipitation: 14 to 16 inches

Mean annual soil temperature: 54 to 56 degrees F

Frost-free period: 130 to 160 days

Classification: Coarse-silty, mixed, mesic Aridic Ustochrepts

Typical Pedon

Hidvalle very fine sandy loam, 1 to 6 percent slopes, about 400 feet west and 1,700 feet south of the northeast corner of sec. 20, T. 26 N., R. 9 W.

A—0 to 2 inches; reddish brown (5YR 5/3) very fine sandy loam, dark reddish brown (5YR 3/3) moist; weak thick platy structure; soft, very friable, nonsticky and nonplastic; many very fine roots; many very fine interstitial pores; noneffervescent; slightly alkaline (pH 7.4); abrupt smooth boundary.

Bw1—2 to 6 inches; reddish brown (5YR 4/4) very fine sandy loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and slightly plastic; many very fine roots; common very fine tubular pores; noneffervescent; slightly alkaline (pH 7.6); abrupt smooth boundary.

Bw2—6 to 18 inches; reddish brown (5YR 4/4) very fine sandy loam, dark reddish brown (5YR 3/4) moist; weak coarse prismatic structure; slightly hard, friable, nonsticky and slightly plastic; many very fine roots; common very fine tubular pores; noneffervescent; slightly alkaline (pH 7.6); abrupt wavy boundary.

Bk1—18 to 29 inches; reddish brown (5YR 5/3) very fine sandy loam, dark reddish brown (5YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; many very fine roots; common very fine tubular pores; few fine soft calcium carbonate masses and thin coatings lining pores; strongly effervescent, 5 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); clear wavy boundary.

Bk2—29 to 42 inches; reddish brown (5YR 5/3) very fine sandy loam, dark reddish brown (5YR 3/3) moist; weak coarse subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; many very fine roots; common very fine tubular pores; few fine and medium soft calcium carbonate masses and many thin coatings lining pores and on faces of peds; violently effervescent, 7 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bk3—42 to 60 inches; reddish brown (5YR 5/4) very fine sandy loam, dark reddish brown (5YR 3/4) moist; weak coarse subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; few very fine tubular pores; few thin soft calcium carbonate filaments; strongly effervescent, 6 percent calcium carbonate equivalent; moderately alkaline (pH 8.0).

Range in Characteristics

Bw horizon:
Texture—very fine sandy loam, loam
Reaction—neutral to slightly alkaline

Bk horizon:
Texture—fine sandy loam, very fine sandy loam, loam
Calcium carbonate equivalent—0 to 10 percent
Reaction—slightly alkaline or moderately alkaline

Hindu Series

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately rapid
Landform: Hills and mesas
Parent material: Residuum and colluvium derived from calcareous sedimentary rocks
Slope range: 5 to 45 percent
Elevation: 4,000 to 4,800 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 60 to 70 degrees F
Frost-free period: 175 to 220 days
Classification: Loamy-skeletal, mixed (calcareous), thermic Lithic Torriorthents

Typical Pedon

Hindu extremely cobbly loam, in an area of Hindu-Rock outcrop complex, 5 to 45 percent slopes; about 750 feet west of the southeast corner of sec. 9, T. 27 N., R. 12 W.

A—0 to 3 inches; light brown (7.5YR 6/3) extremely cobbly loam, brown (7.5YR 4/4) moist; weak thick platy structure parting to weak medium subangular blocky; soft, very friable, nonsticky and nonplastic; many very fine roots and few fine roots; many very fine, common fine, and few medium irregular pores and common fine and few medium tubular pores; 40 percent gravel, 40 percent cobble, 10 percent stones; violently effervescent, 26 percent calcium carbonate equivalent; moderately alkaline (pH 8.4); clear wavy boundary.

Bk—3 to 9 inches; light brown (7.5YR 6/4) very gravelly loam, brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine roots and few fine roots; common very fine tubular pores; 40 percent gravel, 10 percent cobble; common thin calcium carbonate coatings on rock fragments and faces of peds; violently effervescent, 31 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); abrupt wavy boundary.

R—9 inches; gray limestone of the lower Supai Formation.

Range in Characteristics

Depth to bedrock: 3 to 19 inches
Content of rock fragments on the surface: 75 to 95 percent

B horizon:
Texture—very gravelly loam, sandy loam, fine sandy loam

Jacques Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Landform: Draws and stream terraces
Parent material: Mixed alluvium derived from the Frazier Well Gravels Formation
Slope range: 1 to 3 percent
Elevation: 5,800 to 6,000 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 130 to 160 days
Classification: Fine, mixed, mesic Cumulic Haplustolls

Typical Pedon

Jacques fine sandy loam, in an area of Frazwell-Jacques complex, 1 to 3 percent slopes; about 2,000 feet north and 100 feet west of the southeast corner of sec. 25, T. 28 N., R. 8 W.

A—0 to 1 inch; brown (7.5YR 5/3) fine sandy loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; many very fine roots and few fine roots; many very fine and fine irregular pores; noneffervescent; neutral (pH 7.2); abrupt smooth boundary.

C1—1 to 5 inches; brown (7.5YR 4/3) sandy clay loam, dark brown (7.5YR 3/3) moist; weak medium subangular blocky structure parting to moderate fine granular; slightly hard, friable, nonsticky and slightly plastic; common very fine roots and few fine roots; common fine irregular pores; noneffervescent; slightly alkaline (pH 7.4); abrupt smooth boundary.

C2—5 to 9 inches; brown (7.5YR 4/3) sandy clay loam, dark brown (7.5YR 3/3) moist; moderate medium subangular blocky structure; hard, friable, slightly sticky and plastic; many very fine roots and common fine roots; common very fine irregular and tubular pores; few thin sand grain coatings on faces of peds; slightly effervescent; slightly alkaline (pH 7.4); abrupt smooth boundary.

C3—9 to 18 inches; brown (7.5YR 5/3) clay, dark brown (7.5YR 3/3) moist; moderate medium angular blocky structure; very hard, firm, sticky and plastic; common very fine roots and few fine roots; common fine

irregular pores; slightly effervescent; slightly alkaline (pH 7.6); clear smooth boundary.
Ck1—18 to 34 inches; brown (7.5YR 5/3) clay, dark brown (7.5YR 3/3) moist; moderate coarse prismatic structure; very hard, firm, sticky and plastic; few very fine roots; common fine irregular pores and common very fine tubular pores; few fine soft calcium carbonate masses; common thin organic matter coatings and soft masses; slightly effervescent; slightly alkaline (pH 7.8); clear smooth boundary.
Ck2—34 to 35 inches; mixed brown (7.5YR 5/3 and 5/4) stratified sandy clay loam and clay loam, dark brown (7.5YR 4/3 and 4/4) moist; weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine roots and few fine roots; common very fine tubular and irregular pores; few fine soft calcium carbonate masses; few very thin strata of sandier material; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.
Ck3—35 to 52 inches; brown (7.5YR 5/4) sandy clay loam, dark brown (7.5YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and few fine roots; many very fine tubular pores and common fine irregular pores; common fine soft calcium carbonate masses and seams; violently effervescent; moderately alkaline (pH 8.2); abrupt smooth boundary.
Ck4—52 to 59 inches; brown (7.5YR 5/4) sandy loam, brown (7.5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine and fine roots; common fine irregular pores; common thin clay films bridging sand grains; few thin soft calcium carbonate masses; violently effervescent; moderately alkaline (pH 8.2); abrupt smooth boundary.
Ck5—59 to 65 inches; brown (7.5YR 5/4) cobbly fine sandy loam, brown (7.5YR 4/4) moist; massive; slightly hard, friable, nonsticky and nonplastic; few very fine roots; common fine irregular pores; 5 percent gravel, 15 percent cobble; few thin calcium carbonate coatings on rock fragments; violently effervescent; moderately alkaline (pH 8.2).

Range in Characteristics

Texture in the control section: Clay loam, clay, sandy clay, sandy clay loam averaging more than 35 percent clay
Calcium carbonate equivalent: 0 to 10 percent
Content of rock fragments in the control section: Less than 10 percent; gravelly or cobbly stone lines are present above the buried horizons in some pedons

C horizon:
Texture—stratified sandy clay loam, clay loam, sandy clay, clay, sandy loam, cobbly fine sandy loam

Lomaki Series

Depth class: Very deep
Drainage class: Somewhat excessively drained
Permeability: Moderate
Landform: Cinder cones
Parent material: Alluvium and colluvium derived from scoriaceous basalt and pyroclastics
Slope range: 15 to 50 percent
Elevation: 5,500 to 5,800 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 150 to 165 days
Classification: Ashy-skeletal over fragmental or cindery, mixed, mesic Ustivitrandic Camborthids

Typical Pedon

Lomaki extremely gravelly loam, in an area of Wukoki-Lomaki complex, 15 to 50 percent slopes, about 11 miles north of Mount Trumbull; 700 feet east and 2,000 feet south of the northwest corner of sec. 23, T. 37 N., R. 8 W.

A—0 to 2 inches; yellowish brown (10YR 5/4) extremely gravelly loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; slightly hard, very friable; many very fine roots; many very fine tubular pores; 70 percent cinders; slightly alkaline (pH 7.8); abrupt smooth boundary.
Bw—2 to 14 inches; yellowish brown (10YR 5/4) extremely gravelly loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, very friable; common very fine roots; common very fine tubular pores; 65 percent cinders; slightly alkaline (pH 7.8); clear wavy boundary.
Bk—14 to 30 inches; yellowish brown (10YR 5/4) extremely gravelly loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, very friable; common fine roots; common very fine pores; slightly effervescent; 65 percent cinders; moderately alkaline (pH 8.2); abrupt wavy boundary.
2C—30 to 60 inches; black cinders; few very fine roots.

Range in Characteristics

Depth to cinders: 20 to 40 inches
Average content of rock fragments in the control section: 60 to 75 percent cinders

The surface is covered with 65 to 100 percent cinders. Some pedons have a cinder lag as much as 2 inches thick on the surface.

B horizon:
Effervescence—noneffervescent to slightly effervescent

Lostman Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately rapid
Landform: Stream terraces
Parent material: Mixed alluvium
Slope range: 1 to 5 percent
Elevation: 3,000 to 4,400 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 60 to 70 F
Frost-free period: 200 to 230 days
Classification: Coarse-loamy, mixed, thermic Typic Camborthids

Typical Pedon

Lostman very gravelly sandy loam, in an area of Arizo-Lostman complex, 1 to 5 percent slopes; in Peach Springs Canyon, about 1,450 feet north and 2,300 feet east of the southwest corner of sec. 15, T. 15 N., R. 11 W.

A—0 to 3 inches; yellowish brown (10YR 5/4) very gravelly sandy loam, dark yellowish brown (10YR 3/4) moist; weak thin platy structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; few very fine roots; many very fine irregular pores; 55 percent gravel; strongly effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Bw1—3 to 8 inches; brown (7.5YR 5/4) gravelly fine sandy loam, dark brown (7.5YR 4/4) moist; strong coarse subangular blocky structure; hard, very friable, nonsticky and nonplastic; common very fine roots and few fine and medium roots; few fine tubular pores; 25 percent gravel; strongly effervescent; moderately alkaline (pH 8.2); abrupt smooth boundary.

Bw2—8 to 21 inches; brown (7.5YR 5/4) gravelly fine sandy loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; many very fine roots, common fine roots, and few medium roots; common very fine and few medium tubular pores; 25 percent gravel; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Bw3—21 to 35 inches; brown (7.5YR 5/4) gravelly fine sandy loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine roots and few fine roots; few very fine and fine tubular pores; 15 percent gravel; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Bk—35 to 49 inches; light brown (7.5YR 6/4) gravelly fine sandy loam, dark brown (7.5YR 4/4) moist; moderate fine subangular blocky structure; soft, very friable, nonsticky and nonplastic; few very fine and fine roots; common very fine tubular pores; 20 percent gravel; very few thin calcium carbonate coatings under rock fragments; strongly effervescent; moderately alkaline (pH 8.4); abrupt smooth boundary.

2Ck—49 to 61 inches; yellowish brown (10YR 5/4) extremely gravelly sandy loam, dark yellowish brown (10YR 4/4) moist; massive; loose, nonsticky and nonplastic; few very fine roots; common very fine and fine irregular pores; 75 percent gravel; very few thin calcium carbonate coatings under rock fragments; violently effervescent; moderately alkaline (pH 8.0).

Range in Characteristics

A horizon:
Texture—very fine sandy loam, very gravelly sandy loam
Content of rock fragments—5 to 55 percent

Bw horizon:
Texture—fine sandy loam, sandy loam, gravelly fine sandy loam, gravelly sandy loam

2C horizon:
Texture—extremely gravelly sandy loam, extremely gravelly loamy fine sand

Lostman Family

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately rapid
Landform: Stream terraces
Parent material: Alluvium derived from limestone and sandstone
Slope range: 1 to 5 percent
Elevation: 3,800 to 4,200 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 59 to 62 degrees F
Frost-free period: 180 to 200 days
Classification: Coarse-loamy, mixed, thermic Typic Camborthids

Typical Pedon

Lostman family, very fine sandy loam, in an area of Lostman family-Harrisburg complex, 1 to 5 percent slopes; about 1,500 feet south and 500 feet west of the northeast corner of sec. 12, T. 32 N., R. 8 W.

A—0 to 2 inches; brown (7.5YR 5/4) very fine sandy loam, dark brown (7.5YR 4/4) moist; weak medium platy structure parting to weak fine granular; soft, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular pores; violently effervescent; moderately alkaline (pH 8.2); abrupt smooth boundary.

Bw1—2 to 16 inches; light brown (7.5YR 6/4) very fine

sandy loam, brown (7.5YR 5/4) moist; moderate coarse prismatic structure; hard, friable, slightly sticky and slightly plastic; common very fine roots; common very fine and few fine tubular pores; few thin calcium carbonate coatings on rock fragments; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bw2—16 to 27 inches; light brown (7.5YR 6/4) very fine sandy loam, brown (7.5YR 5/4) moist; moderate coarse prismatic structure; hard, very friable, slightly sticky and slightly plastic; common very fine roots; common very fine and few fine tubular pores; few thin calcium carbonate coatings on rock fragments; violently effervescent; moderately alkaline (pH 8.4); abrupt smooth boundary.

Bk1—27 to 37 inches; light brown (7.5YR 6/4) silt loam, brown (7.5YR 5/4) moist; weak coarse prismatic structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular and irregular pores; 5 percent gravel; few fine soft calcium carbonate masses and common thin coatings on rock fragments; violently effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

Bk2—37 to 53 inches; light brown (7.5YR 6/4) very fine sandy loam, strong brown (7.5YR 5/6) moist; weak coarse subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few very fine roots; few very fine tubular pores; 5 percent gravel; few fine medium soft calcium carbonate masses; violently effervescent; strongly alkaline (pH 8.6); abrupt wavy boundary.

2Btk—53 to 60 inches; light brown (7.5YR 6/4) very gravelly fine sandy loam, strong brown (7.5YR5/6) moist; moderate fine and medium angular blocky structure; very hard, firm, slightly sticky and slightly plastic; 50 percent gravel; few faint clay films lining pores; many thin calcium carbonate coatings on rock fragments and faces of peds; violently effervescent; strongly alkaline (pH 8.6).

Range in Characteristics

Depth to a buried argillic horizon: 50 to 60 inches or more
Content of rock fragments in the control section: Less than 10 percent
Texture in the control section: Very fine sandy loam, silt loam, or loam

Luzena Series

Depth class: Shallow
Drainage class: Well drained
Permeability: Slow
Landform: Mesas and hills
Parent material: Alluvium and residuum derived from rhyolite and basalt
Slope range: 3 to 20 percent
Elevation: 4,900 to 5,400 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 57 degrees F
Frost-free period: 120 to 160 days
Classification: Clayey, montmorillonitic, mesic Lithic Argiustolls

Typical Pedon

Luzena extremely cobbly sandy loam, in an area of Luzena-Thunderbird complex, 3 to 20 percent slopes; about 1,050 feet east and 800 feet north of the southwest corner of sec. 30, T. 26 N., R. 13 W.

A—0 to 2 inches; brown (10YR 4/3) extremely cobbly sandy loam, dark brown (7.5YR 3/3) moist; weak medium platy structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; common very fine roots; many very fine irregular and vesicular pores; 45 percent gravel, 40 percent cobble; noneffervescent; neutral (pH 7.2); abrupt smooth boundary.

Bt1—2 to 7 inches; brown (7.5YR 4/3) gravelly clay loam, dark brown (7.5YR 3/3) moist; weak medium subangular blocky structure; hard, firm, sticky and plastic; common very fine and fine roots and few coarse roots; many fine tubular pores; 15 percent gravel; few faint clay films lining pores; noneffervescent; neutral (pH 7.2); clear smooth boundary.

