

Contents

	Page		Page
Part I: The landscape	1	Part II: The Soils—Continued	
Physiography, relief, and drainage.....	1	Formation and classification of the soils.....	29
Rock formations.....	2	Factors of soil formation.....	29
Climate.....	3	Parent material.....	30
Vegetation.....	5	Vegetation.....	30
Wildlife.....	6	Climate.....	30
People and their use of the land.....	6	Topography.....	31
Part II: The soils	7	Time.....	31
Descriptions of the soils.....	7	Classification of the soils.....	31
Anthony series.....	7	Zonal order.....	32
Basalt rock land.....	7	Brown soils.....	32
Bridge series.....	11	Reddish Brown soils.....	34
Broliar series.....	12	Chestnut soils.....	36
Cabezon series.....	13	Reddish Chestnut soils.....	36
Carrizo series.....	14	Reddish Prairie soils.....	37
Cornville series.....	14	Intrazonal order.....	38
Courthouse series.....	15	Brown Forest soils.....	38
Friana series.....	15	Calcisols.....	39
Gem series.....	16	Grumusols.....	40
Gila series.....	17	Azonal order.....	41
Glendale series.....	17	Alluvial soils.....	41
Guest series.....	17	Lithosols.....	44
Hantz series.....	18	Chemical and physical properties of the soils.....	45
Hogg series.....	18	Part III: Soil use and management	46
House Mountain series.....	18	Soil management areas.....	46
Jacks series.....	19	1. Siesta-Sponseller area.....	46
Karro series.....	19	2. Broliar area.....	48
Laveen series.....	20	3. Friana area.....	48
Lynx series.....	20	4. Springerville-Gem area.....	49
Mescal series.....	21	5. Stony steep land-Rock land area.....	49
Penthouse series.....	21	6. Retriever-Courthouse area.....	49
Retriever series.....	22	7. House Mountain-Penthouse area.....	50
Riverwash.....	22	8. Karro-Laveen-Guest area.....	50
Rock land-Springerville complex.....	22	Timber management.....	50
Rough broken and stony land, limestone.....	23	Woody species competition.....	51
Sandstone outcrop.....	23	Equipment limitations.....	51
Sandstone rock land.....	23	Windthrow hazard.....	51
Schnebly series.....	23	Erosion hazard.....	51
Siesta series.....	24	Timber suitability groups.....	51
Sponseller series.....	24	Range management.....	52
Springerville series.....	25	Watershed management.....	54
Stagecoach series.....	26	Hydrologic soil groups.....	57
Stony hilly land, ash and tuff.....	27	Erodibility and erosion hazard.....	57
Stony rough land, basalt and cinders.....	27	Wildlife management.....	57
Stony rough land, sandstone.....	27	Development of recreation sites.....	58
Stony steep land, basalt.....	27	Soils in engineering.....	59
Stony very steep land, basalt.....	27	Engineering properties, interpretations, and test data.....	59
Tobler series.....	28	Engineering and agricultural classification of the soils.....	59
Toquop series.....	28	Management groups.....	68
Waldroup series.....	29	Capability grouping of soils.....	72
		Research value of the survey.....	73
		Literature cited	73
		Glossary	74
		Guide to mapping units	Following 75

NOTICE TO LIBRARIANS

Series year and series number are no longer shown on soil surveys. See explanation on the next page.

SOIL SURVEY OF BEAVER CREEK AREA, ARIZONA

BY JOHN A. WILLIAMS AND TRUMAN C. ANDERSON, JR., FOREST SERVICE

SOILS SURVEYED BY TRUMAN C. ANDERSON, JR., ANDREW A. LEVEN, JOHN A. WILLIAMS, DARWIN B. CREZEE, AND WESLEY E. SUHR, FOREST SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE AND SOIL CONSERVATION SERVICE,
IN COOPERATION WITH THE ARIZONA AGRICULTURAL EXPERIMENT STATION

Part I: The Landscape

The Beaver Creek Area, which is in the central part of Arizona (fig. 1), is wholly within the Coconino National Forest. It is approximately 30 miles long by 14 to 22 miles wide, encompassing about 302,205 acres, or about 472 square miles. Most of the land has never been cultivated but has remained in timber, woodland, and grass. Approximately 94 percent is owned by the Federal government, 4 percent is privately owned, and the rest is owned by the State of Arizona. The Area is about evenly divided between Yavapai and Coconino Counties. It is part of the Verde River drainage system. The Verde

River is an important tributary of the Salt River. The nearest settlements are Camp Verde, about 1 mile from the southwest corner, and Sedona, about 5 miles from the northwest corner. Flagstaff is about 38 miles north.

The Area is composed of parts of four ranger districts. The larger part is in the Beaver Creek District, and contiguous parts are in the Long Valley, Sedona, and Mormon Lake Districts. State Highway 79 (Interstate Highway 17) crosses from the southwest part of the Area to the north-central part. Forest Highway 3 follows the eastern boundary, and Forest Development Road 4213 crosses the northern third of the Area.

Physiography, Relief, and Drainage

Most of the Beaver Creek Area is in the Grand Canyon section of the Colorado Plateau physiographic province (2).¹ The rest is in the Mexican Highland section of the Basin and Range physiographic province. A high plateau, sloping mesas and breaks, steep canyons, and valleys characterize the topography. The elevations range from about 3,100 feet to about 8,500 feet. In the valleys the average elevation is about 3,700 feet, and in the higher regions it is about 7,000 feet. Prominent features of the landscape are the Mogollon Rim in the west-central part, Hutch Mountain (8,505 feet) and Buck Mountain (7,590 feet) along the eastern boundary, Apache Maid Mountain (7,315 feet) in the central part, House Mountain (5,100 feet) and Courthouse Butte (5,400 feet) in the northwestern part, Wet Beaver Creek, Dry Beaver Creek, Rarick Canyon, and Woods Canyon.

About three-fourths of the Area is on the Coconino Plateau. The slopes are generally gentle, but there are a few mountains and buttes. On the eastern part of the Plateau, many of the drainageways consist of wide swales, where the direction of slope is indefinite. The western part of the Plateau consists of broad, rolling and undulating uplands extending to the Mogollon Rim. This part of the Plateau is dissected by deep, steep-walled canyons.

The Mogollon Rim and the breaks areas dominate the landscape between the valley of the Verde River and the Plateau. The Rim rises several hundred feet above the surrounding country. It consists of cliffs, escarpments,

¹ Italic numbers in parentheses refer to Literature Cited, p. 73.

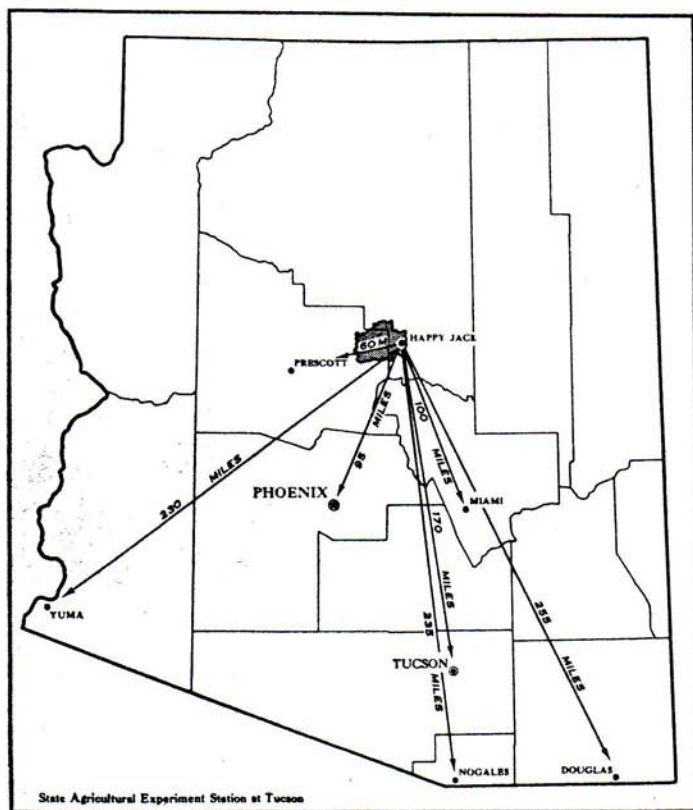


Figure 1.—Location of Beaver Creek Area in Arizona.

and very steep slopes. In places it is cut by canyons extending from the Plateau. The breaks and foothills consist of points of mesas that project, between deeply incised canyons, toward the Verde River, and of remnants of mesas so eroded that they are now low hills.

The Verde River valley consists of terraces, alluvial fans, bottom lands, low mesas, ridges, and draws. Oak Creek and the Verde River flow through or border this part of the Area.

Drainage is toward the southwest. The main drainageways are Wet Beaver Creek and Dry Beaver Creek, which converge to form Beaver Creek about six miles above the point where it empties into the Verde River. Wet Beaver Creek flows the year around, but Dry Beaver Creek flows only during spring runoff or after summer rainstorms. All of the other drainageways are intermittent. Stoneman Lake and its watershed, comprising less than 1,000 acres, forms a small interior basin that has no surface outlet. The main stream channels do not drop abruptly from the Plateau to the valley, as does the intervening land; instead, drainageways cut deeply into the Plateau, and their channels fall gradually from source to outlet.

Rock Formations

The bedrock underlying the Area consists of igneous rocks of volcanic origin and of sedimentary rocks of the Kaibab, Coconino, Supai, and Verde formations (fig. 2). About three-fourths of the Area, including nearly all of the section in the vicinity of Mogollon Rim and part of the Verde River valley, is underlain by volcanic rocks, such as tuff, agglomerate, cinders, and dense and porous types of basalt. These rocks occur as old lava flows and cinder cones. They probably represent several different flows, each with a different geologic history.

The Kaibab formation is represented by a cherty limestone that occurs in only one spot, just northeast of Apache Maid Mountain. The Coconino and Supai formations occur in the vicinity of the Mogollon Rim. The spectacular cliffs around Sedona and in Oak Creek Canyon are exposed sections of these formations (fig. 3). The Coconino formation is a cross-bedded, buff-colored, fine-grained sandstone. The Supai formation consists of sandstone, siltstone, shaly mudstone, and limestone. It is dominantly reddish.

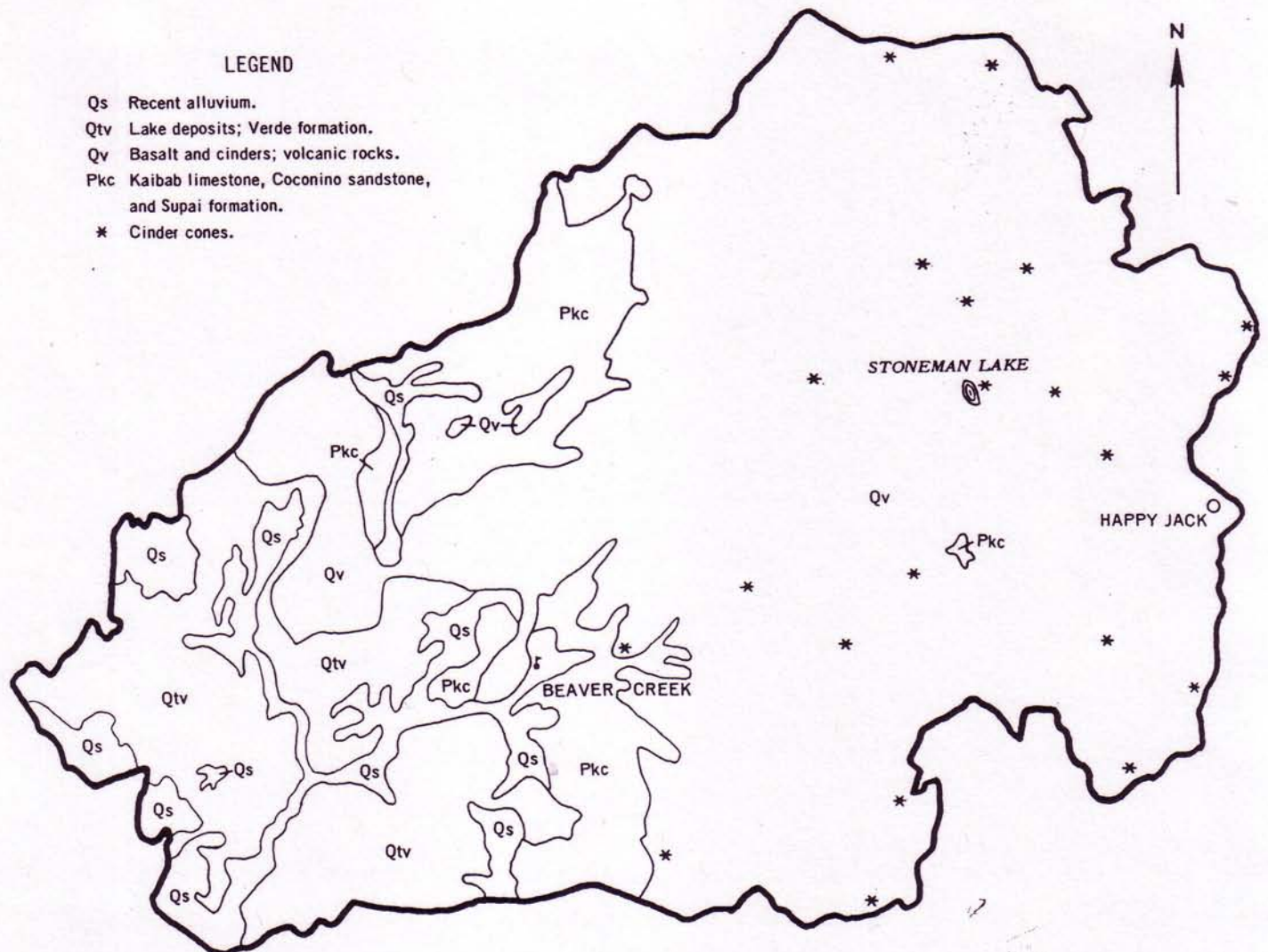


Figure 2.—Rock types in the Beaver Creek Area.



Figure 3.—Sandstone cliff formations. Courthouse Butte and Bell Rock, in the center background, are well-known landmarks.

The Verde formation is an old lakebed deposit. It consists mostly of hard, reprecipitated limestone, marl, and sandstone, but it also contains conglomerate, sandstone, and shale (5). The sandstone is highly calcareous, and both it and the marl weather readily. The hard limestone forms resistant ledges, which are common in the lower parts of the Area.

Climate ²

The climate in the Beaver Creek Area is semiarid and continental. Temperatures vary with elevation. At the lower elevations the weather is mild the year around, but at the higher elevations winters are cold and summers are warm.

The only complete records of climatic data for the Area are at the weather station at Montezuma Castle National Monument, in the Verde River valley. Flagstaff, about 50 miles north of Montezuma Castle, has a climate similar to that of the higher elevations of the Area.

During the period 1931 through 1952, the temperature at Montezuma Castle ranged from a recorded low of 3° F. to a recorded high of 115°. During the same period, the temperature at Flagstaff ranged from a low of -30° to a high of 93°. Tables 1 and 2 give temperature and precipitation data as recorded at Montezuma Castle and Flagstaff.

The average growing season at Montezuma Castle is a period of 210 days. The average date of the latest frost in spring is April 4; the latest recorded date of

a killing frost in spring is May 13. The average date of the earliest frost in fall is October 31; the earliest recorded date of a killing frost in fall is October 13. Table 3 gives the probabilities of last freezing temperatures in spring and first in fall at Montezuma Castle.

The average growing season at Flagstaff is a period of 121 days. The average date of the latest frost in spring is May 30; the latest recorded date of a killing frost in spring is June 18. The average date of the earliest frost in fall is September 28; the earliest recorded date of a killing frost in fall is September 12. Table 4 gives the probabilities of last freezing temperatures in spring and first in fall at Flagstaff.

There are two distinct seasons of precipitation. The summer rainy season brings the most moisture, usually in the form of intense, torrential thunderstorms in July and August. The winter season brings snow to the higher elevations and rain and sometimes snow to the lower elevations in December, January, and February. The amount of snowfall in the vicinity of Montezuma Castle is negligible. The amount of precipitation increases with elevation.

The Beaver Creek Area is practically free of fog and cloudy weather. The sun shines 70 to 80 percent of the daylight hours. The estimated relative humidity at Montezuma Castle averages 56 percent at 6 a.m. and 36 percent at 6 p.m. At Flagstaff it averages 72 percent at 6 a.m. and 45 percent at 6 p.m.

The prevailing winds are from the west and southwest. The movement of the wind is usually gentle, but winds of high velocity occur at times. Tornadoes and cyclones are uncommon. Hailstorms are rare.

²This section was prepared by PAUL C. KANGIESER, State climatologist for Arizona, Department of Commerce.

TABLE 1.—*Temperature and precipitation at Montezuma Castle National Monument*

[Elevation 3,180 feet]

Month	Temperature				Precipitation		
	Average daily maximum ¹	Average daily minimum ¹	Two years in 10 will have about 4 days with ² —		Average total ¹	One year in 10 will have ³ —	
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—
	°F.	°F.	°F.	°F.	Inches	Inches	Inches
January.....	59	26	70	14	1.0	0.1	2.4
February.....	64	28	76	18	.9	.1	1.9
March.....	70	33	82	23	.9	0	2.3
April.....	79	40	92	30	.8	(⁴)	1.7
May.....	88	46	98	37	.3	0	.9
June.....	97	53	107	44	.3	0	.8
July.....	101	63	109	55	1.4	.1	2.8
August.....	98	62	106	54	2.0	.8	4.4
September.....	95	54	104	45	1.4	(⁴)	3.1
October.....	83	43	94	32	.9	(⁴)	2.1
November.....	69	30	81	20	.6	0	1.7
December.....	61	26	71	16	1.1	(⁴)	3.0
Year.....	80	42	⁵ 110	⁶ 10	11.6	7.0	15.5

¹ Based on records for the years 1939 through 1960.² Based on records for the years 1939 through 1964.³ Based on records for the years 1934 through 1963.⁴ Trace.⁵ Average annual highest temperature.⁶ Average annual lowest temperature.TABLE 2.—*Temperature and precipitation at Flagstaff*

[Elevation 6,903 feet]

Month	Temperature				Precipitation ²				
	Average daily maximum ¹	Average daily minimum ¹	Two years in 10 will have about 4 days with ² —		Average total ¹	One year in 10 will have—		Days with snow cover	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January.....	40	14	55	-4	1.8	0.3	4.7	20	6
February.....	43	17	59	2	1.8	.1	3.8	20	4
March.....	50	22	62	7	1.5	.1	3.4	14	5
April.....	59	28	71	18	1.2	.2	2.2	3	2
May.....	68	34	79	24	.5	(³)	1.4	1	2
June.....	77	42	86	31	.7	(³)	2.8	0	0
July.....	81	50	88	41	2.3	.6	4.9	0	0
August.....	79	49	86	41	2.8	.9	5.2	0	0
September.....	75	42	83	32	1.6	(³)	4.5	0	0
October.....	63	31	76	22	1.5	(³)	3.6	1	2
November.....	51	21	64	6	1.0	.2	3.4	8	2
December.....	44	17	58	1	1.6	.1	4.4	14	3
Year.....	61	30	⁴ 90	⁵ -11	18.3	10.6	25.1	81	4

¹ Based on records for the years 1931 through 1960.² Based on records for the years 1950 through 1964.³ Trace.⁴ Average annual highest temperature.⁵ Average annual lowest temperature.

TABLE 3.—Probabilities of last freezing temperatures in spring and first in fall at Montezuma Castle National Monument
[Based on records for the years 1939 through 1964]

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than.....	March 14.	April 1.	April 13.	April 22.	May 11.
2 years in 10 later than.....	March 2.	March 20.	April 3.	April 16.	May 4.
5 years in 10 later than.....	February 7.	February 26.	March 16.	April 2.	April 21.
Fall:					
1 year in 10 earlier than.....	November 21.	November 8.	November 3.	October 25.	October 13.
2 years in 10 earlier than.....	November 30.	November 16.	November 9.	October 29.	October 18.
5 years in 10 earlier than.....	December 18.	December 1.	November 19.	November 7.	October 27.

TABLE 4.—Probabilities of last freezing temperatures in spring and first in fall at Flagstaff
[Based on records for the years 1950 through 1964]

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than.....	April 30.	May 17.	June 5.	June 11.	June 27.
2 years in 10 later than.....	April 23.	May 11.	May 29.	June 7.	June 22.
5 years in 10 later than.....	April 8.	April 29.	May 16.	May 30.	June 12.
Fall:					
1 year in 10 earlier than.....	October 26.	October 21.	September 28.	September 12.	September 10.
2 years in 10 earlier than.....	November 1.	October 26.	October 5.	September 20.	September 13.
5 years in 10 earlier than.....	November 11.	November 4.	October 20.	October 5.	September 20.

Vegetation

The vegetation in the Beaver Creek Area includes many kinds of trees, shrubs, grasses, and other plants. Three broad types of vegetation are represented: the ponderosa pine type, which includes areas of open parks; the pinyon-juniper woodland type, which includes some chaparral brush; and the grassland-desert shrub type. Each of these types is associated with particular soils and with a particular range in altitude and amount of rainfall. Figure 4 shows the general distribution of each of the vegetative types.

The ponderosa pine type is at the highest elevations in the Area, where the average annual precipitation is 18 inches or more. This type occurs on areas of Broliar, Siesta, and Sponseller soils. Much of this zone has had a partial cutting for saw logs. Saplings and pole-size trees constitute most of the remaining stands at the lower margins of this type, but reserve and virgin stands (fig. 5) remain at the higher elevations. The pine forest is dotted with clumps of Gambel oak and New-Mexican locust. There are some alligator juniper trees in the stands of pine, especially near the lower limits. Many of the juniper trees are large and very old. The ground cover in the pine forest generally consists of Arizona fescue, mountain muhly, and blue grama. The open parks

consist chiefly of Friana soils and have a good growth of native grasses and introduced wheatgrasses.

Below the ponderosa pine zone is an extensive pinyon-juniper woodland. The average annual precipitation is

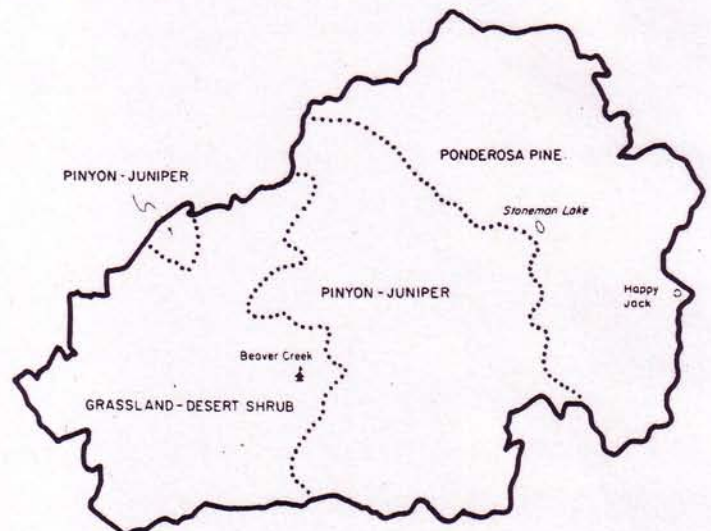


Figure 4.—Distribution of vegetative types in the Beaver Creek Area.



Figure 5.—Stand of ponderosa pine. The soils are of the Broliar and Siesta series.

about 15 inches. The major soils in this zone are those of the Springerville and Gem series. Utah juniper is the principal species. The stands vary from scattered trees to dense growth. Generally, alligator juniper predominates at the higher elevations. Pinyon pine grows only in local areas along with juniper, but it is not common. Chaparral grows in small areas of the driest and rockiest sites. Poor to fair stands of grass grow in open wooded areas and in treeless clearings. Blue grama is the principal species. Toward the lower fringe of the pinyon-juniper woodland, there are dense stands of mature juniper but no other vegetation.

The grassland-desert shrub type of vegetation grows in the valley part of the Area (fig. 6), where the average annual rainfall is 12 inches or less. Although the vegetation is generally sparse and some of the land is nearly barren, some areas have a relatively dense cover. The soils on bottom lands, such as the Guest, Karro, Laveen, and Tobler soils, support the most vegetation. The soils that formed in place, such as the Courthouse, House Mountain, and Retriever soils, are shallow and support only a light cover of plants. Creosotebush, mesquite, canotia, and catclaw are the principal shrubs. There are



Figure 6.—Characteristic landscape in the grassland-desert shrub vegetation zone.

some scattered stands of juniper. The chief grasses are sand dropseed, galleta, blue grama, tobosa, and curly mesquite. Cottonwood, alder, and sycamore trees thrive along the banks of streams.

Wildlife

The combination of ponderosa pine, pinyon-juniper, and grassland-desert shrub vegetative types in the Beaver Creek Area provides a favorable environment for a variety of wildlife. The principal game animals in the Area are mule deer (*Odocoileus hemionus*), whitetailed deer (*Odocoileus virginianus couesi*), elk (*Cervus canadensis nelsoni*), antelope (*Antilocarpa americanus*), bear (*Euarctos americanus*), squirrel (*Sciurus sp.*), cottontail rabbit (*Sylvilagus sp.*), and javelina (*Pecari tajacu sonoriensis*). Game birds are turkey (*Meleagris gallopavo sp.*), Gambel's quail (*Lophortyx gambeli*), and western mourning dove (*Zenaidura macroura marginella*). Rainbow trout (*Salmo gairdneri*) and channel catfish (*Ictalurus lacustris*) inhabit the streams.

Mule deer, the most common big game animals, migrate between the pine forest and the pinyon-juniper woodland as the seasons change. Antelope and wild turkey also inhabit these areas. Whitetailed deer and javelina graze chiefly on the grassland-desert shrub type of vegetation. Gambel's quail and western mourning dove inhabit grassland-desert shrub areas.

Predators include coyotes, mountain lions, foxes, and bobcats. Porcupines and other rodents are common. Waterfowl, such as geese, mallards, and teal, are seen occasionally on ponds and streams, but their numbers are small.

Wet Beaver Creek, Oak Creek, and the Verde River are the only permanent streams in the Beaver Creek Area and the only ones suitable for fish.

People and Their Use of the Land

As early as A.D. 600 the lower reaches of Beaver Creek were inhabited by Indian tribes. Migration from the south brought an agricultural people, who built canals to carry irrigation water from Beaver Creek to their farms. An excellently preserved pueblo stands at Montezuma Castle National Monument as evidence of the culture of these early people.

In 1583 Spanish explorers visited the limestone sinkhole now known as Montezuma's Well. In the early years an Indian trade route from the California coast to northern New Mexico passed through the Beaver Creek Area and the Verde Valley.

White settlers entered the Area in 1850 and established homes near the confluence of Beaver Creek and the Verde River. A cavalry post, Camp Lincoln, was established in 1864. The troops stationed there provided protection against hostile Indians. They also built the first roads in the Area. Camp Lincoln is now known as Camp Verde.

The Area was once part of two Forest Reserves, the San Francisco Mountains Reserve and the Black Mesa Reserve. It was designated a part of the Coconino National Forest in 1908.

The lands of the Beaver Creek Area have been used for grazing domestic livestock since before 1900. Cattle graze at the lower elevations in winter and spring and at the higher elevations in summer and fall. Sheep cross the Area during a period of about two months in spring and again in fall.

Logging under Forest Service administration was begun in the early 1930's. Approximately a quarter of a billion board feet of lumber was cut during the 12-year period of the original harvest. A large-scale second cut was begun in 1961. This cut will remove about a fourth of the overstory. The Area also furnishes a good supply of pulpwood.

The Beaver Creek Area is an important source of water. The Verde River gets an estimated 10 percent of its water from Beaver Creek. The Area is being used for a pilot project in intensive multiple-use management and management for sustained yield of water. This project covers about 91 percent of the Area. The information gained will have lasting value in the management of wild lands, particularly for areas where water production is a major land use.

Part II: The Soils

To get the basic information that is in this report, soil scientists examined the soils in the field to determine the characteristics of the surface soil, the subsoil, and the substratum. Then they plotted the extent of each kind of soil on an aerial photograph. On the basis of facts determined in the course of the field survey and data obtained by physical and chemical analyses in the laboratory, the soils were then classified into orders, great soil groups, series, types and phases.

This part of the report consists of descriptions of all the soils mapped in the Beaver Creek Area; a discussion of soil formation and classification; technical descriptions of representative soil profiles for each series mapped in the Beaver Creek Area; and a discussion of the chemical and physical properties of the soils.

Descriptions of the Soils

Each of the soils, complexes, and land types mapped in the Beaver Creek Area is described in the following pages. The descriptions of color and consistence are for dry soils, unless otherwise indicated. The reaction terms (pH values) used are for dilute soil suspensions, in a ratio of approximately 1:5. Each description includes the symbol that identifies the mapping unit on the soil map in the back of this report. Figures 7 and 8 show relative positions of soils in different parts of the Area.

Each soil description briefly discusses the present uses of the soil and evaluates suitabilities for different uses. The evaluation is based on characteristics of the soil and represents the best knowledge available at the time. No management decisions are implied.

The system of capability classification used by the Soil Conservation Service indicates relative suitability of soils for crops, grazing, forestry, and wildlife. This sys-

tem is described in the section "Capability Grouping of Soils," near the end of this report.

The acreage of the soils mapped in this Area, their proportionate extent, and their capability grouping are given in table 5.

Anthony series

The Anthony series consists of deep, well-drained soils on nearly level and smooth bottom lands and on first and second terraces above stream channels. These soils formed in mixed material washed mostly from sandstone but partly from limestone, basalt, schist, rhyolite, and granite. They occur along Oak Creek and the Verde River, at elevations of 3,100 to 3,500 feet, where the annual precipitation is about 12 inches. They are associated with Gila and Toquop soils. The vegetation consists of creosotebush, mesquite, cacti, and galleta. Most of the acreage has been leveled and is used for cultivated crops under irrigation (fig. 9, p. 11).

Anthony soils are calcareous to the surface. Typically, they have a reddish-brown surface layer that is slightly hard when dry and is massive. There is no clearly expressed subsoil. The substratum is fine sandy loam, stratified in places with fine sand or loamy fine sand. Like the surface layer, it is reddish brown, massive, and slightly hard when dry. The reddish-brown color is typical of these soils.

Anthony fine sandy loam (0 to 5 percent slopes) (An).— This soil is on nearly level bottom lands and terraces. The dominant slope is about 2 percent, but in areas that have been leveled, the slope is 1 percent or less.

Representative profile in a cultivated field:

Surface layer—

0 to 10 inches, reddish-brown fine sandy loam; massive; slightly hard; strongly calcareous; strongly alkaline.

Subsoil and substratum—

10 to 76 inches, reddish-brown fine sandy loam or very fine sandy loam; massive; slightly hard; strongly calcareous; strongly alkaline.

Infiltration is moderate, and permeability is moderate. Typically, the water-holding capacity is medium. Surface runoff is slow, and the erosion hazard is low to moderate. The root zone is deep. Fertility is medium.

Most of this soil is used for irrigated crops and for pasture. Under good management it produces good yields. The principal irrigated crops are alfalfa, small grain, corn, and vegetables. If not irrigated, this soil is used for range. It is moderately well suited to herbage. (Management group 7; range herbage group 2; group 3-a for recreation sites; not assigned to a timber suitability group)

Basalt rock land

Basalt rock land (Ba) consists of clifflike rock outcrops mixed with stony, fine-textured or medium-textured, shallow soil material over basalt. It occurs on steep side slopes of canyons and volcanic cones in the central and eastern parts of the Area. The vegetation on north-facing slopes is dense. It consists of ponderosa pine, alligator juniper, Gambel oak, and grass. The vegetation on other slopes consists of a few ponderosa pines, scattered stands of pinyon pine and juniper, and a ground cover of grass (fig. 10, p. 11). Runoff is rapid. The erosion hazard is high.

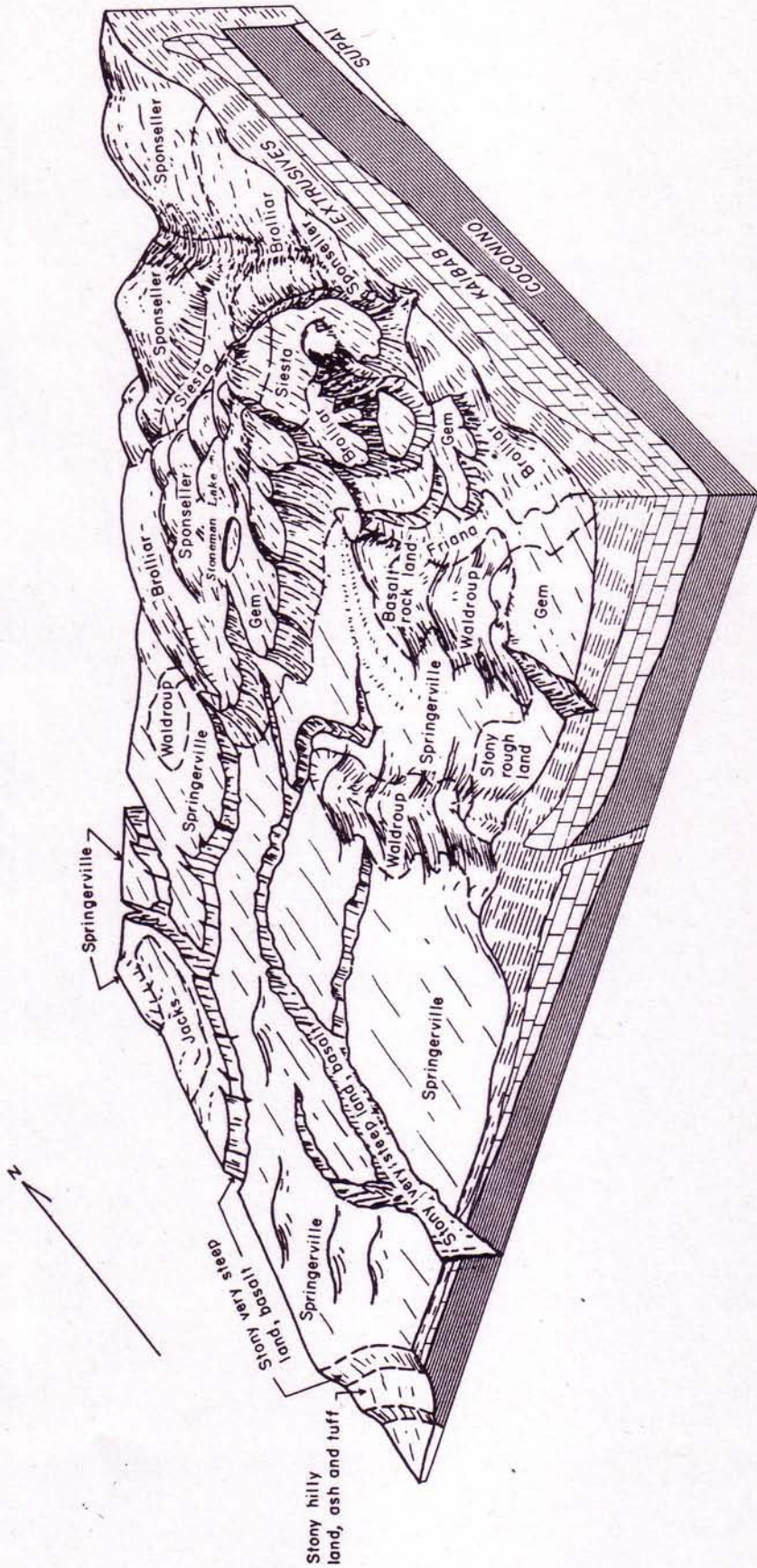


Figure 8.—Typical section of soils, upper part of Beaver Creek Area. Elevations range from 3,800 feet to 8,500 feet.

TABLE 5.—Approximate acreage and proportionate extent of the soils, and their capability grouping

Map symbol	Soil	Extent		Capability subclass
		Acres	Percent	
An	Anthony fine sandy loam (0 to 5 percent slopes)	583	0.2	VI _s
Ba	Basalt rock land	1,443	.5	VIII _s
Bg	Bridge gravelly sandy loam (0 to 10 percent slopes)	339	.1	VI _s
Bl	Bridge stony loam (0 to 5 percent slopes)	611	.2	VI _s
BrB	Brolliar very stony loam, 0 to 10 percent slopes	7,215	2.4	VII _s
BrC	Brolliar very stony loam, 10 to 20 percent slopes	2,305	.8	VII _s
BrD	Brolliar very stony loam, 20 to 30 percent slopes	254	.1	VII _s
BoB	Brolliar stony clay loam, 0 to 10 percent slopes	31,692	10.5	VI _s
BoC	Brolliar stony clay loam, 10 to 20 percent slopes	5,920	2.0	VI _s
BoD	Brolliar stony clay loam, 20 to 30 percent slopes	401	.1	VI _s
Bn	Brolliar silt loam, deep (0 to 5 percent slopes)	8,449	2.8	VI _s
Bm	Brolliar gravelly clay loam (10 to 35 percent slopes)	184	.1	VI _e
Bu	Brolliar clay loam and Alluvial land (0 to 3 percent slopes)	601	.2	VI _s
Bv	Brolliar cobbly loam and Alluvial land (0 to 3 percent slopes)	178	.1	VI _s
Bp	Brolliar very rocky complex (5 to 15 percent slopes)	480	.2	VII _s
Ca	Cabezon very stony loam (0 to 20 percent slopes)	1,007	.3	VI _s
Cc	Cabezon stony clay loam, dark variant (0 to 5 percent slopes)	82	(¹)	VI _s
Cd	Cornville fine sandy loam (0 to 10 percent slopes)	3,063	1.0	VI _e
Cg	Cornville gravelly sandy loam, thin solum variant (0 to 20 percent slopes)	119	(¹)	VI _c or VI _e
Ch	Courthouse gravelly fine sandy loam (10 to 40 percent slopes)	4,363	1.4	VI _e or VII _e
Cs	Courthouse stony fine sandy loam (5 to 20 percent slopes)	552	.2	VI _s
Fn	Friana soils (0 to 2 percent slopes)	3,272	1.1	VI _s
Fk	Friana clay, black variant (0 to 2 percent slopes)	170	.1	VI _w
Gm	Gem clay loam (0 to 10 percent slopes)	4,626	1.5	VI _s
Gn	Gem-Springerville complex (0 to 5 percent slopes)	537	.2	VI _s
Gs	Gila very fine sandy loam, reddish variant (0 to 5 percent slopes)	376	.1	VI _c
Gt	Glendale silt loam (0 to 5 percent slopes)	2,300	.8	VI _c
Gu	Guest clay (0 to 3 percent slopes)	3,183	1.1	VI _s
Ha	Hantz silty clay (0 to 5 percent slopes)	540	.2	VI _s
Hg	Hogg stony silt loam (0 to 10 percent slopes)	134	(¹)	VI _s
Hm	House Mountain stony loam (0 to 10 percent slopes)	4,274	1.4	VII _s
Ja	Jacks fine sandy loam (0 to 15 percent slopes)	1,126	.4	VI _s or VI _e
Jc	Jacks very rocky fine sandy loam (15 to 30 percent slopes)	327	.1	VII _s
Ka	Karro and Laveen fine sandy loams (0 to 10 percent slopes)	5,627	1.9	VI _s
La	Laveen gravelly sandy loam (5 to 20 percent slopes)	1,522	.5	VII _e
Ln	Lynx silt loam (0 to 3 percent slopes)	176	.1	VI _c
Ly	Lynx silt loam, heavy subsoil variant (0 to 5 percent slopes)	104	(¹)	VI _c
Ms	Mescal fine sandy loam (0 to 10 percent slopes)	928	.3	VI _s
Pc	Penthouse cobbly clay loam (0 to 5 percent slopes)	1,383	.4	VI _s
Ph	Penthouse stony loam (0 to 5 percent slopes)	114	(¹)	VI _s
RrC	Retriever very stony loam, 0 to 20 percent slopes	15,576	5.2	VII _s
RrD	Retriever very stony loam, 20 to 40 percent slopes	12,718	4.2	VII _s
Re	Retriever loam (0 to 5 percent slopes)	2,476	.8	VII _s
Rw	Riverwash	3,155	1.0	VIII _w
Rx	Rock land-Springerville complex (5 to 35 percent slopes)	6,259	2.1	VII _s and VIII _s
Ry	Rough broken and stony land, limestone	5,645	1.9	VIII _s
Sa	Sandstone outcrop	4,131	1.4	VIII _s
Sd	Sandstone rock land	6,217	2.0	VIII _s
Se	Schnebley very stony clay loam (10 to 20 percent slopes)	477	.2	VII _s
Sg	Siesta stony silt loam (0 to 15 percent slopes)	9,652	3.2	VI _s
Sf	Siesta silt loam, deep (0 to 10 percent slopes)	4,822	1.6	VI _s or VI _e
ShD	Sponseller stony silt loam, 15 to 40 percent slopes	3,686	1.2	VI _s or VII _s
ShC	Sponseller stony silt loam, 5 to 15 percent slopes	4,950	1.6	VI _s
SnB	Springerville very stony clay, 0 to 10 percent slopes	48,952	16.2	VII _s
SnC	Springerville very stony clay, 10 to 20 percent slopes	14,875	4.9	VII _s
SnD	Springerville very stony clay, 20 to 30 percent slopes	8,035	2.6	VII _s
Sm	Springerville cobbly clay (0 to 5 percent slopes)	3,230	1.1	VI _s
Sl	Springerville clay, red phase (0 to 10 percent slopes)	2,071	.7	VI _s or VI _e
Sk	Springerville clay (0 to 10 percent slopes)	525	.2	VI _s
So	Stagecoach cobbly sandy loam (5 to 15 percent slopes)	345	.1	VII _s
Sr	Stony hilly land, ash and tuff (15 to 35 percent slopes)	2,395	.8	VII _s
Ss	Stony rough land, basalt and cinders (20 to 60 percent slopes)	7,941	2.6	VII _s
St	Stony rough land, sandstone	1,030	.3	VII _s
Su	Stony steep land, basalt	13,802	4.6	VII _s
Sv	Stony very steep land, basalt	14,462	4.8	VIII _s
Tb	Tobler fine sandy loam (0 to 5 percent slopes)	1,789	.6	VI _c
Tg	Tobler gravelly fine sandy loam, brown variant (5 to 15 percent slopes)	117	(¹)	VI _c or VI _e
To	Toquop loamy fine sand (0 to 5 percent slopes)	338	.1	VI _s
Tx	Toquop-Carrizo complex (0 to 20 percent slopes)	416	.1	VI _s or VII _s
Wg	Waldroup gravelly loam, moderately deep (5 to 30 percent slopes)	906	.3	VI _e
Wc	Waldroup clay loam, deep (0 to 5 percent slopes)	438	.1	VI _s
Wa	Waldroup loam, brownish variant (0 to 5 percent slopes)	214	.1	VI _s
	Total	302,205	100.0	

¹ Less than 0.05 percent.



Figure 9.—An area of Anthony fine sandy loam. This is one of the few places in the Beaver Creek Area that is irrigated and used for cultivated crops.

Areas of this land type having a north aspect are moderately well suited to production of timber. Areas having a south aspect are only poorly suited to production of timber. Only the less steep areas can be used for grazing. This land type is important as a habitat for wildlife and as a source of water. Careful management is needed to prevent excessive disturbance of the soil. (Management group 12; range herbage group 5; not assigned to a timber suitability group nor to a group for recreation sites)

Bridge series

The Bridge series consists of moderately deep and deep, well-drained, very strongly calcareous soils on alluvial fans and sloping uplands. These soils formed partly in basaltic alluvium and partly in volcanic ash and tuffaceous material. They occur at elevations of 3,700 to 3,800 feet. They lie next to Retriever, Guest, Stagecoach, and Mescal soils. The vegetation consists chiefly of mesquite, juniper, catclaw, canotia, cacti, locoweed, tobosa, fluffgrass, and foxtail barley. More than half of the surface is barren. Pebbles of chert and basalt are numerous.

