

SOIL SURVEY OF

**Santa Cruz** and Parts of

**Cochise** and **Pima Counties, Arizona**



**United States Department of Agriculture**  
**Soil Conservation Service and Forest Service**  
In cooperation with  
**Arizona Agricultural Experiment Station**

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1967-70. Soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1971. This survey was made cooperatively by the Soil Conservation Service, the Forest Service, and the Arizona Agricultural Experiment Station. It is part of the technical assistance furnished to the Hereford and Pima Natural Resource Conservation Districts.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

## HOW TO USE THIS SOIL SURVEY

**T**HIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

### Locating Soils

All the soils of the survey area are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by a symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

### Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the woodland group and range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suit-

ability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

*Farmers and those who work with farmers* can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units, the range sites, and the woodland groups.

*Foresters and others* can refer to the section "Woodland," where the soils of the survey area are grouped according to their suitability for trees.

*Game managers, sportsmen, and others* can find information about soils and wildlife in the section "Wildlife."

*Ranchers and others* can find, under "Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

*Community planners and others* can read about soil properties that affect the choice of the sites for dwellings, industrial buildings, and recreation areas in the sections "Engineering Uses of the Soils" and "Recreation."

*Engineers and builders* can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

*Scientists and others* can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

*Newcomers in the survey area* may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county in the section "Additional Features of the Survey Area."

**Cover:** An area of White House gravelly loam, 0 to 10 percent slopes, in Loamy Upland range site, 16- to 20-inch precipitation zone.

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# SOIL SURVEY OF SANTA CRUZ AND PARTS OF COCHISE AND PIMA COUNTIES, ARIZONA

BY M. L. RICHARDSON, SOIL CONSERVATION SERVICE, AND  
S. D. CLEMMONS AND J. C. WALKER, FOREST SERVICE<sup>1</sup>

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

**T**HE SURVEY AREA is in the southeastern part of Arizona and is bordered by Mexico on the south (fig. 1). It includes all of Santa Cruz County and the adjacent parts of Pima and Cochise Counties in the Coronado National Forest. Total land area is about 1,098,300 acres, or 1,716 square miles. Of the total, 373,940 acres is private and State land and 724,360 acres is National Forest, including 53,159 acres of the Santa Rita Experimental Range.

The survey area is in the Sonoran Desert section of

the Basin and Range Province (5).<sup>2</sup> More than half of the area is mountainous, and much of the rest is deeply dissected old alluvial fans. Elevation ranges from 2,840 feet to 9,466 feet. Annual precipitation ranges from 11 inches to about 28 inches.

Most of the acreage in the survey area is used as range. About 3,000 acres is used for irrigated crops. Some pine and fir woodlands are at the higher elevations, but they are not economically significant for wood crops, because the terrain is rugged. Four man-made lakes, ranging in size from 60 to 250 acres and used for recreation, are in the survey area, as well as other forest recreational sites. Large tracts of range are being subdivided for residential and commercial uses. Nogales is a major port of entry; it is a major processing and distribution point for produce from Mexico to markets in the United States and Canada.

In 1970 the estimated population of the survey area was about 14,000. Lack of water limits urban growth in most areas.

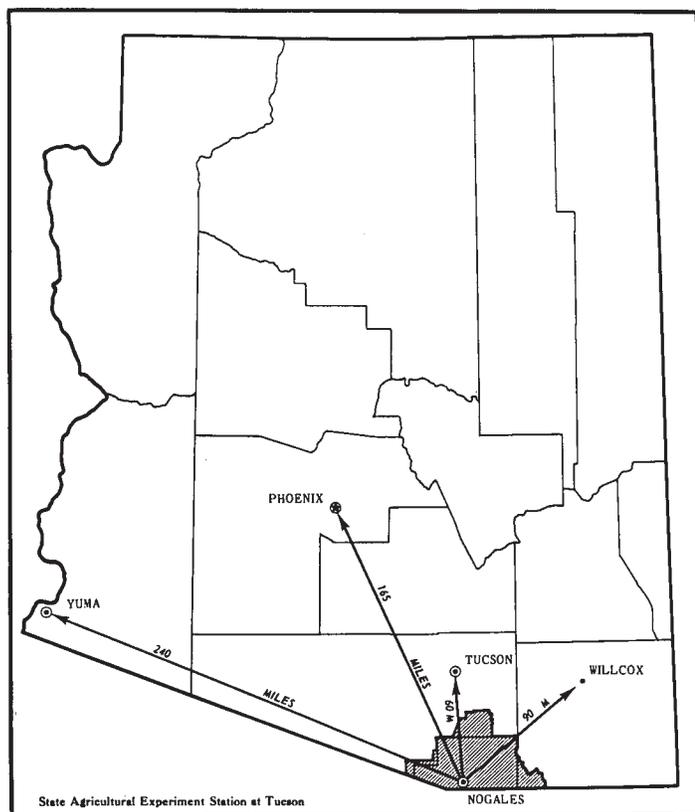
## *How This Survey Was Made*

Soil scientists made this survey to learn what kinds of soil are in the survey area, where they are located, and how they can be used. The soil scientists went into the area knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles

<sup>1</sup> Others who contributed to the mapping of the survey area were J. E. BROWN and W. P. TRIPP, Soil Conservation Service, and T. C. ANDERSON and A. A. LEVEN, Forest Service.

<sup>2</sup> *Italic numbers in parentheses refer to Literature Cited, p. 99.*



**Figure 1.**—Location of Santa Cruz and parts of Cochise and Pima Counties in Arizona.

with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. White House and Sonoita, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, White House cobbly sandy loam, 1 to 15 percent slopes, is one of several phases within the White House series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

A mapping unit consists of all the areas shown on a soil map that are identified by a common symbol. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Three such kinds of mapping units are shown on the soil map of the survey area: soil complexes, soil associations, and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map at the scale of mapping used. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Grabe-Comoro complex, 0 to 5 percent slopes, is an example.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of mapping them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the

dominant soils, joined by a hyphen. Fanno-Luzena association, rolling, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. If there are two or more dominant series represented in the group, the name of the group ordinarily consists of the names of the dominant soils, joined by "and." Torrifluvents and Haplustolls are an example.

In most areas surveyed, there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called miscellaneous land types and are given descriptive names. Mine pits and dumps is an example.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kind of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants, and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or its high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil, and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial interpretations of soils. They test these interpretations by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the interpretations according to the results of their studies and consultation. Thus, the interpretations that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

### **General Soil Map**

The general soil map at the back of this survey shows, in color, the soil associations in the survey area. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in an area, who want to compare different parts of an area, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in the survey area are discussed in the following pages.

Textural classes used in these associations refer to surface textures of representative profiles of the series unless otherwise stated.

### 1. *Comoro-Pima association*

*Deep sandy loams and clay loams; on flood plains*

This association is on the flood plain of the Santa Cruz River. It is north of Nogales. Slope ranges from 0 to 10 percent. The soils are well drained. They formed in recent alluvium and are more than 60 inches deep. Natural vegetation is desert shrubs and sparse grasses. Elevation ranges from 3,000 to 5,000 feet. Average annual precipitation is 11 to 20 inches, and mean annual temperature is 57° to 65° F. The frost-free season is 180 to 265 days.

This association makes up about 1 percent of the survey area. It is about 55 percent Comoro soils and 33 percent Pima soils. The remaining 12 percent is Grabe and Guest soils.

Comoro soils are sandy loam throughout. They are grayish brown in the upper part and light brownish gray in the lower part. They are mainly on the sides of the flood plain and are mostly on deposits from side drainageways.

Pima soils are dark grayish-brown and grayish-brown clay loam throughout. They are on the central part of the flood plain and border the Santa Cruz River.

Runoff is slow, and the hazard of erosion is slight. Low-lying areas along the Santa Cruz River and its side drainageways are subject to flooding.

This association is used for irrigated crops and pasture, building and industrial sites, recreation, wildlife habitat, and limited livestock grazing. Most of the irrigated land in the survey area is in this association.

### 2. *Continental-Sonoita association*

*Deep gravelly sandy loams; on fans and terraces*

This association is on fans and terraces on both sides of the Santa Cruz River. It extends from the northern boundary of the survey area southward to the vicinity of Tumacacori. Slopes range from 1 to 20 percent. The soils are more than 60 inches deep. Vegetation is desert shrubs and grass. Elevation ranges from 2,900 to 5,000 feet. Average annual precipitation is 10 to 14 inches, and mean annual temperature is 59° to 65° F. The frost-free season is 200 to 270 days.

This association makes up about 6 percent of the survey area. It is about 24 percent Continental soils, 21 percent Sonoita soils, and 14 percent each of Rillino, Comoro, and Anthony soils. The remaining 13 percent is Eba soils, gravelly alluvium in the drainageways, Calciorthids-Haplargids association, Pinaleno soils, and small areas of Cave soils and Pima variant and Anthony variant soils.

Continental soils are on older fans or terrace remnants. They have a surface layer of reddish-brown gravelly sandy loam and a subsoil of reddish-brown and red gravelly clay. They have a distinct lime zone at a moderate depth.

Sonoita soils are on reworked fan remnants. They have a surface layer of brown gravelly sandy loam and a subsoil of weakly developed reddish-brown, light-brown, and yellowish-red gravelly sandy loam.

Runoff is slow or medium. The hazard of erosion is slight. Gentle winter rains are absorbed and produce little runoff, but brief, hard summer thundershowers at times produce rapid runoff and moderate to high sedimentation.

The association is mainly used for grazing by livestock and wildlife. A major part of the Santa Rita Experimental Range lies within this association. Some areas are used for homesites.

### 3. *Bernardino-White House-Hathaway association*

*Deep gravelly clay loams, gravelly sandy loams, gravelly loams, or clays; on fans or piedmont plains*

This association is mainly in the Sonoita-Elgin area and in the San Raphael Valley. Slopes range from 0 to about 45 percent. The soils are more than 60 inches deep, and they formed in old alluvium from igneous and calcareous sedimentary rocks. Vegetation is mainly perennial grasses and forbs. A few oak and juniper trees are at the higher elevations. Elevation ranges from 3,300 to 5,400 feet. Average annual precipitation is 12 to 20 inches, and mean annual temperature is 57° to about 65° F. The frost-free season is 160 to 240 days.

This association makes up about 10 percent of the survey area. It is about 38 percent Bernardino soils, 28 percent White House soils, and 15 percent Hathaway soils. The remaining 19 percent is Kimbrough, Bonita, Guest, Pima and Caralampi variant soils.

Bernardino and Hathaway soils occur in a highly mixed pattern. Bernardino soils have a surface layer of dark-brown gravelly clay loam and a subsoil of dark reddish-brown gravelly clay loam or clay. They have a zone of lime accumulation at a depth of 10 to 20 inches.

Hathaway soils have a surface layer of brown gravelly sandy loam and gravelly sandy clay loam and a substratum of grayish-brown, light-gray, and pinkish-gray gravelly sandy loam and light reddish-brown sandy loam. They are strongly calcareous. They contain more than 35 percent, by volume, gravel and cobbles.

White House soils have a surface layer of brown gravelly loam and a subsoil of reddish clay or clay loam and yellowish and pink gravelly sandy clay loam. They have a weak lime zone deep in the profile. They contain less than 35 percent, by volume, rock fragments.

Runoff is slow or medium, and the hazard of erosion is slight to high. Most soils have moderate or high available water capacity. This association is mainly used for grazing by livestock and wildlife. Large areas in the vicinity of Sonoita are being subdivided into homesites.

#### 4. *Caralampi-White House-Hathaway association*

*Deep gravelly loams or gravelly sandy loams; on dissected fans and piedmonts in a very warm climate*

This association is on deeply dissected old alluvial fans and piedmonts that form a series of narrow-top ridges and long axial waterways that have short side drainageways. It is mainly in the central part of the survey area, but small areas are in the southwestern part. Vertical relief ranges from 50 to about 200 feet, and slopes range from 10 to 60 percent. The soils are more than 60 inches deep. They formed in old alluvium from mixed igneous and sedimentary rocks. Vegetation is mainly grama grasses, forbs, and scattered brush. Elevation ranges from 3,000 to 5,400 feet. Average annual precipitation is 12 to 18 inches, and mean annual temperature is 57° to 65° F. The frost-free season is from 190 to 230 days.

This association makes up about 18 percent of the survey area. It is about 40 percent Caralampi soils, 31 percent White House soils, and 12 percent Hathaway soils. The remaining 17 percent is Signal soils, recent alluvium in the drainageways, and small areas of Bernardino soils.

Caralampi soils have a surface layer of dark-brown gravelly sandy loam and a subsoil of dominantly reddish-brown and yellowish-red gravelly sandy clay loam and very gravelly sandy loam. They have more than 35 percent, by volume, gravel in the subsoil. Slopes are 10 to 60 percent.

White House soils have a surface layer of brown gravelly loam and a subsoil of reddish clay or clay loam and yellowish and pink gravelly sandy clay loam. They have a weak lime zone deep in the profile. They are less than 35 percent, by volume, rock fragments. Slopes are 10 to 35 percent.

Hathaway soils have a surface layer of brown gravelly sandy clay loam and a substratum of grayish-brown, light-gray, and pinkish-gray gravelly sandy loam and light reddish-brown sandy loam. They are strongly calcareous. They are more than 35 percent, by volume, gravel and cobbles. Slopes are 10 to 50 percent.

Runoff is slow to rapid, and the hazard of erosion is slight to high. Permeability is moderate or slow, and available water capacity is low to high.

This association is mainly used for grazing by livestock and wildlife. Large areas in the vicinity of Nogales are being subdivided for homesites.

#### 5. *Casto-Martinez-Canelo association*

*Deep gravelly sandy loams, gravelly loams, gravelly clay loams, gravelly sandy clay loams, or very gravelly sandy loams; on dissected fans and piedmonts in a warm climate*

This association is on dissected high old alluvial fans or piedmonts in the southeastern part of Santa Cruz

County and the southwestern part of Cochise County. Areas range from long, narrow, rounded ridges that have steep side slopes to fairly broad-top, gently sloping mesas that have steep side slopes. Slopes range from about 1 percent on the tops of mesas to 40 percent on the sides. Vertical relief ranges from 25 feet to about 200 feet. The soils are more than 60 inches deep. They formed in old alluvium from mixed sedimentary and igneous rocks. Vegetation is oak and juniper trees, shrubs, and grasses. Elevation ranges from 5,000 to 6,500 feet. Average annual precipitation is 15 to 20 inches, and mean annual temperature is about 53° to 57° F. The frost-free season is 140 days to about 200 days.

This association makes up about 7 percent of the survey area. It is about 46 percent Casto soils, 18 percent Martinez soils, and 12 percent Canelo soils. The remaining 24 percent is alluvium in the drainageways and small areas of White House soils and Calciorthids-Haplargids association.

Casto soils are deep, well-drained, slowly permeable soils. They are more than 35 percent, by volume, gravel and cobbles and are neutral to moderately alkaline. They have a surface layer of dark grayish-brown very gravelly sandy loam and a subsoil of dark grayish-brown, reddish-brown, and pinkish-gray gravelly sandy clay loam. They are on the sides and tops of narrow ridges and the steep side slopes of broad-top ridges.

Martinez soils are deep, well-drained, slowly permeable soils. They contain a small amount of gravel. They have a surface layer of brown gravelly loam and clay loam and a subsoil that is dark-brown, dark yellowish-brown, and yellowish-brown clay in the upper part and yellowish-brown, red, and brownish-yellow gravelly sandy clay in the lower part. They are on the nearly level tops of the broader ridges.

Canelo soils are deep, somewhat poorly drained, very slowly permeable soils. They are more than 35 percent, by volume, gravel and cobbles and are slightly acid to extremely acid. They have a surface layer of brown gravelly sandy loam and subsurface layer of very pale brown and light-gray very gravelly sandy loam. The subsoil is mostly pinkish-white, reddish-yellow, yellowish-red, and red very gravelly or very cobbly clay or sandy clay. These soils are on the sides and tops of narrow ridges.

Runoff is slow or medium, and the hazard of erosion is slight to high. Permeability is slow to very slow, and available water capacity is low to high.

This association is used for range, wildlife habitat, and recreation. An area near Parker Canyon Lake is subdivided for homesites and campsites.

#### 6. *Lampshire-Chiricahua-Graham association*

*Shallow and very shallow very cobbly loams, very cobbly clay loams, or cobbly sandy loams; on foothills and mountains in a very warm climate*

This association is on lower mountains and foothills west of the Santa Cruz River and in parts of the Santa Rita and Patagonia Mountains. Bedrock is predominantly rhyolite, andesite tuffs, granite, and tuff-conglomerate. In a few small areas, it is shale. Slopes range from 0 to 60 percent. Vegetation is grass and

shrubs at lower elevations and oak and juniper trees at higher elevations. Elevation ranges from 3,000 to 5,500 feet. Average annual precipitation is 12 to 18 inches, and mean annual temperature is 57° to 64° F. The frost-free season is 170 to 220 days.

This association makes up about 41 percent of the survey area. It is 28 percent Lampshire soils, 13 percent Chiricahua soils, 10 percent Graham soils, and 15 percent Rock outcrop. The remaining 34 percent is Atascosa and Schrap soils and alluvium in the drainageways.

Lampshire soils are on mountains. They are 4 to 20 inches deep to igneous bedrock. The surface layer is very gravelly, very cobbly, or very stony loam and sandy loam.

Chiricahua soils are on foothills and low mountains. They are 10 to 20 inches deep to weathered granitic or tuff-conglomerate bedrock. They have a surface layer that is mostly dark-brown cobbly sandy loam. The subsoil is mostly dark reddish-brown gravelly clay loam or clay.

Graham soils are on the lower parts of mountains. They are 10 to 20 inches deep to andesite or andesite-tuff bedrock. They have a surface layer of grayish-brown cobbly clay loam and a subsoil of dark-brown or dark grayish-brown clay.

Runoff is medium or rapid, and the hazard of erosion is slight to high. Permeability above bedrock is moderate or slow, and available water capacity is very low or low.

This association is used for range, wildlife habitat, recreation, and homesites.

#### 7. *Faraway-Rock outcrop-Barkerville association*

*Very shallow and shallow very cobbly or cobbly fine sandy loams or sandy loams and areas of Rock outcrop; on mountains in a warm climate*

This association is on the higher ranges of the Santa Rita, Patagonia, and Huachuca Mountains and on part of the Canelo Hills. Slopes range from 10 to 60 percent. Vegetation is ponderosa pine, Douglas-fir, and white fir at high elevations and tree-oak juniper, pinyon pine, Arizona madrone, and Chihuahuah pine at lower elevations. Shrubs and grass form an understory. Elevation ranges from 5,000 to 7,500 feet. Average annual precipitation is 16 to 25 inches, and mean annual temperature is 50° to 58° F. The frost-free season is 140 to 220 days.

This association makes up about 12 percent of the survey area. It is 38 percent Faraway soils, 22 percent Rock outcrop, and 21 percent Barkerville soils. The remaining 19 percent is Gaddes, Fanno, Hogris, and Telephone soils, Luzena variant soils, Fanno variant soils, and alluvium in the drainageways.

Faraway soils are on mountains between areas of Rock outcrop. They are 4 to 20 inches deep to rhyolite, andesite, or rhyodacite bedrock and are mostly very cobbly sandy loams.

Rock outcrop is mainly bare bedrock, rock ledges, and pinnacles near mountain tops. It is mostly granite, andesite, rhyolite-tuffs, rhyodacite, limestone, sandstone, and quartzite.

Barkerville soils are on mountains that are dissected

by numerous drainageways. They are 10 to 20 inches deep over weathered granite and are gravelly or cobbly sandy loam.

Runoff is medium or rapid, and the hazard of erosion is moderate or high. These soils have very low available water capacity because they are shallow and have a high content of rock fragments.

This association is used for range and wildlife, water supply, recreation, and limited timber production. Much of the area is too steep and rocky for use by livestock.

#### 8. *Tortugas-Rock outcrop association*

*Shallow and very shallow very cobbly loams and areas of Rock outcrop; mainly on limestone mountains in a warm climate*

This association is mostly on limestone mountains, but also included are small areas of quartzite, sandstone, and shale rocks. Slopes range from 5 percent to more than 60 percent. At the lower elevations the vegetation is brush and grass, and at higher elevations it is oak, juniper, and pine trees. Elevation ranges from 4,800 to 7,000 feet. Average annual precipitation ranges from 16 to 24 inches, and mean annual temperature is 48° to 58° F. The frost-free season is 140 to 220 days.

This association makes up about 5 percent of the survey area. It is 33 percent Tortugas soils and 25 percent Rock outcrop. The remaining 42 percent is Mabray, Faraway, Chiricahua, and Telephone soils.

Tortugas soils are on limestone mountains between areas of Rock outcrop. They are very cobbly loam 6 to 20 inches deep, and they formed mostly in residuum from limestone.

Rock outcrop consists mainly of bare bedrock, rock ledges, and pinnacles near mountaintops.

Runoff is medium or rapid, and the hazard of erosion is slight to moderate. These soils have very low available water capacity because they are shallow and have a high content of rock fragments.

This association is used for range, wildlife habitat, and recreation. Most of the area is too rocky and steep for livestock grazing.

### *Descriptions of the Soils*

In this section the soils of the survey area are described in detail and their use and management are discussed. Each soil series is described in detail and then, briefly, the mapping units in that series are described. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for dry soil unless

otherwise stated. The profile described in the soil series is representative for mapping units in that series. If a given mapping unit has a profile different in some way from the one described in the series, these differences are stated in the description of the mapping unit or they are apparent in the name of the mapping unit. The description of each mapping unit contains suggestions on how the soil can be managed.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Torrifluvents and Haplustolls, for example, do not belong to a soil series, but nevertheless are listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a sym-

bol. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, range site, and range productivity group in which the mapping unit has been placed. The page for the description of each capability unit and range site can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about terminology and the methods of soil mapping can be obtained from the Soil Survey Manual (10).

TABLE 1.—Approximate acreage and proportionate extent of the soils

| Soil   | Area   |                  | Soil   | Area      |                  |
|--|--------|------------------|--|-----------|------------------|
|  | Acrea  | Percent          |  | Acrea     | Percent          |
| Anthony soils  | 10,050 | 0.9              | Hathaway soils, 1 to 40 percent slopes, eroded                   | 6,530     | 0.6              |
| Anthony soils, very gravelly variants                          | 780    | .1               | Hogris-Telephone association, steep                              | 230       | ( <sup>1</sup> ) |
| Atascosa very gravelly sandy loam, 30 to 50 percent slopes     | 6,900  | .6               | Hogris-Telephone-Rock outcrop association, very steep            | 2,200     | .2               |
| Barkerville-Gaddes complex, 10 to 30 percent slopes            | 9,480  | .9               | Kimbrough soils, 2 to 10 percent slopes                          | 2,770     | .3               |
| Barkerville-Gaddes association, steep                          | 38,670 | 3.5              | Lampshire very gravelly sandy loam, 0 to 25 percent slopes       | 2,280     | .2               |
| Bernardino-Hathaway association, rolling                       | 75,630 | 6.9              | Lampshire very gravelly sandy loam, 25 to 50 percent slopes      | 32,920    | 3.0              |
| Bonita clay, 0 to 5 percent slopes                             | 390    | ( <sup>1</sup> ) | Lampshire-Chiricahua association, steep                          | 86,800    | 7.9              |
| Calciorthids-Haplargids association                            | 2,410  | .2               | Lampshire-Graham-Rock outcrop association, steep                 | 95,600    | 8.7              |
| Canelo gravelly sandy loam, 0 to 20 percent slopes             | 300    | ( <sup>1</sup> ) | Luzena gravelly loam, deep variant, 5 to 20 percent slopes       | 4,850     | .4               |
| Canelo very gravelly sandy loam, 20 to 40 percent slopes       | 7,510  | .7               | Mabray-Chiricahua-Rock outcrop association, steep                | 8,970     | .8               |
| Canelo cobbly sandy loam, 0 to 20 percent slopes               | 1,130  | .1               | Martinez gravelly loam   | 11,940    | 1.1              |
| Caralampi gravelly sandy loam, 10 to 40 percent slopes         | 37,090 | 3.4              | Mine pits and dumps  | 250       | ( <sup>1</sup> ) |
| Caralampi gravelly sandy loam, 10 to 60 percent slopes, eroded | 29,610 | 2.7              | Pima soils   | 18,000    | 1.6              |
| Caralampi gravelly loam, brown variant, 1 to 5 percent slopes  | 1,900  | .2               | Pima clay loam, sandy clay loam subsoil variant                  | 920       | .1               |
| Casto very gravelly sandy loam, 10 to 40 percent slopes        | 33,280 | 3.0              | Pinaleno gravelly sandy loam, 0 to 10 percent slopes             | 11,160    | 1.0              |
| Cave gravelly sandy loam                                       | 800    | .1               | Rillino soils, 8 to 40 percent slopes, eroded                    | 10,550    | 1.0              |
| Chiricahua cobbly sandy loam, 10 to 45 percent slopes          | 8,500  | .8               | Rock outcrop-Lithic Haplustolls association                      | 60,350    | 5.5              |
| Chiricahua-Lampshire association, rolling                      | 36,120 | 3.3              | Rock outcrop   | 550       | .1               |
| Comoro sandy loam, 5 to 10 percent slopes                      | 2,290  | .2               | Schrap very shaly clay loam, 5 to 20 percent slopes <sup>1</sup> | 4,900     | .4               |
| Comoro soils, 0 to 5 percent slopes                            | 37,170 | 3.4              | Schrap cobbly clay loam, 20 to 50 percent slopes                 | 2,300     | .2               |
| Continental soils, 1 to 10 percent slopes                      | 15,350 | 1.4              | Signal soils, 1 to 20 percent slopes                             | 11,920    | 1.1              |
| Continental-Rillino complex, 1 to 40 percent slopes, eroded    | 4,320  | .4               | Sonoita gravelly sandy loam, 1 to 8 percent slopes               | 14,520    | 1.3              |
| Eba very gravelly sandy loam, 0 to 10 percent slopes           | 4,320  | .4               | Sonoita gravelly sandy loam, 8 to 20 percent slopes              | 410       | ( <sup>1</sup> ) |
| Fanno-Luzena association, rolling                              | 10,380 | 1.0              | Torrifluvents and Haplustolls                                    | 7,930     | .7               |
| Fanno soils, acid variants, 20 to 50 percent slopes            | 1,980  | .2               | Tortugas-Rock outcrop complex, 5 to 25 percent slopes            | 9,220     | .8               |
| Faraway-Rock outcrop complex, 10 to 30 percent slopes          | 32,720 | 3.0              | Tortugas-Rock outcrop complex, 25 to 60 percent slopes           | 14,040    | 1.3              |
| Faraway-Rock outcrop complex, 30 to 60 percent slopes          | 44,180 | 4.0              | White House gravelly loam, 0 to 10 percent slopes                | 24,360    | 2.2              |
| Faraway-Tortugas-Rock outcrop association, steep               | 18,030 | 1.6              | White House gravelly loam, 10 to 35 percent slopes               | 42,490    | 3.9              |
| Gaddes very gravelly sandy loam, 5 to 30 percent slopes        | 1,810  | .2               | White House cobbly sandy loam, 1 to 15 percent slopes            | 14,760    | 1.3              |
| Grabe-Comoro complex, 0 to 5 percent slopes                    | 12,100 | 1.1              | White House-Bonita complex, 0 to 10 percent slopes               | 6,130     | .6               |
| Grabe soils  | 5,910  | .5               | White House-Caralampi complex, 10 to 35 percent slopes           | 34,820    | 3.2              |
| Graham soils, 5 to 20 percent slopes                           | 11,990 | 1.1              | White House-Hathaway association, steep                          | 27,490    | 2.5              |
| Graham soils, 20 to 50 percent slopes                          | 5,670  | .5               | Water areas  | 640       | .1               |
| Guest soils  | 9,220  | .8               |  |           |                  |
| Hathaway gravelly sandy loam, 20 to 50 percent slopes          | 7,510  | .7               | Total  | 1,098,300 | 100.0            |

<sup>1</sup> Less than 0.1 percent.

## Anthony Series

The Anthony series consists of well-drained soils that are 60 inches or more in depth. These soils formed in stratified alluvium weathered from granite, rhyolite, tuffs, and limestone on alluvial fans and flood plains. Slopes are 0 to 5 percent. Elevation ranges from 2,900 to 3,800 feet. Vegetation is dominantly mesquite, paloverde, burweed, three-awns, bush muhly, annuals and cacti. Average annual precipitation is 11 to 12 inches, and mean annual temperature is 65° F. The frost-free season is 200 to 250 days.

In a representative profile the surface layer is light yellowish-brown fine sandy loam about 3 inches thick. The underlying material is brown and reddish-brown sandy loam stratified with sand to loam and gravelly sand to gravelly loam to a depth of 60 inches or more. The profile is mildly alkaline in the surface layer and moderately alkaline below the surface layer. It is calcareous throughout.

Permeability is moderately rapid, and available water capacity is moderate. Effective rooting depth is 60 inches or more.

These soils are used for range, recreation, and wild-life habitat.

Representative profile of Anthony fine sandy loam in an area of Anthony soils, 350 feet north of the south quarter corner of sec. 3, T. 18 S., R. 14 E., on the Santa Rita Experimental Range, Pima County:

- A1—0 to 3 inches, light yellowish-brown (10YR 6/4) fine sandy loam, dark yellowish brown (10YR 4/4) when moist; weak, thick, platy structure and weak, fine, granular; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine and fine roots; many very fine interstitial pores and few fine tubular pores; 5 percent gravel by volume; slightly effervescent in spots; mildly alkaline; clear, wavy boundary.
- C1—3 to 8 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine and fine roots; very fine and fine tubular pores; 5 percent gravel by volume; slightly effervescent but strongly effervescent in spots; moderately alkaline; clear, wavy boundary.
- C2—8 to 22 inches, brown (7.5YR 5/4) sandy loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and nonplastic when wet; common very fine and fine roots; many fine interstitial pores and common very fine and fine tubular pores; 15 percent gravel by volume; strongly effervescent; moderately alkaline; clear, wavy boundary.
- C3—22 to 36 inches, reddish-brown (5YR 5/4) gravelly light sandy loam, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine and fine roots; many fine interstitial pores; 20 percent gravel by volume; slightly effervescent; moderately alkaline; clear, wavy boundary.
- C4—36 to 47 inches, brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist; slightly sticky and slightly plastic when wet; common very fine and fine roots; many very fine and fine tubular pores; 5 percent gravel by volume; strongly effervescent; moderately alkaline; abrupt, wavy boundary.
- C5—47 to 60 inches, brown (7.5YR 5/4) light sandy loam, dark brown (7.5YR 4/4) when moist; massive;

slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine and fine roots; many fine tubular pores; 15 percent gravel by volume; strongly effervescent; moderately alkaline.

The A horizon has hue of 10YR or 7.5YR, value of 5 or 6 when dry and 3 or 4 when moist, and chroma of 2 to 4. It is fine sandy loam, sandy loam, or gravelly sandy loam. It is mildly alkaline to moderately alkaline and is effervescent in places. The C horizon has hue that is generally 10YR or 7.5YR but is 5YR in places, value of 5 to 7 when dry and 4 or 5 when moist, and chroma of 2 to 6. It is dominantly sandy loam or fine sandy loam and contains as much as 35 percent gravel. It is stratified with thin layers that range from sand to loam and are gravelly in places. Gravel is mostly fine.

**An—Anthony soils.** The soils in this undifferentiated group are on alluvial fans and flood plains. Slopes are dominantly 1 to 3 percent but range from 0 to 5 percent. Numerous shallow drainageways dissect the areas. The surface is 10 to 40 percent gravel. Along drainageways the soils are generally gravelly throughout. Low hummocks around vegetation and low rodent mounds and burrows are common.

The dominant soil in this mapping unit is Anthony fine sandy loam, and this soil has the profile described as representative of the series. Other soils in this mapping unit are similar, but they have a surface layer of sandy loam and gravelly sandy loam.

Included with these soils in mapping are small areas of Sonoita soils and small areas of gravelly and very gravelly Torrifluvents along some of the larger drainageways.

Runoff is medium. The hazard of erosion is slight. Some areas are subject to flooding.

These soils are used for range and wildlife habitat. Capability unit VIs, nonirrigated; Sandy Loam range site, 12- to 16-inch precipitation zone; range productivity group 2.

## Anthony Variant

The Anthony variant consists of well-drained soils on alluvial fans. These soils are 60 inches or more in depth. They formed in recent gravelly alluvium derived from granitic and limestone rocks. Slopes are 1 to 5 percent. The vegetation is dominantly creosote-bush, mesquite, paloverde, ocotillo, fluffgrass, three-awn, bush muhly, and wolftail. Elevation ranges from 3,000 to 3,600 feet. Average annual precipitation is about 12 inches, and mean annual temperature is 65° F. The frost-free season is 200 to 250 days.

In a representative profile the upper 16 inches is pale-brown and light yellowish-brown fine sandy loam. Below this is light yellowish-brown very gravelly fine sandy loam to a depth of 60 inches or more. The profile is moderately alkaline and calcareous throughout.

Permeability is moderately rapid, and available water capacity is low. Effective rooting depth is more than 60 inches.

These soils are used for range and wildlife habitat.

Representative profile of Anthony fine sandy loam, very gravelly variant, in an area of Anthony soils, very gravelly variants, 1,980 feet east and 2,310 feet north of the southwest corner of sec. 32, T. 13 S., R. 15 E., on the Santa Rita Experimental Range, Pima County:

A1—0 to 2 inches, pale-brown (10YR 6/3) fine sandy loam, dark brown (10YR 4/3) when moist; weak, thick, platy structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; few very fine and fine roots; common very fine interstitial pores; 5 percent gravel by volume; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

C1—2 to 16 inches, light yellowish-brown (10YR 6/4) fine sandy loam, dark brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; common fine and very fine roots; common very fine interstitial pores; 5 to 10 percent gravel by volume; violently effervescent; moderately alkaline; gradual, wavy boundary.

IIC2—16 to 60 inches, light yellowish-brown (10YR 6/4) very gravelly fine sandy loam, dark brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; many fine and very fine roots; common very fine interstitial pores; 40 percent gravel and 15 percent cobbles by volume; violently effervescent; moderately alkaline.

The A horizon has hue of 10YR or 7.5YR, value of 5 to 7 when dry and 3 to 5 when moist, and chroma of 2 to 4. It is 5 to 40 percent gravel.

The C1 horizon has hue of 10YR or 7.5YR, value of 5 or 6 when dry and 3 or 4 when moist, and chroma of 3 or 4. It is fine sandy loam or gravelly fine sandy loam and is 5 to 35 percent gravel and as much as 15 percent cobbles.

The IIC horizon has hue of 10YR or 7.5YR and value of 5 to 7 when dry and 3 to 5 when moist. It is gravelly or very gravelly fine sandy loam or sandy loam. It is 35 to 70 percent gravel and cobbles. The content of cobbles is as much as 15 percent in places. The A and C1 horizons are strongly effervescent to violently effervescent, and the IIC horizon is violently effervescent. Pinkish-white or white lime filaments, soft masses, and gravel coatings are common throughout the C horizon.

**Ao—Anthony soils, very gravelly variants.** The soils in this undifferentiated group are on alluvial fans that are dissected by numerous shallow drainageways. Slopes are 1 to 5 percent. The surface layer is fine sandy loam, sandy loam, gravelly fine sandy loam, and gravelly sandy loam. About 10 to 40 percent of the surface is gravel, and as much as 5 percent is cobbles. An Anthony fine sandy loam, very gravelly variant, in an area of this mapping unit has the profile described as representative of these soils.

Included with these soils in mapping were small areas of Cave and Anthony soils.

Runoff is medium, and the hazard of erosion is slight. Flash floods occasionally occur during the rainy season and sometimes overflow the natural drainage channels.

These soils are used for range and wildlife habitat. Capability unit VIs, nonirrigated; Sandy Loam range site, 12- to 16-inch precipitation zone; range productivity group 3.

### Atascosa Series

The Atascosa series consists of well-drained soils that are 4 to 20 inches in depth. These soils formed in material weathered from rhyolitic-tuff conglomerate. They are on hills and ridges. Slopes are convex and range from 30 to 50 percent. Elevation is 3,600 to 4,700 feet. Vegetation is scattered oak and mesquite trees and perennial grasses; grammas, bluestems, and three-awns are dominant. Average annual precipita-

tion is 14 to 18 inches, and mean annual temperature is 57° to 63° F. The frost-free season is 200 to 250 days.

In a representative profile the surface layer is dark grayish-brown very gravelly sandy loam about 2 inches thick. The subsoil is dark-gray very gravelly sandy clay loam about 7 inches thick overlying fractured rhyolitic-conglomerate bedrock at a depth of about 9 inches. The surface layer is neutral, and the subsoil is mildly alkaline.

Permeability is moderate to bedrock, and available water capacity is very low. Effective rooting depth is 4 to 20 inches.

These soils are used for range and wildlife habitat.

Representative profile of Atascosa very gravelly sandy loam, 30 to 50 percent slopes, in range, 1,320 feet east and 1,980 feet north of the southwest corner of sec. 2, T. 23 S., R. 11 E., Santa Cruz County:

A1—0 to 2 inches, dark grayish-brown (10YR 4/2) very gravelly sandy loam, very dark grayish brown (10YR 3/2) when moist, crushed color is grayish brown (10YR 5/2); weak, fine and medium, granular structure; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; common fine roots; common fine interstitial pores; 30 percent gravel and 20 percent cobbles by volume; neutral; abrupt, wavy boundary.

B2t—2 to 9 inches, dark-gray (10YR 4/1) very gravelly sandy clay loam, very dark grayish brown (10YR 3/2) when moist, crushed color is gray (10YR 5/1); weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; common fine roots; few fine tubular pores; few thin clay films on faces of peds and in pores; 25 percent gravel, 25 percent cobbles and occasional stones; mildly alkaline; abrupt, irregular boundary.

R—9 to 15 inches, white (10YR 8/2) fractured rhyolitic conglomerate bedrock.

Depth to bedrock ranges from 4 to 20 inches. The A horizon has hue of 7.5YR or 10YR, value of 2 or 3 when moist, and chroma of 1 to 3. It is gravelly loam, gravelly sandy loam, or very gravelly sandy loam. The B horizon has hue of 7.5YR or 10YR, value of 2 or 3 when moist, and chroma of 1 to 3. The Bt horizon is gravelly or very gravelly sandy clay loam. The profile is 35 to 50 percent or more gravel and cobbles and is slightly acid to mildly alkaline.

**AtF—Atascosa very gravelly sandy loam, 30 to 50 percent slopes.** This soil is on long convex ridges of consolidated rhyolitic conglomerate fans on the east and west side slopes of the Atascosa Mountains. The surface is 50 to 60 percent gravel, 5 to 10 percent cobbles, and a few stones. This soil has the profile described as representative of the series.

Included in mapping are ledges of tuff-conglomerate Rock outcrop in 20 to 30 percent of the area. Also included are 5 to 10 percent each of Graham and Lampshire soils, small areas of Caralampi soils, and about 5 percent narrow bands of Comoro soils and gravelly Haplustolls in the drainageways.

Runoff is rapid. The hazard of erosion is moderate.

This soil is used for range and wildlife habitat. Capability unit VIIs, nonirrigated; Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 4.

### Barkerville Series

The Barkerville series consists of well-drained soils

on mountains and hills. These soils are 20 to 40 inches in depth over slightly weathered granite bedrock. Slopes range from 10 to 60 percent. At the lower elevations the vegetation is dominantly oak, pinyon pine, juniper, manzanita, squawberry, plains lovegrass, and grama grasses. At higher elevations it is Ponderosa, Chihuahua, and limber pine and deergrass. Elevation ranges from 5,000 to 7,500 feet. Average annual precipitation is 18 to 25 inches, and mean annual temperature ranges from 50° to 57° F. The frost-free season is 160 to 220 days.

In a representative profile the surface layer is dark grayish-brown cobbly sandy loam about 6 inches thick. The underlying material is yellowish-brown coarse sandy loam, about 8 inches thick, over yellowish-brown to white granite that grades into more consolidated bedrock at a depth of about 30 inches. The surface layer is mildly alkaline, and the underlying material is neutral to slightly acid.

Permeability is moderate or moderately rapid, and available water capacity is very low. Effective rooting depth is 20 to 40 inches.

These soils are used for range, wildlife habitat, recreation, and mining. A small amount of timber is produced above an elevation of about 7,000 feet.

Representative profile of Barkerville cobbly sandy loam in an area of Barkerville-Gaddes complex, 10 to 30 percent slopes, in the southwest quarter of the southwest quarter of sec. 28, T. 23 S., R. 16 E., Santa Cruz County:

- A1—0 to 6 inches, dark grayish-brown (10YR 4/2) cobbly sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine and fine roots; common very fine and fine interstitial pores; 20 percent cobbles and gravel and a few stones; mildly alkaline; gradual, wavy boundary.
- C1—6 to 14 inches, yellowish-brown (10YR 5/4) coarse sandy loam, dark yellowish brown (10YR 4/4) when moist; weak, medium, subangular blocky structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine and fine roots; common very fine and fine interstitial pores; 5 to 10 percent gravel; neutral; abrupt, wavy boundary.
- C2—14 to 30 inches, yellowish-brown (10YR 5/6), yellow (10YR 7/6), and white (10YR 8/2) decomposed granite.
- R—30 to 40 inches, white (10YR 8/2) and yellow (10YR 7/6) granite bedrock.

Depth to weathered granite ranges from 10 to 20 inches, and depth to consolidated, slightly weathered granite ranges from 20 to 40 inches. Stones and cobbles make up 0 to 30 percent of the profile. The profile is 12 to 50 percent fine angular gravel and averages less than 35 percent gravel, cobbles, and stones.

The A horizon has hue of 10YR and 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is gravelly sandy loam or cobbly sandy loam. A thin (less than 1 inch) layer of very gravelly loamy sand is on the surface in places. The A horizon ranges from slightly acid to mildly alkaline.

The C horizon has hue of 10YR or 7.5YR, value of 5 to 8 when dry and 4 to 7 when moist, and chroma of 2 to 6. It is slightly acid to mildly alkaline. The C1 horizon is sandy loam or gravelly sandy loam.

**BaE—Barkerville-Gaddes complex, 10 to 30 percent slopes.** This mapping unit is on low mountains and

foothills that are dissected by numerous short drainageways. It is about 50 percent Barkerville soils, 20 to 30 percent Gaddes soils, and 20 to 30 percent included soils and Rock outcrop.

Barkerville soils are on all aspects. The surface layer is dominantly cobbly sandy loam, but in places it is gravelly, very gravelly, very cobbly, and stony sandy loam. Gaddes soils are commonly on south and west aspects in areas where slopes are gentle. Both soils have profiles similar to those described as representative of their series, except for the texture of the surface layer. The surface is 30 to 60 percent gravel, 5 to 20 percent cobbles, and as much as 10 percent stones.

Included in mapping are areas of Rock outcrop on low ridges and ledges and areas of Comoro gravelly sandy loam along drainageways and on short alluvial fans. Each of these included areas makes up 10 to 15 percent of the mapped areas.

Runoff is medium. The hazard of erosion is moderate.

These soils are used for range, wildlife habitat, and recreation. A few small mines produce copper, lead, zinc, and molybdenum. Capability unit VIe, nonirrigated; Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 4.

**BgF—Barkerville-Gaddes association, steep.** This association is on granitic mountains. It is mainly in the Santa Rita and Huachuca Mountains. Slopes range from 30 to 60 percent. The soils are generally in an intermingled pattern, and the proportion of one soil to another varies within a mapped area. In a few mapped areas the Gaddes soils are lacking. The mapping unit is about 60 percent Barkerville soils, 25 percent Gaddes soils, and 15 percent Rock outcrop.

Barkerville soils and Rock outcrop are generally steeper than Gaddes soils. Areas of Rock outcrop are low ledges and occasional ridges and pinnacles. Barkerville and Gaddes soils in this unit have profiles similar to those described as representative of their series, but the sandy loam surface layer is gravelly, very gravelly, cobbly, very cobbly, or stony. About 50 percent of the surface is gravel, 20 percent is cobbles, and 10 percent is stones.

Included in mapping are areas above 7,500 or 8,000 feet that are slightly colder.

Runoff is rapid. The hazard of erosion is high.

These soils are used for range, wildlife habitat, and recreation. There is a limited amount of timber production at the higher elevations, and a few mines are in the mapped areas. Capability unit VIIe, nonirrigated; Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 4; woodland suitability group 2 above an elevation of about 7,000 feet.

## Bernardino Series

The Bernardino series consists of well-drained soils that are 60 inches or more in depth. These soils formed in old alluvium weathered from acid and basic igneous rock, tuff, and limestone. They are on dissected old fans. Slopes are 2 to 30 percent. Elevation ranges from

4,000 to 5,200 feet. Vegetation is mostly curly mesquite, grama, cane beardgrass, and other grasses. Mimosa, guajillo, beargrass, and mesquite are present in small amounts, and a few oak and juniper are at higher elevations. Average annual precipitation is 14 to 20 inches, and mean annual temperature is 58° to 63° F. The frost-free season is 160 to 220 days.

In a representative profile the surface layer is dark-brown gravelly clay loam about 2 inches thick. The subsoil is dark reddish-brown gravelly clay loam and gravelly clay about 13 inches thick. The substratum to a depth of 85 inches is pinkish-gray gravelly sandy loam that contains common, white, soft to hard masses of lime. The profile is mildly alkaline in the surface layer and upper part of the subsoil and is moderately alkaline below a depth of 9 inches. It becomes strongly calcareous at a depth of about 15 inches.

Permeability is moderately slow or slow, and available water capacity is moderate. Effective rooting depth is 60 or more inches.

These soils are used for range, wildlife habitat, and homesites.

Representative profile of Bernardino gravelly clay loam in an area of Bernardino-Hathaway association, rolling, 500 feet west and 650 feet north of southeast corner of sec. 20, T. 20 S., R. 17 E., 2 miles southeast of Sonoita:

A1—0 to 2 inches, dark-brown (7.5YR 3/2) gravelly clay loam, dark reddish brown (5YR 3/2) when moist; weak, medium, platy structure parting to moderate, fine, granular; slightly hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots; many very fine interstitial pores; mildly alkaline; abrupt, smooth boundary.

B21t—2 to 9 inches, dark reddish-brown (5YR 3/3) gravelly clay loam, dark reddish brown (5YR 3/2) when moist; moderate, fine and medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots and few medium roots; few very fine tubular pores and interstitial pores; common thin patchy clay films on faces of peds and in pores; mildly alkaline; clear, wavy boundary.

B22t—9 to 15 inches, dark reddish-brown (5YR 3/4) gravelly clay, dark reddish brown (5YR 3/4) when moist; moderate, fine and medium, subangular and angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few very fine and medium roots; few very fine tubular pores and common very fine interstitial pores; common thin clay films on faces of peds and in pores; few strongly effervescent spots; moderately alkaline; clear, wavy boundary.

C1ca—15 to 48 inches, pinkish-gray (5YR 7/2) gravelly sandy loam, reddish brown (5YR 5/3) when moist; massive; very hard when dry, friable when moist, nonsticky and slightly plastic when wet; few very fine and fine roots; many very fine and fine interstitial pores; common, fine, white and pinkish-white filaments of lime, hard when dry and firm when moist; violently effervescent; moderately alkaline; gradual, smooth boundary.

C2ca—48 to 85 inches, pinkish-gray (5YR 7/2) gravelly sandy loam, reddish brown (5YR 5/3) when moist, massive; very hard when dry, friable when moist, nonsticky and slightly plastic when wet; many very fine and fine interstitial pores; few, fine, pinkish-white filaments of lime; strongly effervescent; moderately alkaline.

Depth to the high-lime zone ranges from 10 to 20 inches. The A horizon has hue of 10YR to 5YR, value of 4 to 6

when dry and 3 to 5 when moist, and chroma of 2 to 4. It is slightly acid to mildly alkaline. It is 20 to 50 percent gravel.

The Bt horizon has hue that is dominantly 5YR but ranges from 2.5YR to 7.5YR, value of 3 to 5 when dry and 3 or 4 when moist, and chroma of 3 to 6. It is gravelly clay loam or gravelly clay and contains 10 to 30 percent gravel and a few cobbles. It is mildly alkaline to moderately alkaline and noneffervescent to strongly effervescent.

The Cca horizon has hue of 5YR or 7.5YR, value of 6 to 8 when dry and 4 to 7 when moist, and chroma of 1 to 4. It contains lime in the form of filaments, coatings on gravel, and discontinuous layers that are strongly cemented in places. It is 30 to 60 percent gravel and contains a few cobbles.

#### **BhD—Bernardino-Hathaway association, rolling.**

The soils in this association are on dissected old fans and plains. Slopes range from 2 to 30 percent. The soils are commonly intermingled, and the proportion of one soil to another varies within mapped areas. About 55 percent of the association is Bernardino gravelly clay loam and gravelly loam that commonly have slopes of less than 15 percent; 25 percent is Hathaway gravelly or very gravelly sandy loam or loam; and about 20 percent is included soils. Bernardino gravelly clay loam has the profile described as representative of the Bernardino series. The surface is about 20 to 50 percent gravel and a few cobbles.

Included in mapping are about 10 percent White House soils in some of the flatter areas, 5 to 10 percent Pima and Guest soils along the narrow drainageways, and small areas of Kimbrough soils on some ridge crests. Also included are small areas of Hathaway soils that have short slopes of more than 30 percent and extend into drainageways.

Runoff is medium. The hazard of erosion is slight.

These soils are used for range and wildlife habitat. Several areas near Sonoita are being subdivided for homesites. Capability unit VIe, nonirrigated; Bernardino part in Clay Loam Upland range site, 12- to 16-inch precipitation zone, and Clay Loam Upland range site, 16- to 20-inch precipitation zone; Hathaway part in Limy Slopes range site, 12- to 16-inch precipitation zone, and Limy Slopes range site, 16- to 20-inch precipitation zone; both parts in range productivity group 2.

#### **Bonita Series**

The Bonita series consists of well-drained soils that are 60 inches or more in depth. These soils formed in old alluvium derived from andesite and diorite rocks and from clay shale. They are on uplands and on valley plains that are slightly concave in places. Slopes are 0 to 5 percent. Elevation ranges from 4,800 to 5,200 feet. Vegetation is dominantly curly mesquite, gramas, and tobosa. Average annual precipitation is 16 to 20 inches, and mean annual temperature is 57° to 62° F. The frost-free season is 160 to 210 days.

In a representative profile the surface layer is dark-brown clay about 11 inches thick. The underlying material is dark-brown clay to a depth of about 31 inches. Below this, to a depth of 60 inches or more, is light-brown gravelly clay loam. The profile is neutral in the upper part of the surface layer and moderately alkaline below. It is strongly calcareous below a depth of 31 inches.

Permeability is very slow, and available water capacity is high. Effective rooting depth is 60 inches or more. These soils are used for range and wildlife habitat. Representative profile of Bonita clay, 0 to 5 percent slopes, in the southeast corner of the southwest quarter of the northwest quarter of sec. 27, T. 23 S., R. 17 E., Santa Cruz County:

- A11—0 to 1 inch, dark-brown (7.5YR 4/2) gravelly clay, dark brown (7.5YR 3/2) when moist; strong, very fine and fine, granular structure; hard when dry, friable when moist, sticky and plastic when wet; few fine roots; many fine interstitial pores; 20 percent gravel and a few cobbles; slightly effervescent in spots; neutral; abrupt, smooth boundary.
- A12—1 inch to 11 inches, dark-brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; weak, medium, prismatic structure; hard when dry, friable when moist, sticky and plastic when wet; common fine roots; few fine tubular pores; many pressure faces; common fine lime concretions; slightly effervescent in spots; moderately alkaline; gradual, wavy boundary.
- C—11 to 31 inches, dark-brown (7.5YR 4/2) clay with common, fine, brown (7.5YR 4/4) mottles, dark brown (7.5YR 3/2) when moist; weak, coarse, prismatic structure; very hard when dry; firm when moist, very sticky and very plastic when wet; common fine roots; many very fine tubular pores; many medium and large slickensides and pressure faces, 1 to 6 inches across; common fine nodules of lime, slightly to strongly effervescent; moderately alkaline; gradual, wavy boundary.
- IIBtcab—31 to 69 inches, light-brown (7.5YR 6/4) gravelly clay loam, brown (7.5YR 4/4) when moist; massive; very hard when dry, friable when moist, sticky and plastic when wet; few fine roots; common fine tubular pores; common thin clay films in pores and few thin clay films on faces of peds; 15 percent gravel; common pinkish-white (7.5YR 8/2) veins and masses of lime up to 3 inches wide; strongly effervescent; moderately alkaline.

The A horizon ranges from neutral to moderately alkaline. Pebbles, cobbles, or stones cover 20 to 50 percent of the surface, but they average less than 15 percent in the A and C horizons. When this soil is dry, it forms cracks that are ½ inch to 2 inches wide and 20 to 36 inches deep. The A and C horizons have hue of 10YR to 5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 2 to 4. They are mainly clay or silty clay, but in some places there is a thin surface horizon of heavy silty clay loam or clay loam that is gravelly or cobbly in places. In places the A and C horizons contain segregated calcium carbonate. The IIBtcab horizon, where present, is 15 to 60 percent gravel and cobbles. In places the profile is calcareous throughout.

**BoB—Bonita clay, 0 to 5 percent slopes.** This soil is on uplands. Cracks that are ½ inch to 2 inches wide and 20 to 36 inches deep form when the soil dries, and the soil swells when wet. About 5 to 15 percent of the surface is gravel, and 0 to 10 percent is cobbles. Included in mapping are areas of White House and Graham soils. These areas make up about 5 percent of the mapped area.

Runoff is very slow. The hazard of erosion is slight. This soil is used for range and wildlife habitat. Capability unit VIe, nonirrigated; Clay Upland range site, 16- to 20-inch precipitation zone; range productivity group 2.

### Calciorthids-Haplargids Association

**Ca—Calciorthids-Haplargids association.** The soils in this association are on ridge remnants of deeply

dissected lower ends of old piedmont fans. Local relief is between 25 and 200 feet. Slopes are dominantly 30 to 60 percent but range from 15 percent to more than 100 percent. Elevation is 3,000 to 5,200 feet. At higher elevations vegetation is scattered oak, juniper, and grasses. At lower elevations it is mainly desert shrubs and sparse grasses. Much of the area is barren. Average annual precipitation ranges from 11 to 18 inches.

Calciorthids make up about 35 percent and Haplargids 30 percent of this mapping unit.

Calciorthids are mostly deep, well-drained soils that are loam, sandy clay loam, or sandy loam throughout and contain 15 percent or more rock fragments. They are calcareous and have a moderate or moderately slow permeability and a moderate or low available water capacity. Runoff is medium or rapid, and the hazard of erosion is high.

Haplargids are mostly deep, well-drained soils that have a surface layer of gravelly or very gravelly sandy loam or sandy clay loam, a subsoil of sandy clay loam, clay loam, or clay modified by 15 percent or more rock fragments, and a substratum of gravelly or very gravelly sandy clay loam or gravelly or very gravelly sandy loam. Permeability is moderate or moderately slow, and available water capacity is moderate. Runoff is rapid, and the hazard of erosion is high.

Included in mapping are small scattered areas of White House, Bernardino, and Casto soils in upland areas and some narrow bands of Torrifluvents in the drainageways. Included areas make up about 35 percent of this mapping unit.

Erosion is severe in many places, and soil slips are common at the heads of drainageways and on the lower slopes along stream channels.

These soils are used for range and wildlife habitat. Capability unit VIIe, nonirrigated; Calciorthids in Limy Upland range site, 12- to 16-inch precipitation zone, and Haplargids in Loamy Hills range site, 12- to 16-inch precipitation zone; range productivity group 4.

### Canelo Series

The Canelo series consists of somewhat poorly drained soils that are 60 inches or more in depth. These soils formed in very gravelly and cobbly old alluvium weathered from rhyodacite, rhyolite, andesite, sandstone, and quartzite. They are on long narrow ridge remnants of dissected old alluvial fans. Slopes are 0 to 40 percent. Elevation ranges from 5,000 to 6,000 feet. Vegetation is dominantly oak, juniper, manzanita, mesquite, grammas, and bluestems (fig. 2). Average annual precipitation is 16 to 20 inches, and mean annual temperature is 53° to 57° F. The frost-free season is 140 to 200 days.

In a representative profile the surface layer is brown gravelly sandy loam about 5 inches thick. The subsurface layer is very pale brown and light-gray very gravelly sandy loam about 9 inches thick. The subsoil is mostly pinkish-white, reddish-yellow, yellowish-red, light-red, and red very gravelly sandy clay loam, very gravelly clay, or very cobbly sandy clay to a depth of 60 inches or more. Gray mottles indicate that drainage below a depth of about 14 inches is poor. The profile is



Figure 2.—Typical vegetation in an area of Canelo gravelly sandy loam, 0 to 20 percent slopes.

slightly acid in the surface layer, medium acid in the subsurface layer and upper part of the subsoil, and extremely acid in the lower part of the subsoil.

Permeability is very slow. Water perches at a shallow depth following wet periods. Available water capacity is low or moderate. Effective rooting depth is 60 inches or more.

These soils are used for range and wildlife habitat.

Representative profile of Canelo gravelly sandy loam, 0 to 20 percent slopes, 0.8 mile south-southeast of Canelo pass cattleguard, approximately 2,000 feet east of west quarter corner of sec. 30, T. 22 S., R. 18 E., Santa Cruz County:

A1—0 to 5 inches, brown (10YR 5/3) gravelly sandy loam, dark brown (7.5YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many very fine and fine roots; common fine interstitial pores and tubular pores; 35 percent gravel and 5 percent cobbles; slightly acid; abrupt, smooth boundary.

A2—5 to 7 inches, very pale brown (10YR 7/3) very gravelly sandy loam, brown (7.5YR 5/4) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; common very fine and fine roots; common fine interstitial pores and tubular pores; 40 percent gravel and 10 percent cobbles; medium acid; abrupt, smooth boundary.

A3—7 to 14 inches, light-gray (10YR 7/2) very gravelly

sandy loam, light brown (7.5YR 6/4) when moist, few, fine, distinct, brownish-yellow (10YR 6/8) mottles, yellowish brown (10YR 5/8) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine and fine roots; few fine tubular pores; 45 percent gravel and 10 percent cobbles; medium acid; clear, wavy boundary.

B21tg—14 to 23 inches, pinkish-white (7.5YR 8/2), reddish-yellow (7.5YR 6/6), yellowish-red (5YR 5/8), and light-gray (10YR 7/1) very gravelly heavy sandy clay loam, light brown (7.5YR 6/4), strong brown (7.5YR 5/6), and yellowish red (5YR 4/8) when moist; few, fine, distinct, light-gray (10YR 7/1) mottles; moderate, medium, subangular and angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common very fine and few fine roots; common very fine tubular pores; common thin clay films on faces of peds and in pores; 60 percent gravel and 10 percent cobbles; medium acid; clear, wavy boundary.

B22tg—23 to 34 inches, white (10YR 8/2) very gravelly clay, light gray (10YR 7/2) and very pale brown (10YR 7/4) when moist; many, medium and coarse, distinct, red (10YR 4/6) mottles, red (10YR 4/6) when moist; moderate, medium, subangular and angular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; few fine and very fine roots; few thin clay films on faces of peds; 60 percent gravel and 10 percent cobbles; extremely acid; clear, wavy boundary.

B3t—34 to 60 inches, light-red (2.5YR 6/6) and red (2.5YR

4/6) very cobbly sandy clay, red (2.5YR 4/6) when moist; common, fine, distinct, pinkish-gray (7.5YR 7/2) mottles, brown (7.5YR 5/4) when moist; moderate, medium and fine, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; few fine tubular pores; common moderately thick clay films on faces of peds and in pores; 30 percent gravel and 35 percent cobbles; extremely acid.

The A1 horizon has hue of 10YR or 7.5YR, value of 4 to 6 when dry and 3 or 4 when moist, and chroma of 2 to 4 when dry or moist. The A2 horizon has a hue of 10YR or 7.5YR, value of 5 to 7 when dry and 4 to 6 when moist, and chroma of 2 to 5. The A3 horizon has hue of 10YR to 5YR, value of 5 to 8 when dry and 4 to 6 when moist, and chroma of 2 to 4. Mottles have value of 6 to 8 when dry and 5 to 7 when moist, and chroma of 1 to 8. The A3 horizon is 35 to 60 percent gravel and 5 to 20 percent cobbles. The A horizon is slightly acid or medium acid.

The B2tg and B3t horizons have hue of 10YR to 5YR, value of 5 to 8 when dry and 4 to 6 when moist, and chroma of 2 to 4. Mottles have value of 3 to 8 when dry or moist. Gray mottles have chroma of 1 or 2. Red mottles appear to be from parent rock and have chroma of 6 to 8. The B2tg and B3t horizons are very gravelly sandy clay loam, very gravelly clay loam, very gravelly clay, or very cobbly sandy clay. Structure is weak to moderate and fine to coarse subangular or angular blocky. The Bt horizon is medium acid to extremely acid.

**CbD—Canelo gravelly sandy loam, 0 to 20 percent slopes.** This soil is on remnants of old dissected alluvial fans. It has the profile described as representative of the series. The surface is about 20 to 30 percent gravel, 0 to 10 percent cobbles, and a few stones. Included in mapping are about 5 percent each of Casto, Martinez, and Comoro soils.

