U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION, THOMAS F. HUNT, DIRECTOR; CHARLES F. SHAW, IN CHARGE SOIL SURVEY.

RECONNOISSANCE SOIL SURVEY OF THE SAN DIEGO REGION, CALIFORNIA.

BY

L. C. HOLMES, OF THE U. S. DEPARTMENT OF AGRICULTURE, IN CHARGE, AND R. L. PENDLETON, OF THE UNIVERSITY OF CALIFORNIA.

MACY H. LAPHAM, INSPECTOR WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1915.]

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LETTER OF TRANSMITTAL

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., December 18, 1916.

SIR: During the field season of 1915 a reconnoissance soil survey was made of the San Diego region, California. This work was done in cooperation with the University of California Agricultural Experiment Station, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this survey and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1915, as provided by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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RECONNOISSANCE SOIL SURVEY OF THE SAN DIEGO REGION, CALIFORNIA.

By L. C. HOLMES, of the U. S. Department of Agriculture, In Charge, and R. L. PENDLETON, of the University of California.—Area Inspected by MACY H. LAPHAM.

DESCRIPTION OF THE AREA.

LOCATION.

The San Diego region is situated in the extreme southwestern corner of California, including that part of the State lying west of longitude 116° 30′ and south of latitude 33° 30′. It is bounded on the west by the Pacific Ocean and on the south by the international boundary line separating the United States and Mexico. The coast line trends southeastward, and the width of the area east and west diminishes from about 72 miles along its northern to about 37 miles on its southern boundary. It is approximately 66 miles in length, north and south, and contains 3,182 square miles, or 2,036,480 acres. The area comprises the western two-thirds of San Diego County, containing practically all the developed parts of the county, together with small parts of Riverside and Orange Counties.[1]

FIG. 1.—Sketch map showing location of the San Diego area, California.

TOPOGRAPHY.

The greater part of the area is distinctly mountainous and rugged, but it contains numerous sharply outlined small valleys or basins. The area includes most of the ranges and plateaulike uplands lying between the southern part of the interior desert basin of California and the ocean.

Along the western margin lies a rather sharply defined coastal plain, presenting a striking contrast to the prevailing mountainous

[1] The area coincides in extent with Southern California Sheet No. 2 of the U. S. Geological Survey, which is compiled on a reduced scale from several topographic sheets. These were used as bases in the preparation of the soil map accompanying this report.

topography. This plain begins with several interrupted shelves along the coast in the northern part of the area and becomes better defined in the vicinity of Oceanside, thence continuing southward in a belt with an average width of about 12 miles. On the east the coastal plain gives way at altitudes of 500 or 600 feet to higher elevations. Viewed from these it appears as a plain sloping to the ocean, with deeply intrenched valleys having many lateral tributaries flanked by rough, broken slopes. (Plate I, fig. 1.) Many irregular fragments of the original surface remain as upland mesas or rather gently sloping plains which, in some instances, are surrounded by lower and more uneven areas. The plain is crossed at nearly right angles to its longer axis by streams issuing from the mountains and is also trenched by many lesser streams originating within the coastal plain or rising at the base of the mountains.

The various drainage valleys divide the plain into segments which rise from the ocean by low terraces or by rather sudden ascents. Elevations of 300 feet or more are sometimes reached within a mile of the beach. The maximum elevation on the side nearest the mountains is 500 feet or more. Soledad Mountain, near La Jolla, and one or two other elevations rise above the remnants of the original plain, but only slightly modify a topography which is primarily due to erosion of water-laid materials.

The coastal plain gives way abruptly to the mountainous topography typical of the greater part of the area. Rugged, extremely rocky ranges, some having a northwest-southeast trend and others seemingly unrelated in position and direction, here give rise to one of the roughest and most diversified areas in the State. There seems to be little relation in elevation between many of the ranges or single mountains, but in general the elevation increases toward the east and northeast. The steep topography and the rocky and shallow nature of the soil render the greater part of the mountain masses nonagricultural, in contrast to the favorable topography and soils in the numerous agriculturally important mountain basins and valleys.

The San Ysidro Mountains, near the southern border of the area and about 14 miles inland, rise abruptly from an elevation of about 600 feet above sea level at the margin of the coastal plain to a height of 3,572 feet within a distance of about 3 miles. The country east of these mountains includes numerous peaks ranging in elevation up to 4,000 feet or more. There are no large valleys or basins here and little tillable land. (Plate I, fig. 2.) The deeply set minor valley at Eisenecke and the hanging valley near Potrero are good examples of their kind.

Some of the highest elevations in the area are encountered near the middle of its eastern boundary. The three peaks of the Cuyamaca group, the highest of which reaches 6,515 feet above sea level, rise

from a plateaulike upland which breaks into the desert on the east by sudden descents just beyond the area. Some ranges of regular northwest and southeast trend, including the Volcan, Aguanga, and Agua Tibia Mountains, lie north and northwest of the Cuyamaca group. Many peaks here reach elevations of over 5,000 feet, and Palomar Mountain rises to a height of 6,126 feet. The Santa Margarita Mountains, in the northwestern part of the area, occupy a plateau over 2,000 feet in elevation which extends toward the ocean through lower, exceedingly rough surfaces. Within the area there are scores of other ridges, peaks, and locally prominent short ranges, some of which are of striking outline or bear interesting relations to drainage development or geologic processes. Granite is the most common rock throughout the mountains and it is abundant in the form of rocky faces and bowlders.

The mountainous part of the survey is a region of extreme topographic contrasts. The ruggedness of the mountains and the smoothness of the inclosed basins and valleys are in many places due to the erosion of the uplands and the lodgment of the material in the level or depressed areas. Strips of bottom land border the main streams through the mountainous region. Some of the valleys continue for miles with a rather uniform width of usually much less than 1 mile. In other places the bottom land narrows or disappears between rocky uplands, but may reappear farther upstream as pockets of alluvium deeply set in mountainous surroundings. The San Luis Rey and San Diego Rivers and numerous other rivers and small creeks have eroded valleys which include flat alluvial lands of more or less agricultural importance.[1]

In addition to the stream valleys there are a number of broad structural basins or valleys, which vary widely in size, elevation, relation to stream development, and importance. (Pl. II, fig. 1.) The Escondido, Poway, and Elcajon Valleys, each covering several square miles, lie along the line of contact between the coastal plain and the granitic mountains, at elevations ranging from 400 to 600 feet above sea level. The Valle de Pamo surrounding Ramona lies at an elevation of about 1,500 feet. The San Jose Valley, in the northeastern part of the area, the largest of the intermountain basins, ranges up to 3,000 feet or more in elevation. (Pl. II, fig. 2.) A distinct depression extends northwesterly from this valley and connects several basins locally known as Aguanga, Dodge, and Oakgrove Valleys. Chihuahua, Tule, and San Felipe Valleys are typical of

[1] During the winter of 1915–16 heavy rains caused unprecedented floods which swept through the valleys, eroding the original material and depositing stony and sandy débris in their upper courses and deeply covering much of the flood plain material in their lower parts with finer sediments. In several of the valleys, notably the Otay, Mission, and San Luis Rey, the material has been so much altered that present conditions are not correctly shown by the soil map prepared previously to the floods.

numerous other basins that occur in the northeastern part of the area. Some of the valleys are merely filled sags or accumulations of debris from the mountains, while others seem to be filled and modified rift valleys. Many of the minor valleys or mountain flats are hanging valleys, such as the Padre Barona Valley, the ravine outlet of which drops over 600 feet within a distance of little more than one mile beyond the valley.

Drainage.

Practically all the area is drained directly into the Pacific Ocean, but a comparatively short strip along the extreme eastern margin lies beyond the irregular divide separating the coast drainage from that tributary to the desert basin to the eastward. Tule Creek, Palm Canyon, the San Felipe Valley, Oriflamme Creek, and other small canyons carry the drainage of the eastward slope of the divide. Several main streams head in the series of high mountain basins and pursue a general southwestward course to the ocean. The Temecula River enters the area near the middle of its northern boundary line and flows for a short distance through a rolling country bordered by broad flat bottoms (Pl. III, fig. 1), which are terminated abruptly by a canyon a few miles in length. Beyond this point to the ocean this stream is known as the Santa Margarita River. A few miles farther south is the San Luis Rey River, which in its lower course roughly parallels the Santa Margarita. The San Luis Rey rises at the junction of several small streams in the San Jose Valley and flows for several miles through a canyon before opening into a narrow valley which continues to the mouth of the stream at Oceanside. This river drains an area of about 600 square miles.

Escondido Creek has its source in the confluence of several small creeks in the Escondido Valley. The San Dieguito River, which discharges at Del Mar, rises in the high mountain ridges in the eastern part of the area and drains a basin of about 400 square miles. It is known as Santa Ysabel Creek above the San Pasqual Valley. The San Diego River heads on the northwest slopes of the elevated region of which the Cuyamaca Peaks are the culminating points. It flows almost southward for several miles and then southwestward to its mouth at False Bay, just north of San Diego. The San Diego, like several of the other main streams, is flanked by alluvial bottoms along its lower course. The Sweetwater River heads southeast of the Cuyamaca Peaks and roughly parallels the course of the San Diego River to its outlet at San Diego Bay. Its basin is narrow, covering little more than 200 square miles. The Otay River drains a small basin in the southwestern corner of the area and flows into San Diego Bay. The Tia Juana River rises within the area but flows south of the Mexican line for a short distance. It discharges into the ocean about 2 miles north of the international boundary. Its principal

tributary is Cottonwood Creek, which rises at the confluence of several tributaries in the southeastern part of the area.

In addition to the main streams, there are numerous watercourses which rise from 10 to 20 miles inland and pursue rather parallel courses to the ocean. The most striking features of the drainage system of the area are the regular, parallel courses of the streams and the absence of large lateral tributaries. The drainage basins are, in general, elongated strips without such fanlike widening around their headwaters as is common in many regions.

Cities and Towns.

The San Diego area in 1910 contained about 63,000 inhabitants. of which less than 2,000 lived in the included parts of Orange and Riverside Counties. The population is largely concentrated around San Diego Bay and several other coast centers. San Diego, the county seat of San Diego County, is the principal city, with a population of 39,578 in 1910. It is the largest city in the State south of Los Angeles and for many hundreds of miles to the east. The city is situated upon San Diego Bay, a natural land-locked harbor, which, excepting San Francisco Bay, is the largest on the California coast. Coronado, with a population of 1,477, and National City, with a population of 1,733, are situated near San Diego. Oceanside, La Jolla, Del Mar, Encinitas, and Carlsbad are other coast towns. Capistrano lies several miles inland, on the northern border of the area. There are many towns and villages throughout the mountain region. Many of these are situated in the basins or valleys, as Escondido, with a population of 1,334 in 1910, Elcajon, Lakeside, Ramona, and Temecula. La Mesa, Fallbrook, Julian, and Alpine are towns in upland, rolling situations.

Transportation Facilities.

The area is, on the whole, rather poorly supplied with railroad transportation facilities. The principal route is the "Surf Line" of the Southern California Railroad, a branch of the Atchison, Topeka & Sante Fe system. This follows the coast as far south as San Diego and is the main rail outlet to both the north and the east for the entire area. Originally another outlet to the east was afforded by a line extending northeasterly from Oceanside. On account of difficulties of maintenance through the Temecula Canyon this route was abandoned, and the line is now operated only from Fallbrook to the coast. A branch of the Southern California Railroad extends from Oceanside to Escondido, a distance of about 22 miles, and serves a considerable region in the western part of the mountainous section of the area. Three local lines connect San Diego with La Jolla, 11 miles to the northwest; with La Mesa, Elcajon, Lakeside, and Foster, the latter about 25 miles to the northeast; and with La

Presa, 9 miles east. An electric railway connects San Diego, National City, Chulavista, and Otay. A line under construction from San Diego eastward will give the southern part of the area a more direct outlet to and from the east. The lack of railroad facilities in the mountainous part of the area is largely compensated for by motor-truck lines, which reach all the main settlements over an excellent system of mountain roads.

In addition to the railroads and highways, the San Diego area has good facilities for water transportation, the harbor at San Diego being excellent.

Markets.

The agricultural products of the area, including specialized crops, like beans and citrus fruits, and among the extensive crops, grain, are marketed widely over the United States and foreign countries. The markets for hay and dairy products are largely within the State.

CLIMATE.

General Conditions.

In general the climate of the region is similar to that of much of southern California lying outside the limits of the survey, though the temperature, rainfall, and other climatic factors vary considerably in different parts of the included area. The year consists of a dry summer season and a relatively wet winter season.

The climate is extremely pleasant and healthful and attracts large numbers of health seekers and tourists each year. The temperature is in general favorable for the production of a wide range of crops, the growing season being long, except in the more elevated areas. In the mountain districts the annual rainfall is moderately heavy, but in general it is insufficient for highly specialized agriculture without irrigation. In some localities, however, where favorable conditions of soil and rainfall exist, certain crops have been successful without irrigation. Over much of the area the lack of rainfall prevents agriculture, except the growing of grain and a few other crops of minor importance.

Excessive winds, hailstorms, and other unfavorable climatic phenomena rarely occur. Some of the ridges near the eastern border of the area are occasionally swept by strong winds entering or leaving the desert regions. Occasional dry, parching east winds, known as "desert winds," sometimes continue for days. These winds in some cases are injurious to crops.

Precipitation.

Nearly all the rainfall occurs during the period from October to April. Showers occur frequently in the summer months, but they are rarely of much value for crops.

Differences in elevation and position with respect to near-by mountain masses cause wide ranges in the rainfall within short distances; many of the mountain valleys have much less rainfall than neighboring mountain slopes, and certain valleys have considerably more than others. Although in general the precipitation increases from the coast eastward to the higher elevations, the conditions are suddenly reversed when the summit of the desert divide is reached, and the small part of the area lying east of the divide presents a marked contrast to the coastward slopes in rainfall and general appearance of the land. Still farther to the east, beyond the limits of the area, the rainfall amounts to only 2 or 3 inches a year.

The following table shows the mean monthly and annual precipitation as recorded at several stations within the area:

Mean monthly and annual precipitation, in inches.

Station.	Length of record, years.	Elevation.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
San Diego	53	93	1.77	1.93	1.52	0.63	0.23	0.06	0.06	0.11	0.08	0.34	0.95	1.84	9.62
Point Loma	9	302	2.31	2.10	2.38	.43	.20	.09	.03	.18	.16	.67	1.14	1.31	11.02
Fallbrook	29	700	3.38	3.38	2.99	1.33	.62	.11	.03	.04	.10	.71	1.46	2.88	17.14
Escondido	19	657	3.75	2.59	3.19	1.00	.42	.08	.03	.08	.07	.50	1.33	1.65	14.89
Elcajon	16	482	2.57	2.43	2.78	.70	.41	.12	.11	.10	.14	.48	1.32	1.37	12.52
Poway	27	460	3.19	2.64	2.65	1.13	.54	.07	.04	.03	.08	.59	1.22	1.88	13.79
Aguanga	4	1,986	3.51	1.97	3.03	.91	.26	T.	.16	.54	.40	.27	.88	1.36	13.29
Warner	6	3,165	3.92	2.99	3.41	.77	.27	.04	.72	1.37	.62	.97	1.25	2.74	18.47
Julian	27	4,500	5.33	5.19	6.99	3.15	1.45	.06	.50	.09	.10	.79	2.18	2.63	28.46
Cuyamaca	25	4,677	6.85	7.32	8.19	2.31	2.05	.23	.33	.62	.57	1.65	3.30	5.07	38.49
Descanso	12	3,400	4.75	3.58	5.12	1.39	.86	.02	.32	.60	.14	1.27	1.99	2.07	22.11

The records of the San Diego and Point Loma stations show an annual rainfall of 9 to 12 inches immediately along the coast. The stations of Fallbrook, Escondido, Elcajon, and Poway occupy similar positions in basins or semibasins along the western margin of the main mountain ranges. They are all about 14 miles inland and range in elevation only from 460 to 700 feet, yet show differences of several inches in annual rainfall. Aguanga and Warner are situated within intermountain basins in the northeastern part of the area, and represent a region with climatic features gradually approaching those of the desert to the eastward. Julian, Cuyamaca, and Descanso, in the eastern and southeastern parts of the area, lie within the more elevated region and show the largest precipitations recorded. The higher mountain regions often receive considerable snowfall, the average fall, unmelted, at Cuyamaca being 35 inches annually.

San Diego is reported to have received only 3.91 inches of rainfall in the driest year on record, Fallbrook 8 inches, and Cuyamaca 9.15

inches. For the wettest year on record the precipitation at these stations was 24.29 inches, 39.10 inches, and 66.27 inches, respectively. San Diego averages 266 clear, 49 partly cloudy, and 50 cloudy days a year. The average for Fallbrook is 274 clear, 46 partly cloudy, and 45 cloudy days, and for Cuyamaca 220 clear, 79 partly cloudy, and 66 cloudy days. At San Diego there are on an average 43 rainy days a year, at Fallbrook 35 rainy days, and at Cuyamaca 60.

Temperature and Frost.

The mean monthly and annual temperatures decrease considerably with rise in elevation, and the higher lying areas show a much greater range in temperature from month to month. The records of the station at Cuyamaca show a maximum temperature of only 96° F., with a mean for the coldest month of the year of only 37.1° and for the warmest month of 67.2°, while the records of the station at Escondido, in a valley near the line of contact between the mountain and coastal lowland regions, show an absolute maximum temperature of 113° F., a monthly mean for January of 49.5°, and a mean for July of 72.3°. The records of the station at San Diego show that the prevailing temperatures along the coast are slightly lower than those of the more inland valley areas. They are also much more even, the monthly means as recorded at San Diego ranging only from 54° F. in January to 68.7° in August, with a maximum recorded temperature of 101°. The lowest temperature recorded at the Cuyamaca station is —1° F. and the lowest at San Diego, 32° F.

The table below shows the mean monthly and annual temperature as recorded at several stations within the area.

Mean monthly and annual temperature.

Month.	Station and length of record.				
	San Diego, 41 years.	Escondido, 18 years.	Elcajon, 13 years.	Poway, 23 years.	Cuyamaca, 13 years.
	°F.	°F.	°F.	°F.	°F.
January	54.0	49.5	52.3	48.0	37.1
February	54.6	52.3	54.2	49.5	37.8
March	56.2	54.9	56.4	52.4	40.7
April	58.2	58.4	59.7	55.8	45.6
May	60.8	63.0	62.7	60.6	50.1
June	63.8	68.2	67.2	65.1	60.4
July	66.9	72.3	72.6	68.9	67.2
August	68.7	72.2	73.5	69.6	66.0
September	66.9	68.5	70.9	65.9	60.1
October	63.0	62.1	65.5	59.4	51.2
November	59.0	55.8	59.1	53.5	44.0
December	55.7	50.7	54.1	51.1	38.6
Year	60.6	60.7	62.4	53.8	49.9

The occurrence of frost varies widely with the elevation and topographic situation. The Weather Bureau records do not show the occurrence of killing frost at the San Diego station. The average date of the first killing frost in the winter season in the inland valley areas, according to the records of the Escondido, Elcajon, and Poway stations, is between December 14 and 17, but the average date of the last killing frost in the spring ranges from January 19 at Poway to February 14 at Elcajon and March 15 at Escondido. At Cuyamaca, in the interior of the mountain region, with an elevation of 4,677 feet above sea level, the average date of the last killing frost in the spring is April 20, and that of the first in the fall, October 19.

AGRICULTURE.

The early agricultural development of the territory included in the San Diego region centered around the efforts of the Mission Fathers. The mission near San Diego, known as that of San Diego de Alcala, was founded in 1769, and that of San Juan Capistrano in 1776, the latter being considered as probably the most magnificent of all the California missions. The Mission San Luis Rey de Francia, near Oceanside, was founded in 1798. The Mission Fathers and their associated workers quickly established a crude agriculture and a little later developed some irrigation systems of quite remarkable efficiency. Several fruits and garden crops were introduced in addition to the staple crops such as grain. Later grain growing became an important industry in the uplands. Some of the present localized industries also have developed gradually from the discoveries and efforts of the mission workers.

At present the agricultural practices in this region are not undergoing such rapid change as in many other parts of the State, but there is a gradual tendency toward more intensive forms of agriculture. The best soils occur in small areas or in valley depressions often widely separated by areas of nonagricultural land. This comparative isolation tends to retard any sweeping change in the agriculture. The scarcity of water for irrigation is a very strong factor in limiting intensive development. The present system of agriculture consists of the extensive production of unirrigated grain and grain hay, with a smaller acreage of unirrigated, more intensively grown crops on the moister and better suited soils, and a still smaller acreage of irrigated, intensive crops.