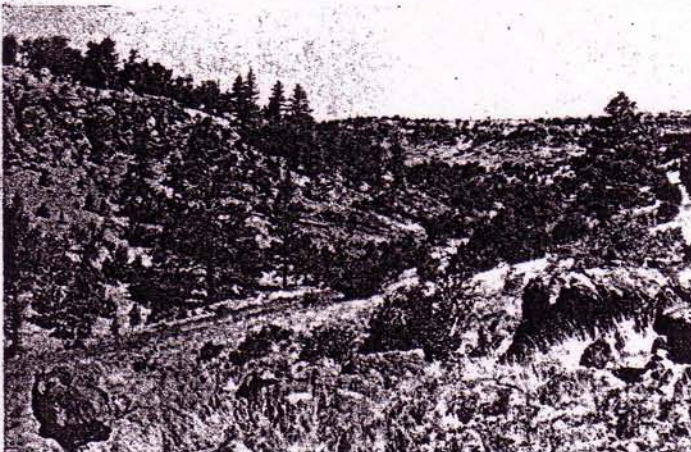


Figure 10.—An area of Basalt rock land. This land type supports various kinds of trees and grasses.

Bridge soils have a brown, gravelly surface layer that is soft when dry and friable when moist and has granular structure. Their subsoil is grayish brown to brown, is slightly hard when dry and friable when moist, and has blocky structure or is massive.

Bridge gravelly sandy loam (0 to 10 percent slopes) (Bg).—This soil is on alluvial fans in the western part of the survey Area. It is well drained. The vegetation consists chiefly of grasses and desert shrubs (fig. 11). More than half of the surface is barren.

Representative profile:

Surface soil—

0 to 3 inches, brown gravelly sandy loam; granular structure; soft; moderately alkaline.

Subsoil—

3 to 31 inches, brown to very pale brown gravelly loam and light sandy clay loam; blocky structure or massive; slightly hard; moderately alkaline.

Substratum—

31 to 36 inches +, pinkish-white tuff, ash, gravel, and cobbles; massive; very strongly calcareous; strongly alkaline.



Figure 11.—An area of Bridge gravelly sandy loam. The sloping areas in the background are Sandstone rock land.

Infiltration and permeability are moderate. The water-holding capacity is medium. Surface runoff is medium, and the erosion hazard is moderate. The root zone is deep. Fertility is low.

This soil is used for winter grazing. It does not produce timber. It is only moderately well suited to herbage, and the potential for natural recovery of vegetation is low. The sustained yield of water is low, but the water-storage capacity is adequate for the amount of rain received. (Management group 7; range herbage group 3; group 3-a for recreation sites; not assigned to a timber suitability group)

Bridge stony loam (0 to 5 percent slopes) (Bl).—This soil occurs on gently rolling low ridges and old terraces. It generally lies upslope from Bridge gravelly sandy loam (0 to 10 percent slopes).

This soil is used for winter grazing. It does not produce timber. It is only moderately well suited to herbage, and the potential for natural recovery of vegetation is low. Sustained yield of water is low, but the water-storage capacity is adequate for the amount of rainfall

received. Careful management is needed, as this soil cuts and washes easily if the plant cover is depleted. (Management group 6; range herbage group 3; group 3-a for recreation sites; not assigned to a timber suitability group)

Brolliar series

The Brolliar series consists of moderately deep and deep, well-drained, noncalcareous soils on nearly level to hilly uplands. These soils formed in material weathered from porous basalt. They occur at elevations of 6,500 to 7,600 feet, where the annual precipitation is 20 to 23 inches. They adjoin Siesta, Sponseller, and Friana soils. The plant cover consists chiefly of ponderosa pine, Gambel oak, Arizona fescue, mountain muhly, bluegrass, squirreltail, and junegrass.

Brolliar soils have a dark-brown surface layer that is soft when dry and has platy structure. Their subsoil is reddish brown and is hard when dry. It has blocky structure. Basalt bedrock is at a depth of 2 to 5 feet. Stones and cobblestones cover 20 to 60 percent of the surface of most areas. A layer of undecomposed and partly decomposed pine needles overlies the mineral soil.

Brolliar very stony loam, 0 to 10 percent slopes (BrB).—This soil is moderately deep or deep. It is on uplands in the eastern part of the survey Area. Basalt stones and cobblestones cover as much as 60 percent of the surface. The vegetation consists chiefly of ponderosa pine and grass.

Representative profile in an area of cutover ponderosa pine:

- Surface soil—
0 to 5 inches, dark-brown very stony loam; platy structure; soft; slightly acid or neutral.
- Subsoil—
5 to 34 inches, reddish-brown light clay or clay; blocky structure; hard; neutral.
- Bedrock—
34 inches +, basalt.

Infiltration is moderate, and permeability is slow. The water-holding capacity is medium. Surface runoff is slow, and the erosion hazard is low. The root zone is moderately deep. Fertility is high.

This soil is used principally for timber, herbage, wildlife, and water yield. It is well suited to timber and moderately well suited to herbage. It supports vigorous stands of pine. It provides good habitats for wildlife and affords good opportunities for development of recreational facilities. The capacity for underground storage of water and sustained yield of water is medium. (Management group 3; timber suitability group 2; range herbage group 3; group 1-a for recreation sites)

Brolliar very stony loam, 10 to 20 percent slopes (BrC).—This soil is shallower than Brolliar very stony loam, 0 to 10 percent slopes, and has more outcrops of basalt. Like that soil, it occurs on uplands in the eastern part of the survey Area.

Surface runoff is medium. The erosion hazard is moderate but would be high except for the protection provided by the surface rocks and stones.

This soil is well suited to timber and supports a good stand of pine. It is moderately well suited to herbage. Its usefulness for recreation sites is limited by the moderately steep slopes. It is well suited to wildlife, particularly deer and elk. The capacity for water storage

is medium, and sustained yield is medium. (Management group 3; timber suitability group 2; range herbage group 3; group 1-b for recreation sites)

Brolliar very stony loam, 20 to 30 percent slopes (BrD).—This soil is similar to and occurs in close association with Brolliar very stony loam, 10 to 20 percent slopes. It occupies ridges, side slopes, and short, steep breaks. In most places it is 24 to 30 inches deep over basalt bedrock. The steep slopes cause rapid runoff, and the erosion hazard is high.

This soil supports good stands of pine. It is well suited to timber but only moderately well suited to herbage. The water-storage capacity is medium, and sustained water yield is medium. Hunting is the only recreational use. Disturbance of the soil and plant cover must be kept to a minimum because of the high erosion hazard. (Management group 3; timber suitability group 2; range herbage group 3; group 1-c for recreation sites)

Brolliar stony clay loam, 0 to 10 percent slopes (BoB).—This soil occupies ridges, swales, and gentle slopes on rolling uplands. Stones, cobblestones, and gravel cover the surface. There are a few rock outcrops.

This soil (fig. 12) is 27 to 41 inches deep over basalt bedrock. Its surface layer is 3 to 6 inches thick. In places the soil is gravelly throughout.

Infiltration is moderate, and permeability is slow. The available water-holding capacity is medium. Surface runoff is slow, and the erosion hazard is moderate. The root zone is moderately deep. Fertility is medium.

This soil is used for ponderosa pine and for summer grazing. It is moderately well suited to timber and herbage. Its capacity to store water underground is limited by slow permeability. Its capacity for sustained yield is medium. (Management group 3; timber suitability group 3; range herbage group 3; group 2-a for recreation sites)

Brolliar stony clay loam, 10 to 20 percent slopes (BoC).—This soil occupies sloping uplands and ridges. It has more rock outcrops than Brolliar stony clay loam, 0 to 10 percent slopes.

This soil is used for the production of timber and herbage, for water yield, and for wildlife habitats. It is somewhat more difficult to manage than the less sloping stony clay loam. (Management group 3; timber suitability group 3; range herbage group 3; group 2-b for recreation sites)

Brolliar stony clay loam, 20 to 30 percent slopes (BoD).—This soil is on uplands and ridges. It has more rock outcrops than Brolliar stony clay loam, 0 to 10 percent slopes.

This soil is used for the production of timber and herbage, for water yield, and for wildlife habitats. It is considerably more difficult to manage than the less sloping stony clay loams. (Management group 3; timber suitability group 3; range herbage group 3; group 2-c for recreation sites)

Brolliar silt loam, deep (0 to 5 percent slopes) (Bn).—This soil occurs on uplands in the eastern part of the survey Area. It has a few basalt cobblestones on the surface in most places. The depth to basalt bedrock ranges from 40 to 60 inches. The texture of the surface layer is heavy loam in places. The moisture-supplying capacity is high.



Figure 12.—Profile of Broliar stony clay loam, 0 to 10 percent slopes.

This soil is used for timber and grass, to both of which it is well suited. It provides good summer range. Its capacity for sustained water yield is high. It is suitable for recreational use and for wildlife habitats. (Management group 2; timber suitability group 1; range herbage group 2; group 1-a for recreation sites)

Broliar gravelly clay loam (10 to 35 percent slopes) (Bm).—This soil occurs on alluvial and colluvial toe slopes. It is gravelly throughout and has some cobbles and stones below a depth of about 24 inches.

Surface runoff is medium, and the erosion hazard is moderate. The available moisture-holding capacity is high. The root zone is deep. Fertility is high.

This soil is well suited to timber and moderately well suited to herbage. Suitability for wildlife habitats is good; there are avenues of escape, and trees provide concealment. The capacity to store water underground is high, and the potential for sustained yield is medium. Careful management is needed on the steeper slopes. (Management group 2; timber suitability group 2; range herbage group 3; group 1-b for recreation sites)

Broliar clay loam and Alluvial land (0 to 3 percent slopes) (Bu).—This unit occupies low terraces and valley fill in the eastern part of the survey Area. It is about half Broliar clay loam and half Alluvial land. The vegetation consists of a fair stand of ponderosa pine and a ground cover of mixed grasses.

In many places the surface is covered with a thin mat of pine needles. The texture of the surface layer ranges

from clay loam to loam. In some areas of Broliar clay loam the subsoil is distinct, but in others it is weakly defined. Alluvial land is stratified. In some places there are a few stones and cobbles on the surface. The depth to basalt or stones and cobbles ranges from 20 to 40 inches.

Infiltration is rapid, but permeability is slow. Surface runoff is slow. The erosion hazard is low, and little or no erosion has taken place. There is a hazard of flooding. The capacity to store water is medium. Roots are abundant above a depth of 20 inches. Fertility is medium or high.

These areas are highly productive of herbage. They provide good wildlife habitats. Some ponderosa pine grows, but frequent flooding and the variations in depth limit the suitability of these soils for timber. The capacity for sustained water yield is high. Recreational development is limited by the hazard of flooding. (Management group 5; timber suitability group 4; range herbage group 2; group 2-a for recreation sites)

Broliar cobbly loam and Alluvial land (0 to 3 percent slopes) (Bv).—This unit is on recent flood plains in long, narrow canyons in the north-central part of the survey Area. It is about half Broliar cobbly loam and half Alluvial land. The soil material formed in sediments washed from soils derived from basalt. The vegetation consists of a fair stand of ponderosa pine and a ground cover of grama and weeds. Cobbles make up 20 percent or more of the soil mass.

In most places there is a half-inch layer of needle litter on the surface. The texture of the surface layer is cobbly loam or cobbly clay loam. The texture of the subsoil ranges from gravelly clay loam to gravelly clay.

Infiltration is rapid, and permeability is moderately slow or slow. Surface runoff is slow, and the erosion hazard is moderate. The moisture-supplying capacity is moderately low. Roots are plentiful to a depth of 20 inches. Fertility is medium.

This unit is used for production of timber and herbage. It is moderately well suited to timber. It is only poorly suited to herbage because of the number of cobbles on the surface. The capacity for sustained water yield is medium. There are suitable habitats for wildlife, but recreational use is limited by the flood hazard. (Management group 3; timber suitability group 3; range herbage group 4; group 2-a for recreation sites)

Broliar very rocky complex (5 to 15 percent slopes) (Bp).—This unit occupies upland slopes and ridges. It consists of Broliar stony clay loam, which makes up 60 percent of the unit, and basalt outcrops, which make up 40 percent. The Broliar soil is moderately deep and in many places occurs in pockets between the outcrops.

This complex is poorly suited to ponderosa pine. It is moderately well suited or poorly suited to herbage. It provides forage for wildlife. The capacity for water storage is low, and there is little or no potential for sustained yield. (Management group 4; timber suitability group 4; range herbage group 3; group 4-a for recreation sites)

Cabazon series

The Cabazon series consists of shallow, well-drained soils that formed in residuum weathered from basalt. These soils occur on undulating to hilly uplands, at elevations of 6,100 to 7,500 feet, where the annual precipitation

is 16 to 20 inches. They are associated with Broliar, Friana, and Siesta soils. They are mainly in the ponderosa pine forest but fringe into the pinyon-juniper zone. The vegetation is chiefly low-quality ponderosa pine and mixed grasses. Pinyon pine, juniper, snakeweed, and blue grama grow in the fringe areas. Some areas do not support trees.

Cabezon soils have a brown, stony surface layer that is soft when dry and has platy structure. The subsoil is reddish-brown clay or clay loam that has subangular blocky structure. Typically, Cabezon soils are very stony.

Cabezon very stony loam (0 to 20 percent slopes) (Ca).—This soil is on uplands a few miles northeast of the Happy Jack Administrative Site. Many cobblestones and fragments of basalt occur on the surface and within the profile. In some places there are many rounded boulders on the surface.

Representative profile in an area of cutover pine:

Surface soil—

0 to 3 inches, brown very stony loam; platy structure; soft; slightly acid.

Subsoil—

3 to 6 inches, reddish-brown stony clay loam; subangular blocky structure; slightly hard; neutral.

Substratum—

6 to 11 inches, reddish-brown clay; subangular blocky structure; very hard; neutral.

Bedrock—

11 inches +, basalt.

Infiltration is moderate, and permeability is slow. The water-holding capacity is low. Surface runoff is slow, and the erosion hazard is low. The root zone is shallow. Fertility is low.

This soil is used for ponderosa pine and for summer grazing. It is moderately well suited to herbage but poorly suited to timber. The capacity for water storage is low, and there is little potential for sustained yield of water. The stands of pine are too sparse to provide adequate concealment for wildlife. (Management group 4; timber suitability group 4; range herbage group 3; group 4-b for recreation sites)

Cabezon stony clay loam, dark variant (0 to 5 percent slopes) (Cc).—This soil is on uplands in the eastern part of the survey Area. It occurs as small treeless spots in the pine forest; the vegetation is almost exclusively annual grama grasses. In most places the slope is 1 percent. Water ponds on this soil during wet seasons, but there is no evidence of poor drainage. There are a few small outcrops of basalt.

The depth to hard, porous basalt ranges from 10 to 20 inches; in most places bedrock is at a depth of 18 inches. The texture of the surface layer is stony clay loam or silty clay loam. Its color is dark grayish brown in most places but reddish brown where cinders have been an influence. The subsoil is massive, reddish clay.

Infiltration is moderate, and permeability is slow. Movement of water is restricted in the subsoil. The water-holding capacity is low. The erosion hazard is low. The root zone is shallow. Fertility is low.

Although this soil is but poorly suited to herbage, it has some use for summer grazing. It is not suited to timber, and it has no value for recreational purposes. Its usefulness for wildlife habitats is very limited. Its capacity for sustained yield of water is low. (Management group 4; timber suitability group 5; range herbage group 4; group 4-a for recreation sites).

Carrizo series

The Carrizo series consists of gravelly, highly stratified soils that formed in mixed alluvium. These soils occur on flood plains and bottom lands along the Verde River at elevations of 3,100 to 3,600 feet, where the average annual precipitation is 10 to 12 inches. They are excessively drained and calcareous. They are closely associated with Toquop soils. The vegetation consists of cottonwood, willow, mesquite, bermudagrass, and annual weeds.

Carrizo soils consist of light-brown, stratified very gravelly coarse sand, very gravelly fine sand, and very gravelly loamy fine sand.

In this survey Area, Carrizo soils were mapped only as part of a complex with the Toquop soils. The description of this complex is under the heading "Toquop series."

Cornville series

The Cornville series consists of deep, well-drained soils on alluvial fans and stream terraces. These soils formed in mixed alluvium washed from sandstone, limestone, and basalt. They occur at elevations of 3,100 to 3,600 feet, where the annual precipitation is about 11 inches. The fans and terraces are 20 to 100 feet above present stream channels. They adjoin Karro, Laveen, Glendale, and Gila soils. The plant cover consists mainly of mesquite, creosotebush, snakeweed, yucca, tobosa, sideoats grama, and black grama. There is some algerita. Vegetation covers only about 15 percent of the surface.

Cornville soils have a yellowish-red surface layer that is hard when dry and is massive or has prismatic structure. Their subsoil is yellowish red and hard when dry and has prismatic structure. Their substratum has a high content of lime. Its upper part is pinkish white, hard when dry, and massive; its lower part is light reddish brown, loose, and single grain.

Cornville fine sandy loam (0 to 10 percent slopes) (Cd).—This soil occurs on alluvial fans and terraces in valleys. Included in the areas mapped is a small acreage on the sides of low ridges, where the slope is as much as 20 percent. The included areas are calcareous.

Representative profile in an area used for range:

Surface soil—

0 to 7 inches, yellowish-red fine sandy loam; prismatic structure or massive; hard; noncalcareous; moderately alkaline.

Subsoil—

7 to 32 inches, yellowish-red heavy fine sandy loam; prismatic structure; hard; noncalcareous; moderately alkaline.

Substratum—

32 to 57 inches, pinkish-white heavy fine sandy loam; massive; hard; very strongly calcareous; strongly alkaline.

57 to 88 inches, light reddish-brown loamy fine sand; single grain; loose; slightly calcareous; strongly alkaline.

Infiltration is rapid, and permeability is moderate. The capacity to hold water is medium. Runoff is slow to medium, and the erosion hazard is moderate. The root zone is deep. The organic-matter content is low. Fertility is medium.

This soil is used chiefly for winter range. It is moderately well suited to herbage. Small areas are irrigated and used for alfalfa, corn, and garden crops. (Manage-

ment group 8; range herbage group 3; group 1-a for recreation sites; not assigned to a timber suitability group)

Cornville gravelly sandy loam, thin solum variant (0 to 20 percent slopes) (Cg).—This soil is on old terraces and terrace breaks, near the Beaver Creek Ranger Station. In most places the slope is not more than 10 percent, but it is as much as 20 percent on terrace breaks. There is much chert gravel; most of it is on the surface or at a depth of 3 to 4 inches. The thickness of the surface layer ranges from 3 to 5 inches. In most places the texture of the surface layer is gravelly sandy loam, but in some places it is gravelly loamy sand. The texture of the subsoil is sandy clay loam or loam. There are many pebbles in the profile.

Infiltration and permeability are moderate. Surface runoff is medium, and the erosion hazard is moderate. The moisture-holding capacity is medium. The root zone is deep. Fertility is medium.

Under careful management this soil is well suited to herbage. Its capacity to store water underground is medium. (Management group 8; range herbage group 2; group 1-b for recreation sites; not assigned to a timber suitability group)

Courthouse series

The Courthouse series consists of shallow to moderately deep, gently sloping to steep, well-drained soils. These soils formed in place over red sandstone of the Supai formation and have been influenced by a basalt component. They occur at elevations of about 4,000 feet. They are associated with Springerville, Guest, Penthouse, Mescal, and Stagecoach soils. They lie downslope from Schnebly soils and upslope from Tobler soils. The predominant vegetation is catclaw, mesquite, juniper, turbinella oak, snakeweed, Rothrock grama, and sideoats grama.

Courthouse soils are calcareous to the surface. They have a red to reddish-brown surface layer of fine sandy loam that is soft when dry and friable when moist and has blocky structure. Their subsoil is red gravelly heavy fine sandy loam that is friable when moist and has blocky structure. Light-red, hard, calcareous sandstone is at a depth ranging from 12 to 24 inches. In most places, but not all, the subsoil is distinct.

Courthouse gravelly fine sandy loam (10 to 40 percent slopes) (Ch).—This soil is shallow. It is on gently sloping to steep uplands in the western part of the survey Area. Gravel and cobbles occur on the surface, and ledge rock is exposed in places.

Representative profile:

Surface soil—

0 to 3 inches, reddish-brown gravelly fine sandy loam; platy structure; soft; calcareous; moderately alkaline.

Subsoil—

3 to 9 inches, red gravelly heavy fine sandy loam; blocky structure; hard; calcareous; moderately alkaline.

Substratum—

9 to 14 inches, red very gravelly light clay loam; subangular blocky structure; calcareous; moderately alkaline.

Bedrock—

14 inches +, sandstone.

Infiltration and permeability are moderate. Surface runoff is medium or rapid, and the erosion hazard is high. The water-holding capacity is low. The root zone is shallow. Fertility is low.

The less sloping areas are used for winter grazing, but such use is limited in many places because of steep slopes and exposed ledge rock. The capacity for water storage is low. (Management group 11; range herbage group 4; group 4-c for recreation sites; not assigned to a timber suitability group)

Courthouse stony fine sandy loam (5 to 20 percent slopes) (Cs).—This soil is shallow and stony. The depth to sandstone is 14 inches in most places. Stones cover about 30 percent of the surface. In some places there are ledges and outcrops of sandstone.

This soil has limited use for winter grazing. Mesquite and catclaw compete strongly with the grass. The capacity for water storage is low. (Management group 11; range herbage group 3; group 4-b for recreation sites; not assigned to a timber suitability group)

Friana series

The Friana series consists of deep, dark-colored, non-calcareous soils in depressions. These soils are nearly level or very gently sloping. They make up the open parks and meadows in the pine forest. They formed in sediments derived from basalt, cinders, and ash, washed from the surrounding uplands. They occur at elevations of 7,000 to 7,500 feet, where the annual precipitation is 20 to 23 inches. They are downslope from Broliar, Siesta, and Sponseller soils. The plant cover consists chiefly of native grasses, such as mountain brome, Arizona fescue, blue grama, and introduced western wheatgrass. There are many iris plants and a few Gambel oak trees.

Broliar soils have a brown to dark-brown surface layer that is hard when dry and has platy or subangular blocky structure. Their subsoil is reddish brown, is very hard when dry, and has blocky structure. Their substratum is vari-colored, and in many places it is mottled. It is very hard when dry and is massive or has blocky structure. These soils range from slightly acid in the surface layer to mildly alkaline in the substratum.

Friana soils (0 to 2 percent slopes) (Fn).—This undifferentiated unit consists of Friana clay loam (fig. 13), Friana silty clay loam, and Friana clay. These soils occur together in a pattern so complex that mapping them separately was not practicable. They make up the open parks and meadows in the pine forest. Schroeder Park and Mule Park are examples of the landscape. Friana clay loam is the dominant soil. Generally, the pattern is such that Friana clay occupies the central part of the parks, and Friana silty clay loam and Friana clay loam surround the clay and fringe into the adjacent Broliar and Siesta soils. Included in the areas mapped are small acreages of somewhat poorly drained soils and soils that have a bleached surface layer. These soils are wet part of the year; runoff from adjacent soils causes ponding. In most places they are free of coarse fragments, but there are scattered areas where the surface is covered with fragments of stone 2 to 10 inches in diameter.

Representative profile of Friana clay loam in a meadow:

Surface layer—

0 to 11 inches, brown to dark-brown light clay loam; platy or subangular blocky structure; hard; slightly acid.

Subsoil and substratum—

11 to 55 inches, reddish-brown clay; blocky structure; slightly or mildly alkaline.

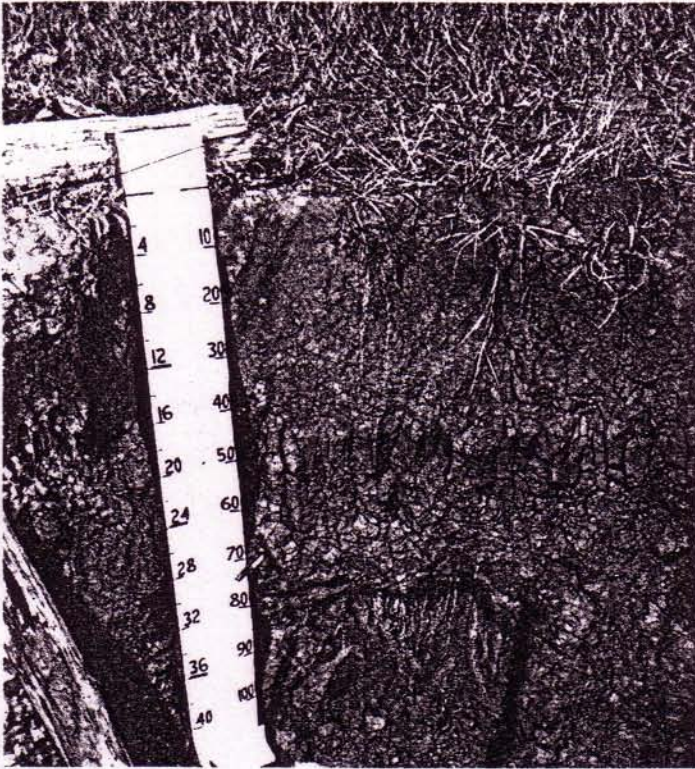


Figure 13.—Profile of Friana clay loam.

Infiltration is moderate, and permeability is very slow. Surface runoff is slow, and the erosion hazard is low. The available moisture-holding capacity is moderate. The root zone is deep. Fertility is high.

These soils are well suited to production of range herbage, but they are unsuitable for timber. They provide most of the summer feed for the herds of elk, and they provide much of the forage for livestock. Their capacity to store water is medium. The potential for natural recovery of vegetation is good. (Management group 1; range herbage group 1; group 2-a for recreation sites; not assigned to a timber suitability group)

Friana clay, black variant (0 to 2 percent slopes) (Fk).—This soil occurs in the small open parks in the pine forest. It is similar to Friana soils (0 to 2 percent slopes), but it is black and occurs at higher elevations. It is imperfectly drained and is mottled with brown, reddish brown, yellowish red, and yellowish brown below a depth of 10 inches. Infiltration is moderate, and permeability is slow. Surface runoff is slow. The erosion hazard is low, but there are some cuts and gullies. Fertility is high.

This soil is well suited to herbage and could produce a large volume of usable forage. It is not suited to timber. It is a choice feeding area for wildlife. The capacity for water storage is medium. (Management group 1; range herbage group 1; group 3-a for recreation sites; not assigned to a timber suitability group)

Gem series

The Gem series consists of moderately deep and deep, dark-colored soils on undulating uplands. These soils formed in material derived from basalt and cinders. They occur chiefly in the east-central part of the survey Area,

in the fringe area between the ponderosa pine forest and the pinyon-juniper woodland, at elevations of 6,500 to 7,000 feet, where the annual precipitation is 18 to 19 inches. They adjoin Broliar and Springerville soils. The vegetation consists of blue grama, squirreltail, three-awn, ring muhly, snakeweed, some alligator juniper, and scattered ponderosa pines and Utah junipers.

Gem soils have a very dark grayish-brown surface layer that is soft when dry and has granular structure. Their subsoil is brown and extremely hard and has prismatic or blocky structure. Their substratum is reddish yellow and reddish brown. It is hard when dry and is massive. In most places the lower part of the substratum is calcareous. Cobblestones and angular fragments of basalt occur on the surface.

Gem clay loam (0 to 10 percent slopes) (Gm).—This soil is on undulating uplands. Cobblestones and fragments of basalt occur on the surface but are not so numerous that the soils are considered stony or cobbly. About 10 to 12 percent of the areas mapped consists of Springerville clay.

Representative profile in a grassy area:

- Surface soil—
0 to 3 inches, very dark grayish-brown clay loam; granular structure; soft; slightly acid.
- Subsoil—
3 to 28 inches, brown clay; prismatic or blocky structure; extremely hard; neutral.
- Substratum—
28 to 44 inches, reddish-brown and reddish-yellow very gravelly clay to clay loam; massive; hard; strongly calcareous below a depth of 37 inches; mildly alkaline to moderately alkaline.
- Bedrock—
44 inches +, basalt and cinders.

Infiltration is moderate, and permeability is slow. The available moisture capacity is medium. Surface runoff is slow, and the erosion hazard is low. The root zone is moderately deep. Fertility is high.

This soil is well suited to production of herbage and is used for summer grazing. It is poorly suited to timber. It is well suited to wildlife, particularly to antelope. Recreational use is limited to hunting. The capacity to store water is moderate, and the potential for sustained yield of water is low. (Management group 5; timber suitability group 5; range herbage group 2; group 1-a for recreation sites)

Gem-Springerville complex (0 to 5 percent slopes) (Gn).—This complex occurs as isolated, nearly treeless spots in the ponderosa pine forest and in the fringe area between the ponderosa pine forest and the pinyon-juniper woodland. The soils are so intricately mixed that mapping them separately was not practicable. Gem clay loam makes up about 60 percent of the complex, and Springerville very stony clay makes up about 40 percent. These soils range from 30 to 38 inches in depth. They crack when dry. There are stones and cobblestones on the surface. The vegetation consists mainly of native grasses, but there are scattered stunted ponderosa pine and alligator juniper trees.

Infiltration is moderate until the clay particles are wet enough to swell and expand. Permeability is slow or very slow. The available moisture capacity is medium. Surface runoff is slow, and the erosion hazard is low.

This complex is well suited to production of herbage. It is poorly suited to timber. Its capacity to store water is medium, and sustained yield of water is low. (Management group 5; timber suitability group 5; range herbage group 2; group 2-a for recreation sites)

Gila series

The Gila series consists of deep, well-drained, calcareous soils on bottom lands and low terraces. These soils are dominantly fine sandy loams. They formed in alluvium derived from sandstone, limestone, basalt, granite, rhyolite, and greenstone. They occur along Oak Creek and the Verde River at elevations of 3,100 to 3,500 feet, where the average annual rainfall is about 12 inches. They are associated with Cornville, Anthony, and Toquop soils. The Cornville soils are on higher terraces, and the Anthony and Toquop soils occupy lower bottom lands. The vegetation is mainly acacia and cottonwood trees, galleta, sand dropseed, and annual weeds.

Gila soils have a reddish-brown surface layer that is hard when dry and is massive. This is underlain by reddish-brown stratified layers that are slightly hard or hard and massive. In most places the texture is uniform throughout the profile, but in a few places finer textured material, such as silty clay loam, occurs at a depth of 3 feet or more. All of the Gila soils are calcareous; the surface layer is slightly calcareous to strongly calcareous, and the substratum is very strongly calcareous.

Gila very fine sandy loam, reddish variant (0 to 5 percent slopes) (Gs).—This soil is on alluvial bottom lands in the western part of the Area, along the Verde River and Oak Creek. The slopes are dominantly 2 percent or less.

Representative profile in a cultivated field:

Surface soil—

0 to 9 inches, reddish-brown very fine sandy loam; massive; hard; strongly calcareous; moderately alkaline.

Subsoil—

9 to 37 inches, reddish-brown very fine sandy loam; massive; hard to slightly hard; strongly calcareous; moderately alkaline.

Substratum—

37 to 74 inches +, reddish-brown very fine sandy loam or silt loam; thin strata of silty clay loam; massive; hard; very strongly calcareous; moderately alkaline.

Infiltration and permeability are moderate. The moisture-holding capacity is generally high. Surface runoff is slow. The hazard of gully erosion is moderate. The root zone is deep. Fertility is medium.

This soil is used primarily for irrigated crops and for pasture. Under good management it produces good yields. The principal irrigated crops are alfalfa, small grain, corn, and vegetables. The nonirrigated acreage is used for range, to which it is moderately well suited. (Management group 7; range herbage group 2; group 3-a for recreation sites; not assigned to a timber suitability group)

Glendale series

The Glendale series consists of deep, well-drained, strongly calcareous soils on smooth alluvial fans and in depressions. These soils developed in outwash from limestone. They occur at elevations of 3,500 feet, where the annual precipitation is 11 to 13 inches. They adjoin Karro, Hantz, and Retriever soils. In many places the vegetation is dominantly dense stands of creosotebush.

Other plants include mesquite, winterfat, galleta, sand dropseed, sideoats grama, and black grama. About half of the surface is barren.

Glendale soils are calcareous to the surface. They have a pale-brown surface layer that is soft when dry and has platy structure. Their subsoil and substratum are pale brown, are soft when dry, and have subangular blocky structure. In some places the subsoil and substratum are somewhat stratified.

Glendale silt loam (0 to 5 percent slopes) (Gt).—This soil occurs on alluvial fans and in basins in the western part of the Area. In most places limestone gravel occurs on the surface. Slopes are dominantly 2 percent or less.

Representative profile in an area used for range:

Surface layer—

0 to 15 inches, pale-brown silt loam; platy structure; soft; strongly calcareous; moderately alkaline.

Subsoil—

15 to 36 inches, pale-brown heavy silt loam; subangular blocky structure; soft; strongly calcareous; moderately alkaline.

Substratum—

36 to 52 inches, pale-brown loam; subangular blocky structure; soft; strongly calcareous; moderately alkaline.

Infiltration is rapid when the soil is dry and moderate when the soil is wet. Permeability is moderate. The moisture-holding capacity is high. Surface runoff is slow. The hazard of gully erosion is high. The root zone is deep. Fertility is high.

This soil is moderately well suited to herbage and is used chiefly as winter range. Grazing should be carefully controlled in order to maintain a cover of vegetation dense enough to counteract the high erosion hazard. (Management group 6; range herbage group 3; group 3-a for recreation sites; not assigned to a timber suitability group)

Guest series

The Guest series consists of deep, well-drained, calcareous soils on alluvial fans and bottom lands. These soils formed in alluvium derived mainly from basalt but partly from limestone. They occur at elevations of 3,500 to 3,900 feet, where the annual precipitation is about 12 inches. They adjoin Karro, Retriever, and Stagecoach soils. The vegetation consists of mesquite, catclaw, and tobosa. Some areas are nearly barren, but others have a dense stand of tobosa.

Guest soils have a brown surface layer that is slightly hard when dry and has platy structure. Their subsoil and substratum are brown and have blocky structure. The subsoil is hard or very hard, and the substratum is hard. In many places small pebbles of basalt have accumulated on the surface.

Guest clay (0 to 3 percent slopes) (Gu).—This soil is on alluvial fans and flood plains in the western part of the Area. It is slightly calcareous to strongly calcareous throughout.

Representative profile in an area used for range:

Surface soil—

0 to 3 inches, brown clay; platy structure; slightly hard; calcareous; moderately alkaline.

Subsoil—

3 to 32 inches, brown silty clay; blocky structure; very hard; calcareous; moderately alkaline.

Substratum—

32 to 50 inches, brown silty clay loam; blocky structure; hard; calcareous; moderately alkaline.

Infiltration is moderate, and permeability is slow. The water-holding capacity is high. Surface runoff is slow. The hazard of gully erosion is moderate to high, and gullies and headcuts are common. This soil is fertile, and the organic-matter content of its surface layer is high. The root zone is deep.

This soil is well suited to production of range herbage, but when the plant cover is depleted natural recovery of vegetation is slow. Most of the acreage is used for winter range, but small areas are irrigated. Yields of irrigated crops vary with management. (Management group 10; range herbage group 2; group 2-a for recreation sites; not assigned to a timber suitability group)

Hantz series

The Hantz series consists of deep, well-drained, very strongly calcareous soils on alluvial fans and bottom lands. These soils formed in outwash weathered from shale and limestone. They occur at elevations of 3,100 to 3,300 feet, where the estimated annual precipitation is 11 inches. The Hantz soils lie next to Glendale, Cornville, and Gila soils. The vegetation consists of sparse stands of tobosa, snakeweed, chamiso, and mesquite. Most of the acreage is nearly barren.

Hantz soils are very strongly calcareous to the surface. They have a light brownish-gray surface layer that is very hard and has subangular blocky structure. Their subsoil and substratum are light grayish brown and very hard. In some places the structure is weakly expressed, and in others these layers are massive.

Hantz silty clay (0 to 5 percent slopes) (Ha).—This soil is on alluvial fans in the western part of the Area. In many places it extends from the fans onto the bottom lands. In most places limestone gravel and fragments of limestone occur on the surface. The topography is generally smooth, but there are some gullies.

Representative profile in an area used for range:

- Surface soil—
0 to 3 inches, light brownish-gray silty clay; subangular blocky structure; very hard; very strongly calcareous; moderately alkaline.
- Subsoil and substratum—
3 to 60 inches, light brownish-gray silty clay; blocky and platy structure; very hard; very strongly calcareous; moderately alkaline or strongly alkaline.

Infiltration is moderate, and permeability is slow. The moisture-holding capacity is high. Surface runoff is slow. The hazard of gully erosion is high because this soil receives runoff from other areas. The root zone is deep. Fertility is medium.

This soil is moderately well suited to herbage. Except for small irrigated areas, it is used mostly for winter range. The potential for natural recovery of vegetation is poor. Loss or depletion of the plant cover accelerates the formation of headcuts and gullies. Yields of irrigated crops vary, depending on management. Use of these areas for recreational purposes and as wildlife habitats is not significant. (Management group 10; range herbage group 3; group 3-a for recreation sites; not assigned to a timber suitability group)

Hogg series

The Hogg series consists of moderately deep, well-drained, stony soils on uplands. These soils formed in

material weathered from cherty limestone and from sandstone. Although the cherty limestone is slightly calcareous, these soils are noncalcareous throughout. They occur in the pine forest in the east-central part of the Area, at elevations of about 6,500 feet, where the average annual precipitation is about 19 inches. They adjoin Lynx, Siesta, Broliar, and Friana soils. The vegetation consists mainly of ponderosa pine, Gambel oak, New-Mexican locust, alligator juniper, pinyon pine, and blue grama.

Hogg soils have a brown surface layer that is slightly hard when dry and has platy structure. Their subsoil is reddish brown and extremely hard and has blocky structure. Their substratum is reddish yellow and is hard when dry. It is massive. The texture of the surface layer is clay loam in places.

Hogg stony silt loam (0 to 10 percent slopes) (Hg).—This soil is on uplands in a small area just east of Apache Maid Mountain. There are many stones and cobbles on the surface and much chert gravel.

Representative profile in a cutover area of ponderosa pine:

- Surface soil—
0 to 9 inches, brown stony silt loam to stony clay loam; platy structure; slightly hard; slightly acid.
- Subsoil—
9 to 27 inches, reddish-brown clay; blocky structure; extremely hard; slightly acid to medium acid.
- Substratum—
27 to 32 inches, reddish-yellow silty clay; massive; hard; neutral.
- Bedrock—
32 inches +, limestone or sandstone.

Infiltration is moderate, and permeability is slow. The moisture-holding capacity is medium. Surface runoff is slow, and the erosion hazard is low. The root zone is moderately deep. Fertility is medium.

This soil is well suited to herbage and timber. It has good potential for recreational use and as wildlife habitats. It has medium capacity for water storage, and the sustained yield of water is medium. (Management group 3; timber suitability group 3; range herbage group 3; group 1-a for recreation sites)

House Mountain series

The House Mountain series consists of very shallow and shallow, well-drained soils on uplands. These soils formed in material weathered from basalt. They occur in the western part of the Area at elevations of about 3,700 feet, where the average annual precipitation is about 12 inches. They are upslope from Guest and Karro soils and adjacent to Courthouse, Penthouse, Retriever, and Schnebly soils. The vegetation is mainly mesquite, turbinella oak, sideoats grama, black grama, three-awn, fluffgrass, snake-weed, algerita, and juniper. More than half of the surface is barren.

House Mountain soils have a brown color that is inherited from the parent basalt. Their surface layer is soft when dry and has platy structure or is massive. It overlies a layer that is soft when dry and has blocky structure or is massive. Under this is brown soil material in cracks in very hard basalt. In places these soils are noncalcareous, and in other places they are strongly calcareous.

House Mountain stony loam (0 to 10 percent slopes) (Hm).—This soil occurs on mesa tops, ridges, and un-

dulating and rolling uplands. About half of the surface is covered with basalt stones and cobblestones, and there are many outcrops of basalt. Stringers of shallow loam and clay loam material of alluvial origin extend into areas of this soil.

Representative profile in an area used for range:

- Surface soil—
0 to 2 inches, brown stony loam to stony clay loam; platy structure; soft; noncalcareous; mildly alkaline.
- Subsoil—
2 to 10 inches, brown stony loam; blocky structure or massive; soft; noncalcareous; mildly alkaline; clay loam in lower part.
- Substratum—
10 to 12 inches, brown very stony clay loam soil material, and very hard basalt that contains some lime; mildly alkaline.
- Bedrock—
12 inches +, basalt.

Infiltration and permeability are moderate. The moisture-holding capacity is low. Surface runoff is medium, and the erosion hazard is moderate. The root zone is very shallow or shallow.

This soil is moderately well suited to production of herbage. It can be used for winter grazing and as a wildlife habitat. Its capacity for water storage is low. (Management group 11; range herbage group 4; group 4-a for recreation sites; not assigned to a timber suitability group)

Jacks series

The Jacks series consists of well-drained, moderately deep, noncalcareous soils on mesas. These soils formed in material weathered from sandstone. They occur in the western part of the Area at elevations of 5,200 feet, where the average annual precipitation is about 16 inches. They adjoin Springerville soils and are upslope from several land types. The vegetation is mainly manzanita, turbinella oak, ceanothus, pinyon pine, juniper, yucca, blue grama, and sideoats grama. Much of the surface is barren.

Jacks soils have a surface layer that is brown to yellowish red and slightly hard or hard. They have platy or subangular blocky structure. Their subsoil is yellowish red and very hard and has blocky structure. In most places the subsoil directly overlies sandstone bedrock, but in some places a substratum underlies the subsoil.

Jacks fine sandy loam (0 to 15 percent slopes) (Ja).—This soil is on the top of Horse Mesa. Coarse fragments and slabs of Coconino sandstone cover 2 to 50 percent of the surface. This is the only soil in the Area on which significant amounts of chaparral grow.

Representative profile under a cover of chaparral:

- Surface soil—
0 to 9 inches, brown to yellowish-red fine sandy loam; platy and subangular blocky structure; slightly hard to hard; slightly acid to neutral.
- Subsoil—
9 to 24 inches, yellowish-red sandy clay and clay; blocky structure; very hard; neutral to mildly alkaline.
- Parent rock—
24 inches +, reddish-yellow, hard sandstone.

Infiltration is rapid, and permeability is slow. The water-holding capacity is medium. Surface runoff is medium, and the erosion hazard is high. The root zone is moderately deep. Fertility is moderate.

This soil is moderately well suited to herbage. It is not suited to production of timber. Desirable browse makes it a good habitat for deer. Inaccessibility limits its potential for recreational use. The capacity for sustained yield of water is medium to low. (Management group 8; range herbage group 3; group 2-a for recreation sites; not assigned to a timber suitability group)

Jacks very rocky fine sandy loam (15 to 30 percent slopes) (Jc).—This soil occurs on moderately steep and steep hillsides near Horse Mesa. It is closely associated with Jacks fine sandy loam (0 to 15 percent slopes). Large slabs of Coconino sandstone are on the surface. The vegetation consists of ceanothus, manzanita, mountain-mahogany, yucca, mesquite, blue grama, sideoats grama, and sparse stands of pinyon pine and juniper. Surface runoff is rapid, and the erosion hazard is moderate.

This soil is well suited to use as a wildlife habitat. Ceanothus and mountain-mahogany are desirable browse plants that provide winter feed. Runoff from this soil supplies water to the adjacent Jacks soils. (Management group 8; range herbage group 5; group 4-c for recreation sites; not assigned to a timber suitability group)

Karro series

The Karro series consists of deep, well-drained soils on alluvial fans and terraces. These soils formed in mixed alluvium derived from limestone, sandstone, and shale. They occur in the western part of the Area in the grassland-desert shrub zone, at elevations of 3,500 to 4,000 feet, where the average annual precipitation is about 12 inches. The vegetation is mesquite, canotia, creosotebush, yucca, algerita, sideoats grama, three-awn, and needle-and-thread. Much of the surface is barren.

Karro soils are calcareous throughout. They have a light-brown, soft surface layer that has platy or subangular blocky structure or is massive. The subsoil and substratum are brown to pink, are hard or extremely hard, and have blocky or platy structure or are massive.

The Karro soils in the Beaver Creek Area were mapped as part of an undifferentiated unit with Laveen soils. In this Area the Karro and Laveen soils are the most extensive of all of the soils derived from alluvium. They are adjacent to Retriever, Hantz, House Mountain, and Glendale soils.

