Series 1930 Number 15

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
The El Cajon Area, California

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and
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United States Department of Agriculture

Bureau of Chemistry and Soils

In cooperation with the
University of California Agricultural Experiment Station

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SOIL SURVEY OF THE EL CAJON AREA, CALIFORNIA

By R. EARL STORIE, University of California, In Charge, and E. J. CARPENTER, United States Department of Agriculture

AREA SURVEYED

The El Cajon area is in San Diego County, in the extreme southwestern part of California, with the Pacific Ocean on the west and the Mexican State of Baja California on the south (fig. 1). The city of San Diego and San Diego Bay are within the area. Los Angeles is distant about 125 miles to the northwest. The area, which includes 605 square miles, or 387,200 acres, is roughly square in outline. On the north it joins with the Oceanside area (*8*),[1] following the north line of T. 15 S. The eastern boundary is formed by a north-south line, about 1 mile east of Alpine. The San Ysidro Mountains, which border the area on the southeast in the vicinity of Otay Mesa, are not included in the survey. The area covered by the present survey is also included in the earlier more extensive and less detailed reconnaissance soil survey of the San Diego region, California (*5*).

FIGURE 1.—Sketch map showing location of the El Cajon area, California.

The part of San Diego County described in this report consists of a mountainous highland district and a coastal-plain district of flat-topped seacoast terraces, locally known as mesas (*3*). The average width of the coastal plain in this area is about 11 miles, and there is a sudden change to the rough rugged topography of the mountainous district. The coastal plain is dissected by stream channels, some of which extend from the mountainous area to the coast, and a few extend a short distance back from the ocean and drain only the mesas. The El Cajon Valley, which lies between the coastal plain and mountains as a boxlike basin, is the only large valley in the area. It ranges in elevation from 350 to 500 feet above sea level.

The coast line north of San Diego Bay is bordered by cliffs ranging in elevation from 40 to 100 feet above sea level. San Diego Bay is separated from the ocean by a narrow sand spit about 10 miles long, extending from North Island to the mouth of Tia Juana River. Tia Juana Valley is cut off from the sea by a narrow stretch of dune sand. The sand spit extending south from North Island ranges from 10 to 15 feet above sea level. Point Loma is a peninsular promontory forming the northwestern boundary of San Diego Bay. This peninsula is about 7 miles long, from north to south, and the width ranges from one half mile on the south to 3 miles on the north. Its greatest elevation is about 400 feet. At one time San Diego River

[1] Italic numbers in parentheses refer to Literature Cited, p. 42.

168082—34——1

flowed into San Diego Bay, cutting off Point Loma from the mainland, but the channel was changed by man, and the river now flows into Mission Bay which is a shallow bay having an area of about 8 square miles. The entrance to Mission Bay is nearly closed by Medanos Point, a sand bar extending southward from the north shore. The water in the channel is only about 4 feet deep and in most of the bay averages less than 2 feet at low tide, as the silting-up process has progressed very rapidly since San Diego River has been flowing into it.

San Diego, Sweetwater, Tia Juana, and Otay Rivers drain most of the area. Sweetwater and Otay Rivers empty into San Diego Bay, and Tia Juana River flows into the Pacific Ocean between San Diego Bay and the international boundary separating the United States and Mexico. Tia Juana River enters the United States from Mexico at Tia Juana and does not drain much land in this area. Run-off from these streams is checked by storage reservoirs. The streams in Soledad, Rose, and San Clemente Canyons drain only the coastal plain. Narrow strips of agricultural land extend from the coast up all the major stream valleys.

The coastal plain has an elevation ranging from a few feet above sea level to approximately 600 feet at the base of the highland area. Lindavista Mesa has an elevation of approximately 400 feet. In the region above San Diego Bay there are five terraces, as viewed from the south. These lie at elevations of about 20, 50, 100, 250, and 500 feet, respectively, above sea level and have been considerably modified by erosion. Poway Mesa, in the northern part of the area east of Miramar, represents the eroded remnants of an old mesa sloping from about 1,200 feet on the east to about 900 feet on the west. The crests of ridges on this mesa are very narrow, and the canyons are close together.

The highland part of the area extends from the highest terraces to the eastern boundary. It is an area of rough relief, with steep mountain walls covered with large granitic boulders. Much of it is mapped as rough stony land, and the Vista and Fallbrook soils are mapped on the less stony and less steep slopes. Elevations range from 500 to more than 3,700 feet above sea level. Lyons Peak, in the eastern part of the area, has an elevation of 3,755 feet, and San Miguel Mountain, which is east of Sweetwater Reservoir, has an elevation of 2,573 feet.

The first settlement in California was made along San Diego Bay. Juan Rodriquez Cabrillo discovered the bay in September 1542 when a party went on shore looking for water (7). Viscaino appeared off San Diego Bay in November 1602 and gave the bay its name. Many Indians were reported living along the bay at that time. The first Spanish settlement was not made until the summer of 1769, when Old Town was established on the south bank of San Diego River. The Spanish soldiers built a fort on Presidio Hill overlooking Old Town and the valley of San Diego River, and the first mission in California was dedicated by Father Junipero Serra on July 16, 1769. From 1821 to 1846 the territory was under Mexican rule.

San Diego County was created in 1850, soon after California was taken over by the United States. The increase in population from this date to 1885 was slow, but during the boom days of 1886–89 most of the present towns were laid out. A large part of this devel-

opment was owing to the completion of the Atchison, Topeka & Santa Fe Railway in 1885. The increase in population bordering the bay and in the El Cajon Valley has been large during the last 10 years. The census of 1920 gives the population of San Diego as 74,361, National City 3,116, Chula Vista 1,718, Coronado 3,289, La Mesa 1,004, East San Diego 4,148, and El Cajon 469. Figures for 1930 give the population of San Diego as 147,995, National City 7,301, Chula Vista 3,869, Coronado 5,425, La Mesa 2,513, and El Cajon 1,050.

The population is largely urban. Many small farms are located within the corporate limits of cities. No census figures are available giving the distribution of population of the area, as it includes only a part of San Diego County, but it can safely be estimated that more than 95 percent would be classed as urban.

Transportation facilities are good. The Atchison, Topeka & Santa Fe Railway has its western terminus in San Diego, via Los Angeles. The San Diego & Arizona Railway also gives rail transportation to the east through El Centro, Calif., and Yuma, Ariz. A branch of this line extends from San Diego east through La Mesa, El Cajon, and Lakeside. Paved highways extend throughout most of the developed districts, and the rest of the area is served by good dirt roads.

A large proportion of truck, dairy products, and small fruits is marketed locally in San Diego. The citrus products are marketed on the coast or in eastern markets. A small percentage of the grapes is used locally, but the greater part is shipped in refrigerator cars to eastern markets. Field crops, such as alfalfa and barley, are used locally for feed.

CLIMATE

The climate of the El Cajon area is characterized by a lack of extremes in temperature and by a dry atmosphere, which attract many health seekers and tourists. About 75 percent of the rainfall comes during the months of December, January, February, and March. The amount of rainfall increases gradually with the increase in elevation toward the east. Records along the coast show an annual rainfall ranging from 9 to 13 inches. The amount increases to about 17 inches in the extreme eastern part of the area at an elevation of 2,000 feet. There is a wide range in precipitation between the wettest and driest years. Three or four dry years may succeed each other, causing a shortage of moisture for plants and little run-off for supplying wells and storage reservoirs. The reservoirs and river gravels receive their supply of water from the watershed of the back country, where the rainfall is much greater than that in the El Cajon area. Cuyamaca, at an elevation of 4,677 feet and 18 miles northeast of Alpine, has a mean annual rainfall of 39.87 inches.

Considerable run-off occurred and some damage was caused by the torrential rains of 1905, 1909, and 1916, which occurred in late winter and early spring. With scanty vegetative cover, run-off is rapid at such times, causing much erosion on the slopes and filling the narrow valleys with coarse sandy material.

The district immediately bordering the coast has an oceanic climate which is temperate, and the seasonal and daily range of temperature are slight, probably less than anywhere else in the United States. A temperature above 90° F. very seldom occurs, and a temperature of 32° or less is a rarity. The valleys back from the

coast and the higher-lying areas show a much greater range in monthly and daily temperature.

The occurrence of frost differs in different parts of the area, depending on the local topographic position, exposure to coast breezes, and general air drainage. Killing frosts rarely occur in the territory immediately bordering the coast, hence vegetables and other crops may be grown in this locality during the winter. The Weather Bureau station at El Cajon is located in the center of an inland valley. The average date of the first killing frost at this station is November 27, and the average date of the last is February 23. Certain slopes having good air drainage are not subject to killing frost, but frost often occurs a short distance away in depressions and valleys. For this reason, citrus fruits are usually planted on land having a sloping surface. Orchard heaters are used on the flatter and colder spots.

Winter and spring crops, such as barley and wheat, are grown without irrigation, but all summer crops are irrigated, as very little or no rain occurs during this time of the year. The annual rainfall is also low for crop growth along the coast, and it may be safely stated that moisture is the limiting factor in crop development in this area. Water for irrigation is both expensive and scarce. Grapes and olives in the El Cajon Valley and the intermountain valleys are grown without irrigation. All citrus fruits and avocados are irrigated.

After the winter rains a cover of grass springs up, which dries up during the summer. This has a marked effect on the organic content of the soils, which ranges from fair to low. A few scattered live oaks grow in the canyons of the highland district. The natural vegetation of the coastal plain is predominantly chamiso and winter grasses.

Tables 1, 2, and 3 give the more important climatic data as recorded at the Weather Bureau stations at San Diego, El Cajon, and Cuyamaca.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at San Diego, San Diego County, Calif.*

[Elevation, 87 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1863)	Total amount for the wettest year (1884)
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*
December	56.0	84	32	1.87	0.04	5.12
January	54.3	83	25	2.06	.32	1.34
February	55.1	85	34	2.03	1.09	9.05
Winter	55.1	85	25	5.96	1.45	15.51
March	56.7	99	36	1.72	.33	6.23
April	58.5	96	39	.77	.13	2.84
May	60.8	98	45	.35	.02	2.17
Spring	58.7	99	36	2.84	.48	11.24
June	63.9	94	50	.05	.00	.31
July	66.2	93	54	.03	.00	.00
August	68.7	93	54	.04	.00	(1)
Summer	66.3	94	50	.12	.00	.31
September	67.1	110	50	.08	.36	.07
October	63.7	96	44	.54	.00	.35
November	59.7	93	36	.76	.73	.11
Fall	63.5	110	36	1.38	1.09	.53
Year	61.0	110	25	10.30	3.02	27.59

[1] Trace.

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at El Cajon, San Diego County, Calif.*

[Elevation, 560 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1903)	Total amount for the wettest year (1927)
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*
December	53.4	92	23	1.97	0.10	3.11
January	52.4	88	19	3.24	.84	.45
February	53.8	89	25	2.57	2.97	12.78
Winter	53.2	92	19	7.78	3.91	16.34
March	56.2	96	29	2.58	1.33	2.74
April	59.2	102	31	.84	1.29	1.42
May	62.2	106	34	.55	.14	.59
Spring	59.2	106	29	3.97	2.76	4.75
June	67.8	113	41	.08	(1)	.14
July	73.0	107	45	.08	0	(1)
August	73.6	108	45	.10	0	(1)
Summer	71.5	113	41	.26	0	.14
September	71.0	110	37	.15	(1)	0
October	64.8	107	33	.57	.20	3.08
November	58.8	98	25	1.19	0	.24
Fall	64.9	110	25	1.91	.20	3.32
Year	62.2	113	19	13.92	6.87	24.55

[1] Trace.

TABLE 3.—*Normal monthly, seasonal, and annual temperature and precipitation at Cuyamaca, San Diego County, Calif.*

[Elevation, 4,677 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1905)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	38.8	60	5	5.93	12.80	2.78	2.7
January	38.1	68	2	6.97	2.05	9.87	7.4
February	40.6	68	−1	7.76	2.05	15.91	13.0
Winter	39.1	68	−1	20.66	16.90	28.56	23.1
March	42.5	75	11	7.40	0	15.63	9.9
April	47.1	81	20	3.01	0	3.64	2.1
May	52.2	96	22	1.92	1.00	7.11	.2
Spring	47.2	96	11	12.33	1.00	26.38	12.2
June	62.6	97	29	.32	.50	0	0
July	68.9	96	38	.42	0	0	0
August	67.9	97	29	.67	.50	(1)	0
Summer	66.4	97	29	1.41	1.00	(1)	0
September	61.8	95	20	.56	.30	1.01	0
October	52.4	88	23	1.93	0	(1)	0
November	44.9	75	13	2.98	0	10.15	2.1
Fall	53.0	95	13	5.47	.30	11.16	2.1
Year	51.4	97	−1	39.87	19.20	66.10	37.4

[1] Trace.

AGRICULTURE

The agricultural history of the El Cajon area began with the founding of the San Diego Mission in 1769.[2] An early chronicler of the missions states:

> There were Indian towns whose people lived on grass, seeds, deer, fish, and rabbits * * * the Indians were at war with one another and the inland ones being barred out from the sea with its fish resources were often in a state of famine.

The final location of the San Diego Mission, 6 miles up San Diego River from the presidio, owed its selection to the agricultural advantages of the site. Padre Jaume, it is recorded, favored this site on account of its agricultural advantages, although Father Junipero Serra, the founder, opposed it and desired that the mission remain at the presidio site. Controversies between the military-minded authorities of the presidio and the agricultural-minded clergy of the mission have continued even to the present day, the presidio having become the city of San Diego, and the old mission lands having come into possession of the agriculturists. The ownership of the waters of San Diego River has led to bitter controversies between agriculturists and the city of San Diego and probably will finally be settled only by the highest courts. The agricultural development of that part of the area lying directly east of San Diego has been due to the agricultural use of the water of San Diego River, and it is inconceivable that these improved lands will ever be deprived of their water supply.

The first impounding dam for irrigation purposes in California was constructed under the supervision of the mission fathers about 1810. The dam was located in San Diego River a few miles up from San Diego Mission, and the waters were brought down to the valley lands near the mission in a carefully constructed tile and masonry conduit. Remains of the dams (two were built, about a mile apart) and the conduit can still be seen in the so-called "Mission Gorge" of San Diego River. The crops of this period were largely grain, including wheat, barley, and oats; vegetables, such as beans and lentils; a few fruits, including olives, figs, and grapes; and some livestock was raised.

The century following the founding of the mission was one of military, civil, and economic instability, and civic and agricultural development progressed slowly. In 1870, the population of San Diego County was 4,951, of which one half was in the city. The total value of all kinds of property in the county was $1,722,851, two thirds of which was in the city. There were 1,790 houses in the county, of which 915, or more than one half, were in the city. The statistics of production of that period showed the number of fruit trees in the county to be 223; the total number of grapevines, 1,487; the number of acres planted to grain, including wheat, barley, and corn, 3,126.

The county was at that time much larger than at present; but most of the development had taken place around the established missions. With this small agricultural development and no other resources, it is not surprising that the city went through a series of depressions and reverses. In 1873, the population of San Diego declined to 2,500 and National City to a few score, and the streets of both towns were almost deserted.