Bt2—7 to 12 inches; brown (7.5YR 4/3) gravelly clay loam, dark brown (7.5YR 3/3) moist; moderate coarse subangular blocky structure; very hard, very firm, very sticky and very plastic; common fine roots and few medium and coarse roots; common fine tubular pores; 15 percent gravel, 5 percent cobble; few distinct clay films lining pores; noneffervescent; slightly alkaline (pH 7.4); abrupt smooth boundary.

R1—12 to 17 inches; fractured and weathered rhyolite; abrupt smooth boundary.

R2—17 inches; hard rhyolite.

Range in Characteristics

Depth to bedrock: 10 to 20 inches
Content of rock fragments on the surface: 60 to 95 percent

Bt horizon:
Texture—gravelly clay loam or clay

Lykorly Series

Depth class: Very deep
Drainage class: Well drained

Permeability: Moderately slow
Landform: Stream terraces and fan terraces
Parent material: Alluvium derived dominantly from limestone and sandstone
Slope range: 1 to 6 percent
Elevation: 5,400 to 6,500 feet
Mean annual precipitation: 14 to 18 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days
Classification: Fine-loamy, mixed, mesic Aridic Haplustalfs

Typical Pedon

Lykorly gravelly loam, 1 to 4 percent slopes, about 1,450 feet west and 2,875 feet south of the northeast corner of sec. 20, T. 29 N., R. 6 W.

A—0 to 1 inch; light brown (7.5YR 6/4) gravelly loam, brown (7.5YR 5/4) moist; weak thick platy structure; soft, very friable, nonsticky and nonplastic; many very fine roots; many very fine vesicular pores; 15 percent gravel; noneffervescent; slightly acid (pH 6.4); abrupt smooth boundary.

E—1 to 2 inches; light yellowish brown (10YR 6/4) loam, yellowish brown (10YR 5/4) moist; weak thick platy structure; slightly hard, very friable, sticky and plastic; many very fine roots; many very fine vesicular pores; noneffervescent; slightly acid (pH 6.4); abrupt smooth boundary.

Bw—2 to 4 inches; dark yellowish brown (10YR 4/4) loam, dark yellowish brown (10YR 3/4) moist; weak fine subangular blocky structure parting to moderate fine granular; slightly hard, friable, sticky and plastic; many very fine roots; many very fine tubular pores; noneffervescent; slightly acid (pH 6.4); clear smooth boundary.

2Bt1—4 to 11 inches; dark yellowish brown (10YR 4/4) and brown (7.5YR 5/4) clay loam, dark yellowish brown (10YR 3/4) and dark brown (7.5YR 4/4) moist; moderate fine prismatic structure parting to moderate fine subangular blocky; hard, very firm, very sticky and very plastic; many very fine roots; many very fine tubular pores; common clay films bridging sand grains; common pressure faces; organic matter stains along planar voids; noneffervescent; slightly acid (pH 6.5); clear smooth boundary.

2Bt2—11 to 25 inches; dark yellowish brown (10YR 4/4) and brown (7.5YR 5/4) clay loam, dark yellowish brown (10YR 3/4) and dark brown (7.5YR 4/4) moist; weak medium prismatic structure parting to weak medium subangular blocky; hard, firm, sticky and plastic; common very fine roots; many very fine tubular pores; common clay films bridging sand grains; noneffervescent; neutral (pH 7.0); clear smooth boundary.

2Btk—25 to 31 inches; brown (10YR 5/3) loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; hard, firm, sticky and plastic; common very fine roots; many very fine tubular pores; clay bridging sand grains; strongly effervescent; slightly alkaline (pH 7.4); clear smooth boundary.

3Bk—31 to 44 inches; brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; hard, firm, sticky and plastic; common fine roots; many very fine tubular pores; few soft calcium carbonate masses; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

4Btkb—44 to 60 inches; yellowish red (5YR 5/6) clay, yellowish red (5YR 5/6) moist; moderate coarse prismatic structure parting to moderate medium subangular blocky; very hard, very firm, very sticky and very plastic; few fine roots; few fine tubular pores; many clay films bridging sand grains; many pressure faces; common fine soft calcium carbonate masses; strongly effervescent; slightly alkaline (pH 7.8).

Range in Characteristics

Depth to an argillic horizon: 3 to 10 inches
Content of calcium carbonate: Less than 15 percent

A horizon:
Texture—gravelly loam, extremely gravelly loam

E horizon:
Does not occur in some pedons

Bw horizon:
Does not occur in some pedons

Bt horizon:
Texture—loam, silt, clay loam
Reaction—slightly acid to slightly alkaline

Btk horizon:
Texture—loam, silt loam, clay loam
Reaction—slightly alkaline to moderately alkaline

Btkb horizon:
Does not occur in some pedons

Meriwhitica Series

Depth class: Very shallow
Drainage class: Well drained
Permeability: Moderate
Landform: Hills, mesas, and plateaus
Parent material: Residuum derived dominantly from limestone
Slope range: 1 to 35 percent
Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 55 to 58 degrees F
Frost-free period: 135 to 175 days

Classification: Loamy-skeletal, mixed (calcareous), mesic Lithic Ustic Torriorthents

Typical Pedon

Meriwhitica extremely cobbly loam (fig. 18), in an area of Curhollow-Rolie-Meriwhitica association, 1 to 35 percent slopes; about 2,200 feet south and 200 feet east of the northwest corner of sec. 27, T. 27 N., R. 12 W.

A—0 to 3 inches; pale brown (10YR 6/3) extremely cobbly loam, brown (10YR 4/3) moist; moderate thick platy structure parting to moderate fine granular; slightly hard, very friable, slightly sticky and nonplastic; common very fine roots and few fine roots; many very fine and few fine irregular pores; 25 percent gravel and channers, 45 percent cobble and flagstones, 20 percent stones; violently effervescent, 29 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); abrupt wavy boundary.

Bk—3 to 8 inches; yellowish brown (10YR 5/4) extremely cobbly loam, dark yellowish brown (10YR 4/4) moist; moderate medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine and fine roots and few coarse roots; many very fine and few fine tubular pores; 30 percent gravel, 35 percent cobble; few thin calcium carbonate coatings lining pores and on faces of peds and common thin coatings on rock fragments; violently effervescent, 24 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); abrupt wavy boundary.

R—8 inches; thin bedded, gray limestone.

Range in Characteristics

Depth to limestone: 3 to 10 inches

Average content of rock fragments in the surface horizon: 85 to 90 percent

Average content of rock fragments in the subsoil: 35 to 85 percent

Metuck Series

Depth class: Very shallow and shallow

Drainage class: Well drained

Permeability: Moderate

Landform: Canyon escarpments

Parent material: Residuum derived dominantly from calcareous sandstone of the Supai Formation

Slope range: 15 to 60 percent

Elevation: 4,500 to 5,800 feet

Mean annual precipitation: 14 to 16 inches

Mean annual soil temperature: 54 to 57 degrees F

Frost-free period: 135 to 170 days

Classification: Loamy-skeletal, mixed (calcareous), mesic Lithic Ustorthents

Typical Pedon

Metuck extremely channery fine sandy loam, in an area of Metuck-Rock outcrop complex, 15 to 60 percent slopes; about 1,450 feet south and 1,500 feet west of the northeast corner of sec. 9, T. 26 N., R. 9 W.

A—0 to 1 inch; reddish brown (5YR 5/4) extremely channery fine sandy loam, dark reddish brown (5YR 3/4) moist; weak fine platy structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; common very fine irregular pores; 70 percent gravel and channers, 25 percent flagstones and stones; violently effervescent, 21 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); clear wavy boundary.

Bw—1 to 8 inches; reddish brown (5YR 5/4) very channery fine sandy loam, reddish brown (5YR 4/4) moist; weak fine subangular blocky structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; many very fine roots and few fine and medium roots; common very fine irregular pores; 40 percent channers; violently effervescent, 21 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); abrupt wavy boundary.

BCk—8 to 10 inches; light reddish brown (5YR 6/3) very channery very fine sandy loam, reddish brown (5YR 5/3) moist; weak medium platy structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots and few fine roots; 40 percent channers; common thin calcium carbonate coatings on rock fragments; violently effervescent, 38 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); abrupt wavy boundary.

Cr—10 to 12 inches; fractured, weathered sandstone; few fine roots; few thin calcium carbonate coatings in fractures; violently effervescent; abrupt smooth boundary.

R—12 inches; hard, calcareous sandstone.

Range in Characteristics

Average content of rock fragments in the surface lag layer: 65 to 95 percent

Depth to bedrock: 3 to 17 inches; commonly less than 10 inches

Average content of rock fragments in the control section: 35 to 50 percent

Bk horizon (if it occurs):
Thickness—less than 6 inches

Mextank Series

Depth class: Very deep

Drainage class: Well drained

Permeability: Moderate
Landform: Fan terraces
Parent material: Limestone and sandstone colluvium
Slope range: 5 to 20 percent
Elevation: 5,600 to 6,000 feet
Mean annual precipitation: 16 to 18 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 140 to 160 days
Classification: Loamy-skeletal, mixed, mesic Aridic Calciustolls

Typical Pedon

Mextank extremely gravelly fine sandy loam, in an area of Mextank-Lykorly-Disterheff complex, 2 to 20 percent slopes; about 2,200 feet west and 2,300 feet north of the southeast corner of sec. 34, T. 20 N., R. 8 W.

A—0 to 1 inch; brown (7.5YR 5/3) extremely gravelly fine sandy loam, dark brown (7.5YR 3/2) moist; moderate thick platy structure; slightly hard, very friable, nonsticky and nonplastic; many very fine roots; common very fine tubular and irregular pores; 90 percent gravel; violently effervescent; slightly alkaline (pH 7.7); abrupt smooth boundary.

BA—1 to 5 inches; brown (7.5YR 5/3) very gravelly fine sandy loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine tubular pores and common very fine irregular pores; 35 percent gravel; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Bk1—5 to 14 inches; brown (7.5YR 5/3) very gravelly loam, dark brown (7.5YR 3/3) moist; weak medium subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; common very fine roots, many fine roots, and few medium and coarse roots; common very fine irregular pores; 40 percent gravel; common thin calcium carbonate coatings and thin pendants on rock fragments; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Bk2—14 to 27 inches; brown (7.5YR 5/2) very cobbly loam, dark brown (7.5YR 3/2) moist; weak fine and medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine and medium roots and few very fine and coarse roots; common fine tubular pores and common very fine irregular pores; 20 percent gravel, 25 percent cobble, 5 percent stones; common thin calcium carbonate coatings and many pendants on rock fragments; violently effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bk3—27 to 36 inches; brown (7.5YR 5/4) very gravelly loam, dark brown (7.5YR 4/4) moist; moderate fine subangular blocky structure; slightly hard, very friable, slightly sticky and nonplastic; few very fine and fine roots and common medium roots; common very fine irregular pores and few fine tubular pores; common thin calcium carbonate coatings and many pendants on rock fragments; 50 percent gravel; violently effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Bk4—36 to 50 inches; brown (7.5YR 5/4) very gravelly sandy clay loam, dark brown (7.5R 4/4) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; few fine and medium roots; common very fine irregular pores; 50 percent gravel; common thin calcium carbonate coatings and many pendants on rock fragments; violently effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

2Ck—50 to 60 inches; light brown (7.5YR 6/4) extremely gravelly coarse sandy loam, strong brown (7.5YR 4/6) moist; massive; slightly hard, very friable, nonsticky and nonplastic; few fine and medium roots; common very fine and fine irregular pores; 60 percent gravel, 5 percent cobble; common thin calcium carbonate coatings and many pendants on rock fragments; violently effervescent moderately alkaline (pH 8.2).

Range in Characteristics

Depth to a calcic horizon: 1 to 20 inches
Content of rock fragments in the control section: 35 to 60 percent
Texture in the control section: Very gravelly or very cobbly loam, fine sandy loam, sandy clay loam
Content of calcium carbonate: 5 to 30 percent

Milkweed Series

Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Landform: Fan terraces
Parent material: Alluvium derived from sedimentary and igneous rocks
Slope range: 2 to 20 percent
Elevation: 4,600 to 5,500 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 120 to 160 days
Classification: Loamy-skeletal, mixed, mesic, shallow Aridic Ustochrepts

Typical Pedon

Milkweed extremely gravelly loam, in an area of Milkweed-Quartermaster-Buckndoe complex, 2 to 20 percent slopes; about 1,600 feet north and 2,400 feet east of the southwest corner of sec. 13, T. 26 N., R. 14 W.

Figure 16.—Profile of the Bleumont soil.

Figure 17.—Profile of the Disterheff soil.

Figure 18.—Profile of the Meriwhitica soil.

Figure 19.—Profile of the Peachsprings soil.

Figure 20.—Profile of the Rolie soil.

A—0 to 2 inches; dark yellowish brown (10YR 4/4) extremely gravelly loam, dark brown (10YR 3/3) moist; weak thick platy structure parting to weak fine granular; soft, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular pores; 80 percent gravel; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Bk1—2 to 8 inches; brown (10YR 4/3) very gravelly loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many very fine roots, many fine roots, and few medium roots; common very fine and fine tubular pores; 40 percent gravel; few thin calcium carbonate coatings on rock fragments; violently effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Bk2—8 to 11 inches; dark yellowish brown (10YR 4/4) very gravelly loam, dark yellowish brown (10YR 3/4) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots, common fine roots, and few medium and coarse roots; common very fine and fine tubular pores; 45 percent gravel, 5 percent cobble and hardpan fragments; common thin calcium carbonate coatings on rock fragments; violently effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

2Bkm1—11 to 28 inches; fractured, calcium carbonate cemented hardpan; few fine and medium roots in fractures; abrupt wavy boundary.

2Bkm2—28 to 60 inches; indurated, calcium carbonate cemented hardpan.

Range in Characteristics

Average content of rock fragments in the surface lag layer: 60 to 90 percent

Depth to a calcium carbonate cemented hardpan: 10 to 20 inches

Calcium carbonate equivalent: 30 to 40 percent

Average content of rock fragments: 35 to 60 percent, dominantly gravel

B horizon:

Texture—very gravelly loam, fine sandy loam

Milok Series

Depth class: Very deep

Drainage class: Well drained

Permeability: Moderate

Landform: Fan terraces

Parent material: Limestone alluvium

Slope range: 4 to 12 percent

Elevation: 4,300 to 4,600 feet

Mean annual precipitation: 10 to 14 inches

Mean annual soil temperature: 53 to 56 degrees F

Frost-free period: 150 to 165 days

Classification: Coarse-loamy, mixed, mesic Ustollic Calciorthids

Typical Pedon

Milok gravelly sandy loam, in an area of Milok-Pastern complex, 4 to 12 percent slopes; about 2,300 feet east and 200 feet south of the northwest corner of sec. 12, T. 24 N., R. 12 W.

A—0 to 2 inches; brown (10YR 5/3) gravelly sandy loam, dark brown (10YR 4/3) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; many very fine roots; common very fine tubular pores; 20 percent gravel; violently effervescent, 21 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Bw—2 to 6 inches; brown (10YR 5/3) gravelly sandy loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; many very fine roots; common very fine tubular pores; 20 percent gravel; violently effervescent, 22 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); clear wavy boundary.

Bk1—6 to 25 inches; pale brown (10YR 6/3) gravelly sandy loam, brown (10YR 5/3) moist; weak fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine roots; common very fine tubular pores; 30 percent gravel; violently effervescent, 28 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bk2—25 to 37 inches; very pale brown (10YR 7/3) gravelly loam, light brown (7.5YR 6/4) moist; weak very fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine tubular pores; 20 percent gravel; violently effervescent, 38 percent calcium carbonate equivalent; moderately alkaline (pH 8.2); abrupt smooth boundary.

2Bk3—37 to 60 inches; light brown (7.5YR 6/4) loam, brown (7.5YR 5/4) moist; moderate coarse subangular blocky structure; very hard, firm, nonsticky and nonplastic; few very fine roots; many very fine tubular pores; 10 percent gravel; few fine soft calcium carbonate masses; violently effervescent, 23 percent calcium carbonate equivalent; moderately alkaline (pH 8.2).

Range in Characteristics

Depth to a calcic horizon: 6 to 20 inches

Reaction: Slightly alkaline or moderately alkaline

Content of clay in the control section: 5 to 18 percent

Content of rock fragments: 5 to 30 percent gravel

Naha Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately rapid
Landform: Flood plains
Parent material: Stratified alluvium derived dominantly from sedimentary rock
Slope range: 0 to 3 percent
Elevation: 3,100 to 4,200 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 59 to 64 degrees F
Frost-free period: 180 to 200 days
Classification: Sandy over loamy, mixed (calcareous), mesic Typic Torriorthents

Typical Pedon

Naha loamy fine sand, in an area of Cowan family-Naha complex, 0 to 3 percent slopes; about 900 feet west and 2,100 feet south of the northeast corner of sec. 22, T. 33 N., R. 4 W.