Runoff is medium. The hazard of erosion is moderate.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Loamy Upland (oak) range site, 16- to 20-inch precipitation zone; range productivity group 3.

**CdE—Canelo very gravelly sandy loam, 20 to 40 percent slopes.** This soil is on long narrow ridges that are remnants of dissected old alluvial fans. Slopes are 20 to 25 percent on the tops of the ridges and 30 to 40 percent on the sides. The surface is about 40 to 50 percent gravel, 0 to 10 percent cobbles, and 0 to 5 percent stones. Included in mapping are small areas of Casto soils and narrow bands of gravelly Haplustolls in the drainageways.

Runoff is medium. The hazard of erosion is high.

This soil is used for range and wildlife habitat. Capability unit VIe, nonirrigated; Loamy Upland (oak) range site, 16- to 20-inch precipitation zone; range productivity group 3.

**CeD—Canelo cobbly sandy loam, 0 to 20 percent slopes.** This soil is on long, narrow, convex ridge remnants of old dissected fans. The tops are nearly level, and the side slopes are steep. Slopes are mainly 3 to 15 percent. This soil has a profile similar to the one described as representative of the series, but the surface and subsurface layers contain 15 to 20 percent cobble-size rock fragments and scattered stones. Areas of this soil are adjacent to rocky hills of rhyolite tuffs and rhyodacite, and outcrops of these materials are on the lower slopes.

Included in mapping are areas of Casto soils, small areas where bedrock is at a depth of only 3 to 5 feet,

and small narrow areas of Martinez soils. Included areas make up about 5 to 10 percent of this mapping unit.

Runoff is medium. The hazard of erosion is moderate.

This soil is used for range and wildlife habitat. Capability unit VIe, nonirrigated; Loamy Upland (oak) range site, 16- to 20-inch precipitation zone; range productivity group 3.

## Caralampi Series

The Caralampi series consists of well-drained gravelly soils that are 60 inches or more in depth. These soils formed in old alluvium weathered from granite, andesite, rhyolite, dacite, and tuffs. They are on long narrow ridge remnants of dissected old alluvial fans. Slopes are 10 to 60 percent. Elevation ranges from 3,000 to 5,000 feet. Vegetation is mainly grama grasses, curly mesquite, and false mesquite, plus scattered mesquite and mimosa bushes. A few oak and juniper trees are at higher elevations and on north slopes. Average annual precipitation is 14 to 18 inches, and mean annual temperature is 57° to 64° F. The frost-free season is 190 to 260 days.

In a representative profile the surface layer is dark-brown gravelly sandy loam about 2 inches thick. The subsoil is about 40 inches thick. In sequence downward, it is 11 inches of dark-brown, dark reddish-brown, and yellowish-red very gravelly sandy clay loam; 10 inches of yellowish-red and reddish-yellow gravelly sandy clay loam; and 19 inches of reddish-brown and light reddish-brown very gravelly sandy loam. The substratum is light-brown gravelly sandy loam to a depth of 60 inches or more. The profile is slightly acid throughout.

Permeability is moderately slow, and available water capacity is low. Effective rooting depth is 60 inches or more.

These soils are used for range, wildlife habitat, homesites, and community uses.

Representative profile of Caralampi gravelly sandy loam, 10 to 40 percent slopes, 2,800 feet north and 1,600 feet west of southeast corner of sec. 36, T. 23 S., R. 13 E., in road cut 2½ miles north-northwest of Nogales:

A1—0 to 2 inches, dark-brown (7.5YR 4/4) gravelly sandy loam, dark reddish brown (5YR 3/4) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; common very fine and fine roots; common very fine interstitial pores; 30 percent medium and coarse gravel by volume; slightly acid; abrupt, smooth boundary.

B21t—2 to 5 inches, dark-brown (7.5YR 4/2) very gravelly sandy clay loam, dark brown (7.5YR 3/2) when moist; weak, fine, subangular blocky structure; slightly hard when dry; friable when moist; slightly sticky and plastic when wet; common very fine and fine roots; many very fine interstitial pores; 55 percent fine, medium, and coarse gravel by volume; slightly acid; clear, wavy boundary.

B22t—5 to 9 inches, dark reddish-brown (5YR 3/4) very gravelly sandy clay loam, dark reddish brown (5YR 3/4) when moist; weak, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when

wet; many very fine and fine roots; common very fine interstitial and tubular pores; few thin clay films on faces of peds; 50 percent fine, medium, and coarse gravel by volume; slightly acid; abrupt, wavy boundary.

B23t—9 to 13 inches, yellowish-red (5YR 4/6) very gravelly sandy clay loam, dark red (2.5YR 3/6) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; many very fine and fine roots; common very fine interstitial and tubular pores; common thin clay films on faces of peds and in pores; 50 percent fine, medium, and coarse gravel by volume; slightly acid; clear, wavy boundary.

B24t—13 to 23 inches, yellowish-red (5YR 4/6) and reddish-yellow (5YR 6/6) gravelly sandy clay loam, yellowish red (5YR 4/6) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine and fine roots; few very fine tubular pores; common thin clay films on faces of peds; 40 percent fine, medium, and coarse gravel by volume; slightly acid; clear, wavy boundary.

B31t—23 to 31 inches, reddish-brown (5YR 5/4) very gravelly sandy loam, reddish brown (5YR 4/4) when moist; common, fine, faint, pink (5YR 7/3) and light reddish-brown (5YR 6/3) mottles, light reddish brown (5YR 6/4) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine and fine roots; few very fine tubular pores; few thin clay films in pores; 50 percent fine, medium, and coarse gravel by volume; slightly acid; clear, wavy boundary.

B32t—31 to 42 inches, light reddish-brown (5YR 6/4) very

gravelly sandy loam, reddish brown (5YR 4/4) when moist; massive; hard when dry, friable when moist, nonsticky and slightly plastic when wet; few very fine roots; few thin clay films in pores; 50 percent fine and medium gravel by volume; slightly acid; clear, wavy boundary.

C—42 to 60 inches, light-brown (7.5YR 6/4) gravelly sandy loam, dark brown (7.5YR 4/4) when moist; massive; hard when dry, friable when moist, nonsticky and nonplastic when wet; 30 percent fine and medium gravel by volume; slightly acid.

The A horizon has hue of 10YR to 5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 2 to 4. It is medium acid to slightly acid.

The Bt horizon has hue of 7.5YR to 2.5YR, value of 4 to 6 when dry and 3 to 6 when moist, and chroma of 2 to 6. It is gravelly sandy clay loam, very gravelly sandy clay loam, gravelly or very gravelly clay loam, or gravelly or very gravelly sandy loam. The B horizon is 35 to 70 percent gravel and is slightly acid to mildly alkaline.

The C horizon has hue of 7.5YR or 5YR, value of 5 to 7 when dry and 3 to 5 when moist, and chroma of 2 to 6. The soil generally is noncalcareous throughout the profile, but it is slightly calcareous in the lower part of the B3 horizon or in the C horizon in places.

**CgE—Caralampi gravelly sandy loam, 10 to 40 percent slopes.** This soil is on the remnants of dissected valley side slopes in the south-central part of Santa Cruz County. Areas are fairly large. Slopes on the ridgetops are 10 to 20 percent, and on the lower side slopes are 20 to 40 percent. This soil has the profile described as representative of the series (fig. 3). The surface is 30 to 40 percent gravel and 0 to 5 percent cobbles.



Figure 3.—Road cut in Caralampi gravelly sandy loam, 10 to 40 percent slopes, showing dark surface layer and light substratum.

Included in mapping are small areas of White House soils on some of the broader ridgetops; gravelly, moderately coarse textured and coarse textured soils in recent alluvium in the drainageways; and Hathaway soils on some of the steeper side slopes. Included areas make up about 10 percent of this mapping unit.

Runoff is medium. The hazard of erosion is high.

This soil is used principally for range and wildlife habitat. Much of the acreage north of Nogales is being subdivided for homesites and other community uses. Capability unit VIe, nonirrigated; Sandy Loam range site, 12- to 16-inch precipitation zone; range productivity group 3.

**CgF2—Caralampi gravelly sandy loam, 10 to 60 percent slopes, eroded.** This soil is on long narrow ridge remnants of old dissected fans. Slopes are 10 to 30 percent on the crowns and 30 to 60 percent on the lower side slopes. Slip scars at the heads of drainageways and stream cuts at the bases of slopes are common. The surface is 30 to 40 percent gravel and 0 to 10 percent cobbles.

Included in mapping are small areas of White House soils on the ridgetops; small areas of steep, eroded very gravelly soils that do not have a subsoil; small areas of cobbly or very cobbly soils; and a few small areas near the mountains west of Nogales that have a thicker than normal surface layer, a thinner subsoil, and moderate to strong tuff cementation in the substratum. Included areas make up about 5 percent of the mapped area.

Runoff is rapid. The hazard of erosion is high.

This soil is used mostly for range and wildlife habitat. A few areas are being subdivided as homesites. Capability unit VIIe, nonirrigated; Sandy Loam range site, 12- to 16-inch precipitation zone; range productivity group 3.

### Caralampi Variant

The Caralampi variant consists of well-drained, nearly level to gently sloping soils that are 60 inches or more in depth. These soils formed in old alluvium from mixed sources. They are on old alluvial fans. The subsoil lacks the reddish-brown colors of the Caralampi series. Slopes are 1 to 5 percent. Elevation is 4,800 to 5,100 feet. Vegetation is mostly grama grasses, cane beardgrass, plains lovegrass, and three-awns. Average annual precipitation is 16 to 18 inches, and mean annual air temperature is 57° to 60° F. The frost-free season is 200 to 210 days.

In a representative profile the surface layer is dark-brown gravelly loam about 11 inches thick. The upper 12 inches of the subsoil is light yellowish-brown very gravelly light sandy clay loam, and the next 16 inches is yellowish-brown very gravelly clay loam. The lower part of the subsoil, to a depth of 60 inches or more, is strong-brown clay and yellowish-red gravelly sandy clay. The profile is medium acid in the surface layer, neutral in the upper part of the subsoil, and mildly alkaline in the lower part of the subsoil.

Permeability is moderately slow, and available water capacity is moderate. Effective rooting depth is 60 inches or more.

These soils are used for range and wildlife habitat.

Representative profile of Caralampi gravelly loam, brown variant, 1 to 5 percent slopes, in grassland, 290 feet south and 1/4 mile west of road junction, northwest corner of the southwest quarter of the northwest quarter of sec. 11, T. 23 S., R. 17 E., Santa Cruz County:

A11—0 to 3 inches, dark-brown (10YR 4/3) gravelly loam, dark yellowish brown (10YR 3/4) when moist; weak, medium and thick, platy structure; slightly hard when dry, friable when moist, nonsticky and slightly plastic when wet; many very fine and fine roots; few very fine tubular and interstitial pores; medium acid; abrupt, smooth boundary.

A12—3 to 11 inches, dark-brown (7.5YR 4/4) gravelly loam, dark reddish brown (5YR 3/4) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, nonsticky and slightly plastic when wet; common fine and very fine roots; common very fine interstitial pores and few very fine and fine tubular pores; medium acid; clear, smooth boundary.

B21t—11 to 23 inches, light yellowish-brown (10YR 6/4) very gravelly light sandy clay loam, dark yellowish brown (10YR 4/4) when moist; weak to moderate, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine and fine roots; common very fine and few fine tubular and interstitial pores; few thin clay films in pores; neutral; clear, smooth boundary.

B22tb—23 to 39 inches, yellowish-brown (10YR 5/6) very gravelly heavy clay loam, dark yellowish brown (10YR 4/4) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few fine and very fine roots; common fine tubular pores and few fine interstitial pores; few clay films in pores and root channels; common dark stains in old root channels and on faces of peds; neutral; clear, smooth boundary.

IIB23tb—39 to 47 inches, strong-brown (7.5YR 5/6) clay, yellowish red (5YR 4/8) when moist; strong, medium, prismatic structure; very hard when dry, firm when moist, sticky and very plastic when wet; few fine and very fine roots; few very fine interstitial pores; continuous thick clay films and common black manganese stains on faces of peds; slightly effervescent on rock fragments in places; mildly alkaline; gradual, smooth boundary.

IIB24tb—47 to 60 inches, yellowish-red (5YR 5/6) gravelly sandy clay, yellowish red (5YR 4/8) when moist; weak, medium, prismatic structure; hard when dry, friable when moist, sticky and plastic when wet; few very fine roots; common very fine interstitial pores; common thin clay films and common black (10YR 2/1) manganese stains on faces of peds; slightly effervescent in spots on faces of peds and under gravel; mildly alkaline.

Depth to very gravelly material ranges from 8 to 16 inches. The A horizon has hue of 10YR to 5YR, value of 4 or 5 when dry and 2 to 4 when moist, and chroma of 2 to 4. It is medium acid to slightly acid. It is 15 to 30 percent gravel.

The Bt horizon has hue of 10YR to 5YR, value of 4 to 6 when dry and 3 or 4 when moist, and chroma of 3 to 6. It is heavy loam, sandy clay loam, or clay loam, is 35 to 70 percent gravel, and is neutral to mildly alkaline.

The IIBtb horizon ranges from clay to loamy sand. It is 10 to 60 percent gravel and cobbles. The undersides of the gravel and cobbles in the lower part of the profile have lime coatings in places.

**C1B—Caralampi gravelly loam, brown variant, 1 to 5 percent slopes.** This soil is in several large areas in the San Raphael Valley. The surface is 30 to 40 percent gravel. This soil has the profile described as representative of the Caralampi variant soils. Included

in mapping are small areas of White House and Bernardino soils.

Runoff is medium. The hazard of erosion is slight.

This soil is used for range and wildlife habitat. Capability unit VIe, nonirrigated; Loamy Upland range site, 16- to 20-inch precipitation zone; range productivity group 3.

### Casto Series

The Casto series consists of well-drained soils that are 60 inches or more in depth. These soils formed in gravelly old alluvium weathered from andesite, rhyodacite, sandstone, shale, and limestone. They are on deeply dissected alluvial fans that have long axial and short side drainageways. Slopes are 10 to 40 percent. Elevation is 5,000 to 6,500 feet. Vegetation is mainly oak, juniper, manzanita, gramas, and bluestems. Average annual precipitation is 16 to 20 inches, and mean annual temperature is 53° to 57° F. The frost-free season is 160 to 200 days.

In a representative profile the surface layer is dark grayish-brown very gravelly sandy loam about 1 inch thick. The subsoil is about 27 inches thick. The upper 10 inches is dark grayish-brown and reddish-brown gravelly sandy clay loam. The lower 17 inches is reddish-brown and pinkish-gray very gravelly sandy clay loam. The substratum is pinkish-white very gravelly sandy loam to a depth of 60 inches or more (fig. 4). The profile is neutral in the surface layer and upper part of the subsoil, medium acid and mildly alkaline in the lower part of the subsoil, and moderately alkaline in the substratum, which is also slightly calcareous.

Permeability is slow, and available water capacity is low. Effective rooting depth is 60 inches or more.

These soils are used mainly for range and wildlife habitat. Small areas are used for cabin sites and recreation.

Representative profile of Casto very gravelly sandy loam, 10 to 40 percent slopes, 500 feet south and 700 feet east of the west quarter corner of sec. 8, T. 23 S., R. 19 E., Cochise County:

- A1—0 to 1 inch, dark grayish-brown (10YR 4/2) very gravelly sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots; common fine interstitial and tubular pores; 55 percent gravel and a few cobbles by volume; neutral; abrupt, smooth boundary.
- B21t—1 inch to 5 inches, dark grayish-brown (10YR 4/2) gravelly sandy clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; many very fine, fine, and medium roots; few fine tubular pores; few thin clay films on faces of peds and in pores; 20 percent gravel and 15 percent cobbles by volume; neutral; clear, smooth boundary.
- B22t—5 to 11 inches, reddish-brown (5YR 4/4) gravelly heavy sandy clay loam, reddish-brown (5YR 4/4) when moist; moderate, medium and coarse, subangular and angular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; common fine and medium roots; few fine tubular pores; common moderately thick clay films on faces of peds and in pores; 25 percent gravel



Figure 4.—Profile of Casto very gravelly sandy loam showing high content of gravel and cobbles.

and 15 percent cobbles by volume; medium acid; clear, wavy boundary.

- B23t—11 to 16 inches, reddish-brown (5YR 4/3) very gravelly sandy clay loam, reddish brown (5YR 4/3) when moist; many medium and coarse distinct pinkish-gray (7.5YR 7/2) mottles, brown (7.5YR 5/2) when moist, mottles appear to be weathered gravel; moderate, medium and coarse, subangular and angular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; common fine and medium roots; few fine tubular pores; common moderately thick clay films on faces of peds and in pores; 35 percent gravel and 15 percent cobbles by volume; medium acid; clear, wavy boundary.
- B31t—16 to 22 inches, pinkish-gray (7.5YR 7/2) and reddish-brown (5YR 4/4) very gravelly sandy clay loam, brown (7.5YR 5/2) and reddish-brown (5YR 4/4) when moist; weak, fine and medium, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; few fine and medium roots; common moderately thick

clay films on faces of pedis and in pores; 35 percent gravel and 15 percent cobbles by volume; neutral; clear, wavy boundary.

- B32t**—22 to 28 inches, pinkish-gray (7.5YR 7/2) and reddish-brown (5YR 4/4) very gravelly sandy clay loam, light brown (7.5YR 6/4) and reddish brown (5YR 4/4) when moist; massive; very hard when dry, firm when moist, sticky and plastic when wet; few fine roots; common moderately thick clay films on surface of gravel; 60 percent gravel and 10 percent cobbles by volume; slightly effervescent in spots; mildly alkaline; clear, irregular boundary.
- C1ca**—28 to 45 inches, pinkish-white (7.5YR 8/2) very gravelly sandy loam, brown (7.5YR 5/2) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; 60 percent gravel and 10 percent cobbles by volume; slightly effervescent; moderately alkaline; diffuse, wavy boundary.
- C2ca**—45 to 60 inches, pinkish-white (7.5YR 8/2) very gravelly sandy loam, brown (7.5YR 5/2) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; 50 percent gravel and 10 percent cobbles by volume; strongly effervescent; moderately alkaline.

The A1 horizon has hue of 7.5YR or 10YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 to 4. It ranges from slightly acid to mildly alkaline. It is 35 to 70 percent or more gravel and cobbles, of which about 5 percent is cobbles.

The B2t horizon has hue of 10YR to 5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 2 to 4. It is gravelly clay loam, very gravelly clay loam, gravelly sandy clay loam, and very gravelly sandy clay loam. It is medium acid to neutral. The B3t horizon has hue of 7.5YR or 5YR, value of 4 to 7 when dry and 4 to 6 when moist, and chroma of 2 to 6. It is very gravelly clay loam or very gravelly sandy clay loam. It is slightly acid to mildly alkaline. The Bt horizon ranges from 35 to 70 percent rock fragments, of which as much as 15 percent is cobbles.

The Cca horizon has hue of 7.5YR or 5YR, value of 6 to 8 when dry and 4 to 6 when moist, and chroma of 2 to 4. It is mildly alkaline to moderately alkaline and about 3 to 8 percent calcium carbonate. The Cca horizon is very gravelly sandy clay loam or very gravelly sandy loam. It is 35 to 75 percent gravel and as much as 15 percent cobbles.

**Cme**—Casto very gravelly sandy loam, 10 to 40 percent slopes. This soil is on long narrow ridgetops and side slopes of deeply dissected remnants of old alluvial fans. The surface is 30 to 60 percent gravel and 5 to 20 percent cobbles. This soil has the profile described as representative of the series.

Included in mapping are about 5 percent Canelo soils, 5 percent or less White House and Martinez soils on some of the wider ridgetops, and about 5 percent gravelly, medium- to coarse-textured recent alluvial soils in drainageways. Also included are soils in an area of about 1,800 acres northeast of Lochiel that are similar to the Casto soils but that have a strongly acid to very strongly acid subsoil and lack a horizon of lime accumulation.

Runoff is medium. The hazard of erosion is moderate.

This soil is used for range and wildlife habitat. An area near Parker Canyon Lake is subdivided for homesites and campsites. Capability unit VIe, nonirrigated; Loamy Upland (oak) range site, 16- to 20-inch precipitation zone; range productivity group 3.

## Cave Series

The Cave series consists of well-drained soils that are 4 to 20 inches in depth to an indurated lime-

cemented hardpan. These soils formed in old gravelly alluvium weathered from limestone, granite, and other igneous rocks. Slopes are dominantly 2 to 3 percent but range from 0 to 5 percent. Elevation is 3,200 to 3,800 feet. Vegetation is dominantly whitethorn, creosote bush, cacti, desert zinnia, and fluffgrass. Average annual precipitation is 11 to 12 inches, and mean annual temperature is about 64° F. The frost-free season is 240 to 270 days.

In a representative profile the surface layer is light yellowish-brown and yellowish-brown gravelly sandy loam about 7 inches thick over a lime-cemented hardpan. The hardpan, about 11 inches thick, is white, extremely hard, and very gravelly. Below the hardpan, to a depth of 60 inches or more, is brown, pinkish-white, and pink, strongly calcareous very gravelly sandy loam. The profile is moderately alkaline and strongly calcareous throughout.

Cave soils have moderate permeability to the hardpan and very slow permeability or are impermeable in the indurated layer. Available water capacity is very low. Effective rooting depth is 4 to 20 inches.

These soils are used for range and wildlife habitat. Representative profile of Cave gravelly sandy loam, 1,650 feet south and 700 feet west of northeast corner of sec. 4, T. 18 S., R. 15 E., Pima County:

- A11**—0 to 1 inch, light yellowish-brown (10YR 6/4) gravelly sandy loam, dark yellowish brown (10YR 3/4) when moist; weak, thick, platy structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine roots; few very fine and fine interstitial pores; 35 percent gravel by volume; strongly effervescent; moderately alkaline; abrupt, smooth boundary.
- A12**—1 inch to 7 inches, yellowish-brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 3/4) when moist; weak, fine, subangular blocky structure; extremely hard when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine roots; common very fine and fine interstitial pores; 30 percent gravel by volume; strongly effervescent; moderately alkaline; abrupt, smooth boundary.
- C1cam**—7 to 18 inches, white (10YR 8/2) indurated pan with continuous lamina along upper boundary, very pale brown (10YR 7/3) when moist; massive; extremely hard when dry, very firm when moist; 65 percent gravel by volume; violently effervescent; moderately alkaline; clear, smooth boundary.
- C2ca**—18 to 60 inches, brown (7.5YR 5/4), pinkish-white (7.5YR 8/2) and pink (7.5YR 7/4) very gravelly sandy loam, dark brown (7.5YR 4/4) and light brown (7.5YR 6/4) when moist; massive; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; 70 percent rock fragments by volume; violently effervescent; moderately alkaline.

Depth to the indurated lime-cemented hardpan ranges from 4 to 20 inches. The A horizon has hue of 10YR or 7.5YR, value of 5 to 7 when dry and 3 or 4 when moist, and chroma of 3 or 4. It is gravelly sandy loam or gravelly loam and contains 15 to 35 percent gravel.

The C1cam horizon is continuously indurated except for scattered cracks and pockets. Rodents have ruptured the pan in places. Thin cemented layers are common below the hardpan. The C1cam and underlying layers are 35 to 65 percent gravel and 5 to 10 percent cobbles. The materials below the pan range from gravelly or very gravelly sandy loam to gravelly or very gravelly loamy sand.

**Cn**—Cave gravelly sandy loam. This soil is on alluvial fans of material that weathered from lime-

stone hills. Slopes range from 0 to 5 percent. Shallow drainageways cross the area. The surface is 30 to 40 percent gravel and a few cobbles. This soil has the profile described as representative of the series.

Included in mapping are Anthony variant soils in the drainageways and a soil that has a thin, reddish-brown, clayey subsoil and a strong lime zone at a depth of 10 to 20 inches. These included soils each make up about 5 percent of the mapped area.

Runoff is medium. The hazard of erosion is moderate.

This soil is used for experimental range and wildlife<sup>o</sup> habitat. Capability unit VII<sub>s</sub>, nonirrigated; Limy Upland range site, 12- to 16-inch precipitation zone; range productivity group 4.

## Chiricahua Series

The Chiricahua series consists of well-drained soils that are 10 to 20 inches in depth over weathered, coarse-grained, consolidated granitic or granitic-conglomerate bedrock. They are on foothills and low mountains. Slopes are generally 5 to 30 percent but are as much as 45 percent in places. Elevation ranges from 3,000 to 5,400 feet. Vegetation is dominantly grama grasses, curly mesquite, catclaw, mimosa, ocotillo, false mesquite, agave, cacti, and mesquite. A few oak and juniper trees are commonly on north slopes. Average annual precipitation is 12 to 18 inches, and mean annual temperature is 57° to 64° F. The frost-free season is 170 to 240 days.

In a representative profile the surface layer is dark-brown cobbly sandy loam about 3 inches thick. The subsoil is dark reddish-brown gravelly clay loam and clay about 16 inches thick. The underlying material is strongly weathered granite or granodiorite about 9 inches thick over granite bedrock. The surface layer is slightly acid, and the subsoil is neutral.

Permeability is moderately slow, and available water capacity is low. Effective rooting depth is 10 to 20 inches.

These soils are used mainly for range and wildlife habitat. Several areas are used for mining.

Representative profile of Chiricahua cobbly sandy loam, 10 to 45 percent slopes, at the northeast corner of the northwest quarter of the southwest quarter of sec. 8, T. 21 S., R. 14 E., Santa Cruz County:

A1—0 to 3 inches, dark-brown (7.5YR 4/2) cobbly sandy loam, dark brown (7.5YR 3/2) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine and fine roots; common very fine and fine interstitial pores; 20 percent cobbles and 25 percent gravel by volume; slightly acid; clear, smooth boundary.

B21t—3 to 11 inches, dark reddish-brown (2.5YR 3/4) gravelly heavy clay loam or clay, dark reddish brown (2.5YR 3/4) when moist; weak, medium and coarse, prismatic structure; very hard when dry, friable when moist, sticky and plastic when wet; common very fine and few fine roots; very few fine and very fine tubular pores; common thin clay films on faces of pedis; 20 percent gravel and 5 percent cobbles by volume; neutral; clear, wavy boundary.

B22t—11 to 19 inches, dark reddish-brown (5YR 3/4) gravelly clay loam, dark reddish brown (5YR 3/4)

when moist; weak, medium and coarse, subangular blocky structure; very hard when dry, friable when moist; sticky and plastic when wet; common very fine and few fine roots; few very fine tubular pores; common thin clay films on faces of pedis; many pink (7.5YR 7/4) and reddish-yellow (7.5YR 7/6) weathered rock fragments; 25 percent gravel and 10 percent cobbles by volume; neutral; abrupt, irregular boundary.

C—19 to 28 inches, pink (7.5YR 7/4) and reddish-yellow (7.5YR 7/6) strongly weathered granite or granodiorite; massive; extremely hard when dry, extremely firm when moist; few roots in crevices; few clay films on rock faces.

R—28 inches, extremely hard granite bedrock.

Depth to weathered bedrock ranges from 10 to 20 inches. Depth to consolidated bedrock ranges from 20 to 30 inches. The A horizon has hue of 7.5YR to 2.5YR, value of 4 to 6 when dry and 3 or 4 when moist, and chroma of 2 to 4. It is medium acid to slightly acid.

The Bt horizon has hue ranging from 7.5YR to 2.5YR, value of 3 to 5 when dry and 3 or 4 when moist, and chroma of 3 to 6. It is heavy clay loam, gravelly clay loam, clay, or gravelly clay and contains 10 to 35 percent gravel and cobbles. The content of gravel is 10 to 20 percent and of cobbles is 0 to 15 percent. The Bt horizon ranges from slightly acid to mildly alkaline.

**CoE—Chiricahua cobbly sandy loam, 10 to 45 percent slopes.** This soil is on ridges and low mountains that are dissected by many short, moderately steep drainageways. This soil has the profile described as representative of the series.

Included in mapping are areas of soils that have a surface layer of cobbly loam and cobbly clay loam. Also included are about 5 percent Rock outcrop and as much as 5 percent Caralampi and White House soils.

Runoff is medium. The hazard of erosion is moderate.

This soil is used for range, wildlife habitat, and mining. Capability unit VI<sub>e</sub>, nonirrigated; Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 4.

**CrD—Chiricahua-Lampshire association, rolling.** The soils in this association are about 60 percent Chiricahua cobbly sandy loam, 20 percent Lampshire very cobbly loam or very gravelly sandy loam, and 20 percent Rock outcrop, Calciorthids-Haplargids association, and other included soils. Chiricahua soils are on the smoother side slopes and saddles of granitic mountains. Slopes are 5-percent to about 15 percent. Lampshire soils are on the steeper, rockier parts. Slopes are short and as much as 45 percent. The surface is 35 to 50 percent gravel, 10 to 35 percent cobbles, and 0 to 5 percent stones.

Included in mapping are about 5 percent Rock outcrop, 5 percent sandy loam and gravelly sandy loam alluvium in drainageways and on short alluvial fans, and about 5 percent a yellowish-red, very gravelly soil that is less than 10 inches deep to bedrock. Also included and making up about 3 percent are areas of Calciorthids-Haplargids association.

Runoff is medium. The hazard of erosion is moderate. Common shallow gullies and a few deep gullies are in the drainageways and in the areas of Calciorthids-Haplargids association.

These soils are used for range, wildlife habitat, homesites near Nogales, and a few mines. Capability

unit VIe, nonirrigated; Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 4.

### Comoro Series

The Comoro series consists of well-drained soils that are 60 inches or more in depth. These soils formed in recent alluvium weathered from mixed rock. They are on flood plains and alluvial fans. Slopes are 0 to 2 percent on the flood plains and 1 to about 10 percent on the fans. Elevation is 3,000 to 5,000 feet. Vegetation is desert shrubs at the lower elevations, shrubs and grasses on the intermediate fans, and oak-savannah at higher elevations. Average annual precipitation is 12 to 20 inches, and mean annual temperature is 57° to 64° F. The frost-free season is 170 to 265 days.

In a representative profile the surface layer and upper part of the substratum are grayish-brown sandy loam about 36 inches thick. The lower part of the substratum is light brownish-gray gravelly sandy loam to a depth of 60 inches or more. The profile is moderately alkaline and calcareous throughout.

Permeability is moderately rapid or rapid, and available water capacity is moderate. Effective rooting depth is 60 inches or more.

These soils are used for range, wildlife habitat, homesites, and other community purposes. Small areas along the Santa Cruz river are in irrigated pasture and crops.

Representative profile of Comoro sandy loam, in an area of Comoro soils, 0 to 5 percent slopes, ¼ mile east and 2 miles south of Kinsley Ranch, 75 feet north and 20 feet east of fence corner, in the southwest corner of the southeast quarter of the southwest quarter of sec. 7, T. 20 S., R. 13 E., Santa Cruz County:

- Ap—0 to 14 inches, grayish-brown (10YR 5/2) sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine roots; common very fine irregular pores; slightly effervescent; moderately alkaline; abrupt, smooth boundary.
- C1—14 to 23 inches, grayish-brown (10YR 5/2) sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine roots; common very fine irregular and tubular pores; slightly effervescent; moderately alkaline; clear, smooth boundary.
- C2—23 to 36 inches, grayish-brown (10YR 5/2) light sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; few fine roots; common very fine and fine irregular pores; strongly effervescent; moderately alkaline; clear, smooth boundary.
- IIC3—36 to 60 inches, light brownish-gray (10YR 6/2) gravelly sandy loam, dark yellowish brown (10YR 4/4) when moist; massive; loose when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine irregular pores; slightly effervescent; moderately alkaline.

The A horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is fine sandy loam, sandy loam, loamy very fine sand, gravelly fine sandy loam, or gravelly sandy loam. It contains thin strata of silt loam, loamy sand, and gravelly loamy sand and is 5 to 35 percent gravel.

The C horizon has hue of 10YR or 7.5YR, value of 5 or 6

when dry and 3 or 4 when moist, and chroma of 2 to 4. It is sandy loam to loamy sand and contains 5 to 50 percent gravel.

The profile is commonly calcareous throughout, but some places are noncalcareous or are calcareous only in the lower part. The profile is neutral to moderately alkaline.

**CsC—Comoro sandy loam, 5 to 10 percent slopes.** This soil is on alluvial fans. The parent material is granodiorite. Elevation is 4,800 to 5,200 feet. Vegetation is scattered oak trees and brush that has a grass understory. Average annual precipitation is about 18 inches. This soil has a profile similar to the one described as representative of the series but contains fine granitic gravel about 2 to 5 millimeters in diameter.

Included in mapping and making up about 15 percent of the mapped area is a moderately deep soil that is underlain by granite bedrock or by the subsoil of an older, fine-textured soil at a depth of about 30 to 40 inches. Also included are small areas of White House sandy loam, Pima soils, and Guest soils near the centers of the flood plains.

Runoff is medium. The hazard of erosion is slight.

This soil is used for range and wildlife habitat. Capability unit VIe, nonirrigated; Loam Bottom range site, 12- to 20-inch precipitation zone; range productivity group 2.

**CtB—Comoro soils, 0 to 5 percent slopes.** In this undifferentiated group are the sandy loams that are commonly on the wide flood plains and have slopes of 0 to 1 percent. A Comoro sandy loam in an area of these soils has the profile described as representative of the series. In the smaller drainageways and on the fans, the soils generally contain 15 to 35 percent gravel throughout or have gravelly or sandy strata. Slopes are 1 to 5 percent. The surface is 5 percent to about 30 percent gravel with scattered cobbles.

Included in mapping are about 15 percent Torrifluents along stream channels, about 5 percent Grabe soils, and about 10 percent a reddish soil in the northeastern part of the Maria Santissima Del Carmen land grant, Township 24 S., Range 15 E.

Runoff is medium. The hazard of erosion is slight. The soils are subject to seasonal flooding in many places.

Most areas of these soils are used for range and wildlife habitat. A few areas are subdivided for homesites and other community uses. Capability unit IIs-7 irrigated, and VIe, nonirrigated; Loam Bottom range site, 12- to 20-inch precipitation zone; range productivity group 2.

### Continental Series

The Continental series consists of well-drained soils that are 60 inches or more in depth. These soils formed in old alluvium weathered from granite, rhyolite, andesite, and tuffs. They are on valley side slopes that are dissected by shallow drainageways. Slopes are 1 to 15 percent. Elevation is 2,900 to 3,800 feet. Vegetation is desert shrubs, grasses, and cacti. Average annual precipitation is 10 to 14 inches, and mean annual temperature is 60° to 65° F. The frost-free season is 200 to 270 days.

In a representative profile the surface layer is reddish-brown gravelly sandy loam about 6 inches thick. The subsoil is about 46 inches thick. The upper 4 inches is reddish-brown gravelly sandy clay loam; the next 21 inches is reddish-brown clay and red gravelly clay; and the lower 21 inches is reddish-brown and light reddish-brown gravelly and very gravelly sandy clay loam. The substratum is light reddish-brown gravelly sandy loam to a depth of 60 inches or more. The surface layer is neutral, the subsoil is neutral and slightly acid, and the substratum is neutral to moderately alkaline. The profile is strongly calcareous below a depth of about 31 inches.

Permeability is moderately slow or moderate, and available water capacity is moderate. Effective rooting depth is 60 inches or more.

These soils are used for range and wildlife habitat and a few homesites.

Representative profile of Continental gravelly sandy loam in an area of Continental-Rillino complex, 1 to 40 percent slopes, eroded, 800 feet north and 600 feet east of the southwest corner of sec. 14, T. 20 S., R. 12 E., Santa Cruz County:

- A11—0 to 3 inches, reddish-brown (5YR 5/4) gravelly sandy loam, dark reddish-brown (5YR 3/4) when moist; weak, thin and medium, platy structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common fine and very fine roots; many fine interstitial pores; 20 percent fine and medium gravel by volume; neutral; abrupt, smooth boundary.
- A12—3 to 6 inches, reddish-brown (5YR 4/4) gravelly sandy loam, dark reddish brown (5YR 3/4) when moist; weak, fine and medium, granular structure; slightly hard when dry, very friable when moist, slightly sticky and nonplastic when wet; common fine and very fine roots; few fine, very fine and medium tubular pores; 30 percent fine, medium, and coarse gravel by volume; slightly acid; clear, smooth boundary.
- B1t—6 to 10 inches, reddish-brown (5YR 4/4) gravelly sandy clay loam, dark reddish brown (5YR 3/4) when moist; moderate, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and very fine roots; common fine and medium tubular pores; few thin clay films line pores; 30 percent fine, medium, and coarse gravel by volume; neutral; clear, wavy boundary.
- B21t—10 to 19 inches, reddish-brown (2.5YR 4/4) clay, dark red (2.5YR 3/6) when moist; weak, medium and coarse, prismatic structure parting to moderate, medium and coarse, subangular blocky; very hard when dry, friable when moist, sticky and plastic when wet; common fine and very fine roots and few medium roots; common fine tubular pores; common pressure faces; 5 percent by volume, fine, medium, and coarse gravel; neutral; clear, wavy boundary.
- B22t—19 to 31 inches, red (2.5YR 4/6) gravelly clay, red (2.5YR 4/6) when moist; weak, medium, subangular blocky structure; very hard when dry, friable when moist, sticky and very plastic when wet; few fine and very fine roots; few fine and very fine tubular pores; common thin clay films on faces of peds and in pores; 20 percent, by volume, fine and medium gravel; noneffervescent; moderately alkaline; abrupt, wavy boundary.
- IIIB31ca—31 to 38 inches, reddish-brown (2.5YR 5/4) very gravelly sandy clay loam, reddish brown (2.5YR 4/4) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; few fine and very fine roots; common fine and few medium

tubular pores; few thin clay films line pores; 50 percent, by volume, gravel and 5 percent cobbles; common, medium, pinkish-gray (5YR 7/2), irregularly shaped soft filaments of lime; violently effervescent; moderately alkaline; clear, wavy boundary.

- IIB32ca—38 to 52 inches, light reddish-brown (5YR 6/4) gravelly sandy clay loam, reddish brown (5YR 5/4) when moist; massive; hard when dry, friable when moist, sticky and slightly plastic when wet; few very fine roots; few fine and very fine tubular pores and common fine interstitial pores; few thin clay films line pores; 30 percent, by volume, fine and medium gravel; common, medium, pinkish-gray (5YR 7/2) irregularly shaped soft masses and filaments of lime; violently effervescent; moderately alkaline; clear, wavy boundary.

- IICca—52 to 72 inches, light reddish-brown (5YR 6/3) gravelly heavy sandy loam, reddish brown (5YR 5/4) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine roots; common very fine tubular pores and common fine interstitial pores; few thin clay films line pores; 20 percent, by volume, gravel; common, fine, white (5YR 8/1) lime filaments; strongly effervescent in spots; moderately alkaline.

The A1 horizon has hue of 7.5YR or 5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 4 to 6. It is slightly acid to mildly alkaline. It is 5 to 50 percent gravel and cobbles, of which as much as 5 percent is cobbles.

The Bt horizon has hue of 5YR or 2.5YR, value of 3 to 5 when dry and 3 or 4 when moist, and chroma of 4 to 6. The B1t horizon is sandy clay loam, clay loam, gravelly sandy clay loam, or gravelly clay loam. The B2t horizon is heavy clay loam, clay, gravelly heavy clay loam, or gravelly clay. The Bt horizon is neutral to moderately alkaline. It is as much as 25 percent gravel. It has subangular blocky or prismatic structure, and in some profiles it is calcareous in the lower part.

The IIB3ca and IICca horizons have hue of 5YR or 2.5YR, value of 4 to 6 when dry and 4 or 5 when moist, and chroma of 3 to 6. They are clay loam, loam, or sandy loam and contain 10 to 60 percent gravel. These horizons are moderately alkaline. They have few to many, fine to coarse, soft or hard segregations and coatings of lime. Lime content ranges from about 5 to 15 percent or more. In places, there are discontinuous weakly cemented to strongly cemented layers of lime in the IIB3ca horizon. This horizon commonly contains more lime than the IICca horizon. Lime masses are light reddish brown to white.

**CuC—Continental soils, 1 to 10 percent slopes.** The soils in this undifferentiated group are on old alluvial fans or terraces that border both sides of the Santa Cruz River flood plain. The fans are dissected at quarter-mile to half-mile intervals by long, narrow, branching drainageways that have short, steep side slopes. Continental gravelly sandy loam is the dominant soil. About 20 to 25 percent of the soils in this mapping unit have a surface layer of gravelly or cobbly loam or gravelly or cobbly sandy clay loam and are intermingled in an indefinite pattern.

Included in mapping are 5 to 10 percent intermixed Eba and Pinaleno soils; about 5 percent Sonoita soils on secondary low terraces; and 5 percent gravelly Torriffuents in the drainageways. The short, steep escarpments make up 1 percent or less. The surface is about 25 to 50 percent gravel, 1 to 15 percent cobbles, and a few stones.

Runoff is medium. The hazard of erosion is slight.

These soils are used for range, wildlife habitat, and some homesites. Capability unit VIe, nonirrigated;

Loamy Upland range site, 12- to 16-inch precipitation zone; range productivity group 2.

**CvE2—Continental-Rillino complex, 1 to 40 percent slopes, eroded.** This complex is about 65 percent Continental gravelly sandy loam and 20 percent Rillino gravelly loam. The Continental soil is on the tops and upper side slopes of long, narrow ridges formed by dissection of old valley terraces and is in areas of lake sediment. Slopes are 1 percent to about 15 percent. The Rillino soil is on the sides and ends of the ridges. Slopes are 8 to 40 percent. A Continental gravelly sandy loam and a Rillino gravelly loam in an area of this complex have the profiles described as representative of their respective series. The surface is 20 to 50 percent gravel and 0 to 15 percent cobbles.

Included in mapping are about 5 percent Eba soils on the ridgetops, 5 percent Sonoita and Pinaleno soils on some secondary low terraces, and 5 percent gravelly recent alluvium in narrow bands along the drainageways. Also included are small areas of escarpments and land slips that have slopes of 40 to 100 percent.

Runoff is medium on Continental soils and rapid on Rillino soils. The hazard of erosion is high.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Continental part in Loamy Upland range site, 12- to 16-inch precipitation zone, Rillino part in Limy Upland range site, 12- to 16-inch precipitation zone; range productivity group 3.

### Eba Series

The Eba series consists of well-drained, very gravelly soils that are 60 inches or more in depth. These soils formed in old alluvium weathered from granite, rhyolite, andesite, tuffs, and limestone. They are on old piedmont surfaces that have slopes of 0 to 10 percent. Elevation is 3,000 to 3,800 feet. Vegetation is dominantly mesquite, paloverde, ocotillo, burroweed, gramas, three-awns, and cacti. Average annual precipitation is 11 to 14 inches, and mean annual temperature is 60° to 65° F. The frost-free season is 200 to 270 days.

In a representative profile the surface layer is yellowish-red very gravelly sandy loam about 1 inch thick. The subsoil is dark reddish-brown and dark-red very gravelly clay about 49 inches thick. The substratum is reddish-yellow very gravelly sandy loam to a depth of 80 inches or more. The surface layer and subsoil are mildly alkaline, and the substratum is moderately alkaline. The profile is slightly effervescent in the lower part of the subsoil and strongly effervescent in the substratum.

Permeability is slow, and available water capacity is low to moderate. Effective rooting depth is 60 inches or more.

These soils are used for range and wildlife habitat.

Representative profile of Eba very gravelly sandy loam, 0 to 10 percent slopes, on the south side of a large wash 1,640 feet west and 320 feet south of the northeast corner of sec. 30, T. 18 S., R. 14 E., Pima County:

A1—0 to 1 inch, yellowish-red (5YR 5/6) very gravelly sandy loam, yellowish red (5YR 4/6) when moist; weak, fine, granular structure; slightly hard when

dry, friable when moist, nonsticky and nonplastic when wet; common fine roots; common fine interstitial pores; 65 percent gravel and 5 percent cobbles by volume; mildly alkaline; clear, wavy boundary.

B2t—1 inch to 30 inches, dark reddish-brown (2.5YR 3/4) very gravelly clay, reddish brown (2.5YR 4/4) when moist; moderate, fine and medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few fine roots and common very fine roots; few fine tubular pores; common thin clay films on faces of peds; 55 percent gravel and 5 percent cobbles by volume; mildly alkaline; clear, smooth boundary.

B2t—30 to 50 inches, dark-red (2.5YR 3/6) very gravelly clay, dark red (2.5YR 3/6) when moist; strong, fine and medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common very fine roots and few fine films on faces of peds; 50 percent gravel and 20 percent cobbles by volume; slightly effervescent in spots; mildly alkaline; clear, wavy boundary.

Cca—50 to 80 inches, reddish-yellow (5YR 7/6) very gravelly sandy loam, yellowish red (5YR 5/6) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many fine interstitial pores; 60 percent gravel and 10 percent cobbles by volume; strongly effervescent; weakly cemented by lime in places; moderately alkaline.

The A horizon has hue of 7.5YR or 5YR, value of 4 to 6 when dry and 3 and 4 when moist, and chroma of 3 to 6. It is 35 to 65 percent gravel and 0 to 10 percent cobbles.

The B2t horizon has hue of 5YR or 2.5YR, value of 3 to 7 when dry and 3 to 5 when moist, and chroma of 4 to 6. It is gravelly or very gravelly heavy clay loam or clay and contains 35 to 60 percent gravel and 0 to 20 percent cobbles and stones.

The Cca horizon is weakly cemented to strongly cemented by lime in places.

**EbC—Eba very gravelly sandy loam, 0 to 10 percent slopes.** This soil is in several large areas on the lower valley side slopes of the Santa Rita Mountains. It has the profile described as representative of the series. The surface is 30 to 60 percent gravel, 5 to 15 percent cobbles, and a few stones.

Included in mapping are about 15 percent Continental soils on lower side slopes, 5 percent White House soils on upper side slopes, and about 5 percent Pinaleno soils and gravelly alluvium in narrow drainageways.

Runoff is medium. The hazard of erosion is slight.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Loamy Upland range site, 12- to 16-inch precipitation zone; range productivity group 3.

### Fanno Series

The Fanno series consists of well-drained soils that are 20 to 40 inches in depth over clayey shale. They formed in material weathered from clayey shale bedrock. They are on uplands. Slopes are 5 to 20 percent. Elevation is 5,200 to 6,000 feet. Vegetation is dominantly gramas, curly mesquite, bluestems, and scattered oak and juniper trees. Average annual precipitation is 16 to 20 inches, and mean annual temperature is 55° to 59° F. The frost-free season is 170 to 220 days.

In a representative profile the surface layer is dark

reddish-gray gravelly clay loam about 1 inch thick. The subsoil is reddish-brown clay about 24 inches thick. The substratum, to a depth of 40 inches or more, is weak-red weathered clayey shale. The surface layer is slightly acid, the subsoil is neutral or mildly alkaline, and the substratum is moderately alkaline. The parent shale is strongly effervescent on fracture faces. It has a hardness of less than 3 on the Mohs' scale.

Permeability is slow, and available water capacity is low or moderate. Effective rooting depth is 20 to 40 inches.

These soils are used for range and wildlife habitat.

Representative profile of Fanno gravelly clay loam, in an area of Fanno-Luzena association, rolling, in roadcut, on the north side of the Parker Canyon-Montezuma Pass Road, 0.45 mile east of the Lochiel turnoff, 1,100 feet south of the north quarter corner of sec. 3, T. 24 S., R. 19 E., Cochise County:

- A1—0 to 1 inch, dark reddish-gray (5YR 4/2) gravelly light clay loam, dark reddish brown (5YR 3/4) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many fine and very fine roots; many fine interstitial pores; 25 percent gravel and a few cobbles; slightly acid; clear, wavy boundary.
- B21t—1 inch to 8 inches, reddish-brown (5YR 4/4) light clay, dark reddish brown (5YR 3/4) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; many fine and very fine roots and few medium roots; common fine and very fine tubular pores; common thin clay films on faces of peds and in pores; common pressure faces; 5 percent gravel by volume; neutral; clear, wavy boundary.
- B22t—8 to 25 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; moderate, medium and coarse, angular and subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common fine and very fine roots and few medium roots; common fine and very fine tubular pores; common thin clay films on faces of peds and in pores; common pressure faces; few small slickensides in lower part; mildly alkaline; abrupt, wavy boundary.
- C—25 to 40 inches, weak-red (2.5YR 4/2) weathered clayey shale, fractured in places, weak red (2.5YR 4/2) when moist; massive; very hard when dry, firm when moist, slightly sticky and plastic when wet; few fine roots in fractures; few very fine tubular pores; slightly effervescent; strongly effervescent on fracture faces; moderately alkaline.

Depth to the clayey shale ranges from 20 to 40 inches. The A horizon is slightly acid to moderately alkaline, and the B2 horizon is neutral to moderately alkaline. The A horizon has hue of 7.5YR to 2.5YR, value of 4 or 5 when dry, and chroma of 2 to 4. It is gravelly loam, gravelly clay loam, or loam and contains 5 to 35 percent gravel and 0 to 5 percent cobbles. The B2t horizon has hue of 5YR or 2.5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 3 to 6.

**FaD—Fanno-Luzena association, rolling.** This association is about 60 percent Fanno soils and 25 percent Luzena soils. The soils are mainly on the Morita Formation in southwestern Cochise County. Areas are fairly large. Within a given mapped area the relative percentages of soils vary.

The Fanno gravelly clay loam in this association has the profile described as representative of the Fan-

no series. Fanno soils have slopes of dominantly 5 to 20 percent and a surface layer of gravelly loam or gravelly clay loam. The surface layer is 25 to 50 percent gravel and 1 to 5 percent cobbles.

The Luzena gravelly loam in this association has the profile described as representative of the Luzena series. Luzena soils are on low rocky hills and ledges of rhyodacite, feldspathic sandstone, and other rocks intermixed in the formation. They have slopes of 5 to 60 percent. The surface layer is gravelly or cobbly loam or clay loam. The surface is 30 to 50 percent cobbles and 5 to 10 percent stones.

Included in mapping are about 5 percent each of Martinez and White House soils and about 5 percent Faraway soils and Rock outcrop.

Runoff is medium. The hazard of erosion is moderate.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Clay Loam Hills range site, 16- to 20-inch precipitation zone; range productivity group 3.

## Fanno Variant

The Fanno variant consists of well-drained soils that are 22 to 60 inches in depth to bedrock. These soils formed in material weathered from sandstone, phyllite, or siliceous schist. They are on mountainous uplands. They are on steeper slopes, are at higher elevations, and have a cooler, wetter climatic regime than soils in the Fanno series. Slopes are 20 to 50 percent. Elevation is 6,500 to 8,000 feet. Vegetation is pine, fir, oak, juniper, other trees and brush, and sparse grasses. Average annual precipitation is 18 to 24 inches, and mean annual temperature is 47° to 50° F. The frost-free season is 140 to 180 days.

In a representative profile there is a 2-inch layer of pine needle litter and decomposed forest litter on the surface. The surface layer is brown gravelly loam about 1 inch thick. The upper part of the subsurface layer is very pale brown very gravelly loam about 4 inches thick. The lower part of the subsurface layer is very pale brown gravelly silty clay loam about 8 inches thick. The subsoil is very pale brown, yellow, and brownish-yellow clay and gravelly clay about 27 inches thick. The underlying material, to a depth of 44 inches or more, is very pale brown, strongly weathered phyllite bedrock. The surface layer and subsurface layer are slightly acid to medium acid, and the subsoil is medium acid.

Permeability is slow, and available water capacity is moderate. Effective rooting depth is 22 to 60 inches.

These soils are used for wildlife habitat, woodland, water supply, and mining.

Representative profile of Fanno very gravelly loam, acid variant, 20 to 50 percent slopes, in an area of Fanno soils, acid variants, 20 to 50 percent slopes, in roadcut, approximately the center of the southeast quarter of sec. 15, T. 23 S., R. 18 E., Cochise County:

O1—2 inches to 1 inch, pine needle litter.

O2—1 inch to 0, decomposed forest litter.

A1—0 to 1 inch, brown (10YR 5/3) gravelly loam, very dark grayish brown (10YR 3/2) when moist; weak, fine and medium, granular structure;

slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common fine and medium roots; many very fine interstitial pores; 30 percent gravel and 5 percent cobbles, by volume; slightly acid; abrupt, wavy boundary.

- A2—1 inch to 5 inches, very pale brown (10YR 7/3) very gravelly heavy loam, dark yellowish brown (10YR 4/4) when moist; weak, medium and coarse, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine roots; many very fine interstitial pores; 45 percent gravel and 5 percent cobbles, by volume; medium acid; clear, wavy boundary.
- A3—5 to 13 inches, very pale brown (10YR 8/4) gravelly silty clay loam, yellowish brown (10YR 5/8) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; many fine and common medium roots; common, very fine, fine, and medium tubular pores; 30 percent gravel and 5 percent cobbles, by volume; medium acid; clear, wavy boundary.
- B21t—13 to 18 inches, very pale brown (10YR 7/4) gravelly clay, yellowish brown (10YR 5/8) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common fine and medium roots; common fine and medium tubular pores; few thin clay films on faces of peds; 15 percent gravel, by volume; medium acid; abrupt, wavy boundary.
- B22t—18 to 27 inches, yellow (10YR 7/6) clay, strong brown (7.5YR 5/6) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common fine and medium roots; common fine and medium tubular pores; common thin clay films on faces of peds and in pores; few pebbles; medium acid; clear, wavy boundary.
- B3t—27 to 40 inches, brownish-yellow (10YR 6/6) clay, reddish yellow (7.5YR 6/6) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; few fine and medium roots; few fine tubular pores; few gravel-size rock fragments; medium acid; clear, wavy boundary.
- R—40 to 44 inches, very pale brown (10YR 8/4) strongly weathered phyllite bedrock, brownish yellow (10YR 6/8) when moist; massive; very hard, medium acid.

Depth to bedrock ranges from 22 to 60 inches. The A1 horizon has hue of 10YR or 7.5YR and chroma of 2 or 3. It is medium acid or slightly acid. The A2 and A3 horizons have hue of 10YR or 7.5YR, value of 6 to 8 when dry and 4 or 5 when moist, and chroma of 4 to 8. They are gravelly or very gravelly fine sandy loam to gravelly silty clay loam and contain 30 to 60 percent gravel and 1 to 10 percent cobbles. They are medium acid to slightly acid.

The Bt horizon has hue of 10YR to 5YR, value of 4 to 7 when dry and 4 to 6 when moist, and chroma of 3 to 8. It is heavy clay loam, clay, gravelly clay loam, or gravelly clay and contains 5 to 30 percent gravel and 5 to 10 percent cobbles. It is commonly strongly weathered. The Bt horizon is medium acid to slightly acid. The B3t horizon is absent in places.

The upper part of the R horizon is strongly weathered.

**FcF—Fanno soils, acid variants, 20 to 50 percent slopes.** The soils in this undifferentiated group are on mountain uplands. They are in areas of sandstone, quartzite, or phyllite in the Huachuca Mountains. Vegetation is mixed coniferous-deciduous forest and very sparse grasses. The surface layer is gravelly or very gravelly fine sandy loam or gravelly or very gravelly loam. Some areas are cobbly. The surface is 30 to 60 percent gravel, 1 to 20 percent cobbles, and a few stones.

A Fanno very gravelly loam, acid variant, in an

area of these soils has the profile described as representative of the Fanno variant soils.

Included in mapping are about 25 percent Telephone very gravelly loam or fine sandy loam and 15 to 20 percent Rock outcrop. Also included are small areas of Tortugas and Hogris soils.

Runoff is medium. The hazard of erosion is high.

These soils are used for woodland, wildlife habitat, water supply, and some mining. Capability unit VIe, nonirrigated; woodland suitability group is 1 where slopes are less than 30 percent and 2 where more than 30 percent; range productivity group 4; not assigned to a range site.

## Faraway Series

The Faraway series consists of well-drained soils that are 5 to 20 inches in depth to bedrock. These soils formed in material weathered from acid and basic igneous rock. They are on hills and mountains. Slopes are 10 to 60 percent. Elevation is 5,000 to 7,500 feet. Vegetation is dominantly oak, juniper, pinyon pine, manzanita, gramas, and bluestems. Pine and fir are dominant above about 7,000 feet. Average annual precipitation is 16 to 24 inches, and mean annual temperature is 50° to 58° F. The frost-free season is from 140 to 220 days.

In a representative profile the surface layer is dark grayish-brown very cobbly fine sandy loam about 12 inches thick overlying reddish-gray extremely hard, fractured dacite or rhyolite bedrock. The profile is slightly acid and noncalcareous.

Permeability is moderate to bedrock, and available water capacity is very low. Effective rooting depth is 5 to 20 inches.

These soils are used for range and wildlife habitat. At the higher elevations some acreage is used for woodland and water supply.

Representative profile of Faraway very cobbly fine sandy loam, in an area of Faraway-Rock outcrop complex, 10 to 30 percent slopes, 200 feet north of State Highway 83 and 300 feet east of the entrance to Parker Canyon Recreation Area, in the northeast quarter of the southeast quarter of sec. 18, T. 23 S., R. 19 E., Cochise County:

A11—0 to 2 inches, dark grayish-brown (10YR 4/2) very cobbly fine sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine, fine and medium roots; common fine interstitial pores; 40 percent gravel and 25 percent cobbles, by volume; slightly acid; abrupt, smooth boundary.

A12—2 to 12 inches, dark grayish-brown (10YR 4/2) very cobbly fine sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many very fine, fine and medium roots; common fine interstitial pores; 50 percent gravel and 20 percent cobbles, by volume; slightly acid; abrupt, irregular boundary.

R—12 to 18 inches, reddish-gray (10YR 5/1) fractured dacite bedrock; some material from the A12 horizon in fractures.

Depth to bedrock ranges from 5 to 20 inches. A C horizon

is present in places. The A horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is gravelly loam, gravelly fine sandy loam, cobbly loam, cobbly fine sandy loam, very cobbly fine sandy loam, very cobbly loam, or very stony loam, is medium acid to neutral, and 35 to 80 percent gravel, cobbles, and stones. Content of gravel is 20 to 60 percent, of cobbles is 5 to 40 percent, and of stones is 0 to 20 percent.

**FrE—Faraway-Rock outcrop complex, 10 to 30 percent slopes.** This complex consists of about 65 percent Faraway soils and 15 to 30 percent Rock outcrop (fig. 5). A Faraway very cobbly fine sandy loam in an area of this complex has the profile described as representative of the series. The Faraway soils are cobbly or very cobbly fine sandy loam or loam, or they are gravelly or very gravelly fine sandy loam or loam. Small areas are stony. Rock outcrop consists of low ledges and occasional pinnacles of rhyodacite, andesite, diorite, rhyolite, feldspathic sandstone, and shale. Slopes commonly are as much as 30 percent, but in places short slopes are steeper. The surface is 25 to 50 percent gravel, 5 to 25 percent cobbles, and 0 to 10 percent stones.

Included in mapping are about 15 percent Luzena gravelly loam. Also included are small areas of gravelly recent alluvium in drainageways.

Runoff is medium. The hazard of erosion is moderate.

These soils are used mainly for range and wildlife habitat. A part of the Parker Canyon Recreation Area is in this mapping unit. Capability unit VIe, nonirrigated; Faraway soils in Loamy Hills range site, 16- to 20-inch precipitation zone, Rock outcrop part not assigned to a range site; range productivity group 4.

**FrF—Faraway-Rock outcrop complex, 30 to 60 percent slopes.** This complex consists of about 55 percent Faraway soils and 30 percent Rock outcrop. Faraway very cobbly fine sandy loam and loam is on steep mountains between areas of Rock outcrop and has slopes of 35 to 50 percent. Rock outcrop consists of low ledges and occasional pinnacles. It ranges from rhyolite to andesite and has various admixtures of tuff. Shale and feldspathic sandstone make up parts of the west side of the Huachuca Mountains. Rock fragments, mostly of cobble size but ranging from gravel to stones, cover 70 to 80 percent of the surface.

Included in mapping are about 15 percent Luzena gravelly loam, mainly in the Huachuca Mountains. Also included are some areas of soils in the Canele hills that have a thin dark grayish-brown surface layer and a grayish-brown subsurface layer; small areas of reddish clayey soils in southwestern Cochise



*Figure 5.*—An area of Faraway-Rock outcrop complex on a 15 percent slope.

County; gravelly alluvium in drainageways; and some colluvial soils on the toe slopes of the steeper areas.

Runoff is medium. The hazard of erosion is high.

These soils have limited use for range but are well suited to wildlife habitat. Some small areas at higher elevations are used for timber. Capability unit VIIe, nonirrigated; Faraway soils in Loamy Hills range site, 16- to 20-inch precipitation zone, Rock outcrop part not assigned to a range site; range productivity group 4.

**FtF—Faraway-Tortugas-Rock outcrop association, steep.** This association is an irregular pattern of soils and Rock outcrop on steep mountain terrain. It is about 35 percent Faraway very cobbly fine sandy loam or loam, 25 percent Tortugas very cobbly loam, and 25 percent Rock outcrop. Slopes range from 20 to 60 percent. Percentages of the soils and Rock outcrop are variable within mapped areas. Faraway soils are on igneous and tuffaceous rocks and some areas of shale and sandstone. Rock outcrop consists of ledges, reefs, and pinnacles. Gravel, cobbles, and stones cover about 70 percent of the surface between the outcrops.

Included in mapping are about 15 percent Luzena, Telephone, Hogris, and Fanno variant soils. A few areas are above 7,000 feet.

Runoff is medium to rapid. The hazard of erosion is moderate.