The development of the city of San Diego (*9*) and the agriculture of the area have been very closely related. The first real development of the city was in 1881, when directors of the Atchison, Topeka

[2] Prepared in large part by J. G. France, specialist in agricultural extension, University of California, and farm advisor, San Diego County.

& Santa Fe Railway were induced to build a railroad to San Diego, the inducement being the granting of 10,000 acres of the best agricultural land of the Rancho de la Nacion, lying east of San Diego Bay, and several thousand additional acres. This railroad, known as the California Southern, was built from National City to Colton, via Fallbrook and Temecula, and was completed in 1882. The population of National City increased to 1,000 and San Diego gained about 15,000 inhabitants. However, prosperity did not come at once. The California Southern had no eastern connection, and travel and traffic did not develop. The season of 1882–83 was a dry one, and unirrigated crops failed. National City lost half its population and San Diego more than its previous increase. In 1884, floods washed out the roadbed in Santa Margarita and Temecula Canyons, through which the California Southern was built, and nearly a year was consumed in making repairs. In 1885, work was started to extend the line to Barstow to connect with the eastern transcontinental line, causing San Diego to become the western terminus of the Santa Fe system. This line has since been partly abandoned and is superseded by the Santa Fe coast line of later construction. Almost coincident with the completion of the railroad came the development of the San Diego Flume Co. in the San Diego River watershed and the building of Sweetwater Dam providing water sufficient to irrigate from 15,000 to 20,000 acres of land. With this promise the population of San Diego increased from 5,000 in 1885 to 30,000 in 1887. A corresponding agricultural development took place, but vine and tree fruits could not be brought into production quickly enough to support such rapid development, and a period of depression followed the boom period.

Much of the best land was held in old Spanish land grants, and this delayed agricultural development somewhat. The El Cajon ranch including 57,000 acres, and the Rancho de la Nacion, including 27,000 acres, were the first of the grants to be broken up and opened for settlement. A few of the smaller grants are still held practically intact.

The early agricultural crops were principally grain and grain hay. Barley, wheat, and hay appear prominently in the list of exports for the year 1889. Olives and grapes were the fruits most extensively planted before and about the time that irrigation water was made available. Nurserymen report from 30,000 to 40,000 olive trees to have been planted during 1889. In 1890 it was reported that the principal feature of the El Cajon Valley was the raisin industry. There were 3,087 acres planted to the Muscat or raisin grape. It is reported that 50,000 boxes of raisins were shipped in 1888, 90,000 in 1889, and 108,000 in 1890. A great increase in acreage of various crops was reported for the closing years of the eighties, as shown in table 4. Although in 1888 only 27,461 acres of land were under cultivation, in 1889 the area had increased to 62,524 acres.

TABLE 4.—*Acreage of principal crops grown in San Diego County, Calif., in 1888 and 1889*

Crop	1888	1889	Crop	1888	1889
	Acres	*Acres*		*Acres*	*Acres*
Wheat	6,093	14,026	Hay	10,090	9,523
Oats	520	1,550			
Barley	6,496	30,447		*Number*	*Number*
Corn	481	2,084	Grapevines	3,781	4,994
			Fruit trees	191,526	380,176

Much experimenting was done with agricultural crops in the area about this time. One of the early horticulturists is reported to have taken—

a large fruit catalogue and ordered from it every variety of fruit and ornamental tree and shrub, that he might prove what is best adapted to the locality, as well as the most beautiful.

Among the crops tried at this time were the

orange, lemon, grape, lime, citron, guava, apple, apricot, pear, peach, prune, plum, persimmon, pomegranate, quince, fig, olive, English walnut, almond, pecan, mulberry, and in small fruits, the strawberry, raspberry, and blackberry.

Although all these crops are still being grown, only a few of them have developed commercial importance.

In 1929, $431,126 were expended in San Diego County[3] for fertilizer (including commercial fertilizer, manure, and lime), an average of $357.78 a farm for the 1,205 farms reporting. Nearly all the fertilizer is used for potatoes, flowering plants, truck crops, and citrus fruits and is bought ready mixed.

According to the 1930 census, owners operate 82.2 percent of the farms of the county, tenants 10.8 percent, and managers, 7 percent. Land devoted to grain hay and dry-farmed crops is usually rented on a share basis, the owner ordinarily receiving about one fifth of the crop. Irrigated land is usually rented for cash.

The farm laborers are largely Mexicans. They are paid about $3 a day and board themselves. Tractor operators and other special laborers are supplied locally.

The larger farms are well supplied with power machinery, but many of the smaller farms, especially the nonirrigated tracts of intermediate size, are not so well equipped with machinery and buildings. Most of the farm buildings are of light construction and in the more prosperous irrigated districts are, as a rule, very good.

Dairying and poultry raising are the only important livestock industries. The production of beef cattle and sheep has been practically discontinued, and a more intensive type of agriculture has taken its place. Few hogs are raised, feeder pigs being shipped in from outside the county. They are fattened on garbage from the cities.

Dairying is an important industry in the river valleys, and it is very highly specialized. Some dairymen buy all their feed, a few grow all their hay and silage, but none attempt to produce all the necessary feed. The milk produced is all sold as fresh milk. With the exception of ice cream, no dairy products are manufactured. Dairy cattle are largely high-grade Holstein-Friesians, with some Guernseys and Jerseys. Only a few purebred herds are kept.

Poultry raising is the most extensive and important of the livestock industries and, like the dairy industry, is highly specialized. Poultry ranches are scattered throughout the area, Chula Vista, La Mesa, and El Cajon all being important centers. The size of the flocks ranges from a few hundred to several thousand birds, the average flock consisting of about a thousand birds. The White Leghorn breed predominates, and many poultrymen raise Rhode Island Reds. Many poultrymen have fine breeding flocks, and the quality of the birds is in general high. A number of large hatcheries supply the commercial egg producer with his replacement stock each year. The poultry industry has had a sound development and is capable of some expansion.

[3] Figures are not available for the amount used within the area included in this survey.

The agriculture of this area is highly specialized, as no general farming and little diversification is practiced. Although practically all crops are grown, only a few are of commercial importance. The principal export crops are oranges, lemons, avocados, grapes, winter-grown vegetables (including celery, cauliflower, tomatoes, potatoes, peppers, and squash), summer vegetables (including string beans and Lima beans), and bulbs (including freezias, gladioluses, narcissuses, ranunculas, and anemones). Most of the export crops can be profitably increased as additional irrigation water is made available.

Agricultural imports include canned and dried products of all kinds, apples, peaches, pears, potatoes, cantaloupes, butter, cheese, grain, and alfalfa hay. Few, if any, of these imports could profitably be produced in the El Cajon area.

With specialized crops, such as citrus fruits, avocados, bulbs, and winter vegetables, climate is a very important factor. These crops can only be grown in frost-free or comparatively frost-free districts, and this factor, together with the water supply, is usually considered first. In fact, in many places in the area such crops are grown on rather poor soils, the reasons being that a water supply is available and that the location is comparatively frost free. Local subdivision activities have also caused small tracts to be brought under cultivation, where a number of different crops may be grown irrespective of soil conditions or adaptation to these particular crops.

Citrus fruits are of first importance among the fruit crops. The acreage devoted to them has increased as water has been made available for irrigation. Lemons are of greatest importance, considered both in regard to acreage and value, being grown on about 2,135 acres,[4] located largely at Chula Vista, Lemongrove, and El Cajon. Some of the oldest lemon plantings in the State are located at Chula Vista, but some of these are being removed to make way for other crops and for residential development. Lemons are grown on a large number of different soils, a frost-free location being the determining factor.

Valencia oranges are second in importance among citrus fruits, being grown on 737 acres, and navel oranges rank third, on 571 acres. Most of the orange acreage is confined to the district surrounding El Cajon Valley, including the Grossmont, Lakeside, and Bostonia districts. Orchard heating in citrus orchards is used on the lower more frosty slopes. The orange acreage is increasing somewhat in the vicinity of El Cajon Valley.

The development of the avocado has been phenomenal in the last 5 years. Early plantings were made at El Cajon, Chula Vista, and Point Loma, the first commercial planting being made about 1913. In 1925, about 20 acres were in avocado trees and in 1930 about 1,700 acres, with indications of a further increase. The extension of this industry in the El Cajon area has been largely caused by the promotional activity of various real-estate organizations, and it is economically unsound considered agriculturally, owing to high land and water costs, together with the small size of the units that have been sold. The climatic conditions over much of the area seem well suited to the production of this crop, but the trees are extremely sensitive to poor drainage.

[4] Statement by J. G. France, county farm advisor.

A large number of varieties of avocados are grown along the coast, many of them still experimentally. The Fuerte is the most popular variety, and the Dickinson, Anaheim, and Puebla are also popular.

The El Cajon Valley was at one time one of the important grape districts of San Diego County, and the acreage slowly increased until 1923, since which time it has slowly decreased. In recent years a shift has taken place from raisin to table and juice grapes. The Muscat grape, which is the leading variety, fortunately can be used for raisin, table, or juice purposes. Sultanina (Thompson Seedless), Flame Tokay, and Verdal, are other varieties of some importance. The Emperor, although extensively planted about 1921, has never proved well adapted to the area. The Red Muscat and Castiza (Maraville de Malaga) show promise as new table-grape varieties.

The growing of winter truck crops is an important industry, especially along the coast, where winter crops are not damaged by frosts and where they mature at a time when prices are good. Celery, cauliflower, tomatoes, cabbage, and potatoes are the leading vegetables grown for shipping. The celery industry is centered around Chula Vista, tomatoes are grown mainly around La Mesa, and potatoes near El Cajon.

Celery was reported grown on 650 acres in 1929 in the Chula Vista district. Yields ranging from 300 to 400 crates an acre are obtained. Celery is an irrigated crop and very costly to grow as it requires a great deal of hand labor. Tomatoes are usually grown on the heavier-textured soils. As a general rule the fields are small and scattered. A large number of small truck farms are scattered throughout the area, from which fresh vegetables are furnished the city throughout the year.

Blackberries, Logan blackberries, and Young dewberries do well in this area, even on the poorer soils, and are of some commercial importance. Strawberries do not seem to be well adapted. They do somewhat better on the granitic soils than in the coastal-plain area.

Bulbs are becoming an important commercial crop in the area around Chula Vista. Gladioluses are the leading crop, with some narcissuses, Chinese lilies, ranunculas, and anemones.

The Mission olive was introduced at an early date in the El Cajon area, but the acreage is now decreasing. Olives from a number of small improperly cared for groves are harvested, the groves are unirrigated, and they are scattered over the area.

This area is not well adapted to the production of many deciduous fruits, on account of the warm winter climate which does not allow sufficient winter dormancy for the trees. Peaches and plums are about the only deciduous-tree fruits of commercial importance, and the peach acreage is decreasing. A small acreage of Japanese persimmons is developing in the El Cajon Valley, and one commercial planting of Chinese jujubes is near Lemongrove.

Most of the grain is cut for hay. Barley is the leading grain crop, wheat and oats being of minor importance, as are also grain sorghums and corn. Corn is grown to some extent for silage on stream-bottom land.

Alfalfa is grown on land near stream beds, where water may be pumped cheaply.

Owing to the extremely specialized type of agriculture, very little attempt is made by the farmers to follow any system of crop rotation.

Fields devoted to truck crops are often put in peas or lettuce in the fall. After the winter crops are off the ground in the spring, the land can be prepared for the less hardy, "summer," crops, such as beans, tomatoes, peppers, and other truck crops. This practice is followed by many small farmers who must make the soil produce throughout the entire year. Lima beans are often planted as a summer crop. They are grown extensively east of Chula Vista and on the Otay Mesa. They are planted between April 15 and May 15 and are harvested in late summer or early fall. Yields range from six to twelve 2-bushel sacks an acre, with irrigated plantings on good soil yielding heavier.

Avocados are usually set out on comparatively frost-free locations where there is little danger of frost damage (*4*). Lemons and avocados are not so hardy as oranges, and care must be used in the location of plantings of these fruits. About 70 avocado trees are set out to the acre. They are usually planted on the contour, and some of the groves on steep slopes are terraced in order to facilitate irrigation and prevent erosion.

Cultural methods in avocado and citrus orchards are similar. Small avocado trees are usually protected by some type of wind shelter, such as burlap sacks or a lath screen. Avocado and citrus trees are irrigated mainly by means of basins or furrows. A few orchardists use the overhead sprinkling system which is common in the Carlsbad district in northern San Diego County. Experiments carried on in 1926 and 1927 in the Escondido, Fallbrook, and Vista districts (*2*) on citrus and avocado groves show a seasonal use ranging from 8 to 20 inches of irrigation water an acre. The lower figures represent the amount of water used on the younger groves. The investigators estimate that the irrigation requirement of mature groves, with 100 percent of the soil mass moistened at each irrigation, would range from 16 to 27 acre-inches a year. Using the present irrigation practice, the seasonal requirement was estimated to range from 10.5 to 18.5 inches an acre. These investigations were conducted on Fallbrook sandy loam and Vista sandy loam soils. From 3 to 6 irrigations are given at intervals ranging from 30 to 45 days, and winter irrigations are required in years of low rainfall. Barnyard manure is the most common soil enrichment used, and winter cover crops are used to some extent. Bean straw is utilized by some growers, and nitrogenous commercial fertilizers are in use on many citrus groves.

Potatoes are usually planted in the fall or early winter on a sandy soil, and they are harvested in March and April. These early potatoes are grown in frost-free locations and are shipped as new potatoes in lug boxes at a time when prices are good.

The acreage of tomatoes varies considerably from year to year. The early crop is planted in May and harvested in July, and later plantings are harvested from October to January.

Land utilized for truck crops is fertilized heavily, either with barnyard manure or mixed commercial fertilizer. For potatoes, commercial fertilizer, consisting of 4-8-4,[5] 8-8-4, or 7-12-6 mixtures, is usually applied at the time of planting.

The acreage devoted to grain crops is decreasing each year. These crops are planted from December to February so as to benefit from the winter rains. A small acreage of grain land is summer fallowed.

[5] Percentages, respectively, of nitrogen, phosphoric acid, and potash.

In a year of good rainfall the grain acreage is large, and in a season deficient in rainfall it is very low. Yields of grain vary according to the amount of moisture available for growth. Varieties of wheat include Defiance and Escondido, and Golden Mariout is the principal variety of barley.

Alfalfa is cut from 4 to 7 times a season and yields from 5 to 8 tons an acre on the deep soils of the river bottoms. Dairy cattle are pastured on much of the alfalfa land. A large quantity of water is used for alfalfa, as much of the land is very sandy and must be irrigated once or twice a month during the growing season. Water is supplied by wells located near the river channels where the lift is not excessive, and field distribution is made by means of border checks.

SOILS AND CROPS

In many cultivated areas of the El Cajon area no correlation seems to exist between the type of agriculture practiced and the soil type. The availability of irrigation water and frost conditions more often determine the crop that shall be grown than does the character of the soil, although, where conditions are favorable to the production of a diversity of crops, preference is given the crop best adapted to a certain soil type. The agriculture of this area is limited by the water supply and its distribution.