Grain and grain hay are the staple crops for the soils which are incapable of producing other crops with the local rainfall. They are nearly always grown without irrigation. The seasonal conditions sometimes determine whether the crop shall be cut for hay or allowed to mature. Barley occupies a larger acreage than any other grain,

there being, according to the census, 17,745 acres in this crop in San Diego County in 1909. Oats and wheat were next in order, grown on 7,690 and 7,268 acres, respectively. Rye, kafir, and milo occupied very small areas. Corn is locally an important crop, but is grown almost entirely on the bottom lands along the streams. There were 4,544 acres of corn in San Diego County in 1909.

In 1909, 68,844 acres of various grains were cut green for hay, in addition to which there were 9,269 acres in tame or cultivated grasses and forage crops, and 2,792 acres of wild grasses harvested. Timothy, clover, and millet, or Hungarian grass, occupy only a very small part of the area in tame grasses. Alfalfa, grown on 2,566 acres, is produced almost entirely on the stream-bottom lands, and usually under irrigation (Pl. III, fig. 1), although on some of the moister soils irrigation is not necessary. The yield averages about 5 tons per acre per season. The value of the cereals produced in San Diego County in 1909 was $458,836 and of the hay and forage, $1,110,127.

Beans, of which the lima is the leading variety, are grown to an important extent in the valleys near the coast. (Pl. III, fig. 2) This crop in 1909 occupied 3,492 acres in San Diego County, with a production of 45,661 bushels, valued at almost $100,000. The seed is planted and the crop matured after the spring rains cease, without other moisture than that stored in the soil. Sugar beets are grown in some of the valleys in the northwestern part of the area.

Over much of the area the local climatic conditions are well suited to the production of various fruits, as well as nuts and other specialized crops. These have received some attention for many years and their production tends to increase in importance as the irrigation possibilities are slowly developed. Citrus fruits are grown on a small scale in several localities. The northern parts of the Escondido and Elcajon Valleys are sufficiently frost free for the production of these fruits and in both valleys oranges and lemons are commercially important. On some of the moderately elevated lands east of San Diego Bay, as around Chulavista and La Mesa, extensive plantings of lemons have been made. Orange and lemon orchards are invariably irrigated. The production of these fruits in the sections of favorable climatic conditions is largely limited by the amount of water available for irrigation.

There were 37,662 apple trees in San Diego County in 1910, mainly in the moderate to high elevations in the eastern part of the area. The number of peach trees amounted to 29,800. Olives were introduced into the area at a very early date and small scattered orchards of great age, together with newer plantings, are widely distributed. The fruit is used both for pickling and for the manufacture of oil. Figs are not of much commercial importance. There are some good pear and apricot orchards.

In that part of the area lying within San Diego County there were in 1909, 19,651 nut trees, of which 9,279 were almond and 9,159 English walnut. In addition, there are several walnut groves in the included part of Orange County.

Grapes are an important and profitable crop locally. More than three-fourths of the grapes grown in the area are produced in the Elcajon and Escondido Valleys. It is reported that at the present time there are in San Diego County 140 acres of table grapes, 1,299 acres of wine grapes, and 1,982 acres of raisin grapes. The fruit is usually grown without irrigation and yields are sometimes lowered by drought.

Dairying is locally an important industry, carried on in connection with alfalfa growing or the use of native grasses and hay. Some of the valley soils give heavy yields of alfalfa, which is used for the feeding of dairy stock. Dairy products in San Diego County in 1910, excluding those used in the home, were valued at $474,779, and the income from animals sold or slaughtered amounted to $614,766. Poultry and eggs are largely produced as incidentals in systems of farming devoted largely to some other product, but in some cases poultry raising is a special interest. Poultry and egg production in San Diego County in 1909 reached in value $357,579.

The average size of the farms in San Diego County in 1910 is reported as 363.1 acres. The census reports 2,298 farms in the county, of which 80.3 per cent are operated by owners, 15.7 per cent by tenants, and 4 per cent by managers.

SOILS.

CLASSIFICATION.

The three main physiographic divisions included in this survey, viz, mountains, the coastal plain, and the valleys, are associated with three classes of soil material. The soils of the area may, therefore, be broadly separated into three groups, conforming to the three physiographic divisions, namely, (1) residual soils derived through the disintegration or weathering in place of consolidated rocks, (2) soils derived through the weathering and other modification of old unconsolidated water-laid deposits, and (3) recent-alluvial soils, consisting of comparatively recent wash from soils of the first two groups, the material having been laid down as alluvial fans or in stream bottoms along present drainage ways or in flattened depressions. These three groups of soils are not everywhere sharply separated but typically are distinct.

The soils of the different groups are separated into series, a series including types similar in color, structure, origin, and mode of formation. The separation of the types in any series is based upon

texture or mechanical composition, which depends upon the proportions of the several grades of mineral particles which compose the soil.[1]

In addition to the soils of the three principal groups so far discussed, four miscellaneous types of material are mapped in this survey. These include areas in which the soil is mainly nonagricultural, owing to lack of drainage, periodical inundation, rough topography, stony surface, or some other factor.

The area is prevailingly a region of brown soils, although there are numerous and important exceptions in this respect. Soils of sandy loam texture predominate, probably as a result of the derivation of the greater part of the material directly or indirectly from granitic rocks, high in quartz.

Residual Soils.

The residual soils, together with the associated Rough stony land, constitute by far the most extensive group. They occur in the mountainous parts of the area and comprise a large proportion of the agricultural land. In general, they are rolling to hilly, and in many places occupy rather inaccessible positions on ridges or isolated mountain crests. These soils are usually well drained. They are mainly dry farmed, although locally irrigated. Large areas of unarable rough, stony, or steep land are included. The residual soils mapped usually occur in irregularly shaped bodies within areas of Rough stony land and in the most rocky and precipitous situations occur only in small, widely scattered patches. They range in elevation from a few hundred feet above sea level in the western and northern parts to 4,000 feet or more in the eastern part of the region in which they occur. The soil material varies greatly in depth from place to place or even within the same area.

The soils of the residual group have been derived in place through the weathering and disintegration of the underlying consolidated rocks, which include both igneous and sedimentary formations, and the series differentiation is based in part on the character of the parent rock. Igneous and altered igneous rocks are by far the most extensive, covering, in fact, the greater part of the San Diego area. Granite and gneiss greatly predominate, though there are less extensive occurrences of schist and fine-grained basic igneous rocks.

Soils from coarsely crystalline granitic rocks.—The soils derived from the coarsely crystalline granites and gneisses are divided on the basis of color into three series, the Sierra series of red soils, the Holland series of brown soils, and the Siskiyou series of gray soils.

[1] The general nature of a reconnoissance survey requires that certain types of a series or even certain series be grouped together in mapping, so that the type is not invariably the unit as in the detail survey.

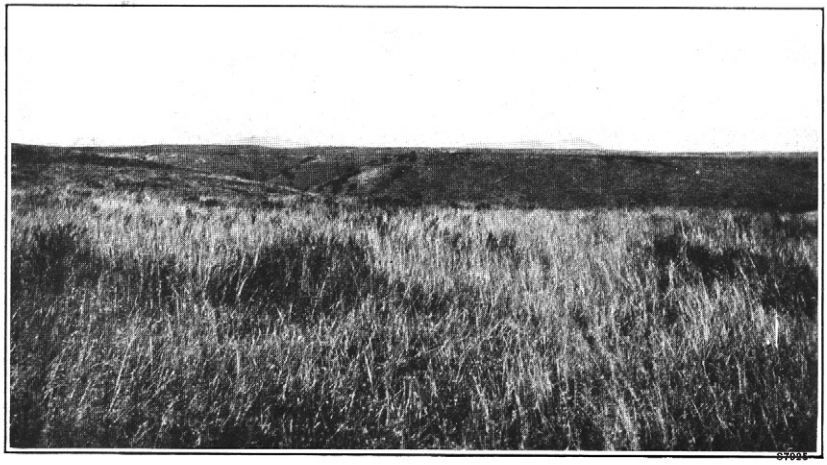


FIG. 1.—VIEW SHOWING GENERAL TOPOGRAPHY OF HIGH ERODED COASTAL PLAIN EAST OF FALSE BAY.

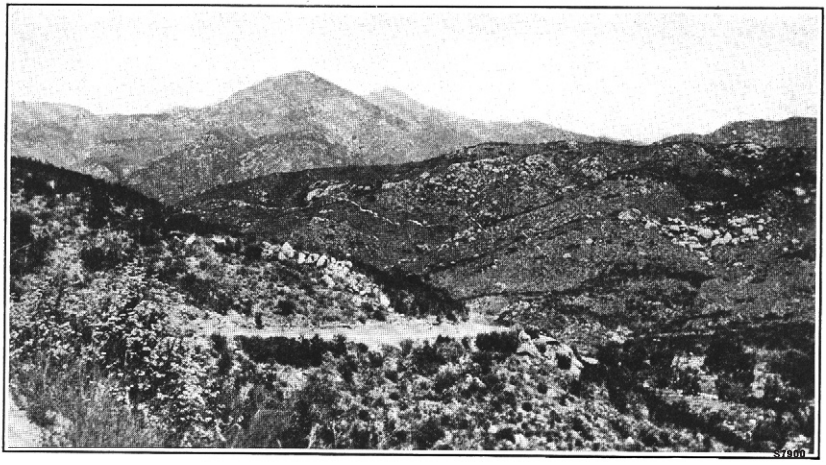
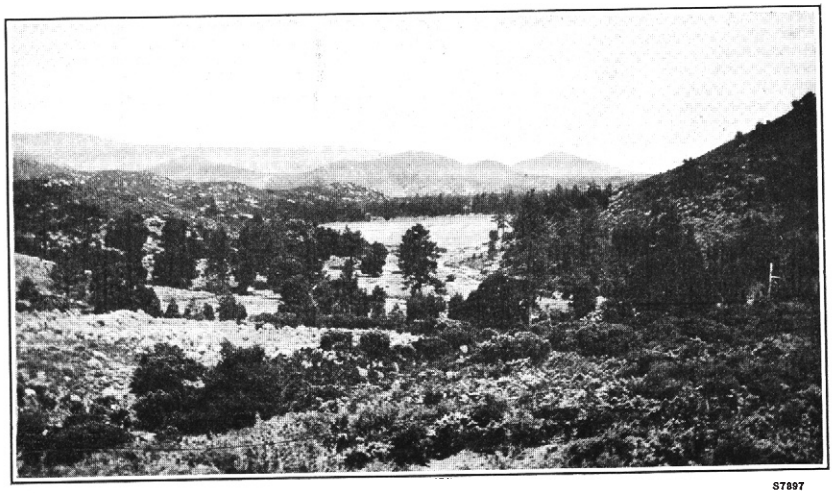
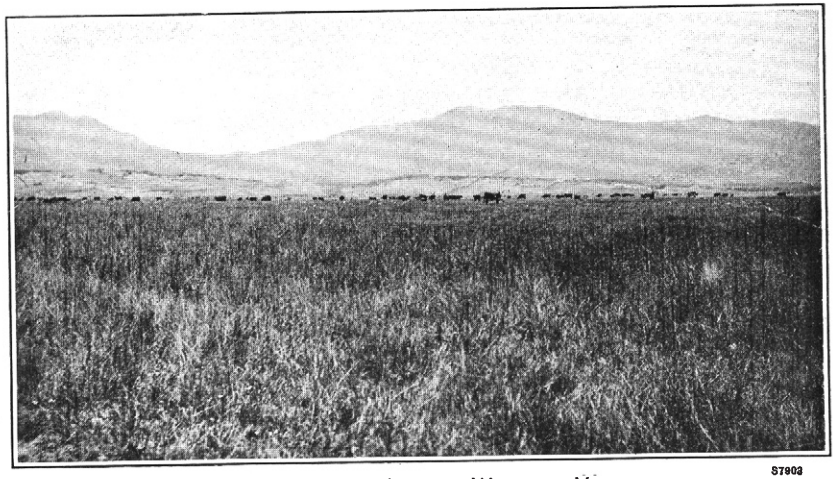


FIG. 2.—ROUGH MOUNTAINOUS DISTRICT NEAR EISENECKE, MAPPED AS ROUGH STONY LAND.



S7897

FIG. 1.—NEAR DESCANSO, OVERLOOKING PINE VALLEY, ONE OF THE SMALL STRUCTURAL VALLEYS IN THE MOUNTAINOUS REGION IN THE EASTERN PART OF THE SURVEY.



S7903

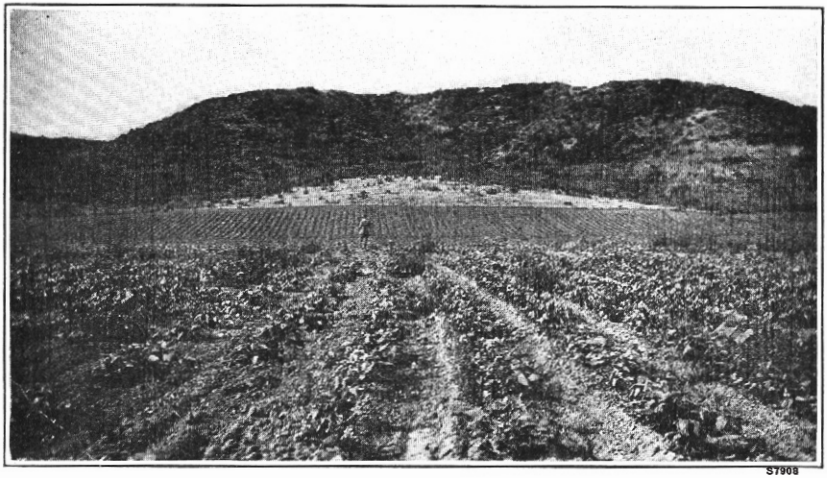
FIG. 2.—VIEW IN SAN JOSE, OR WARNER'S VALLEY.

Cattle grazing on alluvial soils of the Foster series.

S7905

FIG. 1.—ALFALFA ON FOSTER SANDY LOAMS NEAR TEMECULA.

Soils of the Ramona series occupy the eroded terraces and lower hills in distance.



S7908

FIG. 2.—LIMA BEANS ON SOILS OF THE YOLO SERIES OCCUPYING SMALL ALLUVIAL FANS IN SMALL VALLEY EAST OF DELMAR.

The Sierra series includes soils of light-red or distinctly reddish brown color, often micaceous. The soil material sometimes extends to the underlying parent rock without much change, but typically the surface soil is underlain by a reddish-brown to red, compact, heavier subsoil, this resting upon the bedrock at varying depths, usually less than 6 feet. These soils are frequently shallow. They sometimes carry rock fragments, contain frequent rock outcrops, and include rough, rocky areas unsuitable for agriculture. They occupy rolling or mountainous land and are usually well drained. This series is of fairly large extent. It is mapped in two groups, the stony loams and the sandy loams, and a single type, the loam.

The soils of the Holland series are brown or slightly reddish brown when wet, usually micaceous, and of friable structure. The material sometimes extends to the parent rock with little variation, but often a lighter brown or yellowish-brown subsoil is developed. In places the subsoil is more nearly reddish brown than yellowish brown and more compact and heavier in texture. The depth of the soil covering ranges from a few inches to several feet and, as in the Sierra series, the parent rock is usually partially disintegrated in its upper portion. The underlying granitic or related quartz-bearing crystalline rock is commonly exposed in massive outcrops or forms scattered bowlders. The topography is rolling to hilly and mountainous, and drainage is complete, being excessive in all the steeper areas. These soils occur extensively and are important. They are mapped in three groups, the sandy loams, the loam type, and the Holland and Siskiyou sandy loams (undifferentiated).

The soils of the Siskiyou series are typically light gray or gray in color. The surface soil sometimes grades into the parent rock through layers of partially disintegrated material, there being no distinct change with increase in depth, except that the texture becomes coarser. In places, however, a distinct, compact, heavier textured subsoil of reddish-brown, or more rarely red, color is developed. The soil covering is often shallow, but is several feet deep over much of the country occupied. The Siskiyou soils occur in rolling or mountainous areas and contain massive rock outcrop and granitic bowlders in varying quantities. Drainage is usually well developed or even excessive. The series is of small extent in the San Diego area and is mapped in one group consisting of Holland and Siskiyou sandy loams (undifferentiated), the Holland soils predominating.

Soils from fine-grained crystalline igneous rocks.—The fine-grained basic or quartz-free igneous rocks give rise to types classed in the Aiken series, including red soils, and the Olympic series, consisting of brown soils.

The soils of the Aiken series are typically medium red in color, but include color variations ranging from dark reddish brown to deep red. The soil material often extends to bedrock with little change in color or texture, but in places a subsoil is developed, redder in color, more compact in structure, and heavier in texture than the surface soil. The depth of the soil material ranges from a few inches to several feet. The bedrock usually lies within 6 feet of the surface. The Aiken soils are usually redder in color than those of the Sierra series. The Aiken soils occupy rolling or mountainous surfaces, and rock outcrop and rough, rocky areas occur in many places. Drainage is usually good or even excessive. The agricultural worth of these soils is dependent upon a number of factors, including depth of soil, the local liability to frost, the rainfall, and the possibilities of irrigation. These soils are not extensive. They are mapped in two groups, the stony loams and the loams.

The Olympic series consists of light-brown to dark-brown, non-micaceous surface soils, usually underlain by lighter brown or reddish-brown subsoils of the same or quite similar texture. The material sometimes extends to the bedrock without appreciable change in color or texture. Areas of shallow soil are common, although the partially disintegrated upper layers of the bedrock are often 4 feet or more below the surface. The parent formations giving rise to these soils, consisting typically of basic igneous and metamorphosed igneous rocks, are in places not sharply distinguished from those giving rise to the Holland, Sierra, and Siskiyou soils. Angular rock fragments, rock outcrop, and small areas of Rough stony land characterize the Olympic soils. They occupy rolling to mountainous surfaces and in places are excessively drained. The Olympic soils are of small extent and are classed in two groups, the loams and the adobe soils.

Soils from sedimentary rocks.—The residual soils derived from sedimentary rocks are of small extent. They occupy rather rough surfaces. Rocks giving rise to these soils are mainly rather calcareous soft shales and sandstones. The derivative soils, dark gray to black in color, are classed in the Diablo series. A large area included with Rough broken land is also underlain by sedimentary rocks.

The surface soils of the Diablo series are typically dark gray to black, but in the areas of shallow soil the color is in many cases lighter gray or brownish. The surface soils often rest directly upon the underlying rock, though typically they are underlain by lighter colored, grayish, brownish, or yellowish subsoils. The surface soil is apparently high in organic matter and both surface soil and subsoil are rather calcareous. In places the bedrock lies near the surface, but ordinarily the surface soil and subsoil together are several feet

deep, though they seldom extend to a depth of more than 6 feet. The Diablo soils occupy foothill or mountainous areas with rolling to steep surfaces. Smoothly rounded hills are common. The soils are well drained. The run-off is rapid upon the steeper slopes, and small landslides sometimes occur in the rainy seasons. The Diablo series is mapped in one group, the adobe soils.

Coastal-Plain and Old Valley-Filling Soils.

The soils derived from coastal-plain and old valley-filling material consist of the weathered products of unconsolidated water-laid deposits of varying texture. The material since its deposition has in general been elevated, and at the present time these soils occupy surfaces intermediate in elevation between the residual soils and the recent-alluvial soils. Differences in the original character of the deposits and in the degree and nature of subsequent changes resulting from weathering and erosion have given rise to soils of several distinct series.

In the mountainous parts of the area there are many basins or narrow stream valleys which, in addition to their recent-alluvial bottoms or floors, contain remnants of older floors or of old alluvial fans. These remains of an older sedimentary filling in many places occur as marginal areas or terraces around the rims of the basins and modify the otherwise extremely sharp break in topography between the recent valley floors and the adjacent mountains. They range in elevation from slightly above to considerably above the recently formed soils, and in the latter case are in some places subject to severe erosion. The original valley floors represented by these deposits have been eroded away, either as an accompaniment of their elevation or as a result of the development of lower drainage outlets. The Elcajon, Escondido, San Jose, and Temecula Valleys, and other similar basins in the mountainous areas, contain important areas of these older alluvial deposits. (Pl. IV, fig. 1.) Similar deposits of elevated terraces occur discontinuously along the larger streams issuing from the mountains.

While the mountain basin and stream terrace areas of these old alluvial soils are important, the most extensive development of the soils of this derivation is in the coastal-plain section. This plain undoubtedly owes its general formation to marine deposition, but an indeterminate proportion of the soil material is probably the result of the work of streams during the course of the elevation of the land. Extremely complex soil conditions prevail here, and some of the soils depart more or less from the typical characteristics of the series as mapped in other parts of the State.