A—0 to 4 inches; reddish brown (5YR 5/4) loamy fine sand, dark reddish brown (5YR 3/4) moist; weak medium granular structure; soft, very friable, nonsticky and nonplastic; many very fine roots; many very fine irregular pores; slightly effervescent; slightly alkaline (pH 7.7); abrupt smooth boundary.

Bw1—4 to 9 inches; yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; moderate medium subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; many very fine roots; common very fine tubular pores; strongly effervescent; slightly alkaline (pH 7.7); clear smooth boundary.

Bw2—9 to 13 inches; reddish yellow (5YR 6/6) loamy fine sand, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine roots; common very fine tubular pores; strongly effervescent; slightly alkaline (pH 7.7); abrupt wavy boundary.

C1—13 to 21 inches; light reddish brown (5YR 6/4) sand, yellowish red (5YR 5/6) moist; massive, parting to single grain; loose, nonsticky and nonplastic; common very fine roots; common very fine tubular pores; slightly effervescent; slightly alkaline (pH 7.7); abrupt smooth boundary.

C2—21 to 29 inches; yellowish red (5YR 5/6), reddish yellow (5YR 6/6), and reddish brown (5YR 4/4) silt loam, yellowish red (5YR 5/6 and 4/6) and reddish brown (5YR 4/4) moist; weak medium angular blocky structure; slightly hard, very friable, nonsticky and slightly plastic; common very fine and few medium roots; common very fine tubular pores; electrical conductivity is 10; sodium adsorption ratio is 7; violently effervescent; moderately alkaline (pH 8.1); abrupt smooth boundary.

C3—29 to 38 inches; reddish brown (5YR 4/4) very fine sandy loam, dark reddish brown (5YR 3/3) moist; weak coarse prismatic structure parting to weak coarse angular blocky; soft, very friable, nonsticky and nonplastic; many very fine roots; common very fine tubular pores; electrical conductivity is 13; sodium adsorption ratio is 9; strongly effervescent; moderately alkaline (pH 8.3); abrupt smooth boundary.

C4—38 to 44 inches; reddish yellow (5YR 6/6) fine sand, yellowish red (5YR 5/6) moist; massive; soft, very friable, nonsticky and nonplastic; common very fine roots; common very fine tubular pores; strongly effervescent; moderately alkaline (pH 8.3); abrupt smooth boundary.

C5—44 to 51 inches; reddish yellow (5YR 6/6) sand, yellowish red (5YR 5/6) moist; massive; soft, very friable, nonsticky and nonplastic; common very fine roots; common very fine tubular pores; slightly effervescent; moderately alkaline (pH 8.3); abrupt wavy boundary.

C6—51 to 64 inches; yellowish red (5YR 5/6) loamy fine sand, yellowish red (5YR 4/6) moist; massive; soft, very friable, nonsticky and nonplastic; common very fine roots; common very fine tubular pores; strongly effervescent; strongly alkaline (pH 8.6).

Range in Characteristics

A horizon:
Reaction—slightly alkaline or moderately alkaline

C horizon:
Texture—highly variable and stratified, dominantly very fine sandy loam, loamy fine sand, with strata of sand, very fine sand, loam, silt loam
Salinity (ECe)—8 to 16 dS/m, below a depth of 20 inches
Sodicity (SAR)—6 to 10, below a depth of 20 inches
Reaction—slightly alkaline or moderately alkaline

These soils are a taxadjunct to the Naha series. They have a thermic soil temperature regime and an irregular decrease in organic matter.

Natank Series

Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Landform: Plateaus
Parent material: Alluvium and residuum derived from calcareous sandstone and limestone
Slope range: 2 to 15 percent

Elevation: 6,200 to 6,600 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days
Classification: Fine, montmorillonitic, mesic Aridic Haplustalfs

Typical Pedon

Natank extremely gravelly loam, in an area of Natank-Disterheff-Yumtheska complex, 2 to 35 percent slopes; about 800 feet south and 2,100 feet west of the northeast corner of sec. 12, T. 29 N., R. 7 W.

A—0 to 2 inches; brown (10YR 5/3) extremely gravelly loam, dark brown (10YR 4/3) moist; weak thick platy structure; soft, very friable, nonsticky and nonplastic; common fine roots; common very fine vesicular pores; 65 percent gravel; noneffervescent; slightly acid (pH 6.2); clear smooth boundary.

Bt1—2 to 4 inches; brown (7.5YR 4/4) clay loam, dark brown (7.5YR 3/4) moist; weak fine subangular blocky structure; slightly hard, firm, sticky and plastic; common fine roots; common fine tubular pores; 10 percent gravel; noneffervescent; slightly acid (pH 6.2); clear smooth boundary.

Bt2—4 to 7 inches; reddish brown (5YR 4/3) clay, dark reddish brown (5YR 4/3) moist; moderate medium prismatic structure parting to moderate medium subangular blocky; hard, very firm, sticky and very plastic; many very fine roots; common fine tubular pores; 10 percent gravel; common prominent clay films bridging sand grains and on faces of peds; common pressure faces; noneffervescent; neutral (pH 6.6); clear smooth boundary.

Bt3—7 to 16 inches; reddish brown (5YR 4/4) clay, reddish brown (5YR 4/4) moist; moderate medium prismatic structure parting to moderate medium subangular blocky; very hard, very firm, very sticky and very plastic; common fine roots; common fine tubular pores; 10 percent gravel; common distinct patchy clay films bridging sand grains and on faces of peds; many pressure faces; noneffervescent; neutral (pH 6.6); clear smooth boundary.

2Btk—16 to 22 inches; reddish brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocky structure; very hard, very firm, very sticky and very plastic; common fine roots; common fine tubular pores; 10 percent gravel; common distinct patchy clay films bridging sand grains and on faces of peds; common fine soft calcium carbonate masses; many pressure faces; strongly effervescent, 9 percent calcium carbonate equivalent; slightly alkaline (pH 7.5); abrupt smooth boundary.

Bk—22 to 30 inches; reddish yellow (5YR 6/6) loam, yellowish red (5YR 5/6) moist; massive; hard, friable, slightly sticky and slightly plastic; few fine roots; common fine tubular pores; 7 percent gravel; many fine soft calcium carbonate masses and common thin coatings on rock fragments; violently effervescent, 30 percent calcium carbonate equivalent; slightly alkaline (pH 7.7); abrupt smooth boundary.

R—30 inches; calcareous sandstone.

Range in Characteristics

Depth to bedrock: 20 to 40 inches
Depth to a calcic horizon: 20 to 40 inches
Content of rock fragments: Averages less than 15 percent in the control section
Reaction: Neutral in the upper part to slightly alkaline in the lower part

Bt horizon:
Texture—loam, clay loam, clay

Bk horizon:
Texture—loam, clay loam, clay
Calcium carbonate equivalent—15 to 40 percent

Nickel Family

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderate
Landform: Fan terraces
Parent material: Mixed alluvium
Slope range: 2 to 35 percent
Elevation: 3,700 to 4,200 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 60 to 70 degrees F
Frost-free period: 180 to 220 days
Classification: Loamy-skeletal, mixed, thermic Typic Calciorthids

Typical Pedon

Nickel family extremely gravelly sandy loam, 2 to 35 percent slopes, about 1,150 feet east and 1,450 feet north of the southwest corner of sec. 25, T. 27 N., R. 12 W.

A—0 to 2 inches; dark yellowish brown (10YR 4/4) extremely gravelly sandy loam, dark brown (10YR 3/3) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; few very fine roots; many very fine irregular pores; 50 percent gravel, 20 percent cobble; strongly effervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

Bw—2 to 5 inches; brown (7.5YR 4/4) extremely gravelly fine sandy loam, dark brown (7.5YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many

very fine roots; few very fine tubular pores; 55 percent gravel, 15 percent cobble; few fine soft calcium carbonate masses and thin coatings under rock fragments; strongly effervescent; slightly alkaline (pH 7.8); clear wavy boundary.

Bk1—5 to 12 inches; pinkish white (7.5YR 8/2) very gravelly fine sandy loam, light brown (7.5YR 6/4) moist; weak medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine, few fine, medium and coarse roots; common very fine tubular and irregular pores; 45 percent gravel, 10 percent cobble; common thin calcium carbonate pendants under rock fragments and thin coatings on faces of peds; violently effervescent; moderately alkaline (pH 8.2); clear wavy boundary.

Bk2—12 to 25 inches; pinkish white (7.5YR 8/2) extremely gravelly sandy clay loam, light brown (7.5YR 6/4) moist; weak medium subangular blocky structure; slightly hard, very friable, sticky and plastic; common very fine roots; few very fine tubular pores; 50 percent gravel, 20 percent cobble; common medium soft calcium carbonate masses and many thin coatings on faces of peds and on rock fragments; violently effervescent, 25 percent calcium carbonate equivalent; moderately alkaline (pH 8.3); abrupt wavy boundary.

Bk3—25 to 41 inches; pinkish white (7.5YR 8/2) extremely gravelly sandy clay loam, light brown (7.5YR 6/4) moist; massive; hard, friable, sticky and plastic; few very fine and fine roots; no observable pores; 55 percent gravel, 10 percent cobble; common thick calcium carbonate pendants and thin coatings on rock fragments; violently effervescent, 30 percent calcium carbonate equivalent; strongly alkaline (pH 8.6); abrupt wavy boundary.

2Bk—41 to 60 inches; pink (5YR 7/4) very gravelly sandy loam, yellowish red (5YR 5/6) moist; moderate fine angular blocky structure; extremely hard, firm, nonsticky and slightly plastic; 40 percent gravel; common thin calcium carbonate coatings on faces of peds; violently effervescent, 20 percent calcium carbonate equivalent; strongly alkaline (pH 8.8).

Range in Characteristics

Content of calcium carbonate: 15 to 35 percent in the control section

Depth to a calcic horizon: 8 to 20 inches

Content of rock fragments on the surface horizon: 70 to 90 percent

B horizon:

Texture—very gravelly or extremely gravelly sandy loam, fine sandy loam, very fine sandy loam, sandy clay loam

Pastern Series

Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Landform: Fan terraces
Parent material: Limestone alluvium
Slope range: 4 to 12 percent
Elevation: 4,300 to 4,600 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 53 to 56 degrees F
Frost-free period: 150 to 165 days
Classification: Loamy, mixed, mesic, shallow Ustollic Paleorthids

Typical Pedon

Pastern gravelly sandy loam, in an area of Milok-Pastern complex, 4 to 12 percent slopes; about 500 feet west and 200 feet north of the southeast corner of sec. 5, T. 24 N., R. 12 W.

A—0 to 2 inches; brown (10YR 5/3) gravelly sandy loam, dark brown (10YR 4/3) moist; weak thin platy structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; many fine roots; many fine irregular pores; 25 percent gravel; violently effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw1—2 to 9 inches; yellowish brown (10YR 5/4) gravelly loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; many fine roots; common very fine tubular pores; 25 percent gravel; violently effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw2—9 to 11 inches; brown (10YR 5/3) gravelly loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine tubular pores; 30 percent gravel, mostly hardpan fragments; violently effervescent, 25 percent calcium carbonate equivalent; moderately alkaline (pH 8.2); abrupt smooth boundary.

2Bkm—11 to 21 inches; indurated, calcium carbonate cemented hardpan with thin laminar cap; abrupt smooth boundary.

2Bk1—21 to 47 inches; yellowish brown (10YR 5/4) extremely gravelly sandy loam, dark yellowish brown (10YR 4/4) moist; massive; hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine irregular pores; 80 percent gravel; many calcium carbonate coats on gravel; violently effervescent; moderately alkaline (pH 8.2); abrupt smooth boundary.

2Bk2—47 to 60 inches; yellowish brown (10YR 5/4) extremely gravelly sandy loam, dark yellowish brown

(10YR 4/4) moist; massive; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine irregular pores; 70 percent gravel; many thin calcium carbonate coatings on rock fragments; violently effervescent; moderately alkaline (pH 8.2).

Range in Characteristics

Depth to a hardpan: 10 to 20 inches
Thickness of hardpan: 6 to 24 inches
Content of rock fragments in the control section: 15 to 35 percent gravel
Content of clay: 5 to 15 percent

Peachsprings Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Landform: Fan terraces
Parent material: Mixed alluvium derived from sedimentary and igneous rocks
Slope range: 2 to 15 percent
Elevation: 4,300 to 5,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days
Classification: Fine-loamy, mixed, mesic Ustollic Calciorthids

Typical Pedon

Peachsprings extremely gravelly coarse sandy loam (fig. 19) in an area of Peachsprings-Havasupai complex, 2 to 35 percent slopes, about 600 feet west and 1,300 feet south of the northeast corner of sec. 29, T. 25 N., R. 11 N.

A—0 to 3 inches; brown (10YR 5/3) extremely gravelly coarse sandy loam, dark brown (10YR 4/3) moist; weak medium platy structure parting to moderate fine granular; soft, very friable, slightly sticky and slightly plastic; many very fine and few fine roots; many very fine tubular pores; 70 percent gravel; violently effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw—3 to 8 inches; brown (10YR 5/3) gravelly sandy loam, dark brown (10YR 4/3) moist; weak coarse subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine and few medium roots; 30 percent gravel; violently effervescent; moderately alkaline (pH 8.0); abrupt, wavy boundary.

2Bk1—8 to 21 inches; light brown (7.5YR 6/4) gravelly sandy clay loam, brown (7.5YR 5/4) moist; moderate medium subangular blocky structure; hard, friable, sticky and plastic; common very fine roots; common very fine tubular pores; 20 percent gravel; few thin calcium carbonate coatings lining pores and on faces of peds; violently effervescent; moderately alkaline (pH 8.2); clear wavy boundary.

2Bk2—21 to 32 inches; pink (7.5YR 7/4) gravelly clay loam, light brown (7.5YR 6/4) moist; weak medium prismatic structure parting to weak medium subangular blocky; slightly hard, friable, sticky and plastic; few very fine roots; few very fine tubular pores; 15 percent gravel; few thin calcium carbonate coatings lining pores and on faces of peds; violently effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

3Bkb1—32 to 43 inches; light reddish brown (5YR 6/4) and light brown (7.5YR 6/4) fine sandy loam, reddish brown (5YR 5/4) and brown (7.5YR 5/4) moist; moderate medium angular blocky structure; hard, firm, nonsticky and slightly plastic; few very fine roots; few very fine tubular pores; 5 percent gravel; common thin calcium carbonate coatings lining pores and on faces of peds; violently effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

3Bkb2—43 to 64 inches; light reddish brown (5YR 6/4) and light brown (7.5YR 6/4) sandy loam, reddish brown (5YR 5/4) and brown (7.5YR 5/4) moist; moderate medium angular blocky structure; very hard, firm, nonsticky and nonplastic; few very fine roots; few very fine tubular pores; common thin calcium carbonate coatings on faces of peds; violently effervescent; moderately alkaline (pH 8.4).

Range in Characteristics

Content of calcium carbonate in the control section: 25 to 35 percent
Content of rock fragments on the surface: 30 to 90 percent gravel and 0 to 10 percent cobble

Bw horizon:
Texture—gravelly sandy loam, fine sandy loam

2Bk horizon:
Texture—gravelly sandy clay loam, clay loam, sandy loam

3Bkb horizon:
Texture—sandy loam, fine sandy loam, loamy sand

Pinespring Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Landform: Stream terraces and draws
Parent material: Mixed alluvium derived from Frazier Well Gravels Formation
Slope range: 2 to 5 percent

Elevation: 6,200 to 6,800 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 120 to 150 days
Classification: Fine, montmorillonitic, mesic Pachic Argiustolls

Typical Pedon

Pinespring sandy loam, in an area of Theecan-Pinespring association, 2 to 35 percent slopes; about 1,600 feet west and 3,100 feet north of the southeast corner of sec. 17, T. 28 N., R. 7 W.

A—0 to 2 inches; brown (7.5YR 5/2) sandy loam, dark brown (7.5YR 3/2) moist; weak medium platy structure parting to moderate fine granular; soft, very friable, nonsticky and nonplastic; many fine and common very fine roots; many very fine irregular pores; noneffervescent; neutral (pH 6.6); abrupt smooth boundary.

BA—2 to 9 inches; brown (7.5YR 4/2) sandy clay loam, dark brown (10YR 3/2) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many fine roots and few very fine and medium roots; common very fine irregular pores; noneffervescent; neutral (pH 6.8); abrupt smooth boundary.