These soils have limited use as range but are well suited to wildlife habitat. Small areas are suited to timber. Capability unit VIIe, nonirrigated; Faraway soils in Loamy Hills range site, 16- to 20-inch precipitation zone; Tortugas soils in Limestone Hills range site, 16- to 20-inch precipitation zone, Rock outcrop part not assigned to a range site; range productivity group 4.

## Gaddes Series

The Gaddes series consists of well-drained soils that are 20 to 30 inches in depth over bedrock. They formed on granite hills and mountain uplands. Slopes range from 5 to 45 percent. Elevation is 5,000 to 6,000 feet. Vegetation is dominantly oak, juniper, manzanita, grama grasses, false mesquite, plains lovegrass, and Texas beardgrass. Average annual precipitation is 16 to 20 inches, and mean annual temperature is 54° to 58° F. The frost-free season is 160 to 220 days.

In a representative profile the surface layer is dark grayish-brown gravelly sandy loam and brown sandy loam about 5 inches thick. The subsoil is about 18 inches thick. The upper 11 inches is yellowish-red sandy clay loam over gravelly clay. The lower 7 inches is reddish-brown cobbly sandy clay loam. The underlying material, to a depth of about 30 inches or more, is weathered granite that can be broken by hand but that becomes harder as depth increases. The surface layer is neutral, and the subsoil is slightly acid.

Permeability is moderately slow, and available water capacity is low. Effective rooting depth is 20 to 30 inches.

These soils are used for range, wildlife habitat, recreation, and some mining.

Representative profile of Gaddes very gravelly sandy

loam, 5 to 30 percent slopes, in the southwest quarter of the northwest quarter of sec. 32, T. 23 S., R. 16 E., Santa Cruz County:

- O1— $\frac{1}{4}$  inch to 0, oak and grass litter.
- A11—0 to 2 inches, dark grayish-brown (10YR 4/2) gravelly sandy loam, very dark brown (10YR 2/2) when moist; moderate, very fine and fine, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine and fine roots; many very fine and fine interstitial pores; 15 percent gravel and 5 percent cobbles, by volume; neutral; abrupt, wavy boundary.
- A12—2 to 5 inches, brown (7.5YR 5/4) sandy loam, dark brown (7.5YR 3/2) when moist; moderate, very fine and fine, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine and fine roots; many very fine and fine interstitial pores; 5 percent gravel, by volume; neutral; abrupt, wavy boundary.
- B1—5 to 8 inches, yellowish-red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) when moist; moderate, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine, fine, medium, and coarse roots; common very fine and fine interstitial and tubular pores; 5 to 10 percent gravel by volume; slightly acid; clear, wavy boundary.
- B2t—8 to 16 inches, yellowish-red (5YR 5/8) gravelly clay, yellowish red (5YR 4/8) when moist; moderate, medium, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common fine, medium, and coarse roots; common fine and medium tubular pores; common moderately thick clay films on faces of peds and in pores; 15 to 20 percent weathered gravel, by volume; slightly acid; abrupt, wavy boundary.
- B3t—16 to 23 inches, reddish-brown (5YR 5/4) cobbly sandy clay loam, reddish brown (5YR 4/4) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few medium and coarse roots; few fine and medium tubular pores; few moderately thick clay films on faces of peds; 10 percent weathered gravel and 25 percent cobbles, by volume; slightly acid; clear, wavy boundary.
- C—23 to 30 inches, weathered granite bedrock.

Depth to weathered granite bedrock ranges from 20 to 30 inches. The A horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 to 4. It is slightly acid to neutral. It is 5 to 50 percent gravel and 5 to 20 percent cobbles. Gravel is dominantly fine.

The B horizon has hue of 7.5YR to 2.5YR, value of 3 to 6 when dry and 3 to 5 when moist, and chroma of 3 to 8. It is clay loam, sandy clay loam, gravelly clay, gravelly or cobbly sandy clay loam, or gravelly clay loam and contains less than 35 percent strongly weathered gravel and cobbles. It is slightly acid to neutral.

The weathered granitic material in the C horizon increases in hardness as depth increases.

**GaE—Gaddes very gravelly sandy loam, 5 to 30 percent slopes.** This soil is on the lower slopes of granitic mountains. The slopes are dissected by numerous short and a few long drainageways. The surface is 25 to 50 percent gravel, 5 to 20 percent cobbles, and 0 to 10 percent stones.

Included in mapping are about 10 percent Barker-ville gravelly or cobbly sandy loam on the steeper, rockier parts; 10 to 15 percent Rock outcrop; and about 5 percent Torrifluents in the drainageways.

Runoff is medium. The hazard of erosion is moderate.

This soil is used primarily for range and wildlife habitat. Capability unit VIe, nonirrigated; Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 4.

### Grabe Series

The Grabe series consists of well-drained soils that are 60 inches or more in depth. These soils formed in recent alluvium weathered from mixed igneous and sedimentary rocks. They are on flood plains adjacent to the major streams (fig. 6). Slopes range from 0 to 5 percent. Elevation is 3,000 to 5,400 feet. At the lower elevations vegetation is desert shrubs and grass, and at the higher elevations it is mainly grass and some walnut, oak, or sycamore trees. Average annual precipitation is 11 to 18 inches, and mean annual tempera-

ture is 57° to 64° F. The frost-free season is 170 to 250 days.

In a representative profile the surface layer is dark grayish-brown and dark-brown loam about 48 inches thick. The substratum is brown sandy loam to a depth of 60 inches or more. The profile is moderately alkaline throughout and is slightly calcareous below a depth of 18 inches.

Permeability is moderate, and available water capacity is high. Effective rooting depth is 60 inches or more.

These soils are used for range, wildlife habitat, and for irrigated crops in areas along the Santa Cruz River. A few areas near Nogales are used for homesites and industrial sites.

Representative profile of Grabe loam in an area of Grabe soils, near the north end of the Tubac Country Club, 700 feet west and 600 feet north of the southeast corner of sec. 31, T. 20 S., R. 13 E., Santa Cruz County:

A11—0 to 3 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) when moist; weak, medium, platy structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; few fine roots; few fine tubular pores; 5 percent gravel, by volume; moderately alkaline; abrupt, smooth boundary.

A12—3 to 18 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and very fine tubular pores; 5 percent gravel, by volume; moderately alkaline; clear, smooth boundary.

A13—18 to 48 inches, dark-brown (7.5YR 4/2) loam, dark brown (7.5YR 3/2) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and very fine roots; common fine, very fine, and few, medium tubular pores; 5 to 10 percent gravel, by volume; slightly effervescent in spots; moderately alkaline; clear, wavy boundary.

C—48 to 60 inches, brown (7.5YR 5/2) sandy loam, dark brown (7.5YR 4/2) when moist; massive; slightly hard when dry, very friable when moist, non-sticky and nonplastic when wet; few fine and very fine roots; many fine interstitial pores and few fine tubular pores; few pebbles; slightly effervescent in spots; moderately alkaline.

The A horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry, 2 or 3 when moist, and chroma of 2 or 3. It is loam, gravelly loam, silt loam, very fine sandy loam, or gravelly very fine sandy loam and contains thin strata of gravelly sandy loam or fine sandy loam. It is 0 to 3 percent gravel and 0 to 5 percent cobbles. It is neutral to moderately alkaline and is noneffervescent to strongly effervescent. Lime is generally disseminated in the A horizon, but in places there are fine segregated filaments.

The C horizon has hue ranging from 10YR to 5YR, value of 5 or 6 when dry and 3 or 4 when moist, and chroma of 2 to 4. It is silt loam, loam, sandy loam, or loamy sand, and as much as 70 percent rock fragments.

**GbB—Grabe-Comoro complex, 0 to 5 percent slopes.** The soils in this complex are on flood plains of larger drainageways. Each soil makes up about 40 percent of the mapping unit. The surface layer of both soils is dominantly sandy loam but is gravelly sandy loam, loam, and gravelly loam in places.

Included in mapping and making up about 20 percent of the mapped area are small areas of Pima soils,



Figure 6.—Profile of Grabe loam on the side of a gully. Gullies have entrenched some of the flood plains along the major streams.

Torrifluvents, very gravelly Haplustolls, and soils that are shallow over sand and gravel.

Runoff is medium or slow. The hazard of erosion is slight, but some areas receive damaging runoff from higher lying areas and are subject to severe gully erosion.

These soils are used mainly for range and wildlife habitat. A few small areas along the Santa Cruz River are used for irrigated pasture. Capability units IIs-7, irrigated, and VIe, nonirrigated; Loam Bottom range site, 12- to 20-inch precipitation zone; range productivity group 2.

**Ge—Grabe soils.** The soils in this undifferentiated group are in narrow areas in drainageways. Grabe soils make up about 85 percent of the unit. Slopes are dominantly 0 to 1 percent but are as much as 3 percent in places. A Grabe loam in an area of these soils has the profile described as representative of the series. On the narrow flood plains in places the surface layer is sandy loam or gravelly sandy loam, and in places the soil is stratified and gravelly. Included in mapping and making up about 15 percent of the mapped areas are small areas of Comoro and Pima soils and Torrifuvents.

Runoff is slow. Although the hazard of erosion is slight, in places there is gully erosion caused by runoff from higher lying areas.

These soils are used mainly for range and wildlife habitat. Small areas along the Santa Cruz River are cultivated. Part of the city of Nogales is built on these soils. Capability units I-1, irrigated, and VIc, nonirrigated; Loam Bottom range site, 12- to 20-inch precipitation zone; range productivity group 1.

## Graham Series

The Graham series consists of well-drained soils that are 8 to 20 inches in depth over bedrock. These soils formed in residuum weathered from basic igneous and tuffaceous rocks. They are on upland hills that have slopes of 5 to 50 percent. Elevation is 3,000 to 5,500 feet. Vegetation is dominantly grama grasses, curly mesquite, false mesquite, ocotillo, and catclaw; some oak and juniper trees are above an elevation of about 4,000 feet. Average annual precipitation is 12 to 18 inches, and mean annual temperature is 57° to 64° F. The frost-free season is 180 to 250 days.

In a representative profile the surface layer is grayish-brown very cobbly clay loam about 2 inches thick. The subsoil is dark-brown clay about 17 inches thick. Below a depth of about 19 inches is pinkish-white and light reddish-brown fractured andesite-tuff bedrock. The surface layer is neutral, and the subsoil is moderately alkaline. The lower part of the subsoil is slightly calcareous.

Permeability is slow, and available water capacity is low. Effective rooting depth is 8 to 20 inches.

The soils are used for range and wildlife habitat. A few areas are used for homesites and recreation.

Representative profile of Graham very cobbly clay loam from an area of Graham soils, 5 to 20 percent slopes, a third of the way up the east side of a hill, 750 feet west and 1,600 feet south of the northeast

corner of sec. 11, T. 21 S., R. 21 E., Santa Cruz County:

A1—0 to 2 inches, grayish-brown (10YR 5/2) very cobbly clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; many fine roots; many fine interstitial pores; 30 percent cobbles and 20 percent gravel, by volume; neutral; abrupt, wavy boundary.

B21t—2 to 8 inches, dark-brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; moderate, medium and coarse, subangular and angular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; common fine and few medium roots; common very fine tubular pores; common moderately thick clay films on faces of peds and in pores; 5 percent cobbles and 5 percent gravel, by volume; moderately alkaline; abrupt, wavy boundary.

B22t—8 to 19 inches, dark-brown (7.5YR 4/2) clay, dark brown (7.5YR 4/4) when moist; moderate, medium, angular blocky structure; very hard when dry, firm when moist; very sticky and very plastic when wet; common fine and very fine roots; common very fine tubular pores; common thin clay films on faces of peds; 5 to 10 percent gravel and cobbles, by volume; common short slickensides; slightly effervescent in spots; moderately alkaline; abrupt, irregular boundary.

R—19 to 22 inches, pinkish-white (7.5YR 8/2) and light reddish-brown (5YR 6/3) extremely hard fractured andesite-tuff bedrock.

Depth to bedrock ranges from 8 to 20 inches. The A horizon has hue of 7.5YR or 10YR, value of 4 to 5 when dry and 2 or 3 when moist, and chroma of 2 and 3. It is cobbly or gravelly loam, cobbly or gravelly clay loam, very cobbly or very gravelly loam, very cobbly loam, or very cobbly clay loam. It is 20 to 50 percent gravel, 15 to 50 percent cobbles, and 5 to 10 percent stones. It is neutral to mildly alkaline.

The B2t horizon has hue of 7.5YR or 5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 2 to 6. It is heavy clay loam or clay, gravelly or cobbly heavy clay loam, or gravelly or cobbly clay. It is less than 35 percent gravel, cobbles, or stones. It is neutral to moderately alkaline. The lower part of the Bt horizon and the fractured bedrock are calcareous in places.

**GhD—Graham soils, 5 to 20 percent slopes.** The soils in this undifferentiated group are at the foot of basic igneous and tuffaceous mountains. Slopes are dominantly 5 to 20 percent. A Graham very cobbly clay loam in an area of these soils has the profile described as representative of the series. The surface layer of other Graham soils in this unit is gravelly or cobbly loam. The surface is 15 to 50 percent gravel, 0 to 25 percent cobbles, and a few stones.

Included in mapping are about 10 percent each of Lampshire very cobbly loam and Rock outcrop.

Runoff is medium. The hazard of erosion is slight.

These soils are used mainly for range and wildlife habitat. An area adjacent to Sonoita Creek is being developed for homesites. A small area near the Lake Patagonis dam site is used for recreation. Capability unit VIe, nonirrigated; Clay Loam Hills range site, 16- to 20-inch precipitation zone, and Clay Loam Hills range site, 12- to 16-inch precipitation zone; range productivity group 4.

**GhF—Graham soils, 20 to 50 percent slopes.** The soils in this undifferentiated group are on the Atascosa and Tumacacori Mountains, which are mainly of andesite, tuffs, and related basic igneous rock. Graham

cobbly or very cobbly loam or clay loam makes up about 60 percent of the unit. Rock fragments on the surface are dominantly cobbles and stones and cover 60 to 70 percent of the area.

Included in mapping are about 40 percent Rock outcrop, Lampshire soils similar to Chiricahua soils but redder, and small pockets of deep soils similar to Bonita soils.

Runoff is medium. The hazard of erosion is high.

These soils are used for range and wildlife habitat. Capability unit VIIe, nonirrigated; Clay Loam Hills range site, 16- to 20-inch precipitation zone; range productivity group 4.

## Guest Series

The Guest series consists of well-drained soils that are 60 inches or more in depth. These soils formed in fine textured and moderately fine textured alluvium from weathered rocks of mixed sources. They are on flood plains. Slopes are dominantly 0 to 2 percent but are as much as 3 percent in places. Elevation is 3,000 to 5,200 feet. Vegetation is dominantly tobosa, curly mesquite, vine-mesquite, side-oats grama, three-awns, and annual grasses. Average annual precipitation is 12 to 20 inches, but extra water is received from runoff from other areas. Mean annual temperature is 57° to 64° F. The frost-free season is 160 to 250 days.

In a representative profile the surface layer is very dark grayish-brown, dark grayish-brown, and dark reddish-gray clay about 34 inches thick. The substratum is brown gravelly heavy clay loam to a depth of 68 inches or more. The upper part of the surface layer is mildly alkaline, and the lower part of the surface layer and the substratum are moderately alkaline. The lower part of the surface layer is slightly calcareous, and the substratum is strongly calcareous.

Permeability is slow, and available water capacity is high. Effective rooting depth is 60 inches or more.

These soils are used mainly for range and wildlife habitat. A few small areas are used for irrigated crops and pasture.

Representative profile of Guest clay, in an area of Guest soils, 200 feet north of a windmill, 500 feet north and 100 feet west of the east quarter corner of sec. 32, T. 22 S., R. 17 E., Santa Cruz County:

- A11—0 to 3 inches, very dark grayish-brown (10YR 3/2) clay, very dark brown (10YR 2/2) when moist, moderate, fine, granular structure, slightly hard when dry, friable when moist, very sticky and very plastic when wet; many fine and medium roots; many fine and very fine interstitial pores; 5 percent gravel, by volume; mildly alkaline; clear, smooth boundary.
- A12—3 to 14 inches, dark grayish-brown (10YR 4/2) clay, very dark brown (10YR 2/2) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, very sticky and very plastic when wet; common fine and medium roots; common very fine and fine tubular pores; 5 percent gravel, by volume; slightly effervescent; mildly alkaline; clear, wavy boundary.
- A13—14 to 34 inches, dark reddish-gray (5YR 4/2) clay, dark reddish brown (5YR 3/2) when moist; weak medium subangular blocky structure; hard when dry, friable when moist, very sticky and very plastic when wet; common fine and medium roots; many very fine and fine tubular pores; 5 percent

gravel, by volume; slightly effervescent; moderately alkaline; clear, wavy boundary.

C—34 to 68 inches, brown (7.5YR 5/2) gravelly heavy clay loam, dark brown (7.5YR 3/2) when moist; massive; hard when dry, friable when moist, very sticky and very plastic when wet; common very fine, fine and medium roots; many fine and very fine tubular pores; 20 percent gravel, by volume; strongly effervescent; moderately alkaline.

The profile is commonly less than 15 percent gravel. The soils are noneffervescent in places or contain small amounts of calcium carbonate as thin filaments or coatings on pebbles. The profile is neutral to moderately alkaline.

The A horizon has hue of 10YR to 5YR, value of 3 to 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. Slickensides are present in the lower part of the A horizon in some profiles.

The C horizon has hue of 10YR to 5YR, value of 4 to 6 when dry and 3 or 4 when moist, and chroma of 2 to 4. It is heavy clay loam, clay, or silty clay. This horizon is absent in places. Some profiles have thin strata of coarser materials in the lower part of the A horizon or in the C horizon. In places the profile is clay to a depth of 60 inches or more and lacks gravel.

**Gu—Guest soils.** The soils in this undifferentiated group are on flood plains. A Guest clay in an area of these soils has the profile described as representative of the series. Other Guest soils in this mapping unit are similar to the representative soil, but some have a surface layer of loam, clay loam, or silty clay loam, and some are nongravelly throughout. Slopes range from 0 to 3 percent. As much as 10 percent of the surface is covered by gravel.

Included in mapping are about 15 percent Pima and Grabe soils. Also included are small areas of Guest soils, which are underlain at a depth of 24 to 30 inches by reddish, fine-textured material. In a few small areas, the Guest soils have a high water table; these are indicated by wet spot symbols on the soil map.

Runoff is slow. The hazard of erosion is slight.

These soils are used primarily for range and wildlife habitat. A small acreage is irrigated north of Nogales and in the San Raphael Valley. Capability units IIIs-3, irrigated, and VIs, nonirrigated; Clay Bottom range site, 12- to 20-inch precipitation zone; range productivity group 2.

## Hathaway Series

The Hathaway series consists of well-drained, very gravelly, calcareous soils that are 60 inches or more in depth. These soils formed in gravelly old alluvium weathered from igneous, calcareous-sedimentary, and tuffaceous rocks. They are on both the nearly level to gently rolling valley plains and the moderately steep to steep convex ridge remnants of dissected old piedmont fans. Slopes are dominantly 10 to 40 percent but range from 1 to 60 percent. Elevation is 3,600 to 5,400 feet. Vegetation is dominantly black, side-oats, and other grammas; three-awns; false mesquite; and yucca. Average annual precipitation is 12 to 18 inches, and mean annual temperature is 57° to 65° F. The frost-free season is 190 to 260 days.

In a representative profile the surface layer is brown gravelly sandy loam and gravelly light sandy clay loam about 10 inches thick. The upper part of the substratum is grayish-brown, light-gray, and pinkish-gray

gravelly and very gravelly sandy loam about 29 inches thick. The lower part of the substratum, to a depth of 60 inches or more, is light reddish-brown sandy loam. The profile is moderately alkaline and strongly calcareous throughout. It contains more than 15 percent lime in the subsurface layer. It is more than 35 percent gravel throughout.

Permeability is moderate, and available water capacity is low or moderate. Effective rooting depth is 60 inches or more.

These soils are used for range and wildlife habitat. A few areas are used as homesites.

Representative profile of Hathaway gravelly sandy loam, 20 to 50 percent slopes, 1,500 feet south and 400 feet east of the northwest corner of sec. 3, T. 20 S., R. 16 E., about 2.8 miles west of State Highway 83 and 660 feet north of the Gardner Canyon road, 75 feet upslope from base of slope; Santa Cruz County:

- A11—0 to 5 inches, brown (7.5YR 5/2) gravelly sandy loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine and fine roots; many fine interstitial pores; 35 percent gravel, by volume; strongly effervescent; mildly alkaline; clear, wavy boundary.
- A12—5 to 10 inches, brown (7.5YR 5/2) gravelly light sandy clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; common very fine, fine, and medium roots; few fine and medium tubular pores; 40 percent gravel and few cobbles, by volume; violently effervescent; moderately alkaline; clear, wavy boundary.
- C1ca—10 to 13 inches, grayish-brown (10YR 5/2) gravelly sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine, fine, and medium roots; few fine and medium tubular pores; 40 percent gravel and 5 percent cobbles, by volume; with common, medium and large, distinct light-gray (10YR 7/2) lime segregations; violently effervescent; moderately alkaline; clear, wavy boundary.
- C2ca—13 to 20 inches, light-gray (10YR 7/2) gravelly sandy loam, light brownish gray (10YR 6/2) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; common very fine, fine, and medium roots; few fine and medium tubular pores; 40 percent gravel and 5 percent cobbles, by volume; violently effervescent; moderately alkaline; clear, wavy boundary.
- C3ca—20 to 31 inches, pinkish-gray (7.5YR 6/2) and pinkish-white (7.5YR 8/2) very gravelly sandy loam, brown (7.5YR 5/2) and pinkish gray (7.5YR 6/2) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; common very fine, fine and medium roots; 50 percent gravel and 5 percent cobbles, by volume; violently effervescent; moderately alkaline; abrupt, wavy boundary.
- C4ca—31 to 39 inches, pinkish-gray (7.5YR 6/2) and light brown (7.5YR 6/4) very gravelly sandy loam, brown (7.5YR 5/2) and (7.5YR 5/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; few fine roots; common fine interstitial pores; 50 percent gravel and 5 percent cobbles, by volume; violently effervescent; moderately alkaline; abrupt, smooth boundary.
- IIC5ca—39 to 60 inches, light reddish-brown (5YR 6/3)

sandy loam, reddish brown (5YR 4/4) when moist; massive; hard when dry, friable when moist, nonsticky and nonplastic when wet; few fine roots; few very fine and fine tubular pores; 10 percent gravel, by volume; many, medium and large, white (10YR 8/2) soft lime segregations, strongly to violently effervescent; moderately alkaline.

Depth to the Cca horizon ranges from 7 to 16 inches. The profile ranges from slightly effervescent in the A horizon to violently effervescent in the Cca horizon.

The A horizon has hue of 10YR and 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is gravelly sandy loam, gravelly light sandy clay loam, and gravelly or very gravelly sandy loam and contains 30 to 70 percent gravel and 0 to 20 percent cobbles. It has weak, platy, granular structure or weak, subangular blocky structure.

The C horizon has hue of 10YR to 5YR, value of 5 to 8 when dry and 3 to 6 when moist, and chroma of 2 to 4. It is gravelly or very gravelly loam, gravelly or very gravelly sandy loam, and sandy loam and strata of very gravelly loamy sand. It is 35 to 80 percent gravel and 0 to 10 percent cobbles. The Cca horizon has many, fine to coarse, white or light-gray veins, soft masses, and concretions of lime. Some profiles have thin discontinuous layers of weakly cemented to strongly cemented lime. This horizon is 15 to 40 percent calcium carbonate.

**HaF—Hathaway gravelly sandy loam, 20 to 50 percent slopes.** This soil is on long, narrow, convex ridges that have side slopes of 20 to 50 percent (fig. 7). The areas are drained by long axial drainageways and many, short, steep-sided lateral drainageways. The surface is 30 to 60 percent gravel and 1 to 5 percent cobbles. This soil has the profile described as representative of the series.

Included in mapping are about 15 percent Bernardino soils, 5 percent White House soils on some of the broader ridgetops, and 5 percent Torrifluents in drainageways.

Runoff is medium. The hazard of erosion is moderate.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Limy Slopes range site, 16- to 20-inch precipitation zone; range productivity group 3.

**HhE2—Hathaway soils, 1 to 40 percent slopes, eroded.** The soils in this undifferentiated group are on strongly dissected upper old alluvial fans. Slopes on the narrow ridgetops are 1 to 10 percent and on the side slopes are 10 to 40 percent; there are numerous nearly vertical scarps and landslips. A Hathaway gravelly sandy loam in an area of these soils has a profile similar to the one described as representative of the series. Other soils in this unit differ from the one that has the representative profile in slope and surface texture. The surface is 30 to 50 percent gravel and 5 to 15 percent cobbles.

Included in mapping are about 10 percent White House soils on some of the wider ridgetops, about 5 percent each of Bernardino and Kimbrough soils on the upper slopes adjacent to limestone mountains, and about 5 percent gravelly to cobbly alluvial soils in drainageways.

Runoff is rapid. The hazard of erosion is high.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Limy Slopes range site, 12- to 16-inch precipitation zone; range productivity group 3.



Figure 7.—Hathaway gravelly sandy loam, 20 to 50 percent slopes, in Limy Slopes range site, 16- to 20-inch precipitation zone, in background. Grabe-Comoro complex, 0 to 5 percent slopes, in Loam Bottom range site, 12- to 20-inch precipitation zone, in foreground.

## Hogris Series

The Hogris series consists of well-drained soils that are 40 inches or more in depth. These soils formed in residuum and colluvium weathered from siliceous schist, sandstone, shales, tuffs, or quartzite rocks. They are on mountains. Slopes range from 20 to 80 percent. Elevation is 6,000 to 7,500 feet. Vegetation is dominantly pine, oak, juniper, manzanita, deergrass, Texas bluestem, and side-oats grama. Average annual precipitation is 18 to 24 inches, and mean annual temperature is 49° to 57° F. The frost-free season is 140 to 180 days.

In a representative profile there is a 1-inch litter of pine needles and leaves covering the surface. The surface layer is grayish-brown very cobbly sandy loam about 4 inches thick. The underlying layer, to a depth of about 60 inches or more, is pinkish-gray, light-gray, and white very cobbly sandy loam or fine sandy loam. The surface layer is slightly acid, and the underlying layer is medium acid. The profile is 35 to 80 percent cobbles and gravel.

Permeability is moderately rapid, and available water capacity is low. Effective rooting depth is 40 inches to more than 60 inches.

These soils are used for wildlife habitat, water supply, and woodland. Some areas are used for mining.

Representative profile of Hogris very cobbly sandy loam in an area of Hogris-Telephone association, steep, in woodland, approximately 1½ miles southwest of Gate 7, Fort Huachuca Military Reservation, 2,640 feet west and 1,980 feet south of the northeast corner of sec. 10, T. 23 S., R. 19 E., Cochise County:

- O1—1 inch to 0, litter of pine needles and leaves.
- A1—0 to 4 inches, grayish-brown (10YR 5/2) very cobbly sandy loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine and fine roots; many fine interstitial pores; 30 percent cobbles and 25 percent gravel, by volume; slightly acid; abrupt, wavy boundary.
- C1—4 to 9 inches, pinkish-gray (7.5YR 7/2) very cobbly sandy loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine and fine roots; many fine interstitial pores; 35 percent cobbles and 20 percent gravel, by volume; medium acid; clear, wavy boundary.
- C2—9 to 27 inches, white (10YR 8/2) very cobbly fine sandy loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist, nonsticky and slightly plastic when wet; common very fine roots; many very fine and fine tubular pores; 40 percent cobbles and 15 percent gravel, by volume; medium acid; clear, wavy boundary.
- C3—27 to 60 inches, light-gray (10YR 7/2) very cobbly fine sandy loam, brown (10YR 5/3) when moist;

massive; slightly hard when dry, friable when moist, nonsticky and slightly plastic when wet; common very fine roots; many very fine and fine tubular pores; 40 percent cobbles and 10 percent gravel, by volume; medium acid.

Depth to fractured bedrock ranges from 40 inches to more than 60 inches. The A horizon has hue of 10YR or 7.5YR, value of 4 to 6 when dry and 3 or 4 when moist, and chroma of 2 or 3. This horizon is 15 percent to more than 50 percent coarse fragments. It is 20 to 50 percent gravel, 15 to 50 percent cobbles, and 0 to 20 percent stones. It is slightly acid or neutral.

The C horizon has hue of 5YR to 10YR, value of 4 to 8 when dry and 4 to 6 when moist, and chroma of 2 to 4. This horizon is 35 to 80 percent coarse fragments. It is 10 to 50 percent gravel, 15 to 40 percent cobbles, and 0 to 5 percent stones. It is medium acid to neutral.

**HoF—Hogris-Telephone association, steep.** The soils in this association are a mixed pattern of Hogris and Telephone soils on foot slopes of the Huachuca Mountains. About 50 percent of the association is Hogris soils, and 20 percent is Telephone soils. Slopes are mainly 35 to 45 percent but range from 20 to 50 percent. A Hogris very cobbly sandy loam in an area of this association has the profile described as representative of the Hogris series. A Telephone very gravelly loam has the profile described as representative of the Telephone series. Soils in the association have a surface layer of very gravelly or very cobbly sandy loam, fine sandy loam, very fine sandy loam, and loam. The surface is 15 percent to more than 50 percent coarse fragments. These are 20 to 50 percent cobbles, 30 to 50 percent gravel, and as much as 5 percent stones.

Included in mapping are about 10 percent Faraway soils, 10 percent Fanno variant soils, 5 percent Luzena soils, and 5 to 10 percent Rock outcrop. The Rock outcrop consists of ledges of sandstone, phyllite, schist, shales, and tuffs. Small outcrops of limestone conglomerate are in some areas. Much of the bedrock has schistose or shaly structure.

Runoff is medium. The hazard of erosion is moderate.

These soils are used mainly for wildlife habitat and water supply. A limited acreage is in usable timber that is of little economic value at present. Capability unit, VIe, nonirrigated; woodland suitability group 1; range productivity group 4; not assigned to a range site.

**HtF—Hogris-Telephone-Rock outcrop association, very steep.** This association is about 45 percent Hogris soils, 20 percent Telephone soils, and 20 to 25 percent Rock outcrop. Slopes are more than 50 percent and are as much as 90 percent in places. Hogris and Telephone soils in this association have a surface layer of very cobbly or very gravelly sandy loam, fine sandy loam, or very fine sandy loam. The surface is 15 percent to more than 50 percent coarse fragments. These are 20 to 50 percent cobbles; 30 to 50 percent gravel, and 5 percent stones. Rock outcrop occurs as low ledges of rhyodacite-tuffs, sandstone, shale, schist, and phyllite.

Included in mapping are 5 to 20 percent Faraway soils, Fanno variant soils, and a soil that is similar to Hogris soils but has a thicker, dark-colored surface layer.

Runoff is rapid. The hazard of erosion is high.

These soils are used for wildlife habitat and water supply. Some areas are in usable timber, but harvesting is not economically feasible at present. Capability unit VIIe, nonirrigated; woodland suitability group 2; range productivity group 4; not assigned to a range site.

### Kimbrough Series

The Kimbrough series consists of well-drained soils that are 6 to 20 inches in depth to an indurated hardpan. These soils formed in mixed alluvium that weathered from limestone and some igneous rock. They are on outwash fans and foot slopes of limestone hills and mountains. Slopes are 2 to 15 percent. Elevation is 4,400 to 5,200 feet. Vegetation is dominantly black, side-oats, and other grammas and false mesquite and other scattered brush. Average annual precipitation is 12 to 18 inches, and mean annual temperature is 57° to 62° F. The frost-free season is 160 to 200 days.

In a representative profile the surface layer is dark grayish-brown and grayish-brown gravelly loam about 12 inches thick. Below this is a pink indurated gravelly hardpan about 14 inches thick. The substratum, below the hardpan and to a depth of about 60 inches or more, is pink very gravelly loam that is weakly cemented to strongly cemented by lime. The profile is moderately alkaline and strongly calcareous throughout.

Permeability is moderate above the hardpan and very slow in the pan. Available water capacity is very low. Effective rooting depth is 6 to 20 inches, but some roots penetrate the pan through rodent burrows and fractures.

These soils are used for range and wildlife habitat.

Representative profile of Kimbrough gravelly loam in an area of Kimbrough soils, 2 to 10 percent slopes, 800 feet west and 925 feet north of the southeast corner of sec. 16, T. 20 S., R. 18 E., Santa Cruz County:

- A11—0 to 9 inches, dark grayish-brown (10YR 4/2) gravelly loam, very dark grayish brown (10YR 3/2) when moist; moderate, very fine, and fine granular structure; soft to slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and common medium roots; common very fine interstitial pores; 35 percent gravel, by volume; strongly effervescent; moderately alkaline; clear, smooth boundary.
- A12—9 to 12 inches, grayish-brown (10YR 5/2) gravelly loam, dark brown (10YR 3/3) when moist; weak, medium, and coarse, subangular blocky structure parting to moderate fine granular; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine roots, common very fine and fine roots, and few medium roots; common micropores and few very fine tubular pores; 30 percent gravel and a few cobbles; strongly effervescent; moderately alkaline; abrupt, smooth boundary.
- C1cam—12 to 26 inches, pink (7.5YR 8/4), indurated, gravelly, calcareous hardpan; light brown (7.5YR 6/4) when moist; massive; laminar in upper part; extremely hard when dry; extremely firm when moist; 45 percent gravel, by volume; violently effervescent; moderately alkaline; clear, wavy boundary.
- C2ca—26 to 60 inches, pink (7.5YR 8/4), very gravelly loam, light brown (7.5YR 6/4) when moist; massive; hard to very hard when dry, firm when moist, slightly sticky and slightly plastic when wet; few fine, medium, and coarse roots; many micro tubu-

lar pores and few fine tubular pores; 60 percent gravel, by volume; weakly cemented to strongly cemented by lime, violently effervescent; moderately alkaline.

Depth to an indurated or strongly lime-cemented hardpan ranges from 6 to 20 inches. The A horizon has hue of 10YR to 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is 15 to 35 percent gravel and cobbles. These fragments are mostly gravel, but they are as much as 5 percent cobbles. This horizon is mildly alkaline to moderately alkaline.

The C horizon is white to pink, has value of 5 to 8, and has chroma of 2 to 4. The Ccam horizon ranges from fractured and strongly cemented to indurated, continuous laminar pans that are cemented by lime and silica. The hardpan ranges from a laminar cap 1 inch thick to a layer several feet thick. Rodents occasionally rupture the pan and backfill with loose material. Materials below the hardpan are weakly cemented to strongly cemented by lime and are gravelly to very gravelly and cobbly.

**KbC—Kimbrough soils, 2 to 10 percent slopes.** The soils in this undifferentiated group are on the foot slopes of the Mustang Mountains. A Kimbrough gravelly loam in this mapping unit has the profile described as representative of the series. The soils in this unit have a surface layer of gravelly or cobbly loam. The surface is 25 to 50 percent gravel and 1 to 15 percent cobbles.

Included in mapping are about 15 percent Hathaway and Bernardino soils.

Runoff is medium. The hazard of erosion is moderate.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Limy Slopes range site, 12- to 16-inch precipitation zone; range productivity group 3.

## Lampshire Series

The Lampshire series consists of well-drained soils that are 4 to 20 inches in depth over bedrock. These soils formed in residuum weathered from rhyolite, rhyodacite, granite, andesite, tuffs, and tuff-conglomerate. Slopes are 0 to 60 percent. Elevation is 3,400 to 5,400 feet. Vegetation is dominantly grammas and blue-stems; lovegrass; ocotillo, catclaw, mimosa, false mesquite, and other brush, and oak and juniper at an elevation above about 4,000 feet. Average annual precipitation is 12 to 18 inches, and mean annual temperature is 57° to 64° F. The frost-free season is 190 to 250 days.

In a representative profile the surface layer is grayish-brown very cobbly loam about 8 inches thick. It overlies pinkish gray, extremely hard, fractured andesite-tuff bedrock. The profile is neutral. It is more than 35 percent cobbles and gravel.

Permeability is moderate to bedrock, and available water capacity is very low. Effective rooting depth is 4 to 20 inches.

The soils are used mainly for range and wildlife habitat.

Representative profile of Lampshire very cobbly loam from an area of Chiricahua-Lampshire association, rolling, about 2 miles west-northwest of Tubac on the southeast slope of a low hill about 800 feet south and 500 feet west of the northeast corner of sec. 11, T. 21 S., R. 12 E., Santa Cruz County:

A1—0 to 8 inches, grayish-brown (10YR 5/2) very cobbly loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and a few medium roots; many fine tubular pores; 20 percent gravel and 40 percent cobbles, by volume; neutral; abrupt, irregular boundary.

R—8 to 12 inches, pinkish-gray (5YR 7/2) fractured, extremely hard andesite-tuff bedrock.

Depth to bedrock ranges from 4 to 20 inches. Reaction ranges from slightly acid to moderately alkaline. The A horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. In places, mainly on granitic rock, a C horizon of weathered granite is present. The C horizon has hue of 7.5YR or 10YR, value of 6 or 7 when dry and 4 to 6 when moist, and chroma of 2 to 4. The A horizon or A and C horizons are loam or sandy loam and contain 35 to 80 percent coarse fragments. These are 5 to 20 percent cobbles and 20 to 60 percent gravel.

**LaE—Lampshire very gravelly sandy loam, 0 to 25 percent slopes.** This soil is on tops and upper side slopes of ridge remnants of rhyolitic conglomerate. It is on the uplands west and northwest of Nogales. Areas are irregular in shape. Slopes are 0 to 25 percent. This soil has a profile similar to the one described as representative of the series, but it is very gravelly heavy sandy loam, and bedrock is cemented rhyolitic conglomerate. The surface is about 50 to 60 percent gravel and 5 percent cobbles.

Included in mapping are about 5 percent each of Atascosa, Graham, and Caralampi soils, about 5 percent Torrifuents in the drainageways, and about 5 percent Rock outcrop.

Runoff is medium. The hazard of erosion is moderate.

These soils are used for range and wildlife habitat. Capability unit VIIs, nonirrigated; Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 4.

**LaF—Lampshire very gravelly sandy loam, 25 to 50 percent slopes.** This soil is on mountain uplands of rhyolitic, granitic, or tuffaceous rock. Most areas are in the Atascosa and Oro Blanco Mountains. Slopes are 25 to 50 percent. This soil has a profile similar to the one described as representative of the series, but it is very gravelly sandy loam and the fractured bedrock is of variable composition. The surface is about 40 percent gravel, 5 to 10 percent cobbles, and as much as 5 percent stones.

Included in mapping are about 5 to 10 percent Rock outcrop, about 5 to 10 percent Chiricahua soils in some areas, small areas of a shallow or very shallow, very gravelly sandy loam, and about 5 percent Comoro soils and Torrifuents in drainageways.

Runoff is rapid. The hazard of erosion is moderate.

These soils are used mainly for range and wildlife habitat. Capability unit VIIs, nonirrigated; Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 4.

**LcF—Lampshire-Chiricahua association, steep.** The soils in this association are on granitic hills and low mountain uplands. They are about 60 percent Lampshire soils and 25 percent Chiricahua soils, although the percentage of each varies from place to place. Slopes range from 15 to 50 percent. Generally Lamp-

shire soils are on steeper, rockier positions and have slopes of 30 to 50 percent. Chiricahua soils have slopes of 15 to 30 percent. The soils in this complex have profiles similar to those described as representative of their respective series, but the surface layer is cobbly or very cobbly sandy loam or gravelly or very gravelly sandy loam in places. Bedrock is granite, quartzite, or tuff-conglomerate. The surface is 35 to 60 percent gravel and 0 to 20 percent cobbles and stones.

Included in mapping are some areas that are as much as 50 percent Rock outcrop but averages about 10 percent; small areas of gravelly alluvium in drainage ways; and small areas of shallow and very shallow soils that are similar to Lampshire soils.

Runoff is medium or rapid. The hazard of erosion is moderate.

These soils are used mainly for range, wildlife habitat, and recreation. Capability unit VIIs, nonirrigated; Loamy Hills range site, 12- to 16-inch precipitation zone, and Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 4.

**LgF—Lampshire-Graham-Rock outcrop association, steep.** This association is about 35 percent Lampshire soils, 30 percent Graham soils, and 30 percent Rock outcrop, but the percentage of each varies from place to place. Some areas consist mostly of one soil, or the other, and of 10 to 50 percent Rock outcrop. Slopes range from 20 to 60 percent. Lampshire soils are generally on the steeper, rockier positions and have slopes of 30 to 60 percent. Graham soils have slopes of 20 to 30 percent. Rock outcrop is ledges and pinnacles and is dominantly of basic igneous composition. The surface is 10 to 25 percent gravel, 20 to 50 percent cobbles, and 0 to 20 percent stones.

Included in mapping are about 5 percent small areas of colluvium and alluvium on the lower slopes and in drainage ways.

Runoff is medium or rapid. The hazard of erosion is moderate.

These soils are used mainly for range and wildlife habitat. Capability unit VIIs, nonirrigated; Lampshire soils in Loamy Hills range site, 16- to 20-inch precipitation zone, Graham soils in Clay Loam Hills range site, 16- to 20-inch precipitation zone, Rock outcrop part not assigned to a range site; range productivity group 4.

## Luzena Series

The Luzena series consists of well-drained soils that are 7 to 20 inches in depth over bedrock. These soils formed in residuum weathered from rhyolite, dacite, andesite, and related tuffs. Slopes range from 5 to 20 percent. Elevation is 5,000 to 7,000 feet. Vegetation is oak and juniper trees, shrubs, and grass. A few pine trees are at higher elevations. Average annual precipitation is 16 to 20 inches, and mean annual temperature is 52° to 58° F. The frost-free season is 140 to 200 days.

In a representative profile the surface layer is brown gravelly loam about 4 inches thick. The subsoil is dark reddish-gray gravelly clay about 11 inches thick. Bed-

rock is at a depth of about 15 inches. The profile is slightly acid to neutral throughout.

Permeability is slow, and available water capacity is very low. Effective rooting depth is 7 to 20 inches. The surface is covered by 20 to 40 percent gravel, 5 to 20 percent cobbles, and 0 to 10 percent stones.

These soils are used for range and wildlife habitat.

Representative profile of Luzena gravelly loam in an area of Fanno-Luzena association, rolling, approximately 800 feet east-southeast of Wakefield Camp and 75 feet north of the road on a low hill, 1,320 feet north and 1,000 feet east of the southwest corner of sec. 30, T. 23 S., R. 20 E., Cochise County:

- A11—0 to 1 inch, brown (7.5YR 5/2) gravelly loam, dark brown (7.5YR 3/2) when moist; moderate, fine and very fine, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; common fine and very fine roots; many fine interstitial pores; 30 percent gravel and 5 percent cobbles, by volume; neutral; abrupt, smooth boundary.
- A12—1 to 4 inches, brown (7.5YR 5/2) gravelly heavy loam, dark reddish brown (5YR 3/3) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and very fine roots; many fine interstitial pores; 30 percent weathered gravel, by volume; slightly acid; abrupt, wavy boundary.
- B2t—4 to 15 inches, dark reddish-gray (5YR 4/2) gravelly clay, dark reddish brown (5YR 3/4) when moist; moderate, fine and medium, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common fine and very fine roots; common fine tubular pores; common thin clay films on faces of peds and in pores; 15 percent strongly weathered gravel and 10 percent cobbles, by volume; slightly acid; abrupt, irregular boundary.
- R—15 inches, fractured bedrock.

Depth to bedrock ranges from 7 to 20 inches. The A horizon has hue of 7.5YR or 10YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is gravelly loam, cobbly loam, gravelly clay loam, or cobbly clay loam. It is 15 to 40 percent gravel, 5 to 30 percent cobbles, and 0 to 10 percent stones.

The Bt horizon has hue of 7.5YR or 5YR, value of 4 to 5 when dry and 2 to 4 when moist, and chroma of 2 to 6. It is gravelly heavy clay loam, cobbly heavy clay loam, clay, gravelly clay, or cobbly clay. It is 5 to 30 percent gravel and 0 to 10 percent cobbles.

The profile ranges from slightly acid to mildly alkaline.

## Luzena Variant

The Luzena variant consists of well-drained soils that are 20 to 50 inches in depth over bedrock. These soils formed in residuum weathered from rhyolite, diorite, or andesite-tuff bedrock. Slopes are 5 to 20 percent. Elevation is 5,000 to 6,000 feet. Vegetation is dominantly curly mesquite, grama grasses, plains lovegrass, and scattered oak and juniper trees. Average annual precipitation is 16 to 20 inches, and mean annual temperature is 54° to 57° F. The frost-free season is 160 to 200 days.

In a representative profile the surface layer is reddish-gray gravelly loam and brown gravelly clay loam about 10 inches thick. The subsoil is about 24 inches thick. The upper 13 inches is reddish-brown clay; the lower 11 inches is mottled weak-red, reddish-brown, and white clay loam. The underlying material

is mottled reddish-brown and white strongly weathered andesite-tuff bedrock. The surface layer is slightly acid and neutral, and the subsoil is moderately alkaline and slightly calcareous.

Permeability is slow, and available water capacity is low to moderate. Effective rooting depth is 20 to 50 inches.

These soils are used for range and wildlife habitat.

Representative profile of Luzena gravelly loam, deep variant, 5 to 20 percent slopes, near the top of a low rocky ridge, 1,000 feet north and 1,000 feet east of the south quarter corner of sec. 28, T. 22 S., R. 12 E., Santa Cruz County:

- A11—0 to 1 inch, reddish-gray (5YR 5/2) gravelly loam, dark reddish brown (5YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many fine roots; many fine interstitial pores; 15 to 20 percent gravel, by volume; slightly acid; clear, wavy boundary.
- A12—1 to 10 inches, brown (7.5YR 5/2) gravelly clay loam, dark reddish brown (5YR 2/2) when moist; weak, fine, subangular blocky structure parting to moderate fine granules; hard when dry, friable when moist, sticky and plastic when wet; many fine roots; many fine interstitial pores; 15 to 20 percent fine gravel and 5 percent coarse gravel and cobbles, by volume; neutral; clear, wavy boundary.
- B2t—10 to 16 inches, reddish-brown (5YR 5/3) clay, reddish brown (2.5YR 4/3) when moist; moderate medium, subangular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; common fine roots; common very fine tubular pores; common thin clay films on faces of peds; common small slickensides; strongly effervescent in spots; moderately alkaline; clear, wavy boundary.
- B31t—16 to 23 inches, reddish-brown (5YR 5/3) clay, dark reddish brown (5YR 3/3) when moist; massive; very hard when dry, firm when moist, very sticky and very plastic when wet; common fine roots; common very fine tubular pores; common thin clay films on faces of peds; common small slickensides; strongly effervescent in spots; moderately alkaline; clear, wavy boundary.
- B32tca—23 to 34 inches, mottled weak-red (2.5YR 5/2), reddish-brown (2.5YR 5/4), and white (5YR 8/1), clay loam, dark reddish brown (2.5YR 3/4), dark red (2.5YR 3/6), and white (5YR 8/1) when moist; massive, parting to weak, medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; few fine roots; few fine tubular pores; few thin clay films on faces of peds; strongly effervescent in spots; moderately alkaline; clear, wavy boundary.
- R—34 inches, mottled reddish-brown (2.5YR 5/4) and white (5YR 8/1) fractured weathered andesite-tuff bedrock.

Depth to bedrock ranges from 20 to 50 inches. The A horizon has hue of 5YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is gravelly loam or cobbly loam, and contains 15 to 50 percent gravel and 0 to 10 percent cobbles. It ranges from medium acid to mildly alkaline.

The Bt horizon has hue of 7.5YR to 2.5YR, value of 4 or 5 when dry and 3 to 5 when moist, and chroma of 3 to 6. It is clay, gravelly clay, clay loam, or gravelly heavy clay loam.

The B3tca horizon is absent in places, and the C or Cca horizon or B2t horizon is immediately over the R horizon. The B horizon is mildly alkaline to moderately alkaline. The lower part of the Bt horizon and the C horizon, where present, are generally calcareous but are noneffervescent in some areas. The Bt horizon is 5 to 35 percent gravel and 0 to 10 percent cobbles.

**LuD—Luzena gravelly loam, deep variant, 5 to 20 percent slopes.** This soil is in large irregularly shaped areas. The surface is covered by 25 to 40 percent gravel and 5 to 15 percent cobbles.

Included in mapping are 15 to 20 percent Rock outcrop; 5 to 10 percent each of Luzena gravelly loam and Faraway cobbly or very cobbly loam; and about 5 percent each of Bonita and Guest soils.

Runoff is medium. The hazard of erosion is moderate.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Clay Loam Hills range site, 16- to 20-inch precipitation zone; range productivity group 3.

## Mabray Series

The Mabray series consists of well-drained soils that are 4 to 20 inches in depth over bedrock. These soils formed in residuum weathered from limestone. They are on mountains. Slopes are 30 to 45 percent. Elevation is 3,000 to 5,500 feet. Vegetation is dominantly ocotillo, white-thorn, sotol, catclaw, side-oats grama, black grama, and tridens. Scattered oak and juniper trees are at higher elevations. Average annual precipitation is 12 to 18 inches, and mean annual temperature is 57° to 64° F. The frost-free season is 180 to 260 days.

In a representative profile the surface layer, to a depth of about 12 inches, is dark grayish-brown very gravelly or very cobbly loam. This overlies white, extremely hard, fractured limestone bedrock. The profile is moderately alkaline and is more than 35 percent rock fragments.

Permeability is moderate, and available water capacity is very low. Effective rooting depth is 4 to 20 inches.

These soils are used for range, wildlife habitat, and mining.

Representative profile of Mabray very gravelly loam, from an area of Mabray-Chiricahua-Rock outcrop association, steep, about 10 miles east of Amado, 300 feet north of the Glove Mine, approximately 1,250 feet north of the south quarter corner of sec. 30, T. 20 S., R. 13 E., Santa Cruz County:

- A11—0 to 1 inch, dark grayish-brown (10YR 4/2) very gravelly loam, very dark grayish brown (10YR 3/2) when moist; weak, fine and medium, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and few medium roots; common fine and very fine interstitial pores; 35 percent gravel and 15 percent cobbles, by volume; violently effervescent; moderately alkaline; abrupt, wavy boundary.
- A12—1 to 12 inches, dark grayish-brown (10YR 4/2) very cobbly loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and a few medium roots; common fine and very fine tubular pores; 30 percent gravel and 45 percent cobbles, by volume; violently effervescent; common light-gray (10YR 7/2) lime coatings on under side of gravel and cobbles; moderately alkaline; abrupt, irregular boundary.

R—12 to 24 inches, white (10YR 8/1) extremely hard fractured limestone.

Depth to bedrock ranges from 4 to 20 inches. The A horizon has hue of 10YR and 7.5YR, value of 4 and 5 when dry, and chroma of 2 or 3. It is gravelly loam, cobbly loam, very stony loam, very gravelly loam, or very cobbly loam. It is 30 to 60 percent gravel, 10 to 50 percent cobbles, and 0 to 10 percent stones.

In places the profile has a thin C horizon. The C horizon has hue of 10YR or 7.5YR, value of 6 or 7 when dry and 4 to 6 when moist, and chroma of 1 to 4. In some places the lime coatings or lime accumulations are just above bedrock.

**McF—Mabray-Chiricahua-Rock outcrop association, steep.** The soils in this association are in highly faulted and mixed areas of limestone, quartzite, and granite hills and low mountains. The association is about 35 percent Mabray soils, 30 percent Chiricahua soils, and 30 percent Rock outcrop. Mabray soils are on limestone hills and mountains, have slopes mainly of 30 to 45 percent, and are in areas consisting of 25 to 50 percent Rock outcrop. Chiricahua soils are on hills of granite and quartzite, have slopes of 8 to about 30 percent, and are in areas consisting of about 10 to 25 percent Rock outcrop. Within each area the proportion of soil to Rock outcrop varies greatly. A Mabray very gravelly loam in an area of this association has the profile described as representative of the Mabray series. The surface is 30 to 50 percent gravel, 10 to 30 percent cobbles, and 0 to 10 percent stones.

Included in mapping are 5 percent very shallow, light grayish-brown soils on granite; small areas of calcareous, moderately deep, colluvial soils on limestone slopes; narrow bands of gravelly to cobbly alluvial soils in drainageways; and small areas of Kimbrough and Hathaway soils on short fans.

Runoff is medium or rapid. The hazard of erosion is moderate.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Mabray soils in Limestone Hills range site, 12- to 16-inch precipitation zone, Chiricahua soils in Loamy Hills range site, 12- to 16-inch precipitation zone, Rock outcrop part not assigned to a range site; range productivity group 4.

## Martinez Series

The Martinez series consists of well-drained soils that are 60 inches or more in depth. These soils formed in old alluvium weathered from mixed igneous and sedimentary rocks. They are on old piedmont slopes. Slopes are 0 to 3 percent. Elevation is 5,000 to 5,800 feet. Vegetation is mainly grammas, plains lovegrass, bluestems, three-awns, and a few oak trees and manzanita in some areas. Average annual precipitation is 15 to 20 inches, and mean annual temperature is 53° to 57° F. The frost-free season is 140 to 200 days.

In a representative profile the surface layer is brown gravelly loam and clay loam about 6 inches thick. The upper part of the subsoil is dark-brown, dark yellowish-brown, and yellowish-brown heavy clay about 29 inches thick. The lower part of the subsoil is yellowish-brown, red, and brownish-yellow gravelly sandy clay to a depth of about 60 inches or more. The profile is strongly acid and medium acid in the surface layer, slightly acid and neutral in the upper part of

the subsoil, and mildly alkaline and moderately alkaline in the lower part of the subsoil.

Permeability is slow or very slow, and available water capacity is high. Effective rooting depth is 60 inches or more.

These soils are used for range and wildlife habitat.

Representative profile of Martinez gravelly loam, 1.3 miles southwest of intersection of Forest Service roads 48 and 227, and 100 feet north of road 227, approximately 1,600 feet west and 350 feet south of the northeast corner of sec. 9, T. 24 S., R. 19 E., Cochise County:

- A11—0 to 1 inch, brown (10YR 5/3) gravelly loam, dark yellowish brown (10YR 3/4) when moist; weak, thick, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and very fine roots; common fine interstitial and tubular pores; 15 percent gravel, by volume; strongly acid; abrupt, smooth boundary.
- A12—1 to 6 inches, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 3/4) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; common fine and very fine roots; common fine interstitial and tubular pores; 10 percent gravel, by volume; medium acid; clear, smooth boundary.
- B1t—6 to 10 inches, dark-brown (7.5YR 4/4) clay, dark brown (7.5YR 4/4) when moist; moderate, fine and medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; many fine and very fine roots; few, fine and medium, tubular pores; common thin clay films on faces of peds and in pores; 2 percent gravel, by volume; slightly acid; clear, smooth boundary.
- B21t—10 to 18 inches, dark yellowish-brown (10YR 4/4) heavy clay, dark yellowish brown (10YR 3/4) when moist; moderate, medium and coarse, prismatic structure; hard when dry, friable when moist, sticky and very plastic when wet; common fine and very fine roots; few fine tubular pores; many moderately thick clay films on faces of peds and in pores; common slickensides in lower part; neutral; gradual, smooth boundary.
- B22t—18 to 26 inches, yellowish-brown (10YR 5/6) heavy clay, yellowish brown (10YR 5/6) when moist; moderate, medium and coarse, subangular and angular blocky structure; very hard when dry, firm when moist, sticky and very plastic when wet; few fine and very fine roots; few fine tubular pores; many moderately thick clay films on faces of peds and in pores; few pebbles; many slickensides; mildly alkaline; gradual, smooth boundary.
- B23t—26 to 35 inches, yellowish-brown (10YR 5/6) heavy clay, yellowish brown (10YR 5/6) when moist, with a few, fine, distinct yellowish-red (5YR 4/6) mottles, yellowish red (5YR 4/6) when moist; moderate, medium and coarse, subangular and angular blocky structure; very hard when dry, firm when moist, sticky and very plastic when wet; few fine roots; few fine tubular pores; common, moderately thick, clay films on faces of peds and in pores; 5 percent gravel, by volume; common pressure faces; many slickensides; moderately alkaline; clear, wavy boundary.
- B3t—35 to 60 inches, mottled yellowish-brown (10YR 5/6), red (2.5YR 4/8), and brownish-yellow (10YR 6/6) gravelly sandy clay, yellowish brown (10YR 5/6), red (2.5YR 4/8), and brownish yellow (10YR 6/6) when moist; many medium, coarse and distinct mottles; very hard when dry, friable when moist, sticky and plastic when wet; few fine roots; common very fine tubular pores; common thin clay films on faces of peds and in pores; 20 percent

gravel, by volume; slightly effervescent in spots under gravel; moderately alkaline.

The A horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 to 6. It is strongly acid to neutral. It is 5 to 35 percent gravel.

The B1t horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 3 or 4. This horizon is slightly acid to neutral. It is clay loam or clay and contains 0 to 25 percent gravel. The B2t horizon has hue of 10YR to 2.5YR, value of 4 or 5 when dry and 3 to 5 when moist, and chroma of 4 to 8. This horizon is neutral to moderately alkaline. It is heavy clay, clay loam, and sandy clay and contains as much as 5 percent rock fragments. The B3t horizon contains 15 to 60 percent gravel. Some profiles have a thin, discontinuous, light-gray (10YR 7/2) layer immediately overlying the B1t or B2t horizon. A B1t horizon is absent in some places.

**Mg—Martinez gravelly loam.** This soil (fig. 8) is on tops of high mesalike remnants of ancient piedmont plains. Areas are long and from narrow to fairly wide. Slopes are 0 to 3 percent. The old land surface has been deeply dissected by drainageways. The surface is covered by 10 to 35 percent gravel, 0 to 10 percent cobbles, and a few stones.

This soil has the profile described as representative of the series.

Included in mapping are 10 percent White House soils on the lower ends of the fans. Also included are small areas of Casto soils on the upper side slopes of drainageways and upper ends of old fans near the mountains.

Runoff is slow. The hazard of erosion is slight.

This soil is used for range and wildlife habitat. Capability unit VIs, nonirrigated; Loamy Upland range site, 16- to 20-inch precipitation zone; range productivity group 1.

### Mine Pits and Dumps

**Mn—Mine pits and dumps.** This miscellaneous land

consists of mine pits and exploratory diggings, dumps of waste rock, mine roads, buildings, and a few tailing ponds. Most of the workings have been abandoned, but a few are active or are being reactivated. Small areas of soils similar to the soils of adjacent mapping units are between workings, but they have little value for grazing. Most of the areas are unsightly and hazardous. The hazard of erosion is moderate to high.

These areas are used for mining, and because they are commonly unfenced, they are used for range and wildlife habitat. Capability unit VIIIs, nonirrigated; range productivity group 5.

### Pima Series

The Pima series consists of well-drained soils that are 60 inches or more in depth. These soils formed in recent alluvium weathered from mixed rock. They are on flood plains. Slopes are 0 to 3 percent. Elevation is 3,000 to 5,000 feet. Native vegetation is mainly grass and scattered desert shrubs. Average annual precipitation is 11 to 18 inches, and mean annual temperature is 57° to 65° F. The frost-free season is 180 to 250 days.

In a representative profile the surface layer is dark grayish-brown clay loam about 26 inches thick. The next layer is dark grayish-brown loam about 12 inches thick. The substratum is grayish-brown stratified fine sandy loam and very fine sandy loam to a depth of about 60 inches or more. The profile is mildly alkaline in the upper part of the surface layer and moderately alkaline in the underlying layer. It is mildly calcareous throughout.

Permeability is moderate or moderately slow, and available water capacity is high. Effective rooting depth is 60 inches or more.



Figure 8.—An area of Martinez gravelly loam; Faraway soils are in the background. Range site is Loamy Upland, 16- to 20-inch precipitation zone, in fair condition.

These soils are used for range, irrigated crops and pasture, wildlife habitat, and homesites.

Representative profile of Pima clay loam in an area of Pima soils, about 2½ miles south and 1 mile east of Tumacacori, 150 feet east of house on northwest corner of the northeast quarter of sec. 8, T. 22 S., R. 13 E., Santa Cruz County:

Ap—0 to 15 inches, dark grayish-brown (10YR 4/2) clay loam, very dark brown (10YR 2/2) when moist; weak, medium, subangular blocky structures parting to moderate, fine, and very fine, granules; hard when dry, friable when moist, sticky and plastic when wet; many very fine and fine roots; many very fine and fine interstitial pores; very slightly effervescent; mildly alkaline; clear, smooth boundary.

A1—15 to 26 inches, dark grayish-brown (10YR 4/2) clay loam, very dark brown (10YR 2/2) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few fine roots; few very fine tubular pores; few fine distinct white lime filaments; slightly effervescent; moderately alkaline; abrupt, smooth boundary.

AC—26 to 38 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; few fine roots; common very fine and fine pores; few fine distinct white lime filaments; slightly effervescent; moderately alkaline; abrupt, smooth boundary.

C1—38 to 46 inches, grayish-brown (10YR 5/2) fine sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine roots; common very fine and fine pores; moderately alkaline; abrupt, smooth boundary.

C2—46 to 60 inches, grayish-brown (10YR 5/2) very fine sandy loam, dark brown (10YR 3/3) when moist; massive; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine and fine roots; common fine pores; strongly effervescent; moderately alkaline.