These soils are differentiated from the residual soils of sedimentary rock origin on the basis of their derivation from unconsolidated sedi-

ments, but they differ in other important features. They are distinguished from the recent-alluvial soils by their old, modified surfaces and by still more important changes which have come about through weathering, among them the development of prevailingly heavy, compact subsoils, hardpans or cemented substrata. (Plate IV, fig. 1.) Some of the soils are practically nonagricultural under the local rainfall conditions and are capable of little development without irrigation. They are often low in organic matter and unfavorable subsoil conditions greatly decrease their value for dry-farmed crops. Some of the types, however, are fairly well suited to agriculture. On the basis of color, subsoil differences, and the presence or absence of hardpan or gravelly substrata, the soils are classed in seven series which may be broadly grouped into series with grayish soils, series with reddish-brown to red soils, and series with brownish soils.

Gray to black soils.—The surface soils of the Montezuma series are typically dark gray to black, but include small areas of brownish soil representing gradations into associated series. The lighter textured members of the series are friable and retentive of moisture, while the more clayey types usually have a pronounced adobe structure. The content of lime and organic matter in the surface soils apparently is relatively high. The subsoils are lighter colored and sometimes mottled, usually showing various shades of grayish, yellowish or brownish colors. They are often quite calcareous and contain quite distinctly cemented seams or discontinuous layers which do not, however, constitute a typical hardpan. (Pl. IV, fig. 2.) The surface is usually rolling or hilly and is occasionally deeply dissected, though the outlines are in general rounded or steep, rather than broken. Drainage is nearly everywhere good.

The Montezuma soils typically have been derived from old unconsolidated water-laid deposits which have in general been subsequently elevated above their former position. The parent material is sometimes intermittently and feebly consolidated, but the substrata typically are merely compact, fine-textured sediments. It is possible that in the San Diego area a greater proportion of the material was originally of marine deposition than is true of these soils in general elsewhere in the State, and peculiar deeper underlying beds of light-gray or brownish-gray, clayey material are more prominent. In some of the lower, smooth areas these soils are separated with difficulty from those of recent-alluvial origin, although typically they are quite distinct. The Montezuma series is represented in this area by one extensive group of heavy-textured types, the Montezuma adobe soils.

The surface soils of the Las Flores series are light-gray or light brownish gray, merging by reddish-brown or reddish transitions into the soils of the Kimball series. They are typically underlain

at depths ranging from 10 to 24 inches by brown, grayish-brown or reddish-brown, heavier textured, compact subsoils, which usually extend to a depth of 6 feet or more. The subsoil becomes cracked and flinty in structure upon exposure during dry periods and apparently is not readily penetrated by plant roots or water. Hardpan layers and gravelly substrata are not typical of the series. The surface is in many places hummocky or marked with hog wallows, the result of slight wind action. Like the other soils of the coastal-plain division of the area, the Las Flores soils have been derived from both marine and old alluvial-fan or terrace deposits. These have been subjected to much modification by weathering, erosion, and the formation of distinct, compact subsoils. The topography is in general rolling and on the whole favorable for good drainage, but the water collecting in minor depressions moves slowly through the compact subsoils, so that the land is periodically water-logged. The Las Flores soils in this area are classed in one group, the Las Flores and Kimball loams and sandy loams (undifferentiated). The two series differ in color.

Reddish-brown to red soils.—The Redding series typically comprises reddish-brown to red surface soils, but as mapped it includes along the line of contact with associated series small areas of soils of yellowish-red or other colors. Typically a thin layer of compact, heavier textured, clay loam or clay, of more distinctly reddish brown or red color than the surface soil, occurs at a depth of 8 to 18 inches. The surface soil is usually gravelly; the heavier textured subsoil contains some gravel but much less than the soil. The compact subsoil rests upon a reddish hardpan, which varies in hardness and thickness, though relatively impervious to water and impenetrable to the roots of crop plants. Below this occur beds of compact or cemented waterworn gravel, with a small proportion of finer interstitial material. These beds are typical of the series.

The Redding soils as mapped in this area are subject to many variations. In places either the heavy subsoil or hardpan is lacking, and sometimes neither is developed. The soils are prevailingly shallow and of low water-holding capacity, and they are further lowered in value by the relatively impervious underlying hardpan and gravel stratum, which often cause the land to be boggy during the rainy season. The Redding soils have been derived through the weathering of unconsolidated water-laid deposits. The surface is usually that of a slightly uneven mesa or upland plain, but the topography is rough along bluff lines or deeply intrenched drainage ways. The surface is marked in many places with hog wallows. The soils are compact and flinty when dry, and in some localities are not well adapted to dry farming. The series in this survey is represented by one group, the Redding gravelly loams and sandy loams. The typical

hardpan and gravelly substratum are of more than the usual denseness in this area and the gravel is in general partly or wholly cemented, while in other parts of the State this condition is only intermittent.

The surface soils of the Kimball series are a pronounced reddish brown to light red in color, but the series as mapped in this survey often includes brown soil consisting of undifferentiated material of the Ramona or other series. Two rather distinct variations of subsoil occur. Probably the more extensive consists of a compact, reddish-brown or red clay loam or clay, beginning at any depth from 12 to 36 inches and in places extending to a depth of 6 feet or more. The subsoil elsewhere consists of very compact, semicemented material of about the same texture as the surface soil but often slightly lighter in color. The deeper subsoil or substratum in places consists of grayish or reddish, very compact or slightly cemented strata of very fine gravel, sand, silt, and clay. The substrata do not usually contain coarse gravelly layers or true hardpan, but occasionally a hardpan seam occurs, the soil here resembling the San Joaquin soils.

The Kimball soils are usually friable when moist, but become exceedingly hard when dry and uncultivated.

These soils occupy remnants of old valley-filling deposits or occur on smooth-surfaced marine terraces, flanked on the seaward side by low bluffs, and dissected by the depressed valleys of modern streams. In other places where the soil is of earlier deposition the surface is more elevated and rolling. "Hog-wallow" mounds are locally prominent, usually being associated with the heavy-subsoil variation. Drainage is good to excessive, except in places where the downward movement of water is arrested. The Kimball soils are mapped in two groups, the Kimball sandy loams and the Las Flores and Kimball loams and sandy loams (undifferentiated). They differ somewhat from the Kimball soils as previously mapped in the more northern interior of the State, the latter being medium-textured soils derived from remnants of old valley deposits probably laid down in fresh water, whereas in the San Diego area they are, in part at least, derived from marine sediments or marine terraces, are usually light textured, and carry small quantities of iron concretions similar to those contained in the San Joaquin sandy loams.

Typically, the surface soils of the San Joaquin series are pronounced reddish brown to light red or pale red, but as mapped they often include developments of associated soils of brown color. The soil is rarely gravelly, but a gritty texture is common. The surface soil is typically underlain by a thin, heavier textured, red or reddish subsoil which is very compact and hard when dry. The subsoil rests upon brownish or reddish, rather impenetrable hardpan layers ranging from a few inches to several feet in thickness. The depth of

surface soil and subsoil combined is in many places not more than 24 to 30 inches. There are wide variations in the depth of the material and in the order of the various strata, the hardpan in places being exposed at the surface and occasionally occurring at a depth of several feet. The subsoil is sometimes displaced by semicemented strata of material similar to the surface soil in color and texture.

The San Joaquin soils are similar to those of the Redding series in general appearance, but typically lack the gravelly substrata. They occupy sloping to undulating or rolling valley plains or upland mesas of slightly uneven topography. The drainage in general is good, but a "hog-wallow" surface hinders surface run-off, and the movement of water through the soil being retarded by the dense substrata, boggy conditions prevail during the rainy season. On the other hand, the soil becomes compact and bakes when allowed to dry without being cultivated. The San Joaquin series is represented in this area by one group, the sandy loams. As developed here these soils differ somewhat from their occurrence elsewhere in the State in the abundance of small iron concretions, in the probable marine origin of much of the material, and in their occurrence over remnants of high mesas or terraces along the coast.

The Placentia series typically includes types with light-red or red surface soils, but areas of pronounced reddish brown color are included. A heavier textured, very compact subsoil of red or reddish brown color typically occurs at a depth of less than 3 feet, and extends to a depth of 6 feet or more. Usually there is no distinct hardpan layer or gravelly substratum, but discontinuous beds are occasionally encountered. In places the subsoil is sufficiently compact to interfere with the growth of roots and the movement of water, but elsewhere the subsoil is only slightly less friable than the surface soil.

Some of the areas of this series are only slightly elevated above the stream bottoms, but others form distinct benches or old alluvial fans of greater elevation. The topography varies from rather uniformly sloping to rolling. A "hog-wallow" surface, which occurs in many places, restricts the surface drainage, and subdrainage is likewise deficient during the rainy season, owing to the heavy nature of the underlying material. The parent rocks giving rise to the material from which these soils are derived appear to have been largely granitic formations. These soils rank higher in average agricultural value than most of the other soils of coastal-plain and old valley-filling origin. The Placentia soils are mapped in two groups, the sandy loams and the loams.

Brown soils.—The Ramona soils are typically a neutral brown in color, but in places are slightly reddish brown or grayish brown. They are separated from the Placentia soils on the basis of color.

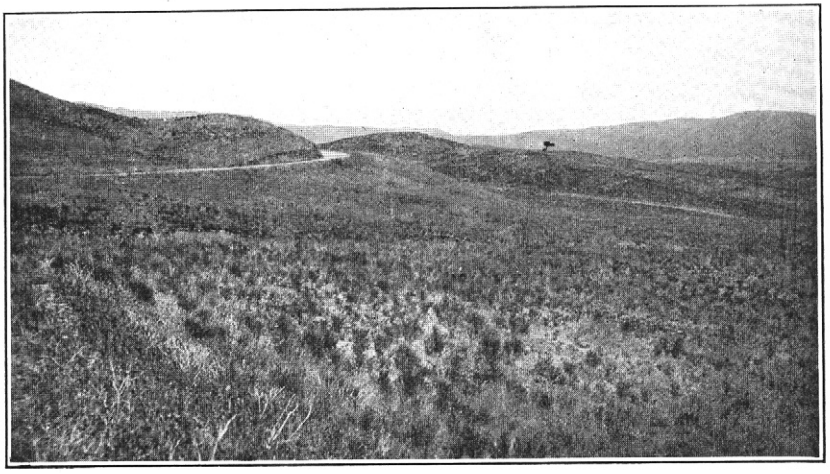
The material is not usually micaceous, but the breaking down of granitic fragments in places gives rise to mica in considerable abundance. A heavier textured, often very compact, more reddish brown or red subsoil usually occurs at depths of less than 24 inches, but may be absent in the gravelly or stony types. The material giving rise to the Ramona soils originally consisted of water-laid deposits probably not essentially different from the present alluvial fans giving rise to the Hanford soils.

The material seems to have been derived typically from granitic rocks. The topography is usually uneven or rolling, with a tendency toward a "hog-wallow" surface in places. Drainage is good except during rainy seasons, when level or depressed areas may become soggy, owing to the heavy nature of the subsoil, which prevents the free downward movement of water. The series is represented in this area by three groups, the stony sandy loams, the sandy loams, and the sandy loams, terrace phase.

Recent-Alluvial Soils.

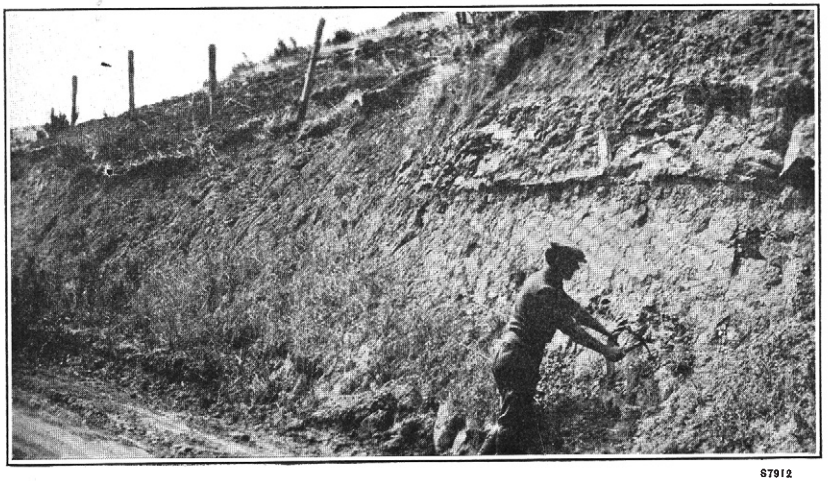
The soils of the recent-alluvial group have been derived from recent or comparatively recent deposits laid down by streams at or near their present levels or distributed by surface wash. They may usually be distinguished from the upland-residual or old-alluvial soils by their comparatively smooth surface and their relation to streams or drainage ways. They occupy several types of topography, ranging from flat, as in stream bottoms, to rather steeply sloping, as in the alluvial fans. They also cover the level floors and sloping sides of some of the mountain basins. In all these widely differing situations the essential characteristics of this group of soils prevail; there is an absence of such secondary development as hardpan or typically heavy subsoils, and the surface soil tends to continue without much variation to a depth of 6 feet or more, where it is displaced by interstratified material of variable texture. The recent-alluvial soils, which are so prominently developed in other parts of the State, as in the Santa Clara, San Joaquin, and Sacramento Valleys, and in the southern California valleys adjacent to Los Angeles, are of rather small extent in this area. They are, however, of great agricultural importance, producing the bulk of the intensively grown crops. They are classed in five series, separated upon the basis of differences in color and origin.

Soils from granitic material.—The soils of the Hanford, Tujunga, and Foster series consist of stream-laid materials derived typically as wash from rocks or upland soils of granitic character. They are all micaceous and the three series often occur with such gradual color gradations that their differentiation in the field is difficult.



S7898

FIG. 1.—OLD VALLEY FILLING MATERIAL IN SAN JOSE, OR WARNER'S VALLEY, GIVING RISE TO SOILS OF THE RAMONA SERIES.



S7912

FIG. 2.—EXPOSURE SHOWING PARTIALLY INDURATED, CALCAREOUS SUBSTRATUM IN MATERIAL OF THE MONTEZUMA ADOBE SOILS.

These soils occupy numerous valleys, alluvial fans, and basins throughout the mountainous regions and their development continues westward along the main streams through the coastal plain.

The types included in the Hanford series typically have brown, light grayish brown, or buff soils, predominantly friable and porous. The soil may extend without distinct change to a depth of 6 feet or more, but is in many places underlain by a slightly lighter colored subsoil, frequently composed of strata of various textures. These soils occur as alluvial fans, flood plains, or terraces. In places they occupy steep alluvial fans, the slope of which decreases as they descend to the valley floors. There are marked contrasts in texture and agricultural value between the stony types of the upper parts and the finer sediments of the lower parts of these fans. Drainage is restricted in places and overflows cover some of the land, but much of the area occupied is well drained. In places rocks other than granitic formations have contributed to the material forming the series. The Hanford soils are among the most important soils in the State, and they are utilized for practically all crops. The Hanford series is mapped in three groups—the Hanford stony sands, the Hanford sandy loams, and the Hanford and Tujunga sands (undifferentiated).

The soils of the Tujunga series are light gray or light brownish gray. They are usually micaceous, are easily tilled, and with the exception of the coarse-textured and stony types are retentive of moisture. Owing to the irregular method of deposition of the material, there is no consistent difference in texture and structure between surface soil and subsoil. Variable strata ranging in texture from the finest to the coarsest materials form the soil column in places, but over important areas the texture is rather uniform to a depth of 6 feet or more. The Tujunga soils occupy alluvial fans, stream bottoms, and terraces. The series as mapped in this area occurs in the group of Hanford and Tujunga sands (undifferentiated), the Hanford soils predominating.

The soils of the Foster series are typically dark grayish brown or very dark brown, sometimes appearing dark gray when wet. They are grouped with the brown soils, but are much darker in color than the associated Hanford soils, though in lighter colored variations it is difficult to separate them in the field from the latter types. They are micaceous and friable. In a few instances the material extends to a depth of 6 feet or more without marked change in color or texture, but the subsoil below 24 to 36 inches is usually lighter in color than the surface soil and often consists of irregularly alternating strata of different textures. The Foster soils are similar in origin to those of the Hanford and Tujunga series, occupying alluvial fans, stream bottoms, and terraces. Although the material is mainly granitic, it is modified in places by material from other kinds of rocks. Drain-

age is usually good, except for occasional overflows in the low-lying areas, which may also have a water table permanently near the surface. The Foster soils constitute an important part of the recent-alluvial soils of the area. They are mapped in three groups, the sandy loams, the fine sandy loam type, and the loams and clay loams, dark-colored phase. The latter group is confined to dark-gray to black soils, frequently poorly drained, which if of greater extent would in a more detailed survey be classed in a distinct series.

Soils from sedimentary or unconsolidated formations.—The Yolo and the Dublin series consist of soils derived as recent alluvium from regions occupied by sedimentary rocks or, more largely, from the unconsolidated deposits of the coastal plain.

The Yolo series is characterized by brown or grayish-brown surface soils. The subsoils are typically lighter colored than the surface soils, being light brown to yellowish brown, although this difference is not always marked. There is no consistent difference in texture between the surface soil and the subsoil; the latter may be heavier or lighter, or it may be made up of alternating strata of different textures. The Yolo soils occur as alluvial fans, sometimes merging to form broad valley slopes, or as stream-bottom and low recent-terrace deposits. The series in its most typical and extensive occurrences has been derived from materials coming from sedimentary or altered sedimentary rocks, but as mapped in this area unconsolidated upland or marine deposits have given rise to the greater part of the material. The surface is gently sloping and smooth or only slightly uneven. Drainage is usually good. The Yolo soils are mapped in three groups, the gravelly sandy loam, the loams and sandy loams, and the clay loams.

The surface soils of the Dublin series are dark gray to black in color. They are typically nonmicaceous. The subsoil is usually lighter colored than the surface soil, being grayish or brownish, but the dark-colored surface soil sometimes extends to a depth of 6 feet or more. The Dublin soils occupy alluvial fans, stream bottoms, and recent flats or terraces, and in places low, stream-built ridges. The drainage is good over most of the lighter textured types, but the heavy soils are in places somewhat depressed and surface drainage is insufficient during the rainy season. The material giving rise to the series in general consists of alluvium transported from upland areas occupied largely by consolidated sedimentary rocks, but in places consists largely of wash from upland plains composed of unconsolidated formations, and in this area it has largely been derived from unconsolidated coastal-plain deposits. The soils as a rule are higher in organic matter and more calcareous than those of the associated Yolo series. The soils of the Dublin series occurring in this area are mapped in one group, Dublin soils, undifferentiated.

Miscellaneous Material.

In addition to the soils of the various series, four types of typically nonagricultural material are mapped. These consist of Rough broken land, Rough stony land, Tidal marsh, and Coastal beach and Dunesand. Tidal marsh includes low, saline areas along the coast or in lower valleys near the coast, where the soil, although variable in all other features, is either very poorly drained or is periodically inundated. Rough broken land and Rough stony land are very extensive types. Coastal beach and Dunesand is of little importance, being confined to some very narrow beaches and other small areas along the shore.

The following table gives the names and the relative and actual extent of the various soils mapped:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Rough stony land	1,031,104	50.5	Yolo loams and sandy loams	10,816	0.5
Sierra sandy loams	183,168	9.0	Tidal marsh	8,384	.4
Rough broken land	156,416	7.7	Foster loams and clay loams, dark-colored phase	7,424	.4
Holland sandy loams	152,832	7.5	Olympic loams	6,656	.3
Montezuma adobe soils	68,224	3.3	Dublin soils, undifferentiated	6,080	.3
Las Flores and Kimball loams and sandy loams, undifferentiated	50,560	2.5	Diablo adobe soils	5,632	.3
Foster sandy loams	48,832	2.4	Yolo gravelly sandy loam	5,440	.3
Redding gravelly loams and sandy loams	47,232	2.3	Aiken loams	4,928	.2
Hanford and Tujunga sands, undifferentiated	34,688	1.7	Hanford stony sands	3,968	.2
Kimball sandy loams	33,088	1.6	Coastal beach and Dunesand	3,840	.2
Hanford sandy loams	33,024	1.6	Ramona stony sandy loams	3,712	.2
Holland and Siskiyou sandy loams, undifferentiated	27,392	1.3	Yolo clay loams	3,520	.2
Foster fine sandy loam	25,344	1.2	Aiken stony loams	1,536	.1
San Joaquin sandy loams	24,896	1.2	Sierra stony loams	1,152	.1
Placentia sandy loams	22,656	1.1	Sierra loam	1,024	.1
Ramona sandy loams	15,744	1.0	Holland loam	960	.1
Terrace phase	4,672		Olympic adobe soils	896	.1
			Placentia loams	640	.1
			Total	2,036,480	

Soils Derived from Residual Material.

SIERRA STONY LOAMS.

Description.—The Sierra stony loams group, indicated on the soil map by stone symbols in the color used for the Sierra loam, includes the stony loam and stony sandy loam of the Sierra series.

The surface soil of the stony loam consists of a light-red or reddish-brown loam. The subsoil is similar to that of the Sierra loam,

with the same variations, the only essential difference being that the Sierra stony loam usually rests upon the parent rock at less depth than does the Sierra loam. The stone content varies considerably, being in places sufficient to render the type practically nonagricultural, while elsewhere only scattered fragments or outcrops occur. Granite material is most in evidence, but finer textured schist is also encountered.