Approximately 20 percent of the land is under cultivation. The acreage was larger when prices of grain and grain hay were higher. More than 60 per cent of the area is too rough or stony for agricultural purposes, and such land has been classed as rough stony and rough broken land.

Soils that are shallow, poorly drained, or contain much alkali are undesirable for avocados. The Vista and Fallbrook soils and other soils of group 1 seem well adapted to avocado culture. Soils of group 4 are not so desirable as they have heavy intractable clay subsoils. Soils of groups 2 and 3 occur in positions that are likely to be too susceptible to frost. Carlsbad loamy fine sand, where of sufficient depth and where the fertility is properly maintained, seems to give good results with avocados.

Lemons are grown almost exclusively on the red and brown granite soils of the Fallbrook and Vista series, and the alluvial granitic soils of the Greenfield, Ramona, and Merriam series. These soils are all of sandy loam texture, and good results are obtained.

Most of the grapes are grown on the granitic soils of the Vista, Fallbrook, Greenfield, Ramona, and Merriam series, without irrigation. The coastal plain is not considered desirable for grapes, owing to the more humid atmosphere. In years of low rainfall, grape yields are low throughout the area.

The soils of groups 2 and 3, especially those that are alkali free and that hold moisture well, are especially adapted to the production of summer vegetables. Most of the celery is grown on Aliso fine sandy loam and Huerhuero fine sandy loam.

Grain and grain hay occupy the largest acreage of the crops grown in the area. These crops are grown on unirrigated land and on all soil types. During years of ample rainfall, good yields are obtained on the Linne and Ayar soils on the Otay Mesa and in the vicinity of

Cockatoo Grove. The granitic soils in the mountainous district produce only fair yields, although the acreage is large.

Bulbs thrive best on the sandy soils of the coastal plain.

The soils of groups 2 and 3, that are not too much affected by alkali salts, are desirable for alfalfa as they are deep and easy to irrigate.

General observations and experience in handling the soils of southern California have disclosed that they are for the most part relatively well supplied with potassium and phosphorus, 2 of the 3 elements most likely to be lacking. These soils are, however, generally deficient in nitrogen and organic matter, and these materials can be supplied by the use of nitrogenous fertilizers, barnyard manure, and cover crops. Organic matter obtained from bulky sources, such as good barnyard manure, bean straw, alfalfa hay, or winter cover crops is giving good results in building up the soils. Winter cover crops, such as purple vetch (*Vicia atropurpurea*) and bitter clover (*Melilotus indica*), are generally used because of the winter rainfall. Where irrigation water is cheap and abundant during the summer months, sweetclover (*M. alba*) may be grown.

As the chemical composition of the soil is not the most important factor in limiting crop growth, such physical characteristics as texture, physical condition, drainage, water-holding capacity, and depth, must be considered. Many of the soils have very heavy clay layers in the subsoil, that limit the penetration of air, water, and plant roots; others are extremely shallow, being underlain by thick hardpan layers or more or less cemented substrata. With the practice of irrigation, care must be used in handling soils with such physical characteristics.

A great diversity of soils exists in the El Cajon area. They range in color from brown to black, most of them being brown or reddish brown. Texturally, they differ widely, although more than 75 percent of them are sandy loams.

In the system of soil classification used, the soils of the area are grouped into series, each series including only those soils of similar color, origin, calcium-carbonate content, profile characteristics, or degree of weathering. The series is further subdivided into types, the types in a series differing from one another only in the matter of texture of the surface layer, which is determined by the relative proportions present of mineral particles of the different sizes. Thus a soil type represents a definite soil having a certain texture, color, origin, sequence of layers of soil material, hardpan, or bedrock, calcium-carbonate content, character of parent material, and other characteristics. The soil type is the unit of soil mapping. Subordinate differences in the character of a soil type are designated as phases of the type.

The soils of this area are divided into four broad groups, as shown in table 5, the soils in each group having more or less the same general agricultural importance, occupying similar topographic positions, and having certain broad soil features in common.

In addition to these soil types four classes of miscellaneous materials, which have not been differentiated as separate soils, are mapped. They are rough broken land; rough stony land; coastal beach, dune sand, and river wash; and made land.

TABLE 5.—*Soil groups in the El Cajon area, California*

Group	Description	Soil series	Group	Description	Soil series
1	Soils weathered in place from underlying consolidated bedrock	Vista. Fallbrook. Konokti. Escondido. Carlsbad. Altamont. Diablo. Ayar. Linne.	3	Moderately weathered alluvial soils	Sorrento. Marina. Greenfield. Botella. Ramona. Hames. Salinas. San Marcos. Olivenhain. Las Flores. Redding.
2	Unweathered alluvial soils	Hanford. Cajon. Agueda. Foster. Alviso.	4	Maturely weathered soils	Aliso. Huerhuero. Merriam. Monserate.

Owing to the less detailed character of the previous reconnaissance survey, to frequent inclusion with individual soil types of locally unimportant or inextensive variations in character, and to continual accumulation of new facts in the development of the science of soil classification, a number of apparent inconsistencies appear in the classification of the soils of this area and in the adjoining and previous surveys. The more important of these are noted and explained under discussions of the soil series and soil types in the following pages of this report. The distribution and location of the different soils are shown on the accompanying soil map, and their acreage and proportionate extent are given in table 6.

TABLE 6.—*Acreage and proportionate extent of the soils mapped in the El Cajon area, California*

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Vista sandy loam	18,240	4.7	Greenfield sandy loam	2,816	0.7
Vista sandy loam, stony phase	18,304	4.7	Botella fine sandy loam	704	.2
Fallbrook sandy loam	7,296	1.9	Ramona sandy loam	3,584	.9
Fallbrook sandy loam, stony phase	3,264	.8	Hames sandy loam	1,792	.5
Konokti stony loam	4,736	1.2	Hames sandy loam, friable-subsoil phase	576	.2
Escondido very fine sandy loam	1,472	.4	Salinas sandy clay loam	832	.2
Escondido very fine sandy loam, stony phase	4,032	1.0	San Marcos fine sandy loam	4,992	1.3
Carlsbad loamy fine sand	4,736	1.2	Olivenhain fine sandy loam	8,704	2.2
Altamont clay loam	1,984	.5	Olivenhain gravelly sandy loam	22,272	5.8
Diablo clay adobe	5,632	1.5	Las Flores loamy fine sand	960	.2
Diablo clay adobe, brown phase	4,608	1.2	Redding gravelly sandy loam	64,768	16.7
Ayar clay	2,240	.6	Redding sandy loam	7,168	1.9
Linne sandy clay loam	16,448	4.2	Aliso fine sandy loam	11,712	3.0
Hanford sandy loam	2,048	.5	Aliso fine sandy loam, heavy phase	512	.2
Hanford sandy loam, dark-colored phase	512	.2	Huerhuero fine sandy loam	6,272	1.6
Hanford sandy loam, gravelly phase	2,048	.5	Merriam sandy loam	2,240	.6
Cajon fine sand	2,176	.6	Monserate sandy loam	9,856	2.5
Foster very fine sandy loam	1,536	.4	Rough broken land	22,208	5.7
Foster very fine sandy loam, gray phase	1,792	.5	Rough stony land	91,008	23.5
Agueda clay loam	1,536	.4	Coastal beach, dune sand, and river wash	6,656	1.7
Alviso very fine sandy loam	5,184	1.3	Made land	1,024	.3
Marina loamy fine sand	4,544	1.2	Total	387,200	------
Sorrento clay loam	2,176	.6			

SOILS OF GROUP 1

The soils of group 1 are developed on consolidated bedrock or cemented hardpanlike material at a depth of less than 6 feet, the average depth to this material being about 3 feet. These soils are spoken of in this report as primary (*6*), or residual, soils, as they have been weathered in place from the underlying consolidated bedrock.

They are developed on rolling or strongly rolling slopes, such as occur in the mountainous parts of the area. The limiting factors affecting the use of these soils are their shallowness in places, their stone content, and their steepness. Soil erosion, or washing, on the steeper slopes may be a serious problem after heavy rains. Most of these soils lie in frost-free situations, owing to good air drainage, and, where water is available for irrigation, they are generally productive for citrus and other fruits.

The Fallbrook, Vista, Konokti, and Escondido soils all occur in the mountainous district (*8*). The Fallbrook and Vista soils are locally known as decomposed granite soils, as they rest on granite bedrock and coarse granitic soil particles make up the soil material. The color of the Vista soils ranges from grayish brown to rich reddish brown, and the Fallbrook soils are pale red or pale reddish brown. The subsoil of the Fallbrook soils is much redder than that of the Vista soils, and it ordinarily has a higher water-holding capacity. The Konokti and Escondido soils are finer textured than the Fallbrook and Vista soils, the bedrock underlying the Konokti soils being diabase and that underlying the Escondido soils being of schistose character. The soils of both series have fairly shallow soils, the Konokti being very stony and having more clay in the subsoil than exists in the Escondido.

The Altamont, Diablo, Linne, and Ayar soils occur on rounded grass-covered hills of the coastal plain. All are underlain at a depth ranging from 18 to 30 inches by moderately consolidated calcareous sediments approaching marl rock in many places. The surface soils of the Linne and Ayar soils contain free calcium carbonate, but the Altamont and Diablo soils are calcareous only in the deeper subsoil material.

All these soils give good results with grain or grain hay in years of ample rainfall, and they are all good pasture soils. Under irrigation, good results are being obtained with tomatoes, peppers, peas, and eggplants on a small acreage.

Vista sandy loam.—More than 50 percent of the tillable land of the back country is composed of Vista sandy loam. Owing to low grain prices, much of the land now remains idle, although it was farmed at one time. Where water is available for irrigation, this is probably the most desirable soil in the area, owing to its texture, frost-free position, and other favorable characteristics. Around El Cajon Valley more than 75 percent of the soil is in citrus fruits, avocados, and grapes.

Vista sandy loam has a brown friable surface soil of sandy loam texture and a slightly heavier subsoil which grades into decomposed granitic bedrock at a depth ranging from 30 to 60 inches. Locally it is known as the brown-granite soil, and it is very productive when sufficient moisture is available for crop growth. The soil is easy to till and takes water readily, although it bakes fairly hard on drying out.

Vista sandy loam, stony phase.—The stony phase of Vista sandy loam is not tilled to a great extent, owing to the large content of boulders over the surface. The quantity of stone present, together with the steepness of some areas, are the only characteristics differentiating soil of the phase from the stone-free soil.

Fallbrook sandy loam.—The surface soil of Fallbrook sandy loam is reddish-brown or dull brownish-red sandy loam or fine sandy loam. The material is friable when moist and bakes fairly hard on drying, as do all the granitic soils of the area. The subsoil is of somewhat heavier texture and rests on disintegrated granitic bedrock at a depth ranging from 30 to 50 inches. Both the surface soil and subsoil take water readily, and good crops are obtained when sufficient moisture is available for plant growth. This soil is not so extensive as the related Vista sandy loam. Areas are at Mount Helix, east of El Cajon Valley, and scattered over the eastern part of the area covered in this survey. Barley, wheat, oats, grain hay, and grapes are the principal crops grown without irrigation. The main irrigated crops are citrus fruits, avocados, and truck crops. This soil, like Vista sandy loam, is adapted to a wide range of crops.

Fallbrook sandy loam, stony phase.—Areas of a stony phase of Fallbrook sandy loam are shown on the map by stone symbols. Their agricultural value depends on the quantity of stones and boulders present. In general such areas are used for grazing, only the stone-free patches being farmed.

Konokti stony loam.—Agriculturally Konokti stony loam is of minor importance. Less than 2 percent of the land is tilled, as most of it is too rough or too stony for tilled crops. In the earlier reconnaissance survey of the San Diego region this soil was included with areas of rough broken land and rough stony land. The largest bodies occur in the vicinity of La Mesa and Lemongrove, and small areas lie near Sweetwater and Otay Reservoirs.

Two small areas of stony clay texture are included with this soil as mapped, one west of Murray Reservoir and the other one half mile west of Sweetwater Reservoir. The soil in each area is shallow and stony and is used only for pasture.

Typically Konokti stony loam consists of brown or reddish-brown friable stony loam that grades into a slightly heavier textured subsoil overlying the parent bedrock. The soil is shallow and stony, bedrock usually occurring within 3 feet of the surface.

Escondido very fine sandy loam.—Escondido very fine sandy loam consists of light-brown or light reddish-brown extremely friable and floury very fine sandy loam or fine sandy loam soil that extends to broken schist bedrock without any visible change in texture, structure, or color. The soil is easy to till, takes water readily, and has a good water-holding capacity. Shattered bedrock occurs at a depth ranging from 18 to 36 inches.

All this soil would be capable of being cultivated to intensive crops were water available for irrigation. Much of it is being used for nonirrigated grapes, grain, and pasture. An area including about 2 square miles lies east of Lakeside, and two bodies are in the vicinity of Isham Springs. One body south of Mount Helix is under irrigation and is used, with very good results, for growing citrus fruits.

Escondido very fine sandy loam, stony phase.—The stony phase of Escondido very fine sandy loam is shallower than typical Escondido very fine sandy loam, and stones are scattered over the surface. Most of the stony phase occurs on fairly rough relief, extending from Spring Valley southeastward to south of Jamul Butte. About 6 square miles of this soil are mapped, but none of the land is tilled.

Carlsbad loamy fine sand.—Typically, Carlsbad loamy fine sand consists of grayish-brown or light brownish-gray loamy fine sand to a depth ranging from 20 to 48 inches. It is underlain by a cemented hardpanlike substratum of red sandstonelike material. The soil above the substratum contains a large number of small brownish-red pellets or concretions about the size of small peas. These extend to the surface, but they do not interfere with cultivation. As mapped in this survey, some of the included material is of somewhat coarser and sandier texture than typical.

Areas of this soil occur on the crests of sea terraces north of La Jolla, on the western edge of Soledad Mountain, on Lindavista Mesa, on Point Loma, and south of San Diego Bay. These ridges, with the exception of one lower-lying area south of the bay, parallel the coast line at an elevation ranging from 200 to 400 feet above sea level. The surfaces and edges of the ridges are eroded, the depth of the soil is variable, and agriculture on it is limited by the degree to which the surface soil has been removed by erosion. Of the 7.4 square miles mapped, less than 100 acres are cropped. This soil in the Oceanside area (*8*) is used to some extent, under irrigation, for avocados, bulbs, and truck crops, as it occurs in frost-free locations near the coast.

The general fertility and organic content of the soil are low, and crops planted on it are heavily fertilized. Irrigation by means of overhead sprinkling is ideal on sandy soil of this character.

Altamont clay loam.—Altamont clay loam occurs on rounded hills east of Sorrento and southeast of La Jolla. One small area lies in Eucalyptus Pass, and a number are along the south side of Sweetwater Valley in the vicinity of Bonita.