The A and AC horizons have hue of 7.5YR or 10YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 1 to 3. They are clay loam, light clay, loam, silty clay loam, or silt loam. The C horizon has hue of 10YR or 7.5YR, value of 5 or 6 when dry and 3 or 4 when moist, and chroma of 2 to 4. The profile is neutral to moderately alkaline. In some places the profile is stratified below a depth of 20 inches.

**Pm—Pima soils.** The soils in this undifferentiated group are on flood plains. Areas are long and narrow. Slopes are 0 to 3 percent. A Pima clay loam in an area of these soils has the profile described as representative of the series. Other Pima soils have a surface layer of loam, silt loam, or silty clay loam.

Included in mapping in about 25 percent of the mapped area are Guest and Grabe soils. Also included are small areas of Torrifluvents.

Runoff is slow. Some areas receive runoff from adjacent lands. The hazard of erosion is slight.

These soils are used for irrigated crops and pasture, wildlife habitat, and homesites. Capability units I-1, irrigated; and VIc, nonirrigated; Loam Bottom range site, 12- to 20-inch precipitation zone; range productivity group 1.

## Pima Variant

The Pima variant consists of well-drained soils that

are 60 inches or more in depth. These soils are on flood plains and low terraces. They formed in thin layers of recent mixed alluvium and the underlying older alluvium. Slopes are 1 to 3 percent. Elevation is 2,850 to 3,200 feet. Vegetation is mesquite, paloverde, burroweed, three-awns, and an introduced lovegrass. Average annual precipitation is 11 to 12 inches, and mean annual temperature is 64° F. The frost-free season is 220 to 265 days.

In a representative profile the surface layer is dark-brown and brown clay loam about 19 inches thick. The subsoil is reddish-brown sandy clay loam about 21 inches thick. The substratum is dark-brown gravelly sandy loam to a depth of about 60 inches or more. The profile is moderately alkaline and slightly calcareous throughout.

Permeability is moderately slow, and available water capacity is high. Effective rooting depth is 60 inches or more.

The soils are used for range and wildlife habitat.

Representative profile of Pima clay loam, sandy clay loam subsoil variant, 3,300 feet south and 100 feet west of the northeast corner of sec. 33, T. 17 S., R. 14 E., Pima County:

A11—0 to 7 inches, dark-brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; moderate, fine and medium, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; common very fine and fine roots, and few medium and coarse roots; common very fine and fine tubular pores, and few medium tubular pores; slightly effervescent; moderately alkaline; clear, wavy boundary.

A12—7 to 19 inches, brown (7.5YR 5/3) clay loam, dark brown (7.5YR 3/3) when moist; weak, medium, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; few very fine and fine roots, and few coarse roots; common very fine tubular pores; slightly effervescent; moderately alkaline; clear, wavy boundary.

IIB21tcab—19 to 26 inches, reddish-brown (5YR 5/4) sandy clay loam, dark reddish brown (5YR 3/4) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few very fine, fine, and coarse roots; common very fine and fine tubular pores; few thin clay films on faces of peds; 5 percent gravel, by volume; strongly effervescent; moderately alkaline; clear, wavy boundary.

IIB22tb—26 to 40 inches, reddish-brown (5YR 5/4) sandy clay loam, dark reddish brown (5YR 3/4) when moist; weak, medium and coarse, subangular blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; few fine, medium, and coarse roots; common very fine tubular pores; few thin clay films on faces of peds; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC—40 to 60 inches, dark-brown (7.5YR 4/4) gravelly sandy loam, strong brown (7.5YR 4/6) when moist; massive; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; approximately 25 percent fine gravel, by volume; slightly effervescent in spots; mildly alkaline.

Depth to the buried B2t horizon ranges from 18 to 27 inches. The A horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is clay loam or silty clay loam and contains 1 to 10 percent gravel.

The IIBtb horizon has hue of 5YR or 7.5YR, value of

4 or 5 when dry and 3 or 5 when moist, and chroma of 3 or 4. It is sandy clay loam or clay loam, is high in coarse sand, and contains 5 to 30 percent fine gravel.

The IIC horizon has hue of 7.5YR or 5YR, value 4 to 6 when dry and 3 or 4 when moist, and chroma of 3 to 6. It is sandy loam, gravelly sandy loam, gravelly loamy sand, sandy clay loam or gravelly sandy clay loam and contains 10 to 35 percent mostly fine gravel.

**Pn—Pima clay loam, sandy clay loam subsoil variant.** This soil is in long narrow areas on flood plains and low terraces. Slopes are 1 to 8 percent. This soil has the profile described as representative of the variant.

Included in mapping are about 5 percent small areas of a soil that has sandy loam overwash on the surface and small areas of Sonoita and Anthony soils. The surface is covered by 5 percent to about 30 percent rock fragments.

Runoff is slow. The hazard of erosion is slight. Numerous shallow and a few deep gullies cross the soil areas. There is occasional flooding from higher areas.

These soils are used for range and wildlife habitat. Capability unit VIc, nonirrigated; Loam Bottom range site, 12- to 20-inch precipitation zone; range productivity group 4.

## Pinaleno Series

The Pinaleno series consists of gravelly, well-drained soils that are 60 inches or more in depth. These soils formed in very gravelly old alluvium weathered from igneous rock. They are on nearly level to gently rolling alluvial fans. Slopes are 0 to 10 percent. Elevation is 3,000 or 4,000 feet. Vegetation is dominantly mesquite, grama grasses, three-awns, burroweed, annual grasses, and cacti. Average annual precipitation is 12 to 15 inches, and mean annual temperature is 62° to 65° F. The frost-free season is 220 to 265 days.

In a representative profile the surface layer is brown gravelly sandy loam about 4 inches thick. The upper part of the subsoil is reddish-brown and yellowish-red gravelly sandy clay loam and very gravelly sandy clay loam about 27 inches thick. The lower part of the subsoil is light reddish-brown very gravelly sandy loam to a depth of about 60 inches or more. The profile is neutral in the surface layer and upper part of the subsoil, mildly alkaline in the middle part of the subsoil, and moderately alkaline in the lower part of the subsoil.

Permeability is moderately slow, and available water capacity is low to moderate. Effective rooting depth is 60 inches or more.

The soils are used for range and wildlife habitat. A few areas are used for homesites.

Representative profile of Pinaleno gravelly sandy loam, 0 to 10 percent slopes, in range, in the center of the northwest quarter of the northwest quarter of sec. 13, T. 19 S., R. 14 E., on range; Pima County:

A1—0 to 4 inches, brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 4/4) when moist; weak, thick, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine roots; common fine interstitial pores; 50 percent gravel, by volume; neutral; abrupt, smooth boundary.

B21t—4 to 10 inches, reddish-brown (5YR 5/4) gravelly sandy clay loam, dark reddish brown (5YR 3/4) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine roots; common fine interstitial pores; few thin clay films on faces of peds and in pores; 50 percent gravel and few cobbles, by volume; neutral; clear, wavy boundary.

B22t—10 to 31 inches, yellowish-red (5YR 4/6) very gravelly sandy clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine roots; few fine tubular pores; few thin clay films on faces of peds and in pores; 55 percent gravel and few cobbles, by volume; noneffervescent; mildly alkaline; clear, wavy boundary.

B3ca—31 to 60 inches, light reddish-brown (5YR 6/4) very gravelly heavy sandy loam, reddish brown (5YR 4/4) when moist; massive; weakly cemented in places; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; few fine roots; few fine interstitial pores; 70 percent gravel and 5 percent cobbles, by volume; slightly effervescent but strongly effervescent in spots; moderately alkaline.

The A horizon has hue of 5YR or 7.5YR, value of 4 to 6 when dry and 3 to 5 when moist, and chroma of 3 or 4. It is slightly acid to mildly alkaline. It is 15 to 60 percent gravel and 0 to 5 percent cobbles.

The Bt horizon has hue of 7.5YR to 2.5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 4 to 6. It is sandy clay loam, heavy sandy loam, loam, or light clay loam and contains 35 to 70 percent gravel and 0 to 15 percent cobbles. It is neutral to moderately alkaline.

The B3ca horizon is replaced by a Cca or IIBcab horizon in places. It has hue of 5YR or 7.5YR, value of 4 to 6 when dry and 3 or 4 when moist, and chroma of 4 to 6. It is sandy clay loam, sandy loam, or loamy sand and contains 35 to 70 percent gravel and 0 to 15 percent cobbles. In the lower horizons lime ranges in content from about 3 to 15 percent and in form from a few filaments and patchy gravel coatings to strong cementation between rock fragments.

**PoC—Pinaleno gravelly sandy loam, 0 to 10 percent slopes.** This soil is on fans and on old terrace remnants. Slopes range from 0 to 10 percent. The surface is covered by 30 to 50 percent gravel and 0 to 20 percent cobbles. This soil has the profile described as representative of the series.

Included in mapping are about 10 to 15 percent Sonoita soils, 5 percent Eba and Continental soils, and narrow bands of Comoro soils, and Torrifluents in the drainageways.

Runoff is slow. The hazard of erosion is slight.

These soils are used mainly for range and wildlife habitat. A few small areas north of Nogales are being subdivided for homesites. Capability unit VIe, nonirrigated; Loamy Upland range site, 12- to 16-inch precipitation zone; range productivity group 3.

## Rillino Series

The Rillino series consists of well-drained calcareous soils that are 60 inches or more in depth. They are on remnants of old alluvial fans and terraces dissected by drainageways. These soils formed in sediment that weathered from mixed igneous and sedimentary rocks and filled in old valleys and lakes. Slopes are 8 to 40 percent. Elevation is 2,800 to 3,400 feet. Vegetation is

dominantly whitethorn, catclaw, mesquite, fluffgrass, three-awns, grama grasses and cacti. Average annual precipitation is 10 to 14 inches, and mean annual temperature is 62° to 65° F. The frost-free season is 220 to 260 days.

In a representative profile the surface layer is brown gravelly loam about 4 inches thick. The underlying layer is pale-brown and very pale brown gravelly loam and loam to a depth of about 60 inches or more. The profile is moderately alkaline and is strongly calcareous throughout. It is less than 35 percent gravel.

Permeability is moderate, and available water capacity is moderate or high. Effective rooting depth is 60 inches or more.

These soils are used for range and wildlife habitat.

Representative profile of Rillino gravelly loam from an area of Rollino soils, 8 to 40 percent slopes, eroded, in range, approximately 2,200 feet north and 800 feet west of the southeast corner of sec. 9, T. 20 S., R. 13 E.:

- A1—0 to 4 inches, brown (10YR 5/3) gravelly loam, dark brown (10YR 3/3) when moist; weak, thin, platy structure in top ½ inch and moderate, fine, and very fine, granular structure in lower part; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many fine and very fine roots; common fine interstitial pores; 40 percent fine and medium gravel, by volume; white lime coating on larger pebbles; violently effervescent; moderately alkaline; abrupt, wavy boundary.
- C1ca—4 to 13 inches, pale-brown (10YR 6/3) gravelly loam, dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure parting to moderate, fine, and very fine, granular; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; many fine and very fine roots; common fine and very fine tubular pores; 25 percent gravel, by volume; few, moderate, distinct white lime concretions and coatings on gravel; violently effervescent; moderately alkaline; clear, wavy boundary.
- C2ca—13 to 26 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; weak, medium, subangular blocky structure parting to moderate very fine granules; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; common fine and very fine roots; common very fine and few fine tubular pores; 10 percent fine gravel, by volume; few, fine to medium, distinct, white, soft lime segregations; violently effervescent; moderately alkaline; clear, wavy boundary.
- C3ca—26 to 60 inches, very pale brown (10YR 7/3) gravelly loam, yellowish brown (10YR 5/4) when moist; massive; slightly 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; 20 to 25 percent, by volume, fine gravel weakly cemented by lime; violently effervescent; moderately alkaline.

The A horizon has hue of 7.5YR or 10YR, value of 5 to 7 when dry and 3 to 4 when moist, and chroma of 2 to 4. It is 25 to 50 percent gravel and 0 to 20 percent cobbles.

The Cca horizon has hue of 7.5YR or 10YR, value of 5 to 8 when dry and 4 to 6 when moist, and chroma of 2 to 4. It is loam or sandy loam and contains 5 to 30 percent gravel and 0 to 5 percent cobbles. The lime consists of few to many, fine to medium, and soft to hard segregations in the form of veins, gravel coatings and concretions. In places gravel is weakly cemented to strongly cemented by lime, and it is commonly coated on the underside.

• R1E2—Rillino soils, 8 to 40 percent slopes, eroded.

The soils in this undifferentiated group are on the ends and sides of long, narrow ridge remnants of dissected alluvial fans on terraces. Areas are large and are irregular in shape. Slopes on the narrow ridge crests are 5 to 10 percent, and on the lower side slopes they are 10 to 40 percent and have occasional nearly vertical scarps. A Rillino gravelly loam in an area of these soils has the profile described as representative of the Rillino series. The other Rillino soils have a surface layer of very gravelly loam or gravelly or very gravelly sandy loam. The surface is covered by 40 to 60 percent gravel and 0 to 15 percent cobbles.

Included in mapping are about 10 percent Continental soils and very gravelly or very cobbly soils on some of the ridgetops, and about 5 percent Torrifluvents in drainageways.

Runoff is rapid. The hazard of erosion is high.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Limy Upland range site, 12- to 16-inch precipitation zone; range productivity group 4.

## Rock Outcrop-Lithic Haplustolls Association

### Rn—Rock outcrop-Lithic Haplustolls association.

The soils in this association are on hills and mountains dominated by rhyolite, andesite, granite, dacite, limestone, quartzite, tuff, and bedded tuff-conglomerate. Slopes are dominantly 15 to 60 percent but range from 5 percent to more than 100 percent. Elevation is 4,000 to 8,400 feet. Average annual precipitation ranges from 12 to 24 inches. Vegetation is sparse stands of trees, shrubs, and grasses. Trees are dominantly oak and juniper and a few pine trees at higher elevations. Shrubs are manzanita, catclaw, mimosa, sumac, and squawberry. Grasses are gramas, blue-stems, and muhlys.

About 50 to 70 percent of the area is Rock outcrop consisting of steep ledges, pinnacles, and nearly barren talus slopes. About 30 to 50 percent of the area is Lithic Haplustolls consisting of shallow and very shallow soils similar to Atascosa, Graham, and Lampshire soils. They are in small areas between Rock outcrops.

These soils are used mainly as wildlife habitat and range. However, the areas are commonly too steep, rough, and inaccessible for use as range. Higher areas produce runoff for water supply and have scenic value. Capability unit VIIIs, nonirrigated for Rock outcrop and VIIIs, nonirrigated for Lithic Haplustolls; Loamy Hills range site, 12- to 16-inch precipitation zone and Loamy Hills range site, 16- to 20-inch precipitation zone; range productivity group 5.

## Rock Outcrop

Rr—Rock outcrop. This miscellaneous land type consists mainly of areas of bare bedrock that commonly are nearly vertical rock ledges and pinnacles near mountaintops. Rock types are limestone, quartzite, quartz monzonite, rhyolite-tuff, andesite, and others. As much as 10 percent of the mapped area has shallow and very shallow soils between outcrops of rock. Slopes are dominantly more than 60 percent. Elevation ranges from 5,000 to 9,450 feet. Average annual precipitation

is 12 to 30 inches. A few trees and shrubs grow in soil areas and in cracks in the rock.

Runoff is very rapid.

Rock outcrop provides wildlife habitat. It also serves as watershed for water supply, and it has scenic value. Capability unit VIIIs, nonirrigated; range productivity group 5; not assigned to a range site.

### Schrap Series

The Schrap series consists of well-drained soils that are 3 to 20 inches in depth over shale. These soils formed mostly in shale residuum. They are on low sedimentary hills on uplands. Slopes are 5 to 50 percent. Elevation is 3,800 to 4,500 feet. Vegetation is dominantly grama grasses, curly mesquite, woolly bunchgrass, bluestems, sparse mesquite, false mesquite, catclaw, ocotillo, and a few oak trees. Average annual precipitation is 14 to 18 inches, and mean annual temperature is about 63° F. The frost-free season is 220 to 260 days.

In a representative profile the surface layer is brown very shaly clay loam about 3 inches thick. The next layer is brown very shaly clay loam that is 85 to 95 percent shale fragments and is about 14 inches thick. The underlying material, to a depth of about 27 inches or more, is mixed yellowish-brown, brown, reddish-yellow, and olive shale. The profile is mildly alkaline throughout.

Permeability is moderately slow, and available water capacity is very low. Effective rooting depth is 3 to 20 inches.

These soils are used for range and wildlife habitat.

Representative profile of Schrap very shaly clay loam, 5 to 20 percent slopes, in range, 500 feet east and 1,300 feet north of the southwest corner of sec. 9, T. 22 S., R. 10 E., Pima County:

- A1—0 to 3 inches, brown (10YR 5/3) very shaly clay loam, dark brown (10YR 3/3) when moist; weak, thin, platy structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; many very fine and fine roots; many fine interstitial pores; 60 percent fine and medium gravel-sized shale fragments, by volume; mildly alkaline; clear, wavy boundary.
- AC—3 to 17 inches, brown (10YR 5/3) very shaly clay loam, dark brown (10YR 3/3) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; common fine and very fine roots; common fine and very fine pores; 90 percent gravel- and cobble-sized shaly fragments, by volume; clear, irregular boundary.
- C2—17 to 27 inches, yellowish-brown (10YR 5/3), brown (10YR 5/3), reddish-yellow (5YR 6/6), and olive (5Y 5/3) shale.

Depth to weathered shale is 3 to 20 inches. The A horizon has hue of 5YR to 10YR, value of 5 or 6 when dry and 3 or 4 when moist, and chroma of 2 to 4. It is slightly acid to mildly alkaline. It is loam or clay loam and contains 50 to 95 percent gravel-sized shale fragments and 5 to 30 percent cobbles.

The C horizon has hue ranging from 10R to 5Y. It is slightly acid to moderately alkaline and is slightly effervescent in spots on shale fragments.

**ScD—Schrap very shaly clay loam, 5 to 20 percent slopes.** This soil is on low sedimentary hills on uplands near Oro Blanco in the western part of the survey area. It has the profile described as representative of

the series. The surface is covered by 35 to 60 percent gravel-sized shale fragments and 0 to 5 percent cobbles.

Included in mapping are about 20 percent Rock outcrop, about 5 percent old alluvium, which has a surface layer and subsoil resembling those of the White House and Caralampi soils and overlies the shale, and narrow bands of medium to moderately coarse Torrifluents in drainageways.

Runoff is medium. The hazard of erosion is moderate.

This soil is used for range and wildlife habitat. Capability unit VIe, nonirrigated; Clay Loam Hills range site, 12- to 16-inch precipitation zone; range productivity group 3.

**ShF—Schrap cobbly clay loam, 20 to 50 percent slopes.** This soil is on sedimentary hills on uplands in the western part of the survey area. This soil has a profile similar to the one described as representative of the series, but the surface layer is 20 to 30 percent cobbles. The cobbles originate mainly from rhyolite-tuff Rock outcrop that, in places, caps the shale ridges. The surface is covered by 20 to 30 percent cobbles and 30 to 50 percent gravel.

Included in mapping are about 25 percent Lampshire soils in areas of rhyolite tuff rocks and 10 to 15 percent Rock outcrop. Also included are small areas of recent alluvial soils bordering drainageways.

Runoff is rapid. The hazard of erosion is high.

This soil is used for range and wildlife habitat. Capability unit VIe, nonirrigated; Clay Loam Hills range site, 12- to 16-inch precipitation zone; range productivity group 4.

### Signal Series

The Signal series consists of well-drained soils that are 60 inches or more in depth. These soils formed in old alluvium weathered from mixed acid and basic igneous and tuffaceous rocks. They are on dissected piedmont slopes that form long convex ridges. Slopes are 1 to 20 percent. Elevation is 3,400 to 5,000 feet. Vegetation is dominantly curly mesquite, grama grasses, plains lovegrass, three-awns, false mesquite, and scattered mesquite and paloverde. Average annual precipitation is 12 to 16 inches, and mean annual temperature is 60° to 65° F. The frost-free season is 200 to 260 days.

In a representative profile the surface layer is brown gravelly loam about 2 inches thick. The subsoil is dark-brown clay about 17 inches thick. The substratum is mottled pinkish-white, reddish-brown, pinkish-gray, pink, and white very gravelly clay loam, very gravelly sandy clay loam, and very gravelly sandy loam to a depth of about 72 inches. The profile is slightly acid in the surface layer and becomes moderately alkaline and strongly calcareous in the lower part of the subsoil and in the substratum.

Permeability is slow, and available water capacity is moderate. Effective rooting depth is 60 inches or more.

These soils are used mainly for range and wildlife habitat. A few areas are used for homesites.

Representative profile of Signal gravelly loam from an area of Signal soils, 1 to 20 percent slopes, in range,

2,200 feet west and 2,000 feet south of the northeast corner of sec. 15, T. 21 S., R. 12 E., Santa Cruz County:

- A1—0 to 2 inches, brown (7.5YR 4/2) gravelly loam, dark brown (7.5YR 3/2) when moist; weak, thick, platy structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common fine roots; few micropores and very fine tubular pores; 30 percent gravel and 20 percent cobbles, by volume; slightly acid; abrupt, smooth boundary.
- B21t—2 to 6 inches, dark-brown (7.5YR 3/2) clay, dark brown (7.5YR 3/2) when moist; weak, medium, prismatic structure parting to moderate, medium and coarse, subangular and angular blocks; very hard when dry, friable when moist, sticky and very plastic when wet; common fine and few coarse roots; few very fine tubular pores; clay films nearly fill pores; few pebbles and cobbles; neutral; clear, smooth boundary.
- B22t—6 to 14 inches, dark-brown (7.5YR 3/2) clay, dark reddish brown (5YR 3/3) when moist; weak, medium, prismatic structure parting to moderate, medium and coarse, subangular and angular blocks; very hard when dry, friable when moist; sticky and very plastic when wet; common fine and few coarse roots; few very fine tubular pores; common small slickensides; 5 percent gravel and cobbles, by volume; moderately alkaline; clear, smooth boundary.
- B23t—14 to 19 inches, dark-brown (7.5YR 4/2) clay, dark reddish brown (5YR 3/4) when moist; weak, medium, prismatic structure parting to moderate, medium and coarse, subangular and angular blocks; very hard when dry, friable when moist, sticky and very plastic when wet; common fine and few medium roots; few very fine tubular pores; common thin clay films on faces of peds and lining pores; common small slickensides; 5 percent gravel and cobbles, by volume; strongly effervescent; moderately alkaline; clear, smooth boundary.
- C1ca—19 to 27 inches, mottled pinkish-white (5YR 8/2), reddish-brown (5YR 5/4), and pinkish-gray (5YR 7/2) very gravelly clay loam, reddish gray (5YR 5/2), reddish brown (5YR 4/4), and pinkish gray (5YR 7/2) when moist; mottles are many, large, and distinct; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; few medium and coarse roots; few very fine interstitial and tubular pores; 50 percent gravel and 20 percent cobbles, by volume; violently effervescent; moderately alkaline; gradual, irregular boundary.
- C2ca—27 to 60 inches, mottled pinkish-white (5YR 8/2), reddish-brown (5YR 5/4), and pinkish-gray (5YR 7/2) very gravelly sandy clay loam, dark reddish gray (5YR 4/2), reddish brown (5YR 4/4), and pinkish gray (5YR 7/2) when moist; mottles are many, large, and distinct; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine roots; few very fine interstitial pores; 40 percent gravel and 20 percent cobbles, by volume; strongly effervescent, violently effervescent in spots; moderately alkaline; gradual, wavy boundary.
- C3ca—60 to 72 inches, white (5YR 8/1) and pink (5YR 7/3) very gravelly heavy sandy loam, pink (5YR 8/3) and reddish brown (5YR 5/4) when moist; massive; hard when dry, friable when moist, non-sticky and nonplastic when wet; few very fine roots; few fine interstitial pores; 60 percent gravel, by volume; violently effervescent; moderately alkaline.

The A1 horizon has hue of 10YR or 7.5YR, value of 3 or 4 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is slightly acid to moderately alkaline. It is 15 to 50 percent gravel and 5 to 25 percent cobbles.

The B2t horizon has hue of 7.5YR or 5YR, value of 3 or 4

when dry and 2 or 3 when moist, and chroma of 2 to 4. It is neutral to moderately alkaline. The Bt horizon is clay or heavy clay loam and contains 1 to 30 percent gravel and 0 to 5 percent cobbles.

The Cca horizon is clay loam, sandy clay loam, or sandy loam and contains 30 to 70 percent gravel and cobbles. As much as 20 percent is cobbles. In places this horizon is weakly lime-cemented, has thin, discontinuous seams or veins of lime, and has lime coatings on gravel.

**SnD—Signal soils, 1 to 20 percent slopes.** This undifferentiated group of soils is on the dissected old piedmont surface east of the Tumacacori Mountains. Slopes on the ridge remnants are mostly 1 to 5 percent on the tops and 10 to 20 percent on the sides. A Signal gravelly loam in an area of these soils has the profile described as representative of the series. The other Signal soils have a surface layer of very gravelly, cobbly, very cobbly loam and gravelly, very gravelly, cobbly, or very cobbly sandy loam. The surface is covered by about 30 to 60 percent gravel and 1 to 5 percent cobbles on the ridgetops and 20 to 40 percent gravel and 10 to 30 percent cobbles on the side slopes.

Included in mapping are about 15 percent White House and Caralampi soils, narrow bands of gravelly and cobbly coarse soils in drainageways, and, near Moyza Canyon, areas of cobbly or stony soils that have slopes of as much as 35 percent.

Runoff is medium. The hazard of erosion is high.

The soils are used mainly for range and wildlife habitat, and a few areas near Tubac and Tumacacori are subdivided for homesites. Capability unit VIe, nonirrigated; Clay Loam Upland range site, 12- to 16-inch precipitation zone; range productivity group 3.

## Sonoita Series

The Sonoita series consists of well-drained soils that are 60 inches or more in depth. These soils formed in old alluvium weathered from granite and related acid igneous rock. They are on alluvial fans and low terraces. Slopes are from 1 to 20 percent. Elevation is 3,800 to 5,000 feet. Vegetation is dominantly mesquite, burweed, three-awns, Rothrock and hairy grammas, annual grasses, and a few oak trees at higher elevations (fig. 9). Average annual precipitation is 10 to 14 inches, and mean annual temperature is 59° to 65° F. The frost-free season is 200 to 265 days.

In a representative profile the surface layer is brown gravelly sandy loam about 4 inches thick. The subsoil is reddish-brown, light-brown, and yellowish-red gravelly sandy loam to a depth of about 70 inches or more. The profile is medium acid and neutral in the surface layer, mildly alkaline in the upper part of the subsoil, and moderately alkaline in the lower part of the subsoil. It is slightly calcareous and strongly calcareous in the lower part of the subsoil.

Permeability is moderately slow, and available water capacity is moderate or low. Effective rooting depth is 60 inches or more.

These soils are used for range and wildlife habitat.

Representative profile of Sonoita gravelly sandy loam, 1 to 8 percent slopes, in range, 660 feet west of the east quarter corner of sec. 23, T. 20 S., R. 12 E., Santa Cruz County:



Figure 9.—Mesquite and burrowed in an area of Sonoita gravelly sandy loam, 1 to 8 percent slopes. Range is in poor condition.

- A11—0 to 2 inches, brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 4/4) when moist; weak, medium, platy structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine interstitial pores; 20 percent mostly fine gravel, by volume; medium acid; abrupt, smooth boundary.
- A12—2 to 4 inches, brown (7.5YR 5/4) gravelly sandy loam, reddish brown (5YR 4/4) when moist; massive; hard when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine and fine roots; common fine interstitial pores and few very fine and fine tubular pores; 20 percent fine gravel, by volume; neutral; clear, smooth boundary.
- B21—4 to 10 inches, reddish-brown (5YR 5/4) gravelly sandy loam, dark reddish brown (5YR 3/4) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and nonplastic when wet; common fine and very fine roots and few medium roots; common very fine and fine tubular pores; 15 percent gravel, by volume; mildly alkaline; clear, wavy boundary.
- B22—10 to 17 inches, reddish-brown (5YR 5/4) gravelly sandy loam, dark reddish brown (5YR 3/4) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and nonplastic when wet; common fine and very fine roots and few medium roots; common very fine and fine tubular pores; 20 percent gravel, by volume; mildly alkaline; clear, wavy boundary.
- B23t—17 to 26 inches, reddish-brown (5YR 5/4) gravelly sandy loam, yellowish red (5YR 4/6) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and very fine roots and few coarse roots; few fine, very fine, and medium tubular pores; common thin clay films on faces of peds and lining pores; 20 percent gravel, few cobbles, by volume; very few very fine white (5YR 8/1) lime filaments; slightly effervescent in spots; moderately alkaline; clear, wavy boundary.
- B24tca—26 to 40 inches, reddish-brown (5YR 5/4) gravelly sandy loam, reddish brown (5YR 4/4) when moist;

weak, medium, subangular blocky structure; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and very fine roots; common fine and very fine tubular pores; few thin clay films on faces of peds and lining pores; 15 percent gravel, by volume; few fine pinkish-white (5YR 8/2) lime filaments; slightly effervescent; moderately alkaline; clear, wavy boundary.

- B25tca—40 to 62 inches, light-brown (7.5YR 6/4) gravelly sandy loam, reddish brown (5YR 4/4) when moist; weak, medium, subangular blocky structure; very hard when dry, friable when moist, slightly sticky and plastic when wet; few fine and medium roots; few fine and medium tubular pores; common thin clay films on faces of peds and lining pores; 20 percent gravel, by volume; common fine pinkish-white (7.5YR 8/2) lime filaments; strongly effervescent to violently effervescent; moderately alkaline; clear, wavy boundary.
- B3ca—62 to 70 inches, yellowish-red (5YR 5/6) gravelly sandy loam, yellowish red (5YR 4/6) when moist; massive; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine and fine tubular pores; 30 percent gravel, by volume; slightly effervescent in spots; moderately alkaline.

The A horizon has hue of 10YR or 5YR, value of 4 to 6 when dry and 3 or 4 when moist, and chroma of 3 or 4. It is medium acid to mildly alkaline. It is 1 to 30 percent gravel and 0 to 5 percent cobbles.

The B horizon has hue of 7.5YR to 2.5YR, value of 4 to 6 when dry and 3 or 4 when moist, and chroma of 3 to 6. It is slightly acid to moderately alkaline. It is sandy loam, loam, or light sandy clay loam that contains 5 to 30 percent gravel and 0 to 5 percent cobbles. Depth to a weak lime zone ranges from 21 to 54 inches.

**SoB—Sonoita gravelly sandy loam, 1 to 8 percent slopes.** This soil is on fans and low terraces adjacent to the Santa Cruz River. It has the profile described as representative of the series. The surface is covered by 15 to 35 percent gravel and 0 to 5 percent cobbles. Included in mapping are about 10 percent Anthony and Comoro soils in the drainageways, soils that con-

sist of 12 to 30 inches of overburden on soils that were formerly Sonoita soils, and about 5 percent Pinaleno, Continental, and Eba soils. Also included are a few short terrace breaks that have slopes of as much as 45 percent.

Runoff is slow, and the hazard of erosion is slight. A few shallow to moderately deep gullies are in the waterways and along trails traversing the areas.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Sandy Loam range site, 12- to 16-inch precipitation zone; range productivity group 2.

**SoD—Sonoita gravelly sandy loam, 8 to 20 percent slopes.** This soil is on the fans of the Huachuca and Santa Rita Mountains. It has a profile similar to the one described as representative of the series, but it contains about 25 percent gravel and 5 percent cobbles, by volume, throughout. Slopes are mostly 8 to 16 percent but are as much as 20 percent in places. The surface is covered by 20 to 50 percent gravel, 5 to 15 percent cobbles, and 0 to 10 percent stones.

Included in mapping are 10 to 15 percent White House and Eba soils and about 5 percent Torrifluvents in drainageways. Also included are a few granitic Rock outcrops and areas of Chiricahua soils on some of the upper slopes and on the sides of some of the drainageways.

Runoff is medium, and the hazard of erosion is slight.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Sandy Loam range site, 12- to 16-inch precipitation zone; range productivity group 3.

## Telephone Series

The Telephone series consists of well-drained soils that are 5 to 20 inches in depth to bedrock. These soils are on moderately steep to very steep mountains. They formed in materials weathered from sandstone, quartzite, siliceous schist, and phyllite. Slopes are dominantly 30 to 50 percent but range from 20 to 80 percent. Elevation is 6,000 to 7,500 feet. Vegetation is dominantly pine, fir, oak, manzanita, and deergrass. Average annual precipitation is 17 to 24 inches, and mean annual temperature is about 47° to 56° F. The frost-free season is 140 to 180 days.

In a representative profile there is a 2-inch litter of pine needles and leaves covering the surface. The surface layer is brown very gravelly loam about 2 inches thick. The underlying material is pink very gravelly loam about 4 inches thick. Red fractured sandstone is at a depth of about 6 inches. The surface layer is slightly acid, and the underlying material is strongly acid.

Permeability is moderate above the bedrock, and available water capacity is very low. Effective rooting depth is 5 to 20 inches. Runoff is medium to rapid, and the hazard of erosion is high.

These soils are used mainly for wildlife habitat, woodland, and water supply. In the survey area these soils are mapped only in an association with Hogris soils and Rock outcrop.

Representative profile of Telephone very gravelly

loam, from an area of Hogris-Telephone association, steep, in woodland, approximately 1,000 feet west and 660 feet north of the southeast corner of sec. 15, T. 23 S., R. 20 E., Cochise County:

O1—2 inches to 0, litter of pine needles and leaves.

A1—0 to 2 inches, brown (10YR 5/3) very gravelly loam, dark brown (10YR 3/3) when moist; weak, very fine and fine, granular structure; soft when dry, very friable when moist, nonsticky and slightly plastic when wet; many very fine and fine roots; many fine interstitial pores; 60 percent gravel and 5 percent cobbles, by volume; slightly acid; abrupt, smooth boundary.

C—2 to 6 inches, pink (7.5YR 7/4) very gravelly loam, dark brown (7.5YR 4/4) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many very fine and fine, and common medium roots; common very fine, fine, and medium tubular pores; 50 percent gravel and 10 percent cobbles, by volume; strongly acid; abrupt, irregular boundary.

R—6 to 30 inches, red (10R 4/6) extremely hard fractured sandstone.

Depth to fractured bedrock is 5 to 20 inches. The profile is strongly acid to slightly acid. The A horizon has hue of 10YR or 7.5YR, value of 5 to 7 when dry and 3 to 5 when moist, and chroma of 1 to 4. It is loam or fine sandy loam and contains 30 to 60 percent gravel and 5 to 20 percent cobbles and stones.

The C horizon has hue of 10YR or 7.5YR, value of 6 or 7 when dry and 3 to 6 when moist, and chroma of 2 to 4. It is very gravelly or very cobbly fine sandy loam or very gravelly or very cobbly light loam and contains 35 to 80 percent gravel and cobbles.

## Torrifluvents and Haplustolls

**Th—Torrifluvents and Haplustolls.** The soils in this mapping unit are in areas of unconsolidated recent alluvium. They are in many of the smaller, steeper drainageways throughout the survey area and on a few fan deltas. The areas are subject to frequent changes in size and shape because of flooding. Slopes are dominantly 1 to 5 percent. Elevation is from 3,000 to 6,000 feet. Average annual precipitation ranges from 11 to 20 inches, but the soils occasionally receive extra water from overflow. Vegetation at the lower elevations is desert shrubs and annuals, and at the higher elevations it is a few oak, sycamore, or other trees and perennial grasses.

Torrifluvents are mostly deep well-drained soils that have a surface layer of sandy loam, loam, or clay loam, which is modified by variable amounts of rock fragments. Underlying layers are stratified sand, sandy loam, loam, sandy clay loam, or clay loam and contain 0 to 50 percent or more rock fragments. Permeability is moderately rapid to moderately slow, and available water capacity is moderate to very low.

Haplustolls are mostly deep, well-drained soils that have a surface layer of sandy loam or sandy clay or both. Underlying layers are generally sandy clay loam and contain more than 15 percent rock fragments. Permeability is moderately slow, and available water capacity is low or moderate.

Included in mapping are small areas of Grabe and Comoro soils at higher elevations and Anthony soils at lower elevations. Some areas have a surface layer of loam or sandy loam that is 10 to 20 inches thick over sand and gravel.

The hazard of erosion is slight or moderate. Waterways are commonly shallowly entrenched. Most areas are subject to flooding and deposition.

These soils are used for range and wildlife habitat. Capability unit VIIw, nonirrigated; Loam Bottom range site, 12- to 20-inch precipitation zone; range productivity group 3.

### Tortugas Series

The Tortugas series consists of well-drained soils that are 6 to 20 inches in depth over bedrock. These soils formed in materials weathered from limestone. They are on hills and mountains. Slopes range from 5 to 70 percent but are dominantly 15 to 45 percent. Elevation is 4,800 to 7,000 feet. Vegetation is dominantly cliffrose, sumac, ocotillo, grama grasses, three-awns, false mesquite, scattered oak and juniper trees, and some pine at higher elevations. Average annual precipitation is 16 to 24 inches, and mean annual temperature is 48° to 58° F. The frost-free season is 140 to 220 days.

In a representative profile the soil is dark grayish-brown very cobbly loam about 14 inches thick. Light-gray, hard, fractured limestone is at a depth of about 14 inches. The profile is strongly calcareous and moderately alkaline throughout.

Permeability is moderate, and available water capacity is very low. Effective rooting depth is 6 to 20 inches.

These soils are used for range and wildlife habitat. Higher elevations produce runoff for water supply.

Representative profile of Tortugas very cobbly loam, from an area of Tortugas-Rock outcrop complex, 25 to 60 percent slopes, in range, midway up the east slope of a limestone hill, ¼ mile north and 600 feet east of the southwest corner of sec. 6, T. 22 S., R. 18 E., Santa Cruz County:

A11—0 to 5 inches, dark grayish-brown (10YR 4/2) very cobbly loam, very dark brown (10YR 2/2) when moist; moderate, very fine, granular structure; soft when dry, friable when moist, slightly sticky and plastic when wet; few fine roots; many fine interstitial pores and few fine tubular pores; 40 percent cobbles and 25 percent gravel, by volume; strongly effervescent; moderately alkaline; clear, wavy boundary.

A12—5 to 14 inches, dark grayish-brown (10YR 4/2) very cobbly loam, very dark brown (10YR 2/2) when moist; weak, medium, subangular blocky structure parting to moderate, fine granular; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; many fine and few medium roots; many fine interstitial pores and few fine tubular pores; 40 percent cobbles and 35 percent gravel, by volume; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

R—14 to 16 inches, light-gray (10YR 7/2) extremely hard fractured limestone.

Depth to hard limestone, marble, or calcareous conglomerate bedrock ranges from 6 to 20 inches. The A horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry and 2 or 3 when moist, and chroma of 2 or 3. It is loam or silt loam and contains 25 to 60 percent gravel, 5 to 50 percent cobbles, and 0 to 30 percent stones.

Some profiles have a thin C horizon. The C horizon has hue of 10YR or 7.5YR, value of 6 to 8 when dry and 4 to 7 when moist, and chroma of 2 to 4. In some places thin lime coatings or segregations coat the parent rock and seal the fractures.

**TrE—Tortugas-Rock outcrop complex, 5 to 25 percent slopes.** This complex is on low limestone hills. About 60 percent of the complex is Tortugas very cobbly loam, and 15 to 25 percent is Rock outcrop. The Tortugas very cobbly loam is between areas of Rock outcrop and has a profile similar to the one described as representative of the series, but the size and amount of rock fragments vary. The surface is covered by 25 to 50 percent gravel, 10 to 40 percent cobbles, and 0 to 20 percent stones. Rock outcrop consists of low ledges and ridges of limestone, limestone-conglomerate, and occasional quartzite.

Included in mapping are 15 to 20 percent thin beds of reddish clay shale and quartzitic sandstone. In these included areas, cobbly soils that have a red clay subsoil have formed over bedrock, which is at a depth of 10 to 24 inches. These fine-textured soils are commonly on toe slopes and in saddles where the softer materials contributed to their formation but have been eroded.

Runoff is medium, and the hazard of erosion is slight.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Tortugas soils in Limestone Hills range site, 16- to 20-inch precipitation zone, Rock outcrop part not assigned to a range site; range productivity group 4.

**TrF—Tortugas-Rock outcrop complex, 25 to 60 percent slopes.** This complex is on limestone mountains. About 50 percent of the complex is Tortugas very cobbly loam, and 40 percent is Rock outcrop. The Tortugas very cobbly loam is between areas of Rock outcrop and has the profile described as representative of the series. The surface is covered by 20 to 40 percent gravel, 10 to 50 percent cobbles, and 0 to 30 percent stones. Rock outcrop consists of low ledges, ridges, and occasional pinnacles of limestone and limestone conglomerate.

Included in mapping are 5 to 10 percent thin beds of reddish clay shale and quartzitic sandstone. In these areas, cobbly soils that have a red clay subsoil have formed over bedrock, which is at a depth of 10 to 24 inches. These areas are commonly on toe slopes and in saddles. Also included are small areas of alluvial and colluvial soils in narrow, steep drainageways and on lower slopes of the steeper mountains.

Runoff is rapid, and the hazard of erosion is moderate.

These soils are used mainly for range and wildlife habitat. Capability unit VIIe, nonirrigated; Tortugas soils in Limestone Hills range site, 16- to 20-inch precipitation zone, Rock outcrop part not assigned to a range site; range productivity group 4.

### White House Series

The White House series consists of well-drained soils that are 60 inches or more in depth. These soils formed in old alluvium weathered from andesite, rhyolite, dacite, granite, and tuffaceous rock material. They are on piedmont slopes. These old piedmont surfaces are dissected in varying degrees. In places only long narrow ridge remnants are left. They have side

slopes of 10 to 40 percent. Elevation is 3,300 to 5,400 feet. Vegetation is dominantly grama grasses, plains lovegrass, curly mesquite, three-awns, false mesquite, scattered mesquite brush, and, at higher elevations, a few oak and juniper trees. Average annual precipitation is 12 to 18 inches, and mean annual temperature ranges from 57° to 65° F. The frost-free season is 190 to 240 days.

In a representative profile the surface layer is brown gravelly loam about 3 inches thick. The subsoil is about 59 inches thick. The upper 23 inches is reddish-brown and dark red clay and clay loam; the next 13 inches is mottled red and pink clay loam; and the lower 23 inches is mottled yellowish-red and pink gravelly sandy clay loam. The substratum, to a depth of about 78 inches or more, is mottled red and pinkish-white gravelly sandy clay loam. The profile is medium acid in the surface layer and moderately alkaline below a depth of about 22 inches.

Permeability is slow, and available water capacity is moderate or high. Effective rooting depth is 60 inches or more.

These soils are used for range, wildlife habitat, and homesites.

Representative profile of White House gravelly loam, 0 to 10 percent slopes, in range, 1.3 miles east south-east of Highway 83 and 0.1 mile south of the El Paso gas pipeline on the Babocomari Grant, 3 miles south and 4.5 miles east of Sonoita, Santa Cruz County:

- A1—0 to 3 inches, brown (7.5YR 5/4) gravelly loam, dark brown (7.5YR 3/2) when moist; weak, thick, platy structure parting to moderate fine granular; slightly hard when dry, friable when moist, non-sticky and slightly plastic when wet; many very fine and fine roots; common fine interstitial pores; 15 percent gravel, by volume; medium acid; clear, smooth boundary.
- B1t—3 to 9 inches, reddish-brown (5YR 5/4) clay loam, dark reddish brown (5YR 3/4) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common fine and very fine roots; few fine and very fine tubular pores; few thin clay films on faces of peds; 2 percent fine gravel, by volume; slightly acid; clear, smooth boundary.
- B21t—9 to 22 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; moderate, medium and coarse, prismatic structure; hard when dry, firm when moist, sticky and plastic when wet; common fine and very fine roots; few very fine interstitial and tubular pores; many moderately thick clay films on faces of peds; few fine pebbles; neutral; clear, wavy boundary.
- B22tca—22 to 26 inches, dark-red (2.5YR 3/6) clay, dark red (2.5YR 3/6) when moist; moderate, medium and coarse, subangular and angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common fine roots; few fine tubular pores; many moderately thick clay films on faces of peds; common pressure faces; common medium slickensides; few pebbles; strongly effervescent; moderately alkaline; clear, wavy boundary.
- B31tca—26 to 39 inches, mottled red (2.5YR 4/6) and pink (5YR 7/4) clay loam, dark red (2.5YR 3/6) and light reddish brown (5YR 6/4) when moist; many, medium and large, distinct mottles; weak, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few fine roots; few very fine and fine tubular pores; common thin clay films on faces of peds; 5 percent gravel, by volume; common, medium, irregularly

shaped lime masses; strongly effervescent; moderately alkaline; gradual, wavy boundary.

B32tca—39 to 49 inches, mottled yellowish-red (5YR 5/6) and pink (5YR 7/4) gravelly sandy clay loam, yellowish red (5YR 4/6) and light reddish brown (5YR 6/4) when moist; many, medium and large, distinct mottles; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; few very fine interstitial pores; 15 percent coarse gravel, by volume; few fine and medium lime masses; slightly effervescent; moderately alkaline; gradual, wavy boundary.

B33ca—49 to 62 inches, mottled yellowish-red (5YR 5/8) and pink (5YR 7/3) gravelly sandy clay loam, yellowish red (5YR 4/8) and light reddish brown (5YR 6/3) when moist; many, medium and large, distinct mottles; massive; hard when dry, friable when moist, sticky and plastic when wet; few very fine interstitial pores; 35 percent medium and coarse gravel, by volume; few fine limestone masses; slightly effervescent; moderately alkaline; gradual, wavy boundary.

Cca—62 to 78 inches, mottled red (2.5YR 5/8) and pinkish-white (5YR 8/2) gravelly sandy clay loam, red (2.5YR 4/8) and pinkish-gray (5YR 7/2) when moist; many medium and large, distinct mottles; massive; hard when dry, friable when moist, sticky and plastic when wet; 30 percent gravel, by volume; slightly effervescent; moderately alkaline.

The A1 horizon has hue of 5YR to 10YR, value of 4 to 6 when dry and 3 or 4 when moist, and chroma of 2 to 4. It is sandy loam, loam, or sandy clay loam and contains 15 to 30 percent gravel and 0 to 30 percent cobbles. It is strongly acid to neutral.

The B horizon has hue of 2.5YR to 7.5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 3 to 6. It is heavy clay loam or clay. The upper 20 inches is 2 to 35 percent gravel. Structure ranges from prismatic to blocky and from weak to strong. Carbonate content, mostly lime, in the lower part of the B horizon and in the C horizon ranges from 2 to 15 percent, by volume. It is in the form of thin coatings on the underside of gravel or in an accumulation of distinct soft masses.

**WgC—White House gravelly loam, 0 to 10 percent slopes.** This soil is on broad piedmont plains dissected by shallow drainageways. It has the profile described as representative of the series. The surface is covered by 10 to 30 percent gravel and a few cobbles. Slopes range from 0 to 10 percent.

Included in mapping are about 10 percent Bernardino gravelly clay loam, commonly on the slope breaks and ends of low ridges, 5 to 10 percent Guest and Pima soils in the swales and drainageways, and small areas of Sonoita soils on some low benches above drainageways. Also included are a few areas of soils that are similar to White House soils but that have more than 15 percent lime in the lower part of the subsoil and the upper part of the substratum; a few small areas of soils that have more than 35 percent gravel in the upper part of the subsoil; and areas at higher elevations in a cooler and wetter climatic zone.

Runoff is slow or medium, and the hazard of erosion is slight.

These soils are used mainly for range and wildlife habitat. Several tracts in the Sonoita area are being subdivided for homesites. Capability unit VIe, nonirrigated; Loamy Upland range site, 12- to 16-inch precipitation zone and Loamy Upland range site, 16- to 20-inch precipitation zone; range productivity group 1.

**WgE—White House gravelly loam, 10 to 35 percent slopes.** This soil is on long narrow sides of ridges

formed by dissection of old valley piedmont plains. Slopes are dominantly 10 to 25 percent, but they are as much as 35 percent in places. The soil has a profile similar to the one described as representative of the series, but it generally contains about 10 percent more rock fragments. The surface is 15 to 35 percent gravel and 5 to 15 percent cobbles.

Included in mapping are about 10 to 15 percent Bernardino soils, Torrifuvents, and Calciorthids-Haplargids association.

Runoff is medium, and the hazard of erosion is high.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; Loamy Upland range site, 12- to 16-inch precipitation zone, and Loamy Upland (oak) range site, 16- to 20-inch precipitation zone; range productivity group 2.

**WhC—White House cobbly sandy loam, 1 to 15 percent slopes.** This soil is on broad ridges of old piedmont remnants near the mountains. Most areas are on the west and northwest side slopes of the Santa Rita Mountains. Slopes are 1 to 5 percent on the mesalike ridgetops and 5 to 15 percent on the upper side slopes. Some slopes are more than 15 percent; this includes a few nearly vertical scarps. This soil has a profile

similar to the one described as representative of the series, but it contains more cobbles in the surface layer and substratum, has a surface layer mainly of cobbly sandy loam, and contains more weathered granite throughout the profile. In places on ridge crowns, near ridge ends, and on high fans near the mountains, the surface layer is very cobbly or very gravelly. A few small areas are stony. The surface is covered by 15 to 60 percent gravel, 5 to 30 percent cobbles, and 0 to 5 percent stones.

Included in mapping are 15 to 20 percent Caralampi and Eba soils, gravelly and cobbly Torrifuvents in drainageways, and small areas of Bernardino and Hathaway soils.

Runoff is medium, and the hazard of erosion is slight.

These soils are used mainly for range and wildlife habitat (fig. 10). An area east of Tubac is being subdivided for homesites. Capability unit VIe, nonirrigated; Loamy Upland range site, 12- to 16-inch precipitation zone; range productivity group 2.

**WnC—White House-Bonita complex, 0 to 10 percent slopes.** The soils in this complex are on piedmont plains. About 65 percent of this complex is White

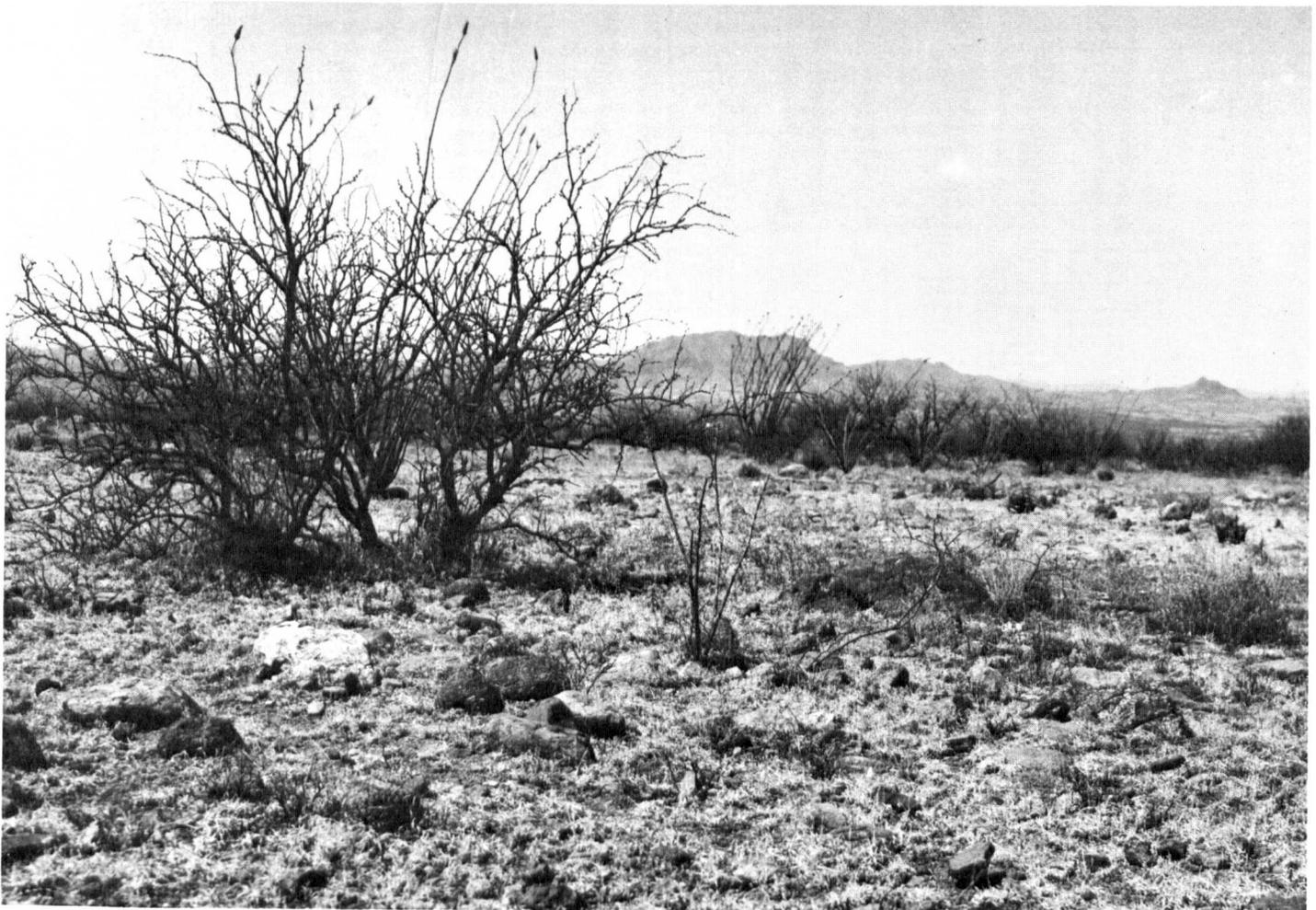


Figure 10.—Range in poor condition in an area of White House cobbly sandy loam, 1 to 15 percent slopes.

House gravelly loam, and 30 percent is Bonita clay or gravelly clay. White House soils commonly have slopes of 2 to 10 percent, and Bonita soils are in slightly concave areas or have slopes of 0 to 1 percent. A White House gravelly loam and a Bonita clay in this complex have the profiles described as representative of their respective series. The surface is covered by 10 to 30 percent gravel and 0 to 5 percent cobbles.

Included in mapping are about 5 percent Bernardino gravelly clay loam and narrow bands of Guest or Pima soils in drainageways.

Runoff is slow, and the hazard of erosion is moderate.

These soils are used for range and wildlife habitat. Capability unit VIe, nonirrigated; White House soils in Loamy Upland range site, 16- to 20-inch precipitation zone, and Bonita soils in Clay Upland range site, 16- to 20-inch precipitation zone; range productivity group 2.

**WoE—White House-Caralampi complex, 10 to 35 percent slopes.** This complex consists of about 45 percent each White House and Caralampi soils. The soils are on long, narrow, roughly parallel, convex ridge remnants formed by deep dissection of old piedmont surfaces. White House soils are generally on the less sloping ridgetops and shoulders that have slopes of 10 to 20 percent. Caralampi soils are generally on the steeper portions that have slopes of 20 to 35 percent (fig. 11). The White House soils have a surface layer of gravelly, cobbly, very gravelly or very cobbly sandy loam or sandy clay loam and cobbly, very gravelly, or very cobbly loam. Gravelly sandy loam is most common. The surface is covered by 15 to 50 percent gravel and 0 to 20 percent cobbles.

Included in mapping are about 5 percent Hathaway soils that have slopes of 35 to 50 percent, and 5 percent Comoro gravelly sandy loam and other gravelly

and very gravelly alluvial soils on the flood plains. Also included are a few areas of Bernardino soils on side slopes and ridge crests.

Runoff is medium, and the hazard of erosion is moderate.

These soils are used mainly for range and wildlife habitat. Several areas north of Nogales on the old Baca Float are being subdivided for homesites. Capability unit VIe, nonirrigated; White House soils in Loamy Upland range site, 12- to 16-inch precipitation zone; Caralampi soils in Sandy Loam range site, 12- to 16-inch precipitation zone; range productivity group 2.

**WtF—White House-Hathaway association, steep.** The soils in this association are on ridge remnants of severely dissected old piedmont surfaces. White House soils make up about 45 percent of the association, and Hathaway soils about 30 percent. White House soils commonly have slopes of 5 to 15 percent. Hathaway soils are commonly steeper, having slopes of 20 to 45 percent. The surface is covered by 15 to 50 percent gravel, 0 to 15 percent cobbles, and a few stones.

Included in mapping were areas of Calciorthids-Haplargids association that have slopes of more than 45 percent Caralampi soils that have slopes of 20 to 40 percent, and small areas of Comoro and other gravelly alluvial soils on the flood plains.

Runoff is rapid, and the hazard of erosion is moderate. High vertical scarps along the waterways are fairly common.

These soils are used for range and wildlife habitat. Parts of the area have been subdivided for homesites. Capability unit VIe, nonirrigated; White House soils in Loamy Upland range site, 12- to 16-inch precipitation zone; Hathaway soils in Limy Slopes range site, 12- to 16-inch precipitation zone; range productivity group 3.



Figure 11.—An area of White House-Caralampi complex. White House soils are in the less sloping areas.

## *Use and Management of the Soils*

The soils of the survey area are used mainly for range. About 3,000 acres along the Santa Cruz River and a small area near Patagonia, on Sonoita Creek, is irrigated for crops. Small areas above an elevation of 7,000 feet have some usable timber. Recreation is increasingly important, and several man-made lakes and campgrounds are within the survey area. Large tracts on private land are being subdivided for homesites.

This section describes the capability classification system used by the Soil Conservation Service and explains the management of the soils by irrigated and nonirrigated capability units. It discusses range for livestock and describes range sites in the survey area. This section also discusses woodland, wildlife, engineering, and recreation and relates the use of the soils to these purposes.

### **Capability Grouping**

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils, the hazard or risk of damage when cultivated, and the way they respond to treatment. The grouping does not take into account major and generally expensive land forming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural crops or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for wildlife habitat, for forest trees, or for engineering.

In the capability system, the kinds of soils are grouped at three levels: the capability class, the subclass, and the unit. These levels are discussed in the following paragraphs.

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

- Class I soils have few limitations that restrict their use.
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both. (None in the survey area.)
- Class V soils are subject to little or no erosion but have other limitations impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife habitat. (None in the survey area.)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes.

**CAPABILITY SUBCLASSES** are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, II<sub>s</sub>. The letter *e* shows that the main limitation is risk of erosion; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used only in some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses because the soils of this class have few limitations. In this survey, soils that would be class I if irrigation water were available are classified VI<sub>c</sub>. On the soils not suitable for crops or where water is not available (classes VI, VII and VIII), the capability class and subclass are considered the capability unit and no further division is made. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture or range, woodland, wildlife habitat, or recreation.

**CAPABILITY UNITS** are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, I-1, or III<sub>s</sub>-3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

### *Management by capability units*

In the following pages the capability units of the survey area are described, and suggestions for the use and management of the soils for irrigation are given. The climatically adapted crops in the survey area referred to in the irrigated capability units of this section include alfalfa, barley, wheat, grain sorghum, and cotton. Adapted irrigated pasture consists of such grasses as tall fescue, orchardgrass, and bermudagrass or of mixtures of these grasses. Specialty crops that can be grown include lettuce, chili peppers, other

vegetables, and pecans. To find the names of the soils in any given unit, refer to the "Guide to Mapping Units."

#### CAPABILITY UNIT I-1, IRRIGATED

This unit consists of well-drained soils that are more than 60 inches deep. The surface layer is loam or clay, and the underlying layers are loam, fine sandy loam, very fine sandy loam, and sandy loam. Permeability is moderately slow or moderate, the water intake rate is slow to moderate, and available water capacity is high.

These soils have few limitations. If adequate irrigation water is available, they are suited to all climatically adapted crops and pasture. They also provide habitat for certain species of wildlife and are suitable for recreation and other uses.

Efficient management of irrigation water and careful maintenance of organic matter and soil tilth are essential.

Leveling to a uniform grade improves irrigation efficiency. In places, flat leveling and basin irrigation are needed to improve water infiltration. Minimum tillage is desirable, especially on soils that have a surface layer of clay loam. All crop residue should be returned to the soil and green-manure crops should occasionally be plowed under. A tillage pan reduces water intake rate. Varying the plowing depth, ripping, tilling at proper moisture content, and growing deep-rooted plants help to prevent the formation of a tillage pan and to break up an existing one.

#### CAPABILITY UNIT II-5-7, IRRIGATED

This unit consists of well-drained soils that are more than 60 inches deep. The surface layer is dominantly sandy loam and loam. The underlying material is sandy loam or gravelly sandy loam. Slopes are 0 to 5 percent. Permeability is moderate to rapid, and available water capacity is moderate to high. Rooting depth is 60 inches or more.

If adequate irrigation is available, these soils are suited to all climatically adapted crops and seeded pasture. They also provide habitat for certain wildlife species and are suitable for recreation and other community uses.

Careful management of irrigation water is essential. Ditches should be lined to reduce seepage. Where needed, the soils should be leveled to a uniform grade. Irrigation runs should be comparatively short on soils that have a rapid intake rate. The interval between irrigations will also be somewhat shorter than for soils that have a moderate or slow intake rate. Over-irrigating should be avoided, because it wastes water through deep percolation and leaches fertilizer below the root zone. The soils that have rapid permeability and those that have slopes of more than 1 percent are well suited to sprinkler irrigation. Using cover crops and returning crop residue to the soil help to prevent soil blowing and to maintain organic-matter content. Green-manure crops, alfalfa, or grass in the rotation help to control erosion.