The stony sandy loam is the less extensive member of the group. Aside from its texture, stone content, and shallower average depth this type is similar to the sandy loam.

Location.—The group is not extensive. It occurs in several small areas, one of which is about 4 miles south of Elcajon, another about 4 miles northeast of Miramar, and a third about 1 mile north of Pala. Numerous patches of rocky soils of the character of this group are included as undifferentiated material in the Sierra sandy loams group.

Topography and drainage.—The topography of the Sierra stony loams is very similar to that of the Sierra sandy loams. In the most rocky areas the land is uneven and difficult to traverse. Drainage is rather excessive, and erosion is rapid in all the steeper situations.

Utilization.—A small proportion of the Sierra stony loams is used for grain and hay production, but the soils are largely uncultivated. Some of the areas of deeper and better soil could be cleared of the brush and stone and made to produce grain and hay crops, but it is probable that most of the land will be used for pasture indefinitely. Areas in which the soil is exceptionally deep are suited to the same range of crops as the Sierra sandy loams.

SIERRA SANDY LOAMS.

Description.—The Sierra sandy loams group comprises the coarse sandy loam, sandy loam, and fine sandy loam of the Sierra series, of which the sandy loam type is by far the most extensive.

The Sierra sandy loam consists of a friable, micaceous, light-red or pronounced reddish brown sandy loam, varying greatly in depth. The soil is rather free from stone fragments even in the midst of rock outcrop, owing to the rather thorough disintegration of the parent rock. Rock outcrop is in places abundant, and in few instances are there large areas without some exposures. Bowlders occur occasionally, but it is not usually necessary to remove many stones to put the land in condition for cultivation, as areas that are suitable for tillage in respect to soil depth and topography are usually also rather stone free. In places the red sandy loam surface soil grades rather sharply at any depth from 10 to 36 inches into a redder subsoil which is typically much heavier in texture, practically a clay loam. The subsoil becomes hard and flinty when dry and cracks upon exposure.

Below the subsoil the material becomes a little more friable in structure and passes through zones of disintegrating granite into the parent rock, which is usually encountered within 6 feet of the surface. A variation in the type occurs where the surface sandy loam extends to the underlying rock with little change except that the material is usually somewhat lighter colored near the bedrock, and varying thicknesses of rotten granite are encountered before the unaltered rock is reached. The parent rock here is encountered at any depth below a few inches, its average depth perhaps being about 3 or 4 feet.

The Sierra fine sandy loam is similar to the sandy loam except in texture. It is in places apparently derived from a rock differing slightly from the granites which normally give rise to the soils of this group and is a little less micaceous. It differs little from the sandy loam in agricultural value.

The Sierra coarse sandy loam is the least extensive member of this group. It is similar to the sandy loam, but carries a sufficient proportion of gritty fragments or coarse sand to make the material a little more porous.

The group as mapped contains a considerable proportion of undifferentiated brown soils really belonging in the Holland series. The color gradations and often the intricate association of the two series made the inclusion of brown soils within the Sierra sandy loams group unavoidable. Although the Sierra soils in the field presents a distinct red color, which is accentuated under wet conditions, hand samples often appear only reddish brown or brown. The sandy loams group also includes some areas where the soil is more stony than usual; these would have been mapped with the Sierra stony loams if practicable. Some of the rather extensive bodies of the sandy loams throughout the mountain region include much of this stony soil, and in places the soils are almost without agricultural value. Some of the areas of the group in T. 14 S., R. 2 E., and in some other places are of this stony character, with frequent rock outcrops, and probably will never be tilled. The stony soil, however, constitutes only a small proportion of the group. A few small, relatively unimportant areas are included in which the material consists of old water-laid, stony deposits.

Location.—This group is one of the most extensive and most widely distributed in the area. It is distinctly associated with the mountainous sections or with the deeply weathered areas of subdued topography surrounding the mountain basins. One of the most extensive areas of the group is in the hills and ridges surrounding the Escondido Valley. The group here, as elsewhere, is interrupted by small areas of Rough stony land and surrounded by larger developments of that type. There is an extensive area at Fallbrook, with

numerous others in the vicinity. The Elcajon Valley is partially surrounded by soils of this group, and they are also prominently developed between this valley and Ramona and to the east and north of the latter place. In the extreme western section of the area, where the rock formations include little granite, this group is not developed, while in the eastern and northeastern sections the residual soils from granite are largely brown in color and are included in the Holland series.

Topography and drainage.—The Sierra sandy loams occupy the smoother, rather rock free, and more deeply weathered parts of the excessively rough and mountainous areas in which they occur. The surface is rolling or hilly. Nearly all the land is tilled or tillable, and the included unarable bodies are usually nonagricultural by reason of their stone content rather than on account of steep surface. Drainage over these soils is typically excellent; the runoff is not often too rapid or damaging, owing to the ease with which the rainfall is absorbed.

Utilization.—The Sierra sandy loams are the principal agricultural soils in the central part of the San Diego area from the north-central part southeastward to the southern boundary. They are recognized as valuable soils for a wide range of fruit and other intensive crops, but they can be fully utilized along these lines only in exceptional cases, owing to a general lack of water for irrigation. As a consequence, their principal use is for growing grain and grain hay. In some places, where the soil is deep and moister than usual, the land is utilized without irrigation for producing fruits, including grapes. Very good results have been obtained, careful cultivation assisting to overcome the disadvantage due to the normally low rainfall. Irrigation has been supplied for some of the soils of this group around Escondido and elsewhere, and where the local climatic conditions are favorable some citrus orchards and many deciduous orchards are in bearing, with more extensive plantings under way. Olives are a prominent crop in some localities. There are many home orchards, vineyards, and gardens on these soils.

SIERRA LOAM.

Description.—The Sierra loam consists of a light-red or pronounced reddish brown, friable loam, which is not usually as micaceous as the soils of the Sierra sandy loams group. The soil may extend with little variation to bedrock, which is encountered at depths ranging from 12 to 48 inches or more, or may be succeeded at any depth below a few inches by a heavier textured, redder, more compact subsoil of clay loam or clay texture. The granite or other parent rock is usually partially disintegrated and open to water

movement and root penetration in its upper layers, thereby increasing the zone for root development. The mantle of soil material overlying the bedrock averages less in depth than in the Sierra sandy loams, and rock outcrops and stone fragments are of more common occurrence.

The type as mapped includes some undifferentiated bodies of Sierra sandy loam and of other similar soils.

Location.—The type is inextensive, being practically confined to the locality southwest of Richland and to an area northeast of Fallbrook. Many small areas are included in the group of Sierra sandy loams, especially south of Julian, this type differing only in its heavier texture.

Topography and drainage.—The surface of the type is rolling or hilly, with many steep, rocky slopes or small, rocky hills unsuitable for cultivation. These represent undifferentiated areas of rough stony land. The smoother slopes and ridges otherwise suitable for tillage often contain rock outcrop, so that the tillable areas are broken in outline and in some instances constitute less than 50 per cent of the land.

Drainage is good to excessive, and erosion is active on many of the steeper slopes.

Utilization.—A part of the Sierra loam not now cultivated can be cleared and devoted to the production of grain and hay, these being the most common crops. A few small vineyards and orchards have been established without irrigation where conditions are most favorable, but it is improbable that fruit growing will be developed to an important extent without irrigation. As in the case of the other residual soils of the area, the elevated position of the Sierra loam makes irrigation difficult, and hay and grain, together with such fruits as can be grown under careful dry-farming methods, will apparently continue to be the principal crops.

HOLLAND SANDY LOAMS.

Description.—The group mapped as the Holland sandy loams includes the coarse sandy loam, sandy loam, and fine sandy loam of the series, the sandy loam being the principal type. These soils typically contain only moderate quantities of stones or bowlders. Small areas of the Sierra sandy loams are included with the group as mapped.

The Holland sandy loam typically consists of a brown, micaceous, friable sandy loam. In places the soil extends to the underlying bedrock with little change, except in color which is lighter brown or a more yellowish brown in the lower depths. The soil grades into the bedrock through varying thicknesses of partially disintegrated

material. Bedrock may occur at any depth below a few inches, and it is usually encountered within the 6-foot profile, the depth averaging between 3 and 4 feet. In places, however, the brown sandy loam surface material gives way at depths ranging from 10 to 36 inches to a reddish, reddish-brown, or red compact clay loam subsoil. This usually grades below into more friable material before the parent rock is reached. Rock outcrop is abundant in this type. Both surface soil and subsoil are receptive and retentive of moisture.

The Holland coarse sandy loam and fine sandy loam are very similar to the sandy loam except in texture. They likewise vary in subsoil development and in depth.

The stone symbol is used on the map to indicate areas in which the rock content and the shallow nature of the soil combine to lower the agricultural value of the land. The content of stone and bowlders ranges from a negligible quantity in some places to excessive quantities in others. The greater part of the stony soil consists of a rather shallow sandy loam, quite similar in most respects to the typical Holland sandy loam. Over a smaller proportion of the land the soil is a coarse sandy loam or a loam. The soil in the stony areas is usually shallower than in areas more free from stones and the soils on the average are not so micaceous. In the area about 3 miles east of Carlsbad some of the land is very rocky and precipitous, resembling Rough stony land, and in general the conditions are rather unfavorable for tillage, although small parts are farmed. The small body about 4 miles southeast of Carlsbad carries a thin veneer of waterworn gravel and over only part of its extent is the soil typical of the Holland series. The area about 5 miles north of Miramar contains some undifferentiated patches of clay adobe which undoubtedly belong to the group of Olympic adobe soils. The body several miles south of San Marcos consists largely of a sandy loam carrying more fine rock and angular fragments than usual.

Some stony areas which are not indicated on the map occur in close association with the stone-free soils of the group, the soil here carrying considerable quantities of large and small angular rock fragments and including many outcrops of granite. In places the soil is quite shallow. Small intermingled tracts of agricultural stone-free soils are included, but on the whole this land is of low agricultural value.

Location.—The Holland sandy loams are important soils in the mountainous parts of the area. The coastal-plain section, owing to the absence of granitic rocks, does not include developments of this group. The area increases toward the eastern margin of the survey, until the group largely supplants the Sierra sandy loams and becomes the dominant residual group. A large area is encountered southwest of Fallbrook and smaller ones occur southward through the country

around Escondido and thence southeastward to the international boundary. Numerous areas occur in the vicinity of the San Jose Valley, near Santa Ysabel, Julian, Cuyamaca, and Descanso and southward.

Topography and drainage.—The topography is rolling, hilly, or mountainous. The stone-free soils occupy moderately rolling areas in the mountain region, occurring on the crests of hills and ridges, on the more gently sloping hill or mountain sides, on the flattened tops of lower spurs, and on narrow benches along the steep mountain slopes. The drainage is thorough, but damaging erosion is rare even on the steeper slopes, owing to the ready absorption of rainfall.

The surface of the stony areas is usually hilly or even mountainous. The drainage is excessive and erosion proceeds almost as rapidly as the accumulation of soil material by weathering. Massive rock outcrops are common, and scattered rock fragments are a characteristic feature. The topography in general would permit of tillage, but the rocky and shallow nature of the soil mainly prohibits cultivation.

Utilization.—Probably much less than 50 per cent of even the less stony part of the Holland sandy loams is tilled. Some of the areas are utilized entirely for the production of grain and grain hay, and these crops occupy the greater part of the cultivated land. Fruit and grapes are produced to some extent without irrigation. Olives and apples are important crops in some localities. Apples are quite extensively grown about Julian.

Only a small proportion of the stony soil is tilled, though the cultivated area will probably be extended where the soil is not too shallow and rocky. The untilled land is covered with brush and is used for pasture. Grain and grain hay are practically the only crops, although in general the crop possibilities on the areas of deeper soil are similar to those on the stone-free areas of the group.

HOLLAND LOAM.

Description.—The Holland loam consists of a brown, friable loam, usually micaceous, extending to a depth of 12 or more inches, resting on bedrock or underlain by a heavier textured, compact subsoil of slightly reddish brown or red color. A stratum of partially weathered rock overlies the bedrock. The type sometimes carries a small proportion of stone fragments and scattered bowlders. In most areas the depth of the soil material is a little less than in the case of the Holland sandy loams. The soil retains moisture well except in the shallower areas.

Location.—The Holland loam occupies a relatively small area. Unimportant developments are included with other groups and types

derived from granitic rocks. The type is mapped in one area just south of Vista and in two areas about 5 miles southwest of Richland, in addition to others of less importance.

Topography and drainage.—The Holland loam does not differ essentially in either surface features or drainage from the Holland sandy loams. As in the case of all the soils derived from the igneous rocks in the mountainous division of the area, this type in places includes slopes and knobs too steep or stony for agricultural use, although the topography over nearly all the type permits of cultivation. The steeper slopes and even some of the moderately smooth parts of the type are excessively drained, the shallow soil affording little opportunity for storing water.

Utilization.—Probably 50 per cent of the type is used in the production of grain hay. Nearly all the remainder is still in its native state and used for pasture. Fruits are grown in a few small orchards and vineyards with careful tillage to conserve soil moisture, but the extension of the area devoted to these crops does not seem practicable. Irrigation can be supplied only in isolated areas.

HOLLAND AND SISKIYOU SANDY LOAMS (UNDIFFERENTIATED)

Description.—The group mapped as the Holland and Siskiyou sandy loams (undifferentiated) comprises the Holland and Siskiyou coarse sandy loams and sandy loams. Probably the greater part of the group consists of brown or grayish-brown soils belonging to the Holland series.

The Holland sandy loam, which is described separately elsewhere in this report, constitutes a part of the group. It usually occurs in this group without the distinct heavy subsoil, the soil material grading into the parent rock without much change in color. In the coarse sandy loam both surface soil and subsoil have a general tendency to be rather loose and incoherent and the material becomes coarser as the parent rock is approached.

The Siskiyou sandy loam is typically a gray or brownish-gray sandy loam of rather incoherent structure. The material becomes coarser with depth and passes into disintegrating granite at any depth from 20 to 30 inches and the latter into solid rock at a depth of several feet. A distinct subsoil is usually lacking, but, in places, the material below the surface soil is darker or more brownish in color. The Siskiyou coarse sandy loam is also rather loose structured.

The soils of this group are rather shallow and in some parts of nearly every area coarse, disintegrating granite comes within a foot of the surface. In such localities large granite bowlders or rock outcrops occur at frequent intervals, but with small stone-free areas intervening. In general, more than 50 per cent of this stony land

is suitable for cultivation, but the tillable areas are very patchy, many of them being only one or two acres in extent.

The soil in many places consists only of disintegrating granite, low in organic matter and unretentive of moisture. This variation is extensively developed in the vicinity of Hot Springs Mountain, in the San Ignacio and Terwilliger Valleys, and east and south of the San Jose Valley.

Location.—The group occupies some moderately extensive bodies in the northeastern part of the area. A few areas occur several miles southeast of Temecula, the soil here being derived in part from unconsolidated, coarse-textured, sedimentary material, apparently originating almost entirely from granites.

Topography and drainage.—The Holland and Siskiyou sandy loams occupy rolling, hilly, or mountainous surfaces. In many places they occur on somewhat gentle slopes or in the less rugged situations intermediate between the rough mountain ranges and the smoother mountain valleys. Elsewhere they may be developed on somewhat uniform minor plateaus or on smoother areas within the mountains. Drainage is usually excessive, and the crop-producing power is lowered by the rather porous structure of the soils.

Utilization.—Over much of the extent of the group, especially in the stony areas, the land is of little agricultural value. Brush and tree growth is often sparse or lacking, but the land supports some grazing plants and is useful for pasture. The included areas of deep soil are used in the production of grain and grain hay, and some small orchards and vineyards have been developed where the moisture conditions are most favorable. Many of the areas lying in the zone of transition from the mountain region to the interior desert have a lower agricultural value than is possessed by similar soils nearer the coast.

AIKEN STONY LOAMS.

Description.—The group mapped as the Aiken stony loams is indicated upon the soil map by stone symbols in the color used for the Aiken loams. It includes the Aiken stony loam as the principal type, with a smaller proportion of Aiken stony clay loam. Small areas of sandy loam and fine sandy loam soil are also included.

The Aiken stony loam consists of a red or brownish-red to pronounced reddish brown friable loam, containing little or no mica. The soil is shallow, usually passing into the underlying rock at some depth between 6 and 18 inches, without distinct change. The stony clay loam differs from the stony loam in little except texture. Stones and rock outcrops are abundant and over much of the group there is but a thin mantle of soil. The stones are usually angular and range in size up to bowlders several feet in diameter. In places the quan-

tity of stones is sufficient to hinder or prohibit tillage. Most of the stones are composed of dark-colored, fine-textured igneous rock, but fine-grained granite also occurs.

Location.—Several areas of the Aiken stony loams occur north and east of Olivenhain. The Rough stony land in this vicinity includes some undifferentiated bodies of these soils.

Topography and drainage.—Over much of the group the surface is rather rough and broken and drainage is excessive, although most of the land is cultivable. The unfavorable topography, however, in addition to the stony, shallow character of the soil, lowers the value of the soils of this group for agriculture.

Utilization.—The greater part of the Aiken stony loams remains in its original condition. Much of it is covered with a growth of brush. There are a few fields of grain and grain hay. The area formed could be extended by clearing other areas where the soil is deep and less stony, but present returns from typical bodies of these soils are apparently rather low.

AIKEN LOAMS.

Description.—The Aiken loams group includes the sandy loam, fine sandy loam, loam, and clay loam. The loam is the most extensive of these soils.

The Aiken loam consists of a red to deep-red or reddish-brown, friable loam, typically not micaceous. Gravel and angular stone fragments, as well as rock outcrops, are a common feature of the soil, and there is a considerable range in the soil depth. The red loam surface soil quite frequently extends to bedrock, which may be reached at any depth from 12 to 36 inches or more. In other places the surface soil is underlain by a distinct, heavier, and more compact subsoil, of redder color. The contact between the soil material and the bedrock is usually through a stratum of partially disintegrated rock, though this stratum is ordinarily not so thick as that found in the Sierra soils. On some of the steeper slopes the bedrock comes sufficiently near the surface to impair the agricultural value of the land. The total depth of the soil mantle averages a little less than in the Holland and Sierra sandy loams.

The Aiken sandy loam is lighter red in color than the loam. In places there is little variation in the material throughout the soil column. Elsewhere there is developed a distinct, heavier textured, and more compact subsoil. The sandy loam member is of small extent. It seems to be related to certain rocks intermediate in character between the dark-colored, basic igneous rocks typically giving rise to the Aiken soils and the granitic rocks forming the material of the Sierra soils.

The Aiken clay loam consists of a red or deep-red, rather friable clay loam, having about the same variations in depth as the Aiken loam. It is not extensive.

The group includes occasional developments of the fine sandy loam type, which is similar to the sandy loam except in its finer texture.

Location.—The Aiken loams occupy some irregular areas northwest of Escondido, in association with the Sierra and Holland soils, from which they are in places rather arbitrarily separated in mapping. An area lies southeast of La Mesa and several others of lesser importance are mapped in other parts of the survey. Small developments of the group are included with the associated residual soils.

Topography and drainage.—The topography of the Aiken loams is rolling to mountainous. Drainage is usually very free and the run-off is rapid. Many steep slopes, ravines, and small rocky areas are included where the land is nonarable, but wherever possible such areas are mapped as Rough stony land.

Utilization.—Probably more than 50 per cent of the Aiken loams is cultivated. Grain and grain hay are by far the most extensively grown crops. A few orchards have been established in the areas of deepest soil, but there has been no development on a large scale. The uncultivated land is covered with brush and is used for grazing. The area under cultivation is increasing slowly.

Except in the most favorable situations, these soils require irrigation for the production of intensive crops. The apparent necessity for practicing dry farming over nearly all the group probably limits its use to hay and grain production, except in the few instances where special methods will make the growing of fruits and grapes profitable. The area near La Mesa supports a few orchards, irrigated in part, and these indicate the value of the soil where irrigation is possible.

OLYMPIC LOAMS.

Description.—The group mapped as the Olympic loams includes the loam and clay loam of the series, the loam predominating.

The Olympic loam consists of a friable brown or dark-brown loam, ordinarily grading into the parent rock without distinct change in color or texture. In places, however, the soil becomes a little lighter colored near the bedrock and occasionally it grades through a reddish-brown clay loam subsoil. The depth to bedrock ranges from 12 to 48 inches or more, although it is usually encountered within the 6-foot section. The soil in many places contains angular rock fragments, and rock outcrops and rocky hills are numerous. Over a considerable proportion of some of the areas the soil is shallow and rather stony.

The Olympic clay loam differs from the loam only in texture. In a few areas the soil possesses an adobe structure, such areas representing occurrences of the Olympic adobe soils. In the area northwest of Las Flores the soil is derived in part from old alluvial deposits and to this extent is not typical.