Karro and Laveen fine sandy loams (0 to 10 percent slopes) (Ka).—Karro soils predominate in some areas of this undifferentiated group, and Laveen soils in others. Overall, Karro soils make up 60 percent of the acreage, and Laveen soils 40 percent.

These are deep soils on old alluvial fans and terraces. The parent material has been strongly influenced by sediments from adjacent limestone formations. Some areas are gullied.

Representative profile of Karro fine sandy loam in an area of native range grasses:

- Surface soil—
0 to 8 inches, light-brown fine sandy loam; platy and subangular blocky structure or massive; soft to slightly hard; strongly calcareous and moderately alkaline.
- Subsoil—
8 to 31 inches, brown loam or heavy fine sandy loam; subangular blocky structure or massive; hard; very strongly calcareous and moderately alkaline.
- Substratum—
31 to 52 inches +, pink loam or fine sandy loam; platy structure; extremely hard; strongly calcareous and moderately alkaline.

Representative profile of Laveen fine sandy loam:

Surface soil—

0 to 6 inches, pale-brown fine sandy loam; platy structure; soft; strongly calcareous and moderately alkaline.

Subsoil—

6 to 18 inches, light reddish-brown gravelly sandy loam; massive; slightly hard; very strongly calcareous and moderately alkaline.

Substratum—

18 to 32 inches +, light-brown to pinkish-white gravelly sandy loam; massive; hard; concretions and nodules of lime; very strongly calcareous and moderately alkaline.

Infiltration is rapid, and permeability is moderate. Surface runoff is slow, but the erosion hazard is high because these soils receive runoff water from other areas. Water-storage capacity is high. The root zone is deep. These soils are fertile.

These soils are moderately well suited to herbage. They are used chiefly for winter range, but a few small areas are irrigated and used for cultivated crops. Yields of irrigated crops vary, depending on management. These soils have good potential as a habitat for gamebirds. (Management group 7; range herbage group 2; group 3-a for recreation sites; not assigned to a timber suitability group)

Laveen series

The Laveen series consists of deep, well-drained, very strongly calcareous fine sandy loams and gravelly sandy loams on alluvial fans and terraces. These soils formed in sediments derived from limestone and sandstone. They occur at an elevation of about 3,900 feet, where the average annual precipitation is about 13 inches. They adjoin Bridge, Retriever, Springerville, and Guest soils. The vegetation is of the grassland-desert shrub type. It consists of scattered juniper trees, mesquite, yucca, cacti, canotia, snakeweed, and native grasses. A large part of the acreage is only sparsely vegetated.

Laveen soils have a pale-brown to pink surface layer that is soft or very soft and has platy or subangular blocky structure. Their subsoil and substratum are pink to white, soft, very strongly calcareous material that has blocky structure or is massive. There are some concretions of lime in the substratum, and some layers in the substratum are weakly cemented.

Laveen gravelly sandy loam (5 to 20 percent slopes) (La).—This soil occurs on eroded terraces in the southwestern part of the Area. Much of the surface is covered with chert, limestone, and sandstone gravel.

Representative profile in an area used for range:

Surface soil—

0 to 1 inch, pale-brown to pink gravelly sandy loam to gravelly loam; platy and subangular blocky structure; very soft or soft; very strongly calcareous; moderately alkaline.

Subsoil and substratum—

1 to 32 inches +, pink and white gravelly sandy loam; blocky structure to massive; soft; very strongly calcareous; moderately alkaline to strongly alkaline.

Infiltration and permeability are moderately rapid. Surface runoff is medium, and the erosion hazard is moderate. The moisture-holding capacity is medium. Grass roots penetrate only the surface layer, but the roots of juniper trees, mesquite, and canotia penetrate the subsoil. The organic-matter content is low. Fertility is low.

This soil is moderately well suited to herbage and is used for range. It has little potential for recreational use but provides a winter habitat for game. It is very strongly calcareous, and only lime-tolerant plants can be used in reestablishing depleted vegetation. The potential for natural recovery of vegetation is low. (Management group 6; range herbage group 3; group 2-b for recreation sites; not assigned to a timber suitability group)

Lynx series

The Lynx series consists of deep, well-drained soils on nearly level or gently sloping low terraces and valley fill. These soils formed in alluvial material washed from basalt and cinders. They occur in the central part of the Area at elevations of 5,500 to 6,500 feet, where the average annual precipitation is about 16 to 20 inches. They are downslope from Springerville soils. These soils are in the pinyon-juniper zone. The vegetation consists mainly of blue grama, annual grasses, weeds, pinyon pine, juniper, and snakeweed.

Lynx soils have a dark grayish-brown surface layer that is hard when dry and has platy structure. Beneath this are layers of brown, hard material that has blocky structure or is massive.

Lynx silt loam (0 to 3 percent slopes) (Ln).—This soil occurs in areas of old valley fill. It is not extensive in this Area.

Representative profile in an abandoned field:

Surface layer—

0 to 10 inches, dark grayish-brown to dark-brown silt loam; platy structure; hard; neutral.

Subsoil—

10 to 35 inches, brown clay loam; subangular blocky structure; hard; neutral to mildly alkaline.

Substratum—

35 to 62 inches +, brown clay; blocky structure to massive; hard; mildly alkaline.

Infiltration is moderate, and permeability is moderately slow. The available water capacity is medium. Surface runoff is slow, and the hazard of gully erosion is moderate. The root zone is deep. Fertility is moderate.

This soil is well suited to herbage. It is used primarily for summer grazing and also provides a habitat for wildlife. Small areas were once cultivated but have been abandoned and have reverted to native range. The capacity for water storage is medium. (Management group 10; range herbage group 2; group 1-a for recreation sites; not assigned to a timber suitability group)

Lynx silt loam, heavy subsoil variant (0 to 5 percent slopes) (Ly).—This soil is on low terraces and on valley fill in canyons in the eastern part of the Area. The elevation is about 6,400 feet. There are many deep gullies, some of which have resulted from erosion in old roads or skid trails. This soil is in the ponderosa pine zone, and the vegetation consists mainly of a good stand of pine, with which is mixed some Gambel oak, New-Mexican locust, and grass.

This soil has a surface layer of silt loam. Its subsoil ranges from clay loam to clay in texture. There is a surface mat of pine-needle litter in areas where the stands of pine are dense.

Infiltration is moderate, and permeability is moderately slow. The capacity to store water is high. Surface runoff is slow, but the hazard of gully erosion is high. When the plant cover is depleted, the bare soil becomes

loose and fluffy, and the soil particles are easily detached and moved by water. The root zone is deep. Fertility is high.

This soil is well suited to timber and herbage (fig. 14). Its capacity for sustained yield of water is high. It presents few problems in management, but considerable care is required to control gullying and the consequent lowering of the water table. Productivity is substantially reduced if gullies develop. (Management group 2; timber suitability group 1; range herbage group 2; group 2-a for recreation sites.)

Mescal series

The Mescal series consists of moderately deep, well-drained, strongly calcareous soils. These soils developed in material weathered from limestone. They occur in level to undulating areas on ridgetops and side slopes in the grassland-desert shrub zone in the western part of the Area. The elevation is about 4,000 feet, and the average annual precipitation is 13 inches. Mescal soils are downslope from Courthouse and Retriever soils and next to Karro and Penthouse soils. The plant cover consists mainly of algerita, canotia, squawberry, juniper trees, sand dropseed, three-awn, and needle-and-thread. A large part of the surface is barren.

Mescal soils are strongly calcareous to the surface. Their surface layer and subsoil are light reddish brown and are soft when dry. The surface layer has platy structure or is massive, and the subsoil is massive. In many places it contains limestone cobbles. Limestone bedrock is at a depth of 16 to 30 inches or more.

Mescal fine sandy loam (0 to 10 percent slopes) (Ms).—This soil is on upland ridges, side slopes, and saddles. The slopes are mostly between 2 and 8 percent, but a few short step breaks of as much as 25 percent gradient are included in the areas mapped. These breaks are made up of limestone outcrops and areas of Retriever soils. Small amounts of gravel and stone occur on the surface.

Representative profile in an area used for range:

Surface soil—

0 to 6 inches, light reddish-brown fine sandy loam; platy structure to massive; soft; strongly calcareous; moderately alkaline.

Subsoil—

6 to 24 inches, light reddish-brown sandy loam or loam; massive; soft; strongly calcareous; moderately alkaline.

Bedrock—

24 inches +, limestone.

Infiltration and permeability are moderate. The capacity to store water is medium. Surface runoff is slow, but the erosion hazard is high. The root zone is moderately deep. Fertility is medium.

Although the vegetation is depleted, this soil has moderate potential for production of herbage. It is used as winter range. (Management group 6; range herbage group 3; group 3-a for recreation sites; not assigned to a timber suitability group)

Penthouse series

The Penthouse series consists of deep, well-drained soils on nearly level and gently sloping old high terraces and the lower parts of fans. These soils developed in material weathered from basalt and sandstone. They occur in the western part of the Area, in the grassland-desert shrub zone, at an elevation of about 3,800 feet,



Figure 14.—An area of Lynx silt loam, heavy subsoil variant. Ponderosa pine and grass grow well on this soil.

where the average annual precipitation is 13 inches. They are associated with Cornville, Courthouse, Karro, Mescal, Retriever, and Guest soils. The vegetation is mainly mesquite, snakeweed, cacti, filaree, juniper, tobosa, and blue grama. Much of the surface is barren.

Penthouse soils have a brown, soft surface layer that has platy structure. Their subsoil is reddish brown, is hard or very hard, and has blocky structure. Their substratum is pink, hard, massive, and strongly calcareous.

Penthouse cobbly clay loam (0 to 5 percent slopes) (Pc).—This soil (fig. 15) is on old terraces and fans. From 20 to 50 percent of its surface is covered with cobbles, gravel, and stones. There are a few shallow gullies.

Representative profile in an area used for range:

Surface soil—

0 to 3 inches, brown cobbly clay loam; platy structure; soft; mildly alkaline.

Subsoil—

3 to 27 inches, reddish-brown clay; blocky structure; hard and very hard; calcareous; moderately alkaline.

Substratum—

27 to 44 inches +, pink clay loam; massive; hard; strongly calcareous; moderately alkaline.



Figure 15.—The dark-colored soil in the center is Penthouse cobbly clay loam. The light-colored soil in the foreground is Retriever very stony loam, 0 to 20 percent slopes. The Mogollon Rim appears in the background.

Infiltration is moderate, but permeability is very slow. The available moisture capacity is medium. Surface runoff is slow, and the erosion hazard is moderate. Roots penetrate deeply but are concentrated in the upper part of the profile. Fertility is moderate.

This soil is moderately well suited to herbage and is used for winter range, but grazing should be carefully controlled. Deer, antelope, and other wildlife graze the forage in severe winters. The capacity to store water underground is only medium. (Management group 9; range herbage group 3; group 2-a for recreation sites; not assigned to a timber suitability group)

Penthouse stony loam (0 to 5 percent slopes) (Ph).—This soil occupies a small area on high terraces above Wet Beaver Creek, near Rimrock. In places there are many large basalt stones and some boulders on the surface. Although a large part of the soil is barren of vegetation, there are many *Christmascactus* plants.

This soil is moderately well suited to production of range herbage and is used for winter range. Antelope and deer make some use of the range in winter. The stones and boulders on the surface make use of machinery difficult. (Management group 9; range herbage group 3; group 2-a for recreation sites; not assigned to a timber suitability group)

Retriever series

The Retriever series consists of very shallow or shallow, well-drained, typically very stony soils on undulating uplands, mesa tops, and moderately steep side slopes. These soils are very strongly calcareous. They formed in material weathered from limestone. They occur in the western part of the Area at elevations of 3,300 to 4,000 feet, where the average annual precipitation is 11 to 13 inches. They are upslope from Guest, Glendale, Karro, and Penthouse soils and next to House Mountain and Laveen soils. They are in the grassland-desert shrub vegetation zone. The plant cover is mainly canotia, Mormon tea, juniper, creosotebush, yucca, snakeweed, sideoats grama, and three-awn. About half of the surface is barren, and there are many coarse fragments and outcrops of limestone.

Retriever soils have a pale-brown surface layer that is soft and has platy structure. Their subsoil is light yellowish brown. It is soft when dry and has blocky structure. The color of these soils ranges from pale brown and light brownish gray to reddish brown.

Retriever very stony loam, 0 to 20 percent slopes (RrC).—This soil is on uplands, mesas, side slopes, and on low, rounded ridgetops. About 30 percent of the surface consists of limestone outcrops, and stones and cobblestones are common.

Representative profile in an area used for range:

Surface soil—

0 to 3 inches, pale-brown very stony loam; platy structure; soft; strongly calcareous; moderately alkaline.

Subsoil—

3 to 9 inches, light yellowish-brown stony loam; blocky structure; soft; very strongly calcareous; moderately alkaline.

Bedrock—

9 inches +, white, hard limestone.

Infiltration and permeability are moderate. Surface runoff is medium, and the erosion hazard is high. The available moisture capacity is low. The root zone is very shallow or shallow. Natural fertility is low.

This soil is poorly suited to herbage. It is used as winter range, but its carrying capacity is low. It provides suitable winter habitats for wildlife. The potential for natural recovery of vegetation is low, and careful management is necessary to maintain the ground cover. The capacity to store water is low. (Management group 6; range herbage group 3; group 4-b for recreation sites; not assigned to a timber suitability group)

Retriever very stony loam, 20 to 40 percent slopes (RrD).—This soil is on steep side slopes of ridges and mesas. Much ledge rock and many limestone outcrops occur on the surface, together with stones and cobblestones. Surface runoff is rapid, and the erosion hazard is high.

This soil is poorly suited to herbage. It is used as winter range, but its carrying capacity is low, and its usefulness is limited by the steep, stony and rocky slopes. It provides suitable winter habitats for wildlife. The potential for natural recovery of vegetation is low, and careful management is necessary to maintain the ground cover. The capacity to store water is low. (Management group 11; range herbage group 4; group 4-c for recreation sites; not assigned to a timber suitability group)

Retriever loam (0 to 5 percent slopes) (Re).—This soil is on gently sloping and gently undulating uplands and flat-topped mesas. There are some limestone outcrops and a scattering of coarse fragments on the surface. Surface runoff is slow, and the erosion hazard is moderate.

Under careful management this soil can be used for winter grazing, but the plant cover is sparse and forage species are depleted. Production of herbage is low, and the potential for natural recovery of vegetation is low. The capacity to store water is low. (Management group 6; range herbage group 4; group 4-a for recreation sites; not assigned to a timber suitability group)

Riverwash

Riverwash (Rw) consists of deposits on the bottoms of Dry Beaver Creek and Wet Beaver Creek and on the bottoms of wide, intermittent drainageways. It is subject to flooding. The soil material is mainly stratified sand, silt, and clay, with varying amounts of gravel, cobblestones, stones, and boulders. The vegetation is made up of cottonwood and sycamore trees, mesquite, willows, grass, and forbs.

During dry periods or at times when the water level is low, livestock can get a little feed, and they bed in the shaded areas. (Management group 13; range herbage group 5; not assigned to a timber suitability group nor to a group for recreation sites)

Rock land-Springerville complex

Rock land-Springerville complex (Rx) consists of Springerville clay, Springerville clay loam, basalt outcrop, stones, cobblestones, and gravel. The amount of rock outcrop ranges from 25 to 60 percent. This complex is on uplands, ridges, and breaks in the western part of the Area. The elevations range from 4,300 to 6,000 feet. The slope range is 5 to 35 percent. Most of the complex has slopes of 5 to 20 percent, but some of the short breaks have slopes of as much as 35 percent. The vegetation consists chiefly of mesquite, catclaw, pricklypear, piñon pine, juniper, canotia, tobosa, and three-awn. A few scattered, slow-growing, poorly formed ponderosa pine trees and some oak brush and blue grama grow at the higher elevations.

Infiltration is moderate, and permeability is very slow. The available moisture capacity is low. Surface runoff is rapid, and the erosion hazard is low.

This complex is very poorly suited to timber and is only fairly well suited to herbage. The less sloping areas are used for grazing. The capacity to store water is low. (Management group 11; range herbage group 3; group 4-b for recreation sites; not assigned to a timber suitability group)

Rough broken and stony land, limestone

Rough broken and stony land, limestone (Ry) is a land type that consists mainly of exposures of the Verde formation in the form of broken ledges and upland breaks. The slope range is 30 to 85 percent. This land type is at an elevation of about 4,000 feet. Pockets of Retriever and Glendale soils occur on slopes and breaks. The Retriever soil is stony sandy loam, and the Glendale soil is silt loam. Both are strongly calcareous. Many stones and cobblestones occur on the surface, and limestone ledges and outcrops are common. The vegetation consists of juniper, canotia, mesquite, catclaw, snakeweed, and some sideoats grama.

The erosion hazard is high. There are some active draws and gullies.

A few of the less sloping areas can be used to a limited extent for grazing. Most of the water runs off, and very little is stored. Plans for use of this land type must take into account the hazard of erosion. (Management group 12; range herbage group 5; not assigned to a timber suitability group nor to a group for recreation sites)

Sandstone outcrop

Sandstone outcrop (Sa) is a land type that consists of three parts.

The first part consists of broad, very gently sloping areas of bare Coconino sandstone on Horse Mesa. The exposed sandstone is nearly devoid of soil or vegetation. These outcrops are associated with Jacks soils.

The second part consists of steep, exposed Coconino sandstone and some outcrops of Supai sandstone on the side slopes of canyons, mainly in the central part of the survey Area. Small amounts of shallow, stony soil material support sparse stands of pinyon pine and juniper trees and patches of grass.

The third part consists of exposed areas of the Kaibab, Coconino, and Supai geologic formations in the form of precipitous cliffs, hundreds of feet high. These cliffs are adjacent to Oak Creek Canyon. They are generally devoid of vegetation, but scattered shrubs cling to pockets of soil on ledges.

This land type has little or no agricultural value. It is not suitable for grazing, and the steep walls are barriers to travel and to the movement of livestock. Rapid surface runoff after heavy rainfall yields water to lower areas. The towering cliffs are a scenic attraction. (Management group 13; range herbage group 5; not assigned to a timber suitability group nor to a group for recreation sites)

Sandstone rock land

Sandstone rock land (Sd) is a land type that consists of two parts.

The first part consists of very steep, rocky side slopes of deep canyons, chiefly in the central part of the Area. In most places basalt overlies Coconino sandstone and forms

many nearly vertical escarpments. Small amounts of shallow, stony soil material are intermixed with the sandstone and basalt. These areas are chiefly in the pinyon-juniper zone. The density of the vegetation varies with the exposure. The vegetation on the north-facing slopes is generally a dense cover of pinyon pine, juniper, oak brush, and grass. The vegetation on other slopes is sparse and scattered and consists of pinyon pine, juniper, and grass. Surface runoff is very rapid after heavy rainfall. The soil material is scant, and the erosion hazard is high.

The second part of the mapping unit consists of two broad, gently sloping or moderately sloping areas of exposed sandstone, limestone, and basalt, one on Horse Mesa and the other atop Munds Mountain. The rock on Horse Mesa is sandstone, and the pockets of soil are sandy loam and loamy sand. The soils on Munds Mountain are loam or clay loam. The depth of the soils rarely exceeds 10 inches, and the average depth is about 6 inches. The vegetation consists of scattered pinyon pine and juniper, and sparse stands of oak brush and various grasses.

This land type is poorly suited to herbage and very poorly suited to timber. The potential for grazing is negligible. There is little or no water-storage capacity, but surface runoff provides water yield. The oak brush supplies forage and cover for wildlife. (Management group 12; range herbage group 5; not assigned to a timber suitability group nor to a group for recreation sites)

Schneibly series

The Schneibly series consists of moderately deep, well-drained, dark-colored, very stony soils on uplands and colluvial foot slopes. These soils formed in material derived from basalt and sandstone. They occur in the grassland-desert shrub zone, at elevations of 4,000 to 4,500 feet, where the average annual precipitation is about 13 inches. They adjoin Courthouse, Retriever, Guest, and House Mountain soils. The vegetation consists mainly of mesquite, catclaw, turbinella oak, juniper, and tobosa. Much of the surface is barren.

Schneibly soils have a reddish-brown surface layer that is soft when dry and has platy structure. Their subsoil is dark reddish brown and very hard when dry. It has blocky structure. Their substratum is light reddish brown and hard when dry. It has blocky structure and contains visible lime. Stones and cobblestones of basalt are common on the surface and throughout the soil mass.

Schneibly very stony clay loam (10 to 20 percent slopes) (Se).—This soil is on uplands and colluvial foot slopes. About 30 percent of the surface is covered with basalt stones and cobblestones. Some of the stones are nearly 2 feet in diameter. They make up about 50 percent, by volume, of the soil mass.

Representative profile in an area used for range:

Surface soil—

0 to 4 inches, reddish-brown very stony clay loam; platy structure; soft; noncalcareous; neutral.

Subsoil—

4 to 22 inches, dark reddish-brown stony clay, reddish-brown clay in lower part; prismatic and blocky structure; very hard; noncalcareous; neutral to mildly alkaline.

Substratum—

22 to 25 inches, light reddish-brown clay; blocky structure; hard; strongly calcareous; moderately alkaline.

Bedrock—

25 inches +, basalt, some of which is coated with lime.

Infiltration is moderate, and permeability is slow. The available moisture capacity is medium. Surface runoff is medium, and the erosion hazard is high. The root zone is moderately deep. Fertility is medium.

This soil is moderately well suited to herbage. It is used for winter grazing and as winter range for game. Water penetrates the soil slowly, and the capacity to store water is medium. (Management group 9; range herbage group 3; group 2-b for recreation sites; not assigned to a timber suitability group)

Siesta series

The Siesta series consists of moderately deep and deep, well-drained, noncalcareous soils on gently rolling and undulating uplands. These soils occur in the eastern part of the Area, at elevations of 6,800 to 8,000 feet, where the average annual precipitation is 20 to 22 inches. They adjoin Broliar, Sponseller, Springerville, Friana, and Gem soils. The plant cover consists of a good stand of ponderosa pine, some Gambel oak, Arizona fescue, junegrass, mountain muhly, blue grama, iris, lupine, and annual weeds.

Siesta soils have a reddish-brown surface layer that is soft when dry and has platy and granular structure. Their subsoil is reddish brown and very hard when dry. It has blocky structure. Their substratum is red, slightly hard when dry, and massive. Bedrock is at a depth of 36 to 60 inches. In most places these soils contain small amounts of rounded gravel.

Siesta stony silt loam (0 to 15 percent slopes) (Sg).—This soil is on uplands. About 15 to 25 percent of the surface is covered with basalt stones and cobbles, cinder fragments, gravel, and cinder bombs.

Representative profile in an area of cutover ponderosa pine:

- Surface soil—
0 to 5 inches, dark reddish-brown stony silt loam; platy and granular structure; soft; noncalcareous; neutral.
- Subsoil—
5 to 31 inches, reddish-brown clay; blocky structure; very hard; noncalcareous; neutral.
- Substratum—
31 to 46 inches, red clay loam; massive; slightly hard; noncalcareous; moderately alkaline.
- Bedrock—
46 inches +, basalt.

Infiltration is moderate, and permeability is slow. The available moisture capacity is high. Surface runoff is slow, and the erosion hazard is low. The root zone is moderately deep or deep. Fertility is high.

This soil is well suited to timber but is somewhat less productive than Siesta silt loam, deep. Its potential for production of herbage is moderately high. It is also suitable for recreation sites and wildlife habitats. The capacity to store water underground is medium or high. (Management group 2; timber suitability group 3; range herbage group 3; group 1-a for recreation sites)

Siesta silt loam, deep (0 to 10 percent slopes) (Sf).—This soil (fig. 16) occurs on colluvial toe slopes on uplands. In most places it has a measurable layer of litter, but in some places the litter is thin and patchy and in others there is none. There are a few surface stones and cobbles.

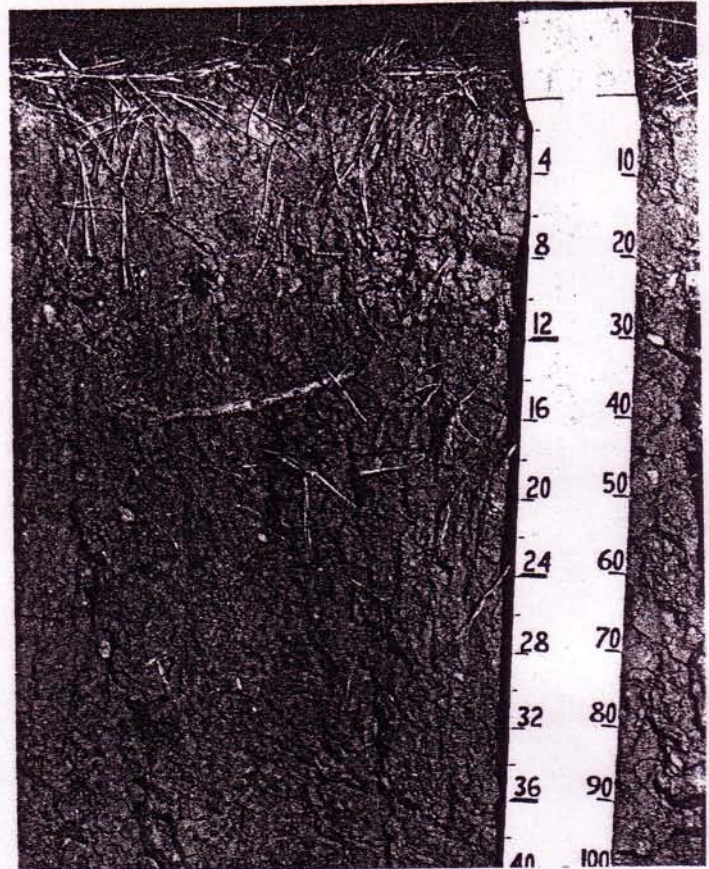


Figure 16.—Profile of Siesta silt loam, deep (0 to 10 percent slopes)

Surface runoff is slow or medium, and the erosion hazard is moderate. The root zone is deep, but roots are plentiful only to a depth of 30 inches. Fine roots are numerous to a depth of about 11 inches.

This is one of the best soils in the Area for production of ponderosa pine. It is well suited to production of herbage and is used for summer grazing. It provides a good habitat for big game. The capacity to store water is high, and the potential for sustained yield of water is high. (Management group 2; timber suitability group 2; range herbage group 2; group 1-a for recreation sites)

Sponseller series

The Sponseller series consists of deep and moderately deep, well-drained, noncalcareous soils on gently sloping to steep side slopes of cinder cones. These soils formed in material weathered from volcanic cinders. They occur in the pine forest in the eastern part of the Area, at elevations of 7,800 feet or more, where the average annual precipitation is 22 to 24 inches. They adjoin Broliar and Siesta soils. The overstory consists of good stands of ponderosa pine, limber pine, Douglas-fir, aspen, Gambel oak, and New-Mexican locust. The ground cover is chiefly Arizona fescue, junegrass, mountain muhly, and blue grama.

Sponseller soils have a stony, dark reddish-brown surface layer that is hard when dry and has platy or granular structure. Their subsoil is reddish brown, is hard when dry, and has blocky structure. Their substratum

gravelly and yellowish red, hard when dry, and massive. Volcanic cinders occur at a depth of 20 to 52 inches. In most places a thick mat of needle litter overlies the mineral soil. There are a few stones and cobblestones and a little gravel. These soils are slightly acid or neutral.

Sponseller stony silt loam, 15 to 40 percent slopes (ShD).—This soil occupies the side slopes of cinder cones. Basalt stones, cinder aggregates, and gravel are common on the surface.

Representative profile in an area of ponderosa pine:

Surface soil—

0 to 8 inches, dark reddish-brown stony silt loam; platy or granular structure; hard; noncalcareous; medium acid to slightly acid.

Subsoil—

8 to 43 inches, reddish-brown clay loam; blocky structure; hard; noncalcareous; slightly acid.

Substratum—

43 to 52 inches, yellowish-red gravelly light clay loam; massive; hard; noncalcareous; neutral.

Bedrock—

52 inches +, volcanic cinders.

Infiltration is moderate, and permeability is moderately slow. The available moisture capacity is high. Surface runoff is slow or medium; the erosion hazard is high. The root zone is deep. Fertility is high.

This soil is used for timber, herbage, wildlife habitats, and water storage and yield. It is well suited to both timber and herbage. It provides good habitats for big game, particularly deer and elk. The capacity to store water underground is high, and sustained yield is high. Recreation could be an important use. (Management group 2; timber suitability group 1; range herbage group 2; group 1-c for recreation sites)

Sponseller stony silt loam, 5 to 15 percent slopes (ShC).—This soil is on the side slopes of cinder cones. Surface runoff is slow, and the erosion hazard is moderate.

This soil is well suited to timber and herbage and is used principally for production of timber and for summer grazing. It produces less pine than Sponseller stony silt loam, 15 to 40 percent slopes. There are good habitats for wildlife. The potential for recreational use is high. The capacity to store water is high, and sustained yield is medium. (Management group 2; timber suitability group 2; range herbage group 2; group 1-a for recreation sites)

Springerville series

The Springerville series consists of moderately deep and deep, well-drained soils on the Coconino Plateau. The slope ranges from level to steep, and the topography from smooth and undulating to rough. These soils developed in material weathered from basalt and cinders. They occur at elevations of 3,500 to 6,500 feet, where the average annual precipitation is about 11 to 18 inches, and are associated principally with Gem, Brolliar, and Waldroup soils. In many places they are dissected by deep canyons.

At elevations of 4,000 to 6,500 feet, the vegetation consists chiefly of pinyon pine and juniper but includes a few Gambel oaks and, on the upper reaches of these soils, scattered ponderosa pine trees. The ground cover and the understory are chiefly blue grama and black grama but include some sideoats grama, squirreltail, turbinella oak, mountain-mahogany, snakeweed, and filaree. At

elevations of 3,500 to 4,000 feet, the vegetation consists of mesquite, canotia, pricklypear, filaree, and tobosa.

Springerville soils have a dark grayish-brown to reddish-brown surface layer that is slightly hard when dry and has platy or granular structure. The underlying layers are brown or reddish brown, are extremely hard when dry, and break into large, blocky aggregates. The lower layers are calcareous in most places. In some places these soils are calcareous to the surface.

Horizons are difficult to distinguish because these soils have a strong tendency to shrink and swell, and much heaving and internal movement result. When the soils are dry, they have cracks half an inch to 2 inches wide and 15 to 20 inches deep. The cracks disappear when the soils are wet.

Springerville very stony clay, 0 to 10 percent slopes (SnB).—This soil occurs on uplands at elevations of 4,500 to 6,500 feet, where the average annual precipitation is 14 to 18 inches. Basalt stones and cobblestones cover 30 to 50 percent of the surface, and many of the stones measure 12 inches across. The stonier areas are difficult to traverse on foot (fig. 17), and travel by vehicles is restricted to roads. Included in the areas mapped are areas of Gem soils, which make up 10 to 15 percent of the unit.

Representative profile in an area covered by juniper trees:

Surface layer—

0 to 3 inches, dark grayish-brown to reddish-brown very stony clay; platy and granular structure; slightly hard; noncalcareous; mildly alkaline.

Subsoil—

3 to 21 inches, brown to reddish-brown clay; massive; extremely hard; noncalcareous; mildly alkaline.

Substratum—

21 to 44 inches, brown to reddish-brown clay; massive; extremely hard and slightly calcareous in the upper part, but highly calcareous with lime concretions in the lower part; moderately alkaline.

Bedrock—

44 inches +, basalt or cinders.

Infiltration is moderate, and permeability is very slow. The available moisture capacity is medium. Surface runoff is slow, and the erosion hazard is moderate. The root zone is moderately deep or deep. Fertility is medium.

This soil is poorly suited to timber because much of it lies below an elevation where the amount of moisture is adequate for the growth of ponderosa pine. It is well suited to herbage and is used as summer range for livestock. It is also prime winter range for deer, antelope, and turkey. It has a high capacity to store water. (Management group 5; range herbage group 3; group 3-a for recreation sites; not assigned to a timber suitability group)

Springerville very stony clay, 10 to 20 percent slopes (SnC).—This soil occurs on short breaks on uplands. It is poorly suited to timber but is well suited to herbage. It provides summer range for livestock and prime winter range for deer, antelope, and turkey. The capacity to store water is high. Surface runoff is medium. This soil is more difficult to manage than Springerville very stony clay, 0 to 10 percent slopes, because of the steeper slope, the outcrops of basalt, and the larger number of stones on the surface. (Management group 5; range herbage group 3; group 3-b for recreation sites; not assigned to a timber suitability group)

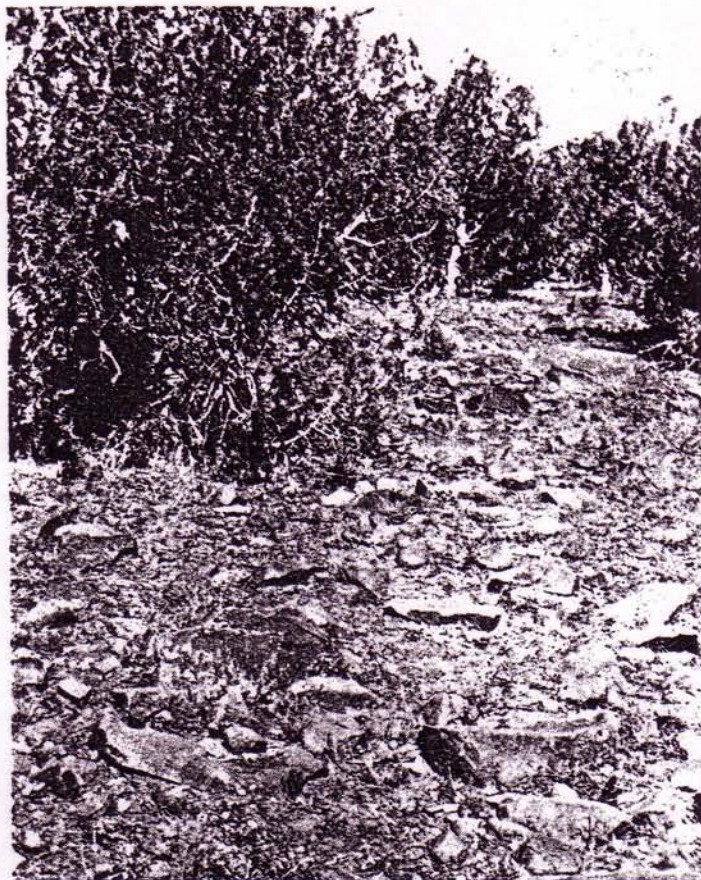


Figure 17.—An area of Springerville very stony clay, 0 to 10 percent slopes. The many large stones and cobbles make walking difficult and limit the use of machinery.

Springerville very stony clay, 20 to 30 percent slopes (SnD).—This soil occurs in close association with large canyons and draws. It is shallower than Springerville very stony clay, 0 to 10 percent slopes. Outcrops of basalt are more numerous than on Springerville very stony clay, 10 to 20 percent slopes. Runoff is rapid, and the erosion hazard is high. Infiltration is slow.

This soil is used for summer range, but it is less suitable for herbage than other Springerville soils. The stony surface and the steep slopes limit its use for grazing. The capacity to store water is medium, but there is little or no potential for sustained yield of water. This soil provides areas of escape and concealment for wildlife, but feed is scarce. (Management group 11; range herbage group 4; group 3-c for recreation sites; not assigned to a timber suitability group)

Springerville cobbly clay (0 to 5 percent slopes) (Sm).—This upland soil is similar to Springerville very stony clay, 0 to 10 percent slopes, except that it is cobbly, calcareous to the surface, and easy to traverse. Basalt cobbles cover 20 to 30 percent of the surface. The depth to bedrock ranges from 30 to 60 inches, but it is commonly 40 to 48 inches.

The root zone is moderately deep, but most of the roots are concentrated in the uppermost 12 inches.

This soil is poorly suited to timber but is well suited to herbage. It provides summer range for livestock and winter range for big game and turkey. The capacity to

store water is high, but there is little potential for sustained yield. (Management group 5; range herbage group 2; group 3-a for recreation sites; not assigned to a timber suitability group)

Springerville clay, red phase (0 to 10 percent slopes) (Sl).—This soil is on uplands along the south-central border of the survey Area. It is similar to Springerville cobbly clay but lacks cobbles and is reddish in color to a depth of about 2 feet. The red color is inherited from the cinder component of the parent material. Below a depth of 50 inches, this soil is very gravelly and is as much as 70 to 80 percent cinders. Roots are plentiful to a depth of 14 inches but are scarce below this depth.

This soil is not suited to the production of timber, because it is below the elevation at which the moisture supply is adequate for ponderosa pine. It is moderately well suited to range herbage and is used for summer grazing. It also supplies forage for wildlife. (Management group 9; range herbage group 3; group 3-a for recreation sites; not assigned to a timber suitability group)

Springerville clay (0 to 10 percent slopes) (Sk).—This soil occurs on old fans and terraces near Rimrock and the Beaver Creek Ranger Station. It is at elevations of 3,500 to 4,000 feet, where the average annual precipitation is 11 to 13 inches. The vegetation consists of mesquite, canotia, pricklypear, filaree, and tobosa.

Representative profile in an area used for range:

Surface layer—

0 to 11 inches, reddish-brown clay; granular structure in uppermost 2 inches, but the rest of the horizon is massive; hard; moderately calcareous; moderately alkaline.

Subsoil and substratum—

11 to 55 inches, reddish-brown clay; massive; extremely hard; strongly calcareous; moderately alkaline.

The subsoil and substratum have many slickensides and pressure faces. The lower part of the profile has a visible zone of lime accumulation. Roots are concentrated in the upper part of the profile.

Infiltration is moderate, and permeability is very slow. Runoff is slow until the uppermost 12 inches of soil has been saturated, then it is medium. The erosion hazard is moderate. The available water capacity is medium. The root zone is moderately deep. Fertility is medium.

This soil is moderately well suited to herbage and is used for winter range. The capacity to store water is medium. (Management group 9; range herbage group 3; group 3-a for recreation sites; not assigned to a timber suitability group)

Stagecoach series

The Stagecoach series consists of moderately deep and deep, well-drained, strongly calcareous soils on old, eroded, sloping and rolling terraces. These soils formed in mixed material washed from limestone and sandstone. They occur at elevations of about 3,900 feet, where the average annual precipitation is about 13 inches. They adjoin soils of the Bridge, Courthouse, Cornville, and Guest series. They are in the grassland-desert shrub vegetation zone. The vegetation consists of scattered juniper trees, mesquite, yucca, cacti, canotia, snakeweed, and sparse stands of grass. About half of the surface is barren.

The surface layer is light reddish-brown, cobbly and gravelly sandy loam. It is soft when dry and has granular structure or is massive. The subsoil and substratum

are pinkish white to reddish brown and very strongly calcareous. They are extremely hard when dry and are massive. There are many lime-coated, rounded cobblestones in the substratum. Some layers in the subsoil and substratum are weakly cemented.

Stagecoach cobbly sandy loam (5 to 15 percent slopes) (So).—This soil occurs on eroded terraces in the southwestern part of the Area. A large part of the surface is covered with chert, limestone, and sandstone gravel. Cobblestones and gravel make up more than half of the subsoil and substratum.

Representative profile in an area used for range:

Surface layer—

0 to 13 inches, light reddish-brown cobbly sandy loam; fine, granular structure or massive; soft; strongly calcareous; moderately alkaline.

Subsoil and substratum—

13 to 28 inches ±, pinkish-white to reddish-brown very gravelly light loam and very gravelly sandy loam; contains cobblestones that are coated with lime; massive; extremely hard; very strongly calcareous; strongly alkaline.

Infiltration and permeability are moderate. The moisture-holding capacity is low. Runoff is medium, and the erosion hazard is moderate. Fertility is low.

This soil is moderately well suited to range herbage and is used as winter range for livestock and as a winter habitat for big game. The potential for natural recovery of vegetation is low. Seeding mixtures should contain lime-tolerant species. (Management group 6; range herbage group 4; group 2-a for recreation sites; not assigned to a timber suitability group)

Stony hilly land, ash and tuff

Stony hilly land, ash and tuff (15 to 35 percent slopes) (Sr) is a land type that consists of shallow, calcareous Bridge soils mixed with basalt outcrops, boulders, angular stones and cobblestones, and gravel. Some of the boulders and stones are nearly 30 inches in diameter. This is an extensive land type. It occurs on moderately steep or steep benches in the western part of the Area, chiefly as a part of the Mogollon Rim. Generally, it has a western exposure. The average annual precipitation is about 13 inches. The vegetation consists chiefly of patches of juniper, canotia, algerita, tobosa, and loco. Much of the surface is barren and severely eroded. The stony material on the surface helps to hold the soil in place.

This land type is poorly suited to herbage, but the less sloping areas can be used to a limited extent for grazing. The capacity for water storage is limited, but after a heavy rain the surface yield of water is good. The potential for natural recovery of vegetation is low. Careful management is needed to control erosion. (Management group 11; range herbage group 4; not assigned to a timber suitability group nor to a group for recreation sites).

Stony rough land, basalt and cinders

Stony rough land, basalt and cinders (20 to 60 percent slopes) (Ss) is a land type that consists of moderately deep, stony and cobbly Brolliar and Siesta soils and outcrops and boulders of basalt. It occurs in the pine forest, mostly in the eastern part of the Area on steep and very steep side slopes of canyons. The soils range from 22 to

about 32 inches in depth. In many places they occur as pockets among outcrops, stones, and cobblestones. The average annual precipitation is about 20 inches. The vegetation consists mainly of ponderosa pine but includes scattered Gambel oak and New-Mexican locust. Some Douglas-fir and limber pine grow on slopes that have a northern exposure. The ground cover consists of Arizona fescue, junegrass, forbs, and annual weeds. In places the surface is covered with a thick layer of needle litter.

This land type is moderately well suited to herbage. Its suitability for timber varies but is generally moderate. It provides suitable habitats for wildlife. Although the water-storage capacity is medium or low, the capacity for sustained yield is good. (Management group 3; timber suitability group 3; range herbage group 4; group 4-c for recreation sites)

Stony rough land, sandstone

Stony rough land, sandstone (St) is a land type that consists of steep and very steep hillsides and canyon walls on which there are shallow, cobbly and stony soils and outcrops of sandstone and basalt. This land type occurs in the vicinity of Woods Canyon, where the average annual precipitation is 18 to 20 inches. The soil material is similar to that of the Jacks soils and in most places is less than 8 inches deep. The slope ranges from 20 to 60 percent. The erosion hazard is high, but the soils have a protective cover of vegetation, consisting of good stands of oak brush, some juniper trees, and moderate stands of blue grama.

The less sloping areas are moderately well suited to herbage. Grass and browse on the moderate slopes supply food for livestock and game. The thickets of oak brush provide bedding and concealment for deer and other wildlife. The capacity to store water is low, but surface runoff provides some water yield. (Management group 12; range herbage group 5; not assigned to a timber suitability group nor to a group for recreation sites)

Stony steep land, basalt

Stony steep land, basalt (Su) is a land type that consists of basalt outcrops, small broken basalt escarpments, and pockets of very shallow and shallow, brown, clayey soils that have stones, cobblestones, and gravel on the surface. This land type occurs on moderate to steep side slopes and on the walls of canyons in the central and western parts of the Area, where the elevation is 4,700 to 6,600 feet and the average annual precipitation is 13 to 16 inches. The soil material is similar to that of the Gem and Schnebly soils. The vegetation consists of turbinella oak, juniper, loco, pricklypear, and sideoats grama. In places the surface is covered with basalt talus, stones, and cobblestones and is devoid of vegetation. These areas are difficult to traverse, either on foot or on horseback.

The less sloping areas are used for grazing, but in most places such use is limited by the steep and rocky slopes. The stony surface sheds water, which flows to the surrounding lower soils. (Management group 11; range herbage group 4; not assigned to a timber suitability group nor to a group for recreation sites)

Stony very steep land, basalt

Stony very steep land, basalt (Sv) is a land type that consists of very steep side slopes of mesas and the steep walls of deep canyons that dissect the Coconino Plateau,

which is in the central part of the survey Area. A thick cover of talus and basaltic colluvium occurs on the surface in areas where the slope is 45 to 90 percent. The average annual rainfall is 13 to 16 inches. This land type is similar to Stony steep land, basalt, except that there is little soil material and the slopes are capped by a continuous escarpment of basalt.