#### CAPABILITY UNIT III-3, IRRIGATED

This unit consists of well-drained soils that are more

than 60 inches deep. The surface layer is mostly clay. The underlying material is gravelly clay loam. Slopes are 0 to 3 percent. Permeability is slow, and available water capacity is high. Initial water intake is rapid when the soil is dry. These soils crack when they dry. Rooting depth is 60 inches or more.

These soils are suited to most climatically adapted crops and pasture grasses under adequate irrigation. They also provide wildlife habitat.

These soils have a slow water intake rate, and they should have nearly flat irrigation gradients. Cultivation should be minimal and at optimum moisture content to avoid compaction or puddling. Pasture should not be grazed when wet. Crop residue should be returned to the soil to help maintain tilth. The cropping system should include soil-building crops such as grass or green manure for about 50 percent of the time. Occasional deep plowing and ripping or subsoiling may be necessary to break up compacted layers and increase water intake.

#### CAPABILITY UNIT VIc, NONIRRIGATED

This unit consists of well-drained soils that are generally more than 10 inches deep. Slopes are mostly 5 to 35 percent but are as much as 40 percent in places. Permeability is moderate, and available water capacity is very low to high.

Runoff is slow to rapid. The hazard of erosion is slight to high.

These soils are not suitable for cultivation. They are mostly used for livestock grazing, recreation, and wildlife habitat.

#### CAPABILITY UNIT VIa, NONIRRIGATED

This unit consists of well-drained, very shallow to deep soils. Slopes are mostly 0 to 20 percent but are as much as 40 percent in places. Permeability is very slow to moderately rapid, and available water capacity is very low to high.

Runoff is very slow to rapid. The hazard of erosion is slight to moderate.

These soils are not suitable for cultivation. They are mostly used for grazing, recreation, and wildlife habitat.

#### CAPABILITY UNIT VIc, NONIRRIGATED

This unit consists of deep, well-drained soils. Slopes are 0 to 5 percent. Permeability is moderately slow to slow, and available water capacity is high.

Runoff is slow. The hazard of erosion is slight.

If irrigated these soils are suited to cultivated crops. They are mostly used for grazing and wildlife habitat.

#### CAPABILITY UNIT VIIc, NONIRRIGATED

This unit consists of well-drained soils. Slopes range from 10 to 80 percent, but most are 40 to 60 percent. Permeability is slow to moderate, and available water capacity is very low to high.

Runoff is slow to rapid. The hazard of erosion is slight to high.

These soils are not suitable for cultivation. They are suited to range, wildlife habitat, woodland, and recreation.

CAPABILITY UNIT VII<sub>s</sub>, NONIRRIGATED

This unit consists of well-drained soils that are less than 10 inches deep to hardpan or bedrock. Slopes are 0 to 60 percent. Permeability is very slow to moderately rapid, and available water capacity is very low to moderate.

Runoff is medium to rapid. The hazard of erosion is moderate to high.

These soils are not suitable for cultivation. They are used for range, woodland, and recreation.

CAPABILITY UNIT VII<sub>w</sub>, NONIRRIGATED

This unit consists of well-drained to excessively drained soils that are subject to frequent flooding. Slopes are 1 to 5 percent. Permeability is rapid to very rapid.

These soils are not suitable for cultivation. They are used for range.

CAPABILITY UNIT VIII<sub>s</sub>, NONIRRIGATED

This unit consists of Rock outcrop, Mine pits and dumps, and small areas of soils that are very shallow and shallow over bedrock. Slopes are 15 percent to more than 60 percent.

Runoff is very rapid to rapid. The hazard of erosion is moderately high to high.

These soils are not suitable for cultivation. They are used for wildlife habitat, water supply, and recreation.

### Irrigation<sup>3</sup>

About 3,000 acres of bottom land along the Santa Cruz River and Sonoita Creek is cultivated in the survey area. Irrigation water is supplied by deep-well turbine pumps. Border, furrow, and some sprinkler irrigation systems are used. Conservation practices that apply to all irrigated soils are briefly discussed in the following paragraphs. More detailed information on cultural practices can be obtained from the Soil Conservation Service and the University of Arizona Cooperative Extension Service. In addition, the soil survey of the adjacent Tucson-Avra Valley Area gives more information on the use and management of similar irrigated soils.

A high level of management provides the following practices, which are more or less interdependent:

1. A properly designed irrigation system.
2. Application of irrigation water according to the kind of soil and the needs of the crop.
3. Conservation cropping systems.
4. Crop residue management.
5. Minimum tillage.
6. Fertilization according to the needs of the crop.
7. Weed, insect, and disease control.
8. Proper management of irrigated pasture.

A properly designed irrigation system is the key factor upon which all other practices depend for profitable crop production. In many cases, this entails level-

ing the land to remove side slope and reducing grades to nearly flat or flat to obtain the proper water penetration. The length of run and the slope gradient used in a particular field should be adapted to the intake rate and available water capacity of the soil. To reduce seepage loss and maintenance costs, the water distribution system should consist of concrete-lined ditches or pipelines. Pipelines have the added advantages of reducing evaporation and of not interfering with farming equipment.

Water application should be timed to prevent crop stress. Roughly, water should be applied when not more than 50 percent of the available moisture is depleted. If a deep preplanting application has been made to fill the lower root zone, only enough water to replenish that used by crops need be applied during the irrigation season. The amount of water needed and the frequency of application depend upon the kind of crop and the kind of soil. The rate of application should be such that runoff and erosion are held to a practical minimum.

Conservation cropping systems are those that maintain or improve the fertility and tilth of the soil and produce profitable yields. Such systems rotate crops that have different rooting habits, nutrient requirements, and residue characteristics. Ordinarily, alfalfa or other deep-rooted legumes are in the rotation. Green-manure crops are in some rotations periodically.

Crop-residue management consists of plowing or disking all crop residue to increase infiltration, maintain organic-matter content, reduce soil loss, and improve soil tilth. Where straw or stalks have been removed in harvesting, periodically using green-manure crops, growing grasses in the rotation, or adding barnyard manure is necessary.

Minimum tillage uses only cultural operations that are essential to produce the crop. Excessive travel of machinery over a soil causes compaction in places and forms tillage pans. Travel over the field by machinery should be done only when the soil is neither too wet nor too dry.

Fertilization is required on all irrigated crops to produce profitable yields. All crops respond to nitrogen fertilizer. Applications of phosphate and, occasionally, of small amounts of trace elements are required for high level production of most crops. Amounts and kinds of fertilizer are largely determined by the kind of crop and the economic situation. Experiments on kinds, amounts, and times of application of fertilizer, together with insect and disease control, and crop varietal trials are conducted by the University Experiment Stations, Agricultural Cooperative Extension Service, and various commercial concerns. The information on their findings is readily available.

Insect and disease control is accomplished in a number of ways. These are by use of cultural practices, predators, systemic insecticides applied at time of planting, and other insecticides or fungicides applied by ground rig or aircraft. Insect control technology is in a state of rapid change, both from the standpoint of insect resistance buildup and new technology of insect control. Of prime concern is the avoidance of the use of any material that is detrimental to the en-

<sup>3</sup> ARNOLD NOWOTNY, conservation agronomist, Soil Conservation Service, helped to prepare this section.

vironment or that is of long-lasting toxicity in the food chain for animals or humans.

Irrigated pasture is one of the major uses of the irrigable land in the survey area. Good management consists of establishing suitable irrigation gradients and distribution systems, fencing for rotation grazing, using a high level of fertilizer, and selecting proper stocking rates for optimum utilization. Various grass-legume mixtures can be used for the desired season of use. Care should be taken to avoid grazing when the soils are wet.

### Estimated Yields

Yields are estimated in table 2 for the principal crops grown on irrigated soils. The estimates assume a high level of management. They are based on data collected by the Soil Conservation Service and the Cooperative Extension Service of the University of Arizona. Yields are given for tall fescue pasture, but other adapted pasture grasses should produce comparable amounts. It should be noted that the yields are averages. Also, in a low intensity survey such as this one, several kinds of included soils are within some mapped areas. These included soils might affect yields upward or downward.

A column giving suitability for pecan production is also given because pecans are grown in the adjacent Santa Cruz Valley in Pima County.

TABLE 2.—*Estimated average yields per acre of the principal crops on irrigated soils under improved management and suitability of the soils for pecans*

| Soil   | Alfalfa                  | Barley      | Grain Sorghum | Tall fescue pasture     | Suitability for pecans |
|--|--------------------------|-------------|---------------|-------------------------|------------------------|
|  | <i>Tons</i> <sup>1</sup> | <i>Tons</i> | <i>Tons</i>   | <i>AUM</i> <sup>2</sup> |                        |
| Comoro soils, 0 to 5 percent slopes.         | 5.8                      | 1.3         | 2.3           | 14                      | Good.                  |
| Grabe soils                                  | 7.0                      | 2.0         | 3.0           | 20                      | Good.                  |
| Grabe-Comoro complex, 0 to 5 percent slopes. | 6.0                      | 1.4         | 2.5           | 16                      | Good.                  |
| Guest soils                                  | 5.5                      | 1.5         | 2.5           | 16                      | Poor.                  |
| Pima soils                                   | 6.5                      | 1.5         | 2.7           | 18                      | Good.                  |

<sup>1</sup> Alfalfa yields are tons per acre on an air-dry basis.

<sup>2</sup> AUM stands for animal-unit-month. It is a term used to express the carrying capacity or grazing value of a pasture. It is the number of months 1 acre will support one animal unit, such as one cow, one steer, one horse, five hogs, or seven sheep or goats, without injury to the pasture; or it is the product of the number of animal units to the acre multiplied by the number of months of grazing.

### Range<sup>4</sup>

More than 90 percent of the survey area is rangeland. Cattle are the main livestock. Horses associated with normal ranching enterprises and various kinds of wildlife also use the range.

Range within the survey area has been used for grazing by domestic livestock for a long time. Cattle were introduced from Mexico in 1539 and several

<sup>4</sup> By ALBERT P. THATCHER, range conservationist, Soil Conservation Service.

times thereafter by Spanish explorers. By 1691 Father Kino established the first settlement in what is now known as Santa Cruz County. He brought cattle with him and developed an economy based on livestock husbandry.

Since the introduction of livestock, much of the land that was once excellent grassland has become infested with brush, trees, cacti, and low-value forbs and grasses.

### Range sites and condition classes

Soils that have the capacity to produce the same kinds, amounts, and proportions of range plants are grouped into range sites. A range site is the product of all environmental factors responsible for its development.

A plant community existing within a range site that has not undergone abnormal disturbance is the potential, or climax, plant community for that site. Climax plant communities are not precise or fixed in their composition; they vary, within reasonable limits, from year to year and from place to place.

Abnormal disturbance, such as overuse by livestock, excessive burning, erosion, or plowing, results in changes in the climax plant community or even complete destruction if disturbance is drastic enough. When the range site has not deteriorated significantly under such disturbances, secondary plant succession progresses in the direction of the natural potential or climax plant community for the site.

Four range condition classes are used to indicate the degree of departure from the potential, or climax vegetation. The classes show the present condition of the native vegetation on a range site in relation to the native vegetation that could grow there.

A range is in excellent condition if 76 to 100 percent of the vegetation is one of the same kind as that in the climax stand. It is in good condition if the percentage is 51 to 75; in fair condition if the percentage is 26 to 50; and in poor condition if the percentage is less than 25.

When changes are caused in the climax plant community by livestock, or disturbance, some plant species will increase, others will decrease. Which species increase or decrease depends upon the grazing animal, season of use, and the degree of utilization. By comparing the composition of the present plant community to the potential plant community, it is possible to see how individual species have increased while others decreased. Plants not present in the climax community which show up in the present plant community are invaders.

The composition of climax and present plant communities, together with other range site information, provides the basis for selecting range management systems.

Management programs on range generally try to increase desirable plants and restore range to as near climax conditions as possible. Some programs are designed to create or maintain plant communities somewhat removed from the climax to fit specific needs in the grazing program, to provide wildlife habitat, or for other benefits. Any management objective should be compatible with conservation objectives.

### Descriptions of range sites

In the following pages, the 19 range sites that are in the survey area are briefly described and the climax plants and principal invaders on the sites are named. Also given is an estimate of the potential annual yield expressed in terms of excellent condition, unless otherwise identified, for favorable and unfavorable seasons. These yields are given as the normal high and low rather than the extremes. Yield is the total annual weight of air-dry herbage per acre, which includes the current year's growth of leaves, stems, twigs, and fruit of all plants on the site. Not all of this herbage is usable by livestock. The range site each soil is in can be determined by referring to the "Guide to Mapping Units" at the back of this soil survey.

Some mapping units, such as Graham soils, 5 to 20 percent slopes, are in two range sites because of their wide spread in precipitation, 12 to 18 inches. Where these soils receive 12 to 16 inches of rain, they are placed in Clay Loam Hills range site, 12- to 16-inch precipitation zone; where they receive 16 to 18 inches of rain, they are placed in Clay Loam Hills (oak) range site, 16- to 20-inch precipitation zone.

#### CLAY BOTTOM RANGE SITE, 12- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are well-drained clays that are more than 60 inches deep. They are on flood plains and in swales that generally receive runoff from surrounding areas (fig. 12). Slopes are 0 to 3 percent. Permeability is slow, and available water capacity is high.

When this site is in excellent condition, the vegetation is 75 to 90 percent side-oats grama, vine-mesquite, and tobosa. Other plants that are present to a lesser extent are cane beardgrass, blue grama, curly mesquite, sacaton, three-awns, and annual grasses and

forbs. When this site is in poor condition, forbs, annual grasses, and three-awns predominate. Causes of range deterioration on this site are accessibility to livestock, green forage plants for a longer period than on adjoining sites, and soil compaction by livestock when the soils are wet.

Water spreading, erosion control, range seeding where needed, and exclusion of livestock when the soils are wet help to maintain and improve this site.

Total herbage production ranges from 2,000 pounds or more per acre in favorable years to 700 pounds per acre in unfavorable years, depending on the amount of precipitation and runoff.

#### CLAY LOAM HILLS RANGE SITE, 12- TO 16-INCH PRECIPITATION ZONE

The soils in this range site are shallow to moderately deep over basic igneous or shale bedrock. They are characterized by a surface layer of cobbly or very shaly clay loam and a thin substratum of weathered shale. Rock outcrop makes up to 10 to 20 percent of the area. Slopes are 5 to 50 percent. Permeability is moderately slow, and available water capacity is low or very low.

Approximately 60 to 70 percent of the climax plant community consists of side-oats grama, Arizona cottontop, cane beardgrass, plains lovegrass, and green sprangletop. Other plants are hairy grama, sprucetop grama, curly mesquite, three-awns, tanglehead, tobosa, mimosa, agave, and false mesquite. Invaders are mesquite, ocotillo, catclaw, and annuals.

Use of this range site is reduced by steep slopes, cobbles and rock. Range cultural practices are restricted mainly to limited brush management, stock trails, and water developments.

Total herbage production ranges from 1,200 pounds per acre in favorable years to 600 pounds in unfavorable years.



Figure 12.—Clay Bottom range site, 12- to 20-inch precipitation zone, in poor condition. Guest soils are in the foreground, and Luzena gravelly loam, deep variant, 5 to 20 percent slopes, is in the background.

## CLAY LOAM HILLS RANGE SITE, 16- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are well drained and are 8 to 50 inches deep. They have a surface layer of thin gravelly or cobbly loam or clay loam and a subsoil of clay over basic igneous or clay shale bedrock. Rock outcrop makes up 5 to 20 percent of the area. Slopes are 5 percent to about 50 percent. Permeability is moderately slow or slow, and available water capacity is low to moderate.

Approximately 75 percent of the climax plant community is grasses. The species represented are side-oats grama, cane beardgrass, plains lovegrass, woolly bunchgrass, crinkleawn, and green sprangletop. Approximately 20 percent of the community is hairy grama, slender grama, wolftail, curly mesquite, three-awns, tobosa, false mesquite, and ratany, and 5 to 10 percent is oak and other trees and shrubs. Invaders are catclaw, ocotillo, cacti, manzanita, burroweed, annuals, and low forbs.

The steeper, rockier areas usually receive only light grazing. Heavy grazing on the more gently sloping soils causes erosion and rapid deterioration of the plant community. Brush management, development of stock water, construction of trails, and fencing to distribute grazing are feasible on this site.

Total herbage production ranges from about 1,500 pounds per acre during favorable years to about 600 pounds in unfavorable years.

## CLAY LOAM UPLAND RANGE SITE, 12- TO 16-INCH PRECIPITATION ZONE

The soils in this range site are deep and well drained. They have a surface layer mostly of gravelly clay loam or gravelly loam and a subsoil of gravelly clay loam, gravelly clay, or clay. Typically, the soils contain less than 50 percent gravel and cobbles. Slopes range from 1 percent to about 30 percent. Permeability is slow or moderately slow, and available water capacity is moderate. Where these soils have good grass cover, the water intake rate is good. If the range cover is depleted, the soil surface tends to crust and seal, reducing the water intake rate and increasing runoff.

Approximately 80 percent of the climax vegetation consists of side-oats grama, cane beardgrass, Arizona cottontop, vine-mesquite, black grama, and plains lovegrass. Other species are blue grama and hairy grama, wolftail, curly mesquite, three-awns, sprucetop grama, slender grama, false mesquite, and ratany. In some areas tobosa is present. As the site deteriorates blue grama, hairy grama, sprucetop grama, three-awns, and annuals become dominant. As deterioration continues, burroweed, groundsel, and annual forbs invade this site.

Range seeding, brush management, water development, and various types of mechanical treatment are feasible for improving this site.

Total herbage production ranges from about 1,800 pounds per acre in favorable years to 500 pounds per acre in unfavorable years.

## CLAY LOAM UPLAND RANGE SITE, 16- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are deep and well drained. They have a surface layer of gravelly clay loam and a subsoil of gravelly clay loam and clay that contains

less than 50 percent rock fragments. Slopes are 2 to 30 percent. Permeability is slow, and available water capacity is moderate. The soils have a good water intake rate where there is good grass cover. Where the cover is deteriorated, they form crusts, water intake is reduced, and runoff is increased.

When this site is in excellent condition, about 50 percent of the vegetation is side-oats grama, plains lovegrass, and vine-mesquite. Other species include blue grama, hairy grama, slender grama, sprucetop grama, tanglehead, curly mesquite, false mesquite, and mimosa. As the range deteriorates, the short-growing species of grammas and curly mesquite tend to dominate the site.

Range reseeding, brush management, water development, and range mechanical treatment are feasible where needed.

Total herbage production ranges from about 2,000 pounds per acre in favorable years to 600 pounds per acre in unfavorable years.

## CLAY UPLAND RANGE SITE, 16- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are deep and well drained. They have a surface layer and subsoil of clay. Slopes are 0 to 5 percent. Permeability is very slow when the soils are wet, but when they are dry they form wide and deep cracks. The initial water intake rate is rapid, and runoff is slow or very slow. Available water capacity is high.

The climax plant community is about 50 percent side-oats grama, plains lovegrass, vine-mesquite, and cane beardgrass. Other species are tobosa, curly mesquite, blue grama, hairy grama, sprucetop grama, and annual grasses. When the site is in poor condition, tobosa, curly mesquite, sprucetop grama, and three-awns predominate.

This site is a good producer of vegetation because it uses nearly all of the precipitation. However, the vegetation responds slowly to management, so care must be taken to prevent deterioration. Where seeding is needed and feasible, and where care is taken to prepare the seedbed, such practices as pitting are used to collect moisture, improve water intake, and speed up site recovery.

Total herbage production when this site is in good to excellent condition ranges from about 1,500 pounds per acre in favorable years to as little as 400 pounds per acre in unfavorable years.

## SANDY LOAM RANGE SITE, 12- TO 16-INCH PRECIPITATION ZONE

The soils in this range site are deep and well drained (fig. 13). They have a surface layer of gravelly loam or gravelly sandy loam and a subsoil of very gravelly sandy clay loam that grades to a substratum of very gravelly sandy loam. Slopes are 0 to 60 percent. Permeability is moderately slow, and available water capacity is low. The water intake rate is good, runoff is medium to rapid, and the hazard of erosion is slight to high.

Approximately 60 to 70 percent of the climax plant community consists of side-oats grama, green sprangletop, plains bristlegrass, black grama, cane beardgrass, bush muhly, and Arizona cottontop. About 30 to 40 percent is three-awns, rothrock grama, hairy grama,



Figure 13.—Sandy Loam range site, 12- to 16-inch precipitation zone, in excellent condition. Soil is Caralampi gravelly sandy loam, 10 to 40 percent slopes.

sprucetop grama, dropseeds, cacti, yucca, false mesquite, annuals, and forbs. As the condition deteriorates, mesquite, catclaw, burroweed, and snakeweed invade.

Where needed, brush management and reseeding (where slopes permit), water development, livestock trails, and fencing to control grazing are feasible. Livestock will graze the steep gravelly or cobbly slopes only when forced to.

Total herbage production ranges from 1,500 pounds per acre in favorable years to 500 pounds per acre in unfavorable years.

In places precipitation on this site is slightly higher than 12 to 16 inches, and the vegetation is oak and juniper. However, the differences are not enough to establish another site.

#### LIMESTONE HILLS RANGE SITE, 12- TO 16-INCH PRECIPITATION ZONE

The soils in this range site are shallow and very shallow over limestone bedrock. They have a surface layer mostly of very cobbly or very gravelly loam. Rock outcrop makes up 25 to 50 percent of the acreage in this site. Slopes range from about 30 to 45 percent. Permeability is moderate, and available water capacity is very low. Soils in this site are generally in association with soils in the Loam Hills range site, 12- to 16-inch precipitation zone. The association is on low limestone, granitic, and rhyolitic mountains and at the lower elevations.

Approximately 50 percent of the climax community is side-oats grama, black grama, cane beardgrass, wolftail, Hall's panicum, and plains lovegrass. Other plants are hairy grama, sprucetop grama, woolly bunchgrass, slim tridens, three-awns, false mesquite, ratany, cliffrose, agave, sotol, catclaw, and cacti. When the site is in poor condition, annuals, three-awns, whitethorn, and cacti predominate.

Brush management, water development, and trail development are feasible on this site.

Total herbage production ranges from 1,600 pounds per acre in favorable years to 300 pounds per acre in unfavorable years.

#### LIMESTONE HILLS RANGE SITE, 16- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are shallow and very shallow and are mostly very cobbly or very gravelly loam over limestone bedrock. Rock outcrop makes up 15 to 40 percent of the acreage of this site. Slopes range from 5 to 60 percent (fig. 14). Permeability is moderate, and available water capacity is very low.

The climax plant community is a mixture of live-oak, grasses, and shrubs. It is less than 10 percent widely spaced oaks, and 60 percent side-oats grama, black grama, cane beardgrass, crinkleawn, Hall's panicum, woolly bunchgrass, plains lovegrass, and cliffrose. Other plants present are hairy grama, sprucetop grama, slim tridens, tanglehead, three-awns, false mesquite, sotol, agave, and beargrass. As the site deteriorates, annuals, cacti, and snakeweed invade.

Brush management and water development are feasible on this kind of range. Building trails in the steeper areas is beneficial in places.

Total herbage production ranges from about 1,800 pounds per acre in favorable years to about 600 pounds per acre in unfavorable years.

#### LIMY SLOPES RANGE SITE, 12- TO 16-INCH PRECIPITATION ZONE

The soils in this range site are well drained and very shallow or shallow over a hardpan, or they are deep. The surface layer is mostly gravelly loam or gravelly sandy loam. The deep soils have an underlying layer of gravelly loam, loam, very gravelly sandy loam, gravelly sandy loam, or sandy loam. The soils are strongly calcareous. Slopes range from 0 to 45 percent. The water intake rate is good, and permeability is moderate to moderately rapid. Available water capacity is moderate or low in the deep soils and very low in the shallow and very shallow soils.

When this site is in excellent condition, the vegetation is 50 to 70 percent side-oats grama and black



Figure 14.—An area of Tortugas very cobbly loam on a 40 percent slope in Limestone Hills range site, 16- to 20-inch precipitation zone. This range site provides one of the better habitats for white-tailed deer.

grama. Other plants are hairy grama, three-awns, tridens, dropseeds, curly mesquite, cliffrose, beargrass, and yucca. When this site is in poor condition, whitethorn, mesquite, catclaw, fluffgrass, burroweed, three-awns, cacti, and annual weeds and grasses invade.

Range seeding, brush management, and water development are feasible. In the smoother and less sloping areas, mechanical practices such as furrowing and pitting are used in places.

Total herbage production ranges from about 900 pounds per acre in favorable years to about 450 pounds per acre in unfavorable years.

#### LIMY SLOPES RANGE SITE, 16- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are deep, well drained, and strongly calcareous. They have a surface layer of gravelly sandy loam and an underlying layer of very gravelly or gravelly sandy loam or sandy loam (fig. 15). Slopes range from 10 to about 50 percent. Permeability is moderate, and available water capacity is low to moderate. The water intake rate is good, runoff is medium, and the hazard of erosion is moderate.

When this site is in excellent condition, the vegetation is 65 to 75 percent side-oats grama, black grama, cane beardgrass, and plains lovegrass. Other plants are three-awns, hairy grama, slender grama, tridens, cliffrose, sotol, beargrass, yucca, and cactus. As the site deteriorates, three-awns, tridens, cacti, and whitethorn increase and mesquite, creosotebush, burroweed, and groundsel invade.

Where needed, brush management, range reseeding, water development, and some mechanical treatments, such as furrowing and pitting, on lesser slopes are feasible.

Total herbage production ranges from as much as 1,200 pounds per acre in favorable years to 750 pounds per acre in unfavorable years.

#### LIMY UPLAND RANGE SITE, 12- TO 16-INCH PRECIPITATION ZONE

The soils in this range site are well drained and strongly calcareous. They have a surface layer of gravelly sandy loam. The underlying layer is indurated and lime cemented in some soils, and in others it is gravelly



Figure 15.—Limy Slopes range site, 16- to 20-inch precipitation zone, in excellent condition in an area of Hathaway gravelly loam on a gently sloping piedmont fan.

loam to loam to a depth of about 60 inches or more. Slopes range from 0 to 40 percent. Permeability is moderate, and available water capacity is low to moderate. Effective rooting depth is 4 to 60 inches.

When this site is in excellent condition, the vegetation is dominantly bush muhly, black grama, whitethorn, creosotebush, and catclaw. Other plants are plains bristlegrass, side-oats grama, slim tridens, Arizona cottontop, cacti, desert zinnia and three-awns. When this site is in poor condition, whitethorn, mesquite, catclaw, fluffgrass, burroweed, and annual weeds and grasses invade.

Limited brush management, range seeding, water development, and some mechanical treatments, such as furrowing and pitting, on lesser slopes are feasible.

Total herbage production ranges from about 900 pounds per acre in favorable years to about 400 pounds per acre in unfavorable years.

#### LOAM BOTTOM RANGE SITE, 12- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are well drained and are more than 60 inches deep. They have a surface layer of mostly loam or clay loam and an underlying layer of stratified sandy loam, loam, and clay loam. The surface layer and underlying layer generally contain gravel and cobbles. These soils are on flood plains and in drainageways that often receive runoff from surrounding uplands (fig. 16). Slopes are 0 to 10 percent. Permeability is moderately rapid to moderately slow, and available water capacity is moderate to high. Runoff is medium to slow, and the hazard of erosion is slight. Some areas are subject to overflow.

When this site is in excellent condition, the vegetation is about 80 percent sacaton and lesser amounts of vine-mesquite and side-oats grama. The main growth of these plants is during July, August, and September. Other plants are blue grama, hairy grama, three-awns, and annuals. When the site is in poor condition, mesquite, burroweed, groundsel, weeds, and annual grasses invade. Scattered trees such as sycamore, cottonwood, walnut, oak, desert willow, and hackberry are along some drainageways.

Many areas of this range site have easy livestock access, gentle topography, good water sources, and longer periods of green growth. This results in heavy use and severe range deterioration. Many of the drainageways are entrenched. Brush management, range seeding, water spreading, erosion control, and fencing to control livestock grazing are necessary in places.

Total herbage production ranges from 5,000 pounds per acre in favorable years to 1,200 pounds per acre in unfavorable years depending on the amount of precipitation and runoff.

#### LOAMY HILLS RANGE SITE, 12- TO 16-INCH PRECIPITATION ZONE

The soils in this range site are well-drained, very gravelly or very cobbly sandy loams or loams that are very shallow or shallow. They formed on lower mountains and foothills in material from acid igneous rock. Rock outcrop makes up about 10 to 50 percent of the site. Slopes range from 0 to 60 percent. Permeability



**Figure 16.**—Nearly level Pima loam in Loam Bottom range site, 12- to 20-inch precipitation zone. This soil receives runoff from the surrounding uplands.

very low to low. Runoff is medium or rapid, and the hazard of erosion is moderate or high.

When this site is in excellent condition, the vegetation is dominantly grasses and scattered shrubs. It is about 75 percent side-oats grama, plains lovegrass, and Arizona cottontop. Other species are blue grama, hairy grama, wolftail, curly mesquite, three-awns, cacti, agave, desert hackberry, paloverde, false mesquite, range ratany, and mimosa. When this site is in poor condition catclaw, mesquite, burroweed, and annuals invade.

Use of this range site is reduced by steep slopes and a cobbly surface. Where slopes and rockiness permit, fencing to control livestock distribution, water and trail development, brush management, and range seeding are feasible for improving this site.

Total herbage production ranges from about 1,200 pounds per acre in favorable years to 500 pounds or less per acre in unfavorable years.

#### LOAMY HILLS RANGE SITE, 16- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are very shallow to moderately deep and well drained. They are on the higher mountain ranges. The surface layer is very gravelly or very cobbly sandy loam, fine sandy loam, or loam. The underlying layer is mostly thin and is similar to the surface layer in texture or is cobbly or gravelly clay loam or clay. Rock outcrop generally makes up 10 to 50 percent of the site. Slopes range from 0 to more than 60 percent (fig. 17). Permeability is moderate to slow, and available water capacity is

very low to low. Runoff is medium or rapid, and the hazard of erosion is moderate or high.

The climax plant community consists of widely spaced live-oak and juniper trees, a few shrub species, and grasses. When the site is in excellent condition, it is about 70 to 80 percent woody species and side-



**Figure 17.**—Area of Loamy Hills range site, 16- to 20-inch precipitation zone, in excellent condition. The soil is a Lampshire cobbly loam that has slopes of 45 percent.

oats grama, Texas bluestem, cane beardgrass, crinkleawn, woolly bunchgrass, and plains lovegrass. When the site is in poor condition, slender grama, sprucetop grama, purple grama, hairy grama, blue grama, three-awns, tanglehead, curly mesquite, wolftail, manzanita, and false mesquite increase. Catclaw, burroweed, mesquite, annuals, and low palatable forbs invade.

Strategic location of livestock water, development of stock trails, fencing to control grazing distribution, brush management and range seeding are feasible for improving this site.

Total herbage production ranges from 1,500 pounds per acre in favorable years to about 600 pounds per acre in unfavorable years.

#### LOAMY UPLAND RANGE SITE, 12- TO 16-INCH PRECIPITATION ZONE

The soils in this range site are well drained and are more than 60 inches deep. They are on old piedmont plains, fans, and terraces. The soils have a surface layer of gravelly or very gravelly sandy loam or loam and an underlying layer of gravelly or very gravelly sandy clay loam to gravelly clay. Slopes range from 0 to 45 percent. Permeability is moderately slow or slow, and available water capacity is low to high. Runoff is slow to high, and the hazard of erosion is slight to high.

Approximately 60 to 70 percent of the climax plant community consists of black grama, Arizona cottontop, bush muhly, side-oats grama, cane beardgrass, and plains bristlegrass. Other species are three-awns, rothrock grama, blue grama, hairy grama, sprucetop grama, sand dropseed, and spike dropseed. When the site is in poor condition, these plants increase, and burroweed, mesquite, groundsel, and annual grasses and weeds invade.

Repeated close grazing during July, August, and September causes the range to deteriorate. Fencing to provide rotation and deferred grazing, stock-water development, brush management, range seeding, and mechanical treatment are feasible for improving this site.

Total herbage production ranges from about 1,200 pounds per acre in favorable years to 500 pounds per acre in unfavorable years.

#### LOAMY UPLAND RANGE SITE, 16- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are deep and well drained. They have a surface layer mostly of gravel, gravelly clay loam, or gravelly sandy loam. They are on deeply dissected old fans, piedmonts, or terraces. Slope ranges from 0 to 60 percent but are commonly less than 35 percent. Permeability is moderately slow to very slow, and available water capacity is low to high. Runoff is slow to rapid, and the hazard of erosion is slight to severe.

Approximately 50 to 60 percent of the climax plant community is side-oats grama, cane beardgrass, Texas beardgrass, plains lovegrass, black grama, Arizona cottontop, green sprangletop, and woolly bunchgrass. Other species are blue grama, hairy grama, slender grama, purple grama, sprucetop grama, three-awns, wolftail, curly mesquite, false mesquite, and mimosa. When the site is in poor condition mesquite, buttonweed, and groundsel invade.

Continued close grazing during the late summer months causes the more palatable species to decrease and the sod-forming grasses and less palatable and woody species to increase. Fencing to control grazing, brush management, range seeding and grazing and mechanical treatment are feasible for improving the site.

Total herbage production ranges from 1,500 pounds per acre in favorable years to about 600 pounds per acre in unfavorable years. The amount of rain received in late summer largely determines the herbage production.

#### LOAMY UPLAND (OAK) RANGE SITE, 16- TO 20-INCH PRECIPITATION ZONE

The soils in this range site are deep and are well drained to somewhat poorly drained. They are on remnants of dissected old alluvial fans, piedmonts, or terraces. They have a surface layer mostly of gravelly, very gravelly, or cobbly sandy loam or loam and a subsoil and substratum of clay, gravelly or very gravelly clay, or very gravelly sandy clay loam. Slopes are 0 to 60 percent. Permeability is slow to very slow, and available water capacity is low to high. Runoff is slow to rapid, and the hazard of erosion is slight to high.

When this site is in excellent condition, the vegetation is scattered live-oak and juniper trees with an understory of about 75 percent cane beardgrass, plains lovegrass, and side-oats grama (fig. 18). Other species are Texas beardgrass, hairy grama, slender grama, three-awns, tanglehead, curly mesquite, false mesquite, deergrass or bullgrass, and manzanita. The oak trees remain fairly stable, regardless of the grazing history. When the site is in poor condition, it is dominated by oak and juniper, manzanita, Texas beardgrass, hairy grama, three-awns, and invaders such as mesquite, annuals, and unpalatable forbs.

Where needed, brush management, range seeding, water development, and fencing for proper grazing use and pasture rotation are feasible.

Total herbage production when the site is in good



Figure 18.—Loamy Upland (Oak) range site, 16- to 20-inch precipitation zone, in excellent condition. Side-oats grama is the dominant grass in this area of Casto very gravelly sandy loam that has a slope of 40 percent.

or excellent condition ranges from about 1,500 pounds per acre in favorable years to 600 pounds per acre in unfavorable years.

### Range productivity groups <sup>5</sup>

The soils in the Coronado National Forest have been placed in five range productivity groups according to their estimated production of range herbage. The estimated productivity of the groups in pounds of usable native herbage per acre when the range is in good condition and in poor condition is as follows:

Group 1: 1,500 pounds or more per acre in good condition and 700 pounds in poor condition.

Group 2: 1,100 to 1,500 pounds per acre in good condition and 500 to 600 pounds in poor condition.

Group 3: 750 to 1,100 pounds per acre in good condition and 400 pounds in poor condition.

Group 4: 250 to 750 pounds per acre in good condition and 200 pounds in poor condition.

Group 5: 250 pounds or less in good condition and 100 pounds or less in poor condition.

These estimates are based on forage clippings made on range in the National Forest area and on yield data from similar soils in other areas. The ratings apply only to the soils within the National Forest. The productivity values are based on the assumption that rainfall is normal.

The soils in groups 1, 2, and 3 make up 36 percent of the National Forest lands in the survey area. They are moderate to high in productivity. Forage production could be improved by more intensive management. The soils in groups 1 and 2 respond especially well to revegetation, control of nonforage plants, and water spreading.

The soils in group 4 are very shallow to moderately deep and are very cobbly or rocky. They are on mountains and foothills. Slopes range from 0 to 80 percent. Revegetation and control of nonforage plants would be costly and difficult, and would produce only small returns.

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 livestock movement.

Table 3 lists the mapping units in each range productivity group and gives their estimated revegetation potential. The Guide to Mapping Units at the back of this survey shows the range productivity group to which each soil in the survey area has been assigned.

### Woodland <sup>6</sup>

This section provides information about the suitability of the soils for the production of timber and other wood products. In the survey area the soils that

<sup>5</sup> By S. D. CLEMMONS and A. A. LEVEN, soil scientists, Forest Service.

<sup>6</sup> By S. D. CLEMMONS and A. A. LEVEN, soil scientists, Forest Service.

TABLE 3.—Range productivity groups of soils on national forest lands

| Range productivity groups and mapping units  | Range revegetation potential |
|--|------------------------------|
| 1: Ge, Mg, Pm, WgC -----   | High.                        |
| 2: BhD, CtB, CuC, GbB, SoB, WnC -----<br>An, BoB, CsC, Gu, WgE, WhC, WoE -----   | High.<br>Moderate.           |
| 3: Ao, CbD, CgE, CmE, CvE2, FaD, Kbc, LuD, SoD, Th, CdE, CeD, CgF2, ClB, EbC, HaF, HhE2, PoC, ScD, SnD, WtF.                       | Moderate.<br>Low.            |
| 4: AtF, BaE, BgF, Ca, Cn, CoE, CrD, FcF, FrE, FrF, FtF, GaE, GhD, GhF, HoF, HtF, LaE, LaF, LcF, LgF, McF, Pn, RIE2, ShF, TrE, TrF. | Low.                         |
| 5: Mn, Rn, Rr -----  | ( <sup>1</sup> )             |

<sup>1</sup> Not applicable.

support timber and woodland are mainly those at higher elevations, where the environment is favorable for trees. Only the soils in forested and wooded areas are discussed in this section.

About 13,000 acres, or 1.2 percent of the survey area, has timber. Most areas of woodland are in uncut virgin trees. Limited areas of trees have been commercially harvested in the Santa Rita Mountains.

Ponderosa pine, Douglas-fir, Chihuahua pine, Apache pine, and timber pine are the timber species in the survey area. They are mostly on National Forest lands. Ponderosa pine makes up most of the timber. At present the remoteness of the stands and the severity of landscapes prevent active economic harvesting, so these timbered areas are mainly used for recreation, water supply, and wildlife habitat.

Ponderosa pine grows best at elevations of 7,000 to 9,500 feet. Aspect has a strong influence on the growth of fir. Douglas-fir is interspersed within the ponderosa pine forest on north-facing slopes at higher elevations. There are a few pure stands of Douglas-fir.

At elevations of 5,000 to 7,000 feet, the tree cover is mostly pinyon pine, juniper, and oak. These species are also common on south-facing slopes at elevations as high as 8,000 feet. About 208,290 acres, or 19 percent of the area, is in such woodland.

Although not usually considered as commercial timber, pinyon pine has commercial value as fenceposts and as mine props and stulls. It produces edible nuts and makes good Christmas trees. Pinyon pine and juniper can be used for pulpwood. Pinyon pine, juniper, and oak also have value as fuel.

### Woodland suitability groups

Timber production for the soils was appraised by using site index data gathered during the survey and by ocular estimates. The productivity rating for ponderosa pine is based on site index values as determined from curves developed by Meyer (7). Table 4 groups the forested soils in the order of their estimated relative suitability for timber. Ratings are given for two groups of soils; in group 1 are soils that are the most productive for ponderosa pine, and in group 2 are

those that are the least productive. Site index, which is used to express productivity, is the average height, in feet, that a specified kind of tree growing on a specified soil will reach in 100 years. In Arizona the site indexes are mainly for ponderosa pine. Table 4 also gives ratings for available water capacity, woody species competition, natural regeneration windthrow hazard, equipment limitations, and erosion hazard.

Available water capacity refers to the amount of water stored in the soil that is available for plant growth. In addition to stored water, woody plants use water collected in bedrock fractures.

Plant competition occurs when a site has been disturbed by fire, cutting, or other factors. Brush, trees, and other plants generally invade the site. Such competition hinders the establishment and growth of desirable tree species. It is most serious on soils of higher fertility and on soils which favor competing plants. A competition rating of *slight* indicates that invasion by undesirable species will have little effect on growth of desirable timber species. A rating of *moderate* indicates that competition will not seriously affect establishment of adequate stands of commercial timber species. A rating of *severe* indicates that competition is strong and interferes with natural regeneration. If seedlings are planted, the competing species must be controlled. Gambel oak and various shrubs are the chief species that compete with ponderosa pine.

Natural regeneration is good to fair on timber-

producing soils in the survey area. Soils that have a surface layer of sandy loam and loam provide the best sites for regeneration. The extremely stony and rocky areas do not regenerate well. Natural regeneration is also low on the steep south- and west-facing slopes, where drying effects of wind and sun are strong.

Because most of the soils have steep slopes and contain considerable amounts of stones and rock outcrop, the use of mechanized tree planters is limited. In such areas, hand planting is required. Most successful regeneration by planting occurs within existing stands, where there is some protection from wind and sun. Also, soil moisture conditions are more favorable on the north-facing slopes than on the south-facing slopes. Shallow and very shallow soil areas should be avoided.

Windthrow hazard indicates adverse soil characteristics that affect the development of tree roots. Windthrow hazard is an evaluation only of soil characteristics and does not consider environmental factors such as windspeed, exposure, or density of stands. Soils that are subject to *slight* windthrow hazard are moderately deep and deep, well drained, and have no restrictive layers. Soils that are subject to a *moderate* windthrow hazard generally are moderately deep, are well drained, and have no restrictive layers; however, depth to bedrock is extremely variable and in places the soils are shallow.

Equipment limitation indicates the limitations im-

TABLE 4.—Woodland suitability groups

[The symbol < means less than]

| Woodland suitability group and map symbol  | Site index | Factors affecting tree growth |                           |                      |                     | Factors affecting tree harvest |                   | Area          | Proportion of timberland |
|--|------------|-------------------------------|---------------------------|----------------------|---------------------|--------------------------------|-------------------|---------------|--------------------------|
|  |            | Available water capacity      | Woody species competition | Natural regeneration | Windthrow hazard    | Equipment limitation           | Erosion hazard    |               |                          |
| Group 1: Very shallow to deep, moderately coarse textured to fine textured, stony soils on steep to very steep mountainsides and mountaintops.<br>HoF and FcF. | 55-74      | Low to moderate.              | Moderate                  | Good to fair.        | Slight to moderate. | Severe                         | Moderate to high. | Acre<br>1,940 | Pct<br>14.8              |
| Group 2: Very shallow to deep, moderately coarse textured to medium textured, very cobbly and stony soils on steep to very steep mountainous terrain.          | <54        | Very low to low.              | Moderate to severe.       | Fair                 | Slight to moderate. | Severe                         | Moderate to high. | 11,060        | 75.2                     |

posed by soils and topography on the use of equipment in harvesting timber. Most of the timber-producing soils in this area have slopes of more than 30 percent, are subject to a high hazard of erosion, or are stony and have rock outcrop. Therefore, in many areas use of mechanized equipment is limited. Haulroads and skidroads are costly to build and maintain. Rock outcrop and boulders interfere with the use of mechanized equipment. Extremely steep canyons and rock outcrop make many areas of good timber inaccessible for logging by present methods. Soils that have a clayey subsoil have equipment limitations when they are wet. An equipment limitation rating of *slight* indicates that there is no special problem in the use of equipment. A rating of *severe* indicates that the type of equipment that can be used is limited and special logging methods may have to be adopted; use of equipment can cause serious damage to the structure and stability of the soil.

Erosion hazard is the susceptibility of the soils to erosion, based on inherent soil characteristics, slope, surface cover of stones and cobbles, and aspect. Ratings indicate susceptibility to erosion when the soil is disturbed or the protective vegetation is destroyed or disturbed. Most of the timbered soils in the area are subject to a moderate to high hazard of erosion mainly because of the steep topography. A rating of *low* indicates that only slight erosion occurs where there has been disturbance or depletion of cover. A *moderate* rating indicates that disturbance of the surface soil and loss of protective vegetation create conditions conducive to erosion; careful planning in the construction of roads, skid trails, and landings is needed to prevent soil loss. A *high* rating indicates that the soils are subject to serious erosion loss if the vegetation is lost or disturbed; harvesting from these soils must be done carefully; logging must be by special methods that minimize soil disturbance; all roads and skidtrails must be carefully located and constructed and must contain adequate drainage to control excessive runoff; following logging operations, the roads must be seeded and treated to reduce runoff and curb soil cutting and washing.

#### Forest management programs

Good forest management practices include fire protection, insect and disease control, thinning and possi-

bly some pruning to improve growth and quality of the stands, reforestation measures, cutting to improve the basal-areas stocking level and proper age class distribution of the stands, and maintaining desirable watershed conditions.

Fire protection is provided through a system of look-outs, fire patrols, and hazard-reduction programs. Proper silvicultural practices and direct control methods provide protection from insects and disease. Non-commercial thinning and commercial cutting along with some pruning of selected crop trees allow the quality and growth potential of timber on the sites to improve. Reforestation is by natural regeneration. Erosion control measures include constructing water bars; cross-ditching; seeding grass, forbs, and browse; and scattering slash in the disturbed areas.

#### Wildlife <sup>7</sup>

Quality wildlife habitat is the most important factor needed to promote wildlife. Knowing the suitability of the soils for producing quality habitat can be a valuable tool for the wildlife manager, and the management of soil, water, and plants to produce a suitable habitat can be effective in maintaining and improving wildlife populations. How soil influences the quality of wildlife habitat under various management regimes can be predicted by knowing the properties of the soils.

Table 5 lists each mapping unit in the survey area and its suitability for producing wildlife habitat. Each kind of soil is rated for eight elements of wildlife habitat and four kinds of wildlife habitat. Some of the soils are rated for both irrigated and nonirrigated uses. It must be noted, however, that the ratings in table 5 do not consider such factors as present land use, populations of existing wildlife, predator-prey relationships, hunting pressure and other factors that require onsite investigation. Also it should be noted that water is of critical importance in developing habitat. A mapping unit may be rated *very poor* when nonirrigated but might be rated *good* if irrigated and if a long growing season, deep soils, and fair to good fertility are present. Irrigation changes the whole sphere of habitat management.

<sup>7</sup> By JOHN YORK, wildlife specialist, Soil Conservation Service.

TABLE 5.—Potential of the soils for producing elements of wildlife habitat and kinds of wildlife

[Dashes in a column indicate the soil does not occur in that habitat element or is not suited to that kind of wildlife. 1 = Good; 2 = Fair; 3 = Poor; 4 = Very poor]

| Soil                | Elements of wildlife habitat |                     |                        |                 |                   |        |                 |                      | Kinds of wildlife |           |          |       |
|---------------------|------------------------------|---------------------|------------------------|-----------------|-------------------|--------|-----------------|----------------------|-------------------|-----------|----------|-------|
|                     | Grain and seed crops         | Grasses and legumes | Wild herbaceous plants | Hard-wood trees | Coniferous plants | Shrubs | Wet-land plants | Shal-low water areas | Open-land         | Wood-land | Wet-land | Range |
| Anthony: An         |                              |                     |                        |                 |                   |        |                 |                      |                   |           |          |       |
| Irrigated           | 1                            | 1                   | 1                      | 1               | 1                 | 1      | 1               | 4                    | 1                 | -----     | -----    | ----- |
| Nonirrigated        | 4                            | 4                   | 3                      | -----           | -----             | 3      | 4               | 4                    | -----             | -----     | -----    | 3     |
| Anthony variant: Ao | 4                            | 4                   | 3                      | 4               | -----             | 3      | 4               | 4                    | -----             | -----     | -----    | 3     |
| Atascosa: AtF       | 4                            | 4                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----             | 3         | -----    | 2     |
| Barkerville:        |                              |                     |                        |                 |                   |        |                 |                      |                   |           |          |       |
| BaE                 | 4                            | 3                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----             | 3         | -----    | 2     |
| BgF                 | 4                            | 3                   | 2                      | -----           | 2                 | 2      | 4               | 4                    | -----             | 2         | -----    | ----- |

TABLE 5.—Potential of the soils for producing elements of wildlife habitat and kinds of wildlife—Continued

| Soil                                    | Elements of wildlife habitat |                     |                        |                 |                   |        |                 | Kinds of wildlife    |           |           |          |       |
|---|------------------------------|---------------------|------------------------|-----------------|-------------------|--------|-----------------|----------------------|-----------|-----------|----------|-------|
|   | Grain and seed crops         | Grasses and legumes | Wild herbaceous plants | Hard-wood trees | Coniferous plants | Shrubs | Wet-land plants | Shal-low water areas | Open-land | Wood-land | Wet-land | Range |
| Bernardino: BhD                         | 4                            | 3                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | -----     | -----    | 2     |
| Bonita: BoB                             | 4                            | 4                   | 3                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| Calciorthids-Haplargids association: Ca | 4                            | 4                   | 3                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| Canelo:                                 |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| CbD                                     | 3                            | 2                   | 2                      | 2               | -----             | 2      | 4               | 4                    | -----     | 2         | -----    | 2     |
| CdE                                     | 4                            | 4                   | 2                      | 2               | -----             | 2      | 4               | 4                    | -----     | 2         | -----    | 2     |
| CeD                                     | 3                            | 2                   | 2                      | 2               | -----             | 2      | 4               | 4                    | -----     | -----     | -----    | 2     |
| Caralampi:                              |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| CgE, ClB                                | 3                            | 3                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | -----     | -----    | 2     |
| CgF2                                    | 4                            | 4                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | -----     | -----    | 2     |
| Casto: CmE                              |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| 10 to 30 percent slopes                 | 3                            | 3                   | 2                      | 2               | -----             | 2      | 4               | 4                    | -----     | 2         | -----    | 2     |
| 30 to 40 percent slopes                 | 4                            | 4                   | 2                      | 2               | -----             | 2      | 4               | 4                    | -----     | 2         | -----    | 2     |
| Cave: Cn                                | 4                            | 4                   | 3                      | 4               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| Chiricahua:                             |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| CoE, CrD                                | 4                            | 4                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | 3         | -----    | 2     |
| Comoro:                                 |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| CsC                                     | 4                            | 4                   | 3                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| CtB                                     |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| Irrigated                               | 1                            | 1                   | 1                      | 1               | -----             | 2      | 4               | 4                    | 1         | -----     | -----    | ----- |
| Nonirrigated                            | 4                            | 4                   | 3                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| Continental:                            |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| CuC                                     | 4                            | 4                   | 3                      | 4               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| CvE2                                    | 4                            | 4                   | 3                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| Eba: EbC                                | 3                            | 3                   | 2                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 2     |
| Fanno: FaD                              | 3                            | 3                   | 2                      | 2               | -----             | 2      | 4               | 4                    | -----     | -----     | -----    | 2     |
| Fanno variant: FcF                      | 3                            | 3                   | 1                      | -----           | 1                 | 2      | 4               | 4                    | -----     | 1         | -----    | ----- |
| Faraway:                                |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| FrE                                     | 3                            | 3                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | 3         | -----    | 2     |
| FrF, FIF                                | 4                            | 4                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | 3         | -----    | 2     |
| Gaddes: GaE                             | 3                            | 3                   | 2                      | 2               | -----             | 2      | 4               | 4                    | -----     | 2         | -----    | 2     |
| Grabe:                                  |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| GbB                                     |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| Grabe part                              |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| Irrigated                               | 1                            | 1                   | 1                      | 1               | -----             | 1      | 4               | 4                    | 1         | -----     | -----    | ----- |
| Nonirrigated                            | 4                            | 4                   | 3                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| Comoro part                             |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| Irrigated                               | 1                            | 1                   | 1                      | 1               | -----             | 2      | 4               | 4                    | 1         | -----     | -----    | ----- |
| Nonirrigated                            | 4                            | 4                   | 3                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| Ge                                      |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| Irrigated                               | 1                            | 1                   | 1                      | 1               | -----             | 1      | 4               | 4                    | 1         | -----     | -----    | ----- |
| Nonirrigated                            | 4                            | 4                   | 3                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| Graham:                                 |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| GhD                                     | 3                            | 2                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | 3         | -----    | 2     |
| GhF                                     | 4                            | 4                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | 3         | -----    | 2     |
| Guest: Gu                               |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| Irrigated                               | 2                            | 2                   | 3                      | 3               | -----             | 3      | 3               | 3                    | 2         | -----     | -----    | ----- |
| Nonirrigated                            | 3                            | 3                   | 3                      | 3               | -----             | 3      | -----           | -----                | -----     | -----     | -----    | 3     |
| Hathaway:                               |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| HaF                                     | 3                            | 3                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | -----     | -----    | 2     |
| HhE2                                    | 3                            | 3                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | -----     | -----    | 2     |
| Hogris:                                 |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| HoF                                     |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| Hogris                                  | 3                            | 3                   | 2                      | -----           | 2                 | 3      | 4               | 4                    | -----     | 2         | -----    | ----- |
| Telephone                               | 4                            | 2                   | 1                      | 2               | 2                 | 3      | 4               | 4                    | 4         | 2         | 4        | 1     |
| HtF                                     |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| Hogris                                  | 4                            | 2                   | 2                      | -----           | 2                 | 2      | -----           | -----                | 3         | -----     | -----    | ----- |
| Telephone                               | 4                            | 2                   | 1                      | 2               | 2                 | 3      | 4               | 4                    | 4         | 2         | 4        | 1     |
| Kimbrough: KbC                          | 4                            | 4                   | 3                      | -----           | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |
| Lampshire:                              |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| LaE                                     | 3                            | 3                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | 3         | -----    | 2     |
| LaF, LcF, LgF                           | 4                            | 4                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | 3         | -----    | 2     |
| Luzena: LuD                             | 3                            | 3                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | 3         | -----    | 2     |
| Mabray: McF                             | 4                            | 4                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | 3         | -----    | 2     |
| Martinez: Mg                            | 3                            | 3                   | 2                      | 3               | -----             | 2      | 4               | 4                    | -----     | -----     | -----    | 2     |
| Mine pits and dumps:                    |                              |                     |                        |                 |                   |        |                 |                      |           |           |          |       |
| Mn                                      | 4                            | 4                   | 3                      | 3               | -----             | 3      | 4               | 4                    | -----     | -----     | -----    | 3     |

TABLE 5.—Potential of the soils for producing elements of wildlife habitat and kinds of wildlife—Continued

| Soil  | Elements of wildlife habitat |                     |                        |                |                   |        |                | Kinds of wildlife   |          |          |         |       |
|---|------------------------------|---------------------|------------------------|----------------|-------------------|--------|----------------|---------------------|----------|----------|---------|-------|
|   | Grain and seed crops         | Grasses and legumes | Wild herbaceous plants | Hardwood trees | Coniferous plants | Shrubs | Wetland plants | Shallow water areas | Openland | Woodland | Wetland | Range |
| Pima:   |                              |                     |                        |                |                   |        |                |                     |          |          |         |       |
| Pm  |                              |                     |                        |                |                   |        |                |                     |          |          |         |       |
| Irrigated                                       | 1                            | 1                   | 1                      | 1              | -----             | -----  | 4              | 4                   | 1        | -----    | -----   | ----- |
| Nonirrigated                                    | 3                            | 3                   | 2                      | 3              | -----             | 2      | 4              | 4                   | -----    | -----    | -----   | 2     |
| Pn  | 4                            | 4                   | 3                      | 3              | -----             | 3      | 4              | 4                   | -----    | -----    | -----   | 3     |
| Pinaleno: PoC                                   | 3                            | 3                   | 2                      | 3              | -----             | 2      | 4              | 4                   | -----    | -----    | -----   | 2     |
| Rillino: RIE2                                   | 4                            | 4                   | 3                      | 3              | -----             | 3      | 4              | 4                   | -----    | -----    | -----   | 3     |
| Rock outcrop-Lithic Haplustolls association: Rn | 4                            | 4                   | 4                      | -----          | -----             | 4      | 4              | 4                   | -----    | -----    | -----   | 4     |
| Rock outcrop: Rr. Too variable to be rated.     |                              |                     |                        |                |                   |        |                |                     |          |          |         |       |
| Schrap:   |                              |                     |                        |                |                   |        |                |                     |          |          |         |       |
| ScD   | 3                            | 3                   | 2                      | 3              | -----             | 3      | 4              | 4                   | -----    | -----    | -----   | 2     |
| ShF   | 4                            | 4                   | 2                      | 3              | -----             | 2      | 4              | 4                   | -----    | -----    | -----   | 2     |
| Signal: SnD                                     | 3                            | 3                   | 2                      | 3              | -----             | 2      | 4              | 4                   | -----    | -----    | -----   | 2     |
| Sonoita: SoB, SoD                               | 3                            | 3                   | 2                      | 3              | -----             | 2      | 4              | 4                   | -----    | -----    | -----   | 2     |
| Torrifluvents and Haplustolls: Th               | 3                            | 3                   | 2                      | -----          | -----             | 3      | 4              | 4                   | 3        | -----    | -----   | 3     |
| Tortugas:                                       |                              |                     |                        |                |                   |        |                |                     |          |          |         |       |
| TrE   |                              |                     |                        |                |                   |        |                |                     |          |          |         |       |
| Tortugas part                                   | 3                            | 3                   | 2                      | 3              | -----             | 2      | 4              | 4                   | -----    | 3        | -----   | 2     |
| TrF   | 4                            | 4                   | 2                      | 3              | -----             | 2      | 4              | 4                   | -----    | 3        | -----   | 2     |
| White House:                                    |                              |                     |                        |                |                   |        |                |                     |          |          |         |       |
| WgC, WhC, WnC                                   | 3                            | 3                   | 2                      | 3              | -----             | 2      | 4              | 4                   | -----    | -----    | -----   | 2     |
| WgE, WoE, WtF                                   | 4                            | 4                   | 2                      | 3              | -----             | 2      | 4              | 4                   | -----    | -----    | -----   | 2     |

Elements of wildlife habitat and kinds of wildlife are rated good, fair, poor, and very poor. The suitability ratings are explained as follows:

A rating of *good* means habitat is easily improved, maintained, or created. There are few or no soil limitations in habitat management, and satisfactory results can be expected. A rating of *fair* means habitat can be improved, maintained or created on these soils but moderate limitations affect habitat management or development. A moderate intensity of management and fairly frequent attention may be required to insure satisfactory results. A rating of *poor* means habitat can be improved, maintained, or created on these soils but the limitations are severe. Habitat management may be difficult and expensive and require intensive effort. Results are questionable. A rating of *very poor* means that under prevailing soil conditions, it is impractical to attempt to improve or create habitat. Unsatisfactory results are probable.

The general rating for each kind of wildlife habitat is made by considering the habitat elements that make up and are the most important to the habitat. For example, the most important habitat elements for openland wildlife are domestic grasses and legumes, grain and seed crops, and wild herbaceous plants; the most important habitat elements for woodland wildlife are domestic grasses and legumes, wild herbaceous plants, hardwood trees and coniferous plants; the most important habitat elements for wetland habitat are wetland plants and shallow water areas; and the most important habitat elements for rangeland habitat are wild herbaceous plants and shrubs.

The eight elements of wildlife habitat and the four kinds of wildlife are defined as follows:

*Grain and seed crops.*—Domestic grain or other seed-producing annuals planted to produce wildlife food. Examples are corn, sorghum, wheat, oats, barley, millet, soybeans, and sunflowers.

*Domestic grasses and legumes.*—Domestic perennial grasses and herbaceous legumes that are planted for wildlife cover and food. Examples are lovegrass, switchgrass, brome, orchardgrass, clover, alfalfa, trefoil, crownvetch, and wheatgrass.

*Wild herbaceous plants.*—Native or naturally established dryland herbaceous grasses and forbs (including weeds) that provide food and cover for wildlife. Examples are wheatgrasses, fescues, grammas, alfilaria, sunflower, croton, pigweed, tumbleweed, and mallow.

*Hardwood trees.*—Hardwood trees in the humid areas include nonconiferous trees and associated woody understory plants that provide wildlife cover or that produce nuts, buds, catkins, twigs, bark, or foliage used as food by wildlife.

*Coniferous plants.*—Cone-bearing trees, shrubs, and associated understory shrubs that furnish wildlife cover or supply food in the form of browse, seeds, or fruitlike cones. They are commonly established through natural processes but may be planted or transplanted. Examples are pine, spruce, fir, and juniper trees.

*Shrubs.*—Shrubby plants and cacti that produce buds, twigs, flowers, or foliage used for food by wildlife or that provide cover and shelter. Examples are creosotebush, mesquite, desert willow, catclaw, ironwood, oak, prickly pear, seepwillow, and four-wing saltbush.

*Wetland plants.*—Annual and perennial wild herbaceous plants of moist or wet sites, exclusive of sub-

merged or floating aquatics, that produce food or cover used extensively by wetland forms of wildlife. Examples are smartweed, wild millet, rushes, sedges, reeds, saltgrass, and cattail.

*Shallow water areas.*—Areas of surface water that have an average depth of less than 5 feet and are useful to wildlife. They may be natural wet areas or those created by dams or levees or by water control devices in marshes or streams. Examples are muskrat marshes, waterfowl feeding areas, wildlife watering developments, wildlife ponds, and beaver ponds.