Location.—Areas of this group aggregating several miles in extent are mapped east of Olivenhain. The most important body, as far as agricultural development is concerned, lies just south and southeast of La Mesa. Several other, smaller areas are mapped, as about 2 miles northwest of Las Flores and several miles north of Miramar.

Topography and drainage.—The topography ranges from rolling to hilly. There are many steep slopes, some of which extend well up the slopes of the mountains. Drainage is good to excessive, and in places erosion keeps pace with soil formation.

Utilization.—Much less than 50 per cent of the land is tilled. More of the type can be brought under cultivation, but there are extensive areas in which the soil is probably too shallow for dry farming. Grain and hay are the most extensively grown crops. Citrus and other fruits with some intensive crops are grown under irrigation near La Mesa, and the results obtained indicate that many crops can be produced successfully where water for irrigation can be secured. Increase in yields and wider utilization of these soils apparently depend on better tillage methods, since extensive irrigation of the upland soils is probably not feasible.

OLYMPIC ADOBE SOILS.

Description.—The group, Olympic adobe soils, includes the clay adobe and clay loam adobe. Unimportant developments of dark-gray to black soils of similar texture, probably belonging in the Climax series, have not been mapped separately, and other variations in color also occur.

The Olympic clay adobe consists of a brown or dark-brown clay with marked adobe structure. The soil is refractory, being sticky when wet and hard when dry, but it is fairly easy to till under certain moisture conditions. It is normally rather free from stone, but rock outcrops are numerous. The soil material may extend to the parent rock with little change, but usually it becomes lighter colored at a depth of 8 to 14 inches and grades below this depth through layers of partially disintegrated rock of considerable thickness before the lower limit of root penetration is reached. The subsoil is sometimes slightly reddish in color, and it is typically more friable than the surface soil. The depth of the soil material is in places 6 feet, but it usually is much less, averaging probably about 3 feet.

The Olympic clay loam adobe does not differ essentially from the clay adobe except in its lighter texture.

Location.—The Olympic adobe soils are of small extent, being practically confined to one area southeast of Buena and another on the west slope of Black Mountain, about 6 miles north of Miramar.

Topography and drainage.—The soils are well drained. The surface ranges from rolling to hilly and includes some steep slopes not suitable for tillage. A few rocky points are included which in more detailed mapping would be differentiated as Rough stony land.

Utilization.—About 50 per cent of the land is used for the production of dry-farmed grain and hay. The soil is capable of storing large supplies of moisture, and good yields are obtained. Over part of the group, however, the soil is shallow. The heavy texture, which hinders cultivation, will probably limit the use of these soils to the production of the present crops. As is true of the other residual types, the Olympic adobe soils can not be as widely used for intensive crops under the normal rainfall as can the deeper, moister, recent-alluvial soils.

DIABLO ADOBE SOILS.

Description.—The Diablo adobe soils include the clay loam adobe and clay adobe, the heavier textured types of the series.

The Diablo clay loam adobe consists of a dark-gray to black, sticky clay loam, often with an appreciable content of gritty material. The soil is usually rather friable under proper moisture conditions, but upon drying it becomes compact and hard, and assumes the typical cracked adobe structure. In this condition it is difficult to till. Gravel or stone fragments are usually lacking. The dark-colored surface material sometimes extends to the underlying rock without distinct change, but is normally underlain at depths ranging from a few inches to 2 or 3 feet by lighter colored and often lighter textured material which grades through partially disintegrated rocks into shales and sandstones. The subsoil is in places dark brown but more often is light grayish brown or mottled, gray, yellow, or brown being the predominating colors. The subsoil varies widely in structure, being in some places rather friable, retentive of moisture, and permeable to plant roots, while elsewhere it is unfavorably compact and dense.

The Diablo clay adobe consists of a dark-gray to black sticky clay, similar to the clay loam adobe, except in its heavier texture and its more pronounced adobe structure. It probably occupies about 50 per cent of the area covered by the group as mapped, differences in texture of the parent rock seeming to influence the distribution of the two types. The surface soil of the clay adobe appears high in organic

matter. The subsoil, as well as the parent rock, is often distinctly calcareous.

In places the soils of this group as mapped differ from the typical Diablo adobe soils. In small areas the soil has the color and other principal features of the Diablo series but is derived from underlying materials only feebly or intermittently consolidated, in this respect resembling the Montezuma adobe soils, which are derived typically from unconsolidated deposits. In other places the soil is brown or dark brown in color, representing included areas of Altamont soils, which are so extensive elsewhere in the State. Soils of more sandy textures than typical are also included; those in the vicinity of the San Juan Capistrano Point are due to a surface deposit of wind-blown material, while in most other places the lighter texture has been caused by differences in the parent rock.

Location.—The Diablo adobe soils are confined to several small bodies in the extreme northwestern part of the area, aggregating in extent several square miles. Small developments of these soils also are included with the Montezuma adobe soils.

Topography and drainage.—The surface of the Diablo adobe soils is rolling or hilly. While the slopes are usually smooth, they are sometimes very steep and on this account difficult to cultivate. On the higher hills the group includes slopes and ravine sides too precipitous for cultivation, these areas being similar to Rough broken land. Drainage is well developed and the run-off is very rapid, but erosion is not pronounced and few gullies have been formed. Small landslides may occur on the steeper slopes in the rainy season.

Utilization.—Probably less than 50 per cent of the total area of these soils is tilled. Their principal use is for the production of dry-farmed grain and hay. The tilled fields are irregular, being interrupted by steeper slopes suitable only for use as pasture. One or two of the bodies mapped include very little cultivated land and are used continuously for pasture. In some of the areas where the soils are more friable and retentive of moisture, beans are grown in a small way. None of the land is irrigated, and its relative elevation and the scarcity of available water render extensive development of irrigation improbable. Under careful methods of tillage it may be profitable to increase the acreage devoted to specialized farming, but hay and grain seem likely to continue to be the principal crops.

Soils Derived from Coastal-Plain and Old Valley-Filling Material.

Montezuma adobe soils.

Description.—The Montezuma adobe soils include the Montezuma clay adobe and clay loam adobe, of which the former is apparently the more extensive.

The Montezuma clay adobe consists of a dark-gray to black clay with typical adobe structure. In drying the soil checks and cracks; the larger cracks, roughly dividing the surface into blocks a foot or more across, may extend to the subsoil. Smaller cracks, both vertical and horizontal, further break up the soil mass. The soil is untillable when wet or dry, but can be pulverized fairly well if cultivated when in an intermediate stage of moisture. When cultivated the excessive cracking is prevented and both the surface soil and subsoil store and retain a large supply of moisture. In places the dark-colored soil extends to a depth of 4 or 5 feet without change, but usually a light-brown, yellowish-brown, or grayish-brown subsoil, similar in texture to or lighter than the surface soil, is developed at any depth from 12 to 35 inches. The subsoil layers are subject to considerable variation in structure, but usually they are quite compact and include occasional semicemented layers. A grayish stratum often underlies the surface soil. Both surface soil and subsoil are apparently calcareous. The deeper underlying material of the type often consists of gray, clayey beds with a peculiar bleached appearance.

The Montezuma clay loam adobe consists of a dark-gray to black clay loam which upon drying assumes a little less pronounced adobe structure than the clay adobe, but is otherwise quite similar.

The soils typical of the group are interrupted by occasional patches of brown soils, and in places brownish gradational soils constitute a considerable percentage of the surface. Over part of the area on Otay Mesa the soil varies distinctly from typical in being underlain at shallow depths by cemented, gravelly layers, such as characterize the Redding soils. In another variation, developed in the same locality but on the higher rolling surfaces, the soil seems to be underlain by consolidated rocks rather than by the deep, unconsolidated clayey sediments commonly encountered. A small proportion of the group contains discontinuous, feebly cemented layers in the substratum. These might be considered as consolidated material, but they are not of sufficient prominence to affect the series classification. It is possible that along the line of contact of these soils with the residual types some of the material has been derived from deeply weathered igneous rocks and should properly be classified with the Climax series.

Location.—The most prominent development of the Montezuma adobe soils is in the country northeast, east, and southeast of Oceanside. The group occurs also in the region south of La Mesa to the international boundary and elsewhere in the coastal-plain belt. It is almost lacking, however, over extensive areas, as from Encinitas southeastward for many miles. In some instances the areas are partly surrounded by residual soils of the mountains, but it is usually bordered on at least one side by coastal-plain soils.

Topography and drainage.—The Montezuma adobe soils typically occupy gently rolling or steeply rolling surfaces. Much of the land is rather free from bold topographic features, although many slopes too steep for cultivation occur. In places northeast and east of Oceanside the Montezuma soils reach elevations of 300 or 400 feet above the near-by valleys, although even here the slopes are smooth rather than broken. With the exception of some flat-surfaced areas, such as that on Otay Mesa, the surface in general favors rapid run-off and good drainage. "Hog-wallow" mounds and depressions are numerous in places, but these are usually associated with the brownish soil representing a gradation into other types.

Utilization and adaptation.—Although nearly all the area of the Montezuma adobe soils is topographically capable of cultivation, it is doubtful whether more than 50 per cent of the land is tilled. Hay and grain are by far the most important crops. While some of the areas, as in the vicinity of Otay Mesa, south of Capistrano, and in more localized developments elsewhere, give fair yields, over much of the group the soils apparently do not produce heavily. They are probably rather poorly adapted to most of the tree fruits, even if irrigation were possible. Beans are grown in places in the better areas of soil, but the total acreage devoted to intensive crops is small.

REDDING GRAVELLY LOAMS AND SANDY LOAMS.

Description.—The Redding gravelly loams and sandy loams group comprises gravelly soils of sandy loam, fine sandy loam, loam, and clay loam texture. The group is largely made up of the gravelly sandy loam and gravelly loam, the former predominating. Although the group is considered one of reddish-brown or red soils, over a large part of its extent the soils are brown. In other respects, however, the types are similar to the typical Redding soils.

The Redding gravelly loam typically consists of a reddish-brown or light-red to red loam, usually with an appreciable content of waterworn gravel. The proportion of gravel varies considerably. In a few places the content is very small; in other places it is large, probably more than 50 per cent of the soil mass.

The gravel particles are usually well rounded and of hard, resistant rocks, mainly quartzitic. The fragments range in size from small pebbles to cobbles 3 or 4 inches in diameter. Fragments of medium size are most numerous. The surface soil usually gives way at a depth of about 8 to 18 inches to a thin layer of exceedingly compact red clay loam or clay, which bakes hard and checks upon exposure during dry periods. This heavy subsoil layer carries less gravel than the surface soil. It gives way within a few inches to a more or less well-defined layer of reddish or brownish hardpan, also relatively free from gravel. This true hardpan may be several inches thick

and is underlain in turn by beds of waterworn gravel mixed with a small proportion of fine material, the mass usually being semicemented or very compact.

The other types of the Redding series included in the group are similar to the loam except in texture.

Variations from the typical cross section of the soils in this group occur in many instances, but the variations are seldom sufficient to influence the agricultural value of the land. In certain places, however, the material has been reworked or eroded, and the unfavorable substrata have been loosened by water action or have been otherwise modified, as by being covered with deeper layers. Such areas of deeper soil are encountered near La Mesa and to a smaller extent elsewhere, occurring usually on slopes where the original surface material has been altered or removed by erosion. Here the distinct hardpan layers may be lacking. Even where the original surface remains undissected the surface soil in places rests directly upon the hardpan, without any intervening heavy subsoil, or even directly upon the semicemented gravel bed without either subsoil or distinct hardpan layers. Some prominent flats of sticky, heavy, adobe-structured, dark-colored soil are occasionally encountered, the most prominent one of which covers several hundred acres northeast of San Diego. This soil is far from typical in color, texture, and probably in subsoil conditions, although the gravelly substrata underlie at least a part of such bodies.

Location.—The most extensive occurrence of the Redding gravelly loams and sandy loams is to the west and south of Miramar, where these soils are the prevailing types over an area of many square miles. They occur also in several isolated bodies farther north in the western part of the area. Numerous irregular bodies lie east and northeast of San Diego, southeast of La Jolla, and in the southwestern part of the area. Small undifferentiated patches of the soils are included with other coastal-plain types in the western part of the area.

Topography and drainage.—The Redding gravelly loams and sandy loams are distinctly upland soils, occupying sloping plains of fairly uniform surface. The group at the eastern limit of its development near Miramar is marked by rather abrupt ascents to the higher lying, more mountainous regions; from here the surface slopes to the west with few prominent inequalities except for the sudden breaks to the sharply intrenched canyons and ravines. Erosion, however, is proceeding only at the heads and sides of the canyons and valleys, and on the whole the surface is unmodified. A few areas, however, have reached a more advanced stage of relief and have a rolling topography. Most of the rainfall is absorbed or retained in the numerous "hog-wallow" depressions characteristic

of the surface. For this reason drainage is insufficient during the rainy season and boggy conditions prevail.

Utilization.—Probably not more than 10 per cent of the area of these soils is under cultivation. It is difficult to grow other crops than hay and grain upon the typical soils without irrigation, and the yields of even these crops are light. A larger area was farmed at some time in the past, but the effort to use the land does not seem to have been successful. Irrigation has been supplied for part of the areas of deeper soil, as near La Mesa, and citrus fruits, grapes, and some other specialized crops are produced in a limited way. Extensive irrigation development on the upland soils of which this group is a part is hardly probable, although a wide range of shallow-rooted crops could undoubtedly be grown were water available. Under dry farming only very localized successes are probable. The shallower areas are not adapted to deep-rooted crops under any conditions.

KIMBALL SANDY LOAMS.

Description.—The Kimball sandy loams include the loamy sand, sandy loam, and fine sandy loam of the series. The loamy sand and sandy loam types, in about equal proportion, constitute the greater part of the group. There are included small areas of the Kimball loam, which are largely confined to the vicinity of Chulavista and southward.

The Kimball sandy loam typically consists of a reddish-brown to light-red nonmicaceous sandy loam, resting in part of the type at some depth between 12 and 36 inches upon a distinctly heavier textured subsoil of yellowish or reddish-brown to red color and ranging in texture from clay loam to clay. Elsewhere the surface soil gives way at about the same depth to very compact, semicemented beds of about the same texture as the surface material but sometimes slightly lighter in color. The surface soil is absorptive, but the subsoil is typically rather impervious to water movement and impenetrable to plant roots. Iron concretions identical with those occurring in the San Joaquin sandy loams are developed in smaller proportions throughout much of this type, but gravels or stone fragments are extremely rare. The deeper underlying substrata often consist of grayish or mottled sandy or clayey material.

The Kimball loamy sand consists of a reddish-brown or light-red sand, carrying small quantities of silt and clay, which slightly increase its water-holding capacity and crop value as compared with a normal sand. The soil is friable when moist, but, like that of the sandy loam, becomes hard and bakes when dry. The type seems to be slightly deeper than the sandy loam and is more often underlain by semicemented beds similar in texture to the surface soil or slightly heavier.

The Kimball fine sandy loam does not differ essentially from the sandy loam, except in its finer texture.

The soils vary from their typical development in several places. The most notable variations in color are due to the inclusion of brown soils. A variation near National City consists of areas wherein the typical soils of the group occupy only the undisturbed ridge crests, much of the surface being badly eroded. Near Otay and elsewhere some areas are underlain by gravelly substrata and probably represent a phase of the Corning soils, mapped elsewhere in the State. The lower lying areas of the group, such as those on Coronado and North Islands, are not much above sea level, and probably have a less compact substratum than is typical of the series. Although the Kimball soils do not typically have distinct hardpan layers, local lenses or sheets of hardpan underlie parts of the group, the soil here representing included bodies of the San Joaquin sandy loams. Slight accumulations of wind-borne material give rise to some of the sandy members of the group.

Location.—The Kimball sandy loams are the principal soils along the coast from a point several miles north of Oceanside to near Encinitas, their development extending inland for a maximum distance of about 3 miles. The group is also important around the southern part of San Diego Bay. Several other bodies occur a few miles farther inland or scattered along the coast.

Topography and drainage.—These soils are largely situated upon terraces or rolling plains fronting on the ocean, with bounding bluffs 15 to 40 or more feet in height. In places they occur farther inland without marked difference in topography from some of the other soils of the upland coastal plain. The continuity of some of the strips along the ocean front is broken in many places by the depressed valleys extending inland from the coast. The group includes some rather level terrace remnants, such as those comprising Coronado and North Islands, that near South San Diego, and the lower terraces at Oceanside and Carlsbad. In addition, it occupies some older, rolling surfaces, as in the vicinity of Encinitas and in the inland extensions of most of the bodies. Sharp breaks in the surface are not common, except along the ocean front or along the valleys, although some sharply rolling or steep slopes occur in the higher elevations. The ravines and canyons that dissect the surface in many places have been largely mapped as Rough broken land. Wind action has materially modified the surface in places, but distinct dunes are of only local development.

The prevailingly light texture of these soils does not permit much run-off and drainage is largely into subsurface layers. Compact substrata in places so far prevent the downward movement of water as to make the soil boggy during the rainy season. "Hog-wallow"

mounds and depressions characterize some of the flatter areas with more impervious subsoil.

Utilization.—Practically no crops other than hay and grain are grown upon these soils without irrigation. The yields are apparently rather light. Probably somewhat more than 50 per cent of the land is under cultivation, the rest being used for pasture or lying idle. The soils appear very low in organic matter and on this account, and owing to the light textures and compact subsoils, they are much less valuable for dry-farmed crops than the recent-alluvial soils. Irrigation has been supplied at Chulavista and Carlsbad and in a smaller way elsewhere, and lemons and other fruits and a wide variety of garden crops successfully grown.

Irrigation seems to be the controlling factor in the development of these soils. Indications are that a great variety of intensive crops can be grown wherever an adequate water supply is available, but that development must be rather limited otherwise. With intensive cropping it may be necessary to use large applications of fertilizer and organic matter. Plantings of eucalyptus trees seem to do well, and the growing of this tree could perhaps well be given more attention on the areas which would otherwise remain idle.

SAN JOAQUIN SANDY LOAMS.

Description.—The San Joaquin sandy loams include the sandy loam and loamy sand of the series, with minor occurrences of fine sandy loam and patches of loam.

The San Joaquin sandy loam consists of a reddish-brown, light-textured, friable sandy loam which averages about 10 inches in depth. The soil appears redder when wet. It is usually free from gravel. A large content of small, spherical iron concretions is a characteristic of the series. Over a small part of the type the surface soil is directly underlain by hardpan, but usually a subsoil is developed at a depth of about 10 inches, consisting in some places of a reddish-brown or red, very compact clay loam extending to a depth of 24 or 30 inches, and in others of a semicemented, brown sandy material of nearly the same texture as the surface soil. These subsoils are typically underlain by beds of hardpan, usually brown or red in color. Exposures show a great range in the thickness of the hardpan. Sometimes it occurs in layers interbedded with gravel, and in many places it is underlain within a few feet by beds of water-worn gravel very similar to those encountered in the Redding soils. Owing to the rather shallow depth of soil and the rather impervious nature of the subsoil and the underlying hardpan, the type has a low water-holding power.

The San Joaquin loamy sand consists of a reddish-brown loamy sand containing iron concretions. The loamy sand is a little lower in

agricultural value than the sandy loam. Wind action has modified the surface and over small areas has accumulated a soil deeper than the average.

In about 50 per cent of the area covered by the San Joaquin series the soils carry an excessive quantity of iron concretions, the particles ranging in diameter up to one-half inch. In exceptional instances these concretions make up more than 50 per cent of the soil mass, and over a large part of the areas northeast of La Jolla and near Del Mar they constitute 15 or 20 per cent of the soil.

The group as mapped includes, near San Diego, somewhat eroded areas, where the soil is typical only on ridges and crests where erosion has been active. The soils on the intervening slopes and eroded areas are of variable character and include undifferentiated bodies of the Montezuma, Redding, and Kimball series. Much of the material included in this group is brown instead of reddish brown or red, although quite typical in all other features.

Location.—The San Joaquin sandy loams occur in some important bodies from the vicinity of Del Mar southward along the western margin of the area. Their development rarely extends inland for more than 4 or 5 miles. The largest area lies several miles north of San Diego.

Topography and drainage.—Soils of this group form mesalike uplands of very irregular outline and slightly uneven surface bounded by steep slopes occupied by Rough broken land. Erosion is not extensive within the area covered by the group, but numerous ravines flanked by Rough broken land have penetrated the larger bodies. The descents to the ocean shore are steep, and the San Joaquin sandy loams rarely grade into other soils without intervening steep areas of Rough broken land. A few inclosed, shallow depressions mark its surface and there are occasionally ridges or low hills. In places a "hog-wallow" surface is developed.