The surface soil consists of brown loam or clay loam. Erosion has been very active, so that areas of heavier soil occur on the slopes where the topsoil has been washed off and the heavy subsoil exposed. The surface soil, at a depth ranging from 6 to 12 inches, rests on a brown compact clay subsoil which in turn grades into a substratum of bedrock of shaly material containing calcium carbonates. The eroded areas are hard to handle, as they are plastic and sticky when wet and bake when dry.

Grain and grain hay are the principal crops grown. Generally speaking, under irrigation this soil would not respond well with deep-rooted crops, owing to the shallowness of the surface soil and to the heavy-textured subsoil. The soil is inextensive. It includes some steep areas, which were in part included with rough broken land in the earlier reconnaissance survey.

Diablo clay adobe.—The surface soil of Diablo clay adobe consists of dark-gray or black clay that shrinks and breaks up into large blocks separated by large cracks when dry. The soil hardens on drying, but progressive shrinking and checking develops a small cloddy structure which makes it easier to handle. When wet, the cracks close and the soil is nearly black. The subsoil in most places is somewhat lighter in color, and it breaks up into granules when exposed to the air, owing to the calcium carbonate content. In most places, at a depth ranging from 24 to 48 inches, a soft marly bedrock high in calcium carbonate occurs. This is a fertile soil, but it is hard to handle, especially when wet, because of its heavy texture.

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This soil occupies the tops and slopes of high terraces on the highest part of the coastal plain. A few cobblestones are scattered over the surface but in few places in sufficient quantities to interfere with cultivation. Areas occur east of Cowles Mountain, on the west slope of El Cajon Valley, northwest of Santee, and south of Sweetwater Reservoir. The largest body lies on top of the Otay Mesa. About 9 square miles of the soil are mapped.

Less than 100 acres are utilized for irrigated crops, such as tomatoes and peppers. About 50 percent of the land is used for pasture and the rest for grain, grain hay, and beans. In the earlier reconnaissance survey, which included the present area, this soil with its brown phase, was mainly included with the Montezuma soils which it resembles in color and profile.

Diablo clay adobe, brown phase.—The brown phase of Diablo clay adobe has the same general characteristics as typical Diablo clay adobe but differs from that soil in having a dull grayish-brown surface soil. Areas occur northeast of Grantville, south of Lemongrove, and east of Spring Valley, totaling about 7.2 square miles. Only a small part of the land is being tilled. An area, about two thirds square mile in extent, 1 mile south of Alpine, has been included in mapping. This area is used for grazing, and at one time hay was grown on it.

Ayar clay.—Ayar clay has a brown clay surface soil that is very loose and friable and has the appearance of being of lighter texture than clay, owing to the flocculating effect of the high calcium carbonate content. The subsoil is light grayish-brown friable clay containing a large amount of calcium carbonate, with pieces of calcareous bedrock embedded throughout the lower part. The parent bedrock, which is highly calcareous, occurs at a depth ranging from 18 to 36 inches below the surface.

The soil occurs in gently rolling areas suitable for cultural operations. It has a high water-holding capacity and, with its ease of tillage, is highly desirable for the production of grain and grain hay. Beans are grown to some extent in rotation with grain. Nearly all this soil has been tilled at some time. An area east of Spring Valley is utilized for irrigated truck crops, including tomatoes, peppers, peas, and eggplant. One area, including about three fourths square mile, north of Isham Springs, has a fairly high content of stones and has never been cropped.

About 1½ square miles of Ayar clay occur north and east of Murray Reservoir. This land is cropped to grain in years of ample rainfall, and yields of 15 or more sacks [6] an acre have been obtained in years of high rainfall.

Linne sandy clay loam.—Linne sandy clay loam is similar in all characteristics to Ayar clay, except that it is slightly lighter in texture and color, the surface soil ranging from dull gray or dull brownish gray to nearly black. The subsoil is dull gray or dull brownish gray. Both surface soil and subsoil consist of friable clay loam high in content of fine and very fine sand and in calcium carbonate. Pieces of marly parent bedrock occur throughout the soil mass and extend to the surface in places. Bedrock lies at a depth ranging from 18 to 36 inches.

[6] The capacity of grain sacks in different markets of California ranges from 100 to 125 pounds and averages about 2 bushels.

The soil has a high water-holding capacity and contains a large quantity of organic matter. It is sticky when wet, but, owing to the flocculating effect of the calcium carbonate present, it is very friable at the ordinary field moisture content.

This soil occurs on rounded grass-covered hills, the largest area being on the mesa between Sweetwater and Otay Reservoirs. A large body lies south of Lower Otay Reservoir on the Otay Mesa. About 14 square miles are included in these two bodies, and all the land is utilized for grain, grain hay, and beans. Smaller bodies, some of which occupy fairly steep slopes, are scattered northward to the vicinity of Murray Reservoir. Where the relief is favorable, all these areas are tilled. Small bodies in the vicinity of Lemongrove and Murray Reservoir are used for irrigated crops. Truck crops appear to do well.

SOILS OF GROUP 2

The soils of group 2 are characterized by loose friable surface soils and subsoils, the soil material being 6 feet deep or deeper. The soils have been recently transported and deposited, by stream action, on stream bottoms or on alluvial slopes. They are subject to overflow which is a serious problem in this area, where the storms may be torrential. The subsoils of many of these soils are open, loose, and porous, absorbing water quickly but having a low water-holding capacity. During the summer, frequent applications of water are needed in most places. Because of their position, most of the areas are easy to irrigate, furrows or checks being constructed with little leveling of the surface. Wells are drilled along the larger stream channels, and water for alfalfa, general field crops, and truck crops, is obtained by pumping, at a moderate cost. Because of the frost danger, the soils of this group are largely used for the more hardy crops. Some of the higher alluvial slopes, which are more frost free, are used for citrus fruits and winter truck crops. Alkali may be present in these soils, where drainage is poor or where the soils adjoin tidal land.

Soils of the Hanford, Cajon, Agueda, Foster, and Alviso series are included in this group.

Hanford sandy loam.—Hanford sandy loam typically consists of light-brown, brown, or dull grayish-brown coarse-textured micaceous sandy loam which may vary little in texture to a depth of 6 feet or deeper, though the subsoil may be made up of strata of different textures. The surface soil and subsoil are friable and porous, so that plant roots and moisture readily penetrate to a great depth. The surface soil contains only a moderate amount of organic matter and is only moderately retentive of moisture. Crops often suffer from drought where irrigation is delayed or is not practiced.

The uniform surface relief of areas of this soil, as well as their location in the valleys, where underground water can be obtained from wells, makes the soil desirable for a large number of irrigated crops, such as alfalfa and vegetables. Citrus fruits and avocados are not usually considered desirable crops, owing to the frost hazard in the lower parts of the valleys where this soil occurs.

Much of the land is subject to overflow during unusual freshets, when coarse material is deposited over the surface or erosion channels are cut through the soil material.

The agricultural value of this soil is largely governed by the water supply. As a rule, the land produces poorly under dry-farming conditions, but it is highly prized where water is available for irrigation.

The individual areas are small, and they are scattered throughout the small foothill valleys, on small alluvial fans, and bordering small intermittent stream ways.

Hanford sandy loam, dark-colored phase.—The dark-colored phase of Hanford sandy loam consists of soil material similar in texture to typical Hanford sandy loam but of dull grayish-brown or dull brownish-gray color, the darker color being caused by the larger content of organic matter, the result of the presence of considerable moisture which has caused a rank growth of water-loving grasses. This dark-colored soil is utilized for the same crops as typical Hanford sandy loam. Small areas occur northwest of Lakeside, 2½ miles northwest and 4 miles east of Moreno, and in Lyons Valley. As the body in Lyons Valley has an excess of moisture during the winter and spring, it is utilized only for pasture.

Hanford sandy loam, gravelly phase.—The gravelly phase of Hanford sandy loam consists of gravelly sandy loam containing much cobbly material. It represents outwash material eroded from the Poway Mesa. The finer-textured material present has the characteristics of the Hanford soils, and the subsoil in most places is gravelly. This soil is of much lower value than typical Hanford sandy loam, owing to its gravelly character. It occurs in Carroll, Rose, San Clemente, Murphy, and Sycamore Canyons, and one small body lies at the lower end of Otay Valley. The total extent of this gravelly soil is about 3 square miles, only a few acres of which are under cultivation.

Cajon fine sand.—The surface soil of Cajon fine sand consists of light-gray or light brownish-gray loose micaceous fine sand or very fine sand, with minor darker-colored inclusions. The material below the surface soil is of the same character but may be variable in texture. Normally some calcium carbonate occurs in both the surface soil and subsoil, although the amount may be very slight in some of the more recently deposited soil. This soil represents very recently deposited soil material or material that is being deposited during unusual floods. The humus content is low, and the soil holds very little moisture. It occurs along present stream channels in the flatter valleys.

About one half square mile of this soil lies in Mission Valley, narrow strips occur along San Diego and Sweetwater Rivers, and about 2 square miles occupy flat lands along the lower end of Tia Juana River. Most of the land is covered by a growth of willows, but about 20 percent is tilled and alfalfa and truck crops are grown. Yields are not so good as those obtained on associated soils of heavier texture, that hold more moisture.

Foster very fine sandy loam.—Foster very fine sandy loam has a dull brownish-gray or dark grayish-brown surface soil of highly micaceous friable very fine sandy loam containing much calcium carbonate. The underlying soil material to a depth of 6 feet or deeper is of similar character but is stratified, the texture of the individual strata ranging from sandy loam to loam. When moist the soil appears browner. It absorbs water readily, holds it well, is easily tilled, and the organic-matter content is fairly high.

Approximately 1 square mile of this soil occurs in Mission Valley, extending from Old Town to above Grantville. Small bodies are east of Lakeside, narrow strips are in Sweetwater Valley, and small areas are west and southwest of Palm City.

In the area, including about 150 acres, 1½ miles southwest of Palm City, the soil differs from typical Foster very fine sandy loam, in that it rests on a deposit of brown clay loam at a depth ranging from 30 to 40 inches below the surface. The soil in this area is an overwash on an older deposit. It is fairly well drained and is utilized for the same crops as typical Foster very fine sandy loam.

Some areas of Foster very fine sandy loam are subject to poor drainage, as they occur on flat valley floors. Most of the poorly drained areas are covered with salt grass, and they contain some alkali. They can be successfully farmed when the water level is kept at a safe distance below the surface, with the exception of small local spots that have a greater concentration of alkali.

The better-drained areas of Foster very fine sandy loam are considered highly desirable for alfalfa and truck crops, and almost all the areas are farmed. Irrigation water is obtained from wells.

Foster very fine sandy loam, gray phase.—The gray phase of Foster very fine sandy loam is similar to typical Foster very fine sandy loam in most respects, but it is lighter gray in color. The soil is extremely high in mica, very floury, and easy to till. Some calcium carbonate may occur in the surface soil, but a greater amount is in the subsoil. The soil profile shows little change to a depth of 6 feet or deeper. The soil has a fairly high water-holding capacity and is easy to irrigate, as it is level and occurs where well water may be obtained with a comparatively low lift.

Nearly 3 square miles of this soil are mapped in Tia Juana Valley. Water is pumped, and practically the entire acreage is utilized for truck crops. Some of the land is subject to overflow. Sandier spots occur where the stream has broken away from its normal channel and deposited soil material during floods. Alkali occurs in small quantities over a part of this soil, but with proper irrigation and good drainage this need not be a serious problem with the kinds of crops grown here.

Agueda clay loam.—Agueda clay loam has a dull brownish-gray or dull-gray surface soil of loam, clay loam, or clay, high in content of calcium carbonate. The subsoil to a depth of 6 feet or deeper has the same characteristics as the surface soil.

This soil material occurs as outwash from the Linne soils, in narrow canyons on the coastal plain and on steep alluvial slopes in the same district. As a rule, the land is well drained and adapted to a wide range of field crops. The individual areas are small, some of them being too small to economically till to field crops, and many of them are surrounded by nonagricultural land.

The moisture-holding capacity of Agueda clay loam is high, and the soil is as well adapted as any soil of the area to nonirrigated row crops, such as beans. Land of this kind is often in danger of erosion and fill during heavy storms, because of its position in narrow canyons.

Alviso very fine sandy loam.—Alviso very fine sandy loam consists of drab or dark brownish-gray mottled soil materials of variable texture, predominantly silt loam or very fine sandy loam. Most of the soil is gray when dry, owing to the high salt content. The

dark brownish-gray subsoil ranges from fine sand to clay, and it is highly mottled. Both surface and subsoil layers may contain free calcium carbonate.

Alviso very fine sandy loam occurs under conditions of very poor drainage on the floors of lagoons. Areas are located around the edges of Mission Bay and San Diego Bay and at the outlet of Tia Juana River. Those parts not under water support a cover of pickleweed and salt grass. Areas that dry out during the summer expose a white bare surface having a heavy crust of alkaline or saline salts. This soil has no agricultural value, except in a few places where some pasture is afforded by salt-loving grasses which grow where the salt content is low. In the reconnaissance survey of earlier date this soil was included with tidal marsh, with which it was associated.

SOILS OF GROUP 3

The soils of group 3 differ from those of group 2 in that they have slightly compact and heavy-textured subsoils. The surface soils are permeable to air and water and the subsoils only slightly less so. They occur on low terraces which are slightly higher than areas occupied by the soils of group 2, and they are less droughty than the soils of group 2, owing to their heavier-textured subsoils. The soils of group 3 are slightly or moderately weathered secondary soils (*6*). These soils are 6 feet deep or deeper. They are fertile and adapted to a wide range of crops where not subject to frequent frost in winter, but because of their position danger of frost is a factor limiting crop production. With the exception of the San Marcos soils, most of the areas are well drained and contain no alkali or saline salts in harmful quantities. They are very good soils for general field crops with irrigation, and without irrigation they give better results than the other soils of the area, owing to their higher water-holding capacity.

Where any of these soils occur on terraces close to the coast they are comparatively frost free, but back from the coast in any of the interior valleys the danger of frost is greater.

The total acreage of the soils of group 3 is not so large as the total acreage of the soils of group 1 or of group 4.

Marina loamy fine sand.—Marina loamy fine sand is characterized by a light-brown or light grayish-brown surface soil developed on sandy beach deposits that have been raised to an elevation ranging from 10 to 30 feet above sea level and occupy flat terraces. The subsoil, to a depth of 6 feet or deeper, consists of light-brown, light grayish-brown, or pale yellowish-brown slightly compact loamy fine sand. Many seams of slight iron cementation occur in the subsoil, also considerable rust-red and rust-yellow mottling.

Areas of Marina loamy fine sand occur in the vicinity of La Jolla, Pacific Beach, Ocean Beach, North Island, Coronado, and on the Coronado Peninsula.

The land is utilized mainly for residential purposes. Although friable, easy to till, and warm, the soil is somewhat lacking in humus and general fertility. These can be supplied by cover crops and by organic and commercial fertilizers. Avocados, bulbs, flowers, and winter vegetables are giving good results on similar soils that are properly irrigated and managed in the Oceanside area.