This land type has little value for grazing. The rough, jagged surface makes walking and climbing extremely difficult and travel by horseback virtually impossible. During periods of heavy rainfall, most of the water runs into the canyons. (Management group 12; range herbage group 5; not assigned to a timber suitability group nor to a group for recreation sites)

Tobler series

The Tobler series consists of deep, well-drained, reddish-brown soils on gently sloping alluvial fans. These soils developed in alluvium washed from sandstone. They occur at elevations of about 4,000 feet, where the average annual precipitation is about 13 inches. They adjoin Courthouse, Schnebly, and Stagecoach soils. The vegetation is mainly mesquite, catclaw, yucca, sand dropseed, and Rothrock grama. Many areas are nearly barren.

Tobler soils have a reddish-brown surface layer that is soft when dry and has platy structure. Their subsoil is reddish brown and hard or slightly hard. It has blocky structure. Their substratum is reddish brown or yellowish red, calcareous, soft or slightly hard, and massive. The reddish color is inherited from the parent sandstone. In places a scattering of gravel covers the surface.

Tobler fine sandy loam (0 to 5 percent slopes) (Tb).—This soil is well drained. It occurs on gently sloping alluvial fans, chiefly near Big Park. Slopes are dominantly 0 to 3 percent.

Representative profile in a grassy area:

Surface soil—

0 to 6 inches, reddish-brown fine sandy loam; soft; platy structure; noncalcareous; neutral.

Subsoil—

6 to 40 inches, reddish-brown fine sandy loam; hard or slightly hard; subangular blocky structure; noncalcareous; mildly alkaline.

Substratum—

40 to 53 inches +, reddish-brown and yellowish-red fine sandy loam; soft or slightly hard; massive; calcareous; visible lime; moderately alkaline.

Infiltration and permeability are moderately rapid. Surface runoff is slow. Nevertheless, the hazard of gully erosion is high because this soil receives runoff water from other soils. Deep, active gullies are common. Wind erosion is active in places. The available moisture capacity is high. The root zone is deep. Fertility is medium.

Some areas of this soil were formerly dryfarmed but have been allowed to revert to native range. The potential for production of range herbage is good. The water-storage capacity is high. (Management group 7; range herbage group 2; group 3-a for recreation sites; not assigned to a timber suitability group)

Tobler gravelly fine sandy loam, brown variant (5 to 15 percent slopes) (Tg).—This soil is similar to Tobler fine sandy loam, except that it is brown, contains basalt cobbles, and has more gravel on the surface and within the soil mass. Its brown color is inherited from a basalt component of the parent material. It lies a little

upslope from Tobler fine sandy loam and is steeper. It is neutral and noncalcareous.

This soil is well suited to production of herbage. It also produces shrubs and browse plants that provide food for wildlife. (Management group 7; range herbage group 2; group 3-a for recreation sites; not assigned to a timber suitability group)

Toquop series

The Toquop series consists of deep, excessively drained, stratified soils on undulating flood plains and low stream terraces of the Verde River and Oak Creek, in the western part of the Area. These soils formed in mixed alluvium derived mainly from sandstone and limestone but partly from basalt and schist. They occur at elevations of 3,100 to 3,600 feet, where the average annual precipitation is 10 to 12 inches. They are associated with Carrizo, Anthony, and Gila soils. The vegetation consists chiefly of cottonwood, sycamore, and willow trees, but includes also some juniper, mesquite, bermudagrass, and weeds.

In most places the surface layer consists of loamy fine sand. It is reddish brown, soft, and massive. The subsoil and substratum are reddish brown, stratified, loose, and single grain. These soils are slightly calcareous and moderately alkaline throughout.

Toquop loamy fine sand (0 to 5 percent slopes) (To).—This is a deep soil. It occurs on ridges and knolls of undulating bottom lands of the Verde River and Oak Creek. It occupies only a small acreage in the Area. In places there is gravel on the surface, and in many places the soil has been cut by sloughs and river channels 3 to 6 feet deep and 10 to 50 feet wide.

Representative profile in an area used for range:

Surface layer—

0 to 16 inches, reddish-brown loamy fine sand; massive; soft; slightly calcareous; moderately alkaline.

Subsoil and substratum—

16 to 54 inches +, reddish-brown fine sand and medium sand; single grain; loose; slightly calcareous; moderately alkaline.

Infiltration and permeability are very rapid. The water-holding capacity is low. Surface runoff is slow; the hazard of gully erosion is high. The root zone is deep. Fertility is low.

This soil is fairly well suited to production of herbage and is used chiefly as range for livestock and wildlife. It has low capacity for water storage and no capacity for sustained yield. Small areas of this soil were formerly irrigated but have been allowed to revert to native range (Management group 7; range herbage group 4; group 3-a for recreation sites; not assigned to a timber suitability group)

Toquop-Carrizo complex (0 to 20 percent slopes) (Tx).—This complex occurs on low ridges, swales, and flood plains along the Verde River and Oak Creek. It is made up of Toquop loamy fine sand and Carrizo very gravelly coarse sand that are so intermingled that mapping them separately was not practicable. The Toquop soil is sandy throughout. The Carrizo soil consists of stratified, light-brown sand, gravel, and cobbles. These soils are 40 to 60 inches deep.

In some respects Toquop-Carrizo complex is much like Riverwash. There are a few stones and much gravel on the surface. The areas are dissected by sloughs and river channels. The vegetation consists of cottonwood, sycamore,

more, and willow trees and a ground cover of grass and weeds. Much of the surface is barren.

Infiltration is rapid, and permeability is very rapid. Runoff is slow, and the erosion hazard is high. The available moisture capacity is low. The root zone is deep. Fertility is low.

Use of this complex is limited by flooding in spring. The low fertility limits the production of herbage. Gamebirds use these bottom lands as nesting areas, and livestock find resting places and watering spots. (Management group 13; range herbage group 5; group 4-b for recreation sites; not assigned to a timber suitability group)

Waldroup series

The Waldroup series consists of moderately deep and deep, well-drained, dark-colored soils on level to rolling and steep uplands. These soils formed in material weathered from basalt and cinders. They occur in the central part of the Area at an elevation of about 6,300 feet, where the average annual precipitation is about 16 inches. They adjoin Gem and Springerville soils. These soils are in the pinyon-juniper zone. The plant cover consists of juniper, turbinella oak, mountain-mahogany, cliffrose, snakeweed, rabbitbrush, blue grama, and Arizona fescue.

Waldroup soils have a reddish-brown surface layer that is hard when dry and has platy and granular structure. Their subsoil is dark reddish brown and very hard when dry. It has blocky structure. Their substratum is red, partly weathered basalt and cinders. A few stones occur on the surface, and there is some cinder gravel within the soil.

Waldroup gravelly loam, moderately deep (5 to 30 percent slopes) (Wg).—This soil is on uplands and on the side slopes of remnants of cinder cones or cinder deposits. A few stones occur on the surface.

Representative profile in an area used for range:

Surface soil—

0 to 6 inches, reddish-brown gravelly loam; platy and granular structure; soft to slightly hard; noncalcareous; neutral.

Subsoil—

6 to 21 inches, dark reddish-brown clay; blocky structure; very hard; mildly alkaline to moderately alkaline.

Substratum—

21 to 25 inches, red, partly weathered basalt rock and cinders; calcareous; massive; moderately alkaline.

Bedrock—

25 inches +, basalt and cinders.

Infiltration is moderate, and permeability is slow. Surface runoff is medium, and the erosion hazard is high. The water-holding capacity is medium. The root zone is moderately deep. Fertility is medium.

This soil is moderately well suited to herbage and is used for summer grazing. It is also suitable as a wildlife habitat. The potential for underground storage of water is medium. The capacity for sustained yield is low. (Management group 9; range herbage group 3; group 2-b for recreation sites; not assigned to a timber suitability group)

Waldroup clay loam, deep (0 to 5 percent slopes) (Wc).—This soil formed in outwash from basalt and cinders. It occurs on alluvial fans, downslope from Waldroup gravelly loam, moderately deep (5 to 30 percent slopes). It is

similar to that soil but is finer textured and more gently sloping.

Surface runoff is slow. Although the erosion hazard is moderate, there are no gullies.

This soil is moderately well suited to herbage and is used for summer grazing. It is well suited to big game, but it does not provide so much usable browse as Waldroup gravelly loam, moderately deep. The capacity to store water underground is medium. Little or no potential exists for sustained yield of water. (Management group 9; range herbage group 3; group 2-a for recreation sites; not assigned to a timber suitability group)

Waldroup loam, brownish variant (0 to 5 percent slopes) (Wa).—Except for its color, texture, and slope, this soil is much like Waldroup gravelly loam, moderately deep (5 to 30 percent slopes). It occurs on gently sloping old alluvial fans in the south-central part of the Area. Stones and gravel cover about 10 percent of the surface, with gravel making up the larger part. Gravel also occurs throughout the soil mass. The uppermost inch of this soil is vesicular and may be a deposition layer. The lower part of the substratum is very weakly calcareous. In places this soil is shallow, and gravel makes up as much as 70 percent of the substratum.

Surface runoff is slow, and the erosion hazard is moderate. Nevertheless, the hazard of gullying is high because this soil receives flow from surrounding land. Rills and several wide, shallow gullies have formed.

This soil is well suited to herbage and is used for summer grazing. It is not suited to timber. The capacity for storage of water that is usable by plants is somewhat limited because, once the water reaches the gravel, it is beyond the reach of plant roots. There are suitable habitats for wildlife. (Management group 10; range herbage group 2; group 3-a for recreation sites; not assigned to a timber suitability group)

Formation and Classification of the Soils

This section describes the major factors of soil formation as they exist in the Beaver Creek Area; discusses briefly the principal processes of soil formation; provides detailed descriptions of soil profiles to illustrate the morphology of the soils that have developed in the Area; and shows how the soils of the Area are classified into categories broader than the series.

Factors of soil formation

Soils are the product of five main soil-forming factors—parent material, living organisms (chiefly vegetation), climate, topography, and time.

Parent material may be material weathered in place from solid rock, or it may be transported material.

Plants provide organic matter that colors the soil and changes its composition. Decomposition of plants produces chemical compounds that contribute to the decomposition of rock and the formation of soil. Plant roots penetrate and fracture rocks, thus opening channels for water. They also stabilize the soil and rock material and thus increase the effectiveness of the other soil-forming factors.

The speed with which a soil forms depends largely on climate. Sunshine, rain, frost, and wind influence the

disintegration of the material from which a soil forms. The kind and amount of vegetation in an area are also influenced by climate.

Relief affects runoff and drainage. More water runs off a steep soil and less enters the ground than is the case in gently sloping areas. The less water entering a soil, the smaller is the amount available for plants, for leaching, for formation and movement of clay, and for decomposition of parent material. Runoff washes rock material from steep slopes and thereby reduces the amount of parent material. Relief also affects climate; it causes fluctuations in temperature and variability in rainfall.

An extremely long time is necessary for soil formation, and any one or all of the five soil-forming factors may change many times, but as time passes, the combined effects of these factors develop a soil profile.

PARENT MATERIAL

In the Beaver Creek Area, parent material is a major factor in the formation of soils. Basic igneous rocks, sedimentary rocks, and unconsolidated deposits have all contributed parent material. The soils formed in material weathered from basalt, volcanic cinders, volcanic ash, limestone, sandstone, shale, and sandy or shaly conglomerate.

Several of the soils developed in place in residuum weathered from various kinds of rocks. Others developed from mixed alluvial sediments deposited in valleys and drainageways. Many of the soils developed in material weathered from basalt, volcanic cinders, agglomerate, and volcanic ash, which are common in this Area. These materials range in thickness from only a few feet to hundreds of feet. The fine-grained basalts and the cinders supplied the parent material of loamy and clayey soils. Many of the soils derived from basalt are stony because basalt resists weathering. Studies of clay minerals indicate that montmorillonite is dominant in soils derived from basalt.

The soils derived from limestone are fairly stable, and the texture of their surface soil ranges from silt loam to loam. Most of the limestone in the Area is part of the Verde formation, but amid the volcanic material, there is one small area of Kaibab cherty limestone, over which the Hogg soils formed. Except for the Hogg soils, the soils derived from limestone have weak profile development. Most of them are calcareous throughout.

Some of the soils formed in material weathered from sandstone of the Coconino and Supai formations. The red Supai sandstone is the parent material of the reddish-brown and red, calcareous Courthouse soils. Coconino sandstone is the parent material of the Jacks soils. Both of these sandstone formations also occur in the Area as steep, naked cliffs and as wind-sculptured landforms.

Old valley fills, old terrace deposits, and more recent alluvial deposits contain a mixture of parent materials that vary widely in composition and texture. Sediments derived from basalt and cinders are moderately fine textured and fine textured. Sediments derived from sandstone are sandy, those derived from limestone are medium textured and generally calcareous, and those derived from shale are fine textured and slowly permeable.

VEGETATION

The soils of the Area developed under three broad types of vegetation—ponderosa pine, pinyon-juniper woodland and grassland-desert shrub. The vegetative types generally occur in a pattern that is controlled by temperature, amount of precipitation, and elevation. Elevation, of course, exerts its influence by modifying temperature and rainfall.

Vegetation adds organic matter to the soil and modifies its structure and physical condition. The horizon most significantly affected is the A1.

The soils that developed under ponderosa pine have a dark-colored A1 horizon that is 5 to 9 inches thick. This horizon has granular structure, and its pH value ranges from 6.1 to 6.5. In many of these soils, the dark color extends into the A3 and B1 horizons.

The soils that developed under pinyon pine and juniper, or that fringe into the ponderosa pine forest, have an A1 horizon much like that of soils in the pine forest. The horizons are thinner, however, and the pH value ranges from 6.6 to 7.6. The soils of the grassland-desert shrub zone are light colored, and their pH values are ordinarily 8.0 or higher.

Soils in the pine forest zone have the thickest layers of litter and the highest content of organic matter. Soils in the pinyon-juniper woodland zone have less litter and a lower content of organic matter than those in the ponderosa pine zone. Soils in the grassland-desert shrub zone generally have an organic-matter content of less than 1 percent and no measurable layer of litter.

In the ponderosa pine zone, the needle litter is distributed uniformly over the soils because of the uniformity of the canopy and the height of the trees. In the pinyon-juniper woodland, the litter is concentrated within the drip zone under the trees. In the grassland-desert shrub zone, the grass and weeds are the principal sources of organic material. The stands of shrubs are too sparse to produce significant amounts of organic residue.

Vegetation not only adds organic material but also modifies the influence of climate on soils. Shade checks evaporation and increases the supply of available moisture. The soil temperature under a dense stand of trees is much cooler than that under a sparse or open stand. This difference in temperature is significant in forested areas.

CLIMATE

The climate in this Area is continental and semiarid to subhumid. It is strongly influenced by elevation. At the higher elevations the weather is cold in winter and warm in summer. At the lower elevations the weather is usually mild the year around, diurnal and seasonal changes in temperature are less significant than at the higher elevations, and there is less precipitation.

The generally warm, sunny weather that prevails from late spring through fall favors the chemical reactions essential in soil development, but the rate and intensity of these reactions depend upon the amount of precipitation. Moisture conditions are more favorable in the ponderosa pine zone and the higher parts of the pinyon-juniper zone than in the grassland-desert shrub zone. At the higher elevations precipitation ranges from 15 to 25 inches annually. Much of it falls as snow, and in years of normal snowmelt the soils absorb much of the mois-

ture. The organic-matter content is higher than that of soils at lower elevations, and the horizon development is more pronounced. At the lower elevations precipitation seldom exceeds 15 inches per year. It usually falls as hard, violent rainstorms, and most of the water is lost through runoff. The organic-matter content of the soils is low, and horizon development is not clearly expressed.

Leaching of bases and other soluble materials and translocation of colloids and other less soluble materials increase as the amount of precipitation increases. Weathering and translocation of soil material are further intensified by periods of freezing and thawing. In normal years the soils at the higher elevations are frozen to a depth of several feet in winter, but freezing and thawing may occur several times. The basaltic parent material at the higher elevations is more resistant than many other kinds of parent material, and the soils are less deep than those of other areas having similar climatic conditions but weaker parent material. The temperature at the lower elevations, in the pinyon-juniper zone, seldom goes below freezing.

TOPOGRAPHY

Topography influences soil formation through its effect on climate and vegetation. Most of the Beaver Creek Area is nearly level or undulating and rolling, but in some of the Area slopes are steep and cliffs, escarpments, and rims are prominent in the landscape. The range in elevation is from about 3,100 feet to about 8,500 feet, and the changes in elevation affect temperature and precipitation. As elevation increases, the average temperature declines and precipitation generally increases. The changes in temperature and precipitation strongly influence the kind and amount of vegetation.

Generally, the deeper and more strongly developed soils are in areas of gentle topography, where runoff is slow, more moisture is retained, and erosion is slight. The shallower, less strongly developed soils are on ridgetops and steep slopes, where runoff is rapid, less moisture is absorbed, and erosion is severe. For example, the gently undulating Springerville soils are deep but stony, and the steep Springerville soils are shallower and have more areas of rock outcrop.

In most mountainous areas, the soils on north-facing slopes are more strongly developed than the soils on south-facing slopes because more moisture is retained on north-facing slopes and vegetation is more plentiful. Such is not the case in the Beaver Creek Area, however. Although some of the north-facing slopes have more vegetation than the adjacent south-facing slopes, the soils show no significant differences. This can be partly explained by the fact that the slopes are short and not very steep. Moreover, many of the steep areas are at low and medium elevations, where aspect has less effect on climate.

TIME

The length of time required for a mature soil to develop depends largely upon the action of climate and vegetation on parent material. In the Beaver Creek Area, the parent material is resistant to weathering, precipitation is relatively low, and many areas are sparsely vegetated.

Most of the upland soils of the Area have distinct horizons, indicating that the soil-forming processes have been active for a long time. Most of the soils that are free of excess lime have an acid A1 horizon, an accumulation of

clay in a B2t horizon, and a concentration of lime in a Cca horizon. The soils that formed in alluvium or in material weathered from strongly calcareous material are youthful; they lack a distinct B horizon, and many are calcareous to the surface and show little accumulation of clay.

Classification of the soils

The system of soil classification that has been commonly used in the United States is the one described in the 1938 Yearbook of Agriculture (10) and subsequent publications (3, 4, and 8). It has six categories. Beginning with the most inclusive, the six categories are the order, the suborder, the great soil group, the family, the series, and the type. Only four of the categories—order, great soil group, series, and type—have been widely used.

The highest categories of this classification scheme are the zonal, intrazonal, and azonal orders. All three orders are represented in the Beaver Creek Area. Ten of the great soil groups are represented: Brown soils, Reddish Brown soils, Chestnut soils, Reddish Chestnut soils, Reddish Prairie soils, Brown Forest soils, Calcisols, Grumusols, Alluvial soils, and Lithosols. The relationship between the orders, the great soil groups, and the series recognized in the Beaver Creek Area is shown in table 6.

TABLE 6.—Classification of soils in the Beaver Creek Area according to 1938 system

Order	Great soil group	Series
Zonal	Brown soils	Friana, Jacks, and Waldroup.
	Reddish Brown soils	Cornville, Courthouse, ¹ Penthouse, ² and Schnebly.
	Chestnut soils	Cabezon and Gem.
	Reddish Chestnut soils	Brolliar and Hogg.
Intra-zonal	Reddish Prairie soils	Siesta.
	Brown Forest soils	Sponseller.
	Calcisols	Bridge, Karro, ³ Laveen, and Stagecoach.
Azonal	Grumusols	Springerville.
	Alluvial soils	Anthony, Carrizo, Gila, Glendale, Guest, ⁴ Hantz, ² Lynx, Tobler, and Toquop.
	Lithosols	House Mountain, Mescal, and Retriever. ⁵

¹ Intergrade to Lithosols.
² Intergrade to Grumusols.
³ Intergrade to Alluvial soils.
⁴ Intergrade to Reddish Brown soils.
⁵ Retriever soils that have a Cca horizon intergrade to Calcisols.

A classification system (7) adopted in 1965 defines classes in terms of observable or measurable properties of soils. This system is designed to accommodate all soils. It has six categories, like the earlier system, but the categories are slightly different. Beginning with the most inclusive, they are the order, the suborder, the great group, the subgroup, the family, and the series.³ The classifica-

³ UNITED STATES DEPARTMENT OF AGRICULTURE. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM, 7TH APPROXIMATION, 1960. (Amended June 1964.)

tion of the soil series identified in this Area according to this system is shown in table 7.

TABLE 7.—Classification of soils in the Beaver Creek Area according to Comprehensive System, 7th Approximation

Order, suborder, great group, and subgroup	Family	Series
ENTISOL		
Fluvent:		
Torrifluent—		
Typic.....	Coarse loamy, mixed, calcareous, thermic.	Anthony, Gila, Tobler, Glendale.
Typic.....	Fine silty, mixed, calcareous, thermic.	
Typic.....	Fine, montmorillonitic, calcareous, thermic.	Hantz.
Orthent:		
Torriorthent—		
Lithic.....	Loamy, mixed, calcareous, thermic.	Courthouse, Retriever.
Lithic.....	Loamy, mixed, nonacid, thermic.	House Mountain.
Typic.....	Coarse loamy, mixed, calcareous, thermic.	Bridge.
Typic.....	Fine loamy, mixed, calcareous, thermic.	Mescal.
Psamment:		
Torrripsamment—		
Typic.....	Sandy, siliceous, nonacid, thermic.	Toquop.
Typic.....	Sandy skeletal, mixed, nonacid, hyperthermic.	Carrizo.
VERTISOL		
Ustert:		
Chromustert—		
Typic.....	Mesic.....	Springerville.
ARIDISOL		
Argid:		
Haplargid—		
Typic.....	Fine loamy, mixed, thermic.	Cornville.
Typic.....	Fine, mixed, thermic.	Penthouse.
Orthid:		
Calciorthid—		
Typic.....	Coarse loamy, mixed, thermic.	Laveen.
Typic.....	Fine loamy, mixed, thermic.	Karro, Stagecoach.
MOLLISOL		
Ustoll:		
Arginstoll—		
Lithic.....	Fine, montmorillonitic, mesic.	Cabezon.
Typic.....	Fine, montmorillonitic, mesic.	Friana, Gem, Schnebly.
Typic.....	Fine, montmorillonitic, frigid.	Hogg, Broliar.
Boroll:		
Cryoboroll—		
Argic.....	Fine loamy, mixed.....	Sponseller.
Ustoll:		
Haplustoll—		
Cumulic.....	Fine loamy, mixed, mesic.	Lynx.
Xeroll:		
Haploxeroll—		
Fluventic.....	Fine, mixed, thermic.....	Guest.

TABLE 7.—Classification of soils in the Beaver Creek Area according to Comprehensive System, 7th Approximation—Continued

Order, suborder, great group, and subgroup	Family	Series
ALFISOL		
Ustalf:		
Rhodustalf—		
Typic.....	Fine, montmorillonitic, mesic.	Waldroup.
Typic.....	Fine, montmorillonitic, frigid.	Siesta.
Haplustalf—		
Typic.....	Fine, mixed, mesic.....	Jacks.

In the following pages the classification of the soils is discussed in terms of the system used before 1965. The horizon designations and the descriptive terminology follow the Soil Survey Manual (11).

ZONAL ORDER

Zonal soils have well-developed characteristics that reflect the influence of the active forces of soil genesis—climate and living organisms, chiefly vegetation (10). In this Area the zonal order is represented by the Brown soils, the Reddish Brown soils, the Chestnut soils, the Reddish Chestnut soils, and the Reddish Prairie soils.

BROWN SOILS

Brown soils develop under short grasses, bunch grasses and shrubs in a warm, semiarid climate. They have a brown surface horizon, and a well-developed B horizon that grades into a light-gray or white calcareous layer at a depth of 1 to 2 feet. In the Beaver Creek Area the Brown great soil group is represented by the Friana, Jacks, and Waldroup series. The Friana soils developed in old basaltic alluvium; the Waldroup soils developed in material weathered from basalt and cinders. Soils of the Jacks series formed in material weathered from Coconino sandstone.

Friana Series

The Friana series consists of deep, noncalcareous Brown soils that formed in old valley fill sediments derived chiefly from basalt, cinders, and ash. These soils occupy depressions and nearly level, low bottoms in small valleys. They occur at elevations of 7,000 to 7,500 feet or more, where the annual precipitation is 20 to 22 inches and the average annual temperature is about 47°F. Drainage is impeded, and water is likely to pond on these soils, particularly after the spring thaw. Although these soils are in the ponderosa pine zone, the vegetation is grass. Western wheatgrass has been introduced, and there is some Arizona fescue. Iris plants grow in the wetter areas.

Typically, the Friana soils have an A1-B1t-B2t-(C horizon) sequence. The A horizon is brown to dark brown and the B2t horizon is reddish brown to dark reddish brown. Profile development varies from place to place as does the degree of wetness.

Representative profile of Friana clay loam; SW $\frac{1}{4}$ sec. 16, T. 17 N., R. 9 E.:

- A11—0 to 3 inches, brown to dark-brown (10YR 4/3) light clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium and coarse, platy structure breaking to moderate, fine, granular; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful fine and few medium roots; few fine tubular pores and many fine interstitial pores; few fine pebbles; noncalcareous; pH 6.5; abrupt, wavy boundary.
- A12—3 to 11 inches, brown to dark-brown (7.5YR 4/2) light clay loam, dark reddish brown (5YR 3/2) when moist; weak, fine and medium, subangular blocky structure breaking to moderate, fine, granular; hard when dry, friable when moist, sticky and plastic when wet; plentiful fine and few medium roots; few fine tubular pores and many fine interstitial pores; noncalcareous; pH 6.5; gradual, wavy boundary.
- B21t—11 to 20 inches, reddish-brown (5YR 4/3) clay loam or light clay, dark reddish brown (5YR 3-4) when moist; weak, coarse, prismatic structure breaking to moderate, medium and coarse, subangular blocky; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; thin, patchy clay films; plentiful fine and few medium roots; few fine tubular pores and many fine interstitial pores; common fine gravel; few fine shotlike manganese concretions; noncalcareous; pH 6.5; gradual, wavy boundary.
- B22t—20 to 55 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/4) when moist; weak, coarse, prismatic structure in upper part of horizon; this grades to strong, medium to coarse, angular blocky material that breaks to strong, fine, angular blocky; very hard when dry, friable when moist, very sticky and very plastic when wet; thin, continuous clay films; few fine roots; few fine tubular pores and common fine interstitial pores; common fine shotlike manganese concretions; noncalcareous; pH 7.5; clear, irregular boundary.
- C—55 to 92 inches +, brown (10YR 5/3) gravelly sandy loam, dark yellowish brown (10YR 4/4) when moist; massive; very hard when dry, firm when moist, nonsticky and slightly plastic when wet; many fine reddish-yellow (7.5YR 6/8) and gray (7.5YR 6/1) weathered cinder fragments; horizon consists of material weathered from ash, cinders, and tuff; some clay in cracks and seams; few fine roots; many fine tubular pores and few fine interstitial pores; noncalcareous; pH 7.5.

In places the texture of the A horizon is clay or silty clay loam. In most places the texture of the B horizon is clay or heavy clay loam. In some areas there is a thin layer of deposition on the surface. Most areas are free of stones, but coarse gravel has accumulated on the surface in some places. The soils in gently sloping areas are better drained and have a redder B horizon than is typical.

Jacks Series

The Jacks series consists of moderately deep, well-drained, noncalcareous, well-developed Brown soils, derived in place from Coconino sandstone. These soils occur on gently sloping or moderately sloping mesas. They are at elevations of about 5,200 feet, where the average annual precipitation is about 16 inches and the average annual temperature is about 55°F. The vegetation consists of manzanita, turbinella oak, ceanothus, pinon pine, juniper, and grama grasses.

Typically, the Jacks soils have an A1-B1-B2t-R horizon sequence. Their B2t horizon is well developed; it has distinct color, structure, and texture.

Representative profile of Jacks fine sandy loam; SW $\frac{1}{4}$ sec. 10, T. 16 N., R. 6 E.:

- A1—0 to 3 inches, brown (7.5YR 4/4) fine sandy loam, dark brown (7.5YR 3/4) when moist; strong, medium, platy structure; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; many fine and medium discontinuous tubular pores; abundant very fine and fine roots; pH 6.4; clear, wavy boundary.
- B1—3 to 9 inches, yellowish-red (5YR 4/6) fine sandy clay loam, yellowish red (5YR 3/6) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist, moderately sticky and moderately plastic when wet; abundant fine and medium roots; few fine pores; pH 6.9; gradual boundary.
- B21t—9 to 17 inches, yellowish-red (5YR 4/6) sandy clay, yellowish red (5YR 4/6) when moist; moderate, fine, angular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; thick, continuous clay films; plentiful fine, medium, and coarse roots; few fine pores; pH 7.2; gradual boundary.
- B22t—17 to 24 inches, yellowish-red (5YR 4/6) clay, yellowish red (5YR 4/6) when moist; strong, fine, angular blocky structure; very hard when dry, friable when moist, very sticky and very plastic when wet; thick, continuous clay films; few fine and medium roots; few slickensides; few cracks and few pores; pH 7.4; abrupt, wavy boundary.
- R—24 inches +, reddish-yellow (7.5YR 8/6) sandstone, reddish yellow (7.5YR 7/6) when moist; hard; pH 7.6.

The color of the A1 horizon ranges from very dark grayish brown to brown, and the texture ranges from very fine sand to fine sandy loam. The color of the B2t horizon ranges from dark brown to yellowish red. A B3t horizon occurs in some places. Stones cover 5 to 50 percent of the surface.

Waldroup Series

The Waldroup series consists of moderately deep and deep, well-drained Brown soils that formed in place in material weathered from basalt and volcanic cinders. These soils occur on side slopes and colluvial toe slopes of cinder cones and on uplands. They are at an elevation of about 6,300 feet, where the average annual precipitation is about 16 inches and the average annual temperature is about 55°F. The plant cover consists of juniper, turbinella oak, mountain-mahogany, cliffrose, and native grasses. Basalt stones cover about 10 percent of the surface.

The Waldroup soils have medial development. They are somewhat redder than is normal for Brown soils. Typically, they have an A1-B1-B2t-B3t-C-R horizon sequence. All horizons are thin. Pebble-sized cinders are common throughout the profile. The A horizon is dark colored. It is underlain by a distinct B horizon that grades to a weak zone of lime accumulation.

Representative profile of Waldroup gravelly loam; NE $\frac{1}{4}$ sec. 11, T. 15 N., R. 7 E.:

- A11—0 to 2 inches, reddish-brown (5YR 4/3) gravelly loam, dark reddish brown (5YR 3/3) when moist; weak to moderate, medium, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful very fine and fine roots; few fine pores; noncalcareous; pH 6.7; clear, smooth boundary.
- A12—2 to 6 inches, dark reddish-brown (5YR 3/2) heavy gravelly loam, dark reddish brown (5YR 3/2) when moist; weak, medium, granular and weak, fine, sub-

angular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful very fine and fine roots; few fine pores; noncalcareous; pH 6.7; clear, smooth boundary.

B1t—6 to 10 inches, dusky-red (2.5YR 3/2) heavy clay loam, dusky red (2.5YR 3/2) when moist; weak, fine, sub-angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; thin, continuous clay films; plentiful fine and medium roots; common medium pores; noncalcareous; pH 7.0; clear, smooth boundary.

B2t—10 to 19 inches, dark reddish-brown (2.5YR 3/4) clay, dark reddish brown (2.5YR 3/4) when moist; moderate, fine, angular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; thin, continuous clay films; plentiful fine and medium roots; common medium pores; some manganese concretions; noncalcareous; pH 7.4; gradual boundary.

B3t—19 to 21 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; weak, fine, angular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; few thin clay films; plentiful fine roots; common medium pores; weakly calcareous; pH 8.0; clear boundary.

C—21 to 25 inches, red (2.5YR 5/6) weathered basalt and cinders, dark red (2.5YR 3/6) when moist; massive; very hard; calcareous; pH 8.2.

R—25 inches +, basalt and cinders.

In places the texture of the A horizon is loam or light clay loam. The C horizon is not calcareous in all places. In places thin, patchy clay films occur within the voids of the cinders and in cracks in the basalt. The depth to basalt and cinders ranges from 25 to 30 inches.

REDDISH BROWN SOILS

Reddish Brown soils develop under shrubs and short grasses in a warm-temperate, semiarid climate. They have a light-brown, slightly reddish surface horizon that grades into reddish-brown or red material that is finer textured than that of the surface horizon. This material is underlain by a horizon of whitish or pinkish lime accumulation. In the Beaver Creek Area the Reddish Brown great soil group is represented by the Cornville, Courthouse, Penthouse, and Schnebly series. The Cornville, Courthouse, and Penthouse soils are minimal Reddish Brown soils; the Schnebly soils are medial Reddish Brown soils. The Courthouse soils intergrade to Lithosols, and the Penthouse soils intergrade to Grumusols.

Cornville Series

The Cornville series consists of deep, well-drained Reddish Brown soils that formed in material weathered from sandstone, with a minor component of limestone and basalt. These soils occur on old terraces that are now 20 to 100 feet higher than the stream channels. They are at elevations of 3,100 to 3,600 feet, where the average annual precipitation is about 11 inches and the average annual temperature is about 61°F. The relief is generally smooth and nearly level. The vegetation is a sparse cover of shrubs and grass.

In the Beaver Creek Area, the Cornville soils best express the concept of Reddish Brown soils. They are characterized by thin A1, B1, B2t, Cca, and C horizons. The B2t and Cca horizons are distinct.

Representative profile of Cornville fine sandy loam in an area used for range, where the plant cover is mesquite,

algerita, tobosagrass, sideoats grama, and black grama; NW $\frac{1}{4}$ sec. 12, T. 15 N., R. 4 E.:

A1—0 to 3 inches, light reddish-brown (5YR 6/4) fine sandy loam, reddish brown (5YR 4/4) when moist; massive; hard when dry, very friable when moist, non-sticky and nonplastic when wet; few fine roots; few fine and medium pores; noncalcareous; pH 8.0; abrupt, smooth boundary.

B1—3 to 7 inches, yellowish-red (5YR 4/6) fine sandy loam, dark yellowish red (5YR 3/6) when moist; weak, coarse, prismatic structure; hard when dry, friable when moist, nonsticky and nonplastic when wet; abundant fine and very fine roots; many very fine and fine tubular pores; noncalcareous; pH 8.2; clear, smooth boundary.

B2t—7 to 19 inches, yellowish-red (5YR 4/6) heavy fine sandy loam, dark yellowish red (5YR 3/6) when moist; moderate, coarse, prismatic structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant fine and very fine roots; many fine and very fine tubular pores; continuous thin clay films in pores; noncalcareous, except where filaments of white lime occur in the lower part of the horizon; filaments are few, fine, and faint; pH 8.2; clear, smooth boundary.

B2t—19 to 32 inches, yellowish-red (5YR 5/6) heavy fine sandy loam, yellowish red (5YR 4/6) when moist; weak, coarse, prismatic structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful very fine and fine roots; many very fine and fine tubular pores; common thin clay films on ped faces and in pores; noncalcareous except where prominent white flecks and filaments of lime occur; flecks and filaments are few to common occasional soft nodules of lime; pH 8.4; clear, wavy boundary.

C1ca—32 to 57 inches, pinkish-white (5YR 8/2) heavy fine sandy loam, light reddish brown (5YR 6/4) when moist; massive; hard when dry, friable when moist slightly sticky and slightly plastic when wet; few fine and very fine roots; common fine and very fine tubular pores; violently calcareous; pH 8.5; clear, wavy boundary.

C2—57 to 88 inches, light reddish-brown (5YR 6/4) loamy fine sand or fine sand, reddish brown (5YR 5/4) when moist; single grain; loose when dry or moist, non-sticky and nonplastic when wet; many very fine interstitial pores; horizon is noncalcareous or slightly calcareous in spots; pH 8.5.

When dry, the soil ranges from reddish brown to yellowish red in color; when moist, from reddish brown to dark reddish brown. The B2t horizon ranges from 15 to 32 inches in thickness, and the Cca from 18 to about 4 inches. Some profiles contain lime-coated pebbles and cobbles at a depth of 24 to 30 inches. Most areas are 48 inches deep or more, but some are only 24 to 30 inches deep.

Courthouse Series

The Courthouse series consists of shallow to moderately deep, well-drained, stony, calcareous Reddish Brown soil derived in place from red sandstone of the Supai formation. These soils occur on gently sloping to steep upland at elevations of about 4,000 feet, where the average annual precipitation is about 13 inches and the average annual temperature is about 60°F. The vegetation consists of catclaw, mesquite, juniper, turbinella oak, and grasses. Gravel and fragments of sandstone cover about 30 percent of the surface and make up about 30 percent of the profile, by volume.

Typically, the Courthouse soils have an A1-B2t-B3tca R horizon sequence. The A1 horizon is reddish brown

and thin, and the B2t is red. Although classified as Reddish Brown soils, they intergrade to Lithosols.

Representative profile of Courthouse gravelly fine sandy loam; NW $\frac{1}{4}$ sec. 24, T. 16 N., R. 5 E.:

A1—0 to 3 inches, reddish-brown (2.5YR 4/4) gravelly fine sandy loam, dark reddish brown (2.5YR 3/4) when moist; weak, thin, platy structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; plentiful roots; few fine pores; calcareous; pH 8.0; clear, wavy boundary.

B2t—3 to 9 inches, red (2.5YR 5/6) heavy gravelly fine sandy loam, dark red (2.5YR 3/6) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine and fine roots; common medium pores; thin, patchy clay films; calcareous; pH 8.0; clear, smooth boundary.

B3tca—9 to 14 inches, red (2.5YR 5/6) very gravelly light clay loam, red (2.5YR 4/6) when moist; weak, fine, subangular blocky structure; hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; plentiful very fine and fine roots; few fine pores; very few thin clay films; calcareous, with veins and concretions of calcium carbonate; pH 8.0; abrupt, wavy boundary.

R—14 inches +, light-red (2.5YR 6/6), hard, massive sandstone, red (2.5YR 5/6) when moist; calcareous.

These soils are typically reddish brown or red with a hue of 2.5YR, but in places the hue is 5YR. In places the texture of the A1 horizon is sandy loam. In places the B2t horizon is weakly expressed. If there is no B3tca horizon, the B2t horizon rests directly on the R horizon. The depth to sandstone bedrock ranges from 12 to 24 inches but is most commonly 14 inches.

Penthouse Series

The Penthouse series consists of deep, cobbly, well-drained Reddish Brown soils, derived chiefly from basalt but partly from sandstone. These soils occur on old high terraces and on the lower parts of old fans. They are at an elevation of about 3,800 feet, where the average annual precipitation is about 13 inches and the average temperature is about 60°F. The plant cover consists of mesquite, snakeweed, cacti, juniper, and filaree.

The Penthouse soils have medial development. They have the well-developed, reddish-brown B horizon and the distinct zone of lime accumulation in the C horizon that are characteristic of Reddish Brown soils. They have a thin A1 horizon, either an A3 or a B1t horizon, a B2t, and a Cca horizon. Although the Penthouse soils are classified as Reddish Brown soils, they have some characteristics of Grumusols.

Representative profile of Penthouse cobbly clay loam; NE $\frac{1}{4}$ sec. 9, T. 14 N., R. 6 E.:

A1—0 to 3 inches, brown (7.5YR 5/4) cobbly clay or clay loam, dark brown (7.5YR 4/4) when moist; moderate, thin, platy structure; soft when dry, friable when moist, moderately sticky and moderately plastic when wet; plentiful fine roots; few fine interstitial pores; noncalcareous; pH 7.6; clear, smooth boundary.

B1t—3 to 10 inches, reddish-brown (5YR 4/3) clay, reddish brown (5YR 4/3) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; plentiful very fine and fine roots; common fine pores; few thin clay films; weakly calcareous in spots; pH 8.0; gradual, smooth boundary.

B2t—10 to 17 inches, reddish-brown (5YR 4/3) heavy clay, reddish brown (5YR 4/3) when moist; moderate, very fine, angular blocky structure; very hard when

dry, firm when moist, very sticky and very plastic when wet; few fine roots; few fine pores; many thin clay films; some slickensides; calcareous; pH 8.2; gradual, wavy boundary.

B2t—17 to 27 inches, reddish-brown (5YR 4/4) heavy clay, reddish brown (5YR 4/4) when moist; weak, fine, subangular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; many clay films; few very fine roots; very few pores; calcareous; pH 8.2; abrupt, wavy boundary.

Cca—27 to 44 inches +, pink (5YR 7/4) heavy clay loam, reddish yellow (5YR 6/6) when moist; massive; cemented; highly calcareous; pH 8.2.

In places the texture of the surface horizon is stony loam. In places the texture of the B2t horizon is heavy clay loam. The Cca horizon ranges from pink to brown in color. It is not cemented in all places.

Schnebly Series

The Schnebly series consists of moderately deep, well-drained Reddish Brown soils derived mainly from basalt but partly from Supai sandstone. These soils occur on sloping uplands and on colluvial foot slopes. They are at elevations of 4,000 to 4,500 feet, where the average annual precipitation is about 13 inches and the average annual temperature is about 60°F. The vegetation is a sparse cover of mesquite, catclaw, juniper, turbinella oak, and tobosa. About 30 percent of the surface is covered with cobblestones and fragments of basalt. Stones are common throughout the profile.

Typically, the Schnebly soils have an A1-B2t-Cca-R horizon sequence. Their A horizon is reddish brown; their B2t horizon is distinct and fine textured.

Typical profile of Schnebly very stony clay loam; NE $\frac{1}{4}$ sec. 23, T. 16 N., R. 6 E.:

A1—0 to 4 inches, reddish-brown (5YR 4/3) very stony clay loam, dark reddish brown (5YR 3/4) when moist; weak, thin, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant very fine and fine roots; few fine pores; noncalcareous; pH 7.2; clear, smooth boundary.

B2t—4 to 14 inches, dark reddish-brown (5YR 3/3) stony clay, dark reddish brown (5YR 3/3) when moist; prismatic structure breaking to moderate, fine, angular blocky; very hard when dry, friable when moist, sticky and plastic when wet; abundant fine roots; few fine pores; thin, continuous clay films; noncalcareous; pH 7.0; clear, smooth boundary.

B2t—14 to 22 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; strong, very fine, angular blocky structure; very hard when dry, friable when moist, very sticky and very plastic when wet; thick, continuous clay films; plentiful fine and medium roots; very few, if any, pores; noncalcareous; pH 7.4; clear, wavy boundary.

Cca—22 to 25 inches, light reddish-brown (2.5YR 6/4) and reddish-brown (2.5YR 5/4) clay, dark red (2.5YR 3/6) when moist; weak, fine, angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few fine roots; thin, patchy clay films; highly calcareous, with lime segregations; pH 8.0.

R—25 inches +, basalt rock, some of which is coated with lime.

These soils are dark grayish brown in places. The texture of the B2t horizon is clay loam in places. Fragments of Supai sandstone occur in the C horizon of some profiles. The depth to bedrock ranges from 24 inches to about 36 inches.

CHESTNUT SOILS

Chestnut soils develop under mixed tall and short grasses in a temperate to cool, subhumid or semiarid climate. They have a dark-brown surface horizon, which grades into lighter colored horizons, and finally, into a horizon of lime accumulation. In this Area the Chestnut soils have a cover of pinyon pine, juniper, ponderosa pine, Gambel oak, and grasses. The Chestnut great soil group is represented in the Beaver Creek Area by the Cabezon and Gem series. These soils formed in residuum weathered from basalt and volcanic cinders.

Cabezon Series

The Cabezon series consists of shallow, dark-colored Chestnut soils that formed in residuum weathered from basalt. These soils occur on undulating uplands. They are at elevations of 6,100 to 7,500 feet, where the annual precipitation is 16 to 20 inches and the average annual temperature is about 47°F. The slope is generally less than 20 percent. The vegetation consists mainly of blue grama and forbs, but there is some ponderosa pine, pinyon pine, and juniper.

The Cabezon soils are characterized by a dark-colored A1 horizon of stony loam and a reddish-brown B2t horizon of blocky clay that lies directly on basalt.