Bt1—9 to 14 inches; brown (7.5YR 4/2) sandy clay loam, dark brown (7.5YR 3/2) moist; moderate medium subangular blocky structure; slightly hard, very friable, sticky and plastic; common fine roots and few very fine and medium roots; common very fine irregular pores and few very fine tubular pores; few faint clay films on faces of peds; noneffervescent; neutral (pH 6.8); abrupt smooth boundary.

Bt2—14 to 33 inches; dark brown (7.5YR 3/2) clay loam, dark brown (7.5YR 3/2) moist; weak medium prismatic structure; hard, firm, very sticky and very plastic; common medium and few very fine and fine roots; common very fine irregular pores and few very fine tubular pores; common faint clay films on faces of peds; noneffervescent; neutral (pH 7.0); clear smooth boundary.

Bt3—33 to 44 inches; brown (7.5YR 4/3) sandy clay, dark brown (7.5YR 4/2) moist; moderate medium prismatic structure; hard, friable, sticky and very plastic; few very fine to medium roots; common very fine irregular pores; common faint clay films on faces of peds; noneffervescent; neutral (pH 7.2); abrupt smooth boundary.

Bt4—44 to 60 inches; brown (7.5YR 4/4) sandy clay loam, brown (7.5YR 4/3) moist; weak coarse prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine to medium roots; common very fine irregular pores; common distinct clay films on faces of peds bridging sand grains; noneffervescent; slightly alkaline (pH 7.4).

Range in Characteristics

Thickness of a mollic epipedon: 20 to 40 inches
Depth to an argillic horizon: 4 to 15 inches
Content of clay in the control section: 35 to 50 percent
Content of rock fragments: Less than 15 percent in the control section

Bt1 and Bt2 horizons:
Texture—sandy clay loam, clay loam, sandy clay
Content of clay—35 to 50 percent
Reaction—neutral or slightly alkaline

Bt3 and Bt4 horizons
Texture—sandy clay loam, sandy clay
Reaction—neutral or slightly alkaline

Pinntank Series

Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Landform: Mesas and plateaus
Parent material: Residuum derived from sedimentary rock
Slope range: 1 to 15 percent
Elevation: 6,600 to 7,400 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 47 to 51 degrees F
Frost-free period: 120 to 150 days
Classification: Fine, montmorillonitic, mesic Vertic Paleustalfs

Typical Pedon

Pinntank loam, in an area of Pinntank-Pocomate-Retsover complex, 1 to 30 percent slopes; about 1,600 feet west and 1,400 feet north of the southeast corner of sec. 27, T. 29 N., R. 8 W.

Oi—1 to 0 inch; slightly decomposed pine litter.

A—0 to 2 inches; brown (7.5YR 4/3) loam, dark brown (7.5YR 3/3) moist; weak fine granular structure; soft, very friable, sticky and plastic; many very fine roots; many very fine irregular pores; 10 percent gravel; noneffervescent; neutral (pH 6.8); abrupt smooth boundary.

Bw—2 to 7 inches; dark brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) moist; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; many very fine roots and few fine and medium roots; common very fine irregular and tubular pores; noneffervescent; neutral (pH 6.6); abrupt wavy boundary.

Bt1—7 to 13 inches; reddish brown (5YR 5/4) clay, reddish

brown (5YR 4/4) moist; strong coarse subangular blocky structure; hard, firm, very sticky and very plastic; common very fine to medium roots and few coarse roots; common very fine tubular pores; common faint clay films lining pores and on faces of peds; noneffervescent; neutral (pH 6.8); clear wavy boundary.

Bt2—13 to 24 inches; reddish brown (5YR 4/4) and yellowish red (5YR 4/6) clay, reddish brown (5YR 4/4) and yellowish red (5YR 4/6) moist; strong coarse prismatic structure; very hard, very firm, very sticky and very plastic; few very fine and fine roots; few very fine tubular pores; common faint clay films lining pores and on faces of peds; many pressure faces; noneffervescent; neutral (pH 6.8); abrupt wavy boundary.

R—24 inches; cherty limestone.

Range in Characteristics

Depth to bedrock: 20 to 40 inches; commonly 22 to 32 inches

A horizon:
Content of rock fragments—10 to 40 percent

Bw horizon:
Does not occur in some pedons

Bt horizon:
Texture—sandy clay, clay

Cr horizon:
Occurs above the R horizon in some pedons

Plaintank Series

Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Landform: Fan terraces
Parent material: Alluvium derived from sedimentary and igneous rocks
Slope range: 1 to 5 percent
Elevation: 4,600 to 5,000 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days
Classification: Loamy-skeletal, mixed, mesic, shallow Petrocalcic Ustollic Paleargids

Typical Pedon

Plaintank extremely gravelly loam, in an area of Plaintank-Barx complex, 1 to 5 percent slopes; about 2,400 feet north and 500 feet east of the southwest corner of sec. 11, T. 26 N., R. 12 W.

A—0 to 2 inches; yellowish brown (10YR 5/4) extremely gravelly loam, dark yellowish brown (10YR 4/4) moist; weak medium platy structure parting to weak fine granular; soft, very friable, nonsticky and slightly plastic; common very fine roots; many very fine irregular pores; 60 percent gravel; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Btk—2 to 12 inches; yellowish brown (10YR 5/4) gravelly loam, dark yellowish brown (10YR 4/4) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots; common fine and few very fine tubular pores; 15 percent gravel; common distinct clay films lining pores; few thin calcium carbonate coatings on rock fragments and faces of peds; violently effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

2Bk1—12 to 17 inches; yellowish brown (10YR 5/4) extremely cobbly loam, dark yellowish brown (10YR 4/4) moist; massive; hard, friable, slightly sticky and slightly plastic; few very fine roots; few very fine irregular pores; 15 percent gravel, 50 percent cobble-sized hardpan fragments; common thick calcium carbonate pendants under rock fragments; violently effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

2Bkm1—17 to 36 inches; indurated, calcium carbonate cemented hardpan; violently effervescent; clear wavy boundary.

3Bkm2—36 to 46 inches; pink (5YR 8/4) moderately cemented very gravelly sandy loam, pink (5YR 8/3) moist; weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few very fine roots in fractures; few very fine irregular pores; 40 percent gravel; violently effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

3Bk2—46 to 60 inches; brown (7.5YR 5/4) very gravelly sandy loam, dark brown (7.5YR 4/4) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; few very fine roots; few very fine irregular pores; 50 percent gravel; few thick calcium carbonate coatings on rock fragments; violently effervescent; moderately alkaline (pH 8.4).

Range in Characteristics

Depth to a hardpan: 10 to 20 inches
Content of rock fragments in the control section: 35 to 60 percent

Btk horizon:
Texture—loam, gravelly loam, cobbly loam

2Bk1 horizon:
Texture—very cobbly loam, extremely cobbly loam

Horizons underlying the hardpan are variable in texture and have weak to moderate cementation

Pocomate Series

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately slow
Landform: Hills and escarpments
Parent material: Limestone residuum and colluvium
Slope range: 15 to 55 percent
Elevation: 6,600 to 7,900 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 47 to 51 degrees F
Frost-free period: 120 to 150 days
Classification: Loamy-skeletal, mixed, mesic Lithic Argiustolls

Typical Pedon

Pocomate extremely cobbly loam, in an area of Pocomate-Rock outcrop complex, 15 to 55 percent slopes; about 600 feet west and 1,100 feet south of the northeast corner of sec. 15, T. 29 N., R. 8 W.

Oi—0.25 to 0 inch; slightly decomposed pine and leaf litter.
A—0 to 3 inches; dark brown (10YR 3/3) extremely cobbly loam, dark brown (7.5YR 3/2) moist; moderate fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular pores; 30 percent gravel, 35 percent cobble, 10 percent stones; noneffervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.
Bt—3 to 8 inches; dark brown (7.5YR 3/2) very gravelly clay loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure parting to moderate fine granular; slightly hard, very friable, sticky and plastic; many very fine roots and few fine to coarse roots; many very fine irregular and few very fine tubular pores; 40 percent gravel and 10 percent cobble; few faint clay films lining pores; noneffervescent; slightly alkaline (pH 7.6); clear wavy boundary.
Btk—8 to 13 inches; brown (10YR 4/3) extremely cobbly clay loam, dark brown (7.5YR 3/3) moist; weak fine and medium subangular blocky structure; slightly hard, friable, sticky and plastic; common very fine, fine, and medium roots; common very fine and fine tubular pores; 30 percent gravel, 40 percent cobble; few faint clay films lining pores; few fine and medium soft calcium carbonate masses and common thin coatings on undersides of rock fragments; violently effervescent; slightly alkaline (pH 7.8); abrupt irregular boundary.
R—13 inches; limestone bedrock; fractured in the upper 3 inches.

Range in Characteristics

Depth to bedrock: 8 to 20 inches
Content of clay: 25 to 35 percent

Bt horizon:
Texture—very gravelly and extremely gravelly, very cobbly and extremely cobbly loam or clay loam

Btk horizon:
Does not occur in some pedons

Poley Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Landform: Fan terraces
Parent material: Alluvium derived dominantly from limestone and sandstone
Slope range: 1 to 8 percent
Elevation: 4,700 to 6,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days
Classification: Fine, mixed, mesic Ustollic Haplargids

Typical Pedon

Poley loam, 1 to 5 percent slopes, about 850 feet west and 2,300 feet north of the southeast corner of sec. 15, T. 29 N., R. 6 W.

A—0 to 1 inch; brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) moist; weak medium platy structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many very fine vesicular pores; 5 percent gravel; noneffervescent; neutral (pH 7.0); abrupt smooth boundary.
E—1 to 3 inches; light yellowish brown (10YR 6/4) loam, yellowish brown (10YR 5/4) moist; weak thick platy structure; slightly hard, friable, slightly sticky and plastic; many very fine roots; many very fine tubular pores; noneffervescent; neutral (pH 6.8); abrupt smooth boundary.
Bt1—3 to 6 inches; reddish brown (5YR 5/4) clay loam, reddish brown (5YR 4/4) moist; weak medium prismatic structure parting to weak medium subangular blocky; hard, firm, sticky and plastic; common very fine roots; many very fine tubular pores; clay bridging sand grains; noneffervescent; neutral (pH 6.8); clear smooth boundary.
Bt2—6 to 14 inches; reddish brown (5YR 5/4) clay loam, reddish brown (5YR 4/4) moist; moderate medium

prismatic structure parting to moderate medium angular blocky; very hard, firm, sticky and very plastic; common very fine roots; common fine tubular pores; few faint clay films bridging sand grains; many pressure faces; noneffervescent; neutral (pH 6.9); clear smooth boundary.

Btk—14 to 27 inches; reddish brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; coarse medium prismatic structure parting to moderate medium angular blocky; very hard, very firm, very sticky and very plastic; few very fine roots; common very fine tubular pores; few faint clay films bridging sand grains; many pressure faces; few fine soft calcium carbonate masses; slightly effervescent; neutral (pH 7.3); abrupt smooth boundary.

Bk—27 to 60 inches; white (10YR 8/1) clay loam, very pale brown (10YR 7/3) moist; massive; hard, firm, sticky and plastic; few fine roots; few fine tubular pores; 5 percent gravel; many soft calcium carbonate masses and coatings on rock fragments; violently effervescent; slightly alkaline (pH 7.8).

Range in Characteristics

Depth to a calcic horizon: 20 to 40 inches

A horizon:
Texture—loam, gravelly loam

E horizon:
Does not occur in some pedons

Bt horizon:
Texture—clay loam, clay
Reaction—neutral or slightly alkaline

Bk horizon:
Texture—clay loam, clay
Calcium carbonate equivalent—15 to 40 percent
Reaction—neutral or slightly alkaline

Prieta Series

Depth class: Shallow
Drainage class: Well drained
Permeability: Slow
Landform: Mesas
Parent material: Basalt residuum
Slope range: 2 to 35 percent
Elevation: 5,400 to 5,800 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days
Classification: Clayey-skeletal, mixed, mesic Lithic Ustollic Haplargids

Typical Pedon

Prieta extremely cobbly loam, in an area of Prieta-Rock outcrop complex, 2 to 35 percent slopes; about 1,200 feet west and 1,300 feet north of the southeast corner of sec. 21, T. 29 N., R. 15 W.

A—0 to 1 inch; brown (10YR 4/3) extremely cobbly loam, brown (10YR 4/3) moist; moderate fine granular structure; soft, very friable, slightly sticky and slightly plastic; common very fine roots; many very fine irregular pores; 65 percent cobble, 15 percent stones; noneffervescent; neutral (pH 6.8); abrupt smooth boundary.

Bt—1 to 7 inches; brown (10YR 4/3) very cobbly clay loam, brown (10YR 4/3) moist; moderate fine subangular blocky structure; hard, firm, sticky and plastic; common very fine to medium roots; common very fine and fine tubular pores; few faint clay films lining pores and on faces of peds; 15 percent gravel, 30 percent cobble; noneffervescent; slightly alkaline (pH 7.6); clear wavy boundary.

Btk—7 to 17 inches; dark brown (7.5YR 3/4) extremely cobbly clay, dark brown (7.5YR 3/4) moist; hard, firm, sticky and very plastic; few very fine and fine roots; few very fine tubular pores; few faint clay films lining pores; 10 percent gravel, 60 percent cobble; noneffervescent with violently effervescent soft calcium carbonate masses; slightly alkaline (pH 7.7); abrupt wavy boundary.

R—17 inches; basalt.

Range in Characteristics

Depth to bedrock: 10 to 20 inches
Content of rock fragments in the control section: 60 percent

Bt horizon:
Texture—very cobbly or extremely cobbly silty clay loam, clay loam, clay
Reaction—neutral or slightly alkaline
Effervescence—noneffervescent or slightly effervescent

Puertecito Series

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately slow
Landform: Plateaus and mesas
Parent material: Colluvium and alluvium derived from the Kaibab Limestone Formation
Slope range: 1 to 12 percent
Elevation: 5,700 to 6,100 feet
Mean annual precipitation: 10 to 12 inches

Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days
Classification: Loamy-skeletal, mixed, mesic Lithic Ustollic Haplargids

Typical Pedon

Puertecito very gravelly loam, in an area of Curhollow-Puertecito complex, 1 to 12 percent slopes; about 2,200 feet west and 1,750 feet north of the southeast corner of sec. 21, T. 29 N., R. 7 W.

A—0 to 2 inches; yellowish brown (10YR 5/4) very gravelly loam, dark yellowish brown (10YR 4/4) moist; weak thick platy structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many very fine vesicular pores; 50 percent gravel; noneffervescent; neutral (pH 7.1); abrupt smooth boundary.

Bt1—2 to 6 inches; brown (7.5YR 4/4) very gravelly clay loam, dark brown (7.5YR 3/3) moist; weak fine subangular blocky structure; hard, friable, sticky and plastic; many very fine roots; common very fine tubular pores; 35 percent gravel; few faint clay films bridging sand grains and on faces of peds; noneffervescent; neutral (pH 7.0); clear smooth boundary.

Bt2—6 to 10 inches; brown (7.5YR 4/4) very gravelly clay loam, dark brown (7.5YR 3/3) moist; weak fine subangular blocky structure; hard, firm, sticky and plastic; common very fine roots; common very fine tubular pores; 50 percent gravel; few faint clay films bridging sand grains and on faces of peds; few thick calcium carbonate pendants on undersides of rock fragments; noneffervescent; neutral (pH 7.1); clear smooth boundary.

Btk—10 to 13 inches; brown (7.5YR 4/3) very gravelly loam, dark brown (7.5YR 3/3) moist; weak fine subangular blocky structure; hard, friable, sticky and plastic; common very fine roots; common very fine tubular pores; 55 percent gravel; few faint clay films bridging sand grains and on faces of peds; common thin calcium carbonate coatings on undersides of rock fragments; strongly effervescent, 11 percent calcium carbonate equivalent; neutral (pH 7.2); abrupt smooth boundary.

2R—13 inches; cherty limestone.

Range in Characteristics

Depth to bedrock: 8 to 20 inches
Content of rock fragments in the control section: 35 to 55 percent, with less than 10 percent cobble

Bt horizon:
Texture—gravelly to very gravelly loam, clay loam

Btk horizon:
Content of lime—8 to 15 percent above the hardpan

Quagwa Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderate
Landform: Draws
Parent material: Alluvium derived dominantly from limestone
Slope range: 1 to 3 percent
Elevation: 5,100 to 5,900 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days
Classification: Fine-loamy, mixed, mesic Ustollic Haplargids

Typical Pedon

Quagwa silt loam, 1 to 3 percent slopes, about 2,500 feet east and 900 feet north of the southwest corner of sec. 10, T. 25 N., R. 10 W.

A—0 to 2 inches; light brown (7.5YR 6/4) silt loam, dark brown (7.5YR 4/4) moist; weak medium platy structure; slightly hard, very friable, sticky and slightly plastic; many very fine roots; many very fine irregular pores; slightly effervescent; slightly alkaline (pH 7.5); abrupt smooth boundary.