Sorrento clay loam.—The surface soil of Sorrento clay loam consists of an 8- to 16-inch layer of brown or light-brown clay loam or loam, in places containing a fair quantity of fine sandy material, and the subsoil is brown or light-brown slightly compact loam or clay loam, containing a small quantity of calcium carbonate. The soil is 6 feet deep or deeper, and it holds moisture well. The surface is smooth, and the land is friable and easy to till. It contains a moderate quantity of organic matter, it is well supplied with plant food, most of it is well drained, and it contains no injurious accumulations of alkali.

The largest bodies are in Rose Canyon, Soledad Valley, Las Choyas Valley, and La Palata Valley. One included area in Cedar Canyon 4 miles west of Dulzura is of gravelly loam texture.

This soil is desirable for a variety of crops. Where climatic and water conditions are favorable, Sorrento clay loam will successfully produce a wide range of crops. Probably one half of the land is irrigated, and vegetables (beans, peas, tomatoes, potatoes, and corn), and walnuts are the principal crops grown.

Greenfield sandy loam.—The surface soil of Greenfield sandy loam consists of brown or light reddish-brown friable micaceous gritty sandy loam extending to a depth ranging from 10 to 14 inches. It includes some rather pronounced red variations. The subsoil is slightly more compact than the surface soil, but typically it is not much heavier in texture. It is micaceous and in most places more reddish brown than the surface soil. This soil differs from Hanford sandy loam in having a subsoil that is more compact, richer brown, and heavier in texture than the surface soil, although the subsoil is not sufficiently compact to retard the penetration of roots or moisture. The soil bakes very hard on drying, but it is friable when moist.

Greenfield sandy loam is scattered over the eastern half of the area on high alluvial fans, valley floors, and in narrow valleys. A total area of 4.4 square miles is mapped in the granitic rock region.

All crops grown in the eastern part of the area are produced on this soil. In the vicinity of El Cajon Valley, the soil is very desirable for citrus fruits and irrigated vegetables. All kinds of truck crops and citrus fruits are grown with irrigation and grain and grapes without irrigation.

Botella fine sandy loam.—Botella fine sandy loam has a dull grayish-brown or dull brownish-gray friable fine sandy loam surface soil ranging in thickness from 10 to 15 inches. The subsoil is of the same color, is slightly compact, and may be of slightly heavier texture. However, the slight compaction is not sufficient to arrest the penetration of roots or moisture but is an advantage in giving the soil a somewhat greater water-holding capacity. In typical Botella fine sandy loam more friable material is present below a depth ranging from 30 to 50 inches.

This soil absorbs moisture readily and is fairly easy to till. It bakes on the surface when dry and has a tendency to be somewhat sticky when moist. It is well drained and has a moderate organic-matter content.

This soil occurs in small valleys in the coastal plain and is developed on outwash from the older and higher terraces. It covers a total area of 1.1 square miles. Bodies occur in Tecolote Valley, Murphy Can-

yon, and north of Santee. Two bodies, one in Paradise Valley and the other northeast of Cowles Mountain, have surface soils of clay loam or clay texture.

This land is utilized mainly for various field crops, including alfalfa, peas, beans, and corn. About half the land is under irrigation, and some truck crops are grown.

Ramona sandy loam.—The surface soil of Ramona sandy loam is brown or reddish-brown friable sandy loam, in many places of rather fine texture. At a depth ranging from 10 to 20 inches this material rests on reddish-brown slightly compact gritty sandy loam or loam. Below this and extending to a depth ranging from 40 to 60 inches is dull brownish-red moderately compact sandy loam. The soil material below this is less compact, of variable texture, and pale reddish brown in color. Ramona sandy loam is associated with the granitic soils. It occurs on flat or gently sloping terraces scattered over the granitic back country. Drainage is good.

Ramona sandy loam occupies 5.6 square miles in the El Cajon area. Bodies of this soil are scattered throughout the valleys of the back country, and fairly large areas occur on the slopes of El Cajon Valley. Nearly all the land is farmed. Where water is available for irrigation, the soil is considered highly desirable for a wide range of crops, including citrus fruits in frost-free locations. In El Cajon Valley, grapes are grown on the lower slopes and citrus fruits on the higher and warmer spots.

Hames sandy loam.—The surface soil of Hames sandy loam consists of light-brown or rich-brown sandy loam extending to a depth ranging from 8 to 12 inches. In spots a few cobblestones, from 1 to 3 inches in diameter, are scattered over the surface of the ground but not in sufficient quantities to interfere with cultivation. The subsoil to a depth of about 40 inches consists of brown or light reddish-brown slightly or moderately compact sandy loam or gritty loam. The material below this is brown or light yellowish-brown slightly compact fine sand, sand, or sandy loam. The soil is permeable to roots and moisture throughout. The quantity of cobblestones in different areas of this soil is variable.

Hames sandy loam occurs on low terraces along the valleys of the coastal plain, and some of the land has been severely eroded. With irrigation water this is a very good soil. Bodies lie one half mile south of Nestor, 2 miles west of Tia Juana, and in Murphy and Alvarado Canyons. The land in Murphy and Alvarado Canyons is not tilled. It contains a rather large quantity of gravel.

Two areas mapped just west of Sweetwater and Otay Reservoirs have considerable gravel scattered over the surface and throughout the soil mass. The surface soil in these areas is somewhat darker than typical Hames sandy loam, and the subsoil contains a larger quantity of clay. The less eroded spots have been locally farmed to grain.

Hames sandy loam, friable-subsoil phase.—Areas mapped as the friable-subsoil phase of Hames sandy loam lie north of Palm City and on terraces along the northern edge of Sweetwater Valley below the reservoir. About 1 square mile is mapped. The subsoil of this phase of soil is very friable, with little compaction or accumulation of clay. The soil has a wide crop adaptation. Citrus fruits and other irrigated crops are grown.

Salinas sandy clay loam.—The surface soil of Salinas sandy clay loam is fairly loose and friable under cultivation, though it tends to run together when wet and bakes on drying if not cultivated. Typically it consists of dull brownish-gray or dull grayish-brown sandy clay loam. It is underlain by light-gray or light brownish-gray calcareous sandy clay loam which extends to a depth of 6 feet or deeper. The subsoil has a high content of calcium carbonate which is evenly distributed throughout the material. Salinas sandy clay loam occurs in small valleys in the coastal plain and is developed on alluvial deposits washed in from various adjacent materials. The water-holding capacity of the soil is high, which makes the land desirable for nonirrigated crops, such as beans and corn. The surface is smooth, and the land can be irrigated easily. About 50 percent is cropped to vegetables.

This soil is not extensive. It occurs in small bodies near Sweetwater Valley. Areas in Long Canyon and Otay Valley have a heavier subsoil than typical.

San Marcos fine sandy loam.—The 10- to 24-inch surface soil of San Marcos fine sandy loam is dull brownish-gray or dull grayish-brown micaceous fine sandy loam of light texture, including some areas of fine sand. The subsoil is of the same color or slightly darker, of slightly heavier texture, and in places slightly compact. The deeper part of the subsoil is highly calcareous and shows evidence of poor drainage as it is mottled with rust-colored iron stains. This soil occurs in the flatter valleys of the larger streams where it is subject to overflow and to poor drainage during winter and spring. The soil material is largely granitic in origin.

This soil is utilized for alfalfa, corn, and general field crops. Its crop possibilities are limited by danger of frost and overflow. Water for irrigation is obtained from wells. Salt grass covers much of the uncultivated land. A small quantity of alkali is present in most of the soil, and local areas contain sufficient alkali to require care in irrigation and management.

Typical bodies of San Marcos fine sandy loam lie along San Diego River at Santee, north of Lakeside, along upper Sweetwater River, along Jamul and Dulzura Creeks, west of Old Town, and in the lower Sweetwater Valley. About 50 percent of the land is cropped to alfalfa and the rest to general field crops, such as corn and beans.

As mapped in the El Cajon area, the soil includes bodies which have a surface overwash of gray fine sand or sandy loam, but the subsoil has the characteristics of typical San Marcos fine sandy loam. In these areas, which are poorly drained and subject to overflow, the sandy noncalcareous surface soil ranges from 20 to 40 inches in thickness. Bodies of this character are at the lower ends of Sweetwater and Mission Valleys, bordering areas of Alviso very fine sandy loam. Salt grass covers a large part of the land, and the alkali content is fairly high. Some pasture is afforded during part of the year.

Included areas of browner color than typical occur at Santee, Lakeside, and the upper end of Dulzura Creek, in which the surface soil is grayish-brown granitic sandy loam or fine sandy loam and the subsoil has the same characteristics as typical San Marcos fine sandy loam, with the calcium carbonate occurring at a depth ranging from 24 to 40 inches below the surface. This land is used for the same crops and has the same value as the typical soil.

SOILS OF GROUP 4

The soils of group 4 are distinct from those of the first three groups. They have friable sandy surface soils that give way abruptly at a depth ranging from about 8 to 16 inches to heavy intractable clay which is practically impervious to air, water, or plant roots. The clay layer is underlain by hardpanlike sediments which range from unconsolidated to firmly consolidated. These soils occupy elevated terraces, and the surface relief is smooth or undulating. The group includes mainly the coastal-plain or sea-terrace soils that occupy the mesas surrounding San Diego. These soils are best adapted to shallow-rooted crops. As the clay layer hinders the penetration of water, irrigation should be frequent and shallow. The soils of the Aliso, Huerhuero, and Merriam series have a higher value than other soils of the group, as they have thicker surface soils which have not been so badly affected by erosion and the subsoils are not quite so intractable. Concentrations of calcium carbonate in the lower part of the subsoils is also an advantage. All the other soils in this group have substrata, occurring at a depth ranging from 18 to 36 inches from the surface, that are extremely cemented or well consolidated, and, so far as crops are concerned, have the same effect as a hardpan or bedrock.

The soils of this group include approximately 35 percent of the El Cajon area. Where not used for residences, more than 50 percent of the total area of the Aliso, Huerhuero, Merriam, and Monserate soils are utilized for agricultural purposes. Less than 1 percent of the combined area of the Olivenhain, Las Flores, and Redding soils, which occupy the more elevated marine terraces, is under cultivation.

Olivenhain fine sandy loam.—The surface soil of Olivenhain fine sandy loam is brown or light grayish-brown friable fine sandy loam, ranging from 6 to 12 inches in thickness. When moist the color of the soil has a pink shade. The surface is characterized by pronounced hog-wallow mounds and depressions. The crests of the knolls have a pink shade, and the soil in the depressions is more gray. The subsoil is distinct from the surface material in every respect, being dull-brown very compact waxy clay which ranges from 10 to more than 20 inches in thickness and rests on moderately consolidated sediments of soft sandstone or clay shale. The underlying sediments range from light brown to light yellowish brown in color. The subsoil is comparatively impervious, and root development and moisture absorption is limited largely to the more pervious surface material. In most places, the surface soil is of low organic-matter content and is slightly acid. In most places, the clay layer and the upper part of the substratum contain some saline salts. As mapped, this soil includes some steep or eroded areas in which the typical profile structure is not developed or has been destroyed.

Olivenhain fine sandy loam occupies level or sloping terraces. Where a hog-wallow surface relief occurs, water is held in the depressions between the knolls for a long time after heavy rains. The vegetal cover consists of light brush and native grasses. On many slopes erosion has stripped off the topsoil, exposing the heavy subsoil, and these spots are barren of any cover. On some of the slopes surrounding the mesas, local areas occur in which the shaly substratum effervesces in acid.

The largest bodies of Olivenhain fine sandy loam lie east of Rose Canyon on the western edge of Lindavista Mesa. Other bodies are at La Jolla and east and southeast of San Diego.

Less than 1 percent of the soil is utilized for tilled crops, most of the land being in pasture. The tilled areas are south and east of San Diego, within the confines of irrigation districts. It is doubtful whether good results will be obtained, as the waxy clay subsoil restricts the downward movement of water and results in poor drainage and poor aeration. Shallow-rooted crops would do better on these areas. The fertility of the soil must be kept up, and care must be used in the application of irrigation water.

Olivenhain gravelly sandy loam.—Olivenhain gravelly sandy loam has the same soil characteristics as Olivenhain fine sandy loam, with the exception of the texture of the surface soil which is gravelly sandy loam or gravelly loamy sand. A few cobblestones are scattered over the surface. This soil has been so badly eroded that the heavy clay subsoil is close to the surface in most places, and the surface layer of gravelly sandy loam does not average more than 8 inches in thickness. Where the surface relief is of hog-wallow configuration, the soil on the tops of the hummocks is somewhat thicker.

This soil is subject to the same limiting factors as Olivenhain fine sandy loam, in addition to the unfavorable gravel content and unfavorable surface relief. A total area of 34.8 square miles is mapped. The soil occurs on Soledad Mountain, north of Old Town, and large bodies extend from San Diego south to the Mexican border.

Olivenhain gravelly sandy loam occupies eroded sea terraces which have lost much of their terrace form through erosion. About 3 percent of the land is used for agriculture, in the vicinity of Lemongrove and on the outskirts of San Diego, National City, and Chula Vista.

Las Flores loamy fine sand.—Las Flores loamy fine sand is not so extensive as Olivenhain fine sandy loam, with which it is associated on the western edge of Lindavista Mesa, south of Sorrento. Only 1½ square miles are mapped.

The surface soil to a depth ranging from 6 to 10 inches is gray or light brownish-gray friable loamy fine sand. It overlies a drab or dull-brown extremely compact sandy clay layer which rests on gray or light yellowish-brown compact softly consolidated sandstone sediments. In most places the soil has a low organic-matter content, is of low fertility, and its water-holding capacity is low. The intractable character of the subsoil limits the penetration of roots and moisture. Saline salts are present in small quantities in the subsoil and upper part of the substratum.

The surface has a hog-wallow configuration on uneroded areas, and water, which does not readily penetrate the subsoil, stands in the depressions for some time after heavy storms. On slopes the once irregular surface has been fairly well leveled by erosion. Only a small acreage of the soil is tilled, and the remainder, although the growth of native grasses is poor, is used for pasture.

As mapped in the El Cajon area, Las Flores loamy fine sand includes small areas having a duller or darker surface soil of loam or clay loam texture. In most places a few cobblestones occur in these variable-textured areas. The subsoil is of the same character as the corresponding layer of typical Las Flores loamy fine sand, but the surface

soil has a better water-holding capacity and is more fertile. Small areas of such character are in the vicinity of Shepherd Canyon, east of Murray Reservoir, and on Otay Mesa. They are utilized for grazing livestock.

Redding gravelly sandy loam.—Redding gravelly sandy loam is the most extensive soil in the area surveyed, but it probably has the smallest agricultural utilization of the soils mapped, except for the scanty pasture it affords. The limiting factors in the agricultural utilization of this soil are its excessive gravel content, shallowness, and poor subdrainage.

Redding gravelly sandy loam has a 5- to 14-inch surface soil consisting of bright brownish-red or light reddish-brown gravelly loam. The content of gravel varies, although in most places it comprises more than 25 percent of the soil mass. The gravel are rounded and range in size from gravel to cobbles 3 or 4 inches in diameter. In most places the size and quantity of the gravel are such that the soil can not be easily tilled. The subsoil is red clay which is very compact but does not contain quite so many cobblestones as the surface soil. It becomes light grayish drab in the deeper part. It is underlain at a depth ranging from 14 to 30 inches by a hardpanlike substratum of pale brownish-red cemented material, with embedded cobblestones.