Representative profile of Cabezon very stony loam in an area where the plant cover is ponderosa pine and grass; SE $\frac{1}{4}$ sec. 12, T. 16 N., R. 8 E.:

A1—0 to 3 inches, brown (7.5YR 4/2) very stony loam, dark brown (7.5YR 3/2) when moist; weak, thin, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant fine roots; fine and medium pores; slightly acid; pH 6.4; clear, smooth boundary.

B1—3 to 6 inches, reddish-brown (5YR 4/3) stony clay loam, dark reddish brown (5YR 3/4) when moist; moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; stones and cobblestones make up about 30 percent of the horizon by volume; plentiful fine and medium roots; plentiful large pores; neutral; pH 6.6; clear, smooth boundary.

B2t—6 to 11 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/4) when moist; moderate, fine, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; thin, continuous clay films on peds; cobblestones make up 15 percent of the horizon by volume; few medium roots; few medium and large pores; neutral; pH 6.8; abrupt boundary.

R—11 inches +, extremely hard, dense basalt.

The A1 horizon has a hue of 10YR in places. Its texture is clay loam in places. The B2t horizon has a hue of 2.5YR in some places because of the influence of the underlying cinders. Its texture is stony clay in places. The depth to bedrock ranges from 10 inches to 20 inches.

Gem Series

The Gem series consists of moderately deep and deep, dark-colored, well-drained Chestnut soils that developed in material weathered from basalt, volcanic cinders, and agglomerate. These soils are at elevations of 6,500 to 7,000 feet, where the annual precipitation is about 18 to 19 inches and the average annual temperature is about 50°F. The vegetation consists dominantly of grass and forbs, but there is some alligator juniper, Utah juniper, and pinyon pine.

Typically, the Gem soils have an A1-B1t-B2t-Cca-R horizon sequence.

Representative profile of Gem clay loam in an area used for range; NE $\frac{1}{4}$ sec. 9, T. 15 N., R. 8 E.:

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) clay loam, very dark brown (10YR 2/2) when moist; strong, fine, granular structure; soft when dry, friable when moist, sticky and plastic when wet; plentiful very fine roots; many very fine interstitial pores; noncalcareous; pH 6.4; abrupt, smooth boundary.

B1t—3 to 12 inches, dark-brown (10YR 3/3) clay, very dark brown (10YR 2/3) when moist; moderate, fine, angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; abundant fine roots; many very fine interstitial pores; very few clay films; noncalcareous; pH 6.8; clear, wavy boundary.

B2t—12 to 20 inches, brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; weak, medium, prismatic structure breaking readily to moderate, fine, angular blocky; extremely hard when dry, firm when moist, very sticky and very plastic when wet; plentiful very fine and fine roots; very few tubular pores; noncalcareous; pH 7.0; gradual, wavy boundary.

B2t—20 to 28 inches, brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; moderate, fine, angular blocky structure; extremely hard when dry, firm when moist, very sticky and very plastic when wet; few very fine roots; many fine pores; noncalcareous; pH 7.2; gradual, wavy boundary.

C1—28 to 37 inches, reddish-brown (5YR 4/4) very gravelly clay, dark reddish brown (5YR 3/3) when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; many unweathered, but easily weathered, minerals; slickensides on faces of large aggregates; few very fine roots; few fine pores; noncalcareous; pH 7.4; gradual, wavy boundary.

C2ca—37 to 44 inches, reddish-yellow (5YR 6/6) very gravelly clay loam, yellowish red (5YR 4/6) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; very few clay films; few fine pores; visible lime; strongly calcareous; pH 8.0.

R—44 inches +, basalt.

In places cobblestones and angular fragments of basalt occur on the surface. The hue of the A horizon is commonly 7.5YR but is 5YR or 10YR in places. The depth to bedrock ranges from 30 to 50 inches.

REDDISH CHESTNUT SOILS

The Reddish Chestnut soils in this Area have a dark-brown, pinkish or reddish surface horizon. They have a firm B horizon that is reddish brown or red in the upper part and lighter colored or gray in the lower part. In places carbonates accumulate in the deeper horizons. In the Beaver Creek Area, the Reddish Chestnut great soil group is represented by the Broliar and Hogg series. The Hogg soils developed in material weathered from cherty limestone. The Broliar soils formed in material weathered from basalt, with a cinder component. The Hogg soils occur chiefly at the lower elevations of the pine forest. The Broliar soils occur at higher elevations; they formed under a more dense forest cover than the Hogg soils.

Broliar Series

The Broliar series consists of moderately deep and deep, well-drained, friable, stony Reddish Chestnut soils that formed in material weathered from porous basalt and influenced by volcanic cinders. These soils occur on uplands at elevations of 6,500 to 7,600 feet, where the

annual precipitation is 20 to 23 inches and the average annual temperature is about 45°F. The vegetation consists of ponderosa pine, Gambel oak, and grass.

The Broliar soils have a brown or dark-brown A1 horizon and a reddish-brown B horizon that contains an accumulation of clay. There is no zone of lime accumulation. Typically, the Broliar soils have an O1-O2-A1-B1t-B2t-R horizon sequence.

Representative profile of Broliar very stony loam in an area of ponderosa pine; SE $\frac{1}{4}$ sec. 12, T. 16 N., R. 8 E.:

O1 and O2—1 inch to 0, decomposed and slightly decomposed pine needles.

A11—0 to 2 inches, brown (7.5YR 4/2) very stony loam, dark brown (7.5YR 3/2) when moist; moderate, thin, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful very fine roots; common very fine interstitial pores; noncalcareous; pH 6.4; clear, smooth boundary.

A12—2 to 5 inches, dark-brown (7.5YR 3/2) heavy stony loam, very dark brown (7.5YR 2/2) when wet; strong, medium, platy structure; soft when dry, friable when moist, sticky and plastic when wet; plentiful very fine roots; common very fine interstitial pores; noncalcareous; pH 6.6; clear, smooth boundary.

B1—5 to 10 inches, reddish-brown (5YR 4/3) clay loam, dark reddish brown (5YR 3/3) when moist; moderate, fine, subangular blocky structure; hard to slightly hard when dry, friable when moist, sticky and plastic when wet; few fine pores; plentiful fine and medium roots; noncalcareous; pH 6.6; clear, smooth boundary.

B21t—10 to 20 inches, reddish-brown (5YR 4/3) light clay, dark reddish brown (5YR 3/3) when moist; strong, fine, angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; thin, patchy clay films; plentiful fine and medium roots; many fine pores; noncalcareous; pH 6.8; gradual boundary.

B22t—20 to 34 inches, dark-brown (7.5YR 3/2) clay, dark brown (7.5YR 3/2) when moist; weak, fine, angular blocky structure; extremely hard when dry, firm when moist, very sticky and very plastic when wet; thin, continuous clay films; few fine, medium, and coarse roots; very few pores; noncalcareous; pH 7.0.

R—34 inches +, basalt.

The stone content of the A horizon ranges up to 60 percent. In places the profile is gravelly throughout. In places the texture of the A horizon is clay loam. The color of the B2t horizon ranges from dark brown to reddish brown but is commonly reddish brown. The depth to basalt bedrock ranges from 2 to 5 feet but is commonly 3 to 4 feet.

Hogg Series

The Hogg series consists of moderately deep, well-drained, stony Reddish Chestnut soils that formed in material weathered from cherty limestone and calcareous sandstone of the Kaibab formation. These soils occur on gently sloping to hilly uplands. They are at elevations of about 6,500 feet, where the average annual precipitation is about 19 inches and the average annual temperature is about 45°F. The vegetation consists of ponderosa pine, Gambel oak, alligator juniper, pinyon pine, and grass. Chert and fragments of cherty limestone occur on the surface.

The Hogg soils are brown to reddish brown and are noncalcareous. They have thin O1 and O2 horizons and

an A1-B1-B2t-C-R horizon sequence. The B2t horizon is well developed and has a distinct reddish-brown color.

Representative profile of Hogg stony silt loam in an area of ponderosa pine, Gambel oak, and grass; SE $\frac{1}{4}$ sec. 32, T. 16 N., R. 8 E.:

O1 and O2—1 inch to 0, decomposed and partly decomposed pine needles.

A1—0 to 4 inches, brown (7.5YR 4/2) stony silt loam, dark brown (7.5YR 3/2) when moist; weak, medium, platy structure; slightly hard when dry, friable when moist, sticky and plastic when wet; plentiful fine and medium roots; many very fine interstitial pores; noncalcareous; pH 6.4; clear, smooth boundary.

B1—4 to 9 inches, reddish-brown (5YR 4/3) gravelly clay loam, dark reddish brown (5YR 3/3) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; plentiful fine roots; few medium pores; noncalcareous; pH 6.4; clear, smooth boundary.

B21t—9 to 16 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; weak, prismatic structure breaking to moderate, fine, angular blocky; extremely hard when dry, firm when moist, very sticky and very plastic when wet; plentiful fine and medium roots; very few fine pores; thin, continuous clay films; noncalcareous; pH 6.0; clear, wavy boundary.

B22t—16 to 27 inches, reddish-brown (5YR 5/4) clay, reddish brown (5YR 4/4) when moist; weak, fine, angular blocky structure; extremely hard when dry, firm when moist, very sticky and very plastic when wet; plentiful fine and medium roots; few fine pores; thin, continuous clay films; noncalcareous; pH 6.3; gradual boundary.

C—27 to 32 inches, reddish-yellow and yellowish-red (5YR 6/6 and 5/6) silty clay; massive; hard when dry, friable when moist, sticky and plastic when wet; few fine roots; few fine pores; noncalcareous; pH 7.0.

R—32 inches +, hard limestone; some sandstone.

The texture of the A horizon is clay loam in some of the areas where this soil adjoins soils formed over basalt. The depth to bedrock ranges from 26 inches to more than 36 inches.

REDDISH PRAIRIE SOILS

Reddish Prairie soils develop in a warm-temperate, humid or subhumid climate. They have a dark-brown or reddish-brown, slightly acid or medium acid surface horizon, grading through somewhat finer textured, reddish material to the parent material. In the Beaver Creek Area the Reddish Prairie great soil group is represented by the Siesta series.

Siesta Series

The Siesta series consists of moderately deep and deep, well-drained Reddish Prairie soils derived in place from basalt and cinders. These soils occur in the ponderosa pine forest on gently rolling or gently undulating uplands. They are at elevations of 6,800 to 8,000 feet, where the annual precipitation is 20 to 22 inches and the average annual temperature is about 45°F. The vegetation consists of good stands of ponderosa pine and a ground cover mainly of Arizona fescue, junegrass, and mountain muhly. Stones, cobblestones, and gravel are common on the surface.

The Siesta soils are noncalcareous, but in places lime occurs as fine seams in the basalt. Generally, these soils have an O1-O2-A1-B1t-B2t-B3t-C-R horizon sequence. Manganese shot and concretions occur in all horizons.

Representative profile of Siesta stony silt loam; NW $\frac{1}{4}$ sec. 32, T. 18 N., R. 8 E.:

- O1 and O2—1 inch to 0, decomposed and partly decomposed pine needles.
- A11—0 to 2 inches, dark reddish-gray (5YR 4/2) stony silt loam, dark reddish brown (5YR 3/2) when moist; weak, thin, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant fine roots; common very fine pores; few manganese concretions; noncalcareous; pH 6.6; abrupt, smooth boundary.
- A12—2 to 5 inches, reddish-brown (5YR 4/3) stony silt loam, dark reddish brown (5YR 3/3) when moist; weak, thick, platy structure that breaks readily to moderate, medium granules; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful fine roots; few manganese concretions; common medium pores; noncalcareous; pH 6.6; clear, smooth boundary.
- B1t—5 to 8 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/4) when moist; strong, fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; plentiful fine and medium roots; few manganese concretions; thin, patchy clay films; common fine pores; noncalcareous; pH 6.8; clear, smooth boundary.
- B21t—8 to 17 inches, reddish-brown (2.5YR 4/4) heavy clay, dark reddish brown (2.5YR 3/4) when moist; moderate, fine, angular blocky structure; very hard when dry, friable when moist, very sticky and very plastic when wet; plentiful fine and medium roots; few manganese concretions; thick, continuous clay films; few fine, medium, and coarse roots; many fine pores; noncalcareous; pH 6.6; gradual, smooth boundary.
- B22t—17 to 21 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; moderate, fine, angular blocky structure; very hard when dry, friable when moist, very sticky and very plastic when wet; plentiful roots; few manganese concretions; thick, continuous clay films; few fine, medium, and coarse roots; few fine pores; noncalcareous; pH 6.8; gradual, smooth boundary.
- B3t—21 to 31 inches, red (2.5YR 4/6) heavy clay loam, dark red (2.5YR 3/6) when moist; weak, medium, angular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; few roots; few manganese concretions; thin, continuous clay films; few fine, medium, and coarse roots; few fine pores; noncalcareous; pH 7.3; gradual, smooth boundary.
- C—31 to 46 inches, red (2.5YR 5/6) clay loam, dark red (2.5YR 3/6) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few roots; few manganese concretions; very few patchy clay films; few medium and coarse roots; many fine pores; noncalcareous; pH 8.0; abrupt, wavy boundary.
- R—46 inches +, basalt rock; few seams of lime in places; some of the basalt is vesicular.

The soil color is dominantly reddish brown, but red, brown, and yellowish red also occur. The texture of the A horizon is stony loam or stony clay loam in places. Some profiles lack a B1t and B3t horizon. The depth to bedrock ranges from 36 inches to more than 5 feet.

INTRAZONAL ORDER

Intrazonal soils have evident, genetically related horizons that reflect the dominant influence of some local factor of relief or parent material over the normal effect of vegetation and climate (10). In this Area the intrazonal order is represented by the Brown Forest soils, the Calcisols, and the Grumusols.

BROWN FOREST SOILS

Brown Forest soils develop from parent material rich in bases. They result mainly from calcification and are affected very little by podzolization. The surface horizon is dark-brown, friable, granular material that is relatively rich in humus. The subsoil is lighter in color and shows little or no evidence of illuviation. In this Area the Brown Forest great soil group is represented by the Sponseller series.

Sponseller Series

The Sponseller series consists of deep, dark-colored, well-drained Brown Forest soils that formed in material weathered from volcanic cinders. These soils occur on the side slopes of cinder cones. They are at an elevation of 7,800 feet or more, where the annual precipitation is about 22 to 24 inches and the average annual temperature is about 45°F. The vegetation consists of mixed conifers and grass. Volcanic bombs and agglomerate cover 10 to 15 percent of the surface. Cinders and agglomerate occur throughout the profile. In many places the content of agglomerate increases with depth.

The Sponseller soils are characterized by well-defined O1 and O2 horizons, a dark-colored A1 horizon, a B2t horizon, and C and R horizons. The B2t horizon is friable when moist but is hard or very hard when dry. The colors of the soil are strongly influenced by the colors of the parent cinders.

Representative profile of Sponseller stony silt loam; NE $\frac{1}{4}$ sec. 29, T. 16 N., R. 9 E.:

- O1 to O2—2 inches to 0, undecayed and partly decayed needles, twigs, and other organic material.
- A1—0 to 3 inches, dark reddish-brown (5YR 3/3) stony silt loam, dark reddish brown (5YR 3/2) when moist; thin, platy structure that breaks readily to moderate, fine, granular; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant fine roots; many very fine pores; noncalcareous; pH 5.9; clear, smooth boundary.
- A3—3 to 8 inches, dark reddish-brown (2.5YR 3/4) stony silt loam, dark reddish brown (2.5YR 2/4) when moist; weak, fine, granular structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant fine roots; common medium pores; noncalcareous; pH 6.4; clear, smooth boundary.
- B1—8 to 17 inches, reddish-brown (2.5YR 4/4) heavy loam, dark red (2.5YR 3/6) when moist; weak, coarse, granular structure; hard when dry, friable when moist, sticky and plastic when wet; plentiful fine and medium roots; many fine pores; few clay films; noncalcareous; pH 6.4; gradual boundary.
- B2t—17 to 28 inches, reddish-brown (2.5YR 4/4) clay loam, dark red (2.5YR 3/6) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; continuous clay films; few fine, medium, and coarse roots; few small pores; noncalcareous; pH 6.4; gradual boundary.
- B2t—28 to 43 inches, yellowish-red (5YR 4/6) light clay loam, yellowish red (5YR 3/6) when moist; moderate, fine, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; few clay films; few fine and medium roots; many fine pores; noncalcareous; pH 6.4; gradual boundary.
- C—43 to 52 inches, yellowish-red (5YR 3/6) gravelly light clay loam, yellowish red (5YR 3/6) when moist; massive; hard when dry, friable when moist, sticky and plastic

when wet; few medium and coarse roots; noncalcareous; pH 7.0.

R—52 inches +, yellowish-red cinders.

In places the texture of the A horizon is stony loam, and that of the B horizon is light clay.

CALCISOLS

Calcisols are soils that have a high content of alkaline earth carbonates. In these soils the formation and movement of clay is retarded, and carbonates accumulate. The Cca horizon varies in thickness and degree of cementation. It has a stronger concentration of lime than the parent material.

In the Beaver Creek Area, the Calcisol great soil group is represented by the Bridge, Karro, Laveen, and Stagecoach series. The Bridge soils have been influenced by basalt and volcanic ash. The Stagecoach, Karro, and Laveen soils developed in material weathered from limestone and sandstone of the Verde formation. The Stagecoach soils have a more prominent concentration of carbonates in the Cca horizon than do the others. The Bridge, Karro, and Laveen soils are classified as minimal Calcisols. The Karro soils intergrade to Alluvial soils.

Bridge Series

The Bridge series consists of moderately deep and deep, well-drained, very strongly calcareous Calcisols that formed partly in basaltic alluvium and partly in volcanic ash and tuffaceous material. These soils occur on gently sloping alluvial fans and undulating terraces at elevations of 3,700 to 3,800 feet, where the average annual precipitation is about 12 inches and the average annual temperature is about 61°F. The vegetation consists of mesquite, juniper, catclaw, canotia, locoweed, and grass.

The Bridge soils are characterized by an A1-C1-C2ca-C3 horizon sequence. They have dark-colored A and C1 horizons, a C2ca horizon that contains many lime concretions, and a C3 horizon of tuff, ash, gravel, and cobbles.

Representative profile of Bridge stony loam in an area used for range, where the vegetation consists of snake-weed, mesquite, cacti, locoweed, filaree, juniper, and catclaw; NW $\frac{1}{4}$ sec. 12, T. 15 N., R. 5 E.:

- A1—0 to 3 inches, brown (10YR 5/3) stony loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; very soft when dry, friable when moist, slightly sticky and slightly plastic when wet; 15 percent stones; common fine interstitial pores; plentiful fine roots; very strongly calcareous; pH 8.4; clear, smooth boundary.
- C1—3 to 10 inches, brown (10YR 5/3) heavy loam or light sandy clay loam, brown (10YR 4/3) when moist; very weak, fine, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and medium roots; few fine pores; very strongly calcareous; pH 8.4; clear, wavy boundary.
- C2ca—10 to 31 inches, very pale brown (10YR 7/3) gravelly loam, pale brown (10YR 6/3) when moist; massive; soft when dry, friable when moist, sticky and plastic when wet; few fine pores; many large, irregularly shaped concretions of lime; very strongly calcareous; pH 8.4; gradual, wavy boundary.
- C3—31 to 36 inches +, pinkish-white (7.5YR 8/2) mixture of tuff, ash, gravel, and cobbles, pinkish gray (7.5YR 6/2) when moist; massive; no roots; very few micro or fine pores; very strongly calcareous; pH 8.6.

In a few places the A1 horizon is noncalcareous. In places its texture is very gravelly loam or cobbly loam. In places the texture of the control section is gravelly heavy sandy loam, gravelly loam, or gravelly light sandy clay loam (18 to 35 percent clay). The depth to underlying ash or tuffaceous material ranges from 24 to 32 inches.

Karro Series

The Karro series consists of deep, well-drained, strongly calcareous Calcisols that formed in alluvium derived chiefly from limestone and sandstone of the Verde formation. These soils occur on generally smooth, short, gently sloping alluvial fans, at elevations of 3,500 to 4,000 feet, where the average annual precipitation is about 12 inches and the average annual temperature is about 61°F.

The Karro soils have an A1 horizon that has lost lime through leaching, a Cca horizon, and a C horizon. They do not have a distinct layer of cementation, and the carbonates in the Cca horizon are concentrated as splotches or veins. There is probably a recharge of highly calcareous material from the Retriever soils on surrounding slopes. Although the Karro soils are classified as minimal Calcisols, they intergrade to Alluvial soils.

Representative profile of Karro fine sandy loam, in an area of Karro and Laveen fine sandy loams, under a cover of range plants; NE $\frac{1}{4}$ sec. 18, T. 15 N., R. 5 E.:

- A11—0 to 3 inches, light-brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) when moist; weak, thick, platy structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; plentiful fine and very fine roots; many fine and very fine interstitial pores; strongly calcareous; pH 8.2; abrupt, smooth boundary.
- A12—3 to 8 inches, light-brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) when moist; very weak, coarse and medium, subangular blocky structure to massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; abundant fine and very fine roots; many fine and very fine tubular and interstitial pores; strongly calcareous; pH 8.3; clear, smooth boundary.
- C1ca—8 to 14 inches, reddish-brown (5YR 5/3) loam or heavy fine sandy loam, reddish brown (5YR 4/4) when moist; very weak, coarse and medium, subangular blocky structure to massive; common, fine, prominent, white filaments and mottles of lime; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant fine and very fine roots; many fine and very fine tubular and interstitial pores; strongly calcareous; pH 8.3; clear, wavy boundary.
- C2ca—14 to 31 inches, brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) when moist; massive; many medium and coarse pinkish-white (7.5YR 8/2) mottles of lime and a few small soft nodules; slightly cemented with lime; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine roots; few very fine tubular and many very fine interstitial pores; violently calcareous; pH 8.3; clear, wavy boundary.
- C3—31 to 52 inches +, pink (5YR 7/4) light loam or fine sandy loam, reddish brown (5YR 4/4) when moist; moderate, thick, platy structure; stratified fragments of sandstone; extremely hard when dry, extremely firm when moist, slightly sticky and slightly plastic when wet; no plant roots or pores; moderately alkaline; (strongly calcareous material between plates, but noncalcareous inside plates).

In places hues are 10YR. In places the texture of the surface layer is very fine sandy loam or loam and the texture of the control section is silt loam or light silty clay loam.

Laveen Series

The Laveen series consists of deep, well-drained, very strongly calcareous Calcisols that formed in mixed material weathered from limestone and sandstone. These soils occur on old eroded terraces at an elevation of about 3,900 feet, where the average annual precipitation is about 13 inches and the average annual temperature is about 60°F. Pebbles of limestone and a few cobblestones occur on the surface.

Typically, the Laveen soils have an A1-C1-C2ca-C3 horizon sequence. In most places the C2ca horizon has concretions and splotches of lime.

Representative profile of Laveen gravelly sandy loam, under a cover of juniper, yucca, turpentine weed, and grass; SE $\frac{1}{4}$ sec. 17, T. 15 N., R. 6 E.:

- A1—0 to 3 inches, pale-brown (10YR 6/3) gravelly sandy loam, brown (10YR 4/3) when moist; weak, thin, platy structure; very soft when dry, very friable when moist, nonsticky and nonplastic when wet; many interstitial pores; few fine and medium roots; violently calcareous; pH 8.4; clear, smooth boundary.
- C1—3 to 11 inches, pink (7.5YR 7/4) gravelly loam, light brown (7.5YR 6/4) when moist; weak, fine, sub-angular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine and medium roots; violently calcareous; pH 8.2; clear, smooth boundary.
- C2ca—11 to 24 inches, white (10YR 8/2) gravelly sandy loam, light gray (10YR 7/2) when moist; massive; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine and medium roots; many concretions and splotches of lime; violently calcareous; pH 8.6; gradual, wavy boundary.
- C3—24 to 32 inches +, pink (5YR 7/4) gravelly sandy loam, light reddish brown (5YR 6/4) when moist; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; violently calcareous; pH 8.4.

In places the color of the A1 horizon is a hue of 7.5YR. There are very few roots below a depth of 11 inches.

Stagecoach Series

The Stagecoach series consists of moderately deep and deep, well-drained, strongly calcareous, cobbly and gravelly Calcisols that formed in mixed sediments weathered from Coconino and Supai sandstone and the Verde formation. These soils occur on old eroded terraces, chiefly at elevations of about 3,900 feet, where the average annual precipitation is about 13 inches and the average annual temperature is about 60°F. The vegetation consists of scattered juniper trees, some mesquite, yucca, cacti, and canotia, and sparse stands of grass. About half of the surface is barren.

Except for the prominent concentration of calcium carbonate in the Cca horizon, the Stagecoach soils show only slight horizon differentiation. The Cca horizon shows some cementation and a slightly higher pH value than the other horizons. Lime-coated, rounded pebbles and cobblestones occur throughout the profile. These soils have thin A1, AC, Cca, and C horizons.

Representative profile of Stagecoach cobbly sandy loam, NW $\frac{1}{4}$ sec. 1, T. 15 N., R. 5 E.:

- A1—0 to 4 inches, brown (7.5YR 5/4) cobbly sandy loam, dark reddish brown (5YR 3/4) when moist; weak, fine, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; plentiful fine and medium roots; common interstitial

pores; strongly calcareous; pH 8.4; clear, wavy boundary.

- AC—4 to 13 inches, light reddish-brown (5YR 6/4) very gravelly loam, reddish brown (5YR 5/4) when moist; massive; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful fine and medium roots; common interstitial pores; strongly calcareous; pH 8.2; abrupt, smooth boundary.
- C1ca—13 to 18 inches, pinkish-white (5YR 8/2) very gravelly loam, pink (5YR 8/3) when moist; massive; extremely hard when dry, friable when moist, nonsticky and nonplastic when wet; semicemented; many lime concretions; very few medium roots; few interstitial pores; violently calcareous; pH 8.9; gradual, wavy boundary.
- C2—18 to 28 inches +, light reddish-brown (2.5YR 6/4) very gravelly light sandy loam, reddish brown (2.5YR 5/4) when moist; massive; extremely hard when dry, friable when moist, nonsticky and nonplastic when wet; semicemented; very few medium roots; few interstitial pores; violently calcareous; pH 8.6.

The Cca horizon is weakly consolidated by lime when dry, but it is friable when moist. The upper part of the Cca horizon is hard and smooth, but the roots of juniper trees can penetrate into this horizon.

GRUMUSOLS

Grumusols are clayey soils characterized by slickensides, a high shrinkage ratio with much cracking and churning, and gilgai relief. They are brown, well drained, and well aerated. In the Beaver Creek Area the Grumusol great soil group is represented by the Springerville series.

Springerville Series

This series consists of deep, well-drained, stony Grumusols that formed over basalt and cinders. They occur on undulating to rough uplands, at elevations of 3,500 to 6,500 feet, where the annual precipitation is 11 to 18 inches and the average annual temperature is about 50°F. The vegetation consists chiefly of pinyon pine and juniper and a ground cover of grass. Basalt stones and cobblestones cover 30 to 50 percent of the surface, but stones do not make up much of the profile.

The Springerville soils are characterized by an A-C-Cca profile sequence, but the horizons are difficult to distinguish. The A horizon is more like a mulch than a distinct horizon. The material below the surface horizon is massive or has weak, blocky structure. There is little variation in clay content throughout the profile. When dry, the soil material is very hard.

Representative profile of Springerville very stony clay, under a cover of juniper trees and grass; NW $\frac{1}{4}$ sec. 24, T. 16 N., R. 7 E.:

- A1—0 to 3 inches, dark grayish-brown (10YR 4/2) very stony clay, very dark grayish brown (10YR 3/2) when moist; weak, platy structure breaking to strong, fine, granular; slightly hard when dry, friable when moist, sticky and plastic when wet; plentiful very fine roots and few fine roots; common very fine interstitial pores; noncalcareous; pH 7.6; clear, smooth boundary.
- A12—3 to 6 inches, brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; extremely hard when dry, very firm when moist, sticky and plastic when wet; few very fine and fine roots; few fine pores; noncalcareous; pH 7.6; clear, wavy boundary.
- C1—6 to 12 inches, brown (7.5YR 4/2) heavy clay, dark brown (7.5YR 3/2) when moist; massive; extremely

hard when dry, very firm when moist, very plastic and sticky when wet; slickensides; few very fine roots; very few fine pores; noncalcareous; pH 7.6; clear, smooth boundary.

C2—12 to 21 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) when moist; massive; extremely hard when dry, very firm when moist, very plastic and sticky when wet; many slickensides; few very fine roots; very few fine pores; noncalcareous; pH 7.8; clear, wavy boundary.

C3—21 to 36 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) when moist; massive; extremely hard when dry, very firm when moist, very plastic and sticky when wet; many slickensides; few very fine roots; slightly calcareous; pH 8.0; clear, wavy boundary.

C4ca—36 to 44 inches +, reddish-brown (5YR 4/3) clay, reddish brown (5YR 4/3) when moist; massive; extremely hard when dry, firm when moist, very sticky and very plastic when wet; few very fine roots; many lime concretions; highly calcareous; pH 8.3.

In some places the texture of the A1 horizon is very stony heavy clay loam, and in some a small amount of finely divided lime occurs in the profile.

AZONAL ORDER

Azonal soils lack a well-developed profile because they are youthful, or because the parent material resists soil-forming processes, or because their relief has prevented development of definite characteristics (10). In this Area, the azonal order is represented by the Alluvial soils and the Lithosols.

ALLUVIAL SOILS

Alluvial soils consist of recent alluvium that is relatively unchanged by environment. Their characteristics are determined largely by the nature of the alluvium and the manner in which it has been sorted and deposited. Climatic conditions, drainage, and vegetation vary widely. In the Beaver Creek Area the Alluvial great soil group is represented by the Anthony, Carrizo, Gila, Glendale, Guest, Hantz, Lynx, Tobler, and Toquop series. The Guest soils intergrade to Reddish Brown soils, and the Hantz soils intergrade to Grumusols.

Anthony Series

The Anthony series consists of deep, well-drained Alluvial soils that formed in material washed chiefly from sandstone, but partly from limestone, basalt, rhyolite, granite, and schist. These soils show only minimum horizonation. They occur on nearly level, smooth, low stream terraces, at elevations of 3,100 to 3,500 feet, where the average annual precipitation is about 12 inches and the average annual temperature is about 61° F. The vegetation consists of a mixed cover of creosotebush, mesquite, cacti, and galleta.

Representative profile of Anthony fine sandy loam, in an abandoned field that was formerly cultivated; SW $\frac{1}{4}$ sec. 14, T. 14 N., R. 4 E.:

Ap—0 to 10 inches, reddish-brown (5YR 4/4) fine sandy loam; dark reddish brown (5YR 3/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; abundant very fine and fine roots; many fine and very fine interstitial pores; strongly calcareous; pH 8.6; abrupt, smooth boundary.

C1—10 to 36 inches, reddish-brown (5YR 4/4) fine sandy loam, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, very friable when

moist, nonsticky and nonplastic when wet; abundant very fine and fine roots; many fine and very fine tubular and interstitial pores; strongly calcareous; pH 8.6; gradual, smooth boundary.

C2—36 to 76 inches, reddish-brown (5YR 4/4) strata of fine sandy loam and very fine sandy loam, but principally fine sandy loam; reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; abundant very fine and fine roots; many fine and very fine tubular and interstitial pores; strongly calcareous; pH 8.6.

In places the texture of the Ap horizon is sandy loam. Strata of loamy fine sand and fine sand occur below a depth of 20 to 30 inches in some profiles.

Carrizo Series

The Carrizo series consists of deep, excessively drained, calcareous, gravelly Alluvial soils that developed in alluvium derived mainly from sandstone, but partly from limestone, basalt, and schist. These soils occur on flood plains, at elevations of 3,100 to 3,600 feet, where the annual precipitation is about 10 to 12 inches and the average annual temperature is about 61° F. They are subject to flooding. A few scattered stones occur on the surface.

The Carrizo soils have only C horizons and are highly stratified. They are moderately alkaline throughout.

Representative profile of Carrizo very gravelly coarse sand, under a plant cover of cottonwood, willow, mesquite, and bermudagrass; SW $\frac{1}{4}$ sec. 24, T. 15 N., R. 4 E.:

C1—0 to 15 inches, light-brown (7.5YR 6/4) very gravelly coarse sand, light brown (7.5YR 6/4) when moist; single grain; loose when dry or moist, nonsticky and nonplastic when wet; 25 percent of this horizon is gravel, 15 percent is cobbles; few fine roots; calcareous; pH 8.1; abrupt, smooth boundary.

C2—15 to 34 inches, light-brown (7.5YR 6/4) stratified very gravelly fine sand and very gravelly loamy fine sand, brown (7.5YR 5/4) when moist; massive; soft when dry, friable when moist; nonsticky and nonplastic when wet; few fine, medium, and large roots; calcareous; pH 8.2; abrupt, smooth boundary.

C3—34 to 40 inches, pink (7.5YR 7/4) sand, light brown (7.5YR 6/4) when moist; single grain; loose when dry or moist, nonsticky and nonplastic when wet; calcareous; pH 8.3; clear, smooth boundary.

C4—40 inches +, light-brown (7.5YR 6/4) gravelly coarse sand, light brown (7.5YR 6/4) when moist; single grain; loose when dry or moist, nonsticky and nonplastic when wet; 15 percent of this horizon is gravel; calcareous; pH 8.3.

In most places these soils are calcareous. In some places the color is a hue of 10YR. In places the texture is loamy sand, sand, or coarse sand. The gravel content of the profile as a whole ranges from 20 to 50 percent. In places cobbles occur in all horizons.

Gila Series

The Gila series consists of deep, well-drained Alluvial soils that formed in alluvium derived mainly from sandstone but partly from limestone, basalt, and acid igneous material. These soils occur on flood plains and low stream terraces, at elevations of 3,100 to 3,500 feet, where the average annual precipitation is about 12 inches and the average annual temperature is about 61° F. The vegetation consists of cottonwood trees and such grasses as galleta and sand dropseed.

The Gila soils are stratified or are uniform in texture, which is mainly very fine sandy loam. Their dominant

reddish color is probably inherited from the sandstone component of the parent material. Most areas of Gila soils are irrigated and receive depositions of silt loam from turbid irrigation water. The depositions vary from field to field, and slight variations in color and texture of the surface soil result. The cultivated areas are used for alfalfa and truck crops.

Representative profile of Gila very fine sandy loam, reddish variant; SE $\frac{1}{4}$ sec. 11, T. 14 N., R. 4 E.:

- Ap—0 to 9 inches, reddish-brown (5YR 5/3) very fine sandy loam, with some deposition of silt loam; dark reddish brown (5YR 3/3) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant fine and very fine roots; many fine and very fine tubular pores and a few medium wormholes; strongly calcareous; pH 8.4; abrupt, smooth boundary.
- C1—9 to 17 inches, reddish-brown (5YR 5/3) very fine sandy loam, dark reddish brown (5YR 3/3) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant fine roots; many fine tubular pores; strongly calcareous; pH 8.4; clear, smooth boundary.
- C2—17 to 37 inches, reddish-brown (5YR 5/3) very fine sandy loam, dark reddish brown (5YR 3/4) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; abundant fine and very fine roots; many medium, fine, and very fine tubular pores and many micro and very fine interstitial pores; strongly calcareous; pH 8.2; abrupt, smooth boundary.
- C3—37 to 74 inches +, reddish-brown (5YR 5/3) very fine sandy loam or silt loam, reddish brown (5YR 4/3) when moist; a few thin strata of light brownish-gray (10YR 6/2) light silty clay loam, dark grayish brown (10YR 4/2) when moist; massive; hard when dry, slightly sticky and slightly plastic when wet; plentiful fine and very fine roots; many fine and very fine tubular pores and many micro interstitial pores; violently calcareous; pH 8.2.

The colors vary about half a unit either way in value and chroma. The pH value ranges from 8.0 to 8.5 in any horizon. In most places there are a few fine plates of mica, but mica does not occur in all profiles. The thin strata of light silty clay loam in the C3 horizon are below a depth of 30 inches in most places; they do not occur in all profiles.

Glendale Series

The Glendale series consists of deep, well-drained, highly calcareous Alluvial soils that formed in alluvium washed mainly from limestone. These soils occur on alluvial fans at elevations of about 3,500 feet, where the average annual precipitation is 11 to 13 inches and the average annual temperature is about 60° F. The vegetation consists of grass and dense stands of creosotebush and mesquite.

The Glendale soils have an A1-AC-Cca-C horizon sequence. They are youthful and have an extremely high content of calcium carbonate throughout the profile.

Representative profile of Glendale silt loam, under a plant cover of creosotebush and grass; NE $\frac{1}{4}$ sec. 4, T. 15 N., R. 5 E.:

- A1—0 to 3 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 4/3) when moist; moderate, medium, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine pores; plentiful very fine and fine roots; strongly calcareous; pH 8.0; gradual, wavy boundary.

AC—3 to 15 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 4/3) when moist; weak, fine, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine pores; plentiful very fine and fine roots; violently calcareous; pH 8.2; gradual, wavy boundary.

Cca—15 to 36 inches, pale-brown (10YR 6/3) heavy silt loam, brown (10YR 4/3) when moist; moderate, fine, subangular blocky structure; soft when dry, friable when moist, sticky and plastic when wet; few fine and very fine roots; few fine pores; visible lime; violently calcareous; pH 8.3; gradual, wavy boundary.

C—36 to 52 inches +, pale-brown (10YR 6/3) loam, brown (10YR 4/3) when moist; weak, fine, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine pores; violently calcareous; pH 8.2.

In places the color of these soils is light brownish gray.

Guest Series

The Guest series consists of deep, well-drained, calcareous Alluvial soils that formed in alluvium derived mainly from basalt, but partly from limestone of the Verde formation. These soils occur on alluvial fans and bottom lands, at elevations of 3,500 to 3,900 feet, where the average annual precipitation is about 12 inches and the average annual temperature is about 61° F. The vegetation consists of mesquite, catclaw, and tobosa. In places the tobosa is dense enough to give an appearance of small tobosa flats.

These soils have an Ap-C2-C3-C4 or a C1-C2-C3-C4 horizon sequence. The C horizons have weak to moderate structure. Although classified as Alluvial soils, the Guest soils intergrade to Reddish Brown soils.

Representative profile of Guest clay in an area used for range; NW $\frac{1}{4}$ sec. 31, T. 15 N., R. 5 E.:

C1—0 to 3 inches, brown (7.5YR 5/4) clay, reddish brown (5YR 4/4) when moist; moderately thin, platy structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many very fine and fine roots; few fine pores; calcareous; pH 8.2; clear, smooth boundary.

C2—3 to 12 inches, brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) when moist; weak, angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots; few fine pores; calcareous; pH 8.3; clear, smooth boundary.

C3—12 to 32 inches, brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) when moist; moderate, fine, angular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; few fine roots; few fine pores; few clay films; calcareous; pH 8.4; clear, smooth boundary.

C4—32 to 50 inches +, brown (7.5YR 4/4) silty clay loam, dark brown (7.5YR 3/3) when moist; very weak, fine, angular blocky structure or massive; hard when dry, friable when moist, sticky and plastic when wet; common fine pores; calcareous; pH 8.4.

In places the color of the C1 horizon is dark grayish brown, and the texture is loam or heavy clay loam. In places the texture of the C2 and C3 horizons is silty clay or clay. In some areas fine gravel occurs on the surface and within the profile.

Hantz Series

The Hantz series consists of deep, well-drained Alluvial soils that formed in material washed from limestone and shale of the Verde formation. These soils occur on

alluvial fans at elevations of 3,100 to 3,300 feet, where the average annual precipitation is about 11 inches and the average annual temperature is about 61° F. They are nearly bare of vegetation, and cracks 1 to 2 inches wide form when the soil is dry. In places fragments of limestone make up as much as 40 percent of the surface horizon.

The Hantz soils have C horizons only. They have weak structure or are massive, and they are violently calcareous throughout. Although classified as Alluvial soils, the Hantz soils intergrade to Grumusols.

Representative profile of Hantz silty clay, under a sparse cover of tobosa and snakeweed; NE $\frac{1}{4}$ sec. 3, T. 14 N., R. 4 E.:

C1—0 to 3 inches, light brownish-gray (10YR 6/2) silty clay, light brownish gray (10YR 6/2) when moist; weak, medium to fine, subangular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; few very fine and fine roots; very fine and fine tubular pores; violently calcareous; pH 8.2; abrupt, smooth boundary.

C2—3 to 22 inches, light brownish-gray (10YR 6/2) silty clay, light brownish gray (10YR 6/2) when moist; weak, medium to coarse, angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; few very fine roots; few fine tubular pores; violently calcareous; pH 8.3; clear, smooth boundary.

C3—22 to 60 inches +, light brownish-gray (10YR 6/2) silty clay, light brownish gray (10YR 6/2) when moist; weak, thick, platy structure breaking to weak, coarse and medium, angular blocky; very hard when dry, firm when moist, very sticky and very plastic when wet; few fine roots; few fine tubular pores; violently calcareous; pH 8.5.

In a few places the color is a hue of 7.5YR. In places these soils are structureless.

Lynx Series

The Lynx series consists of deep, well-drained Alluvial soils that formed in sediments washed from basaltic material. These soils occur on valley fills and on alluvial fans, at elevations of 5,500 to 6,500 feet, where the annual precipitation is 16 to 20 inches and the average annual temperature is about 50° F.

The Lynx soils are weakly developed. They have a dark-brown A horizon overlying a stratified, moderately fine textured C horizon. Roots are plentiful to a depth of 30 inches. Unweathered cinders occur in the C3 horizon. There are no clay films, and there is little change in consistence with depth.

Representative profile of Lynx silt loam in an area used for range, under a cover of blue grama, snakeweed, juniper, pinyon pine, and annuals; NW $\frac{1}{4}$ sec. 33, T. 16 N., R. 7 E.:

A11—0 to 3 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, thin, platy structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful very fine and fine roots; few medium pores; noncalcareous; pH 6.8; clear, smooth boundary.

A12—3 to 10 inches, dark-brown (7.5YR 4/2 to 7.5YR 3/2) heavy silt loam, very dark brown (7.5YR 2/2) when moist; weak, thin, platy structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful very fine and fine roots; few medium pores; noncalcareous; pH 6.6; clear, smooth boundary.

C1—10 to 24 inches, brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; plentiful very fine roots; few fine pores; noncalcareous; pH 6.9; gradual boundary.

C2—24 to 35 inches, brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; plentiful very fine roots; common fine pores; noncalcareous; pH 7.0; gradual boundary.

C3—35 to 54 inches, brown (7.5YR 4/2) gravelly clay loam, dark brown (7.5YR 3/2) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; few very fine roots; few fine pores; noncalcareous; pH 7.4; gradual boundary.

C4—54 to 62 inches +, brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; weak, medium, angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; few weak clay films; very few pores; noncalcareous; pH 7.4.

The moderate, subangular blocky structure of the C1 and C2 horizons does not occur in all places.

Tobler Series

The Tobler series consists of deep, well-drained Alluvial soils that formed in sediments derived chiefly from red, fine-textured sandstone of the Supai formation. These soils occur on alluvial fans, at elevations of about 4,000 feet, where the average annual precipitation is about 13 inches and the average annual temperature is about 60° F. The vegetation consists mainly of mesquite, catclaw, sand dropseed, and Rothrock grama.

Typically, these soils have an A1-C or an Ap-C horizon sequence. The reddish-brown A1 horizon overlies a moderate-grade structural C horizon.

Representative profile of Tobler fine sandy loam in an area now used for range but probably used formerly for cultivated crops; SE $\frac{1}{4}$ sec. 13, T. 16 N., R. 5 E.:

A1 (or Ap)—0 to 6 inches, reddish-brown (5YR 4/4) fine sandy loam, dark reddish brown (5YR 3/4) when moist; weak, thin, platy structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine roots; common interstitial pores; noncalcareous; pH 7.0; clear, smooth boundary.

C1—6 to 13 inches, reddish-brown (2.5YR 4/4) fine sandy loam, dark reddish brown (2.5YR 3/4) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist, nonsticky and nonplastic when wet; many very fine and fine roots; few fine pores; noncalcareous; pH 7.4; clear, smooth boundary.