*Open-land wildlife.*—Birds and animals that inhabit irrigated croplands, pastures, lawns, and areas overgrown with grasses, weeds, herbs, shrubs, and vines. Examples are white-winged dove, Inca dove, mourning dove, desert cottontail, skunk, and songbirds.

*Woodland wildlife.*—Birds and animals of wooded areas containing either hardwood trees or coniferous trees and shrubs, or a mixture of both. Examples are Mearns quail, band-tailed pigeon, deer, Arizona gray squirrel, and turkey. Several rare songbirds are found in this type of habitat.

*Wetland wildlife.*—Birds and animals of swampy, marshy, or high-water-table areas. Examples are muskrat, shore birds, raccoon, rails, waterfowl, dove, and quail.

*Rangeland wildlife.*—Birds and animals of natural rangelands. Examples are mule deer, Coues white-tailed deer, coyote, desert kit fox, jackrabbits, ring-tailed cat, javelina, and coatimundi.

## Engineering Uses of the Soils <sup>8</sup>

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Properties of soils that are highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who:

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the soils on which they

are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.

6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 6, 7, and 8, which show, respectively, results of engineering laboratory tests on soil samples, several estimated soil properties significant to engineering, and interpretations for various engineering uses. This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in table 8, and it also can be used to make other useful maps.

This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths more than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists that is not known to all engineers. The Glossary defines many of these terms as they are commonly used in soil science.

### Engineering classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (2) used by Soil Conservation Service engineers, the Department of Defense, and others, and the AASHTO system (1) adopted by the American Association of State Highway and Transportation Officials.

In the Unified system soils are classified according to particle size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, CL-ML.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance (8). In this system, a soil is placed in one of seven basic groups ranging from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A-1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A-7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are divided as follows: A-1-a, A-1-b, A-2-4,

<sup>8</sup> CLIFFORD E. PARSONS, engineering specialist, Soil Conservation Service, helped to prepare this section.

TABLE 6.—*Engineering*

[Tests performed by Arizona Highway Department. Absence

| Soil name and location   | Parent material   | Arizona report number | Depth     | Moisture density <sup>1</sup> |                  |
|--|---|-----------------------|-----------|-------------------------------|------------------|
|  |   |                       |           | Maximum dry density           | Optimum moisture |
|  |   |                       | <i>In</i> | <i>Lb per cu ft</i>           | <i>Pct</i>       |
| Bernardino gravelly loam: 65 feet west of road, 500 feet south of northeast corner of sec. 1, T. 21 S., R. 16 E. Finer textured than modal.                | Old alluvium derived mainly from limestone but with some influence from sandstone, quartzite, andesite, and tuff. | 63-19375              | 6-16      | 94                            | 21               |
|  |   | 63-19376              | 16-62     | 107                           | 18               |
| Bernardino gravelly clay loam: 500 feet west and 650 feet north of southeast corner of sec. 29, T. 20 S., R. 17 E. Modal.                                  | Alluvium derived from mixed rock including rhyolite, limestone, quartzite, and andesite.                          | 63-20571              | 2-11      | 99                            | 21               |
|  |   | 63-20572              | 15-48     | 118                           | 11               |
|  |   | 63-20573              | 48-85     | 121                           | 11               |
| Continental gravelly clay loam: 1,200 feet north and 300 feet east of southwest corner of sec. 14, T. 20 S., R. 12 E. Modal.                               | Granite, andesite, latite, dacite, and rhyolite.  | 63-19377              | 1-9       | 118                           | 12               |
|  |   | 63-19378              | 18-26     | 116                           | 13               |
|  |   | 63-19379              | 62-75     | 116                           | 13               |
| Continental gravelly sandy loam: NW¼-SW¼ sec. 8, T. 20 S., R. 13 E. Finer textured than modal.   | Alluvium derived from granite, limestone, andesite, and diorite.  | 63-20568              | 2-10      | -----                         | -----            |
|  |   | 63-20569              | 17-25     | 110                           | 15               |
|  |   | 63-20570              | 31-50     | -----                         | -----            |
| Grabe sandy loam or loam: SE¼NE¼ sec. 23, T. 20 S., R. 13 E. Coarser textured than modal.  | Alluvium derived mainly from granite and rhyolite.  | 63-20566              | 4-26      | 114                           | 13               |
|  |   | 63-20567              | 46-56     | -----                         | -----            |
| Pima loam: 150 feet south and 375 feet west of northeast corner of sec. 7, T. 20 S., R. 13 E. Modal.   | Mixed alluvium including material derived from basic and acid igneous rocks, quartzite, shale, and limestone.     | 63-19380              | 0-11      | 94                            | 23               |
|  |   | 63-20564              | 22-29     | 101                           | 20               |
|  |   | 63-20565              | 66-72     | 101                           | 10               |
| White House gravelly sandy loam: 1.3 miles east-southeast along pipeline from intersection with Sonoita-Canelo road and 0.1 mile south of pipeline. Modal. | Alluvium derived from andesite, rhyolite, limestone, and quartzite.   | 63-19372              | 3-8       | 113                           | 14               |
|  |   | 63-19373              | 20-29     | 90                            | 26               |
|  |   | 63-19374              | 40-67     | 112                           | 15               |
| White House cobbly sandy loam: NE¼-NE¼ sec. 7, T. 23 S., R. 14 E. More cobbly than modal.  | Alluvium derived from rhyolite, granite, and andesite.  | 63-19367              | 0-5       | -----                         | -----            |
|  |   | 63-19370              | 10-22     | 93                            | 22               |
|  |   | 63-19371              | 60-70     | 120                           | 12               |

<sup>1</sup>Based on AASHTO Designation T 99-70, Method A (1).<sup>2</sup>Mechanical analyses according to the AASHTO Designation T 88-70 (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 analyzedTABLE 7.—*Estimated properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. fully the instructions for referring to other series that appear in

| Soil series and map symbols | Hydrologic soil group | Depth to bedrock or hardpan | Depth from surface    | USDA texture   | Classification         |                 |
|-----------------------------|-----------------------|-----------------------------|-----------------------|--|------------------------|-----------------|
|                             |                       |                             |                       |  | Unified                | AASHTO          |
| Anthony: An -----           | B                     | <i>Inches</i><br>60+        | <i>Inches</i><br>0-60 | Stratified sandy loam, loam, fine sandy loam, and gravelly sandy loam.         | SM                     | A-2             |
| Anthony variant: Ao ----    | A                     | 60+                         | 0-16<br>16-60         | Fine sandy loam or gravelly fine sandy loam.<br>Very gravelly fine sandy loam. | SM<br>GM, GM-GW,<br>GW | A-4, A-2<br>A-1 |

*test data*

of an entry indicates that no determination was made]

| Mechanical analysis <sup>2</sup> |                |                 |                   |                         |         |          |                     | Liquid limit    | Plasticity index | Classification       |          |
|----------------------------------|----------------|-----------------|-------------------|-------------------------|---------|----------|---------------------|-----------------|------------------|----------------------|----------|
| Percentage passing sieve—        |                |                 |                   | Percentage smaller than |         |          | AASHTO <sup>3</sup> |                 |                  | Unified <sup>4</sup> |          |
| $\frac{3}{4}$ -in                | No. 4 (4.7 mm) | No. 10 (2.0 mm) | No. 40 (0.042 mm) | No. 200 (0.074 mm)      | 0.02 mm | 0.005 mm |                     |                 |                  |                      | 0.002 mm |
|                                  |                |                 |                   |                         |         |          |                     | <i>Pet</i>      |                  |                      |          |
| 100                              | 97             | 93              | 88                | 67                      | 53      | 42       | 34                  | 56              | 39               | A-7-6 (17)           | CH       |
| 96                               | 90             | 81              | 72                | 58                      | 46      | 31       | 7                   | 32              | 14               | A-6 (6)              | CL       |
| 99                               | 88             | 77              | 62                | 52                      | 49      | 41       | 32                  | 71              | 48               | A-7-6 (12)           | CH       |
| 97                               | 77             | 59              | 30                | 12                      | 7       | 4        | 1                   | 35              | 15               | A-2-6 (0)            | SW-SC    |
| 95                               | 62             | 47              | 25                | 8                       | 5       | 2        | 1                   | 33              | 11               | A-2-6 (0)            | SW-SC    |
| 93                               | 82             | 65              | 39                | 28                      | 23      | 19       | 16                  | 50              | 32               | A-2-7 (3)            | SC       |
| 92                               | 75             | 59              | 31                | 26                      | 20      | 18       | 16                  | 85              | 63               | A-2-7 (2)            | SC       |
| 98                               | 95             | 84              | 56                | 36                      | 18      | 9        | 4                   | 38              | 22               | A-6 (3)              | SC       |
| 69                               | 46             | 35              | 21                | 14                      | 9       | 7        | 3                   | 31              | 18               | A-2-6 (0)            | GC       |
| 98                               | 90             | 77              | 58                | 48                      | 37      | 31       | 22                  | 60              | 43               | A-7-6 (11)           | SC       |
| 53                               | 34             |                 |                   |                         |         |          |                     | 23              | 3                |                      |          |
| 100                              | 96             | 91              | 74                | 49                      | 34      | 19       | 12                  | 30              | 15               | A-6 (5)              | SC       |
| 71                               | 45             | 36              | 19                | 5                       | 3       | 3        | 1                   | <sup>5</sup> NP | NP               | A-1-a                | GP-GM    |
|                                  |                |                 |                   | 98                      | 79      | 48       | 20                  | 51              | 28               | A-7-6 (17)           | CH       |
|                                  |                | 100             | 97                | 84                      | 57      | 30       | 15                  | 39              | 19               | A-6 (12)             | CL       |
| 99                               | 96             | 91              | 66                | 3                       | 3       | 1        | 1                   | NP              | NP               | A-3                  | SP       |
| 98                               | 90             | 85              | 73                | 55                      | 33      | 23       | 16                  | 33              | 18               | A-6 (7)              | CL       |
| 100                              | 95             | 89              | 82                | 73                      | 68      | 62       | 59                  | 85              | 62               | A-7-6 (20)           | CH       |
| 88                               | 67             | 57              | 42                | 30                      | 19      | 14       | 13                  | 58              | 37               | A-2-7 (3)            | SC       |
| 65                               | 32             | 26              | 17                | 9                       | 6       | 5        | 4                   | 31              | 13               | A-2-6 (0)            | GP-GC    |
| 99                               | 95             | 88              | 75                | 63                      | 60      | 55       | 48                  | 77              | 55               | A-7-6 (16)           | CH       |
| 86                               | 71             | 57              | 36                | 19                      | 15      | 12       | 8                   | 44              | 28               | A-2-7 (1)            | SC       |

by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

<sup>3</sup> Based on AASHTO Designation M 145-49 (1).

<sup>4</sup> Based on the Unified soil classification system (2).

<sup>5</sup> NP means nonplastic.

*significant in engineering*

The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the first column of the table. The symbol < means less than].

| Coarse fraction greater than 3 inches | Percentage less than 3 inches passing sieve— |        |        |         | Permeability           | Available water capacity     | Reaction  | Shrink-swell potential | Corrosivity to uncoated steel |
|---------------------------------------|--|--------|--------|---------|------------------------|------------------------------|-----------|------------------------|-------------------------------|
|                                       | No. 4  | No. 10 | No. 40 | No. 200 |                        |                              |           |                        |                               |
| <i>Percent</i>                        |  |        |        |         | <i>Inches per hour</i> | <i>Inch per inch of soil</i> | <i>pH</i> |                        |                               |
| 0-5                                   | 70-95  | 65-95  | 35-65  | 20-35   | 2.0-6.0                | 0.09-0.13                    | 7.4-8.4   | Low -----              | High.                         |
| 0-15                                  | 85-100                                       | 65-90  | 45-70  | 25-45   | 2.0-6.0                | 0.11-0.13                    | 7.9-8.4   | Low -----              | High.                         |
| 0-15                                  | 20-40  | 15-30  | 10-20  | 5-15    | 6.0-20                 | 0.05-0.07                    | 7.9-8.4   | Low -----              | High.                         |

TABLE 7.—Estimated properties

| Soil series and map symbols  | Hydrologic soil group | Depth to bedrock or hardpan | Depth from surface        | USDA texture   | Classification           |                        |
|--|-----------------------|-----------------------------|---------------------------|--|--------------------------|------------------------|
|  |                       |                             |                           |  | Unified                  | AASHTO                 |
| Atascosa: AtF -----  | D                     | <i>Inches</i><br>4-20       | <i>Inches</i><br>0-9<br>9 | Very gravelly sandy loam and sandy clay loam. Rhyolitic conglomerate.  | GM-GW, GC                | A-1 or A-2             |
| *Barkerville: BaE, BgF ---<br>For Gaddes part, see Gaddes series.                    | C                     | 10-20                       | 0-14<br>14                | Gravelly sandy loam and cobbly sandy loam. Weathered granite.  | SM                       | A-1, A-2               |
| *Bernardino: BhD -----<br>For Hathaway part, see Hathaway series.                    | C                     | 60+                         | 0-15<br>15-60             | Gravelly clay loam and clay.<br>Gravelly sandy loam -----  | CH<br>SM, SM-SW          | A-7<br>A-1, A-2        |
| Bonita: BoB -----  | D                     | 60+                         | 0-31<br>31-60             | Clay -----<br>Gravelly clay loam -----   | CH<br>CL                 | A-7<br>A-6             |
| Calciorthids-Haplargids association: Ca.<br>Properties too variable to be estimated. |                       |                             |                           |  |                          |                        |
| Canelo: CbD, CdE, CeD ---  | D                     | 60+                         | 0-14<br>14-60             | Gravelly, very gravelly, or cobbly sandy loam.<br>Very gravelly or very cobbly clay, sandy clay or sand clay loam.                                       | SM<br>GC, GM             | A-2<br>A-2             |
| Caralampi: CgE, CgF2 ---   | B                     | 60+                         | 0-23<br>23-60             | Gravelly sandy loam and very gravelly sandy clay loam.<br>Gravelly or very gravelly sandy loam.  | GC or GM<br>SM           | A-2, A-1<br>A-1, A-2   |
| Caralampi variant: CIB ---   | C                     | 60+                         | 0-11<br>11-39<br>39-60    | Gravelly loam -----<br>Very gravelly clay loam -----<br>Clay and gravelly sandy clay.  | SC<br>GC<br>SC or CL     | A-6<br>A-2<br>A-6      |
| Casto: CmE -----   | C                     | 60+                         | 0-28<br>28-60             | Gravelly and very gravelly sandy clay loam.<br>Very gravelly sandy loam ---  | SC<br>GM, GM-GP          | A-2<br>A-1             |
| Cave: Cn -----   | D                     | 4-20                        | 0-7<br>7-18<br>18-60      | Gravelly sandy loam -----<br>Indurated lime hardpan.<br>Very gravelly sandy loam ---   | SM<br>GP                 | A-1, A-2<br>A-1        |
| *Chiricahua: CoE, CrD ---<br>For Lampshire part of CrD, see Lampshire series.        | D                     | 10-20                       | 0-19<br>19-28             | Cobbly or gravelly heavy clay loam or clay.<br>Strongly weathered granite.   | SC                       | A-2                    |
| Comoro: CsC, CtB -----   | B                     | 60+                         | 0-60                      | Sandy loam and gravelly sandy loam.  | SM                       | A-2                    |
| *Continental: CuC, CvE2 ---<br>For Rillino part of CvE2, see Rillino series.         | C                     | 60+                         | 0-10<br>10-31<br>31-72    | Gravelly sandy loam and gravelly sandy clay loam.<br>Gravelly clay and clay -----<br>Gravelly and very gravelly sandy clay loam and gravelly sandy loam. | SM, SC<br>SC or CH<br>SC | A-2<br>A-2, A-7<br>A-2 |
| Eba: EbC -----   | C                     | 60+                         | 0-50<br>50-80             | Very gravelly clay -----<br>Very gravelly sandy loam ---   | GC<br>GM                 | A-2<br>A-1             |
| *Fanno: FaD -----<br>For Luzena part, see Luzena series.                             | C                     | 20-40                       | 0-25<br>25-40             | Clay or gravelly clay -----<br>Weathered clayey shale.   | CH                       | A-7                    |
| Fanno variant: FcF -----   | C                     | 22-60                       | 0-13<br>13-40<br>40-44    | Gravelly or very gravelly loam and gravelly silty clay loam.<br>Gravelly clay and clay -----<br>Weathered phyllite bedrock, fractured.                   | GM, GC<br>CH             | A-2 or A-4<br>A-7      |

## significant in engineering—Continued

| Coarse fraction greater than 3 inches | Percentage less than 3 inches passing sieve— |                         |                         |                         | Permeability                      | Available water capacity                  | Reaction                      | Shrink-swell potential                    | Corrosivity to uncoated steel |
|---------------------------------------|--|-------------------------|-------------------------|-------------------------|-----------------------------------|---|-------------------------------|---|-------------------------------|
|                                       | No. 4  | No. 10                  | No. 40                  | No. 200                 |                                   |   |                               |   |                               |
| <i>Percent</i><br>0-30                | 30-45  | 25-35                   | 20-30                   | 10-25                   | <i>Inches per hour</i><br>0.6-2.0 | <i>Inch per inch of soil</i><br>0.07-0.09 | <i>pH</i><br>6.6-7.3          | Low -----                                 | High.                         |
| 0-30                                  | 80-90  | 50-75                   | 30-50                   | 15-30                   | 0.6-6.0                           | 0.09-0.10                                 | 6.1-7.8                       | Low -----                                 | Moderate.                     |
| 0-5                                   | 85-100                                       | 65-85                   | 60-80                   | 50-75                   | 0.06-0.6                          | 0.14-0.18                                 | 7.4-8.4                       | High -----                                | High.                         |
| 0-5                                   | 75-90  | 50-80                   | 30-50                   | 10-25                   | 0.6-2.0                           | 0.07-0.09                                 | 7.9-8.4                       | Low -----                                 | High.                         |
| 0-5<br>5-10                           | 85-100<br>85-90                              | 80-95<br>80-90          | 80-95<br>60-70          | 70-90<br>50-60          | <0.06<br>0.6-0.2                  | 0.14-0.16<br>0.16-0.19                    | 6.6-8.4<br>7.9-8.4            | High -----<br>High -----                  | High.<br>High.                |
| 0-20                                  | 60-75  | 30-65                   | 30-45                   | 15-30                   | 0.6-2.0                           | 0.05-0.06                                 | 5.6-6.5                       | Low -----                                 | High.                         |
| 5-35                                  | 35-45  | 30-40                   | 20-35                   | 15-25                   | <0.06                             | 0.04-0.06                                 | <4.5-6.0                      | Moderate -----                            | High.                         |
| 0-15                                  | 40-50  | 35-45                   | 20-30                   | 15-25                   | 0.2-0.6                           | 0.07-0.09                                 | 6.1-6.5                       | Moderate -----                            | Moderate.                     |
| 0-15                                  | 60-75  | 40-50                   | 25-35                   | 15-25                   | 0.6-2.0                           | 0.05-0.07                                 | 6.1-6.5                       | Low -----                                 | Moderate.                     |
| 0-5<br>0-10<br>0-5                    | 80-90<br>40-50<br>70-85                      | 60-75<br>25-35<br>50-65 | 50-65<br>20-35<br>50-60 | 35-50<br>15-25<br>35-50 | 0.6-2.0<br>0.6-2.0<br>0.2-0.6     | 0.13-0.14<br>0.07-0.09<br>0.10-0.12       | 5.6-6.5<br>6.6-7.8<br>7.4-8.4 | Low -----<br>Moderate -----<br>High ----- | High.<br>High.<br>High.       |
| 0-15                                  | 60-70  | 30-60                   | 30-50                   | 20-30                   | 0.06-0.2                          | 0.07-0.09                                 | 5.6-7.3                       | Moderate -----                            | High.                         |
| 0-15                                  | 30-50  | 30-45                   | 20-35                   | 10-25                   | 0.6-2.0                           | 0.04-0.07                                 | 7.9-8.4                       | Low -----                                 | High.                         |
| 0-5                                   | 60-70  | 50-60                   | 30-45                   | 15-25                   | 0.6-2.0                           | 0.07-0.09                                 | 7.9-8.4                       | Low -----                                 | High.                         |
| 0-10                                  | 20-35  | 15-30                   | 10-20                   | 0-5                     | 0.6-2.0                           | 0.03-0.05                                 | 7.9-8.4                       | Low -----                                 | High.                         |
| 0-20                                  | 65-75  | 50-65                   | 40-60                   | 25-35                   | 0.2-0.6                           | 0.11-0.13                                 | 5.6-7.8                       | Moderate -----                            | High.                         |
| 0-5                                   | 70-100                                       | 65-95                   | 50-70                   | 20-35                   | 2.0-20                            | 0.09-0.12                                 | 7.9-8.4                       | Low -----                                 | Moderate.                     |
| 0-10                                  | 60-75  | 55-70                   | 25-35                   | 20-30                   | 0.6-2.0                           | 0.07-0.09                                 | 6.1-7.3                       | Low -----                                 | High.                         |
| 0-5<br>0-15                           | 75-90<br>60-75                               | 75-90<br>30-60          | 45-70<br>25-35          | 40-65<br>20-30          | 0.06-0.2<br>0.6-2.0               | 0.10-0.14<br>0.07-0.09                    | 6.6-8.4<br>7.4-8.4            | High -----<br>Moderate -----              | High.<br>High.                |
| 0-15<br>0-15                          | 30-45<br>30-50                               | 25-40<br>30-40          | 20-30<br>20-35          | 20-30<br>10-25          | 0.06-0.2<br>0.6-2.0               | 0.07-0.09<br>0.03-0.04                    | 7.4-8.4<br>7.4-8.4            | Moderate -----<br>Low -----               | Moderate.<br>Low.             |
| 0-5                                   | 90-100                                       | 75-90                   | 65-80                   | 60-75                   | 0.06-0.20                         | 0.12-0.16                                 | 6.1-7.8                       | Moderate -----                            | High.                         |
| 0-15                                  | 50-65  | 35-55                   | 30-45                   | 25-40                   | 0.2-0.6                           | 0.10-0.14                                 | 5.6-6.5                       | Low -----                                 | High.                         |
| 0-10                                  | 85-95  | 70-90                   | 60-85                   | 50-80                   | 0.06-0.2                          | 0.12-0.16                                 | 5.6-6.0                       | High -----                                | High.                         |

TABLE 7.—Estimated properties

| Soil series and map symbols  | Hydrologic soil group | Depth to bedrock or hardpan | Depth from surface             | USDA texture  | Classification              |                       |
|--|-----------------------|-----------------------------|--------------------------------|---|-----------------------------|-----------------------|
|  |                       |                             |                                |   | Unified                     | AASHTO                |
| *Faraway: FrE, FrF, FtF<br>For Tortugas part of FtF, see Tortugas series. Rock outcrop too variable to be estimated.   | D                     | <i>Inches</i><br>5-20       | <i>Inches</i><br>0-12<br>12-18 | Very cobbly fine sandy loam.<br>Dacite bedrock, fractured.  | GM                          | A-1                   |
| Gaddes: GaE  | C                     | 20-30                       | 0-23<br><br>23-30              | Gravelly sandy loam, sandy loam, sandy clay loam, gravelly clay, and cobbly sandy clay loam.<br>Decomposed granite. | SC                          | A-2                   |
| *Grabe: GbB, Ge<br>For Comoro part of GbB, see Comoro series.  | B                     | 60+                         | 0-60                           | Loam and sandy loam   | ML, SM                      | A-4                   |
| Graham: GhD, GhF   | D                     | 8-20                        | 0-19<br>19-22                  | Very cobbly clay loam and clay.<br>Andesite-tuff bedrock, fractured.  | CH                          | A-7                   |
| Guest: Gu  | D                     | 60+                         | 0-68                           | Clay, gravelly clay and gravelly clay loam.   | CH                          | A-7                   |
| Hathaway: HaF, HhE2  | B                     | 60+                         | 0-60                           | Gravelly sandy clay loam, gravelly and very gravelly sandy loam, and sandy loam.                                    | GM, GM-GP                   | A-1                   |
| *Hogris: HoF, HtF<br>For Telephone part, see Telephone series. Rock outcrop part of HtF too variable to be estimated.  | B                     | 40-60+                      | 0-60                           | Very cobbly sandy loam and fine sandy loam.   | SM                          | A-2, A-4              |
| Kimbrough: KbC   | D                     | 6-20                        | 0-12<br><br>12-26<br>26-60     | Gravelly loam<br><br>Indurated lime hardpan.<br>Very gravelly loam (high lime).                                     | GM, GC,<br>SM, SC<br><br>GM | A-2 or A-4<br><br>A-1 |
| *Lampshire: LaE, LaF, LcF, LgF<br>For Chiricahua part of LcF and Graham part of LgF, see those respective series. Rock outcrop part of LgF too variable to be estimated. | D                     | 4-20                        | 0-8<br>8-12                    | Very cobbly loam<br>Andesite-tuff bedrock, fractured.   | GM, GC, ML,<br>or CL        | A-4, A-2              |
| Luzena<br>Mapped only in an association with Fanno soils.  | D                     | 7-20                        | 0-15<br>15                     | Gravelly loam and gravelly clay.<br>Andesite bedrock, fractured.  | CH, CL, SC                  | A-7                   |
| Luzena variant: LuD  | C                     | 20-50                       | 0-34<br><br>34                 | Gravelly clay loam, clay loam, and clay.<br>Weathered andesite-tuff bedrock, fractured.                             | SC, CH, CL                  | A-6 or A-7            |
| *Mabray: McF<br>For Chiricahua part, see Chiricahua series. Rock outcrop too variable to be estimated.   | D                     | 4-20                        | 0-12<br><br>12                 | Very gravelly, or very cobbly loam.<br>Limestone bedrock.   | GC, GM                      | A-2, A-4              |

significant in engineering—Continued

| Coarse fraction greater than 3 inches | Percentage less than 3 inches passing sieve— |        |        |         | Permeability                      | Available water capacity                  | Reaction      | Shrink-swell potential | Corrosivity to uncoated steel |
|---------------------------------------|--|--------|--------|---------|-----------------------------------|---|---------------|------------------------|-------------------------------|
|                                       | No. 4  | No. 10 | No. 40 | No. 200 |                                   |   |               |                        |                               |
| Percent 10-50                         | 35-50  | 30-45  | 25-40  | 15-25   | <i>Inches per hour</i><br>0.6-2.0 | <i>Inch per inch of soil</i><br>0.04-0.07 | pH<br>6.1-7.3 | Low -----              | Moderate.                     |
| 5-25                                  | 80-95  | 75-90  | 60-75  | 25-35   | 0.2-0.6                           | 0.09-0.12                                 | 6.1-7.3       | Moderate -----         | High.                         |
| 0-5                                   | 80-100                                       | 70-100 | 55-80  | 40-70   | 0.6-2.0                           | 0.13-0.18                                 | 7.9-8.4       | Low -----              | High.                         |
| 15-40                                 | 85-100                                       | 80-95  | 70-90  | 60-80   | 0.06-0.2                          | 0.12-0.14                                 | 6.6-8.4       | High -----             | High.                         |
| 0                                     | 90-100                                       | 70-100 | 70-95  | 60-90   | 0.06-0.2                          | 0.12-0.16                                 | 7.4-8.4       | High -----             | High.                         |
| 0-10                                  | 35-55  | 30-50  | 20-35  | 10-25   | 0.6-2.0                           | 0.06-0.09                                 | 7.9-8.4       | Low -----              | High.                         |
| 30-60                                 | 80-95  | 70-85  | 45-70  | 25-40   | 2.0-6.0                           | 0.06-0.08                                 | 5.6-7.3       | Low -----              | Moderate.                     |
| 0-10                                  | 60-80  | 50-70  | 40-65  | 30-50   | 0.6-2.0                           | 0.10-0.13                                 | 7.9-8.4       | Low -----              | Moderate.                     |
| 0-10                                  | 25-40  | 20-35  | 20-30  | 10-25   | 0.2-0.6                           | 0.05-0.08                                 | 7.9-8.4       | Low -----              | Low.                          |
| 5-50                                  | 35-80  | 30-75  | 25-70  | 20-55   | 0.6-2.0                           | 0.05-0.07                                 | 6.6-7.3       | Low -----              | Moderate.                     |
| 0-15                                  | 70-80  | 60-75  | 55-70  | 40-60   | 0.06-0.2                          | 0.10-0.13                                 | 6.1-7.3       | High -----             | High.                         |
| 0-10                                  | 80-95  | 70-85  | 50-75  | 50-70   | 0.06-0.2                          | 0.14-0.16                                 | 6.1-8.4       | High -----             | High.                         |
| 15-50                                 | 40-60  | 35-50  | 30-45  | 20-40   | 0.60-2.0                          | 0.05-0.09                                 | 7.9-8.4       | Low -----              | Moderate.                     |

TABLE 7.—*Estimated properties*

| Soil series and map symbols   | Hydrologic soil group | Depth to bedrock or hardpan | Depth from surface             | USDA texture  | Classification     |                        |
|---|-----------------------|-----------------------------|--------------------------------|---|--------------------|------------------------|
|   |                       |                             |                                |   | Unified            | AASHTO                 |
| Martinez: Mg -----<br>Mine pits and dumps: Mn.<br>Properties too variable to be estimated.  | D                     | <i>Inches</i><br>60+        | <i>Inches</i><br>0-35<br>35-60 | Loam or clay loam and clay<br>Gravelly sandy clay -----   | CH or CL<br>SC     | A-7, A-6<br>A-2, A-7   |
| Pima: Pm -----  | B                     | 60+                         | 0-26<br>26-60                  | Clay loam -----<br>Stratified loam, fine sandy loam, and very fine sandy loam.  | CL<br>ML, CL       | A-7, A-6<br>A-4, A-6   |
| Pima variant: Pn -----  | B                     | 60+                         | 0-19<br>19-40<br>40-60         | Clay loam -----<br>Sandy clay loam -----<br>Gravelly sandy loam -----   | CL<br>SC, CL<br>SM | A-6, A-7<br>A-6<br>A-2 |
| Pinaleno: PoC -----   | B                     | 60+                         | 0-60                           | Gravelly sandy loam, very gravelly sandy clay loam, and sandy loam.   | GM, GC,<br>GC-GW   | A-1, A-2               |
| Rillino: RIE2 -----<br>Rock outcrop-Lithic Haplustolls association: Rn.<br>Properties too variable to be estimated.                                       | B                     | 60+                         | 0-60                           | Gravelly loam and loam -----  | SM, SC             | A-4, A-2               |
| Rock outcrop: Rr.<br>Properties too variable to be estimated.   |                       |                             |                                |   |                    |                        |
| Schrap: ScD, ShF -----  | D                     | 3-20                        | 0-17<br>17                     | Very shaly clay loam -----<br>Fractured shale bedrock.  | GC, GP             | A-1                    |
| Signal: SnD -----   | C                     | 60+                         | 0-19<br>19-72                  | Gravelly loam and clay -----<br>Very gravelly clay loam, very gravelly sandy clay loam, and very gravelly sandy loam. | CH, CL<br>GC, GP   | A-7, A-6<br>A-2        |
| Sonoita: SoB, SoD -----   | B                     | 60+                         | 0-70                           | Gravelly sandy loam -----   | SM                 | A-2                    |
| Telephone -----<br>Mapped only in an association with Hogris soils.   | D                     | 5-20                        | 0-6<br>6-30                    | Very gravelly loam -----<br>Sandstone bedrock.  | GC                 | A-2, A-4               |
| Torrifluvents and Haplustolls: Th.<br>Properties too variable to be estimated.  |                       |                             |                                |   |                    |                        |
| Tortugas: TrE, TrF -----<br>Rock outcrop too variable to be estimated.  | D                     | 6-20                        | 0-14<br>14-16                  | Very cobbly loam -----<br>Limestone bedrock, fractured.   | GC                 | A-2, A-4               |
| *White House: WgC, WgE, WhC, WnC, WoE, WfF.<br>For Bonita part of unit WnC, Caralampi part of WoE, and Hathaway part of WfF, see those respective series. | C                     | 60+                         | 0-39<br>39-78                  | Gravelly loam, clay loam, and clay.<br>Gravelly sandy clay loam -----   | CL<br>SC           | A-4, A-6, A-7<br>A-2   |

significant in engineering—Continued

| Coarse fraction greater than 3 inches | Percentage less than 3 inches passing sieve— |                       |                          |                         | Permeability                         | Available water capacity                        | Reaction                      | Shrink-swell potential                    | Corrosivity to uncoated steel |
|---------------------------------------|--|-----------------------|--------------------------|-------------------------|--------------------------------------|---|-------------------------------|---|-------------------------------|
|                                       | No. 4  | No. 10                | No. 40                   | No. 200                 |                                      |   |                               |   |                               |
| Percent<br>0-5<br>0-5                 | 90-100<br>80-90                              | 85-100<br>65-75       | 70-95<br>60-70           | 65-90<br>35-50          | Inches per hour<br><0.06<br>0.06-0.2 | Inch per inch of soil<br>0.14-0.16<br>0.08-0.14 | pH<br>5.1-6.0<br>8.0-8.4      | High -----<br>High -----                  | High.<br>High.                |
| 0<br>0                                | 100<br>100                                   | 100<br>100            | 95-100<br>65-85          | 75-85<br>50-70          | 0.2-0.6<br>0.6-2.0                   | 0.19-0.21<br>0.13-0.16                          | 7.4-8.4<br>7.4-8.4            | High -----<br>Low to moderate.            | High.<br>High.                |
| 0<br>0<br>0-5                         | 100<br>95-100<br>85-95                       | 100<br>85-95<br>60-80 | 95-100<br>70-85<br>35-50 | 75-85<br>35-50<br>20-35 | 0.2-0.6<br>0.2-0.6<br>0.6-2.0        | 0.19-0.21<br>0.14-0.16<br>0.07-0.09             | 7.9-8.4<br>7.9-8.4<br>7.9-8.4 | High -----<br>Moderate -----<br>Low ----- | High.<br>High.<br>High.       |
| 0-15                                  | 35-50  | 25-40                 | 20-35                    | 10-25                   | 0.2-0.6                              | 0.04-0.07                                       | 6.6-8.4                       | Low -----                                 | High.                         |
| 0-5                                   | 75-90  | 65-75                 | 55-70                    | 35-50                   | 0.6-2.0                              | 0.11-0.13                                       | 7.9-8.4                       | Low -----                                 | High.                         |
| 5-30                                  | 25-40  | 15-35                 | 15-30                    | 10-25                   | 0.2-0.6                              | 0.07-0.09                                       | 6.6-7.8                       | Moderate -----                            | High.                         |
| 0-20<br>0-10                          | 80-95<br>30-55                               | 75-90<br>25-35        | 65-85<br>20-35           | 55-80<br>10-25          | 0.06-0.2<br>0.6-2.0                  | 0.14-0.16<br>0.05-0.07                          | 6.1-8.4<br>7.9-8.4            | High -----<br>Moderate -----              | High.<br>High.                |
| 0-5<br>40-75                          | 70-95<br>45-60                               | 65-75<br>30-55        | 40-65<br>30-50           | 20-35<br>20-40          | 0.2-0.6<br>0.6-2.0                   | 0.07-0.10<br>0.07-0.09                          | 5.6-8.4<br>5.1-6.5            | Low -----<br>Low -----                    | High.<br>Low.                 |
| 40-75                                 | 40-60  | 30-55                 | 30-50                    | 20-40                   | 0.6-2.0                              | 0.04-0.06                                       | 7.9-8.4                       | Low -----                                 | Moderate.                     |
| 0-5<br>0-10                           | 90-100<br>65-75                              | 70-85<br>55-65        | 65-80<br>45-60           | 60-80<br>20-35          | 0.06-0.2<br>0.2-0.6                  | 0.14-0.16<br>0.09-0.10                          | 5.6-8.4<br>7.9-8.4            | High -----<br>Moderate -----              | High.<br>High.                |

TABLE 8.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. Carefully the instructions for referring to other

| Soil series and map symbols  | Degree and kind of limitation for—                  |   |   |  |
|--|---|---|---|--|
|  | Septic tank absorption fields                       | Dwellings without basements   | Sanitary landfill <sup>1</sup> (trench type)  | Local roads and streets  |
| Anthony: An -----  | Generally slight. Severe where subject to flooding. | Generally slight. Severe where subject to flooding.                                       | Generally slight. Severe where subject to flooding.   | Generally slight. Moderate where subject to occasional flooding.   |
| Anthony variant: Ao ---  | Severe: subject to seasonal flooding.               | Severe: subject to seasonal flooding.   | Severe: subject to seasonal flooding.   | Moderate: subject to seasonal flooding.  |
| Atascosa: AtF -----  | Severe: bedrock at a depth of 4 to 20 inches.       | Severe: bedrock at a depth of 4 to 20 inches.   | Severe: bedrock at a depth of 4 to 20 inches.   | Severe: bedrock at a depth of 4 to 20 inches.  |
| *Barkerville: BaE, BgF<br>For Gaddes part, see Gaddes series.                          | Severe: bedrock at a depth of 10 to 20 inches.      | Moderate where slopes are 10 to 15 percent. Severe where slopes are 15 to 60 percent.     | Severe: bedrock at a depth of 10 to 20 inches.  | Severe: slopes of 10 to 60 percent.  |
| *Bernardino: BbD -----<br>For Hathaway part, see Hathaway series.                      | Severe: moderately slow or slow permeability.       | Severe: high shrink-swell potential.  | Slight where slopes are 2 to 15 percent. Moderate where slopes are 15 to 25 percent.  | Severe: high shrink-swell potential.   |
| Bonita: BoB -----  | Severe: very slow permeability.                     | Severe: high shrink-swell potential.  | Severe: excessive fines.  | Severe: high shrink-swell potential.   |
| Calciorthids-Haplargids association: Ca.<br>Properties too variable to be interpreted. |   |   |   |  |
| Canelo: CbD, CdE, CeD --   | Severe: very slow permeability.                     | Moderate: somewhat poorly drained.  | Severe: seasonal high water table.  | Moderate where slopes are less than 15 percent: somewhat poorly drained. Severe where slopes are more than 15 percent. |
| Caralampi: CgE, CgF2 --  | Moderate: moderate permeability.                    | Moderate where slopes are 10 to 15 percent. Severe where slopes are more than 15 percent. | Slight where slopes are 10 to 15 percent. Moderate where slopes are 15 to 25 percent. Severe where slopes are more than 25 percent. | Moderate where slopes are 10 to 15 percent. Severe where slopes are more than 15 percent.                              |
| Caralampi variant: CIB.  | Moderate: moderately slow permeability.             | Moderate: moderate shrink-swell potential.  | Moderate: clay loam, clay, and sandy clay.  | Moderate: moderate shrink-swell potential.   |
| Casto: CmE -----   | Moderate: moderate permeability.                    | Moderate where slopes are 10 to 15 percent. Severe where slopes are more than 15 percent. | Slight where slopes are 10 to 15 percent. Moderate where slopes are 15 to 25 percent. Severe where slopes are more than 25 percent. | Moderate where slopes are 10 to 15 percent. Severe where slopes are more than 15 percent.                              |

*interpretations*

The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow series that appear in the first column of this table]

| Suitability as a source of—   |   |   | Soil features affecting—  |   |
|---|---|---|---|---|
| Road fill   | Sand and gravel   | Topsoil                                     | Pond reservoir areas  | Embankments, dikes, and levees  |
| Good -----  | Poor: 15 to 30 percent fines.   | Poor: excessive rock fragments.             | Moderately rapid permeability.  | Medium shear strength; medium compacted permeability; high piping hazard.         |
| Good -----  | Poor between depths of 0 and 16 inches: excessive fines.<br>Fair between depths of 16 and 60 inches: 35 to 70 percent gravel and cobbles. | Poor: excessive rock fragments.             | Moderately rapid permeability; more than 35 percent, by volume, rock fragments below a depth of 16 inches.  | High shear strength; high or medium compacted permeability; medium piping hazard. |
| Poor: slopes of 30 to 50 percent.   | Unsuited: bedrock at a depth of 4 to 20 inches.   | Poor: bedrock at a depth of 4 to 20 inches. | Bedrock at a depth of 4 to 20 inches; slopes of 30 to 50 percent.   | Medium shear strength; medium compacted permeability; low piping hazard.          |
| Poor: bedrock at a depth of 10 to 20 inches.  | Unsuited: bedrock at a depth of 10 to 20 inches.  | Poor: excessive rock fragments.             | Bedrock at a depth of 10 to 20 inches; slopes of 10 to 50 percent.  | Medium shear strength; medium compacted permeability; medium piping hazard.       |
| Good -----  | Poor: excessive fines   | Poor: excessive rock fragments.             | Slow or moderately slow permeability to a depth of 15 inches; moderate to moderately rapid below a depth of 15 inches; slopes of 2 to 30 percent. | Medium shear strength; medium compacted permeability; medium piping hazard.       |
| Poor: high shrink-swell potential.  | Unsuited: excessive fines.  | Poor: clay texture                          | Very slow and slow permeability; slopes of 0 to 5 percent.  | Low shear strength; low compacted permeability; low piping hazard.                |
| Fair where slopes are less than 25 percent: somewhat poorly drained.<br>Poor where slopes are more than 25 percent.               | Poor: excessive fines   | Poor: excessive rock fragments.             | Very slow permeability; slopes of 0 to 40 percent; more than 35 percent rock fragments by volume.   | Medium shear strength; low compacted permeability; low piping hazard.             |
| Good where slopes are 10 to 15 percent.<br>Fair where slopes are 15 to 25 percent.<br>Poor where slopes are more than 25 percent. | Poor: excessive fines   | Poor: excessive rock fragments.             | Moderate permeability below a depth of 23 inches; slopes of 10 to 60 percent; more than 35 percent rock fragments by volume.                      | High shear strength; medium compacted permeability; medium piping hazard.         |
| Fair: moderate shrink-swell potential.  | Unsuited: excessive fines.  | Poor: excessive rock fragments.             | Moderately slow permeability; more than 35 percent rock fragments by volume.  | Medium shear strength; low compacted permeability; medium piping hazard.          |
| Good where slopes are 10 to 15 percent.<br>Fair where slopes are 15 to 25 percent.<br>Poor where slopes are more than 25 percent. | Poor: excessive fines   | Poor: excessive rock fragments.             | Slopes of 10 to 40 percent; moderate permeability below a depth of 28 inches; more than 35 percent rock fragments by volume.                      | Medium shear strength; low compacted permeability; low piping hazard.             |

TABLE 8.—*Engineering*

| Soil series and map symbols   | Degree and kind of limitation for—                                    |  |  |   |
|---|---|--|--|---|
|   | Septic tank absorption fields   | Dwellings without basements  | Sanitary landfill <sup>1</sup> (trench type)                             | Local roads and streets   |
| Cave: Cn -----  | Generally slight -----  | Moderate: lime hardpan at a depth of 4 to 20 inches.   | Severe: 6 to 20 inches per hour permeability below a depth of 18 inches. | Moderate: lime hardpan at a depth of 4 to 20 inches.  |
| *Chiricahua: CoE, CrD<br>For Lampshire part of CrD, see Lampshire series.     | Severe: bedrock at a depth of 10 to 20 inches.                        | Moderate where slopes are less than 15 percent: bedrock at a depth of 10 to 20 inches.<br>Severe where slopes of more than 15 percent: 20 percent Rock outcrop in CrD. | Severe: bedrock at a depth of 10 to 20 inches.                           | Moderate: bedrock at a depth of 10 to 20 inches.<br>Severe: 20 percent Rock outcrop in CrD.                                       |
| Comoro: CsC, CtB -----  | Generally slight.<br>Severe in CtB: subject to flooding.              | Generally slight.<br>Severe in CtB: subject to flooding.   | Generally slight.<br>Severe in CtB: subject to flooding.                 | Generally slight.<br>Severe in CtB: subject to flooding.  |
| *Continental: CuC,<br>CvE2<br>For Rillino part of CvE2, see Rillino series.   | Moderate: moderate permeability below a depth of 31 inches.           | Severe: high shrink-swell potential.   | Generally slight -----   | Severe: high shrink-swell potential below a depth of 10 inches.   |
| Eba: EbC -----  | Severe: slow permeability.  | Moderate: moderate shrink-swell potential.   | Severe: clay -----   | Moderate: moderate shrink-swell potential.  |
| *Fanno: FaD<br>For Luzena part, see Luzena series.                            | Severe: bedrock at a depth of 20 to 40 inches.                        | Moderate where slopes are less than 15 percent: bedrock at a depth of 20 to 40 inches.<br>Severe where slopes of more than 15 percent.                                 | Severe: bedrock at a depth of 20 to 40 inches.                           | Moderate where slopes are less than 15 percent: moderate shrink-swell potential.<br>Severe where slopes are more than 15 percent. |
| Fanno variant: FcF -----  | Severe: slow permeability.  | Severe: slopes of more than 15 percent.  | Severe: slopes of 20 to 50 percent.                                      | Severe: slopes of more than 15 percent.   |
| *Faraway: FrE, FrF,<br>FtF.<br>For Tortugas part of FtF, see Tortugas series. | Severe: bedrock at a depth of 5 to 20 inches.                         | Severe: bedrock at a depth of 5 to 20 inches.  | Severe: bedrock at a depth of 5 to 20 inches.                            | Severe: bedrock at a depth of 5 to 20 inches.   |
| Gaddes: GaE -----   | Severe: bedrock at a depth of 20 to 30 inches.                        | Moderate where slopes are less than 15 percent: moderate shrink-swell potential.<br>Severe where slopes are more than 15 percent.                                      | Severe: bedrock at a depth of 20 to 30 inches.                           | Severe: 10 to 15 percent Rock outcrop.  |
| *Grabe: GbB, Ge<br>For Comoro part of GbB, see Comoro series.                 | Moderate: moderate permeability.<br>Severe where subject to flooding. | Generally slight.<br>Severe where subject to flooding.   | Generally slight.<br>Severe where subject to flooding.                   | Moderate: some areas subject to flooding.   |

*interpretations*—Continued

| Suitability as a source of—   |   |   | Soil features affecting—  |   |
|---|---|---|---|---|
| Road fill   | Sand and gravel   | Topsoil                                     | Pond reservoir areas  | Embankments, dikes, and levees  |
| Good -----  | Unsuited for sand; fair for gravel below hardpan at a depth of 18 inches. | Poor: excessive rock fragments; high lime.  | Lime hardpan at a depth of 4 to 20 inches; rapid permeability below a depth of 18 inches.               | High shear strength; high compacted permeability; low piping hazard.  |
| Poor: bedrock at a depth of 10 to 20 inches.  | Unsuited: bedrock at a depth of 10 to 20 inches.                          | Poor: excessive rock fragments.             | Hard bedrock at a depth of 10 to 20 inches; slopes of 5 to 45 percent; moderately slow permeability.    | Medium shear strength; low compacted permeability; low piping hazard.   |
| Good -----  | Poor: excessive fines   | Good -----                                  | Moderately rapid or rapid permeability.   | Medium shear strength; medium compaction permeability; high piping hazard.  |
| Fair: moderate shrink-swell potential.  | Poor for sand; fair for gravel in substratum; 15 to 25 percent fines.     | Poor: excessive rock fragments.             | Moderately slow or moderate permeability; slopes of 2 to 15 percent; 15 to 50 percent rock fragments.   | Medium shear strength; low compacted permeability; low piping hazard; slopes of 2 to 15 percent.  |
| Fair: moderate shrink-swell potential.  | Poor: excessive fines   | Poor: excessive rock fragments.             | Moderate or moderately slow permeability; slopes of 0 to 10 percent; 50 percent or more rock fragments. | Medium shear strength; low compacted permeability; medium piping hazard; 50 percent or more, by volume, fragments.  |
| Poor: bedrock at a depth of 20 to 40 inches.  | Unsuited: bedrock at a depth of 20 to 40 inches.                          | Poor: clay texture                          | Moderately slow permeability; bedrock at a depth of 20 to 40 inches; slopes of 5 to 20 percent.         | Low shear strength; low compacted permeability; low piping hazard; slopes of 5 to 20 percent; 50 percent or more, by volume, rock fragments.                  |
| Fair: moderate shrink-swell potential.  | Unsuited -----  | Poor: excessive rock fragments.             | Slow permeability; slopes of 20 to 50 percent; bedrock at a depth of 22 to 60 inches.                   | Low shear strength; low compacted permeability; low piping hazard; slopes of 20 to 50 percent.  |
| Poor: bedrock at a depth of 5 to 20 inches.   | Unsuited: bedrock at a depth of 5 to 20 inches.                           | Poor: bedrock at a depth of 5 to 20 inches. | Moderate permeability; bedrock at a depth of 5 to 20 inches; slopes of 10 to 60 percent.                | Bedrock at a depth of 5 to 20 inches; high shear strength; medium compacted permeability; medium piping hazard; 50 percent or more by volume, rock fragments. |
| Fair where slopes are less than 25 percent: moderate shrink-swell potential.<br>Poor where slopes are more than 25 percent. | Unsuited: bedrock at a depth of 20 to 30 inches.                          | Poor: excessive rock fragments.             | Moderately slow permeability; bedrock at a depth of 20 to 30 inches; slopes of 5 to 45 percent.         | Medium shear strength; low compacted permeability; low piping hazard; slopes of 5 to 45 percent; bedrock at a depth of 20 to 30 inches.                       |
| Fair: excessive fines   | Poor: excessive fines   | Good -----                                  | Moderate permeability   | Medium shear strength; low compacted permeability; medium piping hazard; subject to flooding.   |

TABLE 8.—*Engineering*

| Soil series and map symbols   | Degree and kind of limitation for—   |  |  |  |
|---|--|--|--|--|
|   | Septic tank absorption fields  | Dwellings without basements  | Sanitary landfill <sup>1</sup> (trench type)   | Local roads and streets  |
| Graham: GhD, GhF ----   | Severe: bedrock at a depth of 8 to 20 inches.  | Severe: high shrink-swell potential.   | Severe: bedrock at a depth of 8 to 20 inches.  | Severe: bedrock at a depth of 8 to 20 inches.  |
| Guest: Gu -----   | Severe: slow permeability; some areas subject to flooding.   | Severe: high shrink-swell potential; some areas subject to flooding.   | Severe: clay -----   | Severe: high shrink-swell potential.   |
| Hathaway: HaF, HhE2 --  | Slight where slopes are 1 to 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent. | Slight where slopes are 1 to 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent. | Slight where slopes are 1 to 15 percent. Moderate where slopes are 15 to 25 percent. Severe where slopes are more than 25 percent. | Slight where slopes are 1 to 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent. |
| *Hogris: HoF, HtF -----<br>For Telephone part, see Telephone series.  | Severe: slopes of 20 to 80 percent.  | Severe: slopes of 20 to 80 percent.  | Severe: slopes of 20 to 80 percent.  | Severe: slopes of 20 to 80 percent; 25 percent Rock outcrop in HtF.  |
| Kimbrough: Kbc -----  | Severe: hardpan at a depth of 6 to 20 inches.  | Moderate: hardpan at a depth of 6 to 20 inches.  | Severe: hardpan at a depth of 6 to 20 inches.  | Moderate: indurated lime hardpan at a depth of 6 to 20 inches.   |
| Lampshire: LaE, LaF, LcF, LgF.<br>For Chiricahua part of LcF and Graham part of LgF, see those respective series. | Severe: bedrock at a depth of 4 to 20 inches.  | Severe: bedrock at a depth of 4 to 20 inches.  | Severe: bedrock at a depth of 4 to 20 inches.  | Severe: bedrock at a depth of 4 to 20 inches.  |
| Luzena -----<br>Mapped only in an association with Fanno soils.   | Severe: bedrock at a depth of 7 to 20 inches.  | Severe: bedrock at a depth of 7 to 20 inches.  | Severe: bedrock at a depth of 7 to 20 inches.  | Severe: bedrock at a depth of 7 to 20 inches.  |
| Luzena variant: LuD ---   | Severe: bedrock at a depth of 20 to 50 inches.   | Severe: high shrink-swell potential.   | Severe: bedrock at a depth of 20 to 50 inches.   | Severe: high shrink-swell potential.   |
| Mabray: McF -----<br>For Chiricahua part, see Chiricahua series.  | Severe: bedrock at a depth of 4 to 20 inches.  | Severe: bedrock at a depth of 4 to 20 inches.  | Severe: bedrock at a depth of 4 to 20 inches.  | Severe: bedrock at a depth of 4 to 20 inches.  |
| Martinez: Mg -----  | Severe: slow or very slow permeability.  | Severe: high shrink-swell potential.   | Severe: clay texture   | Severe: high shrink-swell potential.   |

interpretations—Continued

| Suitability as a source of—  |   |                                 | Soil features affecting—   |  |
|--|---|---------------------------------|--|--|
| Road fill  | Sand and gravel   | Topsoil                         | Pond reservoir areas   | Embankments, dikes, and levees   |
| Poor: bedrock at a depth of 8 to 20 inches.  | Unsuited: bedrock at a depth of 8 to 20 inches.                       | Poor: excessive rock fragments. | Slow permeability; bedrock at a depth of 8 to 20 inches; slopes of 5 to 50 percent.  | Bedrock at a depth of 8 to 20 inches; low compacted permeability; low piping hazard; slopes of 5 to 50 percent by volume.                              |
| Poor: excessive fines  | Poor: no sand or gravel.  | Poor: clay texture              | Slow permeability  | Low shear strength; low compacted permeability; low piping hazard.   |
| Good where slopes are 1 to 15 percent.<br>Fair where slopes are 15 to 25 percent.<br>Poor where slopes are more than 25 percent. | Poor for sand.<br>Fair for gravel: 10 to 25 percent fines.            | Poor: excessive rock fragments. | Moderate permeability: slopes of 1 to 60 percent; rock fragments more than 35 percent by volume.   | Medium shear strength; low compacted permeability; low piping hazard; 15 to more than 50 percent rock fragments; slopes of 10 to 40 percent by volume. |
| Fair where slopes are 20 to 25 percent.<br>Poor where slopes are more than 25 percent: 25 percent Rock outcrop in HtF.           | Unsuited: slopes of 20 to 80 percent; 25 percent Rock outcrop in HtF. | Poor: excessive rock fragments. | Moderate permeability; slopes of 20 to 80 percent; bedrock at a depth of 40 to more than 60 inches; more than 50 percent rock fragments in HtF.      | Medium shear strength; medium compacted permeability; medium piping hazard; slopes of 20 to 80 percent; 25 percent Rock outcrop in HtF.                |
| Poor: indurated lime hardpan at a depth of 6 to 20 inches.   | Poor: no sand.<br>Good or fair for gravel below a depth of 6 inches.  | Poor: excessive rock fragments. | Hardpan at a depth of 6 to 20 inches; weakly to strongly lime cemented below a depth of 26 inches, variable permeability; slopes of 2 to 15 percent. | High shear strength; medium compacted permeability; low piping hazard; hardpan at a depth of 6 to 20 inches.   |
| Poor: bedrock at a depth of 4 to 20 inches.  | Unsuited: bedrock at a depth of 4 to 20 inches.                       | Poor: excessive rock fragments. | Moderate permeability; bedrock at a depth of 4 to 20 inches; slopes of 0 to 60 percent.  | Medium shear strength; low compacted permeability; medium piping hazard; bedrock at a depth of 4 to 20 inches.   |
| Poor: bedrock at a depth of 7 to 20 inches.  | Unsuited: bedrock at a depth of 7 to 20 inches.                       | Poor: excessive rock fragments. | Slow permeability; bedrock at a depth of 7 to 20 inches; slopes of 5 to 20 percent.  | Low shear strength; low compacted permeability; low piping hazard; bedrock at a depth of 4 to 20 inches.   |
| Poor: bedrock at a depth of 20 to 50 inches.   | Unsuited: bedrock at a depth of 20 to 50 inches.                      | Poor: excessive rock fragments. | Moderately slow permeability; bedrock at a depth of 20 to 50 inches; slopes of 5 to 20 percent.  | Low shear strength; low compacted permeability; low piping hazard; bedrock at a depth of 20 to 50 inches.  |
| Poor: bedrock at a depth of 4 to 20 inches.  | Unsuited: bedrock at a depth of 4 to 20 inches.                       | Poor: excessive rock fragments. | Bedrock at a depth of 4 to 20 inches; slopes of 30 to 45 percent; 30 percent Rock outcrop.   | High shear strength; medium compacted permeability; low piping hazard; bedrock at a depth of 4 to 20 inches.   |
| Poor: high shrink-swell potential.   | Unsuited: no sand or gravel.  | Poor: clay texture              | Very slow or slow permeability.  | Low shear strength; low compacted permeability; low piping hazard.   |

TABLE 8.—*Engineering*

| Soil series and map symbols  | Degree and kind of limitation for—   |  |  |  |
|--|--|--|--|--|
|  | Septic tank absorption fields  | Dwellings without basements  | Sanitary landfill <sup>1</sup> (trench type)   | Local roads and streets  |
| Mine pits and dumps: Mn.<br>Properties too variable to be interpreted.                         |  |  |  |  |
| Pima: Pm -----   | Moderate: moderate permeability below a depth of 26 inches. Severe in areas subject to flooding. | Severe: high shrink-swell potential; some areas subject to flooding.                     | Generally slight. Moderate where subject to flooding.  | Severe: high shrink-swell potential to a depth of 26 inches.   |
| Pima variant: Pn -----   | Severe: moderately slow permeability; some areas subject to flooding.                            | Generally slight. Severe where subject to flooding.                                      | Generally slight. Severe where subject to flooding.  | Moderate: moderate shrink-swell potential; some areas subject to flooding.   |
| Pinaleno: PoC -----  | Severe: moderately slow permeability.  | Generally slight. Moderate where slopes are 8 to 10 percent.                             | Generally slight -----   | Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 10 percent.   |
| Rillino: RIE2 -----  | Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.         | Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent. | Slight where slopes are 8 to 15 percent. Moderate where slopes are 15 to 25 percent. Severe where slopes are more than 25 percent. | Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.   |
| Rock outcrop-Lithic Haplustolls association: Rn.<br>Properties too variable to be interpreted. |  |  |  |  |
| Rock outcrop: Rr.<br>Properties too variable to be interpreted.                                |  |  |  |  |
| Schrap: ScD, ShF -----   | Severe: shale bedrock at a depth of 3 to 20 inches.  | Severe: shale bedrock at a depth of 3 to 20 inches.                                      | Severe: shale bedrock at a depth of 3 to 20 inches.  | Severe: shale bedrock at a depth of 3 to 20 inches.  |
| Signal: SnD -----  | Moderate: moderate permeability.   | Severe: high shrink-swell potential to a depth of 19 inches.                             | Moderate: excessive fines.   | Severe: high shrink-swell potential to a depth of 19 inches.   |
| Sonoita: SoB, SoD -----  | Generally slight -----   | Generally slight -----   | Generally slight -----   | Slight where slopes are 1 to 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent. |
| Telephone -----<br>Mapped only in an association with Hogris soils.                            | Severe: bedrock at a depth of 5 to 20 inches.  | Severe: bedrock at a depth of 5 to 20 inches; steep slopes.                              | Severe: bedrock at a depth of 5 to 20 inches.  | Severe: bedrock at a depth of 5 to 20 inches.  |

interpretations—Continued

| Suitability as a source of—  |  |  | Soil features affecting—  |   |
|--|--|--|---|---|
| Road fill  | Sand and gravel  | Topsoil                                | Pond reservoir areas  | Embankments, dikes, and levees  |
| Fair: moderate shrink-swell potential.   | Unsuited: no sand or gravel.   | Fair: clay loam or heavy loam texture. | Moderately slow permeability to a depth of 26 inches, and moderate below.   | Medium shear strength; low compacted permeability; medium piping hazard.  |
| Fair: moderate shrink-swell potential.   | Poor: no sand or gravel.   | Fair: clay loam texture.               | Moderately slow permeability to a depth of 26 inches, and moderate below.   | Low shear strength; low compacted permeability; low piping hazard.  |
| Good -----   | Poor for sand. Fair for gravel. 10 to 25 percent fines.                            | Poor: excessive rock fragments.        | Moderately slow permeability; 50 percent or more rock fragments, by volume; slopes of 0 to 10 percent.                                  | Medium shear strength; medium compacted permeability; low piping hazard; slopes of 0 to 10 percent.   |
| Good where slopes are 8 to 15 percent. Fair where slopes are 15 to 25 percent. Poor where slopes are more than 25 percent. | Poor: excessive fines  | Poor: excessive rock fragments.        | Moderate permeability; slopes of 8 to 40 percent; 15 to 35 percent, by volume, rock fragments.  | Medium shear strength; low compacted permeability; medium piping hazard; slopes of 8 to 40 percent.   |
| Poor: shale bedrock at a depth of 3 to 20 inches.  | Unsuited: shale bedrock at a depth of 3 to 20 inches.                              | Poor: excessive rock fragments.        | Slow permeability; bedrock at a depth of 3 to 20 inches; slopes of 5 to 50 percent.   | Medium shear strength; low compacted permeability; medium piping hazard; bedrock at a depth of 3 to 20 inches; slopes of 5 to 50 percent.       |
| Fair: moderate shrink-swell potential.   | Poor for sand. Fair for gravel below a depth of 19 inches; 10 to 25 percent fines. | Poor: excessive rock fragments.        | Slow permeability to a depth of 19 inches and moderate below; 50 percent or more, by volume, rock fragments; slopes of 1 to 20 percent. | Medium shear strength; low compacted permeability; low piping hazard; 50 percent or more, by volume, rock fragments; slopes of 1 to 20 percent. |
| Good -----   | Poor: excessive fines  | Poor: excessive rock fragments.        | Moderately slow permeability; slopes of 1 to 20 percent.  | Medium shear strength; medium compacted permeability; medium piping hazard; slopes of 1 to 20 percent.  |
| Poor: bedrock at a depth of 5 to 20 inches.  | Unsuited: bedrock at a depth of 5 to 20 inches.                                    | Poor: excessive rock fragments.        | Moderate permeability; bedrock 5 to 20 inches; slopes of 30 to 50 percent.  | Medium shear strength; low compacted permeability; low piping hazard; bedrock at a depth of 5 to 20 inches; slopes of 30 to 50 percent.         |

TABLE 8.—*Engineering*

| Soil series and map symbols  | Degree and kind of limitation for—            |   |   |   |
|--|---|---|---|---|
|  | Septic tank absorption fields                 | Dwellings without basements                   | Sanitary landfill <sup>1</sup> (trench type)  | Local roads and streets                       |
| Torrifluvents and Haplustolls: Th.<br>Properties too variable to be interpreted.   |   |   |   |   |
| Tortugas: TrE, TrF -----   | Severe: bedrock at a depth of 6 to 20 inches. | Severe: bedrock at a depth of 6 to 20 inches. | Severe: bedrock at a depth of 6 to 20 inches. | Severe: bedrock at a depth of 6 to 20 inches. |
| White House: WgC, WgE, WhC, WnC, WoE, WtF<br>For Bonita part of WnC, Caralampi part of WoE, and Hathaway part of WtF, see those respective series. | Severe: slow or moderately slow permeability. | Severe: high shrink-swell potential.          | Moderate: excessive fines.                    | Severe: high shrink-swell potential.          |

<sup>1</sup> Interpretations are made to a depth of 60 inches or to bedrock. Onsite study is needed of the deep underlying strata, the

A-2-5, A-2-6, A-2-7, A-7-5, and A-7-6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils, with group index numbers in parentheses, is shown in table 6; the estimated classification, without group index numbers, is given in table 7 for all soils mapped in the survey area.