Large areas surround San Diego and occur on the mesas to the north and east of that city. Very little drainage and erosion have taken place on the tops of the mesas. The surface is covered by hogwallow mounds with intervening depressions, in which the rainfall is caught and retained after heavy rains, resulting in a wet boggy condition of the soil between the knolls during the rainy season. The reaction of this soil is very strongly acid.

Surface drainage along the edge of the Poway Mesa is excessive. Here the soil has been badly eroded, in many places exposing the cobbly substratum, in which the cobblestones are larger than in uneroded areas. Originally this mesa represented a much higher mesa than it does at present. The steeper eroded areas were included with areas of rough broken land in the earlier reconnaissance survey.

Most of the mesas support a thick growth of chamiso, and the surface is covered with moss. Attempts have been made to establish orchards on Redding gravelly sandy loam with but little success. Small acreages are devoted to vegetables, but these are not of commercial importance.

Redding sandy loam.—Redding sandy loam occurs on slightly lower ridges than those occupied by Carlsbad loamy fine sand. It lies on the coastal-plain mesas between bodies of Carlsbad loamy fine sand and Redding gravelly sandy loam. The surface soil consists of reddish-brown or dull-red friable sandy loam or loamy sand ranging from 6 to 24 inches in thickness. Adjoining areas of Carlsbad loamy fine sand, the surface soil is thicker than on the lower-lying areas. The subsoil is red compact clay which, at a depth ranging from 20 to 36 inches, rests on a red or grayish-red cemented substratum similar to that underlying the Carlsbad soils.

None of this soil is used for agriculture, but areas on Point Loma have been developed industrially.

Redding sandy loam occupies a total area of 11.2 square miles in the El Cajon area. The largest body is on Lindavista Mesa about 4 miles north of San Diego, and smaller areas are on Point Loma, at

National City, Fruitdale, Palm City, and southeast of Imperial Beach.

This soil has about the same agricultural value as the Olivenhain soils. It is adapted only to shallow-rooted crops. Care must be used in irrigation not to add too much water at one time. The surface soil is low in organic matter and in general fertility, and it has a low water-holding capacity which can be improved by adding organic matter.

Redding sandy loam joins on the north with Monserate sandy loam of the Oceanside area. The Monserate material occurring along the boundary between the two areas lacks the accumulated lime and is not typical of the Monserate soils, but it was included with those soils in the Oceanside area owing to its local development and small extent.

Aliso fine sandy loam.—The Aliso and Huerhuero soils differ mainly in color. Both are terrace soils occurring at an elevation ranging from 25 to 100 feet above sea level.

Aliso fine sandy loam in the El Cajon area receives a supply of irrigation water. Considerable agricultural use is made of the soil, owing more to the water supply and frost-free location than to its adaptation for crops. Large areas of this soil lie south of San Diego, in the vicinity of National City, Chula Vista, Otay Valley, Sweetwater Valley, and South San Diego, and smaller bodies occur on terraces between Old Town and La Jolla. About 50 percent of the land is included in residential and industrial developments, and the remaining acreage is used for the production of lemons, celery, and other truck crops.

The surface soil of Aliso fine sandy loam to a depth ranging from 8 to 15 inches consists of pronounced reddish-brown or light reddish-brown friable fine sandy loam that is easy to till and holds a fair amount of moisture. The subsoil is dark reddish-brown compact sandy clay ranging in thickness from 15 to 40 inches. The lower part of the sandy clay layer contains a nodular accumulation of lime that causes it to crumble more readily. Below a depth ranging from 30 to 60 inches the subsoil is pale-brown loam or sandy loam. The lower part of the subsoil in many places is very compact, the material approaching a hardpan in spots.

Aliso fine sandy loam, heavy phase.—Areas mapped one half mile northeast of Lemongrove and in the vicinity of Isham Springs have a surface soil of clay loam or clay texture, and they are classified as Aliso fine sandy loam, heavy phase. Small chicken ranches are located on these areas, as the soil is favorable for the production of green feed for the poultry. This heavy soil is hard to handle, owing to its heavy texture, otherwise it gives good results.

Huerhuero fine sandy loam.—As stated in the description of Aliso fine sandy loam, these two soil types are similar, differing principally in color. Huerhuero fine sandy loam does not cover so large a total area as Aliso fine sandy loam.

The largest body of this soil, which lies south of Chula Vista, is utilized for growing lemons, celery, and general truck crops. Other areas occur between La Jolla and Pacific Beach, along the south edge of Otay River Valley, southeast of Cockatoo Grove, in Soledad Canyon, on terraces in Mission Valley, and along the western edge of El Cajon Valley.

The texture of the surface soil of Huerhuero fine sandy loam is not so uniform as that of Aliso fine sandy loam. Typically the surface soil is light brownish-gray or light grayish-brown friable fine sandy loam ranging from 7 to 14 inches in thickness. In many of the swales the texture of the surface soil is variable, in places being as heavy as clay loam. The subsoil to a depth ranging from 20 to 30 inches consists of brown or dull-brown compact clay loam or clay. This layer absorbs moisture very slowly. The lower part of the subsoil is light-brown clay loam or clay, that has a concentration of calcium carbonate in nodules and in the soil cracks. The calcareous layer ranges from 18 to 24 inches in thickness. The soil material below the calcareous layer consists of light yellowish-brown slightly compact clay loam or fine sandy loam.

Huerhuero fine sandy loam is utilized in much the same manner as Aliso fine sandy loam, and its crop limitations are similar.

Merriam sandy loam.—Merriam sandy loam has an 8- to 16-inch surface soil consisting typically of light reddish-brown granitic sandy loam but having some pronounced red inclusions. It averages about 10 inches thick, but considerable surface fill has increased its thickness in many places. The upper part of the subsoil is dull brownish-red compact clay, ranging from 15 to 24 inches in thickness, which grades into a calcareous layer in which the soil material is somewhat duller. The calcareous layer ranges from 8 to 20 inches in thickness and rests on light grayish-brown or light-brown compact sandy loam which is consolidated in places.

The surface soil is friable, except where it is allowed to dry when not cultivated. Normally the subsoil holds up water after heavy rains so that the surface material is water-logged, especially in some of the flatter areas where the surface has a hog-wallow configuration characterized by small mounds and depressions. Most of the bodies of this soil occur on sloping terraces where surface drainage is fairly well developed, and the danger of water-logging is minimized.

Merriam sandy loam occurs in numerous small bodies scattered throughout the eastern part of the area, in the district of granitic rocks, mostly along valley margins or in intermountain basins. Bodies are east of Lakeside, in El Cajon Valley, and southeast of Mount Helix, and scattered areas are southeast of Jamacho. This is an inextensive soil and less than 5 percent of the land is irrigated. The nonirrigated crops include grain, grain hay, and grapes.

Monserate sandy loam.—The surface soil of Monserate sandy loam is brown or light reddish-brown sandy loam of variable thickness. On the higher terraces, such as occur near Grantville, it is about 12 inches thick, and in El Cajon Valley, where there has been considerable alluvial fill, it may continue to a depth of as much as 30 inches. The subsoil is rich-brown or dark chocolate-brown compact clay. It rests at a variable depth on a brown, grayish-brown, or light reddish-brown hardpanlike substratum of fine-textured sediments, that is mottled with spots of calcium carbonate on the top and throughout the upper part. Such spots occur also as nodules in the lower part of the clay layer. The substratum is partly cemented but is soft enough to be penetrated slowly with a soil auger.

Most of the Monserate sandy loam is associated with Merriam sandy loam, and it is developed largely on granitic material, although the parent materials in the lower San Diego River Valley and in the lower

Sweetwater Valley are of mixed origin. This soil occurs on flat gently sloping terraces or in intermountain valleys. Surface drainage in most places is good, but subdrainage is restricted by the heavy clay layer and the cemented substratum. These factors restrict the growth of deep-rooted crops, except on the deeper better-drained areas.

The surface soil has a low or moderate water-holding capacity and a low organic-matter content.

The largest area of Monserate sandy loam is in El Cajon Valley. A small acreage around the rim of the valley is used for citrus fruits and small patches of other irrigated crops. Areas occur in the vicinities of Lakeside, Lakeview, Dehesa, Lemongrove, Sunnyside, Bonita, Jamacho, Dulzura, and Grantville. The soil occupies a total area of 15.4 square miles. All the land has been cleared and is being farmed, but less than 10 percent is irrigated. Many different crops are grown on the irrigated land. Muscat grapes, grain, and grain hay are the nonirrigated crops grown.

MISCELLANEOUS SOIL MATERIALS

Rough broken land.—Rough broken land includes areas of undifferentiated soils that are nonagricultural because of their steep, broken, or eroded surfaces. Some areas have smooth slopes, but they are too steep to be cultivated. Most of the rough broken land is grass covered and has some value for grazing.

In this area, rough broken land is largely confined to the steep broken slopes descending from the mesas of the coastal plain and the slopes of the deeply intrenched valleys of the streams flowing down from the mountains. Most of the soil material consists of the different soils occurring on the coastal plain, which have been badly eroded.

The Poway Hills are classed as this type of miscellaneous material. They are covered with chamiso and other low-growing brush. Many rounded cobblestones occur over these hills. Rough broken land is less extensive than rough stony land in this area.

Rough stony land.—Rough stony land covers nearly 25 percent of the area surveyed. It consists of undifferentiated soil materials typically nonagricultural, partly owing to the mountainous relief but mainly owing to their stony character. Bodies of this character occur over a large part of the mountainous district east of the coastal plain, surrounding the areas of granitic soils.

In some places scant pasturage is afforded during the spring, but in all places excessive rock outcrop and boulders of granitic rocks render the land too rough and stony to be of value in the production of cultivated crops. Most of the soil material between the boulders and outcrops is a granitic sandy loam of the Fallbrook and Vista series.

Coastal beach, dune sand, and river wash.—This classification includes three rather distinct classes of materials. Coastal beach and dune sand occupy an area of wind-blown and wind-swept white sand, parallel to the ocean. Coastal-beach materials occupy smooth shelving beach strands which are periodically swept by high tides. Dune-sand areas consist of hummocky and dunelike areas of loose sand blown inland from coastal-beach deposits and lying above normal tidal overflow. These materials are very low in organic matter and are of low water-holding capacity. Areas occur at Mission Beach,

Ocean Beach, and as a long sand spit extending from North Island on the Coronado Peninsula to the Mexican border. These areas support no vegetal cover and are valueless for agriculture. River wash comprises the sandy or gravelly material, in the recently abandoned or present channel of rivers, which is exposed during dry periods. Most of this material is subject to overflow at each period of high water. In some localities grasses spring up after the high-water stage and afford fair grazing, but most of the land is barren, except for some willow trees, and it has no agricultural value.

Made land.—Made land, as mapped in this survey, includes areas that have been built up from dredging operations in San Diego Bay by constructing levees and filling in material between the levees. Such areas are only a few feet above sea level and are utilized for industrial or governmental purposes. Methods of reclamation are costly and not economically feasible for agricultural purposes. The largest area is used as a United States Marine Corps flying field.

IRRIGATION

Water for irrigation is obtained from storage reservoirs or by pumping from an underground source. The flow of the streams fluctuates greatly with wet and dry years and during a single season, therefore the streams cannot be relied on to supply water by simple diversion. Several large reservoirs supply water for irrigation and domestic purposes, and others are under contemplation. Residential development has progressed at such a rapid rate during the last 10 years that domestic use of water has overshadowed the agricultural use to a great extent.

Reservoirs supplying storage water for irrigation and for the city of San Diego include the Cuyamaca, Morena, Barrett, and Hodges Reservoirs, located outside the boundaries of the El Cajon area, and the Upper Otay, Lower Otay, Sweetwater, and Murray Reservoirs, a short distance east of the city.

The Cuyamaca Reservoir was constructed by the San Diego Flume Co. in 1889, and a flume was built along the south side of San Diego River Valley, to bring water to the city and to irrigate land in the vicinity of El Cajon Valley. In 1925, the La Mesa, Lemongrove, and Spring Valley irrigation district purchased the works of the old San Diego Flume Co. This district supplies water for the El Cajon Valley, La Mesa, Lemongrove, and Encanto localities. It is the largest irrigation district in southern California, in which residential development predominates over agriculture (*1*). The district also pumps from the gravel beds of San Diego River at El Monte. Considerable litigation has resulted with the city of San Diego over the water rights on San Diego River. Cuyamaca Reservoir has a capacity of 11,600 acre-feet. About 3,000 acres are irrigated, one half being in citrus fruits, and approximately 1,000 acres are double cropped to truck crops. Grossmont, Eucalyptus, and Murray Reservoirs are used for distribution purposes. During 1927, water charges were at the rate of $42.19 an acre-foot for land inside the district and $47.14 for land outside the district.

The Lakeside irrigation district supplies water for 320 acres of land near Lakeside, water being obtained from a well in the San Diego River basin and from the Cuyamaca system.

The San Ysidro irrigation district and the Tia Juana River irrigation district were organized for the purpose of supplying water to land in the vicinity of San Ysidro and Imperial Beach. So far the use has been largely residential.

During the boom period of 1888, Sweetwater Dam was constructed on Sweetwater River east of San Diego, to supply water for National City, Chula Vista, and the Sweetwater Valley. A large acreage was set out to lemons and other irrigated crops soon after construction of the dam. Some pumping is carried on in the Sweetwater and Otay River Valleys.

Considerable demand is made on the underground water supply in the Tia Juana and San Diego River Valleys, where the water is used for alfalfa, field crops, and truck crops. In the upper Sweetwater Valley, water is pumped from wells.

ALKALI

Alkali, or saline salt accumulations, occur locally in small spots in some of the valleys and on the low-lying more poorly drained soils, such as occur at the lower end of Tia Juana, Sweetwater, and Mission Valleys.

Alviso very fine sandy loam occupies a position slightly higher than the tidal-marsh land, and it is heavily impregnated with salts. Analysis shows more than 3 percent of salts, most of which is sodium chloride, present in this soil. Other soils that may contain some salts are the soils of the Foster and San Marcos series. Ordinarily the concentration of salts present in these soils is insufficient to injure most field crops if the water table is maintained below the zone of capillary lift; otherwise the salts will be brought to the surface and cause crop damage.

Alkali, or salty, land cannot be reclaimed unless the drainage is good and the water table is kept at a reasonable depth below the surface. After drainage has been established, flooding the soils and adding organic matter may help in their reclamation.

The Alviso soils are unsuited to any form of crop production. They cannot be economically reclaimed under present conditions, owing to their proximity to the ocean and the saline water table that fluctuates with the tides.

Small salty patches occur in places in Huerhuero fine sandy loam, and low to moderate amounts of saline salts normally occur in the clay subsoils of the Olivenhain and Las Flores soils.