C2—13 to 25 inches, reddish-brown (2.5YR 4/4) fine sandy loam, dark reddish brown (2.5YR 3/4) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many very fine and fine roots; few medium pores; few thin clay films; noncalcareous; pH 7.6; clear, smooth boundary.

C3—25 to 40 inches, reddish-brown (2.5YR 5/4) fine sandy loam, dark reddish brown (2.5YR 3/4) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; plentiful very fine and fine roots; few fine pores; noncalcareous; pH 7.8; clear, smooth boundary.

C4—40 to 48 inches, reddish-brown (2.5YR 5/4) fine sandy loam, reddish brown (2.5YR 4/4) when moist; massive; soft when dry, very friable when moist, nonplastic and nonsticky when wet; plentiful fine and

very fine roots; common very fine and fine pores; slightly calcareous; pH 8.0; gradual boundary.
 C5—48 to 53 inches +, yellowish-red (5YR 4/6) fine sandy loam, dark red (2.5YR 3/6) when moist; weak, fine, subangular blocky structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; few very fine and fine roots; few fine pores; highly calcareous; pH 8.2.

In places the surface is covered with gravel, and gravel makes up as much as 15 percent of the profile.

Toquop Series

The Toquop series consists of deep, excessively drained Alluvial soils that formed in material derived mainly from sandstone but partly from limestone, basalt, and schist. These soils occur on flood plains and low stream terraces, at elevations of 3,100 to 3,600 feet, where the average annual precipitation is about 10 to 12 inches and the average annual temperature is about 61° F.

The Toquop soils have only a C horizon. Their texture is uniformly loamy fine sand or fine sand, or it is stratified fine and medium sand. In places there are a few thin strata of loamy sand. These soils are slightly calcareous and moderately alkaline throughout.

Representative profile of Toquop loamy fine sand, under a sparse cover of cottonwood, willow, juniper, mesquite, and bermudagrass; SE $\frac{1}{4}$ sec. 24, T. 15 N., R. 4 E.:

- C1—0 to 16 inches, reddish-brown (5YR 5/3) loamy fine sand, reddish brown (5YR 4/4) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common fine and medium roots and few coarse roots; many fine and very fine interstitial pores; slightly calcareous; pH 8.0; abrupt, smooth boundary.
- C2—16 to 54 inches +, reddish-brown (5YR 5/3) fine sand with much medium sand; reddish brown (5YR 4/3) when moist; single grain; loose when dry or moist, nonsticky and nonplastic when wet; few very fine and fine roots; many fine and very fine interstitial pores; slightly calcareous; pH 8.0.

In places the texture of the surface horizon is sand or sandy loam. In places there are scattered pebbles in the C1 horizon. The texture of the material below the C1 horizon ranges from loamy fine sand to clean sand, medium to fine in size. In places the texture is uniform to a depth of 60 inches. In other places the soil material consists of many strata ranging from a few inches in thickness to more than a foot. In places the sandy material overlies cobbly and gravelly riverwash sediments at a depth of 30 to 50 inches.

LITHOLSOLS

Lithosols are soils that have no clearly expressed soil morphology and consist of a freshly and imperfectly weathered mass of rock fragments. These soils occur mainly on steep slopes. The Lithosol great soil group is represented in the Beaver Creek Area by the House Mountain, Mescal, and Retriever series. The Mescal and Retriever soils formed in material weathered from limestone, and the House Mountain soils formed in material weathered from basalt.

Common characteristics of these soils are stoniness, undulating to steep slopes, a thin A1 horizon with weak, platy or granular structure, and weak or very weak structure below the A1 horizon. These soils are very

shallow to moderately deep. The Mescal and Retriever soils are calcareous, and the House Mountain soils are calcareous in places. The Retriever soils that have a Cca horizon intergrade to Calcisols.

House Mountain Series

The House Mountain series consists of very shallow and shallow, well-drained, dark-colored, stony Lithosols, derived in place from basalt. These soils occur on uplands, at elevations of about 3,700 feet, where the average annual precipitation is about 12 inches and the average annual temperature is about 61° F. The vegetation consists chiefly of mesquite, turbinella oak, grama grasses, algerita, and juniper, but about half of the surface is covered with stones and cobblestones and has no vegetation. There are some outcrops of basalt.

Typically, these soils have an A1-C-R horizon sequence. Their dark colors are inherited from the parent basalt.

Representative profile of House Mountain stony loam in an area used for range; NW $\frac{1}{4}$ sec. 10, T. 15 N., R. 5 E.:

- A1—0 to 2 inches, brown (7.5YR 5/4) stony loam, dark brown (7.5YR 3/4) when moist; weak, thin, platy structure breaking readily to weak, fine, granular; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine and fine roots; few fine pores; noncalcareous; pH 7.7; clear, smooth boundary.
- C1—2 to 8 inches, brown (7.5YR 4/4) stony loam, dark brown (7.5YR 3/4) when moist; weak, fine, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine and fine roots; few fine pores; noncalcareous; pH 7.7; clear, smooth boundary.
- C2—8 to 10 inches, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 3/4) when moist; massive; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine and fine roots; few fine pores; noncalcareous; pH 7.7; clear, wavy boundary.
- C3—10 to 12 inches, brown (7.5YR 5/4) stony clay loam, dark brown (7.5YR 3/4) when moist; massive; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; much hard basalt rock occurs in the soil material; few very fine roots; few fine pores; noncalcareous; pH 7.7; abrupt, wavy boundary.
- R—12 inches +, dark-gray (10YR 4/1) hard basalt rock, very dark gray (10YR 3/1) when moist; rock is coated with manganese and material resembling silica; noncalcareous; pH 7.7.

The content of stones and cobblestones ranges from 30 to 50 percent or more, by volume. The depth to bedrock ranges from 5 to nearly 20 inches but in most places is about 12 inches.

Mescal Series

The Mescal series consists of moderately deep, well-drained, strongly calcareous Lithosols that formed in material weathered from limestone and calcareous sandstone of the Verde formation. These soils occur on side slopes and undulating ridgetops, at an elevation of about 4,000 feet, where the average annual precipitation is about 13 inches and the average annual temperature is about 60° F. The vegetation consists of a sparse cover of algerita, canotia, squawberry, juniper, and grass.

Typically, the horizon sequence is A1-C. The texture of the A1 horizon is commonly fine sandy loam.

Representative profile of Mescal fine sandy loam; SW $\frac{1}{4}$ sec. 4, T. 14 N., R. 6 E.:

A1—0 to 2 inches, light reddish-brown (5YR 6/4) fine sandy loam, reddish brown (5YR 4/4) when moist; weak, thin, platy structure; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; plentiful fine and medium roots; common fine interstitial pores; calcareous; pH 8.0; clear, smooth boundary.

C1—2 to 6 inches, light reddish-brown (5YR 6/4) sandy loam, reddish brown (5YR 5/4) when moist; massive; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful fine and medium roots; common fine interstitial pores; calcareous; pH 8.0; clear, wavy boundary.

C2—6 to 24 inches, light reddish-brown (5YR 6/4) sandy loam or loam, reddish brown (5YR 5/4) when moist; massive; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine and medium roots; few fine interstitial pores; calcareous; a few lime concretions; pH 8.0.

R—24 inches +, grayish-orange-pink limestone.

In places the color is a hue of 7.5YR. In some places the horizon sequence is A-AC-C. The texture of the C horizon is fine sandy loam or light loam in places.

Retriever Series

The Retriever series consists of well-drained, stony and very stony Lithosols that formed in material derived chiefly from limestone of the Verde formation. These soils occur on the flat tops and the side slopes of mesas and on low ridges, at elevations of about 3,300 to 4,000 feet, where the average annual precipitation is 11 to 13 inches and the average annual temperature is about 60° F. The vegetation consists of scattered juniper, cantia, yucca, and grass, but as much as 40 percent of the surface is barren. Outcrops of bedrock are numerous.

These soils generally have an A1-C-R horizon sequence, but some profiles have an A1-C-Cca-R sequence. Those soils that have a Cca horizon are probably intergrading toward Calcisols.

Representative profile of Retriever very stony loam; SW $\frac{1}{4}$ sec. 4, T. 14 N., R. 6 E.:

A1—0 to 3 inches, pale-brown (10YR 6/3) very stony loam, dark brown (10YR 4/3) when moist; weak, very thin, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine roots; plentiful interstitial pores; strongly calcareous; pH 8.3; clear, smooth boundary.

C—3 to 9 inches, light yellowish-brown (10YR 6/4) loam, brown (10YR 5/3) when moist; very weak, fine, subangular blocky structure; soft when dry, friable when moist, slightly plastic when wet; plentiful medium and coarse roots; very few fine pores; violently calcareous; pH 8.4; clear, smooth boundary.

R—9 inches +, white (10YR 8/2) very hard limestone, light gray (10YR 7/2) when moist; pH 8.4.

In places the texture is loam or sandy loam. In places the color of the A1 horizon is a hue of 7.5YR. Stones cover 20 to 60 percent of the surface and make up 20 to 60 percent of the profile. In most places the depth to bedrock is not more than 14 inches, but it is as much as 2 feet in areas where the soil developed in pockets of limestone.

Chemical and Physical Properties of the Soils

Samples from representative profiles of four soils were submitted for laboratory analysis. The data obtained are given in table 8. The soils selected developed in material derived from basalt and volcanic cinders. The Brolliar soils developed mainly in material derived from basalt, but partly in material influenced by cinders. The Siesta soil developed in material strongly influenced by cinders.

Cation-exchange capacity was determined by the ammonium acetate procedure. Exchangeable cations were determined as follows: magnesium by standard volumetric procedure, and potassium by flame spectrophotometer.

The pH values for the several profiles range from medium acid (pH 5.7) to mildly alkaline (pH 7.5). With the exception of Brolliar very stony loam, the reaction is less acid in the B2t horizon. In all of the soils the reaction of the surface layers rises, upon dilution, from medium acid (pH 5.6 to 6.0) to slightly acid (pH 6.1 to 6.5) or neutral (pH 6.6 to 7.3). The rise in pH value is attributed to increased hydrolysis of basic materials.

The electrical conductivity of the samples is low, which appears to be normal for these soils. The calcium carbonate equivalent values range from 0.50 to 2.88 percent. In the field, however, these soils do not effervesce (fizz) upon the application of acid.

The content of organic carbon ranges from 2.41 to 0.22 percent. In all the soils it is higher in the surface horizon than in the other horizons. The content of nitrogen ranges from 0.17 to 0.02 percent. Ordinarily, the content of carbon and nitrogen decreases with depth.

The carbon-nitrogen ratio of the surface layer is generally more than 14:1. All of the soils have a carbon-nitrogen ratio greater than 10:1 throughout the profile. The Siesta soil shows a narrow carbon-nitrogen ratio below a depth of 48 inches. A carbon-nitrogen ratio greater than 20:1 is common in many forest soils, but none of the Beaver Creek Area soils tested have a ratio greater than 18:1. This fact may be the result of climatic factors that stimulate microbial decomposition of plant residue. In most fresh residue, the carbon-nitrogen ratio is wide. As decomposition progresses and carbon dioxide is liberated, the ratio narrows.

The mechanical analysis data reflect the textural range of these soils. The content of sand ranges from 8 to 20 percent, and generally the proportion of sand decreases with depth. Fine sand and very fine sand make up most of the sand fraction of all horizons of the soils. The content of silt ranges from 10 to 56 percent; the largest amount of silt is in the uppermost 12 inches. The content of clay ranges from 26 to 75 percent, and each soil analyzed had a distinctly larger content of clay in its B2t horizon than in other horizons.

The cation-exchange capacity ranges from 21.2 to 75.2 milliequivalents per hundred grams of soil. In most places it is only slightly less than the percentage of clay. This indicates the presence of a clay mineral with a cation-exchange capacity of nearly 100 milliequivalents per 100 grams. Montmorillonite is probably the most plentiful of the clay minerals. The exchange complex is largely calcium and magnesium. The amount of exchangeable potassium is low in all of the soils.

TABLE 8.—Analytical data on selected soils

[Data based on laboratory analyses conducted by Department of Agricultural Chemistry and Soils, College of Agriculture, University of Arizona]

Soil type	Horizon	Depth from surface	Reaction		Electrical conductivity	CaCO ₃ equivalent	Organic matter		C/N ratio	Particle size distribution			Cation-exchange capacity	Exchangeable potassium
			Saturated paste	1:5 soil-water suspension			Or- ganic carbon	Nitro- gen		Sand (2.0- 0.05 mm.)	Silt (0.05- 0.002 mm.)	Clay (less than 0.002 mm.)		
		Inches	pH	pH	Eczl ⁰	Percent	Percent	Percent		Percent	Percent	Percent	Meg. per 100 gm. of soil	Meg. per 100 gm. of soil
Broliar very stony loam.	A12	1 to 5	6.0	6.6	0.37	1.12	2.20	0.13	17	20	47	33	30.2	0.3
	B1	5 to 9	5.7	6.5	.39	.62	1.58	.10	16	19	41	40	34.8	.3
	B2t	9 to 25	5.9	7.0	.44	1.86	1.52	.09	17	14	15	71	62.7	.4
Broliar silt loam.	A12	2 to 7	5.9	6.5	.45	.50	2.30	.16	14	12	54	34	30.0	.2
	B1	7 to 14	5.9	6.6	.46	.87	1.84	.11	17	13	51	36	31.2	.2
	B21t	14 to 29	6.1	6.9	.43	.62	1.54	.09	16	8	42	50	38.3	.3
	B22t	29 to 50	7.0	7.8	.48	1.49	.61	.05	13	10	22	68	54.7	.4
Siesta silt loam.	A11	0 to 2	6.0	6.5	.39	.62	2.41	.17	14	19	55	26	22.2	.6
	A12	2 to 6	5.9	6.4	.38	.62	1.90	.11	17	18	56	26	21.2	.3
	B1	6 to 12	5.9	6.5	.38	1.12	1.35	.09	15	17	53	30	21.8	.2
	B21t	12 to 30	6.5	7.2	.39	1.12	.99	.06	17	9	22	69	48.8	.4
	B22t	30 to 48	7.3	8.0	.80	1.61	.50	.03	15	12	22	66	45.7	.5
	B23t	48 to 72	7.5	8.1	1.00	2.11	.27	.02	11	12	26	62	40.7	.6
	B3t	72 to 80	7.3	8.0	.97	1.86	.22	.02	(¹)	11	14	75	49.1	.4
Broliar stony clay loam.	A12	1 to 6	6.0	6.7	.33	1.37	2.06	.14	15	19	34	47	33.8	.4
	B1	6 to 17	6.1	6.8	.29	.99	1.46	.10	15	14	38	48	33.4	.3
	B2t	17 to 30	6.5	7.3	.45	1.37	.95	.06	15	10	15	75	53.2	.5
	B3-C	30 to 38	6.8	7.6	.45	2.88	.57	.04	13	21	10	69	75.2	.6

¹ Values were based on numerical results too low for meaningful interpretation.

Part III: Soil Use and Management

This part of the soil survey emphasizes the information that is needed in planning the use and management of wild lands.

The Beaver Creek Area is used for experiments to determine the effect on water yield of various treatments of land and vegetation, and for a pilot project in intensive multiple-use management and management for maximum yield of water. Planning for such uses involves consideration of many factors, among which are demand for the products of the Area, competitive demands for the same piece of land, present and anticipated improvements in technology, and, perhaps most important, the potential capability of the soils.

Soil Management Areas

Soils occur in characteristic positions on the landscape and in characteristic geographic patterns. By grouping soils that normally are associated geographically, we get a generalized map that is useful in planning the management of large areas. The soils of the Beaver Creek Area have been placed in eight groups, which in this report are called soil management areas.

Each soil management area has a distinctive pattern of soils, and the soils of one or two series are dominant. Soils within a given area may differ markedly from each

other. The pattern of soils is not exactly uniform in each part of a management area, but the same soils are present in somewhat the same arrangement.

The eight soil management areas in the Beaver Creek Area are shown on the colored map at the back of this report. Such a map cannot be used effectively in intensive planning or in planning management of small areas, but it is useful in planning for broad uses, such as production of water, growing timber, managing range for grazing, improving the watershed, and developing wildlife habitats and recreation sites. The soil management areas are discussed in the following pages, and in table 9 the major characteristics of each of the areas are summarized. For more detailed information about the soils, see the detailed soil map and the section "Descriptions of the Soils."

1. Siesta-Sponseller area

Deep and moderately deep, moderately fine textured and fine textured soils over basalt and cinders

This soil management area is on undulating and rolling uplands, where the elevation is 6,800 to 8,000 feet. Most of the area has slopes of 3 to 15 percent, but the sides of cinder cones have slopes of as much as 40 percent. The soils of this area are deep or moderately deep. They formed in material weathered from basalt and volcanic cinders.

TABLE 9.—Summary of major characteristics of soil management areas

Management area	Percent of survey Area	Component soils		Parent material	Soil pattern	Vegetation zone	Relief
		Name of series and land types	Percent of management area				
1. Siesta-Sponseller.....	7.6	Siesta..... Sponseller.....	62 38	Residuum from basalt and cinders.	Complex...	Ponderosa pine.	Gently sloping to steep.
2. Broliar.....	21.8	Broliar..... Cabezon and Hogg..... Stony rough land, basalt and cinders.	86 2 12	Residuum from basalt, cinders, and limestone.	Complex...	Ponderosa pine.	Gently sloping to steep.
3. Friana.....	1.6	Broliar clay loam and Alluvial land; Broliar cobbly loam and Alluvial land. Friana..... Lynx..... Waldroup.....	16 73 6 5	Alluvium from basalt and cinders.	Simple, uniform.	Ponderosa pine and pinyon-juniper.	Nearly level and gently sloping.
4. Springerville-Gem.....	29.8	Gem..... Gem-Springerville complex; Rock land-Springerville complex. Springerville..... Waldroup.....	5 7 86 2	Residuum from basalt and cinders.	Moderately complex.	Pinyon-juniper.	Gently sloping to steep.
5. Stony steep land-Rock land.	14.4	Basalt rock land..... Sandstone rock land..... Sandstone outcrop..... Stony hilly land, ash and tuff..... Stony rough land, sandstone; Stony steep land, basalt.	7 11 9 6 67	Residuum from basalt, sandstone, and volcanic ash.	Complex...	Pinyon-juniper.	Steep escarpments and cliffs.
6. Retriever-Courthouse.....	15.4	Bridge..... Courthouse..... Jacks..... Mescal..... Retriever..... Rough broken and stony land, limestone. Stagecoach.....	2 11 3 2 66 12 4	Alluvium and residuum from limestone, sandstone, and basalt.	Complex...	Grassland-desert shrub.	Gently sloping to steep.
7. House Mountain-Penthouse.	2.3	House Mountain..... Penthouse..... Schnebly..... Springerville.....	63 22 7 8	Alluvium and residuum from basalt, sandstone, and limestone.	Simple, uniform.	Grassland-desert shrub.	Gently sloping to moderately sloping.
8. Karro-Laveen-Guest.....	7.1	Anthony..... Cornville..... Gila..... Glendale..... Guest..... Hantz..... Karro and Laveen..... Riverwash..... Tobler..... Toquop.....	3 14 2 10 15 2 26 15 9 4	Alluvium from limestone, sandstone, basalt, and cinders.	Complex...	Grassland-desert shrub.	Nearly level and gently sloping.

The Siesta soils have a surface layer of silt loam or stony silt loam and a subsoil of clay. The Sponseller soils have a surface layer of stony silt loam and a subsoil of clay loam. The depth to bedrock ranges from 28 to 60 inches.

This soil management area occupies 23,110 acres, or about 7.6 percent of the survey Area. The Siesta soils constitute 62 percent of the management area, and the Sponseller soils 38 percent. These soils occur together in a complex pattern. The general productivity level is high. The vegetation consists mainly of ponderosa pine and mixed grasses. Gambel oak is scattered throughout the area, and thickets of aspen occupy high, moist sites. This area is important as a source of water for springs and streams.

The soils in this area are well suited to ponderosa pine. Natural regeneration is good. The site index for ponderosa pine is 70 to 85+, the best in the survey Area. The Sponseller soils have the higher values.

The potential for production of range herbage is moderately high, and open areas support good stands of grass. Production of range herbage is higher in this area than in soil management area 2.

The engineering properties are variable. The soils generally have a high content of clay and yield low compacted weights. Roads designed for all-weather use must be surfaced. Stock tank construction presents few, if any, problems on the deeper soils. Fills are stable and impervious if compaction is adequate. Most of the cinders suitable for road surfacing come from this area.

The soils in this area should be managed to maintain a balance among the various uses for which they are suitable. Management plans must take into account the high potential production of timber and herbage.

2. Broliar area

Deep and moderately deep, fine-textured upland soils over basalt

This soil management area is on undulating uplands broken by ridges, canyons, and small drainageways. The elevation is 6,500 to 7,600 feet. Most of the area is moderately sloping, but slopes range from nearly level to steep. The soils of this area are deep or moderately deep. They formed mainly in material weathered from basalt. One small area is underlain by Kaibab limestone.

The soils of this area occur in the pine forest at lower elevations than the soils of the Siesta-Sponseller area. They are clayey throughout and have a firm, tight subsoil. Most of the soils are stony, and there are outcrops of basalt in places.

This soil management area occupies 65,983 acres, or nearly 22 percent of the survey Area. It includes most of the acreage that is used for production of ponderosa pine. The Broliar soils make up 86 percent of the management area, the Cabezon and Hogg soils make up 2 percent, and a land type—Stony rough land, basalt and cinders—makes up the rest. The soils are fertile, and the general productivity level is moderate to high. The vegetation consists mainly of ponderosa pine and mixed grasses. Gambel oak and alligator juniper are scattered

throughout the area. The yield of water is only moderate.

These soils have a medium potential for production of timber and range herbage. Trees grow faster and are of better quality at the higher elevations, and natural regeneration is good. Grasses grow well throughout the area and provide summer grazing for livestock. Deer, elk, and turkey find habitats.

The degree of erosion in area 2 is variable. Depletion of forage species has resulted in loss of some surface soil. A few shallow gullies have formed in old roads. The hazard of sheet erosion could be reduced by increasing the plant cover.

The engineering properties are variable. The soils generally have a high content of clay and yield low compacted weights. They are hard to handle and to work. Unsurfaced roads are soft and sticky and nearly impassable during wet weather. Ruts formed by the wheels of vehicles when the soils are soft do not disappear when the soils dry. There are many suitable sites for stock tanks or ponds, but none in the very stony and rocky areas.

3. Friana area

Deep, moderately fine textured and fine textured soils in open parks and meadows

This soil management area is in open parks and narrow valleys and along the bottoms of drainageways. The elevation is 6,000 to 7,500 feet. The soils are deep, nearly level or gently sloping silt loams, clay loams, or clays, mostly nonstony. They formed in alluvial material derived from basalt and cinders. Part of the area is in the pine forest, and part is in the pinyon-juniper woodland.

This soil management area occupies less than 2 percent of the survey Area. The Friana soils make up about 73 percent of the management area. Broliar clay loam, Broliar cobbly loam, and Alluvial land occupy about 16 percent. Small areas of Lynx and Waldroup soils make up the rest.

These soils have a high potential for production of range herbage. Grasses grow well throughout the area, and western wheatgrass has been introduced in areas of Friana soils. Except in areas of Lynx silt loam, heavy subsoil variant, the potential for production of timber is low. Fertility and moisture-holding capacity are high.

The degree of erosion in area 3 is variable. Depletion of forage species has resulted in loss of some surface soil. There are some gullies, but they are neither extensive nor serious. The hazard of surface and gully erosion can be reduced by increasing and improving the plant cover.

This soil management area has good sites for stock tanks and ponds. The subsurface material is relatively impervious. With care, stable and tight embankments can be built. These soils are not suitable for roads and trails. They are hard to work and yield low compacted weights. Road cuts expose their clayey subsoil and leave a surface that is unstable in wet weather.

These soils produce much high-quality forage when grazed at proper stocking rates. Revegetating selected areas with adapted forage species is beneficial. Although erosion is not now a major problem, misuse could result in erosion.

4. Springerville-Gem area

Deep and moderately deep, fine-textured upland soils over basalt and cinders

This soil management area is on gently sloping to steep uplands, where the elevation is 4,500 to 7,000 feet. Part of it is on steep side slopes of buttes or canyons. The topography is undulating and rolling. The soils are deep or moderately deep. They formed in material derived from basalt and cinders.

The soils of this management area occur in a moderately complex pattern in the pinyon-juniper woodland. They are clayey and very stony. Many stones and cobblestones are on the surface, and some of the soils are stony throughout the profile.

Area 4 is the largest of the soil management areas. It occupies nearly 30 percent of the survey Area. The Springerville soils make up 86 percent of the management area; Gem soils, complexes of Gem and Springerville soils, and Rock land make up 12 percent. Soils of the Waldroup series make up the rest. Fertility and moisture-holding capacity are medium in most of the soils. The principal grasses are blue grama, black grama, western wheatgrass, and foxtail. The vegetation at the higher elevations consists mainly of thick and vigorous stands of Utah juniper, alligator juniper, pinyon pine, and Gambel oak.

These soils have a moderate to high potential for production of range herbage. Their potential for production of timber is low. Some ponderosa pine grows at the higher elevations, but the trees are stunted and of poor quality. Grasses and herbage plants grow better on the Gem soils than on the Springerville soils.

The degree of erosion is slight but variable. There are no deep or extensive gullies. The only evidence of erosion is slight loss of surface soil in places.

The soils in management area 4 have poor engineering qualities. They are dominantly heavy fat clays that yield low compacted weights. They lack stability and are exceedingly difficult to work or to handle when moist. Unsurfaced roads are soft and sticky and nearly impassable in wet weather. Suitable sites for stock tanks or ponds can be found on most of the soils, except in very stony or rocky areas. Construction of fills with bulldozers must be done with care, and such construction should be avoided if possible.

This management area is used chiefly for summer grazing of livestock. It is also important as a big game habitat. Experimental work in plant husbandry and in intensive watershed management is now being carried on in this area, mainly on the Springerville soils. The knowledge gained will have application to Springerville or similar soils in other locations.

5. Stony steep land-Rock land area

Stony hilly land, stony rough land, rock outcrops, cliffs, and escarpments

About two-thirds of this soil management area is composed of Stony rough land, sandstone, and Stony steep land, basalt. There are many rock outcrops, cliffs, and escarpments, and much stony hilly land and stony rough land. The terrain is generally steep. This management area makes up about 14 percent of the survey Area.

This area is unsuitable for grazing, although it produces a small amount of vegetation. Its potential for timber production is extremely limited. Many of the land types have value as wildlife habitats and as a source of surface runoff following heavy summer rainfall. There are some scenic formations, such as Bell Rock, Courthouse Butte, and the multicolored sandstone cliffs adjacent to Big Park. The steep side slopes of canyons are natural barriers to the spread of wildfire.

Use of this area is limited to wildlife habitats and production of water by surface runoff, and it should be left as it is in order to preserve the habitats and to assure continuance of water production.

6. Retriever-Courthouse area

Shallow and moderately deep, medium-textured soils over limestone and sandstone

This soil management area consists of rolling uplands, mesa tops, steep side slopes of mesas, and small V-shaped canyons (fig. 18). The elevation ranges from 3,500 to 4,000 feet. The slopes are nearly level to steep. The soils of this area are shallow to moderately deep, stony and gravelly, and calcareous in most places. They formed in material derived from limestone, sandstone, basalt, and old alluvium. They occur in a complex pattern.

The vegetation consists of desert shrubs and grass. The shrubs, which include canotia, mesquite, creosotebush, and gray thorn, predominate. The grasses include blue grama, black grama, sideoats grama, tobosa, three-awn, and curly mesquite. Much of the area is barren.

This soil management area makes up about 15 percent of the survey Area. The shallow, very stony Retriever soils constitute about 66 percent of the management area, and the shallow, stony and gravelly Courthouse soils make up about 11 percent. A steep land type—Rough broken and stony land, limestone—makes up another 12 percent. Small areas of Bridge, Jacks, Mescal, and Stagecoach soils make up the rest. The Retriever and Mescal soils formed in material weathered from limestone, and the Courthouse and Jacks soils formed in material weathered from sandstone. The Bridge and Stagecoach soils formed in old mixed alluvium.



Figure 18.—Typical landscape in Retriever-Courthouse soil management area.

These soils have a moderate potential for production of range herbage. They do not receive enough precipitation for ponderosa pine. Water production is low. Fertility and moisture-holding capacity are moderate in most places.

Instability of the surface layer, combined with sparseness of vegetation, makes these soils susceptible to erosion by both wind and water, and the hazard of erosion is moderate to high. Rills and small gullies are common on steep slopes. Loss of soil through erosion of the surface layer is common throughout this management area.

Some of the survey Area's best soils for engineering uses occur in this management area. Compacted weights are good, and fills and embankments are stable. Foundation materials are generally free from unfavorable characteristics. Unsurfaced roads require only normal maintenance.

Topographic position and weather conditions make this management area suitable for winter grazing and for winter range for antelope. It provides a habitat for quail, doves, and other gamebirds, and for rabbits and other small game. The chief management problems are revegetating bare or lightly vegetated areas, increasing yields of herbage through control of grazing, and improving game habitats.

7. House Mountain-Penthouse area

Shallow to deep, stony soils, chiefly over basalt

This soil management area is on uplands and old alluvial fans and terraces, where the elevation is 3,600 to 4,500 feet. Most of the area is gently sloping, but some of it is moderately sloping. These soils are shallow to deep and are stony, cobbly, and gravelly. They formed chiefly in material weathered from basalt or in alluvium derived from basalt, but partly in material weathered from sandstone and limestone.

This management area makes up about 2 percent of the survey Area. Most of it is in the region below the Mogollon Rim. The shallow House Mountain soils constitute about 63 percent of the management area, and the deep Penthouse soils make up about 20 percent. Soils of the Springerville and Schnebly series make up the rest.

The vegetation consists of semidesert shrubs, such as canotia, mesquite, and catclaw, and of grasses, including blue grama, black grama, sideoats grama, and tobosa. Juniper trees grow at the higher elevations. About half of the area is bare of vegetation.

These soils have a moderate potential for production of herbage. None of them produce ponderosa pine, because they do not receive enough precipitation. Fertility is moderate.

Loss of soil through erosion is moderate to low. Most of the soils are stable, and even though vegetation is sparse, susceptibility to erosion is not high. There are a few small gullies.

The engineering properties of the soils are variable. Many of the soils are shallow and stony. Deep cuts require removal of a large amount of hard rock. The House Mountain soils have low water-storage capacity; surface runoff is rapid on these soils after rainstorms of even moderate intensity. The Penthouse and Springerville soils are clayey and are extremely poor material for use in construction. They have high water-storage capacity.

The soils in this management area should be used primarily for growing forage for livestock and game. The chief management problems are improvement of the quality and quantity of forage through control of grazing and revegetation of bare or lightly vegetated areas.

8. Karro-Laveen-Guest area

Deep, medium-textured and fine-textured soils on bottom lands and alluvial fans

This soil management area is on alluvial fans and bottom lands. The soils are deep and nearly level or gently sloping. They formed in material derived from limestone, sandstone, shale, basalt, and other rocks. Most of the soils are calcareous to the surface.

This soil management area makes up about 7 percent of the survey Area. Nearly half of the land is privately owned. About 26 percent of the management area is made up of Karro and Laveen fine sandy loams. About 15 percent consists of Guest clays, clay loams, or silty clay loams; about 33 percent of Cornville and Tobler fine sandy loams and Glendale silt loams; about 15 percent of Riverwash; and the rest of small areas of Anthony and Gila fine sandy loams, Toquop loamy fine sands, and Hantz silty clays. The vegetation consists of grasses and desert shrubs, including creosotebush, mesquite, canotia, catclaw, blue grama, black grama, sideoats grama, galleta, tobosa, and sand dropseed. Cottonwood, sycamore, and willow trees grow on bottom lands.

Generally, these soils have a moderate to high potential for production of herbage; they provide most of the winter grazing in this survey Area. Because of their topographic position, they receive moisture in the form of runoff from the surrounding slopes. They do not produce ponderosa pine, because they do not receive enough rain. Fertility is medium, and the moisture-holding capacity is good.

Most of this management area shows the effect of slight sheet erosion. Gullying is severe in some areas, especially on the Karro, Laveen, Tobler, and Guest soils, where gullies are as much as 8 feet deep. In the management area as a whole, water is the chief erosion hazard, but wind erosion is active in barren areas.

Most of the soils in this management area have good engineering properties. Characteristically, they are easy to work and to handle, and they have good compacted weights. Properly constructed embankments have low permeability, high resistance to shear failure, and good bearing capacity.

Climate, slope, topography, and general soil characteristics make this management area valuable as range and as a habitat for wildlife. Careful management increases the yield of herbage and helps to control erosion.

Timber Management

About one-third of the Beaver Creek Area, or nearly 100,000 acres, is commercial forest land. The commercial forests are at the higher elevations, where the environment is favorable for trees. Only those soils used for commercial forest are discussed in this section.

Most of the forested areas have been partly cut over for sawtimber. Saplings and pole-size trees make up most of the residual stands at the lower elevations of the pine forest, but some sawtimber is left at the higher elevations.

The commercial forest could also be used as a source of pulpwood if the need should arise.

Ponderosa pine is the principal timber species and is the most important commercially. Douglas-fir and limber pine are interspersed in the ponderosa pine forest at the higher elevations, chiefly on north-facing slopes.

The Sponseller, Broliar, and Siesta soils are the major timber-producing soils in the Area. Tilt, texture, soil depth, and compactness of the subsoil seem to influence the growth of ponderosa pine in this Area. The better timber-producing soils of the Sponseller, Siesta, and Broliar series are friable and do not have a dense, tight subsoil. Some of the Broliar soils, although of nearly the same texture and depth, have a dense, tight subsoil and are less productive.

Table 10 gives the site index range for each group and the relative severity of some of the factors affecting production of ponderosa pine. The ratings are based on site index values determined from curves developed by Meyer (6). Generally, those soils that have the higher site indexes show greater yields of timber per acre.

Forest management includes protection against fire, insects, and disease; thinning and pruning to improve the quality of the stands; reforestation; cutting to improve the stocking level and age class distribution of the stands; and good management of the watershed.

The timberlands in the Area are under sustained-yield management. Mature and excess trees are cut, and proper stocking levels are maintained to stimulate growth and to sustain yields. Fire protection is provided through a system of lookouts and fire patrolmen and through practices that reduce the fire hazard. Proper silvicultural practices and direct-control methods provide protection against insects and disease. Pruning, noncommercial thinning, and commercial cutting improve the quality of the timber and increase the growth potential. Reforestation is achieved through natural regeneration and by planting and seeding. Cross-ditching, seeding grass, scattering slash, and constructing water bars are practices used to control erosion of skid trails, roads, and landings.

Woody species competition.—Sites that have been disturbed by fire, cutting, or other factors are apt to be invaded by brush, undesirable trees, and other plants. Such competition hinders the establishment and growth of desirable species. A rating of *slight* indicates that invasion by undesirable species will have little effect on growth of desirable species. A rating of *moderate* indicates that competition will not seriously affect establishment of adequate stands of commercial-quality timber. Oak brush and alligator juniper are the chief competing species.

Equipment limitations.—Management of forests may be hampered by soil characteristics and topographic features that restrict or prevent the use of equipment. The chief factors affecting use of equipment on most of the soils in the Area are slope, susceptibility to erosion, and stoniness.

An equipment limitation rating of *slight* indicates that there is no special problem in use of equipment. A rating of *moderate* indicates that not all types of equipment can be used. The location and construction of haul roads, skid trails, landings, and the like must take into account the susceptibility of the soil to erosion. For a short period after the frost leaves the soil in spring, and occasionally after summer rainfall, all the forested soils of the Area are too wet and soft to support equipment.

Windthrow hazard.—Soil characteristics affect the development of tree roots and consequently the resistance of trees to the force of the wind. A rating of *slight* indicates that the roots hold the tree firmly against a normal wind, and windthrow is not common. A rating of *moderate* indicates that root development is not adequate for stability and that windthrow may occur when wind velocity is high and the soils are wet.

Erosion hazard.—The erosion hazard is rated according to inherent soil characteristics, such as slope, surface cover of stones and cobbles, and aspect. Ratings of *slight*, *moderate*, and *severe* are used to indicate susceptibility to erosion if the soil is disturbed or if it lacks a protective cover of vegetation. A rating of *slight* indicates that only a small loss of soil occurs where there has been disturbance or depletion of plant cover. A *moderate* rating indicates that disturbance of the surface layer and loss of protective vegetation result in conditions conducive to erosion. Careful planning and construction of roads, skid trails, and landings are necessary to prevent soil loss. A *severe* rating indicates that the soils are susceptible to serious erosion and soil loss. Harvesting must be done carefully, and special logging methods that minimize soil disturbance are advisable. All roads and skid trails must be carefully located and constructed. They must be adequately drained to control excessive runoff. After logging has been completed, the roads must be seeded to reduce runoff and to curb erosion.

Timber suitability groups

All of the timberland soils of the Beaver Creek Area are under Forest Service administration. They have been placed in five timber suitability groups in order of their estimated relative potential productivity. The groups are numbered in decreasing order of productivity. The "Guide to Mapping Units" at the back of the report shows the suitability groups to which the timberland soils have been assigned.

TIMBER SUITABILITY GROUP 1

The soils of this group are in a high site-quality class. They are deep, medium-textured and moderately fine textured, moderately permeable soils of the Lynx, Broliar, and Sponseller series. Their surface layer is loam, silt loam, or clay loam, and their subsoil is clay or clay loam. They are friable, well drained, and fertile. Their moisture-holding capacity is high. The slope is 0 to 40 percent.

Competition from other woody species ordinarily does not prevent establishment of a good stand of pine. Use of equipment is limited only in the steep part of the Sponseller soil. The erosion hazard is severe, particularly in steep areas and in areas of the Lynx soil. Disturbance of the plant cover increases the erosion hazard.

TIMBER SUITABILITY GROUP 2

The soils of this group are in a high site-quality class. They are moderately deep and deep, medium-textured and moderately fine textured, moderately slowly permeable soils of the Broliar, Siesta, and Sponseller series. Their surface layer is loam or clay loam, 5 to 7 inches thick, and its stone content ranges from 15 to 60 percent. The subsoil is clay or clay loam. These soils are friable.

TABLE 10.—*Timber suitability groups*

Group	Site index ¹ for ponderosa pine	Woody species competition	Equipment limitation	Windthrow hazard	Erosion hazard	Acres	Percent of timberland
1	80 to 85.....	Slight.....	Slight to moderate.	Slight.....	Severe.....	12, 239	13. 0
2	70 to 79.....	Slight.....	Slight to moderate.	Slight.....	Slight to severe....	19, 730	20. 8
3	60 to 69.....	Moderate.....	Moderate.....	Slight.....	Slight to severe....	55, 918	58. 7
4	50 to 59.....	Moderate.....	Slight to moderate.	Moderate.....	Slight to moderate.	2, 083	2. 2
5	Less than 50.....	Moderate.....	Slight.....	Slight.....	Slight.....	5, 245	5. 3

¹ The average height of the dominant and codominant trees at 100 years of age.

They are well drained, and their water-holding capacity is high. The slope is 0 to 35 percent, but most of the acreage is gently sloping or gently undulating.

Competition from other woody species ordinarily does not prevent establishment of a good stand of pine. The equipment limitation is slight to moderate. The use of rubber-tired equipment is limited in very stony areas. The erosion hazard ranges from slight in level or gently sloping areas to severe in steep areas.

TIMBER SUITABILITY GROUP 3

Most of the timberland in this Area consists of soils of this group. These soils are in a medium site-quality class. They are moderately deep, moderately fine textured, moderately slowly permeable or slowly permeable soils of the Broliar, Hogg, and Siesta series, and areas of Alluvial land and Stony rough land, basalt and cinders. Their surface layer is generally loam or clay loam, 3 to 6 inches thick, and their subsoil is firm, plastic clay. They are well drained, but their subsoil generally restricts movement of water. Their moisture-holding capacity is medium or low. These soils occur in rolling areas or on ridges. There are many stones and cobblestones of basalt on the surface. The slope is 0 to 60 percent.

Competition from other woody species is moderate. The equipment limitation is moderate in areas where the slope is more than 20 percent. The use of tracked equipment is difficult in areas of Stony rough land. The erosion hazard is slight to moderate.

TIMBER SUITABILITY GROUP 4

The soils of this group are in a medium site-quality class. They are stony or gravelly, permeable or slowly permeable soils of the Broliar and Cabezon series and areas of Alluvial land. Except for Alluvial land, they are shallow. Their surface layer is loam or clay loam, and their subsoil is clay or clay loam. In most places their moisture-holding capacity is low. There are some outcrops of basalt. The slope is 0 to 20 percent.

Competition from other woody species is moderate. The equipment limitation is slight in level and gently sloping areas but is moderate in steep areas. In very rocky areas the use of tracked equipment is difficult. There is a moderate hazard of windthrow. The erosion hazard is slight to moderate.

TIMBER SUITABILITY GROUP 5

The soils of this group are in a low site-quality class. They are shallow to deep, moderately fine textured and fine textured, moderately slowly permeable or slowly permeable soils of the Cabezon, Gem, and Springerville series. Their surface layer is clay loam or clay, and their subsoil is firm plastic clay. The available moisture capacity is low to moderate.

Ponderosa pine does not normally grow on the Cabezon soil, because this soil is flooded at certain times of the year. Pine grows on the Gem soil, but the trees are stunted and of very poor quality. Those on the Gem-Springerville complex are of even poorer quality. Competition from noncommercial species is strong on the Gem soil.

Range Management

Livestock grazing is an important use of the Beaver Creek Area. Between 2,000 and 3,000 head of cattle are grazed annually. In addition, several thousand sheep cross the Area each year via the Beaverhead-Grief Hill Driveway.

Many kinds of plants grow in the Area. Three major types of vegetation are represented: ponderosa pine, piñon-juniper, and grassland-desert shrub. Each type occupies about the same acreage, but the areas occupied by the three types differ significantly in elevation, climate, topography, and soils.

The soils best suited to the production of herbage in the Beaver Creek Area are those on bottom lands and the deeper and more fertile of those on uplands. These soils are relatively high in natural fertility and have good water-supplying capacity. Shallow, poorly developed, rocky, and sloping soils are likely to be droughty and consequently poor for production of herbage.

The soils in the Beaver Creek Area have been placed in five groups based on estimated productivity for range herbage. Table 11 gives brief descriptions of the five groups and shows their relative productivity in terms of pounds of herbage per acre. The estimates are based on limited studies of clippings made from range on soils of the Beaver Creek Area and on studies of similar soils in other areas. The ratings apply only to soils in this survey Area.

The soils in groups 1, 2, and 3, which make up about 70 percent of the survey Area, are medium or high in productivity. Their productivity could be improved by more intensive management. The soils in groups 1 and 2 respond especially well to revegetation, control of noxious plants, and water spreading.

The Springerville soils in group 3 constitute a large part of the herbage-producing soils in the Area. At present they support a thick, vigorous cover of juniper, which competes with more desirable forage species for

plant nutrients and moisture. Establishment of grass on these heavy clay soils is not an easy task, but methods of converting the juniper woodland to grass and other desirable herbage are now under test in the Beaver Creek Area. When effective methods are developed, the herbage produced by the Springerville soils will provide a significant improvement of range resources.

Group 4 includes most of the rocky, stony, and shallow areas. Revegetation and control of noxious plants would be costly and difficult and would produce but small return.