#### Soil test data<sup>9</sup>

Table 6 contains engineering test data for some of the major soil series in the survey area. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction (or moisture-density) data are important in earthwork. The highest dry density obtained in the compactive test is termed *maximum dry density*. If a soil material is compacted at successively high moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increases in moisture content. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Tests to determine liquid limit and plastic limit measure the effect of water on the strength and consistency of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material

changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from the semisolid to plastic state; and the liquid limit, from a plastic state, to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

#### Estimated engineering properties

Table 7 gives estimates of soil properties important to engineering uses. The estimates are for the major horizons of the representative profile of each soil series in the survey area. These estimates are based on characterization data of selected soils, extrapolation of data from table 6, selected laboratory data provided by the University of Arizona, field descriptions, test data of similar soils in nearby areas, and other sources. These estimates do not cover the full range of variations within a soil series nor of inclusions within a mapping unit. Following are explanations of some of the column headings in table 7.

Hydrologic soil groups are used for estimating the runoff potential of soils on watersheds. Four groups, based on soil properties that influence runoff, are used (12).

The grouping indicates the minimum rate of infiltration at the end of a storm in which the soil has had prolonged wetting and opportunity for swelling, without the protective effect of vegetation.

Group A includes soils that have a high infiltration rate when thoroughly wetted. They are chiefly deep, well-drained to excessively drained sand or gravel. These soils have a high rate of water transmission and have low runoff potential.

Group B includes soils that have a moderate infiltration rate when thoroughly wetted. Their rate of

<sup>9</sup> By WILLIAM MILDNER, Soil Conservation Service.

## interpretations—Continued

| Suitability as a source of—                 |   |  | Soil features affecting—   |   |
|---|---|--|--|---|
| Road fill                                   | Sand and gravel                                 | Topsoil  | Pond reservoir areas   | Embankments, dikes, and levees  |
| Poor: bedrock at a depth of 6 to 20 inches. | Unsuited: bedrock at a depth of 6 to 20 inches. | Poor: excessive rock fragments.                                | Bedrock at a depth of 6 to 20 inches; slopes of 5 to 70 percent. | Medium shear strength; low compacted permeability; low piping hazard; bedrock at a depth of 6 to 20 inches. |
| Poor: high shrink-swell potential.          | Poor: excessive fines                           | Poor: excessive rock fragments in surface layer; clay texture. | Slow or moderately slow permeability; slopes of 0 to 40 percent. | Medium shear strength; low compacted permeability; low piping hazard; slopes of 0 to 40 percent.            |

water table, and the hazards of aquifer pollution and drainage into ground water in landfill deeper than 5 or 6 feet.

water transmission and runoff potential are moderate. These soils are moderately deep or deep, well drained, and have fine to moderately coarse texture.

Group C includes soils that have a slow infiltration rate when thoroughly wetted. Their rate of water transmission is slow, and potential runoff is high. These soils either have a layer that impedes the downward movement of water or they have moderately fine or fine texture.

Group D includes soils that have a very slow infiltration rate when thoroughly wetted. Their rate of water transmission is very slow, and runoff potential is very high. In this group are clay soils that have a high shrink-swell potential; soils that have a permanent high water table; soils that have a clay pan or clay layer at or near the surface; and soils that are shallow over nearly impervious material.

Depth to bedrock or hardpan is distance from the surface of the soil to the upper surface of the bedrock or hardpan.

Soil texture is described in table 7 in the standard terms used by the U. S. Department of Agriculture (10). These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand". "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure, porosity, and texture. The es-

timates in table 7 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed as pH. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or of material having this rating.

Corrosivity, as used in table 7, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel. Rate of corrosion of uncoated steel is related to such soil properties as drainage, texture, total acidity, and electrical conductivity of the soil material. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. A corrosivity rating of *low* means that there is a low probability of soil-induced corrosion damage. A rating of *high* means that there is a high probability of damage, so that protective measures for steel should be used to avoid or minimize damage.

Salinity is not rated in table 7 because soluble salts

are not present in the survey area in enough quantity to be a problem, except in a few small areas.

### Engineering interpretations

The interpretations in table 8 are based on the estimated engineering properties of soils shown in table 7, on test data for soils in this survey area and in areas nearby or adjoining, and on the experience of engineers and soil scientists with the soils in the survey area. In table 8, ratings are used to summarize limitations or suitability of the soils for all listed purposes other than pond reservoir areas and embankments, dikes, and levees.

Soil limitations are indicated by the ratings slight, moderate, and severe. *Slight* means soil properties generally favorable for the rated use, or in other words, limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties are so unfavorable and so difficult to correct or overcome as to require major soil reclamation, special designs, or intensive maintenance.

Soil suitability is rated by the terms *good*, *fair*, *poor*, and *unsuited*, which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the columns in table 8.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material between the depths of 30 inches and 5 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Dwellings, as rated in table 8, are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 8 apply only to a depth of about 6 feet, and therefore, limitation ratings of

*slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but regardless of that, every site should be investigated before it is selected.

Local roads and streets, as rated in table 8, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly of asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material, and also the shrink-swell potential, indicate load-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, presence of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage, and they also reflect the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 8 provide guidance about where to look for probable sources. A soil rated as *good* or *fair* source generally has a layer of sand or gravel at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or its response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments affect suitability, but also considered in the ratings is damage that will result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil are among factors that are unfavorable.

**Recreation**

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 9 the soils of the survey area are rated according to limitations that affect their suitability for camp and picnic areas, playgrounds, paths and trails, and lawns and golf fairways.

In table 9 the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation

can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these is required.

Camp areas are used intensively for tents, small camp trailers, and the activities of outdoor living. Little preparation of the site is required, other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have gentle slopes, good drainage, a surface free of rocks and coarse fragments, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry.

TABLE 9.—*Soil limitations for recreational development*

| Soil series and map symbols  | Camp and picnic areas   | Playgrounds  | Paths and trails   | Lawns and golf fairways  |
|--|---|--|--|--|
| Anthony: An -----  | Generally moderate: dust. Severe in areas subject to flooding.  | Generally moderate: dust. Severe in areas subject to flooding.   | Moderate: dust; some areas subject to flooding.  | Generally slight. Severe in areas subject to flooding.   |
| Anthony variant: Ao ---  | Severe: subject to flooding.  | Severe: subject to flooding.   | Moderate: subject to flooding.   | Severe: subject to flooding.   |
| Atascosa: AtF -----  | Severe: slopes of 30 to 50 percent; more than 50 percent gravel or cobbles or both.   | Severe: slopes of more than 6 percent; more than 20 percent gravel or cobbles or both.                                   | Severe: slopes of more than 25 percent; more than 50 percent gravel or cobbles or both.  | Severe: slopes of 30 to 50 percent; 4 to 20 inches deep over bedrock; droughty.  |
| Barkerville: BaE, BgF ---<br>For Gaddes part, see Gaddes series.                       | Moderate where slopes are 10 to 15 percent; 20 to 50 percent cobbles or gravel or both. Severe where slopes are more than 15 percent.   | Severe: slopes of more than 6 percent; 10 to 20 inches to bedrock; 20 to 50 percent cobbles or gravel or both.           | Moderate where slopes are less than 25 percent: 20 to 50 percent cobbles or gravel or both. Severe where slopes are more than 25 percent.                          | Severe: 10 to 20 inches to bedrock; slopes of 15 to 30 percent; droughty.  |
| Bernardino: BhD -----<br>For Hathaway part, see Hathaway series.                       | Moderate where slopes are less than 15 percent: clay loam; dust; 15 to 50 percent gravel. Severe where slopes are more than 15 percent.   | Moderate where slopes are 2 to 6 percent: gravelly clay loam surface layer. Severe where slopes are more than 6 percent. | Moderate where slopes are less than 25 percent: gravelly clay loam surface. Severe where slopes are more than 25 percent.  | Moderate where slopes are less than 15 percent: gravelly clay loam surface. Severe where slopes are more than 15 percent.  |
| Bonita: BoB -----  | Severe: clay surface layer.   | Severe: clay surface layer.  | Severe: clay surface layer.  | Severe: clay surface layer; slow and very slow permeability.   |
| Calciorthids-Haplargids association: Ca.<br>Properties too variable to be interpreted. |   |  |  |  |
| Canelo: CbD, CdE, CeD ---  | Moderate where slopes are less than 15 percent: somewhat poorly drained; 20 to 50 percent cobbles or gravel, or both. Severe where slopes are more than 15 percent: CdE has more than 50 percent cobbles or gravel or both. | Severe: very slow permeability; more than 20 percent cobbles or gravel or both.  | Moderate where slopes are less than 25 percent: somewhat poorly drained; 20 to 50 percent cobbles or gravel or both. Severe where slopes are more than 25 percent. | Moderate where slopes are less than 15 percent: 20 to 50 percent cobbles or gravel or both; somewhat poorly drained; very slow permeability. Severe where slopes are more than 15 percent. |

TABLE 9.—*Soil limitations for recreational development*—Continued

| Soil series and map symbols  | Camp and picnic areas  | Playgrounds  | Paths and trails   | Lawns and golf fairways  |
|--|--|--|--|--|
| Caralampi: CgE, CgF2   | Moderate where slopes are 10 to 15 percent: 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 15 percent.     | Severe: slopes of more than 6 percent; more than 20 percent gravel or cobbles or both.                             | Moderate where slopes are less than 25 percent: 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 25 percent. | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 15 percent. |
| Caralampi variant: CIB   | Moderate: 20 to 50 percent gravel.   | Severe: more than 20 percent gravel.   | Moderate: 20 to 30 percent gravel.   | Moderate: 20 to 50 percent gravel.   |
| Casto: CmE   | Severe: more than 50 percent gravel or cobbles or both.  | Severe: more than 50 percent gravel or cobbles or both.  | Severe: more than 50 percent gravel or cobbles or both.  | Severe: more than 50 percent gravel or cobbles or both.  |
| Cave: Cn   | Moderate: 20 to 50 percent gravel.   | Severe: 4 to 20 inches to indurated hardpan; 20 to 50 percent gravel.  | Moderate: 20 to 50 percent gravel.   | Severe: 4 to 20 inches to indurated hardpan; droughty.   |
| Chiricahua: CoE, CrD<br>For Lampshire part of CrD, see Lampshire series. | Moderate where slopes are less than 15 percent: 20 to 50 percent cobbles or gravel or both.<br>Severe where slopes are more than 15 percent. | Severe: slopes of more than 6 percent; more than 20 percent cobbles or gravel or both; 10 to 20 inches to bedrock. | Moderate where slopes are less than 25 percent: 20 to 50 percent cobbles or gravel or both.<br>Severe where slopes are more than 25 percent. | Severe: 10 to 20 inches to bedrock.  |
| Comoro: CsC, CiB   | Slight where slopes are less than 8 percent.<br>Moderate where slopes are 8 to 10 percent: CiB subject to flooding.                          | Moderate where slopes are 5 to 6 percent.<br>Severe where slopes are more than 6 percent: CiB subject to flooding. | Slight for CsC.<br>Moderate for CiB: subject to flooding.  | Slight for CsC.<br>Severe for CiB; subject to overflow.  |
| Continental: CuC, CvE2<br>For Rillino part of CvE2, see Rillino series.  | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 15 percent. | Severe: 20 to 50 percent gravel or cobbles or both.  | Moderate where slopes are less than 25 percent: 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 25 percent. | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 15 percent. |
| Eba: EbC   | Severe: 50 to 60 percent gravel or cobbles or both.  | Severe: 50 to 60 percent gravel or cobbles or both.  | Severe: 50 to 60 percent gravel or cobbles or both.  | Severe: 50 to 60 percent gravel or cobbles or both.  |
| Fanno: FaD<br>For Luzena part, see Luzena series.                        | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    | Severe: 20 to 50 percent gravel.   | Moderate: 20 to 50 percent gravel.   | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    |
| Fanno variant: FcF   | Severe: slopes of more than 15 percent; more than 50 percent gravel, cobbles, and stones.  | Severe: slopes of more than 6 percent; more than 20 percent gravel, cobbles, and stones.                           | Severe: more than 50 percent gravel, cobbles, and stones.  | Severe where slopes are more than 15 percent; more than 50 percent gravel, cobbles, and stones.  |
| Faraway: FrE, FrF, FtF<br>For Tortugas part of FtF, see Tortugas series. | Severe: more than 50 percent gravel or cobbles or both.  | Severe: slopes of more than 6 percent; more than 20 percent gravel or cobbles or both; 5 to 20 inches to bedrock.  | Severe: more than 50 percent gravel or cobbles or both.  | Severe: more than 50 percent cobbles or gravel or both; 5 to 20 inches to bedrock.   |
| Gaddes: GaE  | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    | Severe: 20 to 50 percent gravel; slopes of more than 6 percent.  | Moderate where slopes are less than 25 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 25 percent.                    | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    |

TABLE 9.—*Soil limitations for recreational development—Continued*

| Soil series and map symbols  | Camp and picnic areas  | Playgrounds   | Paths and trails  | Lawns and golf fairways  |
|--|--|---|---|--|
| Grabe: GbB, Ge<br>For Comoro part of GbB, see Comoro series.   | Generally slight.<br>Severe where subject to overflow.   | Generally slight.<br>Severe where subject to overflow.  | Generally slight.<br>Severe where subject to overflow.  | Generally slight.<br>Severe where subject to overflow.   |
| Graham: GhD, GhF   | Severe: more than 50 percent cobbles.  | Severe: slopes of more than 6 percent; more than 20 percent cobbles; 8 to 20 inches to bedrock. | Severe: more than 50 percent cobbles.   | Severe: more than 50 percent cobbles; 8 to 20 inches to bedrock.   |
| Guest: Gu  | Severe: clay surface layer.  | Severe: clay surface layer.   | Severe: clay surface layer.   | Severe: clay surface layer; slow permeability.   |
| Hathaway: HaF, HhE2  | Moderate where slopes are less than 15 percent; 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    | Severe: slopes of more than 6 percent; more than 20 percent gravel.                             | Moderate where slopes are less than 25 percent; 20 to 50 percent gravel.<br>Severe where slopes are more than 25 percent. | Moderate where slopes are less than 15 percent; 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    |
| Hogris: HoF, HhF<br>For Telephone part, see Telephone series.  | Severe: more than 50 percent cobbles; more than 15 percent slopes.   | Severe: more than 20 percent cobbles; more than 6 percent slopes.                               | Severe: more than 50 percent cobbles.   | Severe: more than 50 percent cobbles; slopes more than 15 percent.   |
| Kimbrough: KbC   | Moderate where slopes are less than 15 percent; 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 15 percent. | Severe: more than 20 percent gravel or cobbles or both; 6 to 20 inches of indurated hardpan.    | Moderate: 20 to 50 percent gravel or cobbles or both.   | Severe: 6 to 20 inches to hardpan.   |
| Lampshire: LaE, LaF, LcF, LgF<br>For Chiricahua part of LcF and Graham part of LgF, see those respective series. | Severe: more than 50 percent cobbles.  | Severe: more than 20 percent cobbles; 4 to 20 inches to bedrock.                                | Severe: more than 50 percent cobbles.   | Severe: 4 to 20 inches to bedrock; more than 50 percent cobbles.   |
| Luzena<br>Mapped only in an association with Fanno soils.  | Moderate where slopes are less than 15 percent; 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    | Severe: 7 to 20 inches to bedrock; slopes more than 6 percent; more than 20 percent gravel.     | Moderate: 20 to 50 percent gravel.  | Severe: 7 to 20 inches to bedrock.   |
| Luzena variant: LuD  | Moderate where slopes are less than 15 percent; 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 15 percent. | Severe: slopes more than 6 percent; more than 20 percent gravel or cobbles or both.             | Moderate: 20 to 50 percent gravel or cobbles or both.   | Moderate where slopes are less than 15 percent; 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 15 percent. |
| Mabray: McF<br>For Chiricahua part, see Chiricahua series.   | Severe: more than 50 percent gravel or cobbles or both.  | Severe: 4 to 20 inches to bedrock; more than 20 percent gravel or cobbles or both.              | Severe: more than 50 percent gravel or cobbles or both.   | Severe: 4 to 20 inches to bedrock; more than 50 percent gravel or cobbles or both.   |
| Martinez: Mg   | Moderate: clay loam surface layer.   | Moderate: slow or very slow permeability.   | Moderate: clay loam surface layer.  | Moderate: clay loam surface layer; slow or very slow permeability.   |
| Mine pits and dumps: Mn.<br>Properties too variable to be interpreted.   |  |   |   |  |

TABLE 9.—*Soil limitations for recreational development—Continued*

| Soil series and map symbols   | Camp and picnic areas  | Playgrounds   | Paths and trails  | Lawns and golf fairways  |
|---|--|---|---|--|
| Pima: Pm -----  | Generally moderate: clay loam surface layer.<br>Severe where subject to flooding.  | Generally moderate: clay loam surface layer.<br>Severe where subject to flooding.                                 | Generally moderate: clay loam surface layer.<br>Severe where subject to flooding.   | Generally moderate: clay loam surface layer.<br>Severe where subject to flooding.  |
| Pima variant: Pn -----  | Generally moderate: clay loam surface layer.<br>Severe where subject to flooding.  | Generally moderate: clay loam surface layer.<br>Severe where subject to flooding.                                 | Generally moderate: clay loam surface layer, subject to flooding.   | Moderate: clay loam surface layer.   |
| Pinaleno: PoC -----   | Moderate: 20 to 50 percent gravel or cobbles or both.  | Severe: more than 20 percent gravel or cobbles or both.   | Moderate: 20 to 50 percent gravel or cobbles or both.   | Moderate: 20 to 50 percent gravel or cobbles or both.  |
| Rillino: RIE2 -----   | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    | Severe: more than 20 percent gravel.  | Moderate where slopes are less than 25 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 25 percent. | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    |
| Rock outcrop-Lithic Haplustolls association: Rn.<br>Properties too variable to be interpreted.  |  |   |   |  |
| Rock outcrop: Rr.<br>Properties too variable to be interpreted.   |  |   |   |  |
| Schrap: ScD, ShF -----  | Severe: more than 50 percent shale fragments.  | Severe: 3 to 20 inches to shale bedrock; more than 20 percent shale fragments.                                    | Severe: more than 50 percent shale fragments.   | Severe: 3 to 20 inches to shale bedrock; more than 50 percent shale fragments.   |
| Signal: SnD -----   | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    | Severe: more than 20 percent gravel.  | Moderate: 20 to 50 percent gravel.  | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    |
| Sonoita: SoB, SoD -----   | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 15 percent. | Severe: more than 20 percent gravel or cobbles or both.   | Moderate: 20 to 50 percent gravel or cobbles or both.   | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel or cobbles or both.<br>Severe where slopes are more than 15 percent. |
| Telephone -----<br>Mapped only in association with Hogris soils.  | Severe: slopes of more than 15 percent; more than 50 percent gravel or cobbles or both.  | Severe: 5 to 20 inches to bedrock; more than 20 percent gravel or cobbles or both; slopes of more than 6 percent. | Severe: more than 50 percent gravel or cobbles or both.   | Severe: 5 to 20 inches to bedrock; slopes of more than 15 percent; more than 50 percent gravel and cobbles.                                  |
| Torrifluvents and Haplustolls: Th.<br>Properties too variable to be interpreted.  |  |   |   |  |
| Tortugas: TrE, TrF -----  | Severe: more than 50 percent cobbles.  | Severe: more than 20 percent cobbles; 6 to 20 inches to bedrock.  | Severe: more than 50 percent cobbles.   | Severe: 6 to 20 inches to bedrock; more than 50 percent cobbles.   |
| White House: WgC, WgE, WhC, WnC, WoE, WfF.<br>For Bonita part of WnC, Caralampi part of WoE, and Hathaway part of WfF, see those respective series. | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    | Severe: more than 20 percent gravel.  | Moderate where slopes are less than 25 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 25 percent. | Moderate where slopes are less than 15 percent: 20 to 50 percent gravel.<br>Severe where slopes are more than 15 percent.                    |

Picnic areas are attractive natural or landscaped tracts used mainly for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry; are free of flooding during the season of use; and do not have slopes or stoniness that greatly increases cost of leveling sites or of building access roads.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrop, good drainage, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry. If grading and leveling are required, depth to bedrock is important.

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

Lawns and golf fairways are areas to be used for lawns and landscaping in residential areas; around factories and schools; in intensively used parks; and for golf fairways. The ratings are based on soil properties and qualities only, and do not include other features that may be important in site selection. Factors considered are slope, surface texture, stones, cobbles, rock, depth to bedrock or hardpan, natural drainage, flooding, subsoil permeability, available water capacity, and salinity and alkalinity.

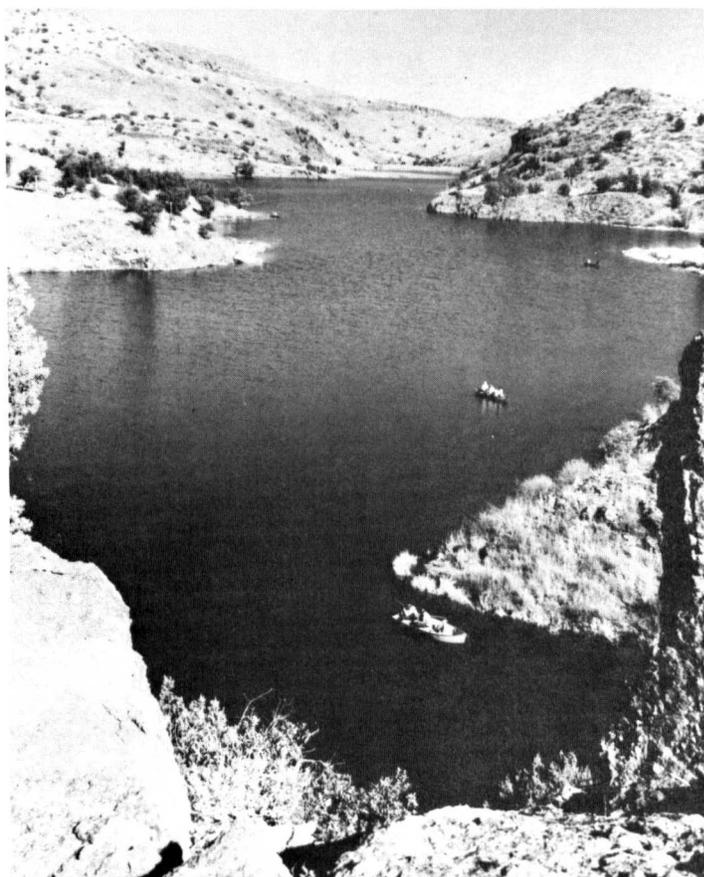
Outdoor recreational activities are increasing in the survey area. Four manmade lakes, ranging in size from 60 acres to 240 acres, are in the area (fig. 19). These are stocked with fish and have camping facilities. One lake is privately owned and managed for commercial recreation. The Forest Service maintains several camping and picnicking areas within the National Forest (fig. 20). Hunting, hiking, horseback riding, and rock collecting are popular activities. A nature conservancy south of Elgin and a bird sanctuary along Sonoita Creek southwest of Patagonia are of interest to many.

## ***Formation and Classification of the Soils***

This section describes the major morphological characteristics of the soils in the survey area. The first part briefly explains factors of soil formation. The second part describes placement of the soils in the classification system. The third part describes laboratory methods and gives laboratory data for selected soils.

### **Factors of Soil Formation**

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic agencies. Characteristics of the soil are determined by the



**Figure 19.**—Pena Blanca Lake recreation area is one of the multiple uses of land administered by the Forest Service. Lampshire and Graham soils are on the surrounding hills where slopes range from 20 to 60 percent.

physical and mineralogical composition of the parent material; the relief, or lay of the land; the plant and animal life on and in the soil; the climate under which the soil material accumulated and has existed since accumulation; and the length of time the forces of soil formation have acted on the parent material.

Climate, vegetation, and animals, are the active agents of soil formation. They act on the parent material and slowly change it to a natural body that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the parent material to change into a soil that has a well-defined profile. Time is required for differentiation of soil horizons by the soil-forming processes. In general, a soil that lacks horizon development is a young, or immature, soil, and a soil that has well-expressed horizons is an older, or mature, soil.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four.



Figure 20.—Campground maintained by the Forest Service in an area of Barkerville soil.

### Parent material

Several types of rock occur in the area. Intrusive crystalline rocks, mainly granitic, make up large parts of the Oro Blanco, Santa Rita, and Patagonia Mountains and the east slope of the Huachuca Mountains. Barkerville, Gaddes, Lampshire, and Chiricahua soils formed on the granitic rocks. Volcanic rocks, including rhyolite, dacite, andesite, and related tuffs form parts of the Atascosa, Tumacacori, San Cayetano, Patagonia, and Santa Rita Mountains and the Canelo Hills. These volcanic rocks were parent material for Graham, Lampshire, Faraway, and Luzena soils. Limestone, sandstone, and shale form parts of the Oro Blanco, northeastern Santa Rita, and Huachuca Mountains and the northern part of the Canelo Hills. Tortugas and Mabray soils formed in limestone material; Telephone soils and Fanno variant soils in sandstone material; and Fanno and Schrap soils in shale material. Consolidated conglomerates and tuffs form parts of the Atascosa Mountains and the adjacent dissected high old fans. Atascosa, Lampshire, and Graham soils formed in these consolidated conglomerates.

Water tends to remove the detritus from the shallow soils on the mountains as rapidly as it forms, especially on the steeper slopes. This material, which may contain particles ranging from clay to stones in size, is deposited on the slopes below the parent rock. Alluvium carried far from the source is commonly a mixture of material from a number of types of rock. The finer alluvium is generally carried the farthest and is generally found near the center of the valleys. Coarser sediment is deposited on the upper parts of the fans.

### Climate

Climate influences the physical and chemical weathering of parent material and largely controls the kinds of plants that grow in a given area. Temperature and moisture are the dominant climatic factors in the formation of soils.

Chemical and biological activity and other soil-forming processes are more rapid under a moist, warm climate than under a cold and moist climate or a warm and dry climate. In general, the speed of a chemical reaction doubles with each 10° C rise in temperature. Where the climate is dry, however, the rate of weathering is slower because scarcity of water limits the weathering that can take place.

Water, as a major source of hydrogen ions, is a principal agent of weathering. Leaching carries away the end products of chemical reactions and allows the reactions to continue. If depth of moisture penetration is limited, leaching is also limited, the end products accumulate, and weathering slows or may stop.

Present climate within the survey area varies considerably. In the semidesertic north-central part, rainfall averages 11 to 12 inches per year at the lowest elevations and the mean annual temperature is about 65° F. At 7,000 to 9,466 feet in the Santa Rita and Huachuca Mountains, average rainfall is 20 to 24 inches or more per year and mean temperature is below 59° F. Sonoita and Continental soils, which formed in the warmer semidesertic part, have less organic matter and are less than Canelo, Casto, and Martinez soils, which formed in the cooler, rainier part of the area. Carbonates have also been leached to a greater depth in the Canelo, Casto, and Martinez soils than in the Sonoita and Continental soils.

Some soils in the area show the effects of past, as well as present, climate. Canelo, Caralampi, Casto, Continental, Martinez, and White House soils, and probably Sonoita soils, formed during or before Pleistocene time. During the Pleistocene the temperature of the region was about 10° F less and the precipitation 10 inches more than at present; this is deducted from the remains of the freshwater lakes that were in many of the basins of the Southwest during the Pleistocene (9). The soils that formed during the Pleistocene were leached of soluble materials to a greater depth than the soils that formed since then. Some of these soluble materials may have been replaced during the drier, warmer climate of the present. The kaolinite is moderate to abundant in most of the Pleistocene and pre-Pleistocene soils. It is more leached of bases and silica than soils forming in the present climate. Entrenchment and dissection of the present drainage system occurred mostly in Pleistocene time.

### Relief

Relief influences soil formation largely by affecting water movement. On the steeper slopes much of the water runs off; little enters the soil, particularly during hard summer rains. Since moisture is essential to weathering, little development takes place. On steep soils, material is removed from the surface about as fast as it is weathered from the parent rock. This results in thin soils that have little chance for any fur-

ther soil formation to take place. Faraway, Barkerville, and Lampshire soils are examples of steep mountainous soils that lack significant development except for the accumulation of organic matter.

Conversely, on gently sloping or concave soils, there is little runoff. Water enters the soil, weathering takes place, soluble elements and clay minerals are leached downward, and soil horizons develop with time. In addition, plants and animals flourish and humus forms in the surface layer. Mature soils, such as the White House and Martinez soils, formed in areas of gentle relief. On some high old alluvial fans in the area, there are also some seasonally wet soils, such as Canelo soils. They were produced by a combination of moderate precipitation, gentle relief, and a slowly permeable substratum.

#### Plant and animal life

The kind and amount of plant and animal life determine both the kind of organic matter that is added to the soil and its placement in the soil. Most of it is added to the surface layer in the form of leaves and roots. There it is acted upon by micro-organisms, insects, and small rodents. Plants recycle mineral elements from deep in the profile and deposit them in the surface layer. Plant residue, especially from grasses, darkens the surface layer and forms granular structure. Deeply penetrating roots break up dense layers in the subsoil and improve the downward movement of water. Rodents and insects mix soil horizons and often improve movement of water and penetration of roots through the soil.

There are four broad types of vegetation in the area. Each vegetation type is generally associated with a kind of soil development. Sonoita and Continental soils are below about 4,000 feet in areas where desert shrubs and sparse grasses dominate. These soils are mostly in typic subgroups. They have clay accumulation in the subsoil. Organic matter is rapidly oxidized and makes up less than 1 percent of the surface layer of these soils. Clay mica is an important constituent, especially in the surface layer.

Caralampi and White House soils are between 4,000 and 5,000 feet in areas of grasses and scattered shrubs. These soils are mostly in Ustollic subgroups. They have clay accumulation in the subsoil and have a surface layer that is more than 1 percent organic matter. Montmorillonite is the dominant clay mineral in these soils, especially in the subsoil.

Casto and Canelo soils are between elevations of about 5,000 and 6,500 feet in areas where the vegetation is oak-juniper (Southern Woodland) and a chaparral and grass understory. Canelo soils are classified as Aqualfs, and Casto soils are classified as Ustalfs. These soils have a prominent horizon of clay accumulation and intermediate amounts of organic matter. Montmorillonite is the dominant clay mineral in most of the soils of this type, but in some of the oldest soils, such as Canelo soils, kaolinite is abundant.

Faraway soils are at an elevation above about 6,500 feet in areas where the vegetation is pine, mixed conifers, deciduous trees, and a sparse grass understory. The Faraway soils are in the lower part of these areas where oak is more common. They are accumulating a

considerable amount of organic matter and are slightly acid. In the pine-fir areas the soils commonly have a litter of needles and duff on the surface and are commonly more acid.

#### Time

The length of time that climatic factors and plants and animals have acted on soil parent material strongly influences the characteristics of the soil. The length of time that parent material is acted on by these soil-forming factors depends on the stability of the landscape.

In the mountains, geologic erosion is active and very little soil material accumulates in place. Most of it is removed by water and downslope mass movement. Hence, the mountainous landscapes are young and the soils that formed on them, such as the Faraway soils, are only weakly developed.

Weakly developed soils also occur on the flood plains of rivers and streams. Here, sediment accumulates more rapidly than it can be modified by soil-forming factors.

Developed soils are mostly on older alluvial fans that extend from the mountains out onto the valley floors. Undeveloped and weakly developed soils occur on younger fans. The range in soil development on the alluvial fans is inferred from the clay-distribution curves for some of the soils (fig. 21). The Sonoita soil,

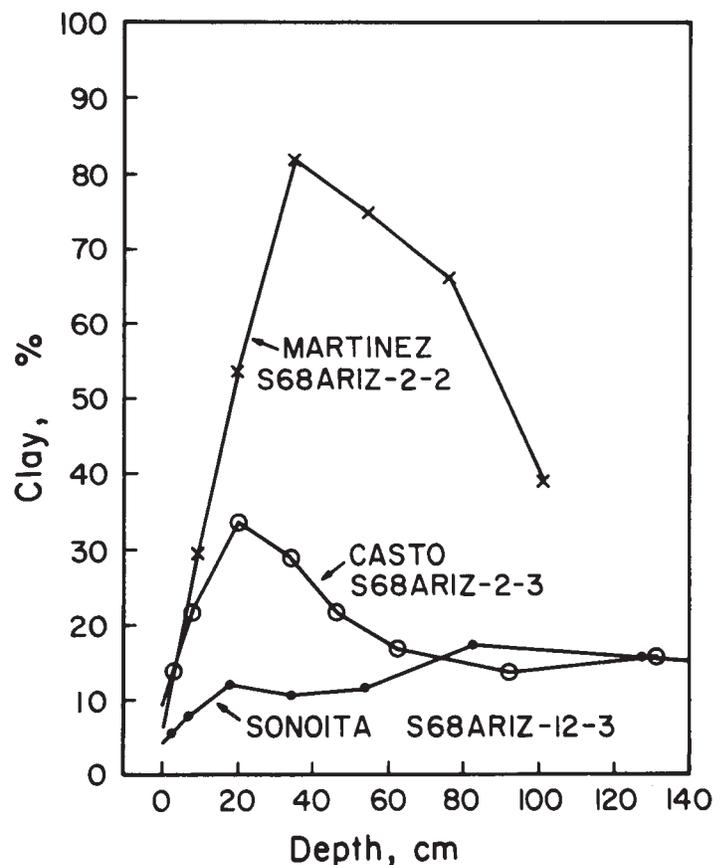


Figure 21.—Distribution of clay in Sonoita, Casto, and Martinez soils.

which is on a broad, relatively level alluvial fan of late Pleistocene age, has little accumulation of clay in its subsoil. In contrast, the Martinez soils, which are on deeply dissected remnants of a high, old alluvial fan of Pliocene age, have a very marked accumulation of clay in the subsoil. The mesalike remnants on which the gently sloping Martinez soils occur are one-eighth mile to one-half mile wide and as much as several miles long. The Casto soils on the upper side slopes of the remnants and the soils on broader, less dissected alluvial fans of intermediate age accumulate intermediate amounts of clay.

### Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation (4). First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in a detailed soil survey, allow us to organize and

apply knowledge about soils in managing farms, ranches, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the classification system should search the latest literature available.

The system of classification as six categories: order, suborder, great group, subgroup, family, and series. The criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. In table 10 the soil series of the survey area are classified. The categories of the current system are defined briefly in the following paragraphs.

**ORDER:** Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are Entisols and Histosols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Ent-i-sol).

TABLE 10.—*Classification of soil series*

| Soil series       | Family   | Subgroup                 | Order      |
|-------------------|--|--------------------------|------------|
| Anthony           | Coarse-loamy, mixed (calcareous) thermic         | Typic Torrifuvents       | Entisols.  |
| Anthony variant   | Loamy-skeletal, mixed (calcareous) thermic       | Typic Torrifuvents       | Entisols.  |
| Atascosa          | Loamy-skeletal, mixed, thermic                   | Lithic Argiustolls       | Mollisols. |
| Barkerville       | Loamy, mixed, mesic, shallow                     | Udorthentic Haplustolls  | Mollisols. |
| Bernardino        | Fine, mixed, thermic                             | Ustollic Haplargids      | Aridisols. |
| Bonita            | Fine, montmorillonitic, thermic                  | Typic Chromusterts       | Vertisols. |
| Canelo            | Clayey-skeletal, mixed, mesic                    | Aeric Ochraqualfs        | Alfisols.  |
| Caralampi         | Loamy-skeletal, mixed, thermic                   | Ustollic Haplargids      | Aridisols. |
| Caralampi variant | Loamy-skeletal, mixed, thermic                   | Ustollic Haplargids      | Aridisols. |
| Casto             | Loamy-skeletal, mixed, mesic                     | Udic Haplustalfs         | Alfisols.  |
| Cave              | Loamy, mixed, thermic, shallow                   | Typic Paleorthids        | Aridisols. |
| Chiricahua        | Clayey, mixed, thermic, shallow                  | Ustollic Haplargids      | Aridisols. |
| Comoro            | Coarse-loamy, mixed, thermic                     | Typic Torrifuvents       | Entisols.  |
| Continental       | Fine, mixed, thermic                             | Typic Haplargids         | Aridisols. |
| Eba               | Clayey-skeletal, mixed, thermic                  | Typic Haplargids         | Aridisols. |
| Fanno             | Fine, illitic, mesic                             | Udic Haplustalfs         | Alfisols.  |
| Fanno variant     | Fine, mixed, mesic                               | Udic Haplustalfs         | Alfisols.  |
| Faraway           | Loamy-skeletal, mixed, mesic                     | Lithic Haplustolls       | Mollisols. |
| Gaddes            | Fine-loamy, mixed, mesic                         | Ustollic Haplargids      | Aridisols. |
| Grabe             | Coarse-loamy, mixed, (calcareous) thermic        | Typic Torrifuvents       | Entisols.  |
| Graham            | Clayey, montmorillonitic, thermic                | Lithic Argiustolls       | Mollisols. |
| Guest             | Fine, mixed, (calcareous) thermic                | Typic Torrifuvents       | Entisols.  |
| Hathaway          | Loamy-skeletal, mixed, thermic                   | Aridic Calciustolls      | Mollisols. |
| Hogris            | Loamy-skeletal, mixed, nonacid, mesic            | Typic Ustorthents        | Entisols.  |
| Kimbrough         | Loamy, mixed, thermic, shallow                   | Petrocalcic Calciustolls | Mollisols. |
| Lampshire         | Loamy-skeletal, mixed, thermic                   | Lithic Haplustolls       | Mollisols. |
| Luzena            | Clayey, montmorillonitic, mesic                  | Lithic Argiustolls       | Mollisols. |
| Luzena variant    | Fine, montmorillonitic, mesic                    | Udic Argiustolls         | Mollisols. |
| Mabray            | Loamy-skeletal, carbonatic, thermic              | Lithic Haplustolls       | Mollisols. |
| Martinez          | Very-fine, kaolinitic, mesic                     | Udic Haplustalfs         | Alfisols.  |
| Pima              | Fine-silty, mixed, thermic                       | Anthropic Torrifuvents   | Entisols.  |
| Pima variant      | Fine-loamy, mixed, thermic                       | Typic Haplustolls        | Mollisols. |
| Pinaleno          | Loamy-skeletal, mixed, thermic                   | Typic Haplargids         | Aridisols. |
| Rillino           | Coarse-loamy, mixed, thermic                     | Typic Calciorthids       | Aridisols. |
| Schrap            | Loamy-skeletal, mixed, nonacid, thermic, shallow | Ustic Torriorthents      | Entisols.  |
| Signal            | Fine, montmorillonitic, thermic                  | Aridic Paleustolls       | Mollisols. |
| Sonoita           | Coarse-loamy, mixed, thermic                     | Typic Haplargids         | Aridisols. |
| Telephone         | Loamy-skeletal, mixed, nonacid, mesic            | Lithic Ustorthents       | Entisols.  |
| Tortugas          | Loamy-skeletal, carbonatic, mesic                | Lithic Haplustolls       | Mollisols. |
| White House       | Fine, mixed, thermic                             | Ustollic Haplargids      | Aridisols. |

**SUBORDER:** Each order is divided into suborders that are based primarily on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is Fluvent (*Fluv*, meaning flood plains, and *ent*, from Entisol).

**GREAT GROUP:** Each suborder is divided into great groups on the basis of close similarities in arrangement and degree of expression of profile horizons, in soil moisture and temperature regimes, and in chemical composition. The names of great groups have three or four syllables and end with the name of a suborder. An example is Torrifluent (*Torri* meaning hot and dry, *fluv*, for flood plains, and *ent*, from Entisols).

**SUBGROUP:** Each great group is divided into three kinds of subgroups: the central (typic) segment of the great group; the intergrades, or transitional forms to other orders, suborders, or great groups; and extra-grades which have some properties representative of the great group but which do not indicate transitions to any other known kind of soil. The name of a subgroup is derived by placing one or more adjectives before the name of the great group. An example is Typic Torrifluents (a typical Torrifluent).

**FAMILY:** Each subgroup is divided into families, which group soils that have similar enough physical and chemical properties that their responses to management and manipulation for use are nearly the same for comparable phases. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, thickness of soil penetrable by roots, available moisture capacity, slope, and consistency. A family name consists of a subgroup name and a series of adjectives. The adjectives are the class names for texture, mineralogy, reaction, and so on that are used as family differentiae. An example is the coarse-loamy, mixed (calcareous), thermic family of Typic Torrifluents.

**SERIES:** The series consists of a group of soils that formed in a particular kind of parent material and have horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, texture, structure, reaction, consistence, and mineralogical and chemical composition. Series names are place names taken from the area where the soil was first defined. An example is the Anthony series.

## Physical and Chemical Data

Many soil characteristics are difficult or impossible to determine without laboratory analyses. Tables 11 and 12 give data on selected soil profiles. The findings were determined as follows. Samples were collected from carefully selected, freshly dug pits. All soils, except for those of the Hathaway series are in the type locations of the series and are described as the representative for that series. The samples taken are con-

sidered typical of the material less than 3 inches in diameter. Material larger than 2 inches in diameter is included in the estimates for coarse fragments in the horizon description and in the table of estimated physical and chemical properties. Except in the clod samples for the bulk density test, the rock fragments greater than 2 millimeters in diameter are discarded after crushing, screening, and weighing. Unless otherwise noted, all laboratory analyses were made on the soil fraction passing the 2 millimeter (No. 10) sieve.

Table 11 gives physical data. Determinations of clay were made by the pipette method (11). Bulk density determinations were made on Saran-treated clods taken at the time of sampling and weighed at the 1/3-bar desorption state and the oven-dry state. Water retention was measured on Saran-tested clods at 1/3- and 15-bar pressure membrane extractions. The COLE (coefficient of linear extensibility) is the calculated expansion of the whole fabric from dry to moist. COLE is the expansion of the fine earth fraction only.

Table 12 gives chemical data. The content of organic carbon was determined by acid dichromate digestion and ferrous sulfate titration. Total nitrogen was determined by the Kjeldahl method. Calcium carbonate equivalent was determined by measurement of the volume of carbon dioxide evolved by treatment with concentrated hydrochloric acid. Iron was extracted by dithionate-citrate and measured with orthophenanthroline colorimetry. Soil reaction was determined by glass electrode in both a 1:1 water-soil mixture and in a 0.01 calcium chloride solution. Cation exchange capacity and extractable bases are by the ammonium acetate method, codes 5A1a, 5B1a, 5B1b, 5C1, 604c, 6N4c, 6P2a, and 6Q2a (11). Electrical conductivity was measured by conductivity bridge on saturation extract. Clay mineralogy is by X-ray diffraction.

## Additional Features of the Survey Area

This section is mainly for readers who are not familiar with the area. It briefly discusses history, farming, climate, natural resources, transportation, and international trade that pertains to the soil survey area.

### History

The first known exploration of the area by white men was in what is now a part of Santa Cruz County. In April, 1539, Fray Marcos de Niza, a Franciscan priest, reached Lochiel, a tiny Indian settlement on the present United States-Mexico border, about 30 miles east of Nogales. His fanciful report of finding the mythical Seven Cities of Cibola brought Francisco Vasquez de Coronado to Eastern Santa Cruz County in 1540. Coronado soon returned to Mexico City, failing in his search for wealth and glory.

The first real settlement by non-Indians came in 1687 when Padre Eusebio Francisco Kino, Jesuit mission builder and colonizer, founded a mission at Guevavi, near Nogales. Another of his missions, at Tumacacori, is now a national monument.

TABLE 11.—*Physical data for*  
 [Analyses by Soil Survey Laboratory, Soil Conservation Service, Riverside, Calif.]

| Soils, sample numbers, and laboratory numbers <sup>1</sup>                             | Horizon | Depth     | Particle-size distribution in material smaller than 2 millimeters |                      |                  |                           |                        |                           |                          |                              |                            |
|--|---------|-----------|---|----------------------|------------------|---------------------------|------------------------|---------------------------|--------------------------|------------------------------|----------------------------|
|  |         |           | Sand (2-0.05 mm)  | Silt (0.05-0.002 mm) | Clay (<0.002 mm) | Very coarse sand (2-1 mm) | Coarse sand (1-0.5 mm) | Medium sand (0.5-0.25 mm) | Fine sand (0.25-0.10 mm) | Very fine sand (0.1-0.05 mm) | Coarse silt (0.05-0.02 mm) |
|  |         | <i>Cm</i> | <i>Pct</i>  | <i>Pct</i>           | <i>Pct</i>       | <i>Pct</i>                | <i>Pct</i>             | <i>Pct</i>                | <i>Pct</i>               | <i>Pct</i>                   | <i>Pct</i>                 |
| Canelo gravelly sandy loam.<br>S68Ariz-12-10-(1-6)<br>(80964-80970)                    | A1      | 0-13      | 60.5  | 32.0                 | 7.5              | 21.5                      | 13.8                   | 7.5                       | 11.1                     | 6.6                          | 15.5                       |
|  | A2      | 13-18     | 56.4  | 35.6                 | 8.0              | 14.9                      | 14.0                   | 8.3                       | 11.9                     | 7.3                          | 16.9                       |
|  | A3      | 18-35     | 53.1  | 35.1                 | 11.8             | 15.9                      | 13.1                   | 7.0                       | 10.6                     | 6.5                          | 14.1                       |
|  | B21tg   | 35-58     | 47.4  | 25.6                 | 27.0             | 15.5                      | 12.7                   | 5.8                       | 8.1                      | 5.3                          | 8.5                        |
|  | B22tg   | 58-85     | 13.1  | 9.1                  | 77.8             | 3.3                       | 3.7                    | 1.9                       | 2.9                      | 1.3                          | 2.4                        |
|  | B3t     | 85-153    | 46.4  | 11.5                 | 42.1             | 20.6                      | 13.1                   | 5.0                       | 5.5                      | 2.2                          | 2.9                        |
| Caralampi gravelly sandy loam.<br>S68Ariz-12-4(1-7)<br>(80979-80986)                   | A1      | 0-5       | 72.9  | 10.9                 | 16.2             | 21.6                      | 23.7                   | 12.2                      | 11.7                     | 3.7                          | 5.8                        |
|  | B21t    | 5-13      | 60.7  | 9.8                  | 29.5             | 21.8                      | 15.3                   | 9.1                       | 10.9                     | 3.6                          | 5.4                        |
|  | B22t    | 13-23     | 54.7  | 10.6                 | 34.7             | 18.9                      | 15.0                   | 8.0                       | 9.2                      | 3.6                          | 4.7                        |
|  | B23t    | 23-33     | 64.4  | 12.2                 | 23.4             | 23.2                      | 18.4                   | 9.1                       | 9.9                      | 3.8                          | 5.4                        |
|  | B24t    | 33-58     | 63.7  | 18.0                 | 18.3             | 15.0                      | 16.2                   | 10.5                      | 14.8                     | 7.2                          | 7.8                        |
|  | B31t    | 58-78     | 68.0  | 18.6                 | 13.4             | 17.5                      | 18.5                   | 10.5                      | 14.4                     | 7.1                          | 7.3                        |
|  | B32t    | 78-105    | 10.9  | 17.2                 | 11.9             | 24.4                      | 20.3                   | 9.6                       | 11.5                     | 5.1                          | 6.4                        |
|  | C       | 105-153   | 73.5  | 17.0                 | 9.5              | 26.1                      | 19.2                   | 10.6                      | 12.8                     | 4.8                          | 7.1                        |
| Casto very gravelly sandy loam.<br>S68Ariz-2-3(1-8)<br>(80995-81002)                   | A1      | 0-3       | 72.1  | 14.4                 | 13.5             | 4.4                       | 13.4                   | 13.4                      | 27.9                     | 13.1                         | 7.6                        |
|  | B21t    | 3-13      | 62.4  | 15.8                 | 21.8             | 4.2                       | 12.4                   | 12.1                      | 23.4                     | 10.3                         | 7.4                        |
|  | B22t    | 13-28     | 51.5  | 14.8                 | 33.7             | 6.2                       | 13.6                   | 9.5                       | 14.6                     | 7.6                          | 5.8                        |
|  | B23t    | 28-40     | 56.0  | 15.2                 | 28.8             | 8.0                       | 16.0                   | 9.8                       | 14.6                     | 7.6                          | 5.6                        |
|  | B31t    | 40-55     | 59.8  | 18.5                 | 21.7             | 8.5                       | 15.7                   | 9.8                       | 16.0                     | 9.8                          | 6.3                        |
|  | B32t    | 55-70     | 58.8  | 24.3                 | 16.9             | 8.4                       | 13.2                   | 7.1                       | 16.3                     | 13.8                         | 9.2                        |
|  | C1ca    | 70-113    | 61.0  | 25.3                 | 13.7             | 12.5                      | 11.2                   | 6.4                       | 17.0                     | 13.9                         | 10.5                       |
|  | C2ca    | 113-150   | 57.4  | 27.1                 | 15.5             | 11.6                      | 11.1                   | 5.9                       | 15.7                     | 13.1                         | 8.4                        |
| Continental gravelly sandy loam.<br>S68Ariz-12-2(1-8)<br>(81017-81025)                 | A11     | 0-8       | 74.6  | 17.5                 | 7.9              | 23.9                      | 18.3                   | 9.7                       | 14.5                     | 8.2                          | 11.7                       |
|  | A12     | 8-15      | 68.2  | 19.5                 | 12.3             | 17.1                      | 18.5                   | 10.6                      | 14.3                     | 7.7                          | 11.9                       |
|  | B1t     | 15-25     | 66.3  | 12.2                 | 21.5             | 36.1                      | 15.6                   | 5.4                       | 5.9                      | 3.3                          | 6.9                        |
|  | B21t    | 25-48     | 46.9  | 8.8                  | 44.3             | 18.4                      | 15.3                   | 5.3                       | 5.5                      | 2.4                          | 4.9                        |
|  | B22t    | 48-78     | 68.0  | 5.3                  | 26.7             | 34.2                      | 22.2                   | 6.4                       | 4.0                      | 1.2                          | 3.4                        |
|  | IIB31ca | 78-95     | 62.6  | 13.1                 | 24.3             | 28.8                      | 19.7                   | 6.2                       | 5.9                      | 2.0                          | 5.3                        |
|  | IIB32ca | 95-130    | 64.1  | 11.6                 | 24.3             | 33.4                      | 17.6                   | 5.9                       | 5.1                      | 2.1                          | 4.6                        |
|  | IICca   | 130-180   | 68.6  | 12.8                 | 18.6             | 26.5                      | 20.7                   | 8.3                       | 9.5                      | 3.6                          | 6.7                        |
| Faraway very cobbly fine sandy loam.<br>S68Ariz-2-7(1-3)<br>(81031-81034)              | A11     | 0-5       | 71.7  | 17.9                 | 10.4             | 10.6                      | 12.7                   | 10.7                      | 24.1                     | 13.6                         | 9.6                        |
|  | A12     | 5-30      | 65.2  | 20.0                 | 14.8             | 5.9                       | 10.6                   | 9.9                       | 24.0                     | 14.8                         | 10.3                       |
|  | R       | 30-43     |   |                      |                  |                           |                        |                           |                          |                              |                            |
| Hathaway gravelly sandy loam, 50 percent slopes.<br>S68Ariz-12-15(1-7)<br>81035-81041) | A11     | 0-13      | 67.6  | 15.6                 | 16.8             | 18.8                      | 13.6                   | 11.0                      | 17.4                     | 6.8                          | 6.9                        |
|  | A12     | 13-25     | 57.8  | 20.6                 | 21.6             | 11.8                      | 11.1                   | 9.7                       | 17.6                     | 7.6                          | 8.1                        |
|  | C1ca    | 25-33     | 54.3  | 24.2                 | 21.5             | 8.6                       | 10.3                   | 9.5                       | 17.4                     | 8.5                          | 8.7                        |
|  | C2ca    | 33-50     | 60.5  | 22.2                 | 17.3             | 12.7                      | 12.7                   | 10.0                      | 17.5                     | 7.6                          | 6.9                        |
|  | C3ca    | 50-78     | 69.8  | 19.4                 | 10.8             | 11.6                      | 14.6                   | 13.1                      | 21.4                     | 9.1                          | 6.2                        |
|  | C4ca    | 78-98     | 75.4  | 16.0                 | 8.6              | 16.4                      | 18.2                   | 14.1                      | 20.5                     | 6.2                          | 6.3                        |
|  | IIC5ca  | 98-115    | 60.7  | 27.1                 | 12.2             | 13.2                      | 13.1                   | 9.3                       | 15.9                     | 9.2                          | 11.2                       |
| Martinez gravelly loam.<br>S68Ariz-2-2(1-7)<br>(81052-81059)                           | A11     | 0-3       | 57.5  | 28.6                 | 13.9             | 18.4                      | 10.7                   | 6.1                       | 13.7                     | 8.6                          | 18.4                       |
|  | A12     | 3-15      | 39.3  | 31.5                 | 29.2             | 4.9                       | 5.5                    | 5.2                       | 14.1                     | 9.6                          | 17.8                       |
|  | B1t     | 15-25     | 26.5  | 19.7                 | 53.8             | 3.8                       | 4.4                    | 3.7                       | 8.8                      | 5.8                          | 10.3                       |
|  | B21t    | 25-45     | 10.3  | 7.7                  | 82.0             | 1.4                       | 1.5                    | 1.4                       | 3.5                      | 2.5                          | 3.6                        |
|  | B22t    | 45-65     | 16.3  | 8.7                  | 75.0             | 2.2                       | 2.9                    | 2.7                       | 5.4                      | 3.1                          | 5.5                        |
|  | B23t    | 65-88     | 24.9  | 9.1                  | 66.0             | 1.8                       | 5.6                    | 5.2                       | 8.5                      | 3.8                          | 3.6                        |
|  | B3t     | 88-115    | 49.6  | 11.6                 | 38.8             | 12.8                      | 16.1                   | 7.8                       | 9.5                      | 3.4                          | 4.8                        |
| Sonoita gravelly sandy loam.<br>S68Ariz-12-3(1-8)<br>(81060-81068)                     | A11     | 0-5       | 75.7  | 18.5                 | 5.8              | 11.0                      | 20.3                   | 12.8                      | 21.2                     | 10.4                         | 13.5                       |
|  | A12     | 5-10      | 72.5  | 19.5                 | 8.0              | 17.3                      | 19.5                   | 10.5                      | 17.2                     | 8.0                          | 13.4                       |
|  | B21     | 10-25     | 69.8  | 18.2                 | 12.0             | 14.5                      | 18.3                   | 10.4                      | 16.9                     | 9.7                          | 8.7                        |
|  | B22     | 25-43     |   |                      |                  |                           |                        |                           |                          |                              |                            |
|  | B23t    | 43-65     | 66.1  | 22.7                 | 11.2             | 12.4                      | 16.7                   | 10.3                      | 16.7                     | 10.0                         | 14.3                       |
|  | B24tca  | 65-100    | 64.1  | 18.7                 | 17.4             | 16.2                      | 17.1                   | 8.9                       | 13.8                     | 8.1                          | 9.7                        |
|  | B25tca  | 100-155   | 57.3  | 27.1                 | 15.6             | 15.2                      | 18.0                   | 8.1                       | 10.0                     | 6.0                          | 14.5                       |
|  | B3ca    | 155-175   | 65.8  | 19.6                 | 14.6             | 14.5                      | 20.0                   | 10.6                      | 14.4                     | 6.3                          | 11.6                       |

selected soil profiles—Continued

Dashes indicate analysis not made. The symbol > means more than; < means less than]

| Particle-size distribution in material smaller than 2 millimeters—Continued |                      |                     | Coarse fragments |              |               |                | Coarse fragment conversion factor (Cm) | Bulk density      |                   |                     | Water content at— |         | Extensibility |       |
|---|----------------------|---------------------|------------------|--------------|---------------|----------------|--|-------------------|-------------------|---------------------|-------------------|---------|---------------|-------|
| Fine silt (0.02–0.002 mm)   | Int II (0.2–0.02 mm) | Fam sand (2–0.1 mm) | Total (>2 mm)    | CF1 (2–5 mm) | CF2 (5–19 mm) | CF3 (19–76 mm) |  | 1/3 bar           | Oven-dry          | 1/3 bar (estimated) | 1/3 bar           | 15 bars | COLEF         | COLE  |
| Pct   | Pct                  | Pct                 | Pct              | Pct          | Pct           | Pct            | G/Cm <sup>3</sup>                      | G/Cm <sup>3</sup> | G/Cm <sup>3</sup> | Pct                 | Pct               | Pct     | Pct           |       |
| 16.5  | 27.9                 | 53.9                | 32               | 9            | 15            | 9              | 0.78                                   | 1.60              | 1.60              | -----               | 10.3              | 4.3     | -----         | ----- |
| 18.7  | 30.6                 | 49.1                | 44               | 7            | 14            | 23             | .69                                    | 1.53              | 1.53              | -----               | 9.7               | 4.2     | -----         | ----- |
| 21.0  | 25.9                 | 46.6                | 43               | 6            | 12            | 26             | .74                                    | 1.25              | 1.25              | -----               | 22.2              | 4.6     | -----         | ----- |
| 17.1  | 18.0                 | 42.1                | 65               | 23           | 2             | 39             | .50                                    | 1.45              | 1.45              | -----               | 21.3              | 8.0     | -----         | ----- |
| 6.7   | 5.1                  | 11.8                | 65               | 6            | 30            | 29             | .54                                    | 1.22              | 1.49              | -----               | 37.9              | 24.1    | 6.9           | 3.5   |
| 8.6   | 7.7                  | 44.2                | 64               | 8            | 18            | 38             | .53                                    | -----             | -----             | 1.30                | -----             | 15.1    | -----         | ----- |
| 5.1   | 14.7                 | 69.2                | 59               | -----        | 17            | 40             | .63                                    | 1.17              | 1.25              | -----               | 14.0              | 9.1     | 2.2           | 1.3   |
| 4.4   | 14.1                 | 57.1                | 79               | 8            | 12            | 59             | .39                                    | 1.09              | .12               | -----               | 17.0              | 15.2    | .9            | .3    |
| 5.9   | 12.8                 | 51.1                | 65               | 17           | 19            | 28             | .55                                    | 1.22              | 1.31              | -----               | 22.3              | 15.5    | 2.4           | 1.3   |
| 6.8   | 13.9                 | 60.6                | 48               | 15           | 20            | 11             | .71                                    | -----             | -----             | 1.30                | -----             | 12.9    | -----         | ----- |
| 10.2  | 22.0                 | 56.5                | 54               | 18           | 22            | 13             | .62                                    | 1.45              | 1.54              | -----               | 19.6              | 12.5    | 2.0           | 1.2   |
| 11.3  | 21.4                 | 60.9                | 49               | 23           | 19            | 7              | .66                                    | 1.48              | 1.59              | -----               | 23.4              | 10.0    | 2.4           | 1.5   |
| 10.8  | 17.0                 | 65.8                | 44               | 13           | 20            | 10             | .72                                    | 1.43              | 1.49              | -----               | 19.8              | 8.7     | 1.4           | 1.0   |
| 9.9   | 17.7                 | 68.7                | 40               | 22           | 14            | 3              | .73                                    | 1.54              | 1.63              | -----               | 16.7              | 8.7     | 1.9           | 1.4   |
| 6.8   | 36.6                 | 59.0                | 73               | 8            | 15            | 49             | .45                                    | -----             | -----             | 1.25                | -----             | 8.5     | -----         | ----- |
| 8.4   | 30.6                 | 52.1                | 20               | -----        | 3             | 13             | .91                                    | 1.34              | 1.58              | -----               | 25.3              | 11.6    | 5.6           | 4.9   |
| 9.0   | 21.6                 | 43.9                | 23               | 1            | 3             | 15             | .90                                    | 1.30              | 1.57              | -----               | 31.2              | 16.8    | 6.5           | 5.6   |
| 9.6   | 21.1                 | 48.4                | 38               | 2            | 6             | 27             | .80                                    | 1.23              | 1.53              | -----               | 33.4              | 15.7    | 7.5           | 5.7   |
| 12.2  | 25.4                 | 50.0                | 36               | 1            | 5             | 26             | .82                                    | 1.21              | 1.37              | -----               | 29.9              | 13.3    | 4.2           | 3.3   |
| 15.1  | 33.4                 | 45.0                | 70               | 7            | 26            | 35             | .50                                    | 1.21              | 1.35              | -----               | 32.8              | 13.0    | 3.7           | 1.7   |
| 14.8  | 35.5                 | 47.1                | 71               | 7            | 39            | 24             | .47                                    | 1.25              | 1.30              | -----               | 28.4              | 12.1    | 1.0           | .5    |
| 18.7  | 31.7                 | 44.3                | 67               | 4            | 8             | 54             | .52                                    | -----             | -----             | 1.26                | -----             | 14.7    | -----         | ----- |
| 5.8   | 27.6                 | 66.4                | 29               | 12           | 17            | -----          | .82                                    | 1.49              | 1.51              | -----               | 4.5               | 3.6     | .4            | .4    |
| 7.6   | 27.1                 | 60.5                | 42               | 11           | 15            | 16             | .72                                    | 1.39              | 1.41              | -----               | 14.2              | 4.7     | .5            | .3    |
| 5.3   | 13.2                 | 63.0                | 40               | 10           | 17            | 13             | .75                                    | 1.35              | 1.39              | -----               | 14.3              | 7.6     | 1.0           | .7    |
| 3.9   | 9.7                  | 44.5                | 6                | 1            | 2             | 3              | .97                                    | 1.33              | 1.51              | -----               | 29.3              | 16.5    | 4.3           | 4.2   |
| 1.9   | 6.1                  | 66.8                | 21               | 12           | 10            | -----          | .87                                    | 1.41              | 1.47              | -----               | 21.6              | 9.1     | 1.4           | 1.2   |
| 7.8   | 10.0                 | 60.6                | 73               | 22           | 14            | 37             | .46                                    | 1.16              | 1.24              | -----               | 31.8              | 9.9     | 2.2           | 1.0   |
| 7.0   | 9.1                  | 62.0                | 58               | 30           | 28            | -----          | .62                                    | -----             | -----             | 1.20                | -----             | 11.6    | -----         | ----- |
| 6.1   | 14.7                 | 65.0                | 20               | 11           | 3             | 5              | .89                                    | 1.31              | 1.37              | -----               | 22.3              | 8.1     | 1.5           | 1.3   |
| 8.3   | 37.3                 | 58.1                | 57               | 8            | 12            | 38             | .60                                    | -----             | -----             | 1.31                | -----             | 7.4     | -----         | ----- |
| 9.7   | 39.2                 | 50.4                | 70               | 6            | 11            | 53             | .45                                    | -----             | -----             | 1.44                | -----             | 8.6     | -----         | ----- |
| -----   | -----                | -----               | -----            | -----        | -----         | -----          | 1.00                                   | 2.46              | 2.47              | -----               | 2.8               | 2.2     | .1            | .1    |
| 8.7   | 22.2                 | 60.8                | 69               | 3            | 17            | 49             | .52                                    | 1.06              | 1.13              | -----               | 20.9              | 10.4    | 1.7           | 1.2   |
| 12.5  | 24.7                 | 50.2                | 53               | 13           | 23            | 17             | .68                                    | 1.13              | 1.19              | -----               | 25.1              | 10.4    | 1.8           | 1.2   |
| 15.5  | 26.3                 | 45.8                | 53               | 14           | 23            | 16             | .68                                    | 1.09              | 1.15              | -----               | 21.2              | 8.5     | 1.5           | .9    |
| 15.3  | 22.9                 | 52.9                | 56               | 9            | 24            | 23             | .65                                    | 1.13              | 1.18              | -----               | 15.7              | 6.5     | -----         | ----- |
| 13.2  | 25.4                 | 60.7                | 71               | 8            | 24            | 38             | .44                                    | 1.37              | 1.37              | -----               | 5.6               | 5.9     | -----         | ----- |
| 9.7   | 21.5                 | 69.2                | 77               | 5            | 28            | 44             | .20                                    | 2.00              | 2.00              | -----               | 14.2              | 7.5     | 1.2           | 1.1   |
| 15.9  | 28.7                 | 51.5                | 9                | 2            | 7             | -----          | .94                                    | 1.66              | 1.72              | -----               | -----             | -----   | -----         | ----- |
| 10.2  | 34.7                 | 48.9                | 9                | -----        | 9             | -----          | .95                                    | -----             | -----             | 1.35                | -----             | 6.5     | -----         | ----- |
| 13.7  | 35.7                 | 29.7                | 13               | -----        | 2             | 10             | .93                                    | 1.41              | 1.49              | -----               | 19.7              | 9.0     | 1.9           | 1.7   |
| 9.4   | 21.2                 | 20.7                | 2                | -----        | 2             | -----          | .99                                    | -----             | -----             | 1.35                | -----             | 16.6    | -----         | ----- |
| 4.1   | 8.0                  | 7.8                 | -----            | -----        | -----         | -----          | 1.00                                   | 1.28              | 1.55              | -----               | 35.4              | 25.3    | 6.6           | 6.6   |
| 3.2   | 11.6                 | 13.2                | 1                | -----        | 1             | -----          | .99                                    | 1.33              | 1.61              | -----               | 33.3              | 24.9    | 6.6           | 6.5   |
| 5.5   | 11.7                 | 21.1                | 6                | -----        | 6             | -----          | .97                                    | -----             | -----             | 1.35                | -----             | 23.3    | -----         | ----- |
| 6.8   | 12.9                 | 46.2                | 18               | -----        | 4             | 14             | .89                                    | 1.40              | 1.55              | -----               | 30.3              | 14.5    | 3.5           | 3.1   |
| 5.0   | 34.6                 | 65.3                | 9                | 7            | 2             | 0              | .94                                    | 1.59              | 1.59              | -----               | 3.2               | 2.3     | -----         | ----- |
| 6.1   | 30.0                 | 64.5                | 16               | 11           | 5             | 0              | .89                                    | 1.65              | 1.65              | -----               | 7.2               | 2.9     | -----         | ----- |
| 9.5   | 27.4                 | 60.1                | 5                | -----        | 5             | -----          | .97                                    | 1.62              | 1.63              | -----               | 5.6               | 3.6     | .2            | .2    |
| -----   | -----                | -----               | 19               | 3            | 1             | 15             | .88                                    | 1.55              | 1.57              | -----               | 7.7               | 3.9     | .4            | .4    |
| 8.4   | 33.5                 | 56.1                | 17               | -----        | 17            | -----          | .90                                    | 1.53              | 1.56              | -----               | 7.6               | 4.1     | .6            | .6    |
| 8.8   | 25.2                 | 56.0                | 4                | -----        | 4             | -----          | .98                                    | 1.57              | 1.65              | -----               | 14.1              | 6.6     | 1.7           | 1.6   |
| 12.6  | 25.6                 | 51.3                | 3                | 2            | 1             | -----          | .98                                    | 1.65              | 1.71              | -----               | 12.6              | 6.3     | 1.2           | 1.2   |
| 8.0   | 25.3                 | 59.5                | 25               | -----        | 5             | 19             | .83                                    | -----             | -----             | 1.65                | -----             | 6.5     | -----         | ----- |