Utilization.—An adequate water supply for irrigation does not seem available for these soils, and they have comparatively little value for dry farming. Nearly all the land is used for pasture. Some grain and hay are produced, but yields are low. In one or two areas of deeper soil irrigation farming has been carried on, with fairly good results. Some extensive plantings of eucalyptus have been made northeast of La Jolla, and the growth has been fair. It is possible that this use of the land could be extended with profit. These soils could be made to produce a variety of shallow-rooted crops under irrigation.

LAS FLORES AND KIMBALL LOAMS AND SANDY LOAMS (UNDIFFERENTIATED)

Description.—The group mapped as the Las Flores and Kimball loams and sandy loams (undifferentiated) includes the sandy loam,

loamy sand, and fine sandy loam of the Las Flores soils and the sandy loam and loam types of the Kimball series, with small inclusions of fine sandy loam and clay loam. The Kimball sandy loam is probably the principal type of the group. The Kimball material is not typical in color, being reddish brown to brown. The typical Kimball material is much redder. It is possible that these soils should be placed in a distinct series of brown soils—the Ramona or some related series.

The Las Flores sandy loam consists of a light-gray or light brownish gray, nonmicaceous sandy loam, which is nearly everywhere free from gravel or rock fragments. Typically an exceedingly compact brown, grayish-brown, or reddish-brown clay loam or clay, subsoil is developed at depths of 10 to 24 inches and continues without much variation to a depth of 6 feet or more. The subsoil becomes hard and flinty when dry and cracks upon exposure. It is usually unfavorable for root development and rather impervious. Distinct hardpan layers or gravelly substrata are normally lacking. The soil is friable when moist, but hard and compact when dry.

The Las Flores loamy sand is practically identical with the sandy loam, except that it is more sandy and of lower water-holding capacity. Some of the small areas of this type have been slightly modified by wind action.

The Las Flores fine sandy loam resembles the sandy loam except in its finer texture. Associated with it are small developments of loamy fine sand or fine sand.

The Kimball sandy loam typically consists of a reddish-brown or brown, nonmicaceous sandy loam. It is usually free from gravel and is easily tilled when moist, but like the other types of the group becomes very hard when dry. At any depth from 12 to 36 inches, the surface grades sharply into a compact, heavy-textured subsoil which normally extends to a depth of 6 feet or more. The subsoil becomes flinty and cracked when dry, and is too compact to be easily permeated by water or penetrated by roots. It ranges in color from brown to reddish brown or even red in a few places, and quite commonly is mottled.

The Kimball loam consists of a rather compact loam, similar in subsoil features to the sandy loam.

Over about 10 per cent of the area mapped the soil varies from the typical. One of the most notable variations occurs in the areas situated several miles inland from the coast between Capistrano and Las Flores. The soils here are largely derived from the weathering of soft or partially cemented sandstones rather than from unconsolidated water-laid deposits. The resulting subsoil is apparently not so compact and heavy textured as that developed elsewhere and rests upon the soft rock within 6 feet of the surface. Similar soil is

developed farther south, at the upper elevation along the line of contact with the larger mountain masses. Over a part of the area mapped in the vicinity of La Jolla and extending eastward from that place the soil is of similar origin and of brown color and if of greater extent would be classed in a distinct series of soils.

The Las Flores and Kimball loams and sandy loams (undifferentiated) are occasionally slightly gravelly, with gravelly strata in the subsoil. This condition is one of the many variations which characterize gradations to associated groups within the coastal plain.

A variation of considerable agricultural importance occurs on some of the slopes leading from the uplands to lower levels along the streams. Many such marginal areas of reworked material occur around the heads or steep slopes of canyons or on lower slopes bordering the valleys. The subsoil here is more friable than typical. The water-holding capacity is consequently higher and as some soil of recent-alluvial origin is included these areas are distinctly better for dry farming.

Location.—The Las Flores and Kimball loams and sandy loams (undifferentiated) occur in numerous bodies throughout the western part of the survey, in the coastal plain. While in some parts of this region, as between La Jolla and Miramar, these soils are of small extent, they are one of the principal groups over broad areas, as to the east of Del Mar.

Topography and drainage.—These soils are usually located on upland plains, the elevation ranging from one hundred to several hundred feet above the present stream bottoms. They occupy remnants of what were formerly more uniformly surfaced deposits but which have in general lost the original level surfaces characterizing some of the associated soils. The roughest areas of these soils are included with the Rough broken land where practicable, but many local steep or choppy surfaces are included in the group. Most of the land, however, is tillable, and farm machinery can be used over much more than 50 per cent of it without great difficulty. A gently rolling to steeply rolling topography prevails. In places in the steeper areas gullies and ravines have been developed, while the ridges and intervening portions are smoothly rounded. On the whole the surface favors good drainage. Numerous small mounds with intervening depressions, however, characterize much of the area covered by the group. The depressions serve as collecting places for rainfall, and percolation is retarded by the compact subsoils. The resulting unfavorable drainage conditions give rise to differences in the structure and texture in the soil on the mounds and in the depressions.

Utilization.—These soils are not very well adapted to dry farming and much of the land has the appearance of being rather unproductive. The heavy, compact subsoils are distinctly unfavorable,

since they restrict the zone of root development. Probably less than 50 per cent of the land is tilled. Much of it is used principally for grazing. Grain hay and grain are by far the most extensive crops. Where the subsoil is more friable than typical the soils are used for growing beans and similar intensive products. In common with many of the other upland soils, irrigation seems necessary for any great extension in the farmed area of these soils, and this can be provided only locally.

PLACENTIA SANDY LOAMS.

Description.—The Placentia sandy loams include the sandy loam, coarse sandy loam and fine sandy loam of the series. Of these the sandy loam member is the most extensive.

The Placentia sandy loam typically consists of a pronounced reddish-brown to red sandy loam, usually nonmicaceous and rather friable except when allowed to dry without cultivation. At depths ranging from 10 to 24 inches the surface soil grades rather sharply into a reddish-brown, yellowish-brown or red, distinct, compact, impervious, heavy clay loam or clay subsoil. There is considerable variation in texture of the subsoil and over important areas it is lighter and more friable, though still less permeable than the surface soil. The type normally does not have gravelly substrata or hardpan layers, but in a few localities the subsoil is so compact that it has much the effect of a true hardpan, and in still smaller bodies a distinct hardpan layer is developed.

The Placentia coarse sandy loam and fine sandy loam are similar to the sandy loam except in texture. The coarse sandy loam which covers only small areas, is a soil of gritty, coarse texture. The fine sandy loam is friable in structure.

Although the group is considered as ranging in color from pronounced reddish brown to red, considerable areas of brown soils are included. The subsoils in the latter case seem to be slightly more friable than those beneath the red or reddish-brown soils. The Escondido and Elcajon Valleys contain quite large areas of these brown-colored soils.

Location.—The Placentia sandy loams occur in numerous bodies through the mountainous parts of the area. Almost invariably they occur along valley margins or as the principal soils of some of the intermountain basins or valleys. In the Escondido Valley they cover several square miles, and west of this valley and southeast of Fallbrook there are smaller developments. The Elcajon Valley and the Ramona district include large areas of these soils, and they cover part of the Poway Valley and other smaller basins and valleys.

Topography and drainage.—These soils are usually slightly elevated above the recent-alluvial bottoms and consist quite plainly of

old-alluvial deposits, which have been weathered and slightly eroded. They are usually quite distinct from the residual soils, but sometimes merge gradually into soils of the recent-alluvial groups. Near Ramona the areas are interrupted by protruding masses of granite. In the Escondido and Poway Valleys these soils are obviously derived from an older valley-filling deposit, the present remnants being interrupted by strips of recent-alluvial soils. In the Elcajon Valley nearly all the slopes and the valley floor are covered with the Placentia soils, and there is little development of recent-alluvial soil. The soil material in the latter region appears younger and less modified by weathering than in other parts of the survey.

The Placentia sandy loams usually occur on sloping or gently undulating surfaces, where the drainage in general is good. A considerable part of the land is, however, hummocky, and where this condition is most pronounced there is a tendency for the depressions to become water-logged during the rainy season, owing to sluggish underdrainage.

Utilization.—The utilization of the Placentia sandy loams has been governed largely by the character of the subsoil and by the supply of water for irrigation. In the Escondido Valley oranges and lemons are produced with irrigation where the climatic conditions are favorable. Grapes are also an important crop, being successfully grown without irrigation in the areas of more friable subsoil. In the Elcajon Valley citrus fruits and grapes are important crops. The former are irrigated, but grapes are sometimes profitably produced here without irrigation, although they give much larger yields when watered.

These soils produce other fruit and garden crops both with and without irrigation and locally they are very valuable types, although the group includes areas of poorer soil, having very compact subsoils. Grain and grain hay are the most extensively grown crops, but are gradually being supplanted by more profitable products.

PLACENTIA LOAMS.

Description.—The Placentia loams group comprises the loam and clay loam of this series. The loam is much the more extensive.

The Placentia loam typically consists of a reddish-brown or red, light to medium textured loam, nearly always free from gravel or rock fragments, underlain at 10 to 18 inches by a more compact red or reddish clay loam subsoil, which usually continues to a depth of 72 inches or more. Under the most favorable conditions the subsoil is only fairly compact and is permeable to both roots and water, but in places it is hard and semicemented. Normally there is no distinct hardpan, but lenses or intermittent layers are developed locally, in which case the soil profile very closely resembles that of

the San Joaquin series, extensively mapped in other parts of the State. The dense subsoils are in places almost as unfavorable to plant growth as a true hardpan.

The Placentia clay loam is similar to the loam except in its heavier texture.

The group contains some brown-colored soil not considered typical of the series. In places these included areas are formed from more recently deposited material. Elsewhere they have been modified by recent stream action.

Location.—The largest area of the Placentia loams occurs near San Marcos. Other important areas are encountered 1 mile north of Escondido, south of Pala, and northeast of Elcajon. Smaller areas of the soils of this group are included with the Placentia sandy loams.

Topography and drainage.—The group occupies sloping or very gently rolling areas, with surface features fairly distinct from those of the recent-alluvial soils and from the higher lying residual soils. Much of the area near San Marcos has a hummocky surface. In general the topography favors good drainage, but the dense subsoil retards underdrainage, and locally the depressions between the mounds retain much water during or shortly after the rainy season. These soils in the Escondido and Elcajon Valleys have a smoother surface and a somewhat higher agricultural value than over most of their extent.

Utilization.—In the better areas in the Escondido and Elcajon Valleys the Placentia loams are valuable soils, utilized for the production of citrus fruits, grapes, and other intensive crops. Irrigation is used for some of the crops, and conservation of moisture by thorough tillage is relied upon for others. The greater part of the area near San Marcos is used either as pasture land or for the production of dry-farmed grain hay.

RAMONA STONY SANDY LOAMS.

Description.—The group mapped as the Ramona stony sandy loams is indicated upon the map by stone symbols in the color used for the Ramona sandy loams. It includes the stony sandy loam, stony coarse sandy loam, and a small proportion of stony sand.

The Ramona stony sandy loam consists of a brown or slightly reddish brown sandy loam carrying much gritty material and small rock fragments and usually large quantities of granitic bowlders, some of which are several feet in diameter. The proportion of stone varies widely but usually the fragments constitute more than 50 per cent of the soil mass to a depth of 6 feet. There is no consistent difference in texture of the fine-earth constituents throughout the

6-foot section, the material as a rule consisting of an unassorted, irregularly stratified mass. The stony sandy loam differs in this respect from most of the types of the series, which have distinct subsoils. The stones scattered over the surface or imbedded in the surface soil in disintegrating give rise to soil material resembling residual accumulations.

The Ramona stony coarse sandy loam and the Ramona stony sand are similar to the stony sandy loam except in the coarser texture of the fine earth.

Location.—The Ramona stony sandy loams group is not extensive. Several bodies occur around the margin of the San Felipe Valley, near the eastern border of the area. The largest development occurs about 3 miles east of Pala. Several other areas ranging in size up to several hundred acres are mapped, these small areas usually lying at the margin of basins or valleys through the mountainous regions.

Topography and drainage.—The group occupies elevated remnants of old, dissected, coarse, stony alluvial fans, undoubtedly very similar to those now occupied by the Hanford stony sands. The surface is usually steeply sloping. Stream action has carved small valleys through the deposits and in most cases has cut off the lower extensions, leaving these soils as segments elevated above the recent-alluvial types. Minor streams are in certain places discharging their sediments over the surface, giving rise to local alluvial deposits not unlike those occupied by the Hanford stony sands. Drainage is excessive, owing both to the position and to the extremely porous character of the soils.

Utilization.—Practically none of the land is cultivated. It is used for pasture. The soils are poorly suited for agriculture, owing to their stony and porous character, and in most cases would be of low value even with irrigation, which does not at present seem possible.

RAMONA SANDY LOAMS.

Description.—The Ramona sandy loams group comprises the sandy loam, coarse sandy loam, and fine sandy loam of the series, the latter two being of small extent.

The Ramona sandy loam consists of a brown, grayish-brown or slightly reddish brown sandy loam of rather friable structure, apparently low in organic matter, and usually free from stones or gravel. At depths ranging from 10 to 24 inches the soil passes into a more compact, yellowish-brown or reddish-brown subsoil, which is in places distinctly heavier in texture than the surface material. In extreme cases the subsoil is sufficiently dense practically to preclude root penetration or water movement.

The Ramona fine sandy loam and coarse sandy loam are closely associated with the sandy loam and have about the same range in subsoil features.

Over part of the group the soil has a grayish color. In places marked variations in the subsoil are encountered. The surface soil occasionally extends to a depth of 6 feet or more without change or may be underlain by rather gravelly, loose structured beds.

Location.—The Ramona sandy loams are rather closely confined to the vicinity of Agua Caliente and Temecula. In the first-named locality, or the San Jose Valley, the group covers numerous irregular areas interrupted by strips of lower lying recent-alluvial soils. In the vicinity of Temecula the bodies are more regular in outline but include some undifferentiated recent-alluvial material.

Topography and drainage.—The Ramona sandy loams occupy rolling or dissected areas occupied originally by rather even surfaced water-laid deposits. The group ranges in elevation from slightly above to 100 feet or more above the present stream bottoms, the latter areas occupying distinct terraces or benches. The most dissected and rougher areas covered by these soils have been included with Rough broken land where possible, but as mapped they include some dissected areas too broken for cultivation. Drainage is good to excessive. Over a part of the area the surface is marked by hummocks and intervening depressions which hold water during the rainy season, underdrainage being arrested by the dense subsoil.

Utilization.—Practically none of the land included in this group in the San Jose Valley is tilled. It is utilized for grazing. Some of the land in the vicinity of Temecula and southeastward is used for grain and hay production and in a small way for intensive crops, such as vegetables and grapes for home use. It is difficult to establish fruit trees and vines without irrigation.

Ramona sandy loams, terrace phase.—The group, Ramona sandy loams, terrace phase, includes soils of about the same range in texture as the typical group. The sandy loam member predominates.

The Ramona sandy loam in this phase consists of the typical brown sandy loam surface soil, with a distinct, more reddish brown or even red, compact, heavier textured subsoil. It is occasionally underlain by gravelly beds. Its principal difference from the typical soil is in its location on rather well defined terraces along the courses of the principal streams where they lie deeply entrenched through the coastal-plain region.

Location.—The terrace phase of the Ramona sandy loams occurs in several bodies along the margin of the Mission, San Dieguito, and San Luis Rey Valleys and elsewhere. Along the Tia Juana River near the southern border of the area the soil is yellower and of heavier texture than typical. The areas northeast of San Onofre seem to consist largely of old terrace deposits derived from sedimentary-rock formations and to this extent are not typical, as most of the material elsewhere has originated from granite or similar rocks.

Topography and drainage.—These soils usually lie from 10 to 40 feet or more above the recent-alluvial types and are usually separated by sharp escarpments from the bordering elevated coastal-plain deposits. Some of the smaller areas consist to a large extent of slopes, but in the larger areas the surface in general may be rather flat. Drainage is good, except where a "hog-wallow" surface occurs locally. Here during the rainy season the depressions are poorly drained, owing to the dense subsoil which retards downward movement of water.

Utilization.—Some of the land of the terrace phase is irrigated and intensively farmed. Citrus and deciduous fruits, in general irrigated, cover a small total area. A few vineyards have been established. Some of the larger areas of the phase are untilled or used only for hay and grain production.

Soils Derived from Recent-Alluvial Material.

HANFORD STONY SANDS.

Description.—The Hanford stony sands group is composed mainly of the stony sand and stony loamy sand and, to a smaller extent, of the stony sandy loam.

The Hanford stony sand consists of a light-brown or light grayish brown sand, ranging in texture from fine to coarse. There are scattered over the surface and throughout the soil mass varying quantities of gravel, angular stone fragments, and bowlders, some of the latter being several feet in diameter. There is considerable variation in the relative proportions of fine earth and stone, the former usually making up more than 50 per cent of the soil mass on the lower parts of the fans and away from the channels traversing their surface, while on the steeper areas, contiguous to the waterways, there may be only enough gravelly sand to fill the interstices between the bowlders.

The type has a variable subsoil. It consists in many places of very irregularly stratified materials, ranging in texture from sand to bowlders in successive layers, while in other places it is composed of an unassorted mass bearing little resemblance to water-laid deposits. The finer material is usually micaceous. The type has a low water-holding capacity.

The Hanford stony loamy sand contains a little more fine material than does the stony sand, although the slightly more loamy texture may not continue beyond a few inches below the surface. In all other features, such as stone content and irregular subsoil conditions, the two types are essentially similar. The stony loamy sand is slightly more retentive of water than the sand.

The Hanford stony sandy loam is of small extent. It is confined to a few places where conditions have been favorable for the deposi-

tion of heavier material than is typical of the Hanford stony sands group. The sandy loam layer may be very shallow, with subsoil conditions similar to those of the stony sand soil.

The group as mapped includes a few ridges or remnants of older fans on which the soils have been weathered. They are slightly reddish brown in color and represent Ramona materials not important enough to warrant separation. The variations in texture and other features within the Hanford stony sands group are not of much agricultural significance, owing to the controlling factors of stony, coarse texture and leachy structure that prevail over these soils.

Location.—The group is not extensive. It occurs in one area near Pala, in two others several miles southeast of that place, and in less important developments elsewhere. It is also encountered in smaller undifferentiated areas in the stony parts of fans mapped with the Foster soils or with other Hanford groups.

Topography and drainage.—The Hanford stony sands usually occupy steeply sloping fans at the base of abrupt mountain faces. The surface is somewhat more uneven than is true in general of recent-alluvial material and is marked by poorly defined, bowlder-strewn stream channels. Drainage over these soils is excessive. In general, there is little run-off, as percolation into the subsurface layers is rapid.

These soils represent the coarsest rocky débris deposited by present streams. While they are similar to the finer textured types of the Hanford series, in origin, mode of formation, and color, they are very much less valuable for agriculture.

Utilization.—A few small fields are devoted to grain and hay production, but aside from this the land is used only for pasture. On account of its stony, porous character and the lack of water for irrigation it seems probable that the tilled area will not be greatly increased in the near future.

HANFORD SANDY LOAMS.

Description.—The Hanford sandy loams group includes the sandy loam, the coarse sandy loam, and the fine sandy loam of the series. Of these the sandy loam is the most extensive.

The Hanford sandy loam consists of a light-brown, medium-brown or grayish-brown friable, sandy loam, usually micaceous. It contains some gravel or stone fragments in places, but except in some of the areas on the steeper fans, where massive bowlders occur, nowhere contains enough stone to be classed as a stony soil. Usually a subsoil, slightly lighter colored than the surface soil, occurs at a depth of 30 or 36 inches. As in the case of the other recent-alluvial soils, the subsoil is in places stratified, heavy and light textures alternating in an irregular manner. The subsoil is on the average lighter tex-

tured than in the Hanford fine sandy loam, and although in places the soil is quite porous and leachy, both surface soil and subsoil typically retain moisture well.

The Hanford coarse sandy loam consists of a sandy loam carrying a sufficient proportion of coarse sand, grit, and fine gravel to lighten the texture and slightly lower the water-holding capacity of the soil. In color, depth, and other features this type closely resembles the sandy loam member. The two types are closely associated.

The Hanford fine sandy loam consists of a light-brown or grayish-brown, micaceous, fine sandy loam of friable structure. It is usually free from gravel, but often contains coarse sandy streaks. The material in places extends to a depth of 6 feet without distinct change in color or texture, but it is usually slightly lighter colored below about 24 inches, and there are often wide variations in texture below this depth. Alternating strata of coarse and fine textured material are common. The type is easily tilled and quite retentive of moisture, except where coarse gravelly or sandy layers make up the subsoil.