TABLE 11.—Range herbage groups

Group and soils	Extent		Estimated productivity of native herbage		Vegetation	
	Acres	Percent of survey Area	Good condition	Fair to poor condition	Type	Typical plants
Group 1: Deep, nearly level or gently sloping soils in basins in mountain parks. The surface layer is loam or clay loam, and the subsoil is clay loam or clay. Infiltration is good, and the soils are permeable. Capacity to supply moisture to plants is high. (Fk, Fn).	3, 442	1. 0	Lb. per acre air dry 1,500 or more.	Lb. per acre air dry 700-----	Open parks and meadows within areas of ponderosa pine.	Arizona fescue, black sporobolus, carex, crested wheatgrass, Kentucky bluegrass, mountain muhly, spike muhly, western wheatgrass.
Group 2: Deep and moderately deep, gently sloping or moderately sloping soils. The surface layer ranges from sandy loam to clay loam in texture. The subsoil ranges from sandy loam to clay. Infiltration is good, and the soils are permeable. Capacity to supply moisture to plants is good. (An, Bn, Bu, Cg, Gm, Gn, Gs, Gu, Ka, Ln, Ly, Sf, ShC, ShD, Sm, Tb, Tg, Wa).	47, 949	16. 0	1,100 to 1,400.	500 to 600----	Ponderosa pine-----	Arizona fescue, black sporobolus, blue grama, Kentucky bluegrass, mountain muhly, muttongrass, pine dropseed, spike muhly, squirreltail, and western wheatgrass.
					Pinyon-juniper-----	Crested wheatgrass, blue grama, black grama, sideoats grama, squirreltail, western wheatgrass, and snakeweed.
					Grassland-desert shrub.	Blue grama, black grama, bush muhly, chamiso, curly mesquite, fluffgrass, little bluestem, snakeweed, tobosa, sand dropseed, poverty three-awn, ring muhly, algerita, mesquite, and winterfat.
Group 3: Shallow to deep, generally stony and gravelly, gently sloping or moderately sloping soils. The surface layer and the subsoil range from sandy loam to clay in texture. Most of the soils take in water well. Permeability is moderate to very slow. Many of the soils have a restricting layer near the surface. Capacity to supply moisture to plants is less than that of the soils in groups 1 and 2. (Bg, Bl, Bm, BoB, BoC, BoD, Bp, BrB, BrC, BrD, Ca, Cd, Cs, Gt, Ha, Hg, Ja, La, Ms, Pc, Ph, RrC, Rx, Se, Sg, Sk, Sl, SnB, SnC, Wc, Wg).	161, 801	53. 5	750 to 1,000--	500-----	Ponderosa pine-----	Arizona fescue, black sporobolus, blue grama, Kentucky bluegrass, mountain muhly, muttongrass, pine dropseed, spike muhly, squirreltail, and western wheatgrass.
					Pinyon-juniper-----	Crested wheatgrass, blue grama, black grama, sideoats grama, squirreltail, western wheatgrass, and snakeweed.
					Grassland-desert shrub.	Blue grama, black grama, bush muhly, chamiso, curly mesquite, fluffgrass, little bluestem, snake-weed, tobosa, sand dropseed, poverty three-awn, ring muhly, algerita, mesquite, and winterfat.

TABLE 11.—Range herbage groups—Continued

Group and soils	Extent		Estimated productivity of native herbage		Vegetation	
	Acres	Percent of survey Area	Good condition	Fair to poor condition	Type	Typical plants
Group 4: Generally shallow, cobbly and stony soils, mixed with ledge rock and rock outcrops in many places. Slopes are moderate to steep. In many places a restricting layer is near the surface. Capacity to supply moisture to plants is low. (Bv, Ch, Cc, Hm, Re, RrD, SnD, So, Sr, Ss, Su, To).	56,942	18.8	<i>Lb. per acre air dry</i> 400 to 700	<i>Lb. per acre air dry</i> 200	Ponderosa pine----- Pinyon-juniper----- Grassland-desert shrub.	Arizona fescue, black sporobolus, blue grama, Kentucky bluegrass, mountain muhly, muttongrass, pine dropseed, spike muhly, squirreltail, and western wheatgrass. Crested wheatgrass, blue grama, black grama, side-oats grama, squirreltail, western wheatgrass, and snakeweed. Blue grama, black grama, bush muhly, chamiso, curly mesquite, fluffgrass, little bluestem, snake-weed, tobosa, sand dropseed, poverty three-awn, ring muhly, algerita, mesquite, and winterfat.
Group 5: Large areas of bare rock, devoid of soil. Extensive areas of rock outcrop mixed with shallow soils. Very steep slopes, with shallow soil material and many ledges, cliffs, and boulders. (Ba, Jc, Rw, Ry, Sa, Sd, St, Sv, Tx).	36,826	12.0	100 to 250	Less than 100	Pinyon-juniper----- Grassland-desert shrub.	Crested wheatgrass, blue grama, black grama, side-oats grama, squirreltail, western wheatgrass, and snakeweed. Blue grama, black grama, bush muhly, chamiso, curly mesquite, fluffgrass, little bluestem, snake-weed, tobosa, sand dropseed, poverty three-awn, ring muhly, algerita, mesquite, and winterfat.

Group 5 includes land types that are poorly suited to production of herbage. Plants generally grow only in pockets where water accumulates and some soil has formed. Many of the land types are steep, and the ledges and escarpments are barriers to the movement of livestock.

Watershed Management

Water is an important product of the Beaver Creek Area, and Beaver Creek produces an estimated 10 percent of the Verde River streamflow. The average amount of discharge from Beaver Creek is estimated at about 50,000 acre feet annually. This amount of water indicates high runoff from the watershed. Most of the water from the watershed comes as runoff following snowmelt in spring. Except for flash floods, summer precipitation adds little volume to the streamflow of Beaver Creek. There are a number of springs in the deeply cut main channel of Wet Beaver Creek, but only a few springs in the rest of the Area.

The effectiveness of a watershed is influenced by geology, topography, vegetation, climate, and soil characteristics. In table 12 the infiltration rate, permeability rate, and water-storage capacity of the soils of this survey Area

are given. A knowledge of these properties is essential in making a survey of the condition of a watershed and in making a detailed hydrologic analysis.

In the Beaver Creek Area, surface runoff is the chief source of water. The capacity of the soils to supply water to streams and drainageways varies. Those soils occurring in areas having more precipitation normally yield more water than soils in areas having less precipitation. Generally, the soils in the ponderosa pine zone yield water over a period of several months, but the soils in the pinyon-juniper and the grassland-desert shrub zones yield water for a period of only several days. In table 12 ratings of potential sustained water yield have been assigned only to those soils that occur in the ponderosa pine zone.

As used in this report, sustained water yield refers to the capacity of the soil to supply water to streams and drainageways over a period of several months. A rating of high identifies those soils that supply water for the longest period of time, and a rating of low identifies those that supply water for the shortest period of time. Most of the miscellaneous land types are not rated for sustained yield, but they are important as water-producing areas. They have a low water-storage capacity, but they produce large amounts of runoff.

TABLE 12.—Hydrologic factors, erodibility classification, and erosion hazard

Map symbol	Soil	Infiltration ¹	Permeability ¹	Water-storage capacity ²	Potential for sustained yield	Erodibility	Erosion hazard
An	Anthony fine sandy loam (0 to 5 percent slopes).	Rapid-----	Rapid-----	Medium-----	(³)-----	High-----	Moderate.
Ba	Basalt rock land-----	(⁴)-----	(⁴)-----	(⁴)-----	(³)-----	(⁴)-----	(⁴).
Bg	Bridge gravelly sandy loam (0 to 10 percent slopes).	Moderate-----	Moderate-----	Medium-----	(³)-----	Moderate-----	Moderate.
Bl	Bridge stony loam (0 to 5 percent slopes).	Moderate-----	Moderate-----	Medium-----	(³)-----	Moderate-----	Moderate.
Bm	Brolliar gravelly clay loam (10 to 35 percent slopes).	Moderate-----	Moderate-----	High-----	Medium-----	Moderate-----	Moderate.
Bn	Brolliar silt loam, deep (0 to 5 percent slopes).	Moderate-----	Slow-----	High-----	High-----	Moderate-----	Low.
BoB	Brolliar stony clay loam, 0 to 10 percent slopes.	Moderate-----	Slow-----	Medium-----	Medium-----	Moderate-----	Moderate.
BoC	Brolliar stony clay loam, 10 to 20 percent slopes.	Moderate-----	Slow-----	Medium-----	Medium-----	Moderate-----	Moderate.
BoD	Brolliar stony clay loam, 20 to 30 percent slopes.	Moderate-----	Slow-----	Low-----	Low-----	Moderate-----	Moderate.
Bp	Brolliar very rocky complex (5 to 15 percent slopes).	Moderate-----	Slow-----	Low-----	Low-----	Moderate-----	Moderate.
BrB	Brolliar very stony loam, 0 to 10 percent slopes.	Moderate-----	Slow-----	Medium-----	Medium-----	Moderate-----	Low.
BrC	Brolliar very stony loam, 10 to 20 percent slopes.	Moderate-----	Slow-----	Medium-----	Medium-----	Moderate-----	Moderate.
BrD	Brolliar very stony loam, 20 to 30 percent slopes.	Moderate-----	Slow-----	Medium-----	Medium-----	Moderate-----	High.
Bu	Brolliar clay loam and Alluvial land (0 to 3 percent slopes).	Rapid-----	Slow-----	Medium-----	High-----	High-----	Low.
Bv	Brolliar cobby loam and Alluvial land (0 to 3 percent slopes).	Rapid-----	Moderately slow.	Medium-----	Medium-----	Moderate-----	Moderate.
Ca	Cabezon very stony loam (0 to 20 percent slopes).	Moderate-----	Slow-----	Low-----	Low-----	Low-----	Low.
Cc	Cabezon stony clay loam, dark variant (0 to 5 percent slopes).	Moderate-----	Slow-----	Low-----	Low-----	Low-----	Low.
Cd	Cornville fine sandy loam (0 to 10 percent slopes).	Rapid-----	Moderate-----	Medium-----	(³)-----	High-----	Moderate.
Cg	Cornville gravelly sandy loam, thin solum variant (0 to 20 percent slopes).	Moderate-----	Moderate-----	Medium-----	(³)-----	High-----	Moderate.
Ch	Courthouse gravelly fine sandy loam (10 to 40 percent slopes).	Moderate-----	Moderate-----	Low-----	(³)-----	Moderate-----	High.
Cs	Courthouse stony fine sandy loam (5 to 20 percent slopes).	Moderate-----	Moderate-----	Low-----	(³)-----	Moderate-----	High.
Fk	Friana clay, black variant (0 to 2 percent slopes).	Moderate-----	Slow-----	Medium-----	Medium-----	High-----	Low.
Fn	Friana soils (0 to 2 percent slopes)-----	Moderate-----	Very slow-----	Medium-----	Medium-----	Moderate-----	Low.
Gm	Gem clay loam (0 to 10 percent slopes)-----	Moderate-----	Slow-----	Medium-----	Medium-----	Low-----	Low.
Gn	Gem-Springerville complex (0 to 5 percent slopes).	Moderate-----	Very slow-----	Medium-----	(³)-----	Low-----	Low.
Gs	Gila very fine sandy loam, reddish variant (0 to 5 percent slopes).	Moderate-----	Moderate-----	High-----	(³)-----	High-----	Moderate.
Gt	Glendale silt loam (0 to 5 percent slopes)-----	Moderate-----	Moderate-----	High-----	(³)-----	High-----	High.
Gu	Guest clay (0 to 3 percent slopes)-----	Moderate-----	Slow-----	High-----	(³)-----	Moderate-----	High.
Ha	Hantz silty clay (0 to 5 percent slopes)-----	Moderate-----	Slow-----	High-----	(³)-----	High-----	High.
Hg	Hogg stony silt loam (0 to 10 percent slopes).	Moderate-----	Slow-----	Medium-----	Medium-----	Moderate-----	Low.
Hm	House Mountain stony loam (0 to 10 percent slopes).	Moderate-----	Moderate-----	Low-----	(³)-----	Low-----	Moderate.
Ja	Jacks fine sandy loam (0 to 15 percent slopes).	Rapid-----	Moderately slow.	Medium-----	(³)-----	High-----	High.
Jc	Jacks very rocky fine sandy loam (15 to 30 percent slopes).	Rapid-----	Slow-----	Low-----	(³)-----	Moderate-----	High.
Ka	Karro and Laveen fine sandy loams (0 to 10 percent slopes).	Rapid-----	Moderate-----	High-----	(³)-----	High-----	High.
La	Laveen gravelly sandy loam (5 to 20 percent slopes).	Moderately rapid.	Moderately rapid.	Medium-----	(³)-----	Moderate-----	Moderate.
Ln	Lynx silt loam (0 to 3 percent slopes)-----	Moderate-----	Moderately slow.	Medium-----	(³)-----	High-----	Moderate.
Ly	Lynx silt loam, heavy subsoil variant (0 to 5 percent slopes).	Moderate-----	Moderately slow.	High-----	High-----	High-----	High.
Ms	Mescal fine sandy loam (0 to 10 percent slopes).	Moderate-----	Moderate-----	Medium-----	(³)-----	High-----	High.
Pc	Penthouse cobby clay loam (0 to 5 percent slopes).	Moderate-----	Very slow-----	Medium-----	(³)-----	Moderate-----	Moderate.

See footnotes at end of table

TABLE 12.—Hydrologic factors, erodibility classification, and erosion hazard—Continued

Map symbol	Soil	Infiltration ¹	Permeability ¹	Water-storage capacity ²	Potential for sustained yield	Erodibility	Erosion hazard
Ph	Penthouse stony loam (0 to 5 percent slopes).	Moderate...	Slow.....	Medium....	(3).....	Moderate...	Moderate.
Re	Retriever loam (0 to 5 percent slopes)...	Moderate...	Moderate...	Low.....	(3).....	High.....	Moderate.
RrC	Retriever very stony loam, 0 to 20 percent slopes.	Moderate...	Moderate...	Low.....	(3).....	Moderate...	High.
RrD	Retriever very stony loam, 20 to 40 percent slopes.	Moderate...	Moderate...	Low.....	(3).....	Moderate...	High.
Rw	Riverwash.....	(4).....	(4).....	(4).....	(3).....	(4).....	(4).
Rx	Rock land-Springerville complex (5 to 35 percent slopes).	Moderate...	Very slow...	Low.....	(3).....	Low.....	Low.
Ry	Rough broken and stony land, limestone.	Moderate...	Moderate...	Low.....	(3).....	Low.....	High.
Sa	Sandstone outcrop.....	(4).....	(4).....	(4).....	(3).....	(4).....	(4).
Sd	Sandstone rock land.....	(4).....	(4).....	(4).....	(3).....	(4).....	(4).
Se	Schnebly very stony clay loam (10 to 20 percent slopes).	Moderate...	Slow.....	Medium....	(3).....	Moderate...	High.
Sf	Siesta silt loam, deep (0 to 10 percent slopes).	Moderate...	Slow.....	High.....	High.....	High.....	Moderate.
Sg	Siesta stony silt loam (0 to 15 percent slopes).	Moderate...	Slow.....	High.....	High.....	Moderate...	Low.
ShC	Sponseller stony silt loam, 5 to 15 percent slopes.	Moderate...	Moderately slow.	High.....	Medium....	Moderate...	Moderate.
ShD	Sponseller stony silt loam, 15 to 40 percent slopes.	Moderate...	Moderately slow.	High.....	High.....	Moderate...	High.
Sk	Springerville clay (0 to 10 percent slopes).	Moderate...	Very slow...	Medium....	(3).....	High.....	Moderate.
Sl	Springerville clay, red phase (0 to 10 percent slopes).	Moderate...	Slow.....	Medium....	(3).....	High.....	Moderate.
Sm	Springerville cobbly clay (0 to 5 percent slopes).	Moderate...	Very slow...	High.....	(3).....	High.....	Moderate.
SnB	Springerville very stony clay, 0 to 10 percent slopes.	Moderate...	Very slow...	High.....	(3).....	Moderate...	Moderate.
SnC	Springerville very stony clay, 10 to 20 percent slopes.	Moderate...	Very slow...	High.....	(3).....	Moderate...	Moderate.
SnD	Springerville very stony clay, 20 to 30 percent slopes.	Slow.....	Slow.....	Medium....	(3).....	Moderate...	High.
So	Stagecoach cobbly sandy loam (5 to 15 percent slopes).	Moderate...	Moderate...	Low.....	(3).....	Moderate...	Moderate.
Sr	Stony hilly land, ash and tuff (15 to 35 percent slopes).	Moderate...	Moderate...	Low.....	(3).....	Moderate...	Moderate.
Ss	Stony rough land, basalt and cinders (20 to 60 percent slopes).	Moderate...	Slow.....	Medium....	Low.....	Moderate...	High.
St	Stony rough land, sandstone.....	Rapid.....	Moderate...	Low.....	(3).....	Moderate...	Moderate.
Su	Stony steep land, basalt.....	Moderate...	Slow.....	Low.....	(3).....	Low.....	Low.
Sv	Stony very steep land, basalt.....	Moderate...	Slow.....	Low.....	(3).....	Low.....	High.
Tb	Tobler fine sandy loam (0 to 5 percent slopes).	Moderately rapid.	Moderately rapid.	High.....	(3).....	High.....	High.
Tg	Tobler gravelly fine sandy loam, brown variant (5 to 15 percent slopes).	Moderate...	Rapid.....	High.....	(3).....	High.....	High.
To	Toquop loamy fine sand (0 to 5 percent slopes).	Very rapid...	Very rapid...	Low.....	(3).....	High.....	High.
Tx	Toquop-Carrizo complex (0 to 20 percent slopes).	Very rapid...	Very rapid...	Low.....	(3).....	Moderate...	High.
Wa	Waldroup loam, brownish variant (0 to 5 percent slopes).	Moderate...	Moderately slow.	Medium....	(3).....	High.....	High.
Wc	Waldroup clay loam, deep (0 to 5 percent slopes).	Moderately slow.	Moderately slow.	Medium....	(3).....	High.....	Moderate.
Wg	Waldroup gravelly loam, moderately deep (5 to 30 percent slopes).	Moderate...	Slow.....	Medium....	(3).....	Moderate...	High.

¹ Very rapid—more than 10 inches per hour; rapid—5 to 10 inches per hour; moderately rapid—2.5 to 5 inches per hour; moderate—0.8 inch to 2.5 inches per hour; moderately slow—0.2 to 0.8 inch per hour; slow—0.05 to 0.2 inch per hour; very slow—less than 0.05 inch per hour.

² High—more than 18 inches; medium—6 to 18 inches; low—less than 6 inches.

³ Potential for sustained yield not rated.

⁴ Miscellaneous land type having so little soil material that estimates are not significant.

Hydrologic soil groups.—Criteria established by hydrologists of the Soil Conservation Service, the Forest Service, and other agencies permit the grouping of soils in relation to their runoff potential. These groupings are based on intake of water at the end of long-duration storms, after prior wetting and opportunity for swelling, without consideration of slope or the effect of vegetation.

There are four hydrologic groups, designated A, B, C, and D.⁴ The soils in group A have the least potential for runoff, and the soils in group D have the highest.

Group A consists of soils that have a high infiltration rate even when thoroughly wetted and are chiefly deep, well-drained to excessively drained sand or gravel or both. Such soils have a high rate of water transmission and a low runoff potential. The Carrizo and Toquop soils are in this group.

Group B consists of soils that have a moderate infiltration rate when thoroughly wetted and are chiefly moderately deep to deep, moderately well drained to well drained, and moderately fine textured to moderately coarse textured. Such soils have a moderate rate of water transmission. The Anthony, Bridge, Gila, Glendale, Karro, Laveen, Mescal, Stagecoach, and Tobler soils are in this group.

Group C consists of soils that have a slow rate of infiltration when thoroughly wetted, chiefly soils that have a layer that impedes downward movement of water and soils that are moderately fine textured to fine textured. Such soils have a slow rate of water transmission. The Broliar, Cornville, Courthouse, Friana, Guest, Jacks, Lynx, Siesta, Sponseller, and Waldroup soils are in this group.

Group D consists of soils that have a very slow rate of infiltration when thoroughly wetted, chiefly clay soils with a high swelling potential, soils with a permanently high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious materials. Such soils have a very slow rate of water transmission. The Cabezon, Gem, House Mountain, Hantz, Hogg, Penthouse, Retriever, Schnebly, and Springerville soils are in this group.

The miscellaneous land types have not been placed in hydrologic groups. The composition of these units is so complex that reliable groupings cannot be made.

In using the hydrologic grouping to estimate runoff potential, it is necessary to take into account precipitation, slope, effect of vegetative cover, and other factors. When an estimate of runoff is needed for use in planning management of a particular watershed or area, a hydrologist should be consulted.

Erodibility and Erosion Hazard

To manage land effectively, it is necessary to know the susceptibility of the soils to erosion. Table 12 gives the erodibility classification and an estimate of the erosion hazard for each of the soils in the Area. The erodibility classification is an indication of the relative resistance of the soils to surface erosion by water. The erodibility classification does not take into account the factors of

climate, vegetation, slope, and volume and velocity of runoff. It depends upon—

1. The stability and size of the soil aggregates.
2. The ease with which the aggregates can be detached and transported by moving water.
3. The permeability of the soil, or the ease with which the soil becomes saturated.
4. The presence of rock or other restricting material near the surface.
5. The water-storage capacity of the soil.
6. The percentage of the surface that is protected by coarse fragments.

Most of the highly erodible soils are those that formed in alluvial sediments. The aggregates of those soils are not stable because soil-forming processes have not been active long enough for a mature soil to develop and for organic matter to accumulate. The uppermost layer of the Karro, Mescal, and Retriever soils is extremely unstable when wet. The layers of soil flow together when wet, and the individual soil grains are easily detached. The Retriever very stony loams have a cover of coarse fragments, which lowers the erodibility classification. The instability of the Hantz soil is inherited from the shale component of its parent material.

The erosion hazard depends partly on erodibility and partly on climate, slope, and other environmental factors. It is an indication of the relative susceptibility of the soils to accelerated erosion if the vegetation is disturbed or destroyed as a result of fire, clear cutting of timber, overgrazing, trampling by livestock, or other causes. The estimates in table 12 are based on conditions in the Beaver Creek Area and take into account the amount and intensity of rainfall in that region.

The erosion hazard is high for 35 percent of the acreage in the Area, moderate for 42 percent, and low for 23 percent.

Wildlife Management⁵

In this section the use of the soils as a habitat for wildlife is discussed, and some management interpretations are given for the major vegetation zones.

PONDEROSA PINE ZONE.—All parts of the ponderosa pine zone are good range for elk, deer, and turkey. There are enough trees to provide adequate cover for escape and concealment, but the supply of forage needs to be increased. The open parks of the Friana soil management area are a major source of feed for elk, deer, and turkey. Some areas are depleted but can be readily seeded to palatable grasses and forbs, such as burnet, clover, and alfalfa. Orchardgrass, wheatgrass, and smooth brome, which grow early in spring, do well on these soils.

The Siesta-Sponseller soil management area and the Broliar soil management area provide the best spring, summer, and fall range for mule deer. The supply of palatable forage, however, needs to be increased. The Siesta, Sponseller, and Broliar soils support serviceberry, elderberry, bitterbrush, and mountain-mahogany. Orchardgrass, wheatgrass, and smooth brome can be interseeded with these. Seeding of browse plants is desirable

⁴ Engineering Handbook, Hydrology, Supplement A, Sec. 4, Soil Conservation Service, USDA.

⁵ This section was prepared in collaboration with JOHN M. HALL, Chief, Wildlife Management Branch, U.S. Forest Service, Region 3.

in areas where the vegetation is being converted and also along logging roads and landings. Elk and deer feed on sprouts of aspen trees, which grow in small groves on areas of Sponseller soils and on the black variant of Friana soils. Cultivation stimulates the growth of aspen. Gambel oak, which grows in both of these soil management areas, provides sprouts and mast for deer and other wildlife.

PINYON-JUNIPER WOODLAND.—The pinyon-juniper zone provides winter range for elk, deer, turkey, and antelope. The thick stands of pine and juniper provide adequate cover for escape and concealment, but in many places the supply of browse has been depleted. Natural watering places are scarce, but there are many suitable sites for development of water supplies in areas of Gem, Springerville, and Waldroup soils.

Most of the pinyon-juniper zone is in the Springerville-Gem soil management area. These soils can produce good stands of palatable browse. Fourwing saltbush, buckwheat, and dwarf rabbitbrush are suitable species. Wheatgrass seedlings supply feed early in spring. Seeding mixtures should include burnet, clover, alfalfa, and other forbs. More forbs and grasses are needed to augment the supply of pinyon nuts and acorns and other mast. The seeds of grass and forbs supply the winter feed for turkey.

Existing stands of palatable browse should be left standing in all areas where juniper is controlled. Islands of juniper should be left to provide protective cover. The Jacks soils support a fair amount of browse. Planting more ceanothus and mountain-mahogany would greatly improve the supply of forage.

GRASSLAND-DESERT SHRUB ZONE.—In years when the moisture supply is normal or better, the grassland-desert shrub zone is excellent range for small game, including quail, dove, and rabbit. The alternating draws and ridges provide good concealment and avenues of escape.

The Penthouse and Springerville soils of the House Mountain-Penthouse soil management area, the Cornville, Guest, Glendale, Karro, and Laveen soils of the Karro-Laveen-Guest soil management area, and the Retriever and Courthouse soils of the Retriever-Courthouse soil management area can be revegetated successfully with forage plants.

Quail need green feed early in spring to insure a good hatch. If grasses are seeded, species adapted to calcareous and moderately alkaline soils should be selected. Fourwing saltbush and buckwheat could be started to supply winter browse for white-tailed deer and other big game. Desert ceanothus is also a good browse species in these areas.

Development of Recreation Sites

The Beaver Creek Area offers opportunities for hunting, fishing, camping, and picnicking. Use of the Area by the public is increasing, and suitable public recreation sites are needed.

The soils of the Area have been placed in groups for recreation sites, as shown in the "Guide to Mapping Units" at the back of this report. This grouping is based on characteristics significant in the design and development of recreational facilities. The criteria are similar to those in

the Work Plan for the National Forest Recreation Survey (12). The main characteristics considered are productivity, stability, depth, permeability, stoniness, and slope. Subgroups mainly indicate differences in slope.

The groupings are not intended as recommendations of locations for recreational developments, but as a guide to the nature of the soils and the terrain and their suitability for recreational activities.

Except for Stony rough land, basalt and cinders, the miscellaneous land types are not included in the groups for recreation sites, because they are unsuitable for recreational development. Steep slopes, exposures of ledge rock, and shallowness would make construction costly and difficult.

GROUP 1 FOR RECREATION SITES

In this group are deep and moderately deep, well-drained, permeable, productive soils. Three subgroups have been established.

The soils of subgroup 1-a have few natural limitations and present little difficulty in construction. In this subgroup are soils of the Broliar, Cornville, Gem, Hogg, Lynx, Siesta, and Sponseller series.

The soils of subgroup 1-b have stronger slopes, and their use for recreation sites requires consideration of the slope. In this subgroup are soils of the Broliar and Cornville series.

The soils of subgroup 1-c are easy to work, but their generally steep slopes limit their suitability for recreation sites and make construction more costly. In this subgroup are soils of the Broliar and Sponseller series. Disturbed areas are easily eroded.

GROUP 2 FOR RECREATION SITES

In this group are deep and moderately deep, relatively stable soils that have medium or high productivity. Three subgroups have been established.

The soils of subgroup 2-a have few, if any, limitations of terrain, but have some characteristics that make them less desirable for recreational use than the soils of group 1. In this subgroup are soils of the Broliar, Friana, Gem, Guest, Jacks, Lynx, Penthouse, Springerville, Stagecoach, and Waldroup series. In several of these soils, cuts 1 to 2 feet deep expose a subsoil of heavy, tight clay. Some areas of the Broliar soils are associated with Alluvial land, and in these areas there is a hazard of overflow. Some areas of the Friana soils have a seasonal high water table.

The soils of subgroup 2-b have stronger slopes than those of subgroup 2-a. In this subgroup are soils of the Broliar, Laveen, Schnebly, and Waldroup series. The slope has to be considered in the planning of design and layout of recreation sites.

Only one soil has been placed in subgroup 2-c. It is a moderately steep soil of the Broliar series. Its slope necessitates extra, and perhaps costly, construction procedures. Disturbed areas are easily eroded.

GROUP 3 FOR RECREATION SITES

In this group are deep and moderately deep, generally unstable soils that are easily eroded. Three subgroups have been established.

The soils of subgroup 3—a present few problems of slope or topography, but they have some characteristics that are not desirable for recreation sites. In this subgroup are soils of the Anthony, Bridge, Friana, Gila, Glendale, Hantz, Karro, Laveen, Mescal, Springerville, Tobler, Toquop, and Waldroup series. With the exception of the Hantz and Springerville soils, all of these soils need protection from erosion during and after construction. The Hantz soil is easily dispersed, and its subsoil is elastic. The Springerville soils have high shrink-swell potential and are poor foundation material. The Friana soil has a seasonally high water table. The Anthony, Bridge, Gila, Glendale, Karro, Laveen, Tobler, and Toquop soils are susceptible to erosion by both wind and water; uncontrolled flow of water on these soils quickly creates cuts and gullies. Also, these soils are easily compacted.

Only one soil has been placed in subgroup 3-b. It is a Springerville soil that has stronger slopes than the Springerville soils of subgroup 3-a but in other respects is like those soils.

Only one soil has been placed in subgroup 3-c. It, too, is a Springerville soil. It is steeper than the Springerville soil of subgroup 3-b but is like that soil in other characteristics.

GROUP 4 FOR RECREATION SITES

In this group are shallow, stony, and rocky soils that have low or medium productivity. Three subgroups have been established.

Subgroup 4-a is made up of gently sloping soils of the Broliar, Cabezon, House Mountain, and Retriever series. These soils are poorly suited to development as recreation sites. Excavation is difficult because bedrock is close to the surface. Revegetation of disturbed areas is not easily accomplished.

The soils of subgroup 4-b have stronger slopes than those of subgroup 4-a. In this subgroup are soils of the Courthouse, Cabezon, and Retriever series, and areas of Rock land-Springerville complex and Toquop-Carrizo complex. Rock outcrops and the slope cause difficulty in grading and other construction operations. Excavations more than 1½ feet deep necessitate removal of hard rock.

The soils of subgroup 4-c are the least suitable in the Area for development of recreation sites. In this subgroup are soils of the Courthouse, Jacks, and Retriever series, and areas of Stony rough land, basalt and cinders. All of the areas are highly susceptible to accelerated erosion if the soils or the plant cover are disturbed.

Soils in Engineering

This section gives information about the engineering properties of the soils. The information can be used in locating sites for structures; for eliminating tests of materials unsuited to a particular use; in locating materials suitable for the type of structure planned; and in choosing the most favorable location, design, and construction for structures.

With the use of the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized that they may not eliminate the need for sampling and testing at

the site of specific engineering works involving heavy loads and excavations deeper than the depth of the layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Engineering properties, interpretations, and test data

Table 13 provides a summary of the engineering properties of the soils of the survey Area. For some soils, the statements concerning permeability, reaction, dispersion, and shrink-swell potential are generalizations based on laboratory data, and for others they are estimates.

Permeability, or ability of the soil to transmit water, is important in the construction of foundations. It is also important in constructing highway embankments and highway subgrades. The ratings are for soils that are not compacted.

Soil reaction is expressed in terms of pH values. A value of pH 7 is precisely neutral; a value lower than 7 indicates acidity, and a higher value indicates alkalinity. The more acid or the more alkaline soils will corrode metal.

The ratings for dispersion indicate the degree of slaking and the rapidity with which the soil structure breaks down. An easily dispersed soil is unstable and lacks binding power. Construction with such materials requires more than the ordinary precaution.

The ratings for shrink-swell potential indicate the volume change to be expected with change in content of moisture. Usually, soils classed as CH or A-7 have a high shrink-swell potential and soils classed as SP or SM have a low shrink-swell potential. Most of the soils having a clayey subsoil tend to slough and slide when very wet because the soil swells as it takes up moisture. On such soils, construction work or transportation of heavy equipment during wet periods is hazardous.

Table 14 shows the relative suitability of the soils of the Area for the engineering practices most commonly needed in the management of wild lands. These interpretations are based on the estimates given in table 13, on test data, and on field experience. Interpretations for land types are not given, because these areas are so complex that useful interpretations cannot be made.

Table 15 gives engineering test data for soil samples from selected profiles in the survey Area. The tests were made in the laboratories of the Arizona Highway Department in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

Engineering and agricultural classification of the soils

Two systems of classifying soils for engineering purposes are in general use. One was developed by the American Association of State Highway Officials, and the other, called the Unified system, by the U.S. Army Corps of Engineers. The bases for the engineering classifications differ from the basis for the textural classification used by the Department of Agriculture.

TABLE 13.—Estimated engineering

Soil series and land types, and map symbols	Depth to bedrock	Depth from surface	Classification	
			USDA texture	Unified ¹
Anthony (An).	<i>Feet</i> 5+	<i>Inches</i> 0 to 60	Fine sandy loam and very fine sandy loam....	SC, SM....
Basalt rock land (Ba).	Properties variable.			
Bridge:				
Gravelly sandy loam (Bg).	3 to 5+	0 to 31	Gravelly sandy loam, loam, and sandy clay loam.	SC, CL- ML.
Stony loam (Bl).	3 to 5+	0 to 3 3 to 27	Stony loam..... Gravelly loam and gravelly clay loam.....	ML, SM..... CL-ML, SM.
Brolliar:				
Gravelly clay loam (Bm).	1½ to 5	0 to 4 4 to 34	Gravelly clay loam..... Clay.....	CL..... CH.....
Clay loam (Bu).	1½ to 5	0 to 44	Thin layer of clay loam over clay.....	CH.....
Silt loam, deep (Bn).	1½ to 5	0 to 44	Thin layer of silt loam over clay.....	CH.....
Stony clay loam (BoB, BoC, BoD, Bp).	1½ to 5	0 to 5 5 to 34	Stony clay loam..... Clay.....	CL..... CH.....
Very stony loam (BrB, BrC, BrD).	1½ to 5	0 to 5 5 to 34	Very stony loam..... Clay.....	GM, GC..... CH.....
Cobbly loam (Bv).	1½ to 5	0 to 5 5 to 34	Cobbly loam..... Clay.....	GM, GC..... CH.....
Cabezon (Ca, Cc).	½ to 2	0 to 11	Stony clay loam or very stony loam.....	CL.....
Carrizo (Mapped only with Toquop series (Tx)).	3½ to 5	0 to 40	Very gravelly coarse sand and sand.....	GP.....
Cornville:				
Fine sandy loam (Cd).	2½ to 6	0 to 60	Fine sandy loam over heavy fine sandy loam...	SM.....
Gravelly sandy loam, thin solum variant (Cg).	2½ to 6	0 to 5 5 to 60	Gravelly sandy loam..... Fine sandy loam and heavy fine sandy loam....	SM..... SM.....
Courthouse (Ch, Cs).	1 to 2	0 to 9 9 to 14	Gravelly fine sandy loam..... Very gravelly clay loam.....	GM..... GC.....
Friana:				
Clay, black variant (Fk).	4 to 5	0 to 55	Clay.....	CH.....
Undifferentiated (Fn).	4 to 5	0 to 11 11 to 55	Silty clay loam, clay loam, or clay..... Clay.....	CL-CH..... CH.....
Gem (Gm, Gn). (For properties of Springerville part of Gn, see Springerville very stony clay.)	2 to 3½	0 to 28 28 to 44	Clay loam..... Very gravelly clay or clay loam.....	CH..... SC.....
Gila (Gs).	5+	0 to 74	Very fine sandy loam.....	SM.....
Glendale (Gt).	5+	0 to 52	Silt loam, heavy silt loam, and loam.....	ML-CL.....
Guest (Gu).	5+	0 to 32 32 to 50	Clay and silty clay..... Silty clay loam.....	CH..... CL.....
Hantz (Ha).	5+	0 to 60	Silty clay.....	CH.....
Hogg (Hg).	2 to 3	0 to 9 9 to 32	Stony silt loam..... Clay and silty clay.....	ML..... CH.....
House Mountain (Hm).	½ to 1½	0 to 12	Stony and very stony loam and clay loam....	SC, GC.....
Jacks (Ja, Jc).	1 to 3	0 to 9 9 to 24	Fine sandy loam..... Sandy clay and clay.....	SC..... CL-CH.....

See footnotes at end of table.

properties of the soils

Classification— Continued	Percentage passing sieve—			Permeability	Reaction	Dispersion	Shrink-swell potential
	AASHO ²	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)				
A-2-----	100	100	20 to 30	<i>Inches per hour</i> 2.5 to 5.0	<i>pH</i> 8.5 to 9.0	Low-----	Low.
A-4, A-6-----	75 to 85	70 to 80	40 to 60	0.5 to 2.5	7.8 to 8.4	Low-----	Low to moderate.
A-4-----	75 to 85	70 to 80	40 to 60	0.5 to 2.5	7.8 to 8.4	Low-----	Low.
A-4, A-6-----	70 to 85	60 to 80	40 to 60	0.2 to 2.5	7.8 to 8.4	Moderate-----	Moderate.
A-6-----	70 to 80	70 to 80	55 to 65	0.2 to 0.8	6.1 to 6.5	Moderate-----	Moderate.
A-7-----	70 to 85	65 to 80	60 to 70	0.05 to 0.2	6.6 to 7.3	Moderate-----	High.
A-6, A-7-----	95 to 100	95 to 100	85 to 95	0.05 to 2.0	6.1 to 7.3	Moderate-----	High.
A-6, A-7-----	95 to 100	95 to 100	85 to 95	0.05 to 2.0	6.1 to 7.3	Moderate-----	High.
A-6-----	70 to 80	70 to 80	55 to 65	0.2 to 0.8	6.1 to 6.5	Moderate-----	Moderate.
A-7-----	95 to 100	95 to 100	70 to 80	0.05 to 0.2	6.1 to 7.3	Moderate-----	High.
A-2-----	30 to 50	30 to 50	15 to 25	0.8 to 2.5	6.2 to 6.4	Low-----	Low.
A-7-----	95 to 100	95 to 100	70 to 80	0.05 to 0.2	6.1 to 7.3	Low-----	High.
A-2-----	30 to 50	30 to 50	15 to 25	0.8 to 2.5	6.2 to 6.4	Low-----	Low.
A-7-----	95 to 100	95 to 100	70 to 80	0.05 to 0.2	6.1 to 7.3	Low-----	High.
A-6-----	50 to 80	70 to 80	50 to 60	0.05 to 0.2	6.1 to 7.3	Low-----	Moderate
A-1-----	10 to 50	10 to 50	0 to 5	>10.0	7.9 to 8.4	Low-----	Low.
A-2-----	100	100	20 to 30	0.8 to 2.5	7.9 to 9.0	Low-----	Low.
A-2-----	75 to 85	70 to 80	15 to 25	0.8 to 2.5	7.9 to 8.4	Low-----	Low.
A-2-----	100	100	20 to 30	0.8 to 2.5	8.5 to 9.0	Low-----	Low.
A-2-----	60 to 80	50 to 80	10 to 20	0.8 to 2.5	7.9 to 8.4	Low-----	Low.
A-2-----	45 to 55	40 to 50	25 to 30	0.8 to 2.5	7.9 to 8.4	Low-----	Low.
A-7-----	100	100	85 to 95	<0.05	6.1 to 7.3	Moderate-----	High.
A-6, A-7-----	100	100	80 to 90	0.2 to 0.8	6.1 to 6.5	Moderate-----	Moderate to high
A-7-----	100	100	85 to 95	<0.05	6.1 to 7.3	Moderate-----	High.
A-7-----	100	100	85 to 95	0.05 to 0.2	6.1 to 7.3	Moderate-----	High.
A-2, A-4-----	40 to 60	30 to 50	30 to 40	0.8 to 2.5	7.4 to 8.4	Low-----	Low.
A-4-----	100	100	35 to 50	0.8 to 2.5	7.9 to 8.4	Moderate-----	Low.
A-4-----	100	100	50 to 60	0.2 to 2.5	7.9 to 8.4	High-----	Low to moderate.
A-7-----	100	100	85 to 95	0.05 to 2.0	7.9 to 8.4	Moderate-----	High.
A-6-----	100	100	80 to 90	0.2 to 0.8	7.9 to 8.4	High-----	Moderate.
A-7-----	100	100	85 to 95	0.05 to 2.0	7.9 to 9.0	High-----	High.
A-4-----	70 to 80	70 to 80	50 to 60	0.8 to 2.5	6.1 to 6.5	Moderate-----	Low.
A-7-----	100	100	85 to 95	0.05 to 0.2	6.1 to 7.3	Moderate-----	High.
A-2, A-4-----	30 to 80	30 to 80	15 to 40	0.8 to 2.5	7.3 to 7.8	Low-----	Moderate.
A-2-----	100	100	25 to 35	2.5 to 5.0	6.1 to 7.3	Low-----	Low.
A-6, A-7-----	100	100	80 to 95	0.05 to 0.2	6.6 to 7.8	Low-----	Moderate to high.

TABLE 13.—Estimated engineering

Soil series and land types, and map symbols	Depth to bedrock	Depth from surface	Classification	
			USDA texture	Unified
Karro (Ka). (For properties of Laveen part of Ka, see Laveen fine sandy loam.)	<i>Feet</i> 2½ to 5	<i>Inches</i> 0 to 8 8 to 52	Fine sandy loam..... Loam, heavy fine sandy loam, and gravelly sandy loam.	SM..... SM, ML.....
Laveen: Gravelly sandy loam (La).	1½ to 5	0 to 32	Gravelly sandy loam.....	GM.....
Fine sandy loam.	2¼ to 5	0 to 8 8 to 52	Fine sandy loam..... Loam, heavy fine sandy loam, and gravelly sandy loam.	SM..... SM, ML.....
Lynx (Ln, Ly).	5+	0 to 32 32 to 62	Silt loam and clay loam..... Clay.....	ML-CL..... CH.....
Mescal (Ms).	1½ to 5	0 to 24	Fine sandy loam to loam.....	SM.....
Penthouse (Pc, Ph).	3 to 4	0 to 27 27 to 44	Cobbly clay loam..... Clay loam.....	CH..... CL.....
Retriever: Loam (Re).	0 to 2	0 to 14	Loam.....	ML.....
Very stony loam (RrC, RrD).	0 to 2	0 to 9	Stony loam.....	GC.....
Riverwash (Rw).	Properties variable.			
Rock land (Rx). (For properties of Springerville part of Rx, see Springerville very stony clay.)	Properties variable.			
Rough broken and stony land, limestone (Ry).	Properties variable.			
Sandstone outcrop (Sa).	Properties variable.			
Sandstone rock land (Sd).	Properties variable.			
Schnebly (Se).	2 to 3	0 to 25	Stony clay loam.....	CL.....
Siesta: Silt loam, deep (Sf).	2 to 5	0 to 5 5 to 31 31 to 46	Silt loam..... Clay..... Clay loam.....	ML..... CH..... CL.....
Stony silt loam (Sg).	2 to 5	0 to 5 5 to 31 31 to 46	Stony silt loam..... Clay..... Clay loam.....	ML..... CH..... CL.....
Sponseller (ShC, ShD).	2 to 5	0 to 8 8 to 52	Stony silt loam..... Clay loam; gravelly between 40 and 52 inches.	ML..... CL.....
Springerville: Clay (Sk, Sl).	2 to 5	0 to 55	Clay.....	CH.....
Cobbly clay (Sm).	2 to 5	0 to 3 3 to 55	Cobbly clay..... Clay.....	CH..... CH.....
Very stony clay (SnB, SnC, SnD).	2 to 5	0 to 3 3 to 44	Very stony clay..... Clay.....	CH..... CH.....
Stagecoach (So).	1½ to 2½	0 to 13 13 to 28	Cobbly sandy loam..... Very gravelly loam and sandy loam.....	GM..... GM.....
Stony hilly land, ash and tuff (Sr).	Properties variable.			
Stony rough land, basalt and cinders (Ss).	Properties variable.			