BW—2 to 5 inches; brown (7.5YR 5/4) silt loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, very friable, sticky and slightly plastic; many very fine roots; common very fine and few fine tubular pores; slightly effervescent; slightly alkaline (pH 7.5); abrupt smooth boundary.

Bt—5 to 14 inches; brown (7.5YR 5/4) silt loam, dark brown (7.5YR 4/4) moist; moderate coarse subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine roots; many very fine and few fine tubular pores; slightly effervescent; slightly alkaline (pH 7.6); abrupt smooth boundary.

Btk1—14 to 30 inches; dark brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/3) moist; moderate coarse prismatic structure parting to moderate medium subangular blocky; hard, friable, sticky and slightly plastic; few very fine roots; common very fine and few fine tubular pores; few fine soft calcium carbonate filaments and thin coatings lining pores and on faces of peds; violently effervescent; slightly alkaline (pH 7.7); clear wavy boundary.

Btk2—30 to 50 inches; dark brown (7.5YR 4/4) clay loam, dark brown (7.5YR 3/4) moist; weak coarse prismatic structure parting to moderate medium subangular blocky; hard, friable, slightly sticky and slightly plastic; few very fine roots; few very fine tubular pores; common fine soft calcium carbonate masses and thin coatings lining pores and on faces of peds; violently

effervescent; slightly alkaline (pH 7.7); abrupt wavy boundary.

Btk3—50 to 62 inches; strong brown (7.5YR 5/6) loam, strong brown (7.5YR 4/6) moist; weak medium prismatic structure; hard, friable, slightly sticky and slightly plastic; few very fine roots; few very fine tubular pores; few thin calcium carbonate coatings lining pores; violently effervescent; slightly alkaline (pH 7.8).

Range in Characteristics

Calcium carbonate equivalent: 1 to 14 percent

Subsoil:

Texture—loam, silt loam, clay loam

Quartermaster Series

Depth class: Moderately deep to a hardpan
Drainage class: Well drained
Permeability: Moderate
Landform: Fan terraces
Parent material: Alluvium derived from limestone and basalt
Slope range: 2 to 12 percent
Elevation: 4,600 to 5,500 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 120 to 160 days
Classification: Fine-loamy, mixed, mesic Aridic Ustochrepts

Typical Pedon

Quartermaster extremely gravelly sandy loam, in an area of Milkweed-Quartermaster-Buckndoe complex, 2 to 20 percent slopes; approximately 2,200 feet west and 2,600 feet south of the northeast corner of sec. 31, T. 28 N., R. 14 W.

A—0 to 2 inches; yellowish brown (10YR 5/4) extremely gravelly sandy loam, dark yellowish brown (10YR 4/4) moist; weak thick platy structure parting to moderate fine granular; soft, very friable, nonsticky and nonplastic; many very fine roots; many very fine interstitial pores; 85 percent gravel; violently effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

Bw—2 to 8 inches; yellowish brown (10YR 5/4) loam, dark yellowish brown (10YR 4/4) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular and irregular pores; 12 percent gravel; violently effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Bk1—8 to 19 inches; yellowish brown (10YR 5/4) loam, dark yellowish brown (10YR 4/4) moist; moderate coarse subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine and few fine and medium roots; common very fine and few fine tubular pores; 10 percent gravel; few fine soft calcium carbonate masses; violently effervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

Bk2—19 to 26 inches; yellowish brown (10YR 5/4) cobbly loam, dark yellowish brown (10YR 4/4) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine roots and few fine, medium, and coarse roots; few very fine tubular pores; 10 percent gravel, 15 percent cobble-sized limestone and hardpan fragments; many thick calcium carbonate pendants under rock fragments; violently effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

Bkm—26 inches; indurated, laminar capped hardpan.

Range in Characteristics

Depth to a hardpan: 20 to 40 inches
Content of rock fragments in the control section: 5 to 30 percent
Content of gravel on the surface: 40 to 85 percent
Reaction: Slightly alkaline or moderately alkaline

Bw horizon:

Texture—sandy loam, loam, sandy clay loam

Bk horizon:

Texture of fine earth—loam, sandy clay loam, cobbly loam

Cementation—weakly cemented to strongly cemented with calcium carbonate in the lower part

Retsover Series

Depth class: Deep
Drainage class: Well drained
Permeability: Slow
Landform: Mesas and plateaus
Parent material: Limestone residuum and local alluvium
Slope range: 1 to 15 percent
Elevation: 6,600 to 7,400 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 47 to 51 degrees F
Frost-free period: 120 to 150 days
Classification: Fine, montmorillonitic, mesic Vertic Haplustalfs

Typical Pedon

Retsover gravelly loam, in an area of Pinntank-Pocomate-Retsover complex, 1 to 30 percent slopes; about 2,400 feet east and 1,800 feet north of the southwest corner sec. 27, T. 29 N., R. 8 W.

Oi—2 to 1 inch; recent pine litter.

Oe—1 to 0 inch; partially decomposed leaf litter.
A—0 to 1 inch; dark brown (10YR 3/3) gravelly loam, very dark brown (10YR 2/3) moist; moderate fine granular structure; soft, very friable, slightly sticky and slightly plastic; common very fine roots; many very fine irregular pores; 15 percent gravel; noneffervescent; slightly acid (pH 6.3); abrupt smooth boundary.
E—1 to 3 inches; brown (10YR 4/3) loam, dark brown (10YR 3/3) moist; moderate thick platy structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular pores and common very fine and fine tubular pores; noneffervescent; slightly acid (pH 6.1); abrupt wavy boundary.
Bt1—3 to 9 inches; dark brown (10YR 3/3) clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and plastic; common very fine roots and few fine and medium roots; common very fine and few fine tubular pores; 5 percent gravel; few faint clay films lining pores; noneffervescent; slightly acid (pH 6.1); abrupt wavy boundary.
Bt2—9 to 19 inches; reddish brown (5YR 4/4) clay, reddish brown (5YR 4/4) moist; moderate coarse prismatic structure; very hard, very firm, very sticky and very plastic; common very fine roots and few fine, medium, and coarse roots; few very fine tubular pores; 5 percent gravel; common faint and distinct clay films lining pores; many pressure faces; noneffervescent; slightly acid (pH 6.4); clear wavy boundary.
Bt3—19 to 34 inches; reddish brown (5YR 4/4) clay, reddish brown (5YR 4/4) moist; strong coarse prismatic structure; very hard, very firm, very sticky and very plastic; few very fine, fine, and coarse roots and common medium roots; few very fine tubular pores; 10 percent gravel; common faint clay films on faces of peds; many pressure faces; noneffervescent; neutral (pH 6.8); abrupt irregular boundary.
Btk—34 to 44 inches; yellowish red (5YR 4/6) and reddish yellow (5YR 7/6) very cobbly clay, reddish brown (5YR 4/4) and reddish yellow (5YR 6/6) moist; weak fine subangular blocky structure; very hard, very firm, very sticky and very plastic; few very fine and fine roots; few very fine tubular pores; 25 percent gravel, 30 percent cobble; few faint clay films on faces of peds; common coarse soft calcium carbonate masses; noneffervescent matrix with violently effervescent concentrations; slightly alkaline (pH 7.4); abrupt wavy boundary.
R—44 inches; limestone.

Range in Characteristics

Depth to bedrock: 40 to 60 inches

A horizon:
Texture—gravelly loam, clay loam

E horizon (if it occurs):
Texture—loam, clay loam

Bt horizon:
Texture—clay loam, clay

Btk horizon:
Texture—very cobbly clay

Rizno Series

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately rapid
Landform: Structural benches on the Esplanade in the Grand Canyon
Parent material: Eolian deposits, alluvium, and residuum derived from sandstone of the Supai Formation
Slope range: 2 to 15 percent
Elevation: 4,000 to 5,500 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 56 to 58 degrees F
Frost-free period: 140 to 180 days
Classification: Loamy, mixed (calcareous), mesic Lithic Ustic Torriorthents

Typical Pedon

Rizno fine sandy loam, in an area of Rizno-Rock outcrop complex, 2 to 15 percent slopes; about 35 degrees, 54 minutes, 9 seconds north latitude and 113 degrees, 14 minutes, 56 seconds west longitude.

A—0 to 3 inches; yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; weak thick platy structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; many very fine roots; common very fine irregular pores; slightly effervescent; slightly alkaline (pH 7.4); clear smooth boundary.
Bw—3 to 8 inches; yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; many very fine roots and few fine and coarse roots; few very fine tubular pores; slightly effervescent; slightly alkaline (pH 7.4); abrupt smooth boundary.
R—8 inches; thin bedded, red sandstone.

Range in Characteristics

Depth to bedrock: 4 to 10 inches
Content of clay: 5 to 18 percent
Content of rock fragments: 0 to 35 percent

Bw or C horizon:
Texture—very fine sandy loam, fine sandy loam

Rolie Series

Depth class: Very shallow and shallow to a hardpan
Drainage class: Well drained
Permeability: Moderate
Landform: Fan terraces
Parent material: Alluvium derived from limestone, dominantly the Willow Springs Formation
Slope range: 1 to 20 percent
Elevation: 4,500 to 6,100 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 53 to 58 degrees F
Frost-free period: 135 to 175 days
Classification: Loamy, mixed, mesic, shallow Ustollic Paleorthids

Typical Pedon

Rolie very gravelly loam (fig. 20), in an area of Poley-Rolie complex, 1 to 8 percent slopes; about 1,800 feet east and 1,000 feet south of the northwest corner of sec. 1, T. 29 N., R. 6 W.

A—0 to 1 inch; yellowish brown (10YR 5/4) very gravelly loam, dark yellowish brown (10YR 4/4) moist; weak thick platy structure; slightly hard, friable, slightly sticky and slightly plastic; many fine roots; many very fine vesicular pores; 40 percent gravel; strongly effervescent; slightly alkaline (pH 7.7); abrupt smooth boundary.

Bk1—1 to 4 inches; dark yellowish brown (10YR 4/4) gravelly loam, dark yellowish brown (10YR 3/4) moist; moderate fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many very fine tubular pores; 20 percent gravel; common thin calcium carbonate coatings on rock fragments; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Bk2—4 to 9 inches; dark yellowish brown (10YR 4/4) cobbly loam, dark yellowish brown (10YR 3/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular pores; 10 percent gravel, 20 percent cobble; common thick calcium carbonate coatings on rock fragments; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Bkm1—9 to 15 inches; fractured, calcium carbonate cemented hardpan with roots and soil along fractures; abrupt smooth boundary.

Bkm2—15 to 60 inches; indurated, calcium carbonate cemented hardpan.

Range in Characteristics

Depth to a hardpan: 6 to 20 inches
Content of rock fragments in the control section: 5 to 35 percent
Content of clay: 20 to 27 percent

Bk horizon:
Texture—gravelly or cobbly loam, silt loam
Reaction—slightly alkaline or moderately alkaline

Saemo Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Moderately slow
Landform: Fan terraces
Parent material: Mixed alluvium
Slope range: 2 to 45 percent
Elevation: 4,000 to 4,800 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days
Classification: Loamy-skeletal, mixed, mesic Ustollic Haplargids

Typical Pedon

Saemo extremely gravelly sandy loam, 2 to 45 percent slopes, about 700 feet east and 1,700 feet north of the southwest corner of sec. 10, T. 25 N., R. 11 W.

A—0 to 2 inches; brown (10YR 5/3) extremely gravelly sandy loam, dark brown (10YR 3/3) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; common very fine roots; many very fine irregular pores; 65 percent gravel, 3 percent cobble, and 2 percent stones; noneffervescent; neutral (pH 6.8); abrupt smooth boundary.

Bt1—2 to 16 inches; dark brown (7.5YR 4/4) very gravelly sandy clay loam, dark brown (7.5YR 4/4) moist; weak medium prismatic structure; very hard, firm, sticky and plastic; common very fine and fine roots and few medium and coarse roots; common very fine and fine tubular pores; 40 percent gravel, 5 percent cobble; common faint and distinct clay films lining pores and on faces of peds; noneffervescent; neutral (pH 6.8); abrupt wavy boundary.

Bt2—16 to 26 inches; strong brown (7.5YR 4/6) very gravelly coarse sandy loam, strong brown (7.5YR 4/6) moist; weak fine subangular blocky structure; hard, friable, nonsticky and nonplastic; common very fine roots and few fine roots; few very fine tubular pores; 40 percent gravel, 10 percent cobble; few faint clay films bridging sand grains; noneffervescent; neutral (pH 6.8); abrupt wavy boundary.

2C1—26 to 34 inches; strong brown (7.5YR 5/6) extremely cobbly loamy coarse sand, strong brown (7.5YR 4/6) moist; massive; slightly hard, friable, nonsticky and nonplastic; few very fine and fine roots; few fine irregular pores; 30 percent gravel, 50 percent cobble; noneffervescent; neutral (pH 7.0); clear wavy boundary.

2C2—34 to 60 inches; strong brown (7.5YR 5/6) extremely cobbly coarse sand, strong brown (7.5YR 4/6) moist; massive; slightly hard, very friable, nonsticky and nonplastic; common very fine and fine roots; common very fine irregular pores; 40 percent gravel, 35 percent cobble; few thin calcium carbonate coatings under rock fragments; noneffervescent matrix with slightly effervescent calcium carbonate concentrations; neutral (pH 7.2).

Range in Characteristics

Content of calcium carbonate in the lower subsoil and substratum: 0 to 10 percent
Content of rock fragments: 35 to 50 percent
Depth to the C horizon: 24 to more than 40 inches

Bt horizon:
Texture—very gravelly coarse sandy loam, sandy loam, sandy clay loam
Content of clay: 18 to 35 percent

C horizon:
Texture—extremely cobbly loamy coarse sand, extremely cobbly coarse sand

Sazi Series

Depth class: Moderately deep
Drainage class: Well drained
Permeability: Moderately rapid
Landform: Mesas
Parent material: Alluvium and eolian deposits derived from sandstone and limestone
Slope range: 1 to 5 percent
Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 10 to 11 inches
Mean annual soil temperature: 55 to 58 degrees F
Frost-free period: 140 to 170 days
Classification: Coarse-loamy, mixed, mesic Ustollic Calciorthids

Typical Pedon

Sazi very gravelly fine sandy loam, 1 to 5 percent slopes, about 700 feet west and 1,800 feet north of the southeast corner of sec. 8, T. 30 N., R. 14 W.

A—0 to 2 inches; light brown (7.5YR 6/4) very gravelly fine sandy loam, brown (7.5YR 5/4) moist; weak medium platy structure; soft, very friable, nonsticky and nonplastic; few very fine roots; common very fine irregular pores; 35 percent gravel; violently effervescent, 10 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Bw—2 to 10 inches; light brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; many very fine roots; common very fine tubular pores; 10 percent gravel; violently effervescent, 10 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); clear wavy boundary.

Bk1—10 to 19 inches; light brown (7.5YR 6/4) gravelly fine sandy loam, brown (7.5YR 5/4) moist; moderate coarse subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine roots; common very fine tubular pores; 15 percent gravel; violently effervescent, 15 percent calcium carbonate equivalent; slightly alkaline (pH 7.7); clear wavy boundary.

Bk2—19 to 25 inches; light brown (7.5YR 6/4) fine sandy loam; brown (7.5YR 5/4) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine roots; few very fine tubular pores; 10 percent gravel; violently effervescent, 16 percent calcium carbonate equivalent; moderately alkaline (pH 7.9); abrupt wavy boundary.

Cr—25 to 32 inches; fractured and weathered sandstone; thin calcium carbonate coatings in fractures.

R—32 inches; calcareous sandstone.

Range in Characteristics

Depth to bedrock: 20 to 40 inches
Content of rock fragments in the control section: 10 percent
Cr horizon: Does not occur in some pedons

Splanod Series

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Landform: Mesas or major structural benches on the Esplanade in the Grand Canyon
Parent material: Residuum and alluvium derived dominantly from sandstone of the Supai Formation
Slope range: 2 to 15 percent
Elevation: 4,000 to 4,800 feet
Mean annual precipitation: 8 to 10 inches
Mean annual soil temperature: 59 to 62 degrees F
Frost-free period: 180 to 200 days
Classification: Loamy, mixed (calcareous), thermic Lithic Torriorthents

Typical Pedon

Splanod very gravelly fine sandy loam, in an area of Splanod-Rock outcrop complex, 2 to 15 percent slopes; near the confluence of National Canyon and the Grand Canyon; approximately 3,500 feet west and 1,000 feet north of the projected southeast corner of sec. 14, T. 32 N., R. 6 W.