In the San Felipe, Oakgrove, and San Jose Valleys the soil is looser in structure than typical, as is apparently true in general of the soils deposited under climatic conditions resembling those of the desert a short distance to the east. The material seems in general to be more nearly unassorted here, with the coarse sandy loam members of the group more extensive than in some of the areas in the vicinity of the Escondido Valley or southeast of Fallbrook. There are included with the group as mapped numerous small areas in which the soil varies widely from typical. It contains some dark grayish brown soils belonging to the Foster series. The differentiation between the Hanford sandy loams and the Foster sandy loams is based entirely on color, and their separation is consequently difficult.

Location.—The Hanford sandy loams are most extensively developed in the San Felipe, Oakgrove, and San Jose Valleys and numerous smaller basins in the northeastern part of the area. There are several bodies along the San Luis Rey River and its tributaries and along minor streams within a radius of several miles of Escondido.

Topography and drainage.—In topography the Hanford sandy loams do not vary essentially from the other recent-alluvial soils. They occupy stream bottoms or sloping alluvial fans, which sometimes merge to form the sloping sides and floors of the mountain basins. The areas are usually small and often consist of extremely narrow alluvial strips deposited in troughs entirely surrounded by residual soils. In some instances the alluvial-fan material has been deposited by streams which practically disappear near the upper part of the fans, surplus waters being distributed across the surface by constantly shifting, poorly defined channels. Where the deposit

has been made by more permanent watercourses the type is likely to be of flatter surface and subject to occasional overflows. Drainage is nearly always adequate and in the eastern part of the San Diego area, nearer the interior desert, underdrainage is particularly rapid, owing to the looser structure of the soil in this region.

Utilization.—On account of differences in elevation, local rainfall, and soil structure the Hanford sandy loams vary widely in utilization from place to place. In the higher mountainous districts they are used for grain and hay production or for grazing. Usually at the lower elevations, in addition to the above uses, these soils are made to produce vegetables and fruit. In the moister areas the types are well adapted to grapes and many other fruits without irrigation. Citrus orchards are established in some places under irrigation where frost conditions are favorable. The deep, friable nature of these soils makes them admirably suited to alfalfa, moisture conditions being the controlling factor. In some areas good yields are obtained without irrigation, while the addition of water is necessary to accomplish the same results elsewhere.

The group consists typically of first-class agricultural soils. Usually, however, they require irrigation for maximum development, and in the most droughty localities this is necessary for even moderate yields.

HANFORD AND TUJUNGA SANDS (UNDIFFERENTIATED).

Description.—The group mapped as the Hanford and Tujunga sands (undifferentiated) includes the sands, fine sands, and loamy sands of the Hanford and Tujunga series, with certain variations. The included Hanford soils greatly predominate in extent.

The Hanford sand consists of a light-brown or grayish-brown, micaceous sand, sometimes quite gravelly. This material may extend to a depth of 6 feet, but irregularly stratified, gravelly and silty or fine sandy layers usually occur below a few inches. The Hanford fine sand and loamy sand are similar to the sand type except in texture.

The various included types of the Tujunga series resemble the Hanford soils except in color. The light-brown Hanford soils and the light-gray Tujunga soils are intimately associated.

Location.—The sandy material composing these soils occurs in two rather distinct developments. Bordering the channel of the San Luis Rey River for many miles along its upper course, and along the San Diego, Tia Juana, and Santa Margarita Rivers the material consists of assorted river sands forming the level flood plains, slightly elevated above the streams and subject to overflows.

In numerous bodies in the northeastern part of the area the material is slightly loamy and consists of deposits laid down as alluvial fans on the floors of small valleys or along intermittent washes. Here it is usually not subject to overflows. The soil carries more angular stone fragments than the river sands and is less stratified. In the beds of canyons or where smaller alluvial strips merge into larger valleys the soil in places carries large quantities of gravel and small bowlders. It has the gritty texture and loose open structure characteristic of the soils deposited under the climatic conditions existing in the northeastern part of the area, which approach those of desert areas. Some of the soils of this group in this region seem of very light sandy loam texture when moistened, although in water-holding capacity and in other general features they appear to belong with this light-textured group rather than with the sandy loams group.

Utilization.—The Hanford and Tujunga sands (undifferentiated) are largely nonagricultural or of low agricultural value under present conditions. Most of the land bordering the main streams is untilled and covered with a growth of brush and trees characteristic of the river bottoms. Most of this land is used for grazing. The soil of the alluvial fans or river flood plains in the northeastern part of the area is also mainly brush covered and is used as pasture land. Much of it would be valuable were irrigation possible, but its power to retain moisture is too low for successful dry farming under the prevailingly light rainfall.

The group as mapped includes some small areas of heavier textured soil than typical, which is more valuable for agriculture, being now utilized to some extent. Even some of the more sandy areas can be made productive where damage from overflow is not too great and irrigation water can be supplied.

FOSTER SANDY LOAMS.

Description.—The group mapped as the Foster sandy loams comprises the sandy loam and coarse sandy loam of the series, and unimportant areas of a dark-colored variation of the fine sandy loam.

The Foster sandy loam consists of a dark-brown or dark grayish brown, micaceous, friable sandy loam, usually rather free from gravel or stones. Typically the Foster soils are darker than the associated Hanford soils, into which they merge. As mapped, small areas of the Hanford sandy loams are included. As is true in general of the recent-alluvial types, the material in places extends to a depth of 6 feet or more without appreciable change in either color or texture. More often, however, the material becomes slightly lighter colored at some depth between 12 and 36 inches and passes either

into lighter or a heavier subsoil which may extend to a depth of 6 feet or may alternate with seams and strata of material of other textures. The subsoil is occasionally quite gravelly and porous, especially near streams or abandoned and filled channels.

The Foster coarse sandy loam is of relatively small extent. It consists of a coarse, gritty sandy loam of lower water-holding capacity than the sandy loam and with a more general development of coarse, leachy subsoil.

Although both types have in places a subsoil of loose and porous structure, over a large proportion of the group both surface soil and subsoil, although permeable to water and readily penetrated by roots, are retentive of moisture.

The fine sandy loam soil included with the group is brown to dark brownish gray in color and is micaceous and friable. Usually the surface soil gives way to a brown subsoil at a depth of 36 inches or less, but the fine sandy loam texture may continue to a depth of 6 feet or more, or alternating strata of material heavier or lighter in texture than the surface soil may be encountered.

Location.—The Foster sandy loams are widely distributed through the area. They usually occur in small or elongated areas bordering streams within or issuing from the high mountain region. The Sweetwater, San Diego, San Dieguito, and San Luis Rey Rivers are bordered in places by rather continuous strips of these soils, while many minor alluvial flats and basins through the mountain region contain smaller areas. A rather typical area of the included darker colored material lies about 3 miles north of Escondido. The group mapped as the Foster loams and clay loams, dark-colored phase, includes some undifferentiated lighter textured material properly belonging with the Foster sandy loams group of soils.

Topography and drainage.—The Foster sandy loams occupy alluvial bottoms, alluvial fans, and the floors of filled mountain basins. The surface is usually rather smooth except for gentle undulations or irregularities along abandoned stream channels. In places in flat-bottomed valleys the soils are only slightly elevated above the main watercourses and are subject to inundation for short periods. Here there is in places a high water table locally associated with injurious accumulations of alkali. Most of the land is well drained, although the type, on account of its depth and position, is relatively moist. The steeper parts of small fans are sometimes excessively drained.

Utilization.—Practically all the Foster sandy loam is tilled. A large percentage of the land is devoted to more intensive and more profitable crops than hay and grain, although the latter are grown in many places. Alfalfa is an important crop, and its production is in many places associated with dairying. Grapes, peaches, apricots,

and a wide variety of other fruits are produced. Beans, corn, and sugar beets are locally important. The intensive development of these soils in certain places has been made possible in large measure through irrigation with water pumped from the coarse strata that in general underlie the alluvial deposits of the area. It has also been possible to utilize much of the land without irrigation, owing to the depth and retentiveness of the soil. The Foster sandy loams rank among the best soils in the area agriculturally, and they are capable of much greater development. In some of the higher situations in the mountains the farming value is lower.

FOSTER FINE SANDY LOAM.

Description.—The Foster fine sandy loam consists of a dark-brown or dark grayish brown, micaceous, friable fine sandy loam. The mica content in certain places, as in parts of the San Pasqual Valley and elsewhere, is very high and gives the soil a greasy feel when moist. The type is nearly always free from gravel. At depths ranging from 24 to 36 inches the material usually becomes slightly lighter in color than above. In many places the fine sandy loam material extends to a depth of 6 feet or more; elsewhere it gives way to strata varying in texture, but rarely heavier than a silt loam. In an important variation developed along stream channels the subsoil is quite sandy or gravelly and more porous, but in general both surface soil and subsoil are very retentive of moisture and well adapted to deep-rooted crops. The type as mapped includes lighter brown, undifferentiated areas of Hanford fine sandy loam or similar types.

Location.—The Foster fine sandy loam is one of the most extensive recent-alluvial soils of the area. It occurs in rather large areas bordering the Santa Margarita, San Luis Rey, San Dieguito, San Diego, Sweetwater, and Temecula Rivers, and in smaller areas along some of the other streams. The type forms nearly all the bottom land along some of the streams and in places extends uninterruptedly along them for many miles.

Topography and drainage.—Practically all of the Foster fine sandy loam occurs as stream-valley material. It is not developed extensively on alluvial fans. The type closely borders the parent streams and extends laterally without much variation to the ascents marking the beginning of the upland soils. Its surface slopes with the parent stream and is uniform, except where traversed by present or abandoned shallow channels. Inundations occasionally cover some of the land but are not of long duration. Drainage is sufficient, except in the lower places, where a high water table has caused the accumulation of injurious quantities of alkali. These poorly drained areas constitute only a small proportion of the total extent of the type, but they affect the value locally, being suitable, under present

conditions, only for grazing. The most important alkali areas occur near the coast, where the Foster fine sandy loam merges into Tidal marsh. Other affected areas are encountered in parts of the San Pasqual Valley and elsewhere.

Utilization.—The Foster fine sandy loam is one of the most productive soils of the area. Its moist, deep, friable nature makes it highly valuable for practically all the common crops, and the crop possibilities are as wide as on any other soil of the area. Except in the poorer developments the land is all in cultivation, much of it being used for special crops, including beans and sugar beets. These give heavy yields. The soil is admirably adapted to alfalfa, and dairying is important in certain places. Many different fruit and garden crops are grown. Irrigation is carried on in many places, water being obtained both by pumping from underground sources and by diversion from the streams. Many crops are grown without irrigation, the soil maintaining a good supply of water where properly tilled, but irrigation is being extended and seems profitable.

FOSTER LOAMS AND CLAY LOAMS, DARK-COLORED PHASE.

Description.—The Foster loams and clay loams as mapped in this area represent in the main a dark-colored phase of these Foster soils. The group as mapped, however, includes some patches of typical Foster material. The group consists largely of the loam, silt loam, clay loam, and silty clay loam types, with small areas of clay and silty clay. The loam and clay loam are the most extensive types.

The Foster loam, dark-colored phase, consists of a dark-gray to black, micaceous, friable loam, usually free from stone or gravel and apparently high in organic matter. The surface soil is normally underlain at some depth between 10 to 24 inches by a lighter colored subsoil ranging in color from brown or grayish brown to gray. Material of loam texture rarely extends to a depth of 6 feet, usually being supplanted in the subsoil by strata of varying texture.

The relatively inextensive silt loam is quite similar to the loam except in texture.

The Foster clay loam, dark-colored phase, consists of a dark-gray to black clay loam, carrying a little finely divided mica. It is easily tilled in the better drained areas. As is true of the other members of the group, the surface soil usually passes into a lighter colored subsoil of variable texture at a depth of less than 3 feet.

The silty clay loam type is similar to the clay loam in depth and tillage features.

The soil of the silty clay and clay members of this group is usually a refractory dark brownish gray to black silty clay or clay, sometimes showing an adobe structure on drying. It is not so

micaceous as the soil of the lighter textured members of the Foster series. These heavy soils are not easily tilled under any moisture conditions and are practically untillable when a little too wet or when dry and compact. Gravel and similar coarse material is rare in these soils. A subsoil, lighter in color than the surface soil, is usually developed, occurring at any depth below a few inches.

Location.—The Foster loams and clay loams, dark-colored phase, are not very extensive. The San Jose Valley, in the northeastern part of the survey, contains several areas. Others occur northwest and north of Escondido, southeast of Bonsall, and elsewhere. Areas of the inextensive and unimportant heavier textured types occur just north of Escondido, south of Vista, and in some other parts of the area surveyed.

Topography and drainage.—The soils of this group are typically rather poorly drained. They occur in slightly depressed, basinlike positions sometimes associated with the obstruction of surface drainage by stream-built ridges. In other places they lie in minor valleys of low gradient. The surface is usually flat or very gently sloping, and the land has a high water table or is covered with standing water either permanently or intermittently. Alkali has accumulated in places.

Utilization.—Grazing is the only use of this land in the San Jose and San Felipe Valleys and in some of the smaller areas elsewhere. There is in general a heavy growth of forage plants in the moist situations here. In places the heavy-textured soils are used for grain and hay production, while in some situations they are too wet for cultivation. Drainage has been provided in places northwest of Escondido. The naturally better drained areas of the group and those artificially improved produce corn and alfalfa in addition to grain and hay.

YOLO GRAVELLY SANDY LOAM.

Description.—The Yolo gravelly sandy loam, which is indicated on the soil map by gravel symbol in the color used for the Yolo loams and sandy loams, consists of a light-brown or brown sandy loam carrying a high percentage of waterworn quartzose gravel particles. The soil is usually nonmicaceous. In some areas the type is comparatively free from gravel, but typically the gravel content is sufficient to render the soil much more leachy and less retentive of moisture. As a rule the gravel content increases with depth and over much of the type strata of gravel intermingled with a smaller proportion of the fine material make up the subsoil below the depth of a few inches. The gravel fragments are generally medium in size, rarely exceeding 3 or 4 inches in diameter.

Included in places with the Yolo gravelly sandy loam are local developments of sand, fine sandy loam or loam soil. These in places have a lower gravel content than the typical sandy loam and vary from that type in agricultural value.

Location.—The Yolo gravelly sandy loam occurs in numerous elongated bodies along streams traversing the coastal plain east of the vicinities of Del Mar, La Jolla, and San Diego, respectively. Some of these strips, as in the San Clemente and Carroll Canyons, continue inland for many miles, scarcely attaining a width of one-eighth mile at any point.

Topography and drainage.—The type occupies narrow alluvial strips along intermittent stream ways and is excessively drained during the greater part of the year, although small areas are subject to overflow during the seasons of greatest rainfall. The type lies slightly above the stream channels and extends with little variation in topography to the bordering bluff lines marking the ascent to the higher lying Redding, Las Flores or similarly situated soils. Numerous small alluvial fans have been deposited along the margin of the larger strips by ravines draining lateral territory. The material has been derived almost entirely from the bordering soils, and its gravel content has originated almost wholly as wash from the Redding gravelly loams and sandy loams.

Utilization.—Most of the type is utilized for pasture in connection with the adjacent Rough broken land or other soils which are likewise largely untilled. In some of the less gravelly areas of better water-holding capacity beans and corn give good yields, and where the conditions are most favorable alfalfa is grown. The location of the type in narrow strips within areas of even less valuable soils tends to retard its development, but the type itself is in general poorly adapted to dry farming.

YOLO LOAMS AND SANDY LOAMS.

Description.—The group mapped as the Yolo loams and sandy loams includes several of the lighter textured members of the series. Of these the loam is the most extensive, with the silt loam, sandy loam, and fine sandy loam of relatively small extent.

The Yolo loam consists of a light-brown or brown, friable non-micaceous loam, usually free from gravel. The color varies within short distances, sometimes being dark gray. When the soil is wet the grayish color becomes more pronounced, the type then resembles the Dublin loam. At some depth between 12 and 30 inches the soil grades into a lighter brown or more yellowish brown layer, which color continues to a depth of 6 feet or more. This subsoil is usually friable in structure. In places it resembles the surface soil in texture,

while elsewhere it is composed of stratified materials of various textures. In a few instances it is a clay loam and occasionally distinct gravelly strata occur, but these extremes are encountered only rarely. Both surface soil and subsoil are open and permeable.

The Yolo silt loam is similar to the loam type except in texture.

The Yolo sandy loam consists of a light-brown or light grayish brown, extremely friable, nonmicaceous sandy loam. Where the type is developed on alluvial fans the soil often extends to a depth of 6 feet or more with little change in texture, though it may become heavier with depth. In the small flat-bottomed valleys the soil in places contains coarser gravelly layers which materially decrease its water-holding capacity. Here, also, it may include gravel streaks, in which the soil resembles the Yolo gravelly sandy loam.

The Yolo fine sandy loam consists of a light-brown, very friable, nonmicaceous fine sandy loam, retentive of moisture. The surface material in places continues to a depth of 6 feet, but typically below a depth of about 24 inches there is developed a slightly lighter colored subsoil, composed of strata varying in texture. The type is most valuable where the entire profile to 6 feet consists of material at least as heavy in texture as the surface soil, while it is least desirable where porous, unretentive substrata are developed.

In the small body in the extreme northwestern corner of the area and the longer one fronting on the ocean southwest of San Onofre the soil material and the topography vary from typical. The numerous small alluvial fans giving rise to the Yolo soils here are extremely variable in character. The color on the average is darker brown or darker grayish brown than is typical of the group. Some of the individual fans are quite gravelly, containing angular or subangular stones, and in places the entire soil column consists of gravelly material with little assortment. In places the soil material overlies older, more compact and weathered terrace deposits within 6 feet of the surface, and it is difficult to distinguish this group of recent-alluvial soils from the older coastal-plain series.

Location.—The Yolo loams and sandy loams are inextensive. They occur in numerous small bodies or strips in the western part of the area from the northern to the southern boundary. The individual areas rarely cover as much as 1 square mile. The group is for the most part included within the belt occupied by soils of coastal-plain origin, but in the northern part of the area it is associated with small streams originating within areas of sedimentary rocks.

Topography and drainage.—Although the group is of recent-alluvial origin, it occupies three types of topography. Probably its most extensive occurrence is in the narrow, elongated valleys

of intermittent streams usually originating within areas of upland coastal-plain soils. It is here only slightly elevated above the parent streams and is separated from the uplands by rather distinct bluffs or steep slopes. The material is distinctly a recent flood-plain alluvium. Drainage is fair, although in places the land is subject to occasional overflow.

In the second type of topography these soils occur on minor alluvial fans, usually deposited by the short intermittent streams occupying ravines or gulches tributary to the larger valleys. Such drainage ways extending back into the coastal plain are sometimes flanked by small coalescing fans. In this manner the alluvial-bottom development and the rather steep alluvial-fan development of the group often merge, being shown on the map in a single soil body.

The third type of topography is illustrated in a small body in the northwestern corner of the area and in another southeast of San Onofre, where the group occupies narrow benches lying between mountainous surfaces and the beach. Numerous canyons and small washes have built up a succession of undulating minor fans which coalesce and slope toward the ocean through slightly flattened lower extremities, while steep bluffs 30 to 50 feet or more in height descend from the benchlike position of the group to sea level. The small stream channels are near the surface on the upper fans, but become more deeply entrenched with approach to the beach line. The material in the upper principal parts of the fans is distinctly of recent deposition, while the substratum and part of the surface material immediately adjacent to the ocean bluffs are undoubtedly rather old and has been modified somewhat by weathering.

Utilization.—Nearly all the land included in this group is tilled. It is used largely in the production of intensive crops, although grain hay and grain are locally the most extensive crops. Beans, of which heavy yields are usually obtained, are one of the principal crops. Sugar beets give good results. Corn and garden crops are produced to some extent. Some of the narrow strips of these soils, extending back into land of low agricultural value, are untilled and used for pasture. In general, the Yolo loams and sandy loams are considered valuable for many crops, and they are important soils, although inextensive.

YOLO CLAY LOAMS.

Description.—The Yolo clay loams group includes the silty clay loam and clay loam of the series, the former probably predominating.

The Yolo silty clay loam consists of a light-brown, medium-brown, or grayish-brown, rather friable, nonmicaceous silty clay loam, normally free from gravel. The material in a few places

extends to a depth of 6 feet without change in texture, but usually a lighter colored subsoil occurs at some depth between 12 and 36 inches. The subsoil is sometimes slightly lighter textured than the surface soil, but in certain places is a little more compact and heavier. It rarely contains gravelly strata, and is easily penetrated by roots. The material is retentive of moisture.

The Yolo clay loam does not vary consistently from the silty clay loam, except in its finer textures. The two types occur closely associated and merge without much change in surface features.

Occasionally the surface soils of these types are underlain by dark-colored subsoils, the group here probably originating from the washing of material over older, poorly drained deposits. In places the typical brown color of these soils gives way to darker shades, and it is sometimes difficult to separate them from the Dublin soils.

Location.—The Yolo clay loams are developed along some of the minor streams of the coastal-plain section. Some of the most important areas occur northeast and southeast of Del Mar and southeast of Carlsbad.