See footnotes at end of table.

properties of the soils—Continued

Classification— Continued	Percentage passing sieve—			Permeability	Reaction	Dispersion	Shrink-swell potential
	AASHO ²	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)				
A-2-----	100	100	25 to 35	<i>Inches per hour</i> 2.5 to 5.0	<i>pH</i> 7.9 to 8.4	High-----	Low.
A-2, A-4-----	75 to 100	75 to 100	30 to 60	0.8 to 2.5	7.9 to 8.4	Moderate-----	Low.
A-2-----	75 to 85	70 to 80	20 to 30	2.5 to 5.0	7.9 to 9.0	Moderate-----	Low.
A-2-----	100	100	25 to 35	2.5 to 5.0	7.9 to 8.4	High-----	Low.
A-2, A-4-----	75 to 100	75 to 100	30 to 60	0.8 to 2.5	7.9 to 8.4	Moderate-----	Low.
A-4, A-6-----	100	100	80 to 90	0.8 to 2.5	6.1 to 7.3	Moderate-----	Low to moderate.
A-7-----	100	100	85 to 95	0.2 to 0.8	7.3 to 7.8	Moderate-----	High.
A-2, A-4-----	100	100	30 to 50	0.8 to 2.5	7.9 to 8.4	Moderate-----	Low.
A-7-----	55 to 85	50 to 80	50 to 65	<0.05	7.3 to 8.4	Moderate-----	High.
A-6-----	90 to 100	90 to 100	80 to 90	0.05 to 0.2	7.9 to 8.4	Moderate-----	Moderate.
A-4-----	100	100	50 to 60	0.8 to 2.5	7.9 to 8.4	Low-----	Low.
A-2, A-4-----	55 to 85	50 to 80	25 to 40	0.8 to 2.5	7.9 to 8.4	Low-----	Low.
A-6-----	55 to 85	50 to 80	50 to 65	0.05 to 0.2	6.6 to 8.4	Moderate-----	Moderate.
A-4-----	95 to 100	95 to 100	80 to 90	0.8 to 2.5	6.6 to 7.3	Moderate-----	Low.
A-7-----	95 to 100	95 to 100	70 to 80	0.05 to 0.2	6.6 to 7.3	Moderate-----	High.
A-6-----	95 to 100	95 to 100	70 to 80	0.2 to 0.8	7.6 to 8.4	Moderate-----	Moderate.
A-4-----	75 to 85	75 to 85	50 to 60	0.8 to 2.5	6.6 to 7.3	Moderate-----	Low.
A-7-----	95 to 100	95 to 100	70 to 80	0.05 to 0.2	6.6 to 7.3	Moderate-----	High.
A-6-----	95 to 100	95 to 100	70 to 80	0.2 to 0.8	7.6 to 8.4	Moderate-----	Moderate.
A-4-----	75 to 85	75 to 85	50 to 60	0.8 to 2.5	5.6 to 6.5	Moderate-----	Low.
A-6-----	75 to 85	70 to 80	60 to 70	0.2 to 0.8	6.1 to 7.3	Moderate-----	Moderate.
A-7-----	95 to 100	95 to 100	90 to 95	<0.05	7.3 to 8.4	Low-----	High.
A-7-----	70 to 80	50 to 80	50 to 70	0.05 to 0.2	7.3 to 7.8	Low-----	High.
A-7-----	95 to 100	95 to 100	90 to 95	<0.05	7.3 to 8.4	Low-----	High.
A-7-----	25 to 55	20 to 50	20 to 45	0.8 to 2.5	7.3 to 7.8	Low-----	High.
A-7-----	95 to 100	95 to 100	90 to 95	<0.05	7.3 to 8.4	Low-----	High.
A-2-----	70 to 80	50 to 80	20 to 30	2.5 to 5.0	7.9 to 8.4	Low-----	Low.
A-2-----	50 to 60	40 to 50	10 to 20	2.5 to 5.0	8.5 to 9.0	Low-----	Low.

TABLE 13.—Estimated engineering

Soil series and land types, and map symbols	Depth to bedrock	Depth from surface	Classification	
			USDA texture	Unified
Stony rough land, sandstone (St).				
Stony steep land, basalt (Su).				
Stony very steep land, basalt (Sv).				
Tobler:				
Fine sandy loam (Tb).	2 to 5+	0 to 53	Fine sandy loam.....	SM.....
Gravelly fine sandy loam, brown variant (Tg).	2 to 5+	0 to 12 12 to 53	Gravelly fine sandy loam..... Fine sandy loam.....	GM..... SM.....
Toquop (To, Tx). (For properties of Carrizo part of Tx, see Carrizo series.)	4+	0 to 54	Loamy fine sand and fine sand.....	SP.....
Waldroup:				
Loam, brownish variant (Wa).	1½ to 4	0 to 6 6 to 24 24 to 48	Loam..... Clay and gravelly clay..... Very gravelly clay.....	ML..... CL-CH..... GC.....
Clay loam, deep (Wc).	1½ to 4	0 to 6 6 to 25	Clay loam..... Clay; many rock fragments in lower part.....	CL..... CH.....
Gravelly loam, moderately deep (Wg).	1½ to 4	0 to 6 6 to 25	Gravelly loam..... Clay with many rock fragments in lower part.....	SM..... CH.....

¹ For an explanation of the Unified system, see "The Unified Soil Classification System" (9).

TABLE 14.—Engineering

[No interpretations are given for the miscellaneous land

Soil series and map symbol	Suitability for use as—		Suitability as a source of—		
	Roadfill	Subbase	Topsoil	Sand and gravel for subgrade	Rock
Anthony (An).....	Good to fair.....	Poor to unsuitable.....	Fair to poor.....	Unsuitable.....	Unsuitable.....
Bridge (Bg, Bl).....	Good to poor.....	Unsuitable.....	Poor.....	Unsuitable.....	Unsuitable.....
Brolliar (Bm, Bn, BrB, BcC, BoD, Bp, BrB, BrC, BrD, Bu, Bv).	Poor.....	Unsuitable.....	Good to fair.....	Unsuitable.....	Poor; basalt.....
Cabezon (Ca, Cc).....	Poor.....	Fair to unsuitable.....	Poor to unsuitable.....	Unsuitable.....	Good to fair; basalt.....
Carrizo (Carrizo soil in Tx).....	Fair.....	Fair to unsuitable.....	Poor.....	Fair.....	Poor; mixture of sand, gravel, stones, and cobblestones.
Cornville (Cd, Cg).....	Fair to poor.....	Unsuitable.....	Fair to poor.....	Unsuitable.....	Unsuitable.....
Courthouse (Ch, Cs).....	Fair.....	Poor to unsuitable.....	Poor.....	Unsuitable.....	Fair to poor; soft sand- stone.

properties of the soils—Continued

Classification— Continued	Percentage passing sieve—			Permeability	Reaction	Dispersion	Shrink-swell potential
	AASHO ²	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)				
				<i>Inches per hour</i>	<i>pH</i>		
A-2-----	90 to 100	90 to 100	20 to 30	2.5 to 5.0	6.9 to 8.4	Moderate.....	Low.
A-2-----	70 to 80	70 to 80	15 to 20	2.5 to 5.0	6.9 to 8.4	Moderate.....	Low.
A-2-----	90 to 100	90 to 100	20 to 30	2.5 to 5.0	6.9 to 8.4	Moderate.....	Low.
A-3-----	100	100	5 to 10	>10.0	7.9 to 8.4	Low.....	Low.
A-4-----	95 to 100	90 to 100	50 to 60	0.8 to 2.5	6.6 to 7.3	Moderate.....	Low.
A-6, A-7-----	75 to 85	70 to 80	60 to 70	0.05 to 0.2	7.3 to 8.4	Moderate.....	High.
A-2-----	25 to 60	20 to 50	20 to 35	0.8 to 2.5	7.3 to 8.4	Low.....	Low.
A-6-----	95 to 100	95 to 100	80 to 90	0.8 to 2.5	6.6 to 7.3	Moderate.....	Moderate
A-7-----	80 to 90	75 to 85	70 to 80	0.05 to 0.2	7.3 to 8.4	Moderate.....	High.
A-2-----	55 to 85	50 to 80	25 to 35	0.8 to 2.5	6.6 to 7.3	Moderate.....	Low.
A-7-----	80 to 90	75 to 85	70 to 80	0.05 to 0.2	7.3 to 8.4	Moderate.....	High.

² For an explanation of the AASHO system, see AASHO Designation: M 145-49 (1).

interpretations

types, because the properties are variable]

Suitability for—

Stock tanks and reservoirs		Terraces and diversions	Water spreading	Range pitting and chiseling	Waterways
Reservoir area	Embankment				
Good to fair-----	Good to fair-----	Fair to poor-----	Fair to poor-----	Good-----	Fair.
Good to fair-----	Good to fair-----	Good to fair-----	Good-----	Good-----	Fair.
Good-----	Fair to poor; heavy clay.	Good to fair-----	Good, but slow permeability.	Good to fair-----	Good if slope is less than 10 percent; poor to unsuitable if slope is more than 10 percent.
Poor to unsuitable.	Fair to poor; heavy clay.	Fair; poor where shallow.	Unsuitable-----	Poor to unsuitable...	Fair to unsuitable.
Unsuitable-----	Unsuitable-----	Unsuitable-----	Unsuitable-----	Unsuitable-----	Poor.
Excellent to good..	Good-----	Good to fair-----	Good, except in areas where slope is more than 15 percent.	Good to fair; needs contouring on slopes.	Good if slope is less than 10 percent; unsuitable if slope is more than 10 percent.
Poor; too shallow..	Good to fair; shallow.	Fair to poor-----	Fair to unsuitable....	Fair to unsuitable....	Fair if slope is less than 10 percent; unsuitable if slope is more than 10 percent.

TABLE 14.—*Engineering*

Soil series and map symbol	Suitability for use as—		Suitability as a source of—		
	Roadfill	Subbase	Topsoil	Sand and gravel for subgrade	Rock
Friana (Fk, Fn).....	Poor.....	Unsuitable.....	Good.....	Unsuitable.....	Unsuitable.....
Gem (Gm, Gn).....	Poor.....	Unsuitable.....	Fair.....	Unsuitable.....	Poor; basalt.....
Gila (Gs).....	Fair to good.....	Very poor to unsuitable.....	Good.....	Unsuitable.....	Unsuitable.....
Glendale (Gt).....	Fair.....	Unsuitable.....	Poor.....	Unsuitable.....	Unsuitable.....
Guest (Gu).....	Poor.....	Unsuitable.....	Good.....	Unsuitable.....	Unsuitable.....
Hantz (Ha).....	Poor.....	Unsuitable.....	Poor.....	Unsuitable.....	Unsuitable.....
Hogg (Hg).....	Poor.....	Unsuitable.....	Fair; too many stones.....	Unsuitable.....	Poor; cherty limestone.....
House Mountain (Hm).....	Poor.....	Unsuitable.....	Poor.....	Unsuitable.....	Good; basalt.....
Jacks (Ja, Jc).....	Poor.....	Unsuitable.....	Fair.....	Unsuitable.....	Poor; sandstone.....
Karro (Karro soil in Ka).....	Fair.....	Unsuitable.....	Poor.....	Unsuitable.....	Unsuitable.....
Laveen (La and Laveen soil in Ka).....	Fair.....	Unsuitable.....	Poor.....	Unsuitable.....	Unsuitable.....
Lynx (Ln, Ly).....	Fair to poor.....	Unsuitable.....	Fair to poor.....	Unsuitable.....	Unsuitable.....
Mescal (Ms).....	Fair to poor.....	Poor to unsuitable.....	Poor.....	Unsuitable.....	Unsuitable.....
Penthouse (Pc, Ph).....	Fair to poor.....	Unsuitable.....	Fair.....	Unsuitable.....	Poor; basalt.....
Retriever (Re, RrC, RrD).....	Fair.....	Unsuitable.....	Poor.....	Unsuitable.....	Poor; soft limestone.....
Schneibly (Se).....	Poor.....	Unsuitable.....	Fair, but many stones.....	Unsuitable.....	Poor; basalt and sandstone.....
Siesta (Sf, Sg).....	Fair to poor.....	Unsuitable.....	Good, but stony.....	Unsuitable.....	Poor; basalt.....
Sponseller (ShC, ShD).....	Fair to poor.....	Unsuitable.....	Good.....	Poor, but could be a source of cinders.....	Unsuitable.....
Springerville (Sk, Sl, Sm, SnB, SnC, SnD).....	Poor.....	Unsuitable.....	Poor; too clayey.....	Unsuitable.....	Fair to poor; basalt.....
Stagecoach (So).....	Fair.....	Poor to unsuitable.....	Poor.....	Unsuitable.....	Unsuitable.....
Tobler (Tb, Tg).....	Good to fair.....	Poor to unsuitable.....	Poor.....	Unsuitable.....	Unsuitable.....
Toquop (To, Toquop soil in Tx).....	Good.....	Poor.....	Poor.....	Poor.....	Unsuitable.....
Waldroup (Wa, Wc, Wg).....	Fair to poor.....	Unsuitable.....	Good to fair.....	Poor to unsuitable; could be a source of cinders in places.....	Fair to unsuitable.....

interpretations—Continued

Suitability for—					
Stock tanks and reservoirs		Terraces and diversions	Water spreading	Range pitting and chiseling	Waterways
Reservoir area	Embankment				
Excellent.....	Good to fair.....	Good.....	Good.....	Good.....	Good.
Excellent to good.....	Poor; heavy clay.....	Good.....	Good; but slow permeability.	Good.....	Good.
Fair.....	Fair.....	Good.....	Good.....	Good.....	Good.
Excellent.....	Fair; high in silt.....	Good.....	Good.....	Good.....	Fair.
Excellent.....	Fair.....	Good.....	Good, but slow permeability.	Good.....	Good.
Excellent.....	Poor; too clayey.....	Poor.....	Poor.....	Good.....	Fair.
Fair; lacks depth.....	Good.....	Good.....	Good, but slow permeability.	Good.....	Good.
Poor; too shallow.....	Poor; stony and shallow.	Poor.....	Unsuitable.....	Unsuitable.....	Fair.
Good, but lacks depth in places.	Good.....	Good.....	Good, but slow permeability.	Good.....	Fair if slope is less than 10 percent; unsuitable if slope is more than 10 percent.
Good to fair.....	Good.....	Good.....	Good, but highly erodible.	Good.....	Fair.
Poor; much cobble and gravel.	Good.....	Fair.....	Poor.....	Fair.....	Fair if slope is less than 10 percent; unsuitable if slope is more than 10 percent.
Excellent.....	Good to fair.....	Good.....	Poor; not needed.....	Good.....	Good to fair.
Fair.....	Fair.....	Fair.....	Fair, except in areas where slope is 15 percent or more.	Good to fair; should be contoured if slope is more than 15 percent.	Fair if slope is less than 10 percent; unsuitable if slope is more than 10 percent.
Fair.....	Fair.....	Good.....	Good.....	Good.....	Good.
Fair to unsuitable.....	Fair to poor.....	Fair to unsuitable.....	Fair to unsuitable.....	Fair to unsuitable.....	Fair to unsuitable.
Poor; shallow.....	Fair to poor; stony and clayey.	Fair.....	Fair, except on slopes of more than 15 percent.	Fair if on contour.....	Unsuitable.
Good; poor in shallow areas.	Good to fair.....	Good.....	Good.....	Good.....	Good if slope is less than 10 percent; unsuitable if slope is more than 10 percent.
Fair; cinders in places.	Good to fair.....	Good, except on steep slopes.	Poor; not needed.....	Unsuitable.....	Unsuitable.
Excellent to good, but poor in steep areas; much cobble and gravel.	Poor; heavy, fat clay.	Fair to poor; limitations are steepness or too much rock or stone.	Fair, except in areas where slope is more than 15 percent; very slow permeability.	Good; contours needed on slopes; unsuitable where rocky and shallow.	Fair if slope is less than 10 percent; unsuitable if slope is more than 10 percent.
Poor; much cobble and gravel.	Good.....	Fair.....	Poor.....	Fair.....	Fair if slope is less than 10 percent; unsuitable if slope is more than 10 percent.
Good, but poor where shallow.	Good.....	Good to fair.....	Unsuitable.....	Fair if on contour.....	Fair.
Unsuitable.....	Poor.....	Unsuitable.....	Poor; not needed.....	Poor.....	Fair.
Poor; lacks depth.....	Fair.....	Good, except on steep slopes.	Good, except where slope is more than 15 percent.	Good to fair; contours needed if slope is more than 15 percent.	Good, except on steep slopes.

TABLE 15.—Engineering

[Tests performed by the Arizona Highway Department in accordance with standard

Soil name and location of sample	Parent material	Arizona report No.	Depth from surface	Horizon	Moisture-density ¹	
					Maximum dry density	Optimum moisture
Brolliar silt loam, deep. NW $\frac{1}{4}$ sec. 11, T. 16 N., R. 8 E. (Modal profile.)	Basalt and cinders.	62-430	<i>Inches</i> 14-29	B21.....	<i>Lb. per cu. ft.</i> 89	<i>Percent</i> 30
		62-431	29-50	B22.....	81	28
Brolliar very stony loam. NW $\frac{1}{4}$ sec. 9, T. 16 N., R. 9 E. (Less stony than modal profile.)	Cinders and basalt rock.	62-429	9-25	B2.....	75	41
Siesta silt loam, deep. SW $\frac{1}{4}$ sec. 20, T. 16 N., R. 9 E. (Modal profile.)	Cinders and ash.	62-425	5-13	B1.....	105	19
		62-426	13-33	B21.....	92	27
		62-427	33-64	E22.....	104	18
		62-428	64-108	D.....	82	28
SE $\frac{1}{4}$ sec. 5, T. 16 N., R. 9 E. (Modal profile.)	Cinders and ash.....	62-432	12-30	B21.....	86	33
		62-433	30-48	B22.....	86	33
		62-434	48-72	B23.....	91	29
Brolliar stony clay loam. NW $\frac{1}{4}$ sec. 4, T. 15 N., R. 9 E. (Modal profile.)	Basalt.....	62-423	1-9	A12.....	96	23
		62-424	22-32	B23.....	90	28
NW $\frac{1}{4}$ sec. 15, T. 16 N., R. 8 E. (Modal profile.)	Basalt and cinders.....	62-435	17-30	B2.....	83	35
Friana clay loam. NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 12, T. 16 N., R. 9 E. (Modal profile.)	Ash, cinders, and tuff.....	62-27115	3-11	A12.....	97	22
		62-27116	20-38	B2.....	91	29
		62-27117	74-92	C1.....	86	31

¹ Based on AASHTO Designation: T 99-57, Method A or C (1).² Mechanical analysis according to AASHTO Designation T 88-57 (1). Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser

The AASHTO system (1) of classifying soils is based on field performance of soils in highways. In this system soil materials are classified into seven groups, designated A-1 through A-7. The best materials for engineering purposes (gravelly soils of high bearing capacity) are classified as A-1, and the poorest (clayey soils having low strength when wet) are classified as A-7. Most highway engineers classify soils in accordance with the AASHTO system.

The Unified system (2) is based on identification of soils according to texture and plasticity and on performance as engineering construction material. In this system, soils are placed in 15 groups, each identified by a letter symbol. The symbols SC and SM represent sand mixed with fines (clay and silt); CL and ML represent clay and silt that have a low liquid limit; CH represents clay and silt that have a high liquid limit; and GP and GM represent gravel and mixtures of gravel and sand. Soils that have characteristics that place them in a border zone between two major classes are given borderline classifications, such as ML-CL or SM-SC.

The U.S. Department of Agriculture system of classifying soils according to texture is primarily for agricultural use, but the textural classification is useful in engineering also.

Estimated classifications of all soils in the Beaver Creek Area according to all three of these systems are given in table 13. Laboratory-determined engineering classifications for selected soils of the Area are given in table 15.

Management Groups

Individual soils differ widely in use suitability and in management needs. To simplify the discussion of management, the 72 soils and land types in the Beaver Creek Area have been arranged in 13 management groups, as shown in the "Guide to Mapping Units" at the back of this report. Each group is composed of soils that are about the same in use suitability and in management needs. The soils in each group may or may not be geographically associated. Suggestions that apply to

test data

procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis ²								Liquid limit	Plasticity index	Classification	
Discarded in field sampling (estimated)		Percentage passing sieve ³ —								AASHO	Unified ⁴
Larger than 3-in.	Smaller than 3-in.	3-in.	¾-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)				
Percent	Percent										
			100	99	99	97	94	87	69	A-7-6(20).....	CH.
	2	100	98	96	94	91	86	116	94	A-7-6(20).....	CH.
3	2	100	97	87	84	80	74	119	91	A-7-6(20).....	CH.
		100	94	92	90	84	70	40	23	A-6(12).....	CL.
		100	95	93	91	89	81	90	70	A-7-6(20).....	CH.
5	5	100	81	71	65	59	53	76	58	A-7-6(13).....	CH.
		100	99	96	95	94	90	109	88	A-7-6(20).....	CH.
					100	99	93	115	96	A-7-6(20).....	CH.
					100	98	93	81	62	A-7-6(20).....	CH.
			100	98	97	95	89	70	53	A-7-6(20).....	CH.
6	2	100	95	94	92	90	85	51	28	A-7-6(17).....	CH.
6	2	100	85	85	84	84	80	101	78	A-7-6(20).....	CH.
		100	87	86	85	80	74	98	74	A-7-6(20).....	CH.
				100	99	94	88	46	25	A-7-6(15).....	CL.
					100	98	95	72	55	A-7-6(20).....	CH.
					100	90	46	53	25	A-7-6(8).....	SM-SC.

than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for use in naming textural classes for soils.

² Based on sample as received in laboratory. Laboratory test data not corrected for amount discarded in field sampling.

⁴ SCS and Bureau of Public Roads (BPR) have agreed to consider that all soils having plasticity indexes within two points of A-line are to be given a borderline classification. An example of borderline classification obtained by this use is SM-SC.

geographic associations of soils are given in the section "Soil Management Areas."

The management suggestions given in this section are based on the known characteristics and qualities of the soils and on observations of soil behavior in normal use.

Management group 1

This management group consists of level or gently sloping Friana soils. These soils are deep and fertile, and they have a good supply of moisture for plants most of the time. They are nearly free of stones and gravel.

The capacity to store water is only medium, because the permeability of the subsoil is very slow. Sustained water yield is medium. Much of the runoff from surrounding areas drains onto these soils and then into major drainageways. The erosion hazard is low. Gullies and cuts are few and shallow.

Management requirements are simple, compared with those of the other management groups. In many areas the natural vegetation would recover if grazing were

limited. Reseeding has been successful, and pastures could easily be established.

These soils are very well suited to herbage production but unsuitable for timber; they produce no ponderosa pine.

Management group 2

This management group consists of level to steep upland soils of the Broliar, Lynx, Siesta, and Sponseller series. These soils are deep or moderately deep and are highly fertile. They have medium or high moisture-supplying capacity. Most of the acreage is gently sloping or moderately sloping.

The capacity for sustained water yield is high in all of these soils except Broliar gravelly clay loam, which has medium capacity for sustained yield. Permeability is moderately slow or slow. The erosion hazard is low or moderate on the Broliar and Siesta soils and high on the Lynx and Sponseller soils.

These soils are well suited or very well suited to production of timber and herbage, and they should be man-

aged for this use. They now support vigorous stands of ponderosa pine and good stands of grass and other herbage. They have good capacity for natural recovery of vegetation, and their response to management is good.

Most of these soils provide suitable food and cover for wildlife. All of them can be used for recreational development, but plans for such use should take into account their high potential for production of timber, herbage, and water.

Management group 3

This management group consists of level to steep soils of the Broliar and Hogg series and areas of Alluvial land and Stony rough land, basalt and cinders. Most of the acreage is gently sloping or moderately sloping. The soils in this group make up about 19 percent of the survey Area. They are moderately deep or deep, stony, and cobbly.

The fertility of these soils is medium to high. Infiltration is moderate. Permeability is slow because the subsoil is clayey. The capacity for sustained water yield is medium.

The erosion hazard ranges from low to high. It is high in areas of Broliar very stony loam, 20 to 30 percent slopes, and Stony rough land, basalt and cinders (20 to 60 percent slopes). It would be high on several of the other soils, also, except for the protection provided by stones and rocks on the surface.

These soils are moderately well suited to very well suited to production of timber and are poorly suited to well suited to production of herbage. They support most of the ponderosa pine in this Area and provide much of the herbage for summer grazing. The vegetation has fair capacity for recovery, but the response to management is less satisfactory than on the soils in management group 2, and the pine produced is of lower quality.

Most of these soils provide a good environment for wildlife. Browse and other plants furnish food, and trees furnish concealment for deer and other game. Deer, elk, and turkey are common.

The soils of this group could best be managed for production of timber, herbage, and water, and for the protection of wildlife. Disturbance of the soil and the vegetation should be controlled to check erosion, especially on the steeper slopes. Stones and rocks on the surface may interfere with the use of machinery for planting and tillage.

Management group 4

This management group consists of level to moderately steep soils of the Broliar and Cabezon series. Most of the acreage is gently sloping. These soils are shallow or moderately deep and are rocky, stony, or gravelly. Much of the ground is bare. In places there is much basalt outcrop.

The fertility of these soils is low, and productivity is low. Runoff is rapid after snowmelt or intense rainfall, but there is little or no potential for sustained water yield. These soils are permeable to air and water, but they have little space for water storage.

These are the least productive of the soils in the ponderosa pine zone. They are poorly suited to production of timber. The stands of pine are sparse, and the trees

are stunted and of poor quality. Trees do not grow at all on the dark variant of the Cabezon soil. It is doubtful if the returns from practices designed to improve the stands of timber would equal their cost.

These soils are poorly suited to moderately well suited to production of herbage. Some range herbage is produced, but grazing must be carefully controlled to keep the plant cover growing. Natural recovery of vegetation is slow. Reseeding is difficult and usually unrewarding.

Some of the areas produce desirable forage for wildlife. The lack of tree cover, however, makes these soils generally unsuitable for many kinds of wildlife.

Management group 5

This management group consists of level to moderately steep soils of the Broliar, Gem, and Springerville series. The soils in this group are moderately deep or deep and are stony or cobbly. They make up about 23 percent of the survey Area.

The natural fertility of these soils is medium or high. Infiltration is moderate, and permeability is slow or very slow. Runoff is slow, except on the moderately steep slopes, and the erosion hazard is low or moderate. If the plant cover is removed, loss of soil through erosion is continuous.

These soils are well suited to production of herbage. They provide most of the forage in the fringe area between the pinyon-juniper woodland and the ponderosa pine zone. All of the acreage except that on steep slopes could be seeded to grass and to shrubs for forage. Areas of the Springerville soil have been set aside for experimental testing and study of methods of conversion from a juniper type of vegetation to a grass type. A large part of the Springerville soils could be converted, but natural revegetation of these soils is slow.

The soils in this group are unsuited to timber, or poorly suited at best. Most of the acreage is at elevations too low to have enough moisture for pine, but some areas of the Broliar soil support ponderosa pine. A few stunted pine trees are scattered through areas of the Gem soil, but pines do not grow at all on the Springerville soils.

The soils in this group have little potential for development of recreation sites. They are unstable and would compact and crust under traffic. They should be managed for production of herbage and for protection of wildlife. Big game and turkey use these soils for winter range.

Management group 6

This management group consists of level to moderately steep soils of the Bridge, Glendale, Laveen, Mescal, Retriever, and Stagecoach series. The soils in this group are very shallow to deep and are strongly calcareous. They occur on old fans, mesas, undulating uplands, and side slopes. Some of the soils have gravel and cobblestones on the surface.

The fertility of these soils is low to high. Infiltration is moderate, and permeability is moderate. The erosion hazard is moderate or high. Most areas have small cuts and rills, and the Glendale soils have gullied areas.

The soils in this group are poorly suited or only moderately well suited to herbage. The vegetation is sparse, and 30 to 50 percent of the surface is barren. In many

places the plant cover has been depleted by heavy grazing, and natural revegetation generally is extremely slow. The more nearly level areas could be seeded to climatically suited forage plants, preferably lime-tolerant species. Seeding should be timed to coincide with seasonal rainfall. Careful management to control erosion is necessary if the plant cover is removed. These soils are at too low an elevation to support timber.

Management group 7

This management group consists of level to moderately steep soils of the Anthony, Bridge, Gila, Karro, Laveen, Tobler, and Toquop series. The soils in this group are deep but are susceptible to erosion.

The fertility of these soils is low to high. Permeability is moderate to very rapid. The capacity to supply water to plants ranges from low to high. Surface runoff is slow, and the soils can store most of the moisture they receive.

These soils are highly susceptible to gullying and head-cutting because they receive runoff from surrounding areas. Gullying is serious in many areas of Tobler, Karro, and Laveen soils. Smoothing and grading and practices that will control erosion are needed. The gullies divert water and reduce the amount of moisture available to plants.

The soils in this group are fairly well suited or well suited to production of herbage. They provide much of the winter range. The potential for natural recovery of vegetation is generally low, and in some places where the native cover has been depleted, few of the desirable grasses are left. Seeding or planting should be timed to coincide with seasonal rainfall. Failure of the seeds to germinate will leave the soils bare and vulnerable to erosion. These soils are at too low an elevation to support timber.

Management group 8

This management group consists of level to steep soils of the Cornville and Jacks series. The Cornville soils occur below the Mogollon Rim, and the Jacks soils occur on the Plateau above the Rim. These soils are deep or moderately deep and are well drained. They are productive, and even the very rocky phase of the Jacks soils is vegetated. The dominant slopes are gentle and moderate.

Surface runoff ranges from slow to medium for most of the areas, but it is rapid on steep areas of the Jacks soils. The erosion hazard is high or moderate.

Despite the difference in position and elevation among these soils, all of the acreage is used for production of herbage, to which they are well suited or moderately well suited. The Jacks soils are the major shrub-producing soils in the survey Area. They support desirable browse for wildlife and are important as winter range for game. Management should be directed toward production of herbage, maintenance and improvement of forage for wildlife, and protection of the soils from erosion. None of these soils is within the zone in which the moisture supply is adequate for timber.

Management group 9

This management group consists of level to steep, medium-textured and fine-textured soils of the Penthouse,

Schnebly, Springerville, and Waldroup series. These soils are deep or moderately deep and are well drained. Most of the areas are gently undulating to rolling. Stones and cobbles are common on the surface of the Penthouse and Schnebly soils.

The fertility of these soils is medium. Infiltration is moderate, and permeability is moderate to very slow. Surface runoff is slow or medium. The erosion hazard is moderate or high, but no serious loss of soil has occurred. The capacity to supply moisture to plants is medium.

These soils are well suited or moderately well suited to production of herbage. If they are protected, the potential for natural recovery of vegetation is good. Except in steep areas of the Waldroup soil, revegetation with suitable plants can be accomplished fairly easily. The Penthouse and Schnebly soils would be difficult to seed because they have many stones on the surface. The Waldroup soils support browse for wildlife. Waldroup clay loam, deep, produces choice feed for big game. Management should be directed toward improvement and maintenance of the vegetation. These soils do not support timber.

Management group 10

This management group consists of deep, level to gently sloping, medium-textured and fine-textured soils of the Guest, Hantz, Lynx, and Waldroup series. These soils occur on alluvial fans, terraces, and bottom lands. Nearly level areas are common. Headcuts and deep, active gullies are forming in some of the soils, particularly in areas of Guest and Hantz soils.

Infiltration is moderate, and permeability is moderately slow or slow. Surface runoff is slow, and the erosion hazard is generally moderate or high. These soils receive runoff from surrounding areas, but the gullies drain off some of the water before it can soak into the ground. The gullies also drain off part of the water from the subsoil and thus reduce the supply of available moisture.

These soils are fertile and productive. They are well suited to herbage production, and some areas are very well suited. Natural recovery of vegetation is slow, even if the soils are protected, but the ordinary methods of range revegetation can be used. Seeding is easy but should be timed to coincide with seasonal rainfall, particularly in areas of Guest and Hantz soils.

Management should be directed to production of herbage and control of erosion. Gully plugs are needed. These soils are at too low an elevation to support timber.

Management group 11

This management group consists of very shallow to moderately deep, level to steep soils of the Courthouse, House Mountain, Retriever, and Springerville series. The slope is dominantly moderately steep. Also assigned to this management group are stony, steep, and rocky land types. The soils are generally loams or fine sandy loams. Stones, gravel, and rock are common on the surface. In places the stony cover is a deterrent to serious erosion.

Permeability is moderate. The erosion hazard ranges from low to high. All of the areas are susceptible to erosion if the plant cover is removed. Space for water storage is limited in the shallow soils.

Much of the acreage is in the fringe area between pinon-juniper woodland and grassland-desert shrub vegetation. The soils are poorly suited or moderately well suited to herbage. Of the group, the Courthouse and Springerville soils are best suited. The more nearly level areas can be revegetated with suitable grasses and shrubs. Seed would have to be broadcast. Success in revegetation depends upon a high rate of germination and upon the capacity of the young plants to survive in a severe climate.

In areas of the stony, steep, and rocky land types, a large volume of runoff is produced after severe rainstorms.

The soils and land types in this management group are at relatively low elevations and are not suitable for timber.

Management group 12

This management group consists of stony and rocky, steep land types. Patches of shallow or very shallow soil are included. Rock outcrops are numerous, and many stones and cobblestones occur on the surface and within the soil mass. Many areas are difficult to traverse, either on foot or on horseback.

Stony rough land, sandstone, is moderately well suited to grass and browse plants, but grazing is limited by the slope, the outcrops of rock, and the barriers of ledge rock.

Productivity in these areas is low. The moisture-holding capacity is low. Surface runoff is produced in great volume after heavy summer downpours and winter storms of long duration. The erosion hazard is high unless the plant cover is maintained.

These areas provide concealment and avenues of escape for wildlife. They do not support trees. Management should be directed toward conservation of the soil and protection of the watershed values.

Management group 13

This management group consists chiefly of miscellaneous land types, most areas of which have but little vegetation. The land types are Riverwash and Sandstone outcrop. Areas of the Toquop-Carrizo complex are included also.

Riverwash and the Toquop-Carrizo complex provide a limited amount of food for livestock and game. They can be used as resting places for livestock and as nesting areas for gamebirds.

The cliffs mapped as Sandstone outcrop are reddish and buff colored. They have little or no value for production of forage, but they are scenically spectacular. They are a favorite subject for photographers and artists.

Capability Grouping of Soils⁶

Capability grouping is a system of classification used by the Soil Conservation Service to show the relative suitability of soils for crops, grazing, forestry, and wildlife. It is a practical grouping based on the limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. Neither major reclamation

projects nor major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils have been considered in making this classification.

In this system all the kinds of soil are grouped at three levels: the unit, the subclass, and the class.

A capability unit is a group of soils that are similar in management needs, in risk of damage, and in general suitability for use.

A subclass is a broader grouping made up of soils that have the same dominant kind of limitation. The letter symbol *e* means that the main limitation is risk of erosion if the plant cover is not maintained. The symbol *w* means that excess water retards plant growth or interferes with use and management. The symbol *s* means that the soils are shallow, droughty, or stony. The symbol *c* means that the primary limitation is climate that is too dry, or that the distribution of rainfall is unfavorable to production of cultivated crops.

A capability class, which is identified by a Roman numeral, is made up of soils that have limitations and management problems of about the same degree but not necessarily of the same kind. Eight classes have been established. All except class I may have one or more subclasses.

In the capability grouping system, the soils in class I have the widest range of use and the least risk of damage. They are level or nearly level, productive, well drained, and easy to work. They can be cultivated with almost no risk of erosion and will remain productive if managed with normal care.

The soils in class II can be cultivated regularly, but they do not have so wide a range of suitability as the soils in class I. Some of the soils are gently sloping and need moderate care to prevent erosion. Other soils in class II may be slightly droughty, slightly wet, or somewhat limited in depth.

The soils in class III can be cropped regularly, but they need more careful management than the soils of class II, and they have a narrower range of use.

The soils in class IV need careful management if they are cultivated. Many of the soils can be used for cultivated crops occasionally in a system that includes several years of hay or other protective crops.

The soils in classes V, VI, and VII normally should not be used for cultivated crops but can be used for pasture, for woodland, or for plants that shelter wildlife. Some of the soils in these classes can be made usable for special crops, or even suitable for classification in another capability class, by major landforming or reclamation.

The soils in class V are nearly level or gently sloping and are not likely to erode, but they are droughty, wet, low in fertility, or otherwise unsuitable for cultivation.

The soils in class VI have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife. Some of these soils can be cultivated enough to set out forest trees or ornamental plants or to seed pasture crops.

⁶ This section was prepared by MILO S. JAMES, State soil scientist, Soil Conservation Service, Arizona.



Figure 19.—Water flowing through measuring flume. The trees in this study watershed are mainly ponderosa pine. The surrounding soils are of the Brolliar series.

The soils in class VII have more severe limitations than those in class VI and usually provide only poor to fair yields of forage. Yields of forest products are fair to high. These soils have characteristics that severely limit their use for pasture and, in some places, for woodland.

The soils in class VIII have practically no agricultural use. Some of the areas have value for water production and as wildlife habitats. Other areas have scenic value.

The Beaver Creek Area is wholly within the Coconino National Forest. Use of the soils for crops is negligible, and for this reason the soils have been grouped only by subclasses and classes. None are in classes I, II, III, IV, or V, but some, generally those along the Verde River, would be suitable for annual or periodic cultivation if irrigated. Other soils are suited to certain special crops.

The capability subclass of each of the soils is given in table 5, page 10.

Technical assistance on management problems is available from the office of the Soil Conservation Service at Cottonwood.

Research Value of the Survey

Research projects are being carried out in the Beaver Creek watershed to determine the effect of various practices upon water yield. Several small watersheds, 200 to 1,500 acres in size, are being studied. These watersheds are in areas where the vegetation is predominantly Utah juniper, alligator juniper, and ponderosa pine. The water yield from each of the watersheds under study is measured by a stream gage (fig. 19). Gross measurements of water yield are also being made in larger watershed areas.

This soil survey is detailed enough to be of value in water yield research. The soil map and the report are reliable sources of information about the pattern and extent of the various soils and land types in the entire Area. The survey is helpful, too, in making preliminary selection of locations for small plots on which intensive research can be conducted. Use of this survey can save considerable time and effort for the researcher by assuring that plots proposed for research are on important, extensive soils, and that individual plots are on the same kinds of soil.

Literature Cited

- (1) AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS.
1961 STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING Ed. 8, 2 v., illus.
- (2) FENNEMAN, N. M.
1931. PHYSIOGRAPHY OF WESTERN UNITED STATES. 1st ed., 534 pp., illus. New York and London.
- (3) HARPER, W. G.
1957. MORPHOLOGY AND GENESIS OF CALCISOLS. *Soil Sci. Soc. Amer. Proc.* 21(4): 420-424, illus.
- (4) JOHNSON, W. M., CADY, J. G., and JAMES, M. S.
1962. CHARACTERISTICS OF SOME BROWN GRUMUSOLS OF ARIZONA. *Soil Sci. Soc. Amer. Proc.* 26(4): 389-393, illus.
- (5) LEHNER, ROBERT E.
1958. GEOLOGY OF THE CLARKDALE QUADRANGLE, ARIZONA. U.S. Geological Survey. Bul. No. 1021-N.
- (6) MEYER, WALTER H.
1938. YIELD OF EVEN-AGED STANDS OF PONDEROSA PINE. U.S. Dept. Agr. Tech. Bul. No. 630. Rev. 1961.
- (7) SIMONSON, ROY W.
1962. SOIL CLASSIFICATION IN THE UNITED STATES. *In* SCIENCE. v. 137, No. 3535, pp. 1027-1034. American Association for the Advancement of Science. September 28, 1962.

- (8) THORP, JAMES, and SMITH, GUY D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. *Soil Sci. Soc. Amer.* 67: 117-126.
- (9) WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS.
1953. THE UNIFIED SOIL CLASSIFICATION SYSTEM. *Tech. Memo.* 3-357, v. 1.
- (10) UNITED STATES DEPARTMENT OF AGRICULTURE.
1938. SOILS AND MEN. *U.S. Dept. Agr. Ybk.*, 1232 pp., illus.
- (11) ————
1951. SOIL SURVEY MANUAL. *U.S. Dept. Agr. Handbook* 18, 503 pp., illus.
- (12) ————
1959. WORK PLAN FOR THE NATIONAL FOREST RECREATION SURVEY—REVIEW OF THE OUTDOOR RECREATION RESOURCES OF THE NATIONAL FORESTS. *Forest Service.* 123 pp. and app.

Glossary

- Aggregate, soil.** Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.
- Alluvium.** Soil material, such as sand, silt, or clay that has been deposited on land by streams.
- Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.
- 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. In engineering, as used in this report, soil particles smaller than 0.005 millimeter.
- Colluvium.** Soil material, rock fragments, or both, moved by creep, slide, or local wash, and deposited at the base of steep slopes.
- Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—
Loose.—Noncoherent; will not hold together in a mass.
Friable.—When moist, crushes easily under gentle to moderate pressure between thumb and forefinger and can be pressed together into a lump.
Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.
Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.
Sticky.—When wet, adheres to other material; tends to stretch somewhat and pull apart, rather than 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.
- Erosion, soil.** The wearing away or removal of soil material by wind, running water, and other geological agents.
- Exposure.** The direction toward which a slope faces. *Synonym:* aspect.
- Fat clay.** A clay of relatively high plasticity.
- Fertility, soil.** The quality of a soil that enables it to provide compounds in adequate amounts and in proper balance for the growth of specified plants, when other growth factors, such as light, moisture, temperature, and the physical condition of the soil, are favorable.
- Forest.** Land bearing a stand of trees of any age or stature, including seedlings, of species that attain a minimum average height of 6 feet at maturity; or land from which such a stand has been removed but which is not now restocking and which has not been put to other use. Forest on farms is called "farm woodland" or "farm forest."
- Gravel.** Rounded pebbles or angular fragments of rock as much as 3 inches in diameter. The content of gravel is not used in determining the textural class of the soil, but if the soil is as much as 20 percent gravel, the word "gravelly" is added as a prefix to the textural soil name. In engineering, a coarse-grained soil, more than 50 percent of which is retained on a No. 4 (4.7 millimeters) screen.

Horizon, soil. A layer of soil, approximately parallel to the surface that has distinct characteristics produced by soil-forming processes.

Landscape. All the characteristics that distinguish a certain kind of area on the earth's surface and give it a distinguishing pattern, in contrast to other kinds of areas. Any one kind of soil is said to have a characteristic natural landscape, and under different uses it has one or more characteristic cultural landscapes.

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

Loam. Soil consisting of about equal proportions of sand, silt, and clay.

Morphology. The makeup of the soil, including the texture, structure, consistence, color, and other physical, mineralogical, and biological properties of the various horizons of the soil profile.

Noncalcareous. As used in this report, a soil that does not contain enough free lime to effervesce (fizz) with dilute hydrochloric acid.

Parent material. The horizon of weathered rock or partly weathered soil material from which a soil has formed.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *Very slow, slow, moderately slow, moderate, moderately rapid, and rapid.*

Productivity, soil. The present capability of a soil for producing a specified plant or sequence of plants under a specified system of management.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction. The degree of acidity or alkalinity of the soil mass, expressed in words and pH values. A soil that tests to pH 7.0 is precisely neutral in reaction, because it is neither acid nor alkaline. In words, the degrees of acidity or alkalinity are expressed thus:

pH		pH	
Extremely acid...	Below 4.5	Mildly alkaline...	7.4 to 7.8
Very strongly acid.....	4.5 to 5.0	Moderately alkaline.....	7.9 to 8.4
Strongly acid.....	5.1 to 5.5	Strongly alkaline.....	8.5 to 9.0
Medium acid.....	5.6 to 6.0	Very strongly alkaline.....	9.1 and higher.
Slightly acid.....	6.1 to 6.5		
Neutral.....	6.6 to 7.3		

Revegetation. The reestablishment or improvement of a plant cover, either naturally or through reseeding or transplanting.

Sand. As a soil separate, individual rock or mineral fragments ranging from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but sand may be of any mineral composition. As a textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

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 textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Slash. Debris left after logging, pruning, thinning, or brush cutting; also debris left by wind or fire.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. 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 (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer lying beneath the solum, or true soil.

Surface layer (surface soil). Technically, the A horizon; commonly, the part of the soil ordinarily moved by plowing.

Sustained water yield. The amount of water that the soil and underlying material will store and release slowly through springs and seeps to maintain a sustained flow in streams; in contrast with flood yields and surface runoff following storms or rapid snowmelt.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. (See also Clay, Sand, and Silt.) The basic textural classes, in order of increasing proportions of

fine particles, are as follows: sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Water spreading. Diverting runoff from a gully or watercourse onto gently sloping, absorptive soils, in order to conserve waste water, reduce flood peaks, or replenish ground water supplies.

○