SOILS AND THEIR RELATIONSHIPS

The El Cajon area lies in a region of dry summers, and winters during which the rainfall is moderate or low. The climate as a whole may be termed semiarid, as the annual rainfall ranges between 8 and 15 inches. Such climatic influences have caused the development of soils with low organic-matter content and brown color, which are predominantly grass covered during the rainy winter season but are dry and bare during the summer. The natural vegetation in most of the coastal-plain region consists of brush from 3 to 6 feet high.

Differences in degree or stage of weathering and development, geological processes by which the material was accumulated, kinds of parent materials, leaching, calcium-carbonate content, and texture

have all constituted bases on which definition of types and series has been made. In general, the soils of the highland region occur on rolling or hilly relief and have a slightly weathered profile, with the parent rock occurring within a few feet of the surface. The texture of the soils is largely influenced by the character of the parent material. The soils weathered from granite are sandy loams, and those from finer-grained rocks along the western edge of the area are of finer texture and are all brown or reddish brown. The alluvial soils of the stream valleys show little or no profile development, range in color from brown to black, and have a wide range of alkali and calcium-carbonate content. The coastal-plain soils vary greatly, owing to the stage of development, kind of material, and amount of erosion that has taken place since they were laid down. Deep valleys have been cut by erosion, have been partly filled, and different levels have been successively exposed to wave action on this plain. These soils, where occurring on the flat-topped terraces and in areas which have not been eroded, show a mature profile having sandy surface soils and very heavy compact subsoils underlain by moderately consolidated marine sediments. The surface soils are slightly acid in reaction. The A horizons of the maturely weathered soils are much thinner than the A horizons of soils in regions of greater rainfall.

For the purposes of classification and discussion, the soils of the area have been placed in four major groups as shown in table 5. This grouping is based partly on profile characteristics and partly on the character of the parent material.

The light-colored soils of group 1 have weathered in place from the underlying parent consolidated rock, the surface soils being loose and friable. The subsoils are slightly compact and slightly heavier in texture than the surface soils and in most places contain shattered pieces of the parent bedrock.

At a depth ranging from a few inches to 5 feet, the soils rest on the parent material which ranges from granite rock to limestone in this area. All the soils of this group are brown or brownish red, except the Diablo and Linne soils which are dark dull brownish gray or nearly black. The igneous rocks of the highland area give rise to soils of sandy loam or fine sandy loam texture, and the calcareous rocks give rise to heavier-textured members of the Diablo, Ayar, and Linne series.

The profile of Vista sandy loam is typical of the profiles of the light-colored soils of this group. Under virgin conditions the surface inch, or A_1 horizon, consists of dull-brown or light grayish-brown loamy sand containing roots and partly decayed organic material. This horizon contains a high proportion of angular quartz which gives the soil a light-gray appearance and a single-grain structure. The A_2 horizon, which extends to a depth ranging from 10 to 14 inches, is light-brown or light reddish-brown sandy loam of firm consistence, that breaks into clods which may be further broken down under slight pressure to a granular or single-grain structure. The material in this layer has a tendency to bake on drying. The soil material changes gradually to light reddish-brown or dull reddish-brown slightly compact material, the B horizon, of heavier sandy loam, loam, or clay loam texture. This material breaks into clods of irregular size and shape. When moist the material in this horizon shows a slight col-

loidal glazing on the insides of root cavities, which cannot be observed when the soil is dry. Coarse angular quartz particles occur throughout this horizon as well as all others. This horizon gradually changes to a C_1 horizon that is coarser textured, slightly compact, and without structural development. It represents the beginning of the parent rock material, a coarse-grained granite.

The soils of the Altamont series are brown or light brown in the surface soils and brown or rich brown in the subsoils. The soil material immediately overlying bedrock is yellowish brown or grayish brown. Calcium carbonate occurs intermittently in the lower part of the subsoil or in the upper part of the C horizon.

The Diablo soils are very dark brown or almost black, in many places having a faint gray shade. The thickness of the very dark colored layer ranges up to somewhat more than 12 inches. Most areas of these soils are comparatively heavy in texture. The clay adobe and its brown phase are the dominant types mapped in this area. The lower part of the dark-colored layer becomes gradually lighter in color with depth, finally passing at a depth ranging from 2 to more than 3 feet into marl or other soft or semi-indurated calcareous material. The soil described is a well-defined rendzina, although it occurs in a region of low rainfall. It seems to be typical of soils of this group in its existing condition, but its future course of development will be different, provided there be no change of climate in the region, from the normal course of rendzina development. These soils normally occur in a humid environment and maintain their rendzina characteristics only during youth. As the calcium carbonate is slowly leached out under a high rainfall they finally become acid in reaction and under such conditions can no longer retain their high percentage of organic matter. They lose also their rendzina structure and assume the characteristics and profile of normally podzolic soils.

Since the Diablo soils lie in a region where the maximum annual rainfall amounts to no more than 15 inches, it is apparent that they will not develop into podzolic soils but will develop in the direction of the dark-brown members of the pedocalic soils.

The Linne and Ayar soils seem to constitute rendzinas which have passed beyond the stage where these characteristics are typically expressed. The Linne soils have not yet attained the typical pedocalic stage of development but lie in an intermediate stage between typical rendzinas and typical dark-brown soils. They are still dark in color. The Ayar soils seem to occupy a stage somewhat still more advanced than that of the Linne soils.

Group 2 is composed of soil materials that are so young that they lack any structural development or horizons of compaction. They include recent alluvial soil material built up so rapidly that it has not been altered by weathering. These soils occur in the stream valleys and on the alluvial fans and flood plains, and are still in the process of deposition. They are subject to overflow by the bordering streams. These soils are differentiated into series on the basis of differences in color, origin, and lime content. As they have no true soil profile, it is not necessary to describe such pseudoprofiles as may be present. Such profiles are geological rather than pedological.

The soils of the Ramona series, although the profile is somewhat more advanced in stage of development than that of the other members of group 3, are intermediate in age between the Greenfield and

Merriam soils. Following is a profile description of Ramona sandy loam:

A_1. 0 to 2 inches, dull-brown deflocculated loamy sand containing large quartz particles.

A_2. 2 to 10 inches, brown or reddish-brown sandy loam of medium granular structure and well filled with root cavities.

B_1. 10 to 20 inches, brown or reddish-brown slightly compact gritty sandy loam of coarse granular structure and containing root cavities.

B_2. 20 to 50 inches, reddish-brown or dull brownish-red moderately compact sandy loam which breaks up into irregular-shaped clods from 1 to 2 inches in diameter. Dark brownish-red colloidal glazing occurs on the surface of the cracks but does not extend into the interior of the clods, and dark staining is on the surface of root cavities. The interiors of the clods are browner than the exposed surfaces.

C_1. 50 to 72 inches, pale reddish-brown slightly compact sandy loam or fine sandy loam, without definite structure but with considerable pore space.

All horizons contain visible quartz particles and sharp fragments of granitic rock material, as the soil is of granitic origin. In fundamental characteristics, this profile is identical with that of the Vista and associated soils.

The soils of the Salinas series are dark colored and are closely related in general characteristics to some of the dark-colored upland soils.

The soils of group 4 are developed on maturely weathered stream and marine terrace deposits. In age, or stage of weathering, they are all very similar. The soils mapped in this group differ one from another in color, lime content, or other profile distinctions. They all have light-textured surface horizons, slightly acid in reaction, which change abruptly to tight plastic clay having a columnar structure in the upper part and a cubical structure in the lower part. The transition from this horizon to the underlying parent material is gradual. Wherever accumulated calcium carbonate occurs in these soils, it is in the form of nodules in the lower part of the heavy B horizon, just above the point where it grades into the parent material. The Aliso, Huerhuero, and Merriam soils have such characteristics, together with a nodular accumulation of lime. The Monserate soils are characterized by a hardpanlike substratum that contains seams and coatings of lime in the upper part. All the other soils of this group are noncalcareous, and they include members of the Olivenhain, Las Flores, and Redding series.

Following is a description of the profile of the virgin soil of Olivenhain fine sandy loam which shows a typical profile of the soils of this group:

A_1. 0 to 1 inch, deflocculated light brownish-gray loamy fine sand containing a small amount of partly decayed organic matter.

A_2. 1 to 8 inches, light-brown or light grayish-brown friable fine sandy loam that is slightly granular when disturbed but breaks up easily into a powdery mass. The material contains many channels and cavities of roots, as well as organic material in various stages of decay. An abrupt transition to the B_1 horizon occurs within less than one half inch. The reaction is slightly acid.

B_1. 8 to 30 inches, brown or dull reddish-brown compact clay, with a columnar structure, the columns being from 1 to 2 inches in diameter and from 4 to 7 inches in length. The tops of the columns are partly rounded, and a gray layer from one fourth to three eighths inch in thickness covers the tops of the columns. Considerable dark colloidal staining occurs in the upper part of the horizon on the surfaces of root cavities and the faces of the columns. The lower part of this horizon is lighter colored, has less colloidal staining, and breaks up into a cubical structure. The material is slightly alkaline.

C_1. Below 30 inches, light-brown or light yellowish-brown moderately consolidated sediments of marine origin. These sediments are of sandy character and extend to an undetermined depth.

The Olivenhain soils have been studied in detail and recognized only in the more recent soil surveys. In the earlier reconnaissance survey they were not differentiated but were included in the broad groups of soils of the coastal plain, mainly with soils of the Las Flores, San Joaquin, Kimball, and Redding series. They are very similar to the Las Flores soils.

As the soils of the Redding series are extensive in this area, the following description of a typical profile of Redding gravelly sandy loam is given as representative of the soils of this series:

A_1. 0 to one half inch, a fibrous layer of moss, containing some soil material which is distinctly acid in reaction.

A_2. One half to 5 inches, light brownish-red or light reddish-brown granular loam which is slightly acid in reaction.

B_1. 5 to 24 inches, red compact clay which breaks up into ½-inch kernels when crumbled. The lower part of this horizon contains considerable colloidal glazing but only a few root cavities.

B_2. 24 to 28 inches, light grayish-drab clay of amorphous structure.

C. Below 28 inches, a cobbly iron and silica cemented hardpanlike substratum, ranging from red to gray in color. The top of this horizon appears as a cobbly hardpan, but examination shows the layer to extend to a great depth.

The Redding soils occur on a high flat-topped terrace having a hogwallow relief. Under virgin conditions the vegetal cover is chaparral.

The soils of the Merriam series are derived from weathering of material of the same character as that giving rise to the soils of the Ramona series, but which have weathered to a more advanced stage under low rainfall. They are of granitic origin. The surface soil of Merriam sandy loam consists of rich-brown or light reddish-brown sandy loam which ranges in thickness from 8 to 16 inches. The material is friable when moist but bakes very hard on drying. The surface horizon gives a pH value between 6.5 and 7. The B_1 horizon is dull brownish-red very compact clay of jointed or columnar structure. The columns are rounded at the top and have a thin gray floury deposit overlying them. They are about 2 inches in diameter and can be broken into cubes that show colloidal glazing on the cracked surfaces. Considerable dark staining is present. Less colloidal material and a lighter color is noted in the lower part of the horizon. The pH value of the material from this horizon ranges from 7.4 to 8. The thickness of the horizon ranges from 15 to 24 inches. The B_2 horizon has very little colloidal glazing. It consists of dull reddish-brown or dull brownish-red compact material which is somewhat lighter in texture than the horizon above it, and it has a pronounced accumulation of calcium carbonate occurring in soft nodules or seams. Immediately below the calcium-carbonate concentration the soil changes in texture and structure. The C_1 horizon is light-brown fairly compact sandy loam or loam material which can be broken down to a granular structure. All horizons of these soils contain appreciable quantities of gritty material of granitic origin. The Merriam soils are differentiated from the Huerhuero and Aliso soils on the basis of color and gritty character.

The Merriam soils are very similar in color, appearance, and profile development to the soils of the Placentia series which are of extensive occurrence in southern California areas. In the earlier reconnaissance

mapping they were included with the Placentia soils, from which they differ in their slightly more arid environment and in the more distinctive solonetzlike horizon containing accumulated lime.

The results of mechanical analyses (including determination of the finer colloidal, or ultra clay, material) and moisture equivalent determinations of soils of the El Cajon area are given in table 7. These analyses and the pH determinations shown in table 8 were made in the laboratory of the division of soil technology, University of California.

TABLE 7.—*Mechanical analyses and moisture determinations of several soils from the El Cajon area, California*

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay [1]	Colloid [2]	Total clay	Moisture equivalent.
	Inches	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Vista sandy loam:											
577747	0–10	11.3	13.1	6.9	24.4	27.1	10.1	3.2	4.0	7.2	11.4
577748	10–30	10.0	9.6	7.5	20.9	29.1	11.1	3.8	8.4	12.2	12.9
Fallbrook sandy loam:											
577740	0–12	15.8	10.8	9.3	21.1	23.5	9.6	3.3	6.6	9.9	11.3
577741	12–20	15.3	17.1	7.5	22.4	18.5	9.6	4.0	6.6	10.6	11.5
Konokti stony loam:											
577757	0–10	8.4	8.3	4.0	8.8	19.0	34.2	11.1	6.3	17.4	21.3
577758	10–18	5.5	6.6	5.8	9.8	20.9	32.4	11.6	7.6	19.2	19.5
Escondido very fine sandy loam:											
577729	0–10	.9	2.2	1.7	16.0	57.8	13.5	3.4	4.3	7.7	11.9
577730	10–24	.9	2.0	2.2	11.9	61.3	13.6	4.5	3.4	7.9	12.1
Diablo clay adobe:											
577762	0–12	1.6	3.8	10.1	18.5	10.0	12.1	9.5	34.3	43.8	31.0
577763	12–30	1.2	5.6	8.5	16.4	10.5	13.5	9.6	34.7	44.3	31.1
Ayar clay:											
577750	0–10	.4	.8	2.4	13.0	20.5	29.1	14.2	20.0	34.2	20.2
577751	10–20	.4	1.8	1.7	12.6	18.8	32.3	13.4	19.7	33.1	34.1
Linne sandy clay loam:											
577765	0–10	.8	1.9	5.5	23.3	25.4	16.0	7.3	20.5	27.8	29.3
577766	10–28	.6	4.0	4.0	23.0	23.6	14.4	7.6	22.5	30.1	28.3
Hanford sandy loam:											
577734	0–12	9.9	9.0	10.2	24.3	26.2	11.1	3.5	5.8	9.3	12.0
Cajon fine sand:											
577778	0–12	.2	1.0	1.3	40.9	50.7	3.8	.7	1.9	2.6	8.3
Foster very fine sandy loam:											
577725	0–12	.3	1.0	2.3	18.7	47.0	20.0	4.0	6.7	10.7	21.2
Sorrento clay loam:											
577711	0–12	.8	2.0	1.6	6.9	29.6	33.1	11.9	14.2	26.1	25.1
577712	12–72	1.1	1.5	3.0	7.2	27.3	30.7	13.3	16.2	29.5	23.9
Botella fine sandy loam:											
577782	0–14	.2	3.2	14.6	34.4	28.6	7.6	2.4	9.3	11.7	13.4
577783	14–48	.5	4.0	10.4	27.7	25.3	13.9	5.0	13.4	18.4	19.9
Ramona sandy loam:											
577736	0–10	7.0	9.8	5.0	18.8	26.6	19.6	5.7	7.3	13.0	15.5
577737	10–20	6.9	8.9	5.2	17.8	28.3	17.3	6.0	10.0	16.0	15.0
577738	20–50	7.6	7.9	7.0	17.4	28.7	14.8	3.9	12.9	16.8	16.4
Hames sandy loam:											
577774	0– 8	9.9	16.7	12.6	17.1	21.0	12.7	4.3	5.6	9.9	10.4
577775	8–20	5.8	17.1	8.5	20.9	21.2	12.3	5.6	8.5	14.1	9.1
577776	20–40	8.4	21.3	7.9	15.5	18.1	11.1	5.2	12.5	17.7	9.5
Salinas sandy clay loam:											
577780	0–18	.5	1.2	1.2	21.0	30.6	18.2	7.9	20.3	28.2	29.5
577781	18–72	.4	.7	.7	20.5	35.8	17.0	6.7	18.7	25.4	27.4
Olivenhain fine sandy loam:											
577701	0– 8	.4	1.2	5.0	8.3	36.6	33.8	8.6	6.2	14.8	17.6
577702	8–30	.2	.5	1.9	4.7	24.3	29.2	20.4	19.1	39.5	25.5
Las Flores loamy fine sand:											
577716	0– 9	5.8	10.6	9.7	31.9	25.8	9.4	2.9	3.5	6.4	9.0
577717	9–28	1.7	7.3	7.9	22.6	18.9	6.1	1.1	34.4	35.5	37.9
Redding gravelly sandy loam:											
577719	0– 5	4.1	10.2	7.0	11.2	19.0	29.8	7.6	11.2	18.8	18.1
577720	5–24	2.2	4.4	6.7	8.1	11.8	22.7	3.7	40.7	44.4	23.9
577721	24–28	2.1	6.4	3.0	4.9	6.2	12.2	4.8	60.7	65.5	28.8

[1] Clay includes particles from 0.005 to 0.001 millimeter in diameter.
[2] Colloid includes particles less than 0.001 millimeter in diameter.