Topography and drainage.—These soils occupy small alluvial fans or stream bottoms of gentle gradient and relatively smooth surface. They often occur about the mouths of washes issuing from the upland plains into the larger stream valleys. Drainage is usually sufficient, except where the flatter areas encroach upon Tidal marsh or other low-lying areas.

Utilization.—Nearly all this land is dry farmed. Beans are an important crop on the areas near the coast and give heavy yields. Sugar beets, corn, and alfalfa are also grown, and grain and grain hay occupy a relatively large total acreage. While these soils are not extensive, they are important agriculturally.

DUBLIN SOILS (UNDIFFERENTIATED).

Description.—The Dublin soils (undifferentiated) include the clay loam, silty clay loam, loam, silt loam, clay loam adobe, and clay adobe of the series. The clay loam and silty clay loam members are the most extensive.

The Dublin clay loam consists of a dark-gray to black friable clay loam of nonmicaceous character. In the heavier, poorly drained areas it cracks somewhat upon drying, the structure approaching that of the Dublin clay loam adobe. Typically, the soil is easily pulverized, of good water-holding capacity, and apparently high in organic matter. It is usually free from gravel. At any depth from about 12 to 36 inches the material becomes lighter colored and passes into a brownish-gray to light-brown subsoil, usually somewhat simi-

lar to surface soil in texture but often variable. Grayish seams or small lime concretions are encountered in the subsoil in many places, and the greater part of the subsoil material is calcareous.

The Dublin silty clay loam consists of a friable silty clay loam with about the same range in depth as the clay loam member. It has a dark-gray to black surface soil, with a lighter colored and in many places calcareous subsoil.

The Dublin loam consists of a dark-gray to black or dark brownish gray, friable, nonmicaceous loam. At an average depth of about 18 inches the surface soil becomes lighter colored and grades into the brownish or grayish subsoil typical of the series. The subsoil may include strata of different textures. It averages lighter in texture than the subsoil of the heavier types, and gravelly beds are more common. The type has good water-holding capacity, though inferior to the clay loams in this respect.

The Dublin silt loam consists of a friable dark-gray to black silt loam, much like the loam except in texture.

The Dublin clay loam adobe and clay adobe are of small extent. The former typically consists of a dark-gray to black clay loam extending to any depth from 12 to 36 inches, grading into a brown, grayish-brown, or mottled subsoil, often of lighter texture than the surface material. In common with the other alluvial soils, the subsurface layers may be stratified, with the dark color of the surface soil occasionally recurring in the deeper layers. The type is normally free from gravel or stone and, considering its texture, is rather easily tilled under proper moisture conditions, although it is intractable when dry. In this state it cracks and assumes the typical adobe structure.

The Dublin clay adobe consists of a dark-gray to black clay, assuming a more pronounced adobe structure upon drying than is usual with the clay loam adobe. Unimportant variations in texture to a silty clay or sandy clay are not unusual. The surface soil in places extends to a depth of 6 feet or more, but a lighter colored brown or grayish-brown subsoil is usually developed above a depth of 36 inches.

The soil of both the adobe types seems rather high in organic matter and the subsoils are often calcareous and contain lime concretions or seams.

The typical dark-gray to black color of the group gives way occasionally to brownish patches which were necessarily included, these representing gradations into the associated Yolo soils. There are important variations from the typical subsoil conditions. In a few places these soils have been derived from recent alluvial-fan material which has encroached upon older deposits laid down by some of the principal streams. Elsewhere the typically rather fri-

able and permeable subsoil gives way to compact, less favorable strata, in places consisting of heavy clay layers and elsewhere of underlying remnants of older weathered and semicemented deposits. Gravelly, porous subsoils occasionally occur in all the types and sometimes decrease their value markedly.

Location.—The Dublin soils are not extensive. They occur in numerous small bodies or strips scattered through the western part of the area. Important bodies lie near Capistrano and between this place and Oceanside, all within a few miles of the coast. From Oceanside southeastward the group occurs in small areas, but it is of limited extent from the vicinity of Del Mar to San Diego. Southeast of San Diego there are several important areas, although they are not of large total extent. Like the Yolo series, this group is practically confined to the coastal plain and is associated with the small valleys and streams dissecting the upland areas. Three small areas of the adobe types occur near and south of Capistrano where the clay adobe member of the group predominates. Several other similar bodies occur along the streams traversing the coastal plain from Oceanside to the southern border of the area. The adobe soils usually occur in strips. They are most extensive east and southeast of Oceanside.

Topography and drainage.—The Dublin soils occupy two distinct, yet sometimes merging, types of topography. Along the margin of the larger valleys or along the ocean front they occur as small alluvial fans, usually deposited by local washes from the uplands. Minor fans, débris aprons, sometimes coalesce to form a continuous strip along the sides of the larger valleys. The surface here may be somewhat more sloping than is true in general of recent-alluvial deposits. It is gently undulating and well drained.

These soils also occur in small, flat-bottomed valleys. The drainage here may be somewhat restricted, and overflows occasionally occur in some of the lower lying situations around the inland extensions of some of the lagoons near the coast. Here the permanent water-table level is often within 3 or 4 feet of the surface, and there are local accumulations of alkali.

Utilization.—Nearly all the land is used for the production of intensive crops. The area near Capistrano supports some thriving walnut groves, orchards of various fruits, and fields of special crops, including beans. The areas to the northeast of Las Flores are for the most part used as pasture land in conjunction with the surrounding soils. Farther south and within a few miles of the coast, beans are a very important crop on these soils. Heavy yields are usually obtained. Southeast of San Diego the Dublin soils are intensively farmed to a wide variety of fruit and garden crops. Irrigation is desirable here, but much development has taken place under dry

farming. Grain and grain hay, produced without irrigation, are the principal crops on the adobe members of the group. With the exception of some of the poorly drained areas of heavy-textured soil the group is in general very valuable for the production of a wide range of crops.

Miscellaneous Material.

Rough broken land.

Description.—Rough broken land includes areas that are typically nonagricultural on account of unfavorable topography. Practically every area mapped, however, contains patches of tillable soil, and in places such patches constitute in the aggregate almost 50 per cent of the surface. The type is differentiated from Rough stony land largely on the basis that it is typically rather stone free.

Location and topography.—In the San Diego area the soil of Rough broken land has been derived from several classes of material, occupying different types of topography. The most extensive occurrence of the type is within the coastal plain from a point north of Oceanside to the international boundary, where it rather uniformly occupies the steep, broken slopes descending from the mesas and upland plains. The land is cut by the deeply entrenched valleys of some of the principal streams issuing from the mountains, and numerous deep ravines and steep-sided canyons give rise to extensions of the type. In some instances only irregular patches of smooth-surfaced soils are left on the intervening ridges. Rough broken land here shows a rather wide range in soil material.

For instance, ravine sides and abrupt slopes bordering the soils of the Redding series are likely to be covered by reddish, gravelly soils, while near developments of the Montezuma series the soil is usually dark gray to black. Throughout the coastal plain the soil covering is usually rather deep and unconsolidated, and many of the slopes, although they are steep, are unbroken and uniform, contrasting strongly with the stony and shallow Rough stony land.

The large area of Rough broken land east of Miramar consists of very sharply rolling ridges of remarkably uniform outline, where the soil has been derived from consolidated or semiconsolidated conglomerates. Unlike the ravine and valley-side development of the type, it here consists of a cluster of hills rising above all the surrounding land, except those areas occupied by igneous rocks.

There are some large bodies of Rough broken land in the northwestern part of the area which are for the most part mountainous in character. Some of the type here consists of rough and broken areas of the Diablo material. Larger areas include eroded surfaces underlain by loose-structured, sedimentary deposits, the type being rather arbitrarily separated on the east from Rough stony land.

Utilization.—Rough broken land is used largely for pasture. The rainfall is in general not sufficient for successful dry farming on the included tillable patches. Soils mapped separately elsewhere in the area, similar to those occurring in the smoother situations within this type, are farmed with only moderate success where they occur in larger, more uniform bodies, and it is probable that in their poorer, irregular developments within this type they will receive scant attention for an indefinite period. Plantings of eucalyptus have been made in places. The trees seem to thrive when fairly well started, and the growing of these or other trees may finally prove to be the best means of utilizing much of the Rough broken land area.

ROUGH STONY LAND.

Description.—Rough stony land is the most extensive type mapped, covering 50.5 per cent of the area surveyed, and the next most extensive type only 9 per cent. It is typically nonagricultural, owing both to its rough, steep, and mountainous topography and to its exceedingly stony, shallow character. The type includes the nonagricultural land over the exceedingly precipitous, mountainous region, with inclosed mountain basins and small valleys, that constitutes the greater part of the San Diego area. It consists of the main mountain ridges with their steep, brush-covered, rocky slopes. The included agricultural land occurs on rather stone free slopes and ridges and in mountain valleys and basins. Probably in 95 per cent of the type there is possibility of agriculture.

The soil material of Rough stony land is usually a sandy loam in texture, owing to the great predominance of granite in the mountain masses.

The depth to the underlying bedrock is extremely variable, sometimes being several feet even in the midst of abundant rock outcrop, while, on the other hand, whole mountain faces are often practically barren rock.

Utilization.—Much of the Rough stony land supports a heavy growth of brush. Drainage is excessive. The type is used for pasture and for the cutting of fuel and a small quantity of lumber.

TIDAL MARSH.

Description.—Tidal marsh includes a wide variety of sediments laid down at or near tide level and in most places subject to inundation by salt or brackish water. The soil varies according to the origin of the material and the conditions of deposition. Some of the areas adjacent to the coast are extremely sandy, similar in composition to Coastal beach and Dunesand. Elsewhere the soil has been deposited in more inland lagoons and may consist of heavy, plastic, clayey material, as in the Batiquitos Lagoon and the lower estuaries

or extensions of Buena Vista and Loma Alta Creeks. About the mouths of such streams as the Santa Margarita, San Luis Rey, and San Diego Rivers the texture is often that of a fine sandy loam or silt loam. The soil varies as much in color as in texture, ranging from light-brown sands along the coast to black clays in the lagoons. Distinct stratification occurs in some places, but typically there is little change in the material within the depth of 6 feet.

Location.—Tidal marsh occurs in numerous areas along the ocean front, from the vicinity of Oceanside southward to the international boundary. Part of the type lies in strips along the beach, usually separated from the ocean by a narrow ridge of Coastal beach and Dunesand. Still larger areas occupy the lower parts of small valleys as they approach tide level. Some of the more important developments occur around False Bay and San Diego Bay.

Topography and drainage.—The surface is uniformly flat and unbroken except by sloughs and estuaries and the winding channels of streams. The permanent level of the water table is usually within a few inches of the surface, and at times of high tide the surface is covered with water, though in places the land is not now inundated regularly, except to a small extent immediately along the sloughs. Such areas, though not typical, have been mapped as Tidal marsh rather than with the bordering more distinct recent-alluvial soils. Some of the areas of Tidal marsh have only an intermittent connection with the ocean, owing to the barriers of Coastal beach and Dunesand, and remain covered with water during the greater part of the year.

Utilization.—Tidal marsh in its natural state is typically nonagricultural. Nearly all the land carries marine salts in injurious quantities, and poor drainage and liability to inundation further tend to render it valueless. Progress has been made in the reclamation of this class of material in other parts of the State where it occurs more extensively, and it is possible that part of the land in this area will eventually be reclaimed and tilled.

COASTAL BEACH AND DUNESAND.

Description.—The group Coastal beach and Dunesand includes only the two miscellaneous types mentioned. These are composed of three rather distinct classes of material—a narrow strip bordering the ocean, rarely or never exceeding one-eighth mile in width and in places too narrow to map, consisting of wave-worked sand; beach material consisting of banks or slopes of well-rounded gravel, with little finer material; and sand dunes closely associated with the sandy beach and differing little in character of material.

Location.—The soils of this group are confined to the ocean shore, even the dunes in no place extending inland more than a few hundred

feet. The most striking development of the group is in the long, sandy bar that partly encircles San Diego Bay.

Topography and drainage.—The topography is typical of beach and dune areas in general.

Utilization.—This land is wholly nonagricultural, except for one or two small dunes on the bluff in the extreme northwestern corner of the area, which are used for growing grain hay and grain.

IRRIGATION.

Irrigation has not been extensively developed in the San Diego area, owing both to scarcity of available water and to the cost of constructing storage and distributing systems. The flow of the streams fluctuates greatly with wet and dry years, and any further extensive development of irrigation involves problems of storage.[1] Irrigation is carried on at the present time by means of storage, simple diversion from streams, and by pumping from streams or from an underground source. There are in the area several large reservoirs, supplying water for both irrigation and domestic use. Several such reservoirs are in the region east of San Diego, and sites have been selected for others.

The Upper Otay Reservoir, with a capacity of 3,300 acre-feet, is situated on a branch of Otay Creek. The Lower Otay Reservoir is on Otay Creek. It has a capacity of 39,900 acre-feet. The Morena Reservoir, with a capacity of 45,800 acre-feet, is situated near the eastern boundary of the area. The Barrett Reservoir has a capacity of 45,800 acre-feet. These reservoirs constitute a system designed principally to supply water for domestic purposes to the city of San Diego. In some instances the water is conducted to the reservoirs for a considerable distance by conduits.

Lands adjoining the Tia Juana River and Otay Creek are irrigated in part by the means of water pumped from streams or underground sources, and it is reported that water to irrigate about 1,500 acres is obtained by this means. The Sweetwater Reservoir, situated on the Sweetwater River east of San Diego, has a present capacity of 35,422 acre-feet. It is reported that about 4,750 acres are irrigated in the Sweetwater Valley and around Chulavista, nearly all the water coming from this reservoir, although a small proportion is pumped from underlying water-bearing strata.

About 7,200 acres are irrigated along the San Diego River, of which over 1,000 acres are in the Elcajon Valley and a similar acre-

[1] A complete discussion of the subject of irrigation is contained in the Report of the Conservation Commission of the State of California to the Governor and Legislature of California, (1912), under the chapter "Irrigation Resources of Southern California."

age in the Mission Valley and about 4,700 acres in the adjacent uplands.

The Cuyámaca Reservoir, in the eastern part of the area, stores water to supply land in the Elcajon Valley and around La Mesa and Lemongrove.

In addition to the irrigated acreage in the southern part of the area, about 5,000 acres are irrigated in that part north of the San Diego River. About one-fifth of this area lies in the Escondido Valley, the water being diverted from the San Luis Rey River and stored in the Escondido Reservoir, which has a capacity of 3,500 acre-feet. Over 2,000 acres are irrigated in the San Luis Rey Valley and over 1,000 acres in the San Pasqual Valley.

In addition to the larger acreages, there are many small irrigated tracts in the minor valleys of the area. Pumping is successful in many places along the stream bottoms, a good supply of water being found in the underlying strata in many places. Many other reservoir sites have been selected and rather definite plans for their development have been made in some instances.

DRAINAGE AND ALKALI.

Drainage conditions vary widely from place to place in the San Diego area. Drainage is excessive in most of the mountainous regions, sufficient on the mesas and lower uplands, and good on practically all the valley soils. Some of the mountain soils, however, are deeply weathered and absorb and retain moisture to such an extent that they can not be called excessively drained. The upland or mesa soils of moderate elevation in places have a "hog-wallow" surface and a compact subsoil, and are poorly drained and water-logged during the wettest periods. In neither of the foregoing cases, however, is drainage so inadequate as to cause permanent water-logging or alkali accumulations. On the recent-alluvial soils, where the drainage is in general good, the water table lies permanently near the surface in places, usually in the flat-bottomed valleys in the sections of low gradient near the coast. The lower San Luis Rey, San Dieguito, San Diego, and Sweetwater Valleys contain small areas of this character, where in addition to the high water table there are harmful accumulations of various soluble salts, popularly known as alkali.

Such alkali lands in the San Diego area are of small extent and relatively unimportant, although some otherwise very valuable soils are affected to such a degree as to be of low productiveness or, temporarily at least, of no value for cultivated crops. In the San Pasqual Valley and several similar inland valleys or basins there are small flats where high water level and alkali are unfavorable factors.

SUMMARY.

The reconnoissance soil survey of the San Diego area covers 3,182 square miles, or 2,036,480 acres, in the extreme southwestern corner of California.

The topography is predominantly mountainous, but a belt along the western margin of the area consists of an elevated, dissected coastal plain. This reaches elevations of five or six hundred feet above sea level where it breaks, rather abruptly, into the higher mountainous division. Barren exposures of granite and steep surfaces make much of the mountain land nonagricultural. Many peaks and ridges throughout the eastern two-thirds of the area rise 3,000 to 4,000 feet above sea level, and several others approach the highest elevation in the area, 6,515 feet.

Among the mountain ranges and situated at widely varying elevations are numerous flat-bottomed basins or small valleys, contrasting strongly with surrounding rocky upland. Many of the larger streams in the mountain section lie in deeply intrenched, narrow valleys.

Practically all the area is drained directly into the Pacific Ocean by a number of roughly parallel drainage systems which rise on the western slopes of the divide in the eastern part of the area. A few streams draining eastward into the Great Desert Basin of California rise within the northeastern part of the area.

The population of the area in 1910 was about 63,000, this number representing practically the entire population of San Diego County, with the addition of that of a very small part of Orange and Riverside Counties. The population is centered largely about San Diego Bay. San Diego is the largest city in the area. Coronado, National City, Escondido, and Oceanside are some of the other important towns.

The principal railroad line in the area follows the coast southward to San Diego. Branch lines extend inland from Oceanside to Fallbrook and Escondido and from San Diego to La Presa and Foster. A line now under construction from San Diego will give more direct communication to eastern points.

The climate of the San Diego area is mild and equable. The year is characterized by a wetter winter season and a drier summer season. The mean annual rainfall varies from less than 10 inches in certain places along the coast to over 35 inches in some of the elevated inland situations. Snow falls in some of the latter localities, but only locally and for short periods. In general, the temperature conditions are favorable for a wide range of crops, but the rainfall conditions are less favorable.

Parts of the area have been occupied and farmed for considerably more than a century. Development has been gradual, and in later years associated with irrigation. Grain and grain hay continue to be the leading crops, but intensively grown grapes, peaches, olives, citrus, and other fruits, as well as beans, alfalfa, and other field crops, are important locally.

The soils of the area are grouped in three main classes, depending upon the soil-forming materials and the processes by which they have been derived, viz, residual, coastal-plain and old valley-filling soils, and recent-alluvial soils.

The residual soils have been derived in place through the disintegration and weathering of consolidated rocks. They occur almost entirely in the mountainous parts of the area.

The coastal-plain and old valley-filling soils have been derived through the weathering and modification of old unconsolidated water-laid deposits, and are associated with the coastal-plain division of the area or with the high terraces and older and often elevated valley floors which sometimes border the streams or valleys.

The recent-alluvial soils consist of material laid down by comparatively recent stream activities and occur on alluvial fans, in inclosed mountain flats, or as bottom land in the floors of valleys. They have not undergone the aging processes that have modified the old valley-filling soils, and as a consequence are usually friable and uniform to a depth of 6 feet or more, or have irregularly stratified subsoils.

Owing to the prevailingly mountainous character of the area the soils of the residual group are the most extensive, but their elevated position and the difficulty of supplying irrigation water lowers their value for the production of intensive crops. The residual soils are classed in six series. The Sierra series of red soils, the Holland series of brown soils, and the Siskiyou series of gray soils have been derived from coarsely crystalline granites and gneisses; the Aiken series of red soils and the Olympic series of brown soils have originated from igneous rocks of finely crystalline basic or quartz-free character; and the Diablo series of dark-gray to black soils from sedimentary rocks.

The coastal-plain and old valley-filling soils are most extensively developed in the western part of the area, but smaller bodies occur in the stream valleys and mountain basins. They are classed in seven series, the Montezuma and Las Flores series comprising gray to black soils, the Redding, Kimball, San Joaquin, and Placentia series consisting of reddish-brown to red soils, and the Ramona series including brown soils.

The recent-alluvial soils are of smaller relative extent than in other parts of the State. Owing to their retentive, deep nature these soils are better suited to intensive farming than are most of the

upland types. They are classed in five series, the Hanford, Tujunga, and Foster soils having been derived from granitic material, and the Yolo and Dublin soils from sedimentary rock formations or unconsolidated deposits in the upland.

Irrigation has not been extensively developed and a scarcity of water will probably hinder the full development of irrigation indefinitely. Storage of flood waters, diversion of stream flow during the wetter season of the year, and pumping all are utilized to supply water.

Drainage is excessive in most of the mountainous regions, sufficient on the table lands and lower uplands, and good in practically all the valley areas. Some of the moderately elevated upland soils have a "hog-wallow" surface and compact subsoils, and are waterlogged during part of the year. Some of the recent-alluvial soils have a permanently high water table, especially in the valleys near the coast, and include relatively unimportant areas of alkali land.

[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

Areas surveyed in California.

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