A—0 to 1 inch; red (2.5YR 5/6) very gravelly fine sandy loam, dark red (2.5YR 3/6) moist; moderate thick platy structure parting to moderate fine granular; soft, very friable, nonsticky and slightly plastic; few very fine roots; many very fine vesicular pores; 40 percent gravel and 10 percent cobble; strongly effervescent, 30 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Bw—1 to 7 inches; red (2.5YR 4/6) gravelly sandy clay loam, dark red (2.5YR 3/6) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common very fine roots; common very fine tubular pores; 15 percent gravel; strongly effervescent, 33 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); abrupt smooth boundary.

R—7 inches; thin bedded sandstone.

Range in Characteristics

Depth to sandstone or sandy shale: 6 to 20 inches

Bk horizon (if it occurs):
Texture—fine sandy loam or loam

Bw horizon:
Texture—fine sandy loam or gravelly sandy clay loam

Sponiker Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Landform: Draws and stream terraces
Parent material: Alluvium derived from sedimentary rocks
Slope range: 1 to 4 percent
Elevation: 6,500 to 6,700 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 47 to 51 degrees F
Frost-free period: 120 to 150 days
Classification: Fine, montmorillonitic, mesic Pachic Argiustolls

Typical Pedon

Sponiker loam, 1 to 4 percent slopes, 2 miles northwest of Thorton Lookout, about 300 feet west and 2,500 feet south of the northeast corner of sec. 19, T. 29 N., R. 7 W.

A—0 to 3 inches; dark brown (10YR 3/3) loam, very dark brown (10YR 2/2) moist; moderate thick platy structure parting to moderate fine granular; soft, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular pores; 5 percent gravel; noneffervescent; neutral (pH 6.8); abrupt smooth boundary.

Bw—3 to 8 inches; dark brown (7.5YR 3/3) clay loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots and few fine roots; many very fine tubular pores; noneffervescent; neutral (pH 7.0); abrupt wavy boundary.

Bt1—8 to 15 inches; dark brown (7.5YR 3/3) silty clay loam, dark brown (7.5YR 3/3) moist; moderate medium prismatic structure; slightly hard, friable, sticky and plastic; many very fine roots and few fine and medium roots; common very fine and few fine tubular pores; common distinct clay films lining pores; noneffervescent; neutral (pH 7.0); abrupt smooth boundary.

Bt2—15 to 31 inches; dark brown (7.5YR 3/2) silty clay loam, dark brown (7.5YR 3/2) moist; moderate coarse prismatic structure parting to strong medium subangular blocky; very hard, firm, sticky and very plastic; common very fine roots and few fine and medium roots; common very fine and fine tubular pores; common distinct clay films lining pores and on faces of peds; noneffervescent; neutral (pH 7.0); clear wavy boundary.

Bt3—31 to 52 inches; brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) moist; moderate medium subangular blocky structure; hard, friable, sticky and plastic; common very fine and fine roots; common very fine and few fine tubular pores; common distinct clay films lining pores and on faces of peds; noneffervescent; neutral (pH 7.2); clear wavy boundary.

Bt4—52 to 62 inches; brown (7.5YR 4/4) clay loam, dark brown (7.5YR 3/4) moist; weak medium subangular blocky structure; hard, friable, sticky and plastic; few very fine roots; few very fine and fine tubular pores; few distinct clay films lining pores and on faces of peds; noneffervescent; slightly alkaline (pH 7.6).

Range in Characteristics

Thickness of a mollic epipedon: More than 30 inches
Content of clay in the control section: 35 to 50 percent

Bw horizon:
Texture—loam, clay loam

Bt1, Bt2, and Bt3 horizons:
Texture—clay loam, silty clay loam, clay

Bt4 horizon:
Texture—loam, clay loam
Reaction—neutral or slightly alkaline

Tenderfoot Series

Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderately slow
Landform: Plateaus and mesas
Parent material: Alluvium derived dominantly from cherty limestone
Slope range: 1 to 8 percent
Elevation: 5,700 to 6,100 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days
Classification: Loamy-skeletal, mixed, mesic, shallow Petrocalcic Ustollic Paleargids

Typical Pedon

Tenderfoot very gravelly loam, in an area of Curhollow-Tenderfoot complex, 1 to 8 percent slopes; about 2,100 feet west and 1,600 feet north of the southeast corner of sec. 9, T. 32 N., R. 5 W.

A—0 to 3 inches; reddish brown (5YR 5/4) very gravelly loam, reddish brown (5YR 4/4) moist; weak thick platy structure parting to moderate fine granular; soft, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular and vesicular pores; 35 percent gravel; noneffervescent; neutral (pH 6.9); abrupt smooth boundary.

Bt—3 to 9 inches; yellowish red (5YR 4/6) clay loam, reddish brown (5YR 4/4) moist; moderate coarse subangular blocky structure; hard, friable, sticky and plastic; many very fine roots; many very fine tubular pores; 10 percent gravel; few faint clay films lining pores; noneffervescent; neutral (pH 6.9); abrupt wavy boundary.

Bk—9 to 17 inches; reddish brown (5YR 4/4) extremely cobbly clay loam, dark reddish brown (5YR 3/4) moist; moderate fine subangular blocky structure; slightly hard, friable, sticky and slightly plastic; common very fine and fine roots; few very fine tubular pores; 25 percent gravel, 50 percent cobble, dominantly hardpan fragments; few thin calcium carbonate coatings lining pores and on rock fragments; slightly effervescent; neutral (pH 7.0); abrupt wavy boundary.

Bkm—17 to 23 inches; indurated, calcium carbonate cemented hardpan.

R—23 inches; limestone.

Range in Characteristics

Depth to a petrocalcic horizon: 10 to 20 inches, commonly 14 to 20 inches
Depth to limestone: 16 to 40 inches
Content of rock fragments in the control section: 35 to 65 percent gravel and hardpan fragments

Bt horizon:
Texture—sandy clay loam, loam, clay loam
Reaction—neutral or slightly alkaline

Bk horizon:
Texture—very cobbly fine sandy loam, sandy clay loam, loam, clay loam, extremely cobbly clay loam
Reaction—neutral or slightly alkaline

Theecan Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Landform: Fan terraces
Parent material: Mixed alluvium derived from Frazier Well Gravels Formation
Slope range: 2 to 35 percent
Elevation: 6,200 to 6,800 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 120 to 150 days
Classification: Fine, montmorillonitic, mesic Vertic Paleustalfs

Typical Pedon

Theecan very cobbly sandy loam, in an area of Theecan-Pinespring association, 2 to 35 percent slopes; about 1,400 feet west and 850 feet south of the northeast corner of sec. 17, T. 28 N., R. 7 W.

A—0 to 2 inches; brown (10YR 5/3) very cobbly sandy loam, very dark grayish brown (10YR 3/2) moist; moderate medium coarse platy structure parting to moderate fine granular; slightly hard, very friable, nonsticky and nonplastic; common very fine roots and few fine roots; common very fine irregular pores; 25 percent gravel, 20 percent cobble; noneffervescent; neutral (pH 6.6); abrupt smooth boundary.

BA—2 to 5 inches; dark brown (7.5YR 4/2) sandy clay loam, dark brown (7.5YR 3/2) moist; moderate medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine and fine roots; common very fine irregular and tubular pores; noneffervescent; neutral (pH 6.6); abrupt smooth boundary.

Bt1—5 to 9 inches; dark brown (7.5YR 4/2) and yellowish red (5YR 4/6) sandy clay, dark brown (7.5YR 3/2) and

yellowish red (5YR 4/6) moist; weak coarse prismatic structure; hard, firm, sticky and very plastic; few very fine and medium roots and common fine roots; common very fine irregular pores; common faint clay films lining pores and on faces of peds; common pressure faces; noneffervescent; neutral (pH 6.6); clear smooth boundary.

Bt2—9 to 23 inches; yellowish red (5YR 4/6) clay, yellowish red (5YR 4/6) moist; moderate coarse prismatic structure; very hard, very firm, very sticky and very plastic; few very fine and fine roots and common medium roots; common very fine irregular pores and few very fine tubular pores; common faint clay films lining pores and on faces of peds; few pressure faces; noneffervescent; neutral (pH 6.8); gradual smooth boundary.

Bt3—23 to 33 inches; yellowish red (5YR 4/6) sandy clay, yellowish red (5YR 4/6) moist; weak coarse prismatic structure; very hard, firm, very sticky and very plastic; few fine to medium roots; common fine irregular pores and few fine tubular pores; common faint clay films lining pores and on faces of peds; few pressure faces; common faint sand coatings on faces of peds; noneffervescent; neutral (pH 7.0); gradual smooth boundary.

Bt4—33 to 40 inches; yellowish red (5YR 5/6) and strong brown (7.5YR 5/6) sandy clay, yellowish red (5YR 4/6) and strong brown (7.5YR 4/6) moist; moderate medium prismatic structure; hard, firm, sticky and very plastic; few very fine and fine roots; common very fine irregular pores and few very fine tubular pores; common faint clay films lining pores and on faces of peds; noneffervescent to slightly effervescent; neutral (pH 7.2) abrupt smooth boundary.

2C—40 to 58 inches; yellowish red (5YR 5/6) and strong brown (7.5YR 5/6) extremely gravelly loamy coarse sand, yellowish red (5YR 4/6) moist; massive; slightly hard, very friable, nonsticky and nonplastic; few very fine to medium roots; common very fine and fine irregular pores; 65 percent gravel, 10 percent cobble; noneffervescent to slightly effervescent; neutral (pH 7.2); abrupt smooth boundary.

3C—58 to 65 inches; yellowish red (5YR 5/6) and strong brown (7.5YR 5/6) sandy clay loam, yellowish red (5YR 5/6) moist; massive; slightly hard, friable, slightly sticky and plastic; few very fine and fine roots; common very fine irregular pores; noneffervescent to slightly effervescent; neutral (pH 7.2).

Range in Characteristics

Depth to an argillic horizon: 4 to 10 inches
Texture in the control section: Clay or sandy clay
Content of clay: 35 to 50 percent
Content of rock fragments in the control section: Less than 15 percent

Bt horizon:
Texture—sandy clay, clay
Calcium carbonate equivalent—less than 5 percent

C horizon:
Texture—stratified sandy clay loam and extremely gravelly loamy coarse sand
Calcium carbonate equivalent—0 to 10 percent

Thunderbird Series

Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Landform: Hills and mesas
Parent material: Residuum and alluvium derived from rhyolite and basalt
Slope range: 3 to 20 percent
Elevation: 4,900 to 5,400 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 57 degrees F
Frost-free period: 120 to 160 days
Classification: Fine, montmorillonitic, mesic Aridic Argiustolls

Typical Pedon

Thunderbird very cobbly fine sandy loam, in an area of Luzena-Thunderbird complex, 3 to 20 percent slopes; about 1,850 feet north and 950 feet west of the southeast corner of sec. 25, T. 26 N., R. 14 W.

A—0 to 2 inches; dark brown (10YR 4/3) very cobbly fine sandy loam, very dark grayish brown (10YR 3/3) moist; strong thick platy structure; slightly hard, very friable, nonsticky and nonplastic; common very fine roots; many very fine and common fine irregular and vesicular pores; 20 percent gravel, 20 percent cobble, 5 percent stones; noneffervescent; neutral (pH 6.8); abrupt smooth boundary.

Bt1—2 to 6 inches; dark brown (10YR 4/3) cobbly loam, dark brown (10YR 3/3) moist; moderate thick platy structure parting to moderate medium subangular blocky; slightly hard, very friable, sticky and slightly plastic; many very fine and few fine roots; common very fine and fine tubular pores; 5 percent gravel, 10 percent cobble; few faint clay films lining pores; noneffervescent; neutral (pH 6.8); abrupt wavy boundary.

Bt2—6 to 11 inches; dark brown (10YR 4/3) clay loam, dark brown (10YR 2/3) moist; moderate fine and medium subangular blocky structure; hard, friable, sticky and plastic; many very fine and fine roots and

few medium and coarse roots; common very fine and fine and few medium tubular pores; 5 percent gravel, 5 percent cobble; common faint clay films lining pores and on faces of peds; noneffervescent; neutral (pH 7.0); clear wavy boundary.

Bt3—11 to 24 inches; brown (7.5YR 4/3) cobbly clay, dark brown (7.5YR 3/3) moist; weak medium prismatic structure parting to moderate medium subangular blocky; hard, firm, sticky and plastic; common very fine, fine, and medium roots and few coarse roots; many very fine and few fine tubular pores; 5 percent gravel, 10 percent cobble; common faint clay films lining pores and on faces of peds; noneffervescent; neutral (pH 7.0); abrupt wavy boundary.

R—24 inches; hard rhyolite, fractured and weathered in the upper 2 to 3 inches.

Range in Characteristics

Depth to bedrock: 20 to 40 inches
Content of clay in the control section: 35 to 60 percent

Upper subsoil:
Texture—loam, clay loam, cobbly loam

Lower subsoil:
Texture—clay loam, cobbly clay

Topocoba Series

Depth class: Shallow to a hardpan
Drainage class: Well drained
Permeability: Moderately slow
Landform: Plateaus and mesas
Parent material: Alluvium derived from limestone and sandstone
Slope range: 2 to 8 percent
Elevation: 5,800 to 6,200 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 130 to 160 days
Classification: Loamy-skeletal, mixed, mesic, shallow Petrocalcic Paleustalfs

Typical Pedon

Topocoba gravelly very fine sandy loam, in an area of Topocoba-Wodomont association, 2 to 15 percent slopes; about 1,200 feet south and 1,600 feet west of the northeast corner of sec. 8, T. 32 N., R. 2 W.

A—0 to 1 inch; brown (7.5YR 5/4) gravelly very fine sandy loam, dark brown (7.5YR 4/4) moist; weak fine granular structure; soft, very friable, nonsticky and slightly plastic; common very fine roots; common very fine irregular pores; 20 percent gravel; slightly effervescent; neutral (pH 6.9); abrupt smooth boundary.

Bt—1 to 6 inches; reddish brown (5YR 4/4) gravelly sandy clay loam, dark reddish brown (5YR 3/4) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular pores; 15 percent gravel; 5 percent cobble; few faint clay films lining pores; slightly effervescent; neutral (pH 7.3); abrupt smooth boundary.

Bk1—6 to 12 inches; reddish brown (5YR 4/4) extremely cobbly sandy clay loam, dark reddish brown (5YR 3/4) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; few very fine tubular pores; 30 percent gravel, 30 percent cobble; strongly effervescent; slightly alkaline (pH 7.5); abrupt wavy boundary.

Bk2—12 to 17 inches; reddish brown (5YR 5/4) extremely cobbly sandy clay loam, reddish brown (5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few very fine roots; 10 percent gravel, 60 percent cobble, 10 percent stones; violently effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

2Bkm—17 to 22 inches; indurated calcium carbonate cemented hardpan.

3R—22 inches; limestone.

Range in Characteristics

Depth to a hardpan: 10 to 20 inches
Depth to bedrock: 15 to 40 inches
Content of rock fragments in the control section: 35 to 70 percent

Bt horizon:
Texture—gravelly sandy clay loam, loam, clay loam

Bk horizon:
Texture—extremely cobbly sandy clay loam, loam, clay loam
Content of calcium carbonate—10 to 30 percent in the subsoil

Toqui Series

Depth class: Shallow
Drainage class: Well drained
Permeability: Slow
Landform: Plateaus and mesas
Parent material: Alluvium and residuum derived dominantly from Muav limestone
Slope range: 1 to 15 percent
Elevation: 5,000 to 6,600 feet
Mean annual precipitation: 14 to 16 inches

Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 140 to 160 days
Classification: Clayey, montmorillonitic, mesic Lithic Haplustalfs

Typical Pedon

Toqui very gravelly loam, in an area of Toqui-Yumtheska complex, 2 to 30 percent slopes; about 200 feet east and 2,000 feet north of the southwest corner of sec. 13, T. 30 N., R. 7 W.

A—0 to 2 inches; brown (7.5YR 4/4) very gravelly loam, dark brown (7.5YR 3/4) moist; weak thick platy structure; soft, very friable, nonsticky and slightly plastic; many very fine roots; many very fine vesicular pores; 40 percent gravel; noneffervescent; neutral (pH 7.2); clear smooth boundary.

Bt—2 to 9 inches; reddish brown (5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky structure; hard, firm, sticky and plastic; many very fine roots; many fine tubular pores; 15 percent gravel; few faint clay films bridging sand grains; slightly effervescent; neutral (pH 6.9); clear smooth boundary.

Btk1—9 to 12 inches; reddish brown (5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) moist; moderate medium prismatic structure parting to moderate medium subangular blocky; very hard, very firm, very sticky and very plastic; common fine and medium roots; few fine tubular pores; 15 percent gravel; many faint clay films bridging sand grains; few thin calcium carbonate coatings on rock fragments; many pressure faces; strongly effervescent, 7 percent calcium carbonate equivalent; slightly alkaline (pH 7.4); clear smooth boundary.