TABLE 7.—*Mechanical analyses and moisture determinations of several soils from the El Cajon area, California*—Continued

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Colloid	Total clay	Moisture equivalent
	Inches	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Aliso fine sandy loam:											
577770	0–10	1.9	8.5	6.6	25.7	29.4	18.9	4.4	4.6	9.0	12.1
577771	10–20	1.2	4.1	5.4	13.7	18.3	12.8	4.0	40.4	44.4	31.2
577772	20–36	.9	3.0	5.9	15.5	19.8	13.2	-------	-------	41.5	34.6
Huerhuero fine sandy loam:											
577704	0–7	1.7	8.1	7.4	17.8	30.8	23.6	5.1	5.4	10.5	25.1
577705	7–22	1.1	3.4	3.6	12.4	28.5	21.2	6.3	23.4	29.7	30.2
577706	22–40	.1	.8	2.1	6.5	24.5	30.0	11.4	24.9	36.3	42.7
577707	40–60	.5	2.7	3.6	12.4	29.9	25.9	8.7	16.3	25.0	26.6
Merriam sandy loam:											
577743	0–10	6.9	6.6	6.8	18.3	34.1	15.8	5.1	6.4	11.5	12.9
577744	10–30	4.2	6.6	3.6	16.3	24.2	12.0	9.8	23.6	33.4	21.6
577745	30–45	6.6	13.0	7.0	20.4	20.1	10.2	5.1	17.4	22.5	19.3
Monserate sandy loam:											
577754	0–10	5.4	12.0	9.5	22.5	23.2	15.1	4.8	7.5	12.3	13.2
577755	10–24	5.1	8.6	9.5	15.0	15.2	11.2	5.0	30.4	35.4	28.3

TABLE 8.—*pH determinations of soil samples from the El Cajon area, California*

Soil group and type	Sample no.	Depth	pH
		Inches	
Group 1:			
Vista sandy loam	577747	0–10	6.30
Do	577748	10–30	6.80
Fallbrook sandy loam	577740	0–12	6.80
Do	577741	12–30	6.90
Escondido very fine sandy loam	577729	0–10	6.80
Do	577730	10–24	7.00
Carlsbad loamy fine sand	577708	0–12	5.90
Do	577709	12–30	7.19
Altamont clay loam	577713	0–8	6.40
Do	577714	8–30	7.24
Ayar clay	577750	0–10	[1] 8.21
Group 2:			
Foster very fine sandy loam	577725	0–12	[1] 8.98
Group 3:			
Marina loamy fine sand	577785	0–16	6.68
Salinas sandy clay loam	577780	0–18	7.99
Do	577781	18–72	[1] 8.16
Greenfield sandy loam	577731	0–12	6.73
Do	577732	12–40	7.07
Do	577733	40–72	7.17
Group 4:			
Olivenhain fine sandy loam	577701	0–8	6.50
Do	577702	8–30	6.90
Aliso fine sandy loam	577770	0–10	7.65
Do	577771	10–20	7.44
Do	577772	20–36	[1] 7.91
Huerhuero fine sandy loam	577704	0–7	7.70
Do	577705	7–22	7.10
Redding gravelly sandy loam	577719	0–5	6.07
Do	577720	5–24	5.20
Do	577721	24–28	4.35
Merriam sandy loam	577743	0–10	6.60
Do	577744	10–30	7.60
Do	577745	30–45	[1] 8.60

[1] Presence of carbonates shown by effervescence with hydrochloric acid.

SUMMARY

The El Cajon area is located in the extreme southwestern part of San Diego County, Calif., and includes an area of 605 square miles. The Pacific Ocean borders the area on the west.

The area surveyed covers a mountainous region in the eastern half and a coastal-plain area of flat-topped sea terraces on the west.

Lower marine terraces border San Diego Bay. Deep, narrow valleys, including Rose, Mission, Sweetwater, Otay, and Tia Juana, have been cut out by the streams draining the area. El Cajon Valley is a boxlike basin between the coastal plain and the mountainous district.

The population may be considered as largely urban, even those people living in El Cajon Valley and in the district south of San Diego, where there are a large number of farms ranging from one half to 1 acre.

The agriculture is largely governed by the climate and water supply. Winter vegetables, avocados, and citrus fruits require frost-free or nearly frost-free locations. As the average annual rainfall is between 8 and 17 inches, most crops require irrigation. Temperatures along the coast are equable, with an absence of extremely hot or very cold weather, but the extremes are greater back from the coast.

Grain, grain hay, and grapes are the principal nonirrigated crops. The largest acreage of grapes, most of which are of the Muscat varieties, is in El Cajon Valley. The principal irrigated crops are oranges, lemons, avocados, celery, cauliflower, tomatoes, potatoes, peppers, squash, and string beans. Bulbs and cut flowers are crops which are increasing in importance.

Poultry raising is the most extensive and important of the livestock industries. Dairying is carried on in the river valleys.

The soils of the area have been classified in four major groups on the basis of differences in color and the soil profile. This grouping is made on soil characteristics, but there is also a correlation between each soil group and its agricultural value.

The soils of group 1 have weathered in place from the underlying consolidated bedrock. They are referred to in this report as primary or residual soils, and most of them occur in the rolling or mountainous region back from the coastal plain. Bedrock in most places occurs at a depth ranging from 2 to 4 feet below the surface. These soils represent an immature or young stage of weathering, and they have no pronounced accumulation of clay in the subsoil. The soils of the Vista, Fallbrook, Konokti, Escondido, Carlsbad, Altamont, Diablo, Ayar, and Linne series are included in this group. Where the surface relief and frost conditions are favorable, the Vista, Fallbrook, and Escondido soils are well adapted to citrus and other fruit crops. The Altamont, Diablo, Ayar, and Linne soils are utilized for general field crops, such as grain and grain hay. The Konokti soils are very stony, and only a small proportion of them is tilled. The Carlsbad soils are developed on sandy beach deposits underlain by a red hardpanlike substratum. Vista sandy loam is the most important agricultural soil of this group, both as regards area and utilization.

The soils of group 2 are characterized by loose, friable surface soils and subsoils. They are of unweathered, recent-alluvial origin and are more than 6 feet thick. Included in this group are soils of the Hanford, Cajon, Foster, Agueda, and Alviso series. Alviso very fine sandy loam has no agricultural value at present, owing to its low-lying, undrained position and its high salt content. Where irrigation water can be obtained from wells, the other soils of this group are used in the production of alfalfa, general field crops, and truck crops.

Group 3 includes soils differing from those in group 2, in that they have slightly compact or heavier-textured subsoils. They are developed on moderately weathered alluvial deposits and have about the same value as the soils of group 2, but they are less droughty owing to their heavier subsoils. They are deep, fertile, and adapted to a wide range of crops where not subject to frost and where water is available for irrigation. The total acreage of these soils is not so large as the total acreages of groups 1 and 4. Soils of the Marina, Sorrento, Greenfield, Botella, Ramona, Hames, Salinas, and San Marcos series are included in this group. All are well drained, except the San Marcos soils, which may have alkali accumulations in spots. The soils of group 3 occur on low terraces or valley floors at slightly higher elevations than the recent alluvial soils of group 2.

The soils of group 4 are characterized by friable sandy surface soils and heavy compact clay subsoils. In most places the clay layer is underlain by unconsolidated or moderately consolidated hardpanlike sediments of marine origin. Large areas of these soils occur on the mesas of the coastal plain. Of these soils, Redding gravelly sandy loam is extensive, occurring over the Lindavista Mesa and on the mesa on which San Diego is located. It has very little agricultural value. Soils of the Olivenhain and Las Flores series are associated with the Redding soils in the same region. They are only slightly developed for agricultural use. They are best adapted to shallow-rooted crops, because the clay layer retards or prevents the penetration of water and roots. Huerhuero fine sandy loam, Aliso fine sandy loam, and Merriam sandy loam occur on lower terraces. They have a nodular accumulation of lime in the subsoil, and the lower part of the subsoil is made up of unconsolidated sediments. Where irrigation water is available, these soils are extensively developed. Celery and other truck crops are grown on the Aliso and Huerhuero soils in the vicinity of Chula Vista. Merriam sandy loam and Monserate sandy loam occur in the foothill valleys. Monserate sandy loam has a moderately consolidated hardpanlike substratum, mottled with lime seams in the upper part. Both soils are used for grapes in El Cajon Valley.

Four types of miscellaneous soil materials are mapped. These include rough broken land; rough stony land; coastal beach, dune sand, and river wash; and made land. All are nonagricultural. Rough stony land covers 23.5 percent of the El Cajon area.

Water for irrigation is obtained from storage reservoirs and by pumping from wells in the stream gravels in the small valleys of the area. The city of San Diego controls a series of reservoirs in the back country. Domestic use of water in residential districts has overshadowed the agricultural use in the last 10 years owing to a great increase in the population. The La Mesa, Lemongrove, and Spring Valley irrigation district supplies water for irrigation throughout the El Cajon Valley and east of San Diego, and water for irrigation in the Chula Vista and Sweetwater Valley district is obtained from the Sweetwater Reservoir. Pumped water is used for irrigation in the valley of San Diego River, in the upper Sweetwater Valley, and in Tia Juana Valley.

Alkali or saline salt accumulations are present locally in some of the lower valleys and on land close to tidewater.

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U. S. GOVERNMENT PRINTING OFFICE: 1934

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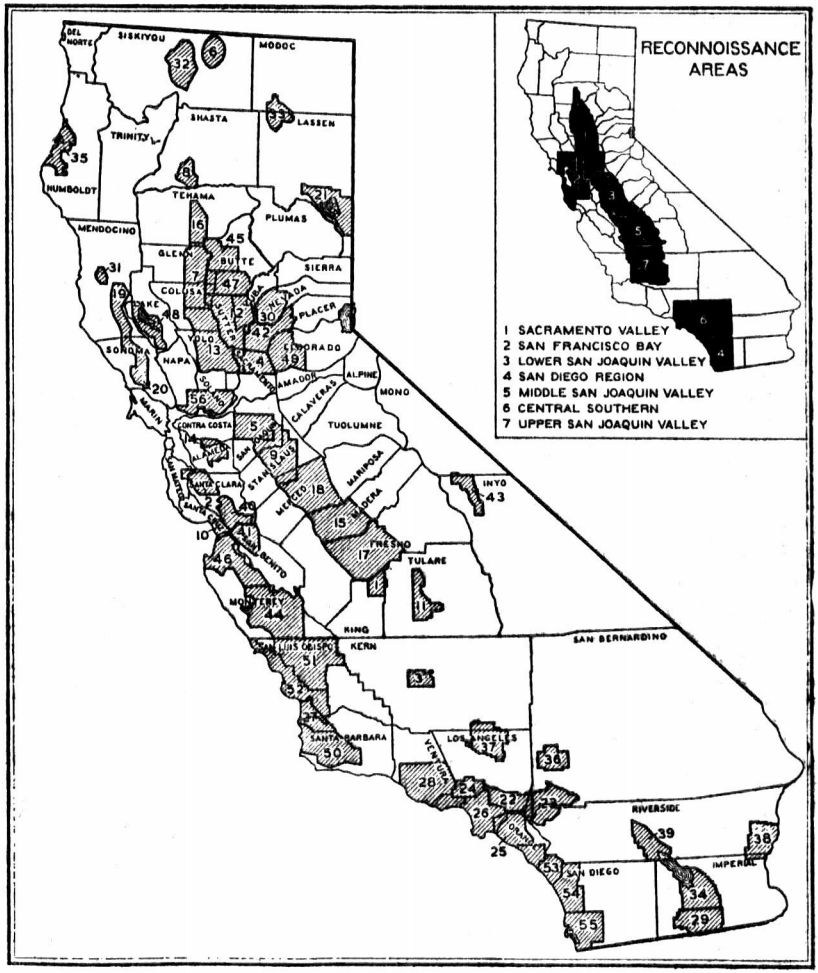

Areas surveyed in California, shown by shading

1. Hanford
2. San Jose
3. Bakersfield
4. Sacramento
5. Stockton
6. Butte Valley
7. Colusa
8. Redding
9. Modesto-Turlock
10. Pajaro Valley
11. Portersville
12. Marysville
13. Woodland
14. Livermore
15. Madera
16. Red Bluff
17. Fresno
18. Merced
19. Ukiah
20. Healdsburg
21. Honey Lake
22. Pasadena
23. Riverside
24. San Fernando
25. Anaheim
26. Los Angeles
27. Santa Maria
28. Ventura
29. El Centro
30. Grass Valley
31. Willits
32. Shasta Valley
33. Big Valley
34. Brawley
35. Eureka
36. Victorville
37. Lancaster
38. Palo Verde
39. Coachella Valley
40. Gilroy
41. Hollister
42. Auburn
43. Bishop
44. King City
45. Chico
46. Salinas
47. Oroville
48. Clear Lake
49. Placerville
50. Santa Ynez
51. Paso Robles
52. San Luis Obispo
53. Capistrano
54. Oceanside
55. El Cajon
56. Suisun

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