TABLE 11.—Physical data for

| Soils, sample numbers, and laboratory numbers <sup>1</sup>  | Horizon | Depth   | Particle-size distribution in material smaller than 2 millimeters |                      |                  |                           |                        |                           |                          |                              |                            |
|---|---------|---------|---|----------------------|------------------|---------------------------|------------------------|---------------------------|--------------------------|------------------------------|----------------------------|
|   |         |         | Sand (2-0.05 mm)  | Silt (0.05-0.002 mm) | Clay (<0.002 mm) | Very coarse sand (2-1 mm) | Coarse sand (1-0.5 mm) | Medium sand (0.5-0.25 mm) | Fine sand (0.25-0.10 mm) | Very fine sand (0.1-0.05 mm) | Coarse silt (0.05-0.02 mm) |
| White House gravelly loam. S68Ariz-12-9 (1-9) (81070-81079) | A1      | 0-8     | 46.0  | 37.9                 | 16.1             | 5.9                       | 7.4                    | 6.2                       | 15.5                     | 11.0                         | 21.0                       |
|   | B1t     | 8-23    | 33.7  | 35.2                 | 31.1             | 3.7                       | 4.6                    | 4.1                       | 12.3                     | 9.0                          | 19.4                       |
|   | B21t    | 23-40   | 15.4  | 15.5                 | 69.1             | 3.3                       | 3.0                    | 1.7                       | 4.4                      | 3.0                          | 7.3                        |
|   | B22t    | 40-55   | 16.2  | 15.9                 | 67.9             | 3.8                       | 2.7                    | 1.9                       | 4.7                      | 3.1                          | 6.4                        |
|   | B23tca  | 55-65   | 22.1  | 19.8                 | 58.1             | 4.6                       | 5.2                    | 2.9                       | 5.6                      | 3.8                          | 6.7                        |
|   | B31tca  | 65-98   | 40.4  | 25.1                 | 34.5             | 8.0                       | 10.2                   | 5.1                       | 10.1                     | 7.0                          | 8.4                        |
|   | B32tca  | 98-123  | 44.3  | 26.6                 | 29.1             | 9.1                       | 12.5                   | 5.6                       | 9.6                      | 7.5                          | 9.5                        |
|   | B33ca   | 123-155 | 54.2  | 18.1                 | 27.7             | 8.4                       | 18.3                   | 6.1                       | 12.7                     | 8.7                          | 3.0                        |
|   | Cca     | 155-195 | 52.4  | 23.5                 | 24.1             | 8.1                       | 11.0                   | 5.6                       | 17.3                     | 10.4                         | 9.8                        |

<sup>1</sup> See the section "Descriptions of the Soils" for the location of the representative profile of the soils.

TABLE 12.—Chemical data for

[Analyses by Soil Survey Laboratory, Soil Conservation]

| Soil, sample number and lab numbers <sup>1</sup>                     | Horizon | Depth     | Organic carbon | Nitrogen   | Carbon-nitrogen ratio | Extractable iron | Calcium carbonate equivalent | Carbonate clay | Reaction             |                             |
|--|---------|-----------|----------------|------------|-----------------------|------------------|------------------------------|----------------|----------------------|-----------------------------|
|  |         |           |                |            |                       |                  |                              |                | 1:1 H <sub>2</sub> O | 1:1 CaCl <sub>2</sub> 0.01N |
|  |         | <i>Cm</i> | <i>Pot</i>     | <i>Pot</i> |                       | <i>Pot</i>       | <i>Pot</i>                   | <i>Pot</i>     | <i>pH</i>            | <i>pH</i>                   |
| Canelo gravelly sandy loam. S68Ariz-12-10 (1-6) (80964-80970)        | A1      | 0-13      | 0.78           | 0.053      | 15                    | 0.5              | -----                        | -----          | 6.3                  | 5.6                         |
|  | A2      | 13-18     | .48            | .030       | 16                    | .5               | -----                        | -----          | 6.1                  | 5.4                         |
|  | A3      | 18-35     | .28            | -----      | -----                 | .5               | -----                        | -----          | 6.2                  | 5.5                         |
|  | B21tg   | 35-58     | .22            | -----      | -----                 | .6               | -----                        | -----          | 5.8                  | 5.3                         |
|  | B22tg   | 58-85     | .30            | -----      | -----                 | 1.0              | -----                        | -----          | 4.4                  | 4.0                         |
|  | B3t     | 85-153    | -----          | -----      | -----                 | 1.1              | -----                        | -----          | 4.3                  | 3.7                         |
| Caralampi gravelly sandy loam. S68Ariz-12-4 (1-7) (80979-80986)      | A1      | 0-5       | 1.93           | .146       | 13                    | 2.0              | -----                        | -----          | 5.9                  | 5.4                         |
|  | B21t    | 5-13      | 1.67           | .127       | 13                    | 1.8              | -----                        | -----          | 6.1                  | 5.6                         |
|  | B22t    | 13-23     | 1.14           | .083       | 14                    | 1.9              | -----                        | -----          | 5.9                  | 5.5                         |
|  | B23t    | 23-33     | .67            | .052       | 13                    | 1.5              | -----                        | -----          | 5.9                  | 5.3                         |
|  | B24t    | 33-58     | .48            | -----      | -----                 | 1.8              | -----                        | -----          | 5.8                  | 5.5                         |
|  | B31t    | 58-78     | .18            | -----      | -----                 | 1.0              | -----                        | -----          | 6.4                  | 5.8                         |
|  | B32t    | 78-105    | -----          | -----      | -----                 | .8               | -----                        | -----          | 6.4                  | 5.8                         |
|  | C       | 105-153   | -----          | -----      | -----                 | .7               | -----                        | -----          | 6.8                  | 5.9                         |
| Casto very gravelly sandy loam. S68Ariz-2-3 (1-8) (80995-81002)      | A1      | 0-3       | 1.27           | .094       | 14                    | .8               | -----                        | -----          | 6.2                  | 5.8                         |
|  | B21t    | 3-13      | 1.24           | .091       | 14                    | .9               | -----                        | -----          | 6.1                  | 5.6                         |
|  | B22t    | 13-28     | .47            | .030       | 16                    | 1.1              | -----                        | -----          | 5.4                  | 5.0                         |
|  | B23t    | 28-40     | .36            | -----      | -----                 | .9               | -----                        | -----          | 5.4                  | 4.9                         |
|  | B31t    | 40-55     | .20            | -----      | -----                 | .9               | -----                        | -----          | 5.8                  | 5.2                         |
|  | B32t    | 55-70     | -----          | -----      | -----                 | .7               | -----                        | -----          | 6.3                  | 5.6                         |
|  | C1ca    | 70-113    | -----          | -----      | -----                 | .6               | 2                            | -----          | 7.8                  | 7.3                         |
|  | C2ca    | 113-150   | -----          | -----      | -----                 | .5               | 5                            | -----          | 7.8                  | 7.4                         |
| Continental gravelly sandy loam. S68Ariz-12-2 (1-8) (81017-81024)    | A11     | 0-8       | .39            | .035       | 11                    | .9               | -----                        | -----          | 6.8                  | 6.3                         |
|  | A12     | 8-15      | .43            | .041       | 10                    | .8               | -----                        | -----          | 6.6                  | 5.9                         |
|  | B1t     | 15-25     | .39            | -----      | -----                 | 1.1              | -----                        | -----          | 6.8                  | 6.1                         |
|  | B21t    | 25-48     | .57            | -----      | -----                 | 1.3              | -----                        | -----          | 7.0                  | 6.4                         |
|  | B22t    | 48-78     | .16            | -----      | -----                 | .8               | -----                        | -----          | 8.0                  | 7.0                         |
|  | IIB31ca | 78-95     | .14            | -----      | -----                 | .4               | 12                           | 2              | 8.3                  | 7.6                         |
|  | IIB32ca | 95-130    | -----          | -----      | -----                 | .4               | 13                           | 2              | 8.4                  | 7.7                         |
|  | IICca   | 130-180   | -----          | -----      | -----                 | .5               | 4                            | -----          | 8.5                  | 7.7                         |
| Faraway very cobbly fine sandy loam. S68Ariz-2-7 (1-3) (81031-81033) | A11     | 0-5       | 1.49           | .104       | 14                    | 1.1              | -----                        | -----          | 6.2                  | 5.5                         |
|  | A12     | 5-30      | 1.35           | -----      | -----                 | .9               | -----                        | -----          | 6.1                  | 5.4                         |
|  | R       | 30-43     | -----          | -----      | -----                 | .2               | -----                        | -----          | 7.5                  | 6.3                         |
| Hathaway gravelly sandy loam. S68Ariz-12-15 (1-7) (81035-81041)      | A11     | 0-13      | 1.64           | .163       | 10                    | .6               | 7                            | -----          | 7.8                  | 7.3                         |
|  | A12     | 13-25     | 1.31           | .135       | 10                    | .5               | 13                           | 3              | 8.0                  | 7.4                         |
|  | C1ca    | 25-33     | 1.03           | .111       | 10                    | .5               | 19                           | 4              | 8.0                  | 7.5                         |
|  | C2ca    | 33-50     | .84            | .086       | 10                    | .5               | 19                           | 3              | 8.0                  | 7.5                         |
|  | C3ca    | 50-78     | .45            | -----      | -----                 | .4               | 18                           | 2              | 8.1                  | 7.5                         |
|  | C4ca    | 78-98     | .23            | -----      | -----                 | .4               | 16                           | 1              | 8.2                  | 7.5                         |
|  | IIC5ca  | 98-115    | -----          | -----      | -----                 | .5               | 13                           | 1              | 8.0                  | 7.5                         |

selected soil profiles—Continued

| Particle-size distribution in material smaller than 2 millimeters—Continued |                      |                     | Coarse fragments |              |               |                | Coarse fragment conversion factor (Cm) | Bulk density |          |                     | Water content at— |         | Extensibility |      |
|---|----------------------|---------------------|------------------|--------------|---------------|----------------|--|--------------|----------|---------------------|-------------------|---------|---------------|------|
| Fine silt (0.02–0.002 mm)   | Int II (0.2–0.02 mm) | Fam sand (2–0.1 mm) | Total (>2 mm)    | CF1 (2–5 mm) | CF2 (5–19 mm) | CF3 (19–76 mm) |  | 1/3 bar      | Oven-dry | 1/3 bar (estimated) | 1/3 bar           | 15 bars | COLEF         | COLE |
| 16.9  | 41.6                 | 35.0                | 16               | 4            | 12            | -----          | 1.91                                   | 1.38         | 1.42     | -----               | 15.8              | 7.0     | 1.0           | 0.9  |
| 15.8  | 36.4                 | 24.7                | 3                | -----        | 3             | -----          | .98                                    | 1.42         | 1.51     | -----               | 18.2              | 10.6    | 2.1           | 2.0  |
| 8.2   | 13.1                 | 12.4                | -----            | -----        | -----         | -----          | 1.00                                   | 1.24         | 1.58     | -----               | 36.9              | 23.5    | 8.4           | 8.4  |
| 9.5   | 12.4                 | 13.1                | -----            | -----        | -----         | -----          | 1.00                                   | 1.23         | 1.59     | -----               | 38.7              | 24.4    | 8.9           | 8.9  |
| 13.1  | 13.8                 | 18.3                | -----            | -----        | -----         | -----          | 1.00                                   | 1.27         | 1.61     | -----               | 37.1              | 21.6    | 8.2           | 8.2  |
| 16.7  | 20.9                 | 33.4                | -----            | -----        | -----         | -----          | 1.00                                   | 1.33         | 1.51     | -----               | 31.1              | 18.8    | 4.3           | 4.3  |
| 17.1  | 22.4                 | 36.8                | -----            | -----        | -----         | -----          | 1.00                                   | 1.29         | 1.45     | -----               | 32.4              | 20.5    | 4.0           | 4.0  |
| 15.1  | 19.4                 | 45.5                | 39               | 1            | 24            | 14             | .76                                    | 1.31         | 1.45     | -----               | 31.8              | 19.1    | 3.4           | 2.6  |
| 13.7  | 31.0                 | 42.0                | 25               | -----        | 2             | 23             | .86                                    | 1.26         | 1.36     | -----               | 31.8              | 17.5    | 2.6           | 2.2  |

selected soil profiles

Service, Riverside, Calif. Dashes indicate analysis not made]

| Extractable bases |           |           |           | Sum of bases | Base saturation | Cation exchange capacity (NH <sub>4</sub> OAc) | Electrical conductivity | Exchangeable sodium | Mineralogy of fraction less than 0.002 millimeter |       |       |
|-------------------|-----------|-----------|-----------|--------------|-----------------|--|-------------------------|---------------------|---|-------|-------|
| Calcium           | Magnesium | Sodium    | Potassium |              |                 |  |                         |                     | I   | II    | III   |
| Meg/100 g         | Meg/100 g | Meg/100 g | Meg/100 g |              | Pct             | Meg/100 g                                      | Mmho/cm                 | Pct                 |   |       |       |
| 2.5               | 0.7       | 0.1       | 0.4       | 3.7          | 80              | 4.6  | -----                   | 2                   | MT 1  | MI 1  | KK 1  |
| 1.9               | .5        | .1        | .4        | 2.9          | 76              | 3.8  | -----                   | 3                   | MI 2  | KK 2  | MT 1  |
| 2.0               | .5        | .1        | .4        | 3.0          | 79              | 3.8  | -----                   | 3                   | MT 1  | MI 1  | KK 1  |
| 6.3               | 1.6       | .1        | .6        | 8.6          | 100             | 6.3  | 0.33                    | 2                   | KK 3  | MI 2  | MT 1  |
| 6.6               | 13.6      | .5        | 1.3       | 22.0         | 94              | 23.5   | -----                   | 2                   | KK 4  | MI 3  | MT 1  |
| 3.9               | 5.8       | .6        | .9        | 11.2         | 75              | 14.9   | -----                   | 4                   | MI 2  | KK 2  | MT 1  |
| 7.5               | 4.7       | .1        | .9        | 13.2         | 81              | 16.2   | -----                   | 1                   | MT 3  | MI 2  | KK 2  |
| 17.3              | 9.1       | .1        | .7        | 27.2         | 100             | 24.0   | .26                     | 0                   | -----   | ----- | ----- |
| 13.1              | 11.3      | .1        | .6        | 25.1         | 96              | 26.2   | -----                   | 0                   | -----   | ----- | ----- |
| 12.9              | 13.0      | .2        | .4        | 26.5         | 100             | 25.2   | -----                   | 1                   | MT 3  | MI 2  | KK 2  |
| 13.8              | 10.5      | .2        | .3        | 24.8         | 97              | 25.6   | -----                   | 1                   | -----   | ----- | ----- |
| 13.9              | 11.6      | .5        | .3        | 26.3         | 100             | 24.3   | -----                   | 2                   | MT 5  | MI 1  | ----- |
| 12.7              | 10.7      | .4        | .2        | 24.0         | 100             | 21.3   | -----                   | 2                   | -----   | ----- | ----- |
| 15.4              | 9.6       | .8        | .3        | 26.1         | 100             | 26.1   | -----                   | 3                   | MT 5  | ----- | ----- |
| 12.2              | 3.0       | .1        | .5        | 15.8         | 86              | 18.4   | .31                     | 1                   | MT 4  | MI 1  | KK 1  |
| 16.5              | 3.4       | .2        | .5        | 20.6         | 78              | 26.5   | -----                   | 1                   | MT 4  | MI 1  | KK 1  |
| 27.4              | 6.4       | .4        | .5        | 34.7         | 89              | 39.0   | .28                     | 1                   | -----   | ----- | ----- |
| 26.9              | 5.8       | .5        | .4        | 33.6         | 91              | 36.9   | .29                     | 1                   | MT 4  | ----- | ----- |
| 30.3              | 6.4       | .5        | .3        | 37.5         | 100             | 36.3   | .23                     | 1                   | -----   | ----- | ----- |
| 27.5              | 5.7       | .8        | .3        | 34.3         | 91              | 37.8   | .36                     | 2                   | MT 5  | ----- | ----- |
| 27.9              | 4.4       | .9        | .3        | 33.5         | 93              | 36.1   | .44                     | 2                   | -----   | ----- | ----- |
| 34.3              | 4.9       | 1.0       | .3        | 40.5         | 97              | 41.9   | .46                     | 2                   | MT 5  | ----- | ----- |
| 4.8               | .9        | -----     | .4        | 6.1          | 100             | 6.0  | -----                   | -----               | MT 2  | MI 2  | KK 2  |
| 4.4               | 1.6       | -----     | .4        | 6.4          | 89              | 7.2  | -----                   | -----               | -----   | ----- | ----- |
| 6.6               | 2.5       | .1        | .6        | 9.8          | 86              | 11.4   | -----                   | 1                   | MI 2  | KK 2  | MT 1  |
| 14.6              | 6.2       | .2        | 1.0       | 22.0         | 94              | 23.3   | -----                   | 1                   | -----   | ----- | ----- |
| 9.8               | 3.7       | .3        | .8        | 14.6         | 73              | 20.0   | .36                     | 1                   | MT 2  | MI 2  | KK 2  |
| 13.7              | 5.1       | .4        | .6        | 19.8         | 100             | 14.2   | .41                     | 3                   | -----   | ----- | ----- |
| 14.0              | 5.5       | .6        | .6        | 20.7         | 100             | 13.8   | .46                     | 4                   | -----   | ----- | ----- |
| 11.1              | 4.1       | .7        | .6        | 16.5         | 100             | 16.2   | .48                     | 4                   | -----   | ----- | ----- |
| 9.8               | 2.6       | .1        | .4        | 12.9         | 100             | 12.6   | -----                   | 1                   | MT 2  | MI 2  | KK 1  |
| 10.1              | 2.9       | .1        | .4        | 13.5         | 89              | 15.1   | -----                   | 1                   | MT 2  | MI 2  | KK 1  |
| 4.0               | 1.3       | .1        | .5        | 5.9          | 100             | 5.0  | -----                   | 2                   | MI 2  | MT 1  | ----- |
| 19.3              | 1.5       | .1        | .5        | 21.4         | 100             | 19.2   | .42                     | 1                   | MT 4  | MI 3  | KK 2  |
| 20.6              | .6        | .1        | .3        | 21.6         | 100             | 19.6   | .34                     | 1                   | -----   | ----- | ----- |
| 19.9              | .7        | .1        | .3        | 21.0         | 100             | 18.2   | .33                     | 1                   | MT 3  | MI 2  | KK 1  |
| 17.9              | 1.0       | .1        | .2        | 19.2         | 100             | 15.0   | .33                     | 1                   | -----   | ----- | ----- |
| 13.8              | .7        | .1        | .1        | 14.7         | 100             | 10.9   | .34                     | 1                   | MT 2  | MI 2  | ----- |
| 12.2              | 1.0       | .1        | .1        | 13.4         | 100             | 10.3   | .35                     | 1                   | -----   | ----- | ----- |
| 15.7              | 2.4       | .2        | .2        | 18.5         | 100             | 17.4   | .36                     | 1                   | -----   | ----- | ----- |

TABLE 12.—*Chemical data for*

| Soil, sample number and lab numbers <sup>1</sup>                   | Horizon | Depth   | Or-<br>ganic<br>carbon | Nitro-<br>gen       | Carbon-<br>nitro-<br>gen<br>ratio | Extract-<br>able iron | Calcium<br>carbon-<br>ate<br>equiv-<br>alent | Car-<br>bonate<br>clay | Reaction                |                                   |
|--|---------|---------|------------------------|---------------------|-----------------------------------|-----------------------|--|------------------------|-------------------------|-----------------------------------|
|  |         |         |                        |                     |                                   |                       |  |                        | 1:1<br>H <sub>2</sub> O | 1:1<br>CaCl <sub>2</sub><br>0.01N |
| Martinez gravelly loam.<br>S68Ariz-2-2(1-7)<br>(81052-81059)       | A11     | 0-3     | <i>Pet</i><br>1.18     | <i>Pet</i><br>0.096 | 12                                | <i>Pet</i><br>2.3     | <i>Pet</i>                                   | <i>Pet</i>             | <i>pH</i><br>5.0        | <i>pH</i><br>4.2                  |
|  | A12     | 3-15    | 1.05                   | .097                | 11                                | 2.3                   |  |                        | 5.5                     | 4.7                               |
|  | B1t     | 15-25   | 1.05                   | .098                | 11                                | 2.1                   |  |                        | 6.1                     | 5.5                               |
|  | B21t    | 25-45   | .79                    | .081                | 10                                | 2.8                   |  |                        | 7.1                     | 6.8                               |
|  | B22t    | 45-65   | .39                    |                     |                                   | 2.6                   |  |                        | 7.8                     | 7.5                               |
|  | B23t    | 65-88   | .21                    |                     |                                   | 2.3                   |  |                        | 8.0                     | 7.5                               |
|  | B3t     | 88-115  |                        |                     |                                   | 1.5                   |  |                        | 8.1                     | 7.2                               |
|  |         |         |                        |                     |                                   |                       |  |                        |                         |                                   |
| Sonoita gravelly sandy loam.<br>S68Ariz-12-3(1-8)<br>(81060-81068) | A11     | 0-5     | .38                    | .031                | 12                                | .5                    |  |                        | 5.7                     | 4.9                               |
|  | A12     | 5-10    | .23                    | .021                | 11                                | .6                    |  |                        | 7.9                     | 7.5                               |
|  | B21     | 10-25   | .23                    |                     |                                   | .6                    |  |                        | 8.0                     | 7.5                               |
|  | B22     | 24-43   | .24                    |                     |                                   | .6                    |  |                        | 7.8                     | 7.0                               |
|  | B23t    | 43-65   |                        |                     |                                   | .5                    |  |                        | 8.2                     | 7.1                               |
|  | B24tca  | 65-100  |                        |                     |                                   | .7                    | 2  |                        | 8.2                     | 7.4                               |
|  | B25tca  | 100-155 |                        |                     |                                   | .6                    | 2  |                        | 8.3                     | 7.5                               |
|  | B3ca    | 155-175 |                        |                     |                                   | .6                    | 1  |                        | 8.4                     | 7.5                               |
| White House gravelly loam.<br>S68Ariz-12-9(1-9)<br>(81070-81078)   | A1      | 0-8     | 1.10                   | .099                | 11                                | 1.9                   |  |                        | 5.3                     | 4.4                               |
|  | B1t     | 8-23    | 1.07                   | .100                | 11                                | 2.2                   |  |                        | 5.8                     | 5.0                               |
|  | B21t    | 23-40   | .98                    | .092                | 11                                | 2.4                   |  |                        | 6.9                     | 6.5                               |
|  | B22t    | 40-55   |                        |                     |                                   | 2.4                   | 1  |                        | 7.8                     | 7.4                               |
|  | B23tca  | 55-65   |                        |                     |                                   | 2.1                   | 9  |                        | 8.0                     | 7.3                               |
|  | B31tca  | 65-98   |                        |                     |                                   | 2.8                   | 10   |                        | 8.1                     | 7.6                               |
|  | B32tca  | 98-123  |                        |                     |                                   | 3.1                   | 1  |                        | 8.0                     | 7.5                               |
|  | B33ca   | 123-155 |                        |                     |                                   | 2.3                   | 1  |                        | 7.9                     | 7.3                               |
|  | Cca     | 155-195 |                        |                     |                                   | 2.3                   | 1  |                        | 7.8                     | 7.3                               |
|  |         |         |                        |                     |                                   |                       |  |                        |                         |                                   |

<sup>1</sup> See the section "Descriptions of the Soils" for the location of representative profiles of these soils.

The first Spanish military outpost was established at Tubac in 1752. The Gadsden Purchase in 1853 brought a few miners and other settlers into the Santa Cruz Valley.

Nogales was founded in 1880 near the time of the completion of the railroads on both sides of the border. Ten years later the population of Nogales had increased to 1,194, largely because of the growth of imports and exports.

Santa Cruz County was organized from a part of Pima County in 1899. Population of the county was 4,545 in 1900 and 14,000 in 1970. About two-thirds of the population of the county is in Nogales, the county seat. Other towns of the county are Patagonia, Sonoita, Elgin, Amado, Tubac, Tumacacori, and Carmen, the latter four being along the railroad and Interstate Highway 19 north of Nogales.

## Farming

The cattle industry, originally introduced by the early Jesuit missionaries, expanded throughout the rich grazing ranges. The former huge Spanish land grants have largely been broken up. Most ranches in the Area range in size from 500 acres to about 60,000 acres but are generally between 3,000 and 10,000 acres. Commonly, small deeded acreages are owned by the rancher and the balance of the range is leased from the National Forest and the State of Arizona.

In 1969, total irrigated cropland was 3,079 acres (13). Crops raised that year were 600 acres of alfalfa,

129 acres of cotton, and 1,300 acres of grain and irrigated pasture; 1,050 acres of cropland was left idle. In 1970 no cotton was raised. Irrigated farms range in size from 5 to 1,100 acres, but most are between 40 and 200 acres. All irrigation is by turbine pumps.

Depth to the water table along the Santa Cruz River flood plain ranges from 20 to 80 feet. The level of the water table does not change drastically, although annual fluctuations in some of the larger wells may be fairly great. Water quality is good to excellent for irrigation. The quantities pumped normally range from about 300 to 1,400 gallons per minute; the average is about 800 gallons per minute.

## Climate <sup>10</sup>

The Area of this survey is relatively small; differences in climate within it are caused mainly by variations in elevation, since the terrain is fairly rugged and mountainous. The area generally has a semi-arid climate typical of that of a steppe, except for areas in the mountains at an elevation above about 7,000 feet, where a highland climate prevails.

In this part of Arizona, about one-half of the annual precipitation falls during thundershowers in July and August. The source of moisture for these storms is the Gulf of Mexico; thus, precipitation is usually slightly higher at stations on the southern slopes of the moun-

<sup>10</sup> By PAUL C. KANGIESER, climatologist for Arizona, National Weather Service, U.S. Department of Commerce.

## selected soil profiles—Continued

| Extractable bases |                  |                  |                  | Sum of bases | Base saturation | Cation exchange capacity (NH <sub>4</sub> OAc) | Electrical conductivity | Exchangeable sodium | Mineralogy of fraction less than 0.002 millimeter |      |      |
|-------------------|------------------|------------------|------------------|--------------|-----------------|--|-------------------------|---------------------|---|------|------|
| Calcium           | Magnesium        | Sodium           | Potassium        |              |                 |  |                         |                     | I   | II   | III  |
| <i>Meg/100 g</i>  | <i>Meg/100 g</i> | <i>Meg/100 g</i> | <i>Meg/100 g</i> |              | <i>Pct</i>      | <i>Meg/100 g</i>                               | <i>Mmho/cm</i>          | <i>Pct</i>          |   |      |      |
| 2.6               | 1.2              |                  | 0.6              | 4.4          | 45              | 9.8  |                         |                     | MI 3  | KK 3 | MT 1 |
| 4.9               | 2.7              | 0.1              | .7               | 8.4          | 66              | 12.8   |                         | 1                   | MI 3  | KK 3 | MT 1 |
| 10.6              | 5.4              | .4               | .7               | 17.1         | 86              | 19.9   |                         | 2                   |   |      |      |
| 15.4              | 15.0             | 1.2              | 1.1              | 32.7         | 100             | 28.7   | 0.41                    | 4                   | KK 4  | MI 3 | MT 1 |
| 17.8              | 14.4             | 1.8              | .9               | 34.9         | 100             | 27.5   | .54                     | 7                   |   |      |      |
| 18.6              | 11.1             | 1.9              | .9               | 32.5         | 100             | 26.7   | .64                     | 7                   |   |      |      |
| 15.2              | 8.8              | 1.7              | .5               | 26.2         | 100             | 21.3   | .36                     | 8                   | KK 4  | MI 3 | MT 1 |
| 5.1               | 2.6              | .1               | .7               | 8.5          | 74              | 11.5   |                         | 1                   | MI 3  | KK 2 | MT 1 |
| 2.5               | .8               | .1               | .4               | 3.8          | 93              | 4.1  |                         | 2                   |   |      |      |
| 4.7               | 1.3              | .1               | .3               | 6.4          | 100             | 5.3  |                         | 2                   | MI 3  | KK 3 |      |
| 6.4               | 1.3              | .1               | .2               | 8.0          | 100             | 6.1  |                         | 2                   |   |      |      |
| 7.9               | 1.4              | .1               | .2               | 9.6          | 100             | 5.0  | .48                     | 2                   | MI 3  | KK 3 |      |
| 18.8              | 4.7              | .3               | .5               | 24.3         | 100             | 9.3  | .72                     | 3                   |   |      |      |
| 16.9              | 3.9              | .6               | .5               | 21.9         | 100             | 8.7  | .76                     | 7                   |   |      |      |
| 13.5              | 3.4              | .9               | .5               | 18.3         | 100             | 9.9  | .74                     | 9                   |   |      |      |
| 4.6               | 2.1              | .1               | .9               | 7.7          | 66              | 11.6   |                         | 1                   | MI 3  | KK 2 |      |
| 10.3              | 3.7              | .1               | 1.0              | 15.1         | 91              | 16.6   |                         | 1                   | MI 3  | KK 2 | MT 1 |
| 20.2              | 9.0              | .7               | 1.5              | 31.4         | 93              | 33.6   |                         | 2                   |   |      |      |
| 23.6              | 9.6              | 1.2              | 1.5              | 35.9         | 100             | 35.9   | .44                     | 3                   | MT 3  | MI 3 | KK 2 |
| 23.8              | 9.7              | 1.2              | 1.3              | 36.0         | 100             | 35.5   | .31                     | 3                   |   |      |      |
| 33.7              | 11.3             | 2.3              | 1.1              | 48.4         | 95              | 50.7   | .58                     | 5                   |   |      |      |
| 32.9              | 12.2             | 2.3              | .9               | 48.3         | 100             | 45.6   | .87                     | 5                   | MT 4  | MI 3 | KK 2 |
| 31.5              | 11.3             | 2.2              | .9               | 45.9         | 100             | 42.5   | 1.45                    | 4                   |   |      |      |
| 23.5              | 10.4             | 2.1              | .8               | 35.8         | 84              | 42.9   | 1.90                    | 4                   | MT 4  | MI 2 | KK 2 |

<sup>3</sup> Mineral code: MT = montmorillonite; MI = mica; KK = kaolinite. Relative amount: 1 = trace; 2 = small; 3 = moderate; 4 = abundant; 5 = dominant.

tain ranges. Some stations at high elevations normally receive more than 10 inches of rain during this 2-month period. In a wet year they can receive as much as 20 inches during the entire summer rainy season, which usually extends from the latter part of June through most of September. Rainfall rates during some of these summer storms can be quite high: the town of Ruby, whose precipitation record runs from 1896 through 1955, received 4.43 inches between 4:00 p.m. and midnight on July 21, 1941.

About 1 year out of 5, a waning tropical disturbance that has entered the State by way of Lower California produces heavy precipitation early in fall. Such precipitation, though rare, is usually heavy and sometimes lasts for several days, in contrast to the summer thunderstorm precipitation, which usually lasts only a few hours.

This part of the State must rely on the Pacific Ocean for its winter moisture, but Santa Cruz County is too far south to be affected by most of the storms that move across the State from the Pacific. Usually, only those storms that enter the west coast of the continent by way of southern California bring moisture to the Area. Such storms produce a slight secondary increase in precipitation from December through March. On the average, October, November, April, May, and most of June are quite dry.

Snowfall over most of this area is rare in winter and usually melts rapidly on the valley floors. At higher elevations, it may accumulate to a depth of several feet. Winter precipitation, in contrast to summer rain-

fall, may sometimes last for several days, although the rate of fall is considerably slower during the winter storms.

Skies are usually partly cloudy on summer afternoons, and temperatures above 100° F are infrequent. After sunset, the sky usually clears and temperature falls to about 30° below the afternoon high by sunrise the following morning.

Winter is characterized by mild, clear days and chilly nights with near-freezing or below-freezing temperatures early in the morning. During winter the daily temperature range is 30° or more, so that temperatures at stations on the valley floors rise to the low or middle sixties in the afternoon, and in about one January out of every five, the afternoon high is at least 80°.

Tables 13 and 14 give specific climatological data for two selected stations in this part of the State.

## Natural Resources

Following the Civil War many mines were located in the survey area. They produced lead, silver, zinc, copper, gold, molybdenum, and tungsten. Most of these were small operations, but the aggregate yield was considerable. Most of the mines closed with the decline in the price of silver, but several are now being reactivated and further explored. At least one large open pit mine is in immediate prospect in the northern part of the Santa Rita Mountains near Helvetia.

The year-round balmy climate is perhaps the major

TABLE 13.—Temperature and precipitation data from two weather stations

| Month                                      | Temperature                  |     |   |   | Precipitation <sup>a</sup> |                           |            |
|--|------------------------------|-----|---|---|----------------------------|---------------------------|------------|
|  | Average daily <sup>1</sup> — |     | Two years in 10 will have at least 4 days with <sup>2</sup> — |   | Average total              | One year in 10 will have— |            |
|  | High                         | Low | 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                                    | 63                           | 30  | 76  | 16  | 1.1                        | 0                         | 2.1        |
| February                                   | 67                           | 32  | 78  | 16  | .8                         | .1                        | 1.8        |
| March                                      | 71                           | 36  | 80  | 22  | .8                         | 0                         | 1.8        |
| April                                      | 78                           | 42  | 88  | 29  | .3                         | 0                         | .8         |
| May  | 86                           | 48  | 95  | 34  | .1                         | 0                         | .4         |
| June                                       | 95                           | 58  | 102   | 41  | .3                         | 0                         | .8         |
| July                                       | 94                           | 65  | 100   | 57  | 3.9                        | 2.0                       | 6.1        |
| August                                     | 91                           | 63  | 97  | 54  | 4.2                        | 1.9                       | 7.1        |
| September                                  | 90                           | 57  | 96  | 44  | 1.5                        | .3                        | 3.2        |
| October                                    | 82                           | 46  | 91  | 32  | .9                         | 0                         | 2.0        |
| November                                   | 73                           | 35  | 81  | 21  | .5                         | 0                         | 1.4        |
| December                                   | 65                           | 30  | 76  | 16  | 1.1                        | 0                         | 2.6        |
| Year                                       | 80                           | 45  | 104   | <sup>a</sup> 11                             | 15.5                       | 11.2                      | 20.2       |
| Santa Rita Experimental Range Headquarters |                              |     |   |   |                            |                           |            |
| January                                    | 58                           | 37  | 70  | 26  | 1.8                        | 0                         | 3.6        |
| February                                   | 61                           | 39  | 72  | 29  | 1.4                        | .3                        | 2.9        |
| March                                      | 66                           | 43  | 76  | 32  | 1.2                        | 0                         | 2.6        |
| April                                      | 75                           | 49  | 86  | 39  | .5                         | 0                         | 1.4        |
| May  | 83                           | 56  | 92  | 47  | .1                         | 0                         | .4         |
| June                                       | 92                           | 65  | 100   | 57  | .7                         | 0                         | 1.9        |
| July                                       | 91                           | 68  | 99  | 63  | 3.9                        | 2.0                       | 5.9        |
| August                                     | 88                           | 66  | 96  | 62  | 4.5                        | 1.7                       | 7.7        |
| September                                  | 87                           | 64  | 93  | 57  | 1.9                        | .3                        | 4.0        |
| October                                    | 79                           | 55  | 88  | 46  | 1.0                        | 0                         | 2.3        |
| November                                   | 68                           | 44  | 78  | 35  | .9                         | 0                         | 2.4        |
| December                                   | 61                           | 39  | 71  | 29  | 1.4                        | .2                        | 3.0        |
| Year                                       | 76                           | 52  | <sup>4</sup> 101  | <sup>5</sup> 22                             | 19.3                       | 13.9                      | 24.9       |

<sup>1</sup> Period 1893–1957 for Nogales, 1917–57 for Santa Rita.<sup>2</sup> Period 1946–62 for Nogales, 1933–62 for Santa Rita.<sup>3</sup> Period 1933–62.<sup>4</sup> Average annual highest.<sup>5</sup> Average annual lowest.

TABLE 14.—Probabilities of last freezing temperatures in spring and first in fall at two weather stations

| 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 |
| Nogales [Period of record, 1945–62]                                    |   |                  |                        |                |                |
| Spring:  |   |                  |                        |                |                |
| 1 year in 10 later than  | March 20                                    | March 27         | April 4                | April 26       | May 23         |
| 2 years in 10 later than   | March 7                                     | March 17         | March 29               | April 20       | May 16         |
| 5 years in 10 later than   | February 10                                 | February 24      | March 18               | April 7        | May 2          |
| Fall:  |   |                  |                        |                |                |
| 1 year in 10 earlier than  | November 16                                 | November 2       | October 30             | October 23     | October 13     |
| 2 years in 10 earlier than   | November 28                                 | November 9       | November 4             | October 28     | October 17     |
| 5 years in 10 earlier than   | December 20                                 | November 22      | November 13            | November 5     | October 25     |
| Santa Rita Experimental Range Headquarters [Period of record, 1933–62] |   |                  |                        |                |                |
| Spring:  |   |                  |                        |                |                |
| 1 year in 10 later than  | January 3                                   | February 9       | February 27            | March 23       | April 10       |
| 2 years in 10 later than   | ( <sup>1</sup> )                            | January 24       | February 12            | March 10       | March 31       |
| 5 years in 10 later than   | ( <sup>1</sup> )                            | ( <sup>1</sup> ) | January 13             | February 13    | March 14       |
| Fall:  |   |                  |                        |                |                |
| 1 year in 10 earlier than  | ( <sup>1</sup> )                            | December 16      | December 4             | November 13    | November 1     |
| 2 years in 10 earlier than   | ( <sup>1</sup> )                            | December 30      | December 16            | November 24    | November 10    |
| 5 years in 10 earlier than   | ( <sup>1</sup> )                            | ( <sup>1</sup> ) | <sup>2</sup> January 9 | December 17    | November 26    |

<sup>1</sup> Threshold did not occur frequently enough during the period of record for computation at this probability level.<sup>2</sup> Fall threshold occurs after end of calendar year at this probability level.

natural resource of the area. Many visitors from the East and Midwest winter in the area. Land companies have bought up large tracts of private ranch land and are subdividing them into 1- to 5-acre lots. A few substantial communities have been established, but most purchases are for future development or for investment.

## Transportation

Nogales is served by a branch of the Southern Pacific Railroad from Tucson, which joins with the Ferrocarril del Pacifico, owned by the Mexican government. This gives daily freight and passenger service between Nogales and Mexico City. Interstate Highway 19, a partially completed divided highway, connects Nogales and Tucson, and State Highway 82 links Nogales to Patagonia, Sonoita, and Cochise County to the east.

## International Trade

With the expansion of agriculture in northwestern Mexico, Nogales has become a major processing and distribution point for Mexican-grown produce bound for markets in the United States and Canada. In 1970 there were at least 40 produce-distributing companies in and around Nogales (3, 6). Nogales is the second largest Mexican-American port of entry in the United States. Ambos Nogales, Mexico, is immediately across the border.

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## Glossary

**Aggregate, soil.** Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

**Alluvial fan.** A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where it flows out onto a level plain or meets a slower stream.

**Available water capacity** (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is expressed in this survey area as inches of water in the soil profile and rated as follows:

|                | <i>Inches</i> |
|----------------|---------------|
| Very low ..... | 2.5           |
| Low .....      | 2.5-5.0       |
| Moderate ..... | 5.0-7.5       |
| High .....     | 7.5           |

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

**Caliche.** A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.

**Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

**Clay film.** A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

**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 when dry or moist; does not hold together in a mass.

*Friable.*—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

*Firm.*—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

*Plastic.*—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

*Sticky.*—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

*Hard.*—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

*Soft.*—When dry, breaks into powder or individual grains under very slight pressure.

*Cemented.*—Hard and brittle; little affected by moistening.

**Effective rooting depth** (soil depth). Depth to a claypan, hardpan, bedrock, or any other layer in the soil that would stop or would hinder the penetration of roots. It is the depth of soil readily penetrated by roots. Depth classes are: *Very deep*, more than 60 inches; *deep*, 40 to 60 inches; *moderately deep*, 20 to 40 inches; *shallow*, 10 to 20 inches; and *very shallow*, less than 10 inches.

**Erosion.** The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

**Flood plain.** Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

**Gravel.** A soil separate made up of pebbles, rounded or angular, that have a diameter ranging from 2.0 to 80 millimeters. The content of gravel is not used in determining the textural class of the soil.

**Grazable woodland.** Woodland in which the understory includes, as an integral part of the forest plant community, plants

that can be grazed without significantly impairing other forest values.

**Hardpan.** A hardened or cemented soil horizon, or layer. The soil material may be sandy or clayey, and it may be cemented by iron oxide, silica, calcium carbonate, or other substance.

**Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

**O horizon.**—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

**A horizon.**—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

**B horizon.**—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

**C horizon.**—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

**R layer.**—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

**Irrigation.** Application of water to soils to assist in production of crops. Methods of irrigation commonly used in this survey area are:

**Border.**—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

**Furrow.**—Water is applied in small ditches made by cultivation implements used for tree and row crops.

**Sprinkler.**—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

**Lime.** Chemically, lime is calcium oxide, but as the term is commonly used, it is also calcium carbonate and calcium hydroxide.

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

**Parent material.** Disintegrated and partly weathered rock from which soil has formed.

**Ped.** An individual natural soil aggregate, such as crumb, a prism, or a block, in contrast to a clod.

**Permeability.** The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are:

|                        | Inches per hour |
|------------------------|-----------------|
| Very slow .....        | Less than 0.06  |
| Slow .....             | 0.06–0.20       |
| Moderately slow .....  | 0.20–0.60       |
| Moderate .....         | 0.60–2.00       |
| Moderately rapid ..... | 2.00–6.00       |
| Rapid .....            | 6.00–20.0       |
| Very rapid .....       | More than 20.0  |

**pH value.** A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

**Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material.

**Reaction, soil.** The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

|                          | pH         |                              | pH             |
|--------------------------|------------|------------------------------|----------------|
| Extremely acid .....     | Below 4.5  | Neutral .....                | 6.6 to 7.3     |
| Very strongly acid ..... | 4.5 to 5.0 | Mildly alkaline .....        | 7.4 to 7.8     |
| Strongly acid .....      | 5.1 to 5.5 | Moderately alkaline .....    | 7.9 to 8.4     |
| Medium acid .....        | 5.6 to 6.0 | Strongly alkaline .....      | 8.5 to 9.0     |
| Slightly acid .....      | 6.1 to 6.5 | Very strongly alkaline ..... | 9.1 and higher |

**Residual material.** Unconsolidated, partly weathered mineral material that accumulates over disintegrating solid rock. Residual material is not soil but is frequently the material in which a soil has formed.

**Sand.** Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

**Series, soil.** A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

**Silt.** Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

**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 on earthy parent material, as conditioned by relief over periods of time.

**Solum.** The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**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 either *single grained* (each grain by itself, as in dune sand) or *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 solum below plow depth.

**Substratum.** Technically, the part of the soil below the solum.

**Surface soil or layer.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

**Terrace (geological).** An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

**Texture, soil.** The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine." Coarse texture includes sand and loamy sand; moderately coarse texture includes sandy loam and fine sandy loam; medium texture includes very fine sandy loam, loam, silt loam, and silt; moderately fine textured includes clay loam, sandy clay loam, and silty clay loam; and fine textured includes sandy clay, silty clay, and clay.

**Topsoil.** A presumed fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress lawns, and gardens.

**Tuff.** Rocks formed of compacted volcanic fragments, usually less than 4 millimeters in diameter.

**Water supplying capacity.** The amount of precipitation less the amount that is lost by runoff and evaporation.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and the soil series to which the mapping unit belongs. In referring to a capability unit or range site, read the introduction to the section it is in for general information about its management.

| Map symbol | Mapping unit  | De-scribed on page | Capability unit |               | Range site  | Page  | Range productivity group                              |
|------------|---|--------------------|-----------------|---------------|---|-------|---|
|            |   |                    | Irrigated       | Nonirri-gated |   |       |   |
| An         | Anthony soils-----  | 7                  | -----           | VI s          | Sandy Loam, 12- to 16-inch precipitation zone         | 53    | 2   |
| Ao         | Anthony soils, very gravelly variants-----                          | 8                  | -----           | VI s          | Sandy Loam, 12- to 16-inch precipitation zone         | 53    | 3   |
| AtF        | Atascosa very gravelly sandy loam, 30 to 50 percent slopes-----     | 8                  | -----           | VII s         | Loamy Hills, 16- to 20-inch precipitation zone        | 56    | 4   |
| BaE        | Barkerville-Gaddes complex, 10 to 30 percent slopes-----            | 9                  | -----           | VI e          | Loamy Hills, 16- to 20-inch precipitation zone        | 56    | 4   |
| BgF        | Barkerville-Gaddes association, steep--                             | 9                  | -----           | VII e         | Loamy Hills, 16- to 20-inch precipitation zone        | 56    | 4 <sup>2/</sup>                                       |
| BhD        | Bernardino-Hathaway association, rolling-----                       | 10                 | -----           | VI e          | -----   | --    | 2   |
|            | Bernardino soils-----   | --                 | -----           | -----         | Clay Loam Upland, 12- to 16-inch precipitation zone   | 53    | --  |
|            |   |                    |                 |               | Clay Loam Upland, 16- to 20-inch precipitation zone   | 53    |   |
|            | Hathaway soils-----   | --                 | -----           | -----         | Limy Slopes, 12- to 16-inch precipitation zone        | 54    | --  |
| BoB        | Bonita clay, 0 to 5 percent slopes----                              | 11                 | -----           | VI e          | Limy Slopes, 16- to 20-inch precipitation zone        | 55    |   |
|            |   |                    |                 |               | Clay Upland, 16- to 20-inch precipitation zone        | 53    | 2   |
| Ca         | Calciorthids-Haplargids association----                             | 11                 | -----           | VII e         | -----   | --    | 4   |
|            |   |                    |                 |               | Calciorthids-----                                     | --    | -----   |
| CbD        | Canelo gravelly sandy loam, 0 to 20 percent slopes-----             | 13                 | -----           | VI e          | Loamy Hills, 12- to 16-inch precipitation zone        | 55    | --  |
|            |   |                    |                 |               | -----   | ----- | Loamy Upland (oak), 16- to 20-inch precipitation zone |
| CdE        | Canelo very gravelly sandy loam, 20 to 40 percent slopes-----       | 13                 | -----           | VI e          | Loamy Upland (oak), 16- to 20-inch precipitation zone | 57    | 3   |
| CeD        | Canelo cobbly sandy loam, 0 to 20 percent slopes-----               | 13                 | -----           | VI e          | Loamy Upland (oak), 16- to 20-inch precipitation zone | 57    | 3   |
| CgE        | Caralampi gravelly sandy loam, 10 to 40 percent slopes-----         | 14                 | -----           | VI e          | Sandy Loam, 12- to 16-inch precipitation zone         | 53    | 3   |
| CgF2       | Caralampi gravelly sandy loam, 10 to 60 percent slopes, eroded----- | 15                 | -----           | VII e         | Sandy Loam, 12- to 16-inch precipitation zone         | 53    | 3   |
| C1B        | Caralampi gravelly loam, brown variant, 1 to 5 percent slopes-----  | 15                 | -----           | VI e          | Loamy Upland, 16- to 20-inch precipitation zone       | 57    | 3   |
| CmE        | Casto very gravelly sandy loam, 10 to 40 percent slopes-----        | 17                 | -----           | VI e          | Loamy Upland (oak), 16- to 20-inch precipitation zone | 57    | 3   |
| Cn         | Cave gravelly sandy loam-----                                       | 17                 | -----           | VII s         | Limy Upland, 12- to 16-inch precipitation zone        | 55    | 4   |

GUIDE TO MAPPING UNITS--Continued

| Map symbol | Mapping unit   | De-scribed on page | Capability unit                      |               | Range site   | Page | Range productivity group      |
|------------|--|--------------------|--------------------------------------|---------------|--|------|-------------------------------|
|            |  |                    | Irrigated                            | Nonirri-gated |  |      |                               |
| CoE        | Chiricahua cobbly sandy loam, 10 to 45 percent slopes-----       | 18                 | -----                                | VIe           | Loamy Hills, 16- to 20-inch precipitation zone     | 56   | 4                             |
| CrD        | Chiricahua-Lampshire association, rolling-----                   | 18                 | -----                                | VIe           | Loamy Hills, 16- to 20-inch precipitation zone     | 56   | 4                             |
| CsC        | Comoro sandy loam, 5 to 10 percent slopes-----                   | 19                 | -----                                | VIe           | Loam Bottom, 12- to 20-inch precipitation zone     | 55   | 2                             |
| CtB        | Comoro soils, 0 to 5 percent slopes----                          | 19                 | IIIs-7 <sup>1</sup> / <sub>2</sub> / | VIe           | Loam Bottom, 12- to 20-inch precipitation zone     | 55   | 2                             |
| CuC        | Continental soils, 1 to 10 percent slopes-----                   | 20                 | -----                                | VIe           | Loamy Upland, 12- to 16-inch precipitation zone    | 57   | 2                             |
| CvE2       | Continental-Rillino complex, 1 to 40 percent slopes, eroded----- | 21                 | -----                                | VIe           | -----  | --   | 3                             |
|            | Continental soils-----   | --                 | -----                                | -----         | Loamy Upland, 12- to 16-inch precipitation zone    | 57   | --                            |
|            | Rillino soils-----   | --                 | -----                                | -----         | Limy Upland, 12- to 16-inch precipitation zone     | 55   | --                            |
| EbC        | Eba very gravelly sandy loam, 0 to 10 percent slopes-----        | 21                 | -----                                | VIe           | Loamy Upland, 12- to 16-inch precipitation zone    | 57   | 3                             |
| FaD        | Fanno-Luzena association, rolling-----                           | 22                 | -----                                | VIe           | Clay Loam Hills, 16- to 20-inch precipitation zone | 53   | 3                             |
| FcF        | Fanno soils, acid variants, 20 to 50 percent slopes-----         | 23                 | -----                                | VIe           | -----  | --   | 4 <sup>2</sup> / <sub>1</sub> |
| FrE        | Faraway-Rock outcrop complex, 10 to 30 percent slopes-----       | 24                 | -----                                | VIe           | -----  | --   | 4                             |
|            | Faraway soils-----   | --                 | -----                                | -----         | Loamy Hills, 16- to 20-inch precipitation zone     | 56   | --                            |
|            | Rock outcrop-----  | --                 | -----                                | -----         | -----  | --   | --                            |
| FrF        | Faraway-Rock outcrop complex, 30 to 60 percent slopes-----       | 24                 | -----                                | VIIe          | -----  | --   | 4                             |
|            | Faraway soils-----   | --                 | -----                                | -----         | Loamy Hills, 16- to 20-inch precipitation zone     | 56   | --                            |
|            | Rock outcrop-----  | --                 | -----                                | -----         | -----  | --   | --                            |
| FtF        | Faraway-Tortugas-Rock outcrop association, steep-----            | 25                 | -----                                | VIIe          | -----  | --   | 4                             |
|            | Faraway soils-----   | --                 | -----                                | -----         | Loamy Hills, 16- to 20-inch precipitation zone     | 56   | --                            |
|            | Tortugas soils-----  | --                 | -----                                | -----         | Limestone Hills, 16- to 20-inch precipitation zone | 54   | --                            |
|            | Rock outcrop-----  | --                 | -----                                | -----         | -----  | --   | --                            |
| GaE        | Gaddes very gravelly sandy loam, 5 to 30 percent slopes-----     | 25                 | -----                                | VIe           | Loamy Hills, 16- to 20-inch precipitation zone     | 56   | 4                             |
| GbB        | Grabe-Comoro complex, 0 to 5 percent slopes-----                 | 26                 | IIIs-7 <sup>1</sup> / <sub>2</sub> / | VIe           | Loam Bottom, 12- to 20-inch precipitation zone     | 55   | 2                             |
| Ge         | Grabe soils-----   | 27                 | I-1 <sup>1</sup> / <sub>2</sub> /    | VIc           | Loam Bottom, 12- to 20-inch precipitation zone     | 55   | 1                             |
| GhD        | Graham soils, 5 to 20 percent slopes---                          | 27                 | -----                                | VIe           | Clay Loam Hills, 16- to 20-inch precipitation zone | 53   | 4                             |
|            |  |                    |                                      |               | Clay Loam Hills, 12- to 16-inch precipitation zone | 52   |                               |
| GhF        | Graham soils, 20 to 50 percent slopes--                          | 27                 | -----                                | VIIe          | Clay Loam Hills, 16- to 20-inch precipitation zone | 53   | 4                             |

GUIDE TO MAPPING UNITS--Continued

| Map symbol | Mapping unit  | De-scribed on page | Capability unit |               | Range site                                      | Page | Range produc-tivity group |
|------------|---|--------------------|-----------------|---------------|---|------|---------------------------|
|            |   |                    | Irrigated       | Nonirri-gated |   |      |                           |
| WoE        | White House-Caralampi complex, 10 to 35 percent slopes----- | 47                 | -----           | VIe           | -----   | --   | 2                         |
|            | White House soils-----                                      | --                 | -----           | -----         | Loamy Upland, 12- to 16-inch precipitation zone | 57   | --                        |
|            | Caralampi soils-----  | --                 | -----           | -----         | Sandy Loam, 12- to 16-inch precipitation zone   | 53   | --                        |
| WtF        | White House-Hathaway association, steep-----                | 47                 | -----           | VIe           | -----   | --   | 3                         |
|            | White House soils-----                                      | --                 | -----           | -----         | Loamy Upland, 12- to 16-inch precipitation zone | 57   | --                        |
|            | Hathaway soils-----   | --                 | -----           | -----         | Limy Slopes, 12- to 16-inch precipitation zone  | 54   | --                        |

1/ The capability units for irrigable soils are described on page 49.

2/ Areas above 7,000 feet are rated also for woodland suitability--see pages 58 through 60.



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