Btk2—12 to 17 inches; reddish brown (5YR 5/4) gravelly clay, reddish brown (5YR 4/4) moist; moderate medium prismatic structure parting to moderate medium subangular blocky; very hard, very firm, very sticky and very plastic; many medium roots and few fine roots; few fine tubular pores; 20 percent gravel, 5 percent cobble; many thin clay films bridging sand grains; common thin calcium carbonate coatings on rock fragments; many pressure faces; strongly effervescent, 15 percent calcium carbonate equivalent; slightly alkaline (pH 7.6); abrupt smooth boundary.

2R1—17 to 20 inches; calcium carbonate coated fractured cherty limestone; few fine roots in fractures; abrupt smooth boundary.

2R2—20 inches; cherty limestone.

Range in Characteristics

Content of clay: More than 35 percent
Depth to bedrock: 10 to 20 inches
Content of calcium carbonate: 5 to 25 percent in the lower subsoil (calcium carbonate may not occur in soils derived from Muav limestone)
Reaction: Neutral or slightly alkaline

A horizon:
Texture—very gravelly loam, very fine sandy loam

B horizon:
Texture—gravelly clay, clay loam, loam

Torriorthents

Depth class: Very shallow to very deep
Drainage class: Excessively drained to well drained
Permeability: Moderate to rapid
Landform: Escarpments of canyons
Parent material: Colluvium and residuum derived from sedimentary rock
Slope range: 35 to 120 percent
Elevation: 2,000 to 5,000 feet
Mean annual precipitation: 8 to 12 inches
Mean annual soil temperature: 59 to 62 degrees F
Frost-free period: 130 to 170 days
Classification: Torriorthents

Reference Pedon

Torriorthents, in an area of Rock outcrop-Torriorthents complex, 35 to 120 percent slopes; about 1,500 feet east and 500 feet north of the southwest corner of sec. 15, T. 32 N., R. 4 W.

A—0 to 2 inches; brown (7.5YR 5/4) extremely gravelly loam, dark brown (7.5YR 4/4) moist; weak thin platy structure; soft, very friable, slightly sticky and nonplastic; many very fine roots; many very fine irregular pores; 65 percent gravel, 10 percent cobble, 5 percent stones, 5 percent boulders; violently effervescent; moderately alkaline (pH 8.2); abrupt irregular boundary.

Bw—2 to 6 inches; brown (7.5YR 5/4) extremely gravelly loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular pores; 35 percent gravel, 5 percent flagstones; violently effervescent; moderately alkaline (pH 8.2); clear wavy boundary.

C1—6 to 13 inches; light brown (7.5YR 6/4) very gravelly loam, brown (7.5YR 5/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; few very fine tubular pores; 50 percent gravel, 5 percent cobble; violently effervescent; moderately alkaline (pH 8.2); abrupt wavy boundary.

C2—13 to 30 inches; pinkish gray (7.5YR 6/2) extremely gravelly loam, brown (7.5YR 5/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; few very fine tubular pores; 60 percent gravel, 10 percent cobble; violently effervescent; moderately alkaline (pH 8.2); abrupt irregular boundary.

C3—30 to 46 inches; light brown (7.5YR 6/4) very gravelly loam, brown (7.5YR 5/4) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; few very fine tubular pores; 55 percent gravel; violently effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

C4—46 to 60 inches; light brown (7.5YR 6/4) very channery loam, brown (7.5YR 5/4) moist; massive; hard, friable, slightly sticky and slightly plastic; few very fine roots; few very fine tubular pores; 50 percent channers, 5 percent cobble, 5 percent stones; violently effervescent; moderately alkaline (pH 8.4).

Range in Characteristics

Highly variable in depth to bedrock, soil texture, and color but loamy-skeletal or sandy-skeletal in most areas.

Tovar Series

Depth class: Moderately deep
Drainage class: Well drained
Permeability: Slow
Landform: Structural benches, plateaus, and mesas
Parent material: Residuum, alluvium, and colluvium derived from sandstone and limestone dominantly from the Supai Formation
Slope range: 1 to 25 percent
Elevation: 5,000 to 6,600 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 52 to 56 degrees F
Frost-free period: 140 to 160 days
Classification: Fine, montmorillonitic, mesic Vertic Paleustalfs

Typical Pedon

Tovar extremely flaggy fine sandy loam, 2 to 25 percent slopes, about 1,600 feet east and 2,400 feet south of the northwest corner sec. 8, T. 26 N., R. 8 W.

A—0 to 1 inch; brown (10YR 5/3) extremely flaggy fine sandy loam, dark brown (10YR 4/3) moist; weak thin platy structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; few very fine roots; many very fine irregular pores; 50 percent channers, 25 percent flagstones, 10 percent stones; noneffervescent; neutral (pH 7.2); abrupt smooth boundary.

E—1 to 2 inches; pale brown (10YR 6/3) very fine sandy loam, dark brown (10YR 3/3) moist; weak thick platy structure; slightly hard, very friable, sticky and plastic; common very fine roots; many very fine vesicular pores; 10 percent channers; noneffervescent; neutral (pH 7.2); clear smooth boundary.

Bt1—2 to 10 inches; reddish brown (5YR 4/3) extremely flaggy clay loam, dark reddish brown (5YR 3/3) moist; moderate medium subangular blocky structure; hard, firm, sticky and plastic; many very fine and fine roots and few medium roots; many very fine and few fine tubular pores; 30 percent channers, 45 percent flagstones; common faint clay films lining pores and on faces of peds; noneffervescent; neutral (pH 7.2); abrupt smooth boundary.

Bt2—10 to 18 inches; yellowish red (5YR 4/6) channery clay, reddish brown (5YR 4/4) moist; strong coarse prismatic structure; very hard, very firm, very sticky and very plastic; common very fine and fine roots and few medium and coarse roots; common fine tubular pores; 20 percent channers; many faint clay films lining pores and on faces of peds; many pressure faces; noneffervescent; neutral (pH 7.2); clear smooth boundary.

Btk—18 to 29 inches; yellowish red (5YR 4/6) and reddish brown (5YR 5/3) flaggy clay, yellowish red (5YR 4/6) and reddish brown (5YR 4/3) moist; coarse medium angular blocky structure; very hard, very firm, very sticky and very plastic; few fine, medium, and coarse roots; few fine tubular pores; 10 percent channers, 10 percent flagstones; many faint clay films lining pores and on faces of peds; common pressure faces; common coarse soft calcium carbonate masses and coatings at bedrock contact; strongly effervescent; moderately alkaline (pH 8.0); abrupt irregular boundary.

R—29 inches; red sandstone.

Range in Characteristics

Depth to bedrock: 28 to 37 inches
Content of rock fragments in the control section: 5 to 35 percent

A horizon:
Texture—very fine sandy loam, extremely flaggy fine sandy loam, extremely cherty very fine sandy loam
Reaction—slightly acid to slightly alkaline

E horizon:
Does not occur in some pedons

Bt horizon:
Texture—extremely flaggy clay loam, extremely flaggy clay, channery clay, clay, clay loam

Reaction—neutral to moderately alkaline
Calcium carbonate equivalent—0 to 10 percent

Turkeytrack Series

Depth class: Very deep
Drainage class: Well drained
Permeability: Slow
Landform: Stream terraces and fan terraces
Parent material: Alluvium derived dominantly from igneous and sedimentary rocks
Slope range: 1 to 6 percent
Elevation: 6,500 to 6,900 feet
Mean annual precipitation: 18 to 20 inches
Mean annual soil temperature: 48 to 52 degrees F
Frost-free period: 120 to 150 days
Classification: Fine, montmorillonitic, mesic Vertic Paleustolls

Typical Pedon

Turkeytrack gravelly loam, 1 to 6 percent slopes, about 1,000 feet west and 300 feet south of the northeast corner sec. 31, T. 29 N., R. 7 W.

Oi—0.5 to 0 inch; slightly decomposed pine litter.
AE—0 to 2 inches; light brown (7.5YR 6/4) and brown (7.5YR 5/4) gravelly loam, dark brown (7.5YR 3/3) moist; moderate thick platy structure parting to weak fine granular; soft, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular pores; 15 percent gravel; noneffervescent; neutral (pH 7.0); abrupt smooth boundary.
Bw—2 to 9 inches; brown (7.5YR 5/3) loam, dark brown (7.5YR 3/3) moist; moderate medium prismatic structure; slightly hard, very friable, sticky and plastic; common very fine and fine roots and few medium roots; common very fine tubular pores; 5 percent gravel; noneffervescent; neutral (pH 6.8); clear smooth boundary.
Bt1—9 to 16 inches; reddish brown (5YR 4/3) cobbly clay, dark reddish brown (5YR 3/3) moist; strong medium prismatic structure; hard, firm, sticky and very plastic; many very fine and fine roots and common medium roots; common very fine tubular pores; 5 percent gravel, 10 percent cobble; common faint clay films lining pores and on faces of peds; few thin organic matter coatings lining pores; noneffervescent; neutral (pH 7.0); gradual smooth boundary.
Bt2—16 to 34 inches; reddish brown (5YR 5/4 and 5/3) gravelly clay, reddish brown (5YR 4/4) moist; strong coarse prismatic structure; very hard, very firm, very sticky and very plastic; common very fine roots and few fine and medium roots; few very fine tubular pores; 10 percent gravel, 5 percent cobble; common faint and distinct clay films lining pores and on faces of peds; noneffervescent; neutral (pH 7.0); clear wavy boundary.
Bt3—34 to 45 inches; yellowish red (5YR 5/6) gravelly clay, yellowish red (5YR 4/6) moist; strong coarse prismatic structure; very hard, very firm, very sticky and very plastic; few very fine and fine roots; few very fine tubular pores; 15 percent gravel, 10 percent cobble; many faint clay films lining pores and on faces of peds; noneffervescent; neutral (pH 7.2); clear wavy boundary.
Btk—45 to 62 inches; yellowish red (5YR 4/6) and pinkish white (5YR 8/2) very cobbly sandy clay, yellowish red (5YR 4/6) and pink (5YR 7/3) moist; strong medium angular blocky structure; very hard, very firm, sticky and very plastic; few very fine and fine roots; few very fine tubular pores; 30 percent gravel, 25 percent cobble; common faint and distinct clay films lining pores and on faces of peds; few medium soft calcium carbonate masses and coatings on rock fragments; noneffervescent matrix with violently effervescent concentrations; slightly alkaline (pH 7.8).

Range in Characteristics

Bw horizon:
Does not occur in some pedons

Bt horizon:
Texture—gravelly or cobbly clay, sandy clay

Btk horizon:
Texture—very cobbly sandy clay, clay
Calcium carbonate equivalent—1 to 15 percent below a depth of 45 inches

Tusayan Series

Depth class: Moderately deep
Drainage class: Well drained
Permeability: Moderate
Landform: Hills
Parent material: Alluvium derived dominantly from limestone
Slope range: 15 to 35 percent
Elevation: 5,600 to 6,000 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 135 to 175 days
Classification: Loamy-skeletal, carbonatic, mesic Ustollic Calciorthids

Typical Pedon

Tusayan extremely gravelly fine sandy loam, in an area of Winona-Rock outcrop-Tusayan complex, 15 to 55 percent

slopes; about 2,100 feet north and 2,600 feet west of the southeast corner of sec. 15, T. 32 N., R. 4 W.

A—0 to 4 inches; brown (10YR 5/3) extremely gravelly fine sandy loam, dark brown (10YR 4/3) moist; moderate fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular pores; 75 percent gravel; violently effervescent, 38 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); clear wavy boundary.

Bk1—4 to 13 inches; yellowish brown (10YR 5/4) very gravelly loam, dark yellowish brown (10YR 4/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; many very fine tubular pores; 50 percent gravel; few medium soft calcium carbonate masses; violently effervescent, 44 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); clear wavy boundary.

Bk2—13 to 22 inches; light yellowish brown (10YR 6/4) very gravelly loam, yellowish brown (10YR 5/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; common very fine tubular pores; 55 percent gravel; common medium soft calcium carbonate masses and thin coatings on rock fragments; violently effervescent, 43 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); abrupt wavy boundary.

R1—22 to 29 inches; fractured, calcium carbonate coated limestone; few very fine roots in fractures; abrupt wavy boundary.

R2—29 inches; limestone.

Range in Characteristics

Depth to limestone: 20 to 40 inches
Content of rock fragments in the control section: 35 to 80 percent
Reaction: Slightly alkaline or moderately alkaline

A horizon:
Calcium carbonate equivalent—less than 40 percent

Bk horizon:
Calcium carbonate equivalent—more than 40 percent

Ustorthents

Depth class: Very shallow to very deep
Drainage class: Well drained
Permeability: Slow to rapid
Landform: Escarpments of canyons
Parent material: Alluvium, colluvium, and residuum derived from sedimentary rocks
Slope range: 35 to 90 percent
Elevation: 6,000 to 7,200 feet
Mean annual precipitation: 14 to 18 inches
Mean annual soil temperature: 48 to 56 degrees F
Frost-free period: 120 to 160 days
Classification: Ustorthents

Reference Pedon

Ustorthents, in an area of Ustorthents-Rock outcrop complex, 35 to 90 percent slopes; about 1,500 feet north and 800 feet east of the southwest corner of sec. 34, T. 30 N., R. 8 W.

A—0 to 1 inch; light brown (7.5YR 6/4) extremely flaggy fine sandy loam, brown (7.5YR 5/4) moist; weak moderately thick platy structure; soft, very friable, nonsticky and nonplastic; many fine roots and common very fine roots; common fine interstitial pores; 40 percent channers, 50 percent flagstones; violently effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

C1—1 to 5 inches; light brown (7.5YR 6/4) channery fine sandy loam, brown (7.5YR 5/4) moist; massive; soft, very friable, nonsticky and nonplastic; many fine roots and common very fine roots; common fine interstitial pores; 20 percent channers; violently effervescent; moderately alkaline (pH 8.2); abrupt smooth boundary.

C2—5 to 18 inches; light brown (7.5YR 6/4) flaggy fine sandy loam, brown (7.5YR 5/4) moist; massive; soft, very friable, nonsticky and nonplastic; common fine roots and few medium roots; common fine interstitial pores; 20 percent flagstones; violently effervescent; moderately alkaline; abrupt smooth boundary.

R—18 inches; sandstone.

Range in Characteristics

Highly variable in depth to bedrock, soil texture, and color but loamy-skeletal or sandy-skeletal in most areas.

Winona Series

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Landform: Hills, mesas, and plateaus
Parent material: Colluvium, alluvium, and residuum derived dominantly from limestone
Slope range: 1 to 55 percent
Elevation: 5,100 to 6,000 feet
Mean annual precipitation: 10 to 12 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 135 to 175 days

Classification: Loamy-skeletal, carbonatic, mesic Lithic Ustollic Calciorthids

Typical Pedon

Winona extremely gravelly loam, in an area of Winona-Rock outcrop-Tusayan complex, 15 to 55 percent slopes; about 1,900 feet north and 2,200 feet east of the southwest corner of sec. 15, T. 32 N., R. 4 W.

A—0 to 2 inches; brown (10YR 5/3) extremely gravelly loam, dark brown (10YR 4/3) moist; weak fine granular structure; soft, very friable, nonsticky and slightly plastic; many very fine roots; common very fine irregular pores; 60 percent gravel, 20 percent cobble, 5 percent stones; violently effervescent, 32 percent calcium carbonate equivalent; moderately alkaline (pH 7.9); clear wavy boundary.

Bw—2 to 10 inches; brown (7.5YR 5/3) extremely gravelly loam, dark brown (7.5YR 4/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular pores; 55 percent gravel, 10 percent cobble; violently effervescent, 37 percent calcium carbonate equivalent; moderately alkaline (pH 7.9); abrupt wavy boundary.

Bk—10 to 17 inches; very pale brown (10YR 7/3) extremely gravelly loam, brown (10YR 5/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; common very fine tubular pores; 50 percent gravel, 10 percent cobble; many coarse soft calcium carbonate masses and thin coatings on rock fragments; violently effervescent, 54 percent calcium carbonate equivalent; moderately alkaline (pH 8.0); abrupt wavy boundary.

R—17 inches; widely fractured limestone, thickly coated with calcium carbonate.

Range in Characteristics

Depth to limestone: 6 to 20 inches

Content of rock fragments in the control section: 35 to 70 percent

A horizon:

Texture—extremely gravelly, extremely cobbly, very stony loam

Bw horizon (if it occurs):

Texture—very gravelly, extremely gravelly fine sandy loam, very fine sandy loam, loam, silt loam

Bk horizon:

Texture—extremely gravelly, extremely stony fine sandy loam, very fine sandy loam, loam, silt loam, clay loam

Reaction—moderately alkaline or strongly alkaline

Wodomont Series

Depth class: Very shallow and shallow

Drainage class: Well drained

Permeability: Moderate

Landform: Plateaus, hills, and mesas

Parent material: Colluvium and residuum derived dominantly from Muav or Redwall limestone of the Supai Formation

Slope range: 2 to 40 percent

Elevation: 4,600 to 6,200 feet

Mean annual precipitation: 14 to 16 inches

Mean annual soil temperature: 54 to 57 degrees F

Frost-free period: 130 to 175 days

Classification: Loamy-skeletal, mixed, mesic Lithic Ustochrepts

Typical Pedon

Wodomont extremely cobbly loam, in an area of Topocoba-Wodomont association, 2 to 15 percent slopes; about 500 feet west and 2,000 feet north of the southeast corner of sec. 9, T. 32 N., R. 2 W.

A—0 to 3 inches; brown (7.5YR 5/3) extremely cobbly loam, dark brown (7.5YR 4/3) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; common very fine roots; common very fine irregular pores; 50 percent gravel, 30 percent cobble; strongly effervescent; slightly alkaline (pH 7.5); abrupt wavy boundary.

Bk1—3 to 12 inches; brown (7.5YR 5/4) extremely cobbly loam, dark brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and plastic; many very fine roots; common very fine tubular pores; 20 percent gravel, 50 percent cobble; common thin calcium carbonate coatings and pendants under rock fragments; violently effervescent, 29 percent calcium carbonate equivalent; slightly alkaline (pH 7.5); abrupt wavy boundary.

Bk2—12 to 15 inches; light brown (7.5YR 6/4) very gravelly loam, dark brown (7.5YR 4/4) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and plastic; few very fine roots; few very fine tubular pores; 35 percent gravel, 15 percent cobble; common medium soft calcium carbonate masses and common thin coatings and pendants on rock fragments; violently effervescent, 51 percent calcium carbonate equivalent; slightly alkaline (pH 7.8); abrupt wavy boundary.

R—15 inches; limestone; fractured and slightly weathered in the upper 1 inch.

Range in Characteristics

Content of calcium carbonate: 20 to 40 percent

Depth to bedrock: 6 to 20 inches

A horizon:
Texture—extremely channery very fine sandy loam, extremely cobbly loam

B horizon:
Texture—extremely cobbly or very gravelly loam, fine sandy loam, very fine sandy loam
Reaction—slightly alkaline or moderately alkaline

Wukoki Series

Depth class: Very deep
Drainage class: Somewhat excessively drained
Permeability: Moderate
Landform: Cinder cones
Parent material: Alluvium and colluvium derived from scoriaceous basalt and pyroclastics
Slope range: 15 to 50 percent
Elevation: 5,500 to 5,800 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 54 to 57 degrees F
Frost-free period: 150 to 165 days
Classification: Ashy-skeletal over fragmental or cindery, mixed, mesic Ustivitrandic Camborthids

Typical Pedon

Wukoki extremely gravelly loam, in an area of Wukoki-Lomaki complex, 15 to 50 percent slopes; about 11 miles north of Mount Trumbull; 680 feet east and 2,050 feet south of the northwest corner of sec. 23, T. 37 N., R. 8 W.

A1—0 to 1 inch; yellowish brown (10YR 5/4) extremely gravelly loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine medium pores; 80 percent cinders; slightly alkaline (pH 7.8); abrupt smooth boundary.
A2—1 to 3 inches; yellowish brown (10YR 5/4) extremely gravelly loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; slightly hard, very friable, nonsticky and nonplastic; few fine roots; many medium tubular pores; 70 percent cinders; slightly alkaline (pH 7.8); abrupt smooth boundary.
Bw—3 to 10 inches; light yellowish brown (10YR 6/4) extremely gravelly loam, dark brown (10YR 4/3) moist; weak very fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; few medium roots; common fine pores; 70 percent cinders; slightly alkaline (pH 7.8); abrupt smooth boundary.
2Ck—10 to 60 inches; black cinders; common medium roots; few thin calcium carbonate coatings on sides and bottoms of cinders.

Range in Characteristics

Depth to cinders: 10 to 20 inches
Content of rock fragments in the control section: 60 to 75 percent cinders

Some pedons have a cinder lag on the surface that is as much as 2 inches thick.

Wyva family

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderately slow
Landform: Hills
Parent material: Basalt residuum
Slope range: 5 to 35 percent
Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 10 to 14 inches
Mean annual soil temperature: 54 to 58 degrees F
Frost-free period: 135 to 175 days
Classification: Loamy-skeletal, mixed, mesic Lithic Ustollic Haplargids

Typical Pedon

Wyva extremely gravelly sandy loam, in an area of Wyva family-Rock outcrop complex, 5 to 35 percent slopes; about 1,600 feet north and 800 feet east of the southwest corner of sec. 33, T. 25 N., R. 11 W.

A—0 to 2 inches; reddish brown (5YR 4/3) extremely gravelly sandy loam, dark reddish brown (5YR 3/4) moist; weak medium platy structure parting to weak medium granular; soft, very friable, slightly sticky and slightly plastic; few very fine roots; many very fine irregular pores; 70 percent gravel, 15 percent cobble, 5 percent stones; noneffervescent; slightly alkaline (pH 7.7); abrupt wavy boundary.
Bt—2 to 9 inches; reddish brown (5YR 4/4) very gravelly clay loam, dark reddish brown (5YR 3/3) moist; moderate medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many very fine roots and common fine and medium roots; common very fine tubular pores; 35 percent gravel, 10 percent cobble; few faint clay films lining pores; noneffervescent; slightly alkaline (pH 7.7); abrupt smooth boundary.
R—9 inches; basalt.

Range in Characteristics

Depth to bedrock: 5 to 20 inches

Bt horizon:
Texture—very gravelly clay loam, sandy clay loam
Reaction—neutral to moderately alkaline
Calcium carbonate equivalent—0 to 10 percent

Yumtheska Series

Depth class: Very shallow and shallow
Drainage class: Well drained
Permeability: Moderate
Landform: Plateaus and mesas
Parent material: Alluvium and residuum derived dominantly from limestone
Slope range: 2 to 35 percent
Elevation: 6,200 to 6,600 feet
Mean annual precipitation: 14 to 16 inches
Mean annual soil temperature: 54 to 56 degrees F
Frost-free period: 130 to 160 days
Classification: Loamy-skeletal, mixed, mesic Lithic Calciustolls

Typical Pedon

Yumtheska extremely cobbly loam, in an area of Toqui-Yumtheska complex, 2 to 30 percent slopes; about 50 feet west and 900 feet south of the northeast corner of sec. 14, T. 30 N., R. 7 W.

A—0 to 2 inches; brown (10YR 5/3) extremely cobbly loam, dark brown (10YR 3/3) moist; weak thin platy structure; soft, very friable, slightly sticky and slightly plastic; common very fine roots; few fine vesicular pores; 30 percent gravel, 35 percent cobble, 10 percent stones; slightly effervescent, 5 percent calcium carbonate equivalent; slightly alkaline (pH 7.6); clear smooth boundary.

Bw—2 to 5 inches; brown (10YR 4/3) very cobbly loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; common fine tubular pores; 15 percent gravel, 30 percent cobble; strongly effervescent, 6 percent calcium carbonate equivalent; slightly alkaline (pH 7.6); clear smooth boundary.

Bk1—5 to 14 inches; brown (10YR 4/3) very cobbly loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many fine roots; common fine tubular pores; 20 percent gravel, 35 percent cobble; common thin calcium carbonate pendants on undersides of rock fragments; violently effervescent, 24 percent calcium carbonate equivalent; slightly alkaline (pH 7.7); clear smooth boundary.

Bk2—14 to 17 inches; brown (10YR 4/3) very cobbly loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and medium roots; common fine tubular pores; 15 percent gravel, 30 percent cobble; common thick calcium carbonate pendants on undersides of rock fragments; violently effervescent, 26 percent calcium carbonate equivalent; slightly alkaline (pH 7.7); abrupt smooth boundary.

R—17 inches; limestone.

Range in Characteristics

Depth to bedrock: 7 to 20 inches
Content of rock fragments in the control section: 35 to 75 percent
Calcium carbonate equivalent: 15 to 40 percent

A horizon:
Texture—very cobbly loam, extremely cobbly loam
Reaction—neutral or slightly alkaline

Bw horizon:
Texture—very cobbly loam, silt loam
Reaction—slightly alkaline or moderately alkaline

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Glossary

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

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.

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

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

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

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

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

Very low	0 to 2.5
Low	2.5 to 5.0
Moderate	5.0 to 7.5
High	7.5 to 10.0
Very high	more than 10.0

Back slope. The geomorphic component that forms the steepest inclined surface and principal element of many hillsides. Back slopes in profile are commonly steep, are linear, and may or may not include cliff segments.

Basalt. Igneous rock formed by the cooling and hardening of a magma associated with volcanic activity and emplaced at or near the earth's surface.

Bedding planes. Fine stratifications, less than 5 millimeters thick, in unconsolidated alluvial, eolian, lacustrine, or marine sediments.

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

Bottom land. The normal flood plain of a stream, subject to flooding.

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

Breaks. The steep to very steep broken land at the border of an upland summit that is dissected by gullies.

Brush management. Use of mechanical, chemical, or biological methods to reduce or eliminate competition of woody vegetation to allow understory grasses and forbs to recover, or to make conditions favorable for reseeding. It increases production of forage, which reduces erosion. Brush management may improve the habitat for some species of wildlife.

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

Canopy. The leafy crown of trees or shrubs.

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

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous

with base-exchange capacity but is more precise in meaning.

Channer. A thin, flat rock fragment as much as 6 inches along the longest axis.

Channery soil material. A soil that is, by volume, 15 to 35 percent thin, flat rock fragments as much as 6 inches along the longest axis. Very channery soil material is 35 to 60 percent of these rock fragments, and extremely channery soil material is more than 60 percent.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Climax vegetation. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

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

Consistence, soil. The degree of cohesion among soil particles and the adhesion of soil to other substances. Consistence is described in terms of the soil's resistance to cracking or breaking when force is applied, the amount of force required to deform but not rupture soil material, and the degree to which soil material adheres to other objects.

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance indistinctly noticeable.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

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.

Corrosivity. The potential or risk of corrosion to uncoated steel or deterioration of concrete.

Cretaceous. The third portion of the Mesozoic Era of geologic time (from approximately 135 to 65 million years ago).

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Decreasers. The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Dip slope. A slope of the land surface, roughly determined by and approximately conforming with the dip of underlying bedded rock.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

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

Draw. A small stream valley, generally more open and with broader bottom land than a ravine or gully.

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

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

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

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

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

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

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Erosion pavement. A layer of gravel or stones that remains on the surface after fine particles are removed by sheet or rill erosion.

Escarpment. A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and produced by erosion or faulting.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Excess salts (in tables). Excess water-soluble salts in the soil that restrict the growth of most plants.

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

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

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Field moisture capacity. The moisture content of a soil,

expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called normal field capacity, normal moisture capacity, or capillary capacity.

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

Flagstone. A thin flat rock fragment 6 to 15 inches (15 to 38 centimeters) long.

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

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

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

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

Foot slope. The geomorphic component that forms the inner inclined surface at the base of a hill. Foot slopes in profile are dominantly concave and may form transition zones between upslope sites of erosion (back slope) and downslope sites of deposition (toe slope).

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

Formation (stratigraphy). The basic rock-stratigraphic unit in the local classification of rocks. A body of rock (commonly a sedimentary stratum or strata, but also igneous and metamorphic rocks) generally characterized by some degree of internal lithologic homogeneity or distinctive lithologic features such as chemical composition, structures, textures, or general kind of fossils.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.6 centimeters) in diameter.

Gravelly soil material. Material that is 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.6 centimeters) in diameter. Very gravelly soil material is 35 to 60 percent of these fragments, and extremely gravelly soil material is more than 60 percent.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

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.

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

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

Holocene. The second epoch of the Quaternary Period of geologic time, extending from the end of the Pleistocene Epoch (about 10 to 12 thousand years ago) to the present.

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 lower case letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, any plowed or disturbed surface layer.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) granular, 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 horizon. The material of a C horizon may be either like or unlike that in which the solum formed.

If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

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

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

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

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

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

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers. Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is the movement of water through soil layers or material.

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

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

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

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

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Jurassic. The second period of the Mesozoic Era of

geologic time (from approximately 195 to 135 million years ago).

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

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

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

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

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

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

Mechanical treatment. Use of mechanical equipment for seeding, brush management, and other management practices.

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

Mesa. A broad, nearly flat topped and commonly isolated upland mass characterized by summit widths that are more than the heights of bounding erosional scarps.

Metamorphic rock. Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement. Nearly all such rocks are crystalline.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. 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 natural elevation of the land surface, rising more than 1,000 feet above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides and considerable bare-rock surface. A mountain can occur as a single, isolated mass or in a group forming a chain or range.

Mudstone. Sedimentary rock formed by induration of silt and clay in approximately equal amounts.

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 that has hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

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

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil, adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

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

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

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

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

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

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

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor filter (in tables). Because of rapid permeability, the soil may not adequately filter effluent from a waste disposal system.

Potential plant community. The plant community on a given site that will be established if present environmental conditions continue to prevail and the site is properly managed.

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.

Prescribed burning. The application of fire to land under such conditions of weather, soil moisture, and time of day as presumably will result in the intensity of heat and spread required to accomplish specific forest management, wildlife, grazing, or fire hazard reduction purposes.

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 increases the vigor and reproduction of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

Quaternary. The second period of the Cenozoic Era of geologic time, extending from the end of the Tertiary Period (about 2 million years ago) to the present, and comprising two epochs, the Pleistocene and the Holocene.

Quartzite. Metamorphic rock formed from sandstone by heat, pressure, and strong silica cementation.

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

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

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

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid	below 3.5
Extremely acid	3.5 to 4.4
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Slightly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock.

Relief. The elevations or inequalities of a land surface, considered collectively.

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

Rill. A steep-sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Riparian. A term pertaining to plants and animals living

on, or adjacent to, the bank or flood plain of an intermittent stream or perennial river.

Rippable. Bedrock or hardpan can be excavated using a single-tooth ripping attachment mounted on a tractor with a 200-300 draw bar horsepower rating.

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

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.

Saline soil. A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Salinity. The degree to which a soil is affected by soluble salts in water. Salinity is expressed as the electrical conductivity (EC) of a saturated extract in mmhos/cm. The degrees of salinity are:

Nonsaline	Less than 2
Very slightly saline	2 to 4
Slightly saline	4 to 8
Moderately saline	8 to 16
Strongly saline	More than 16

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.

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

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

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

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shoulder. The geomorphic component that forms the uppermost, inclined surface at the top of a hill. It is dominantly convex in profile and erosional in origin, and it comprises a transition zone between summits and back slopes

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

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

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

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

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance. In this survey the following slope classes are recognized:

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

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

Small stones (in tables). Rock fragments less than 3

inches (7.6 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Sodicity. The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na to Ca + Mg. The degrees of sodicity and their respective ratios are:

Slight	less than 13:1
Moderate	13-30:1
Strong	more than 30:1

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

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

Stones. Rounded and angular fragments of rock 10 to 24 inches (25 to 60 centimeters) in diameter.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stratified. Arranged in strata, or layers. The term refers to either soil or geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

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, and representing the dissected remnants of an abandoned flood plain, stream bed, or valley floor produced during a former stage of erosion and deposition. Older and higher stream terraces have a relatively flat summit surface (tread), built by stream deposition, and a steep descending slope (riser), graded to a lower base level of erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

Structural bench. A platform-type, nearly level to gently inclined erosional platform developed on resistant strata in areas where geologic erosion has cut into alternating hard and soft rock layers with an essentially horizontal attitude. Their profiles are stair-stepped and angular, they commonly have summits of variable width, and are bounded both above and below, by hills or escarpments.

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. A general term for the top, or highest area of a landform such as a butte, hill, mountain, structural bench, mesa, or plateau. Summits may or may not include distinct crest lines or high points that rise above their general level.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from about 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

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

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.

Tertiary. The first period of the Cenozoic Era of geologic time (from approximately 65 to 2 million years ago).

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sandy soil materials consist of sands (coarse sand, sand, fine sand, very fine sand), loamy sands (loamy coarse sands, loamy sand, loamy fine sand, loamy very fine sand). Loamy soil materials consist of coarse sandy loam, sandy loam, fine sandy loam, very fine sandy loam, loam, silt loam, silt, clay loam, sandy clay loam, and silty clay loam. Clayey soil materials consist of sandy clay, silty clay, and clay.

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Too arid (in tables). The soil is dry most of the time, and vegetation is difficult to establish.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Triassic. The first period of the Mesozoic Era of geologic time (from approximately 230 to 195 million years ago).

Tuff. A compacted deposit that is 50 percent or more volcanic ash and dust.

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

